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INTERNATIONAL KNOWLEDGE SPILLOVERS TO DEVELOPING COUNTRIES: THE CASE OF INDONESIA

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International Knowledge Spillovers to Developing Countries: The Case of Indonesia*

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Abstract:

In recent years, the question of growth and catch-up in East Asia has been the subject of intense academic debate. A crucial aspect of this debate has been the importance of learning and technological upgrading during the process of late industrialisation and catch up. In this paper, we examine for Indonesia, a second tier newly industrialising economy, the importance of learning from imports for manufacturing productivity. We examine this in the background of the effect of shift away from import substitution to export-orientation of the economy during the mid-eighties. We operationalise the concept of learning drawing on the so-called technology spillover literature. Our results indicate that knowledge spillovers have become significant contributors to labour productivity after the liberalisation of the economy. The results also support the view that sectoral specificities and market structures play an important role in the generation of these spillovers.

Keywords: East Asian Growth, productivity, liberalisation, knowledge spillovers, international trade, market structure
JEL: L16, O33, O38, O47, O53

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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 TFP estimates that showed very low contributions to economic growth (Young 1994;Young 1995). The contribution of TFP was particularly low when compared to the advanced, G-5 group of countries (Kim & Lau 1994). Krugman (1994) in his, now well-known article in *Foreign Affairs* provided wide popularity to this so called *accumulationist* theme. Drawing on TFP estimates for Singapore, he raised serious doubts about the sustainability of East Asian growth, suggesting that East Asian growth is driven mainly by *perspiration* (factor intensification) and very little by *inspiration* (productivity improvements). Drawing parallels with industrialisation in the former Soviet Union, he went on to argue that the East Asian “non” miracle would come to an end when the opportunities for utilisation of factors of production were exhausted.

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. The first of these authors also found that the Asian NICs grew much faster than similar countries with high levels of investment, even after accounting for the advantages of “initial backwardness”. Historical case studies too 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. This incentive structure focused on export success as the condition for state support. This has had the effect of placing technological learning at the centre of the industrialisation programme in these countries. Authors in this tradition also pointed out that late industrialisation proceeded in stages, from light and low-tech industries to technologically more advanced industries and therefore from one that was based on cost-based comparative advantage to technology-based competitiveness.

Against the backdrop of this debate, the present paper focuses on the role of international technology transfers, technology spillovers and technological learning in the process of Indonesian industrialisation. Indonesia is one of the second-tier NICS, which reduced its dependence on oil and started exporting manufactured goods in the late 1980s. Indonesian industrialisation is highly dependent on imports of capital goods and intermediate inputs from the advanced economies. These imports can promote accumulationist patterns of growth. They can also result in technological learning and assimilation of internationally available knowledge.

Objectives
This paper pursues the following objectives. First, what has been the relative contribution of technological learning from imported inputs to labour productivity growth, compared to other factors such as, in particular, capital deepening? 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 levels?

In order to examine these issues, we construct a new measure of North-South knowledge spillovers. This measure is assumed to capture the extent to which the Indonesian industry can benefit technologically from the R&D expenditure of the countries in the OECD that export to Indonesia. The sources for our measure are the following: sectoral R&D expenditures and sectoral export intensity figures of Indonesia's leading trade partners in the OECD, a technological distance matrix based on patent data from the European Patent Office, and a structural congruence index that is derived by comparing the sectoral input structures of Indonesia with that of her trade-partners using input-output transaction tables. These data are used to construct international knowledge stocks in Indonesia. These are then combined with Indonesian manufacturing production data to build a panel data set for the period 1980 to 1996. The relatively long time period offers the possibility to examine the effect of the shift from import substituting to the export-oriented phase of industrialisation.

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 discusses the Indonesian and the OECD data sets, and the adjustments made to them. The estimation model is presented in section 5. Findings and conclusions are summarised in sections 6 and 7.

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. Initially, the export-drive was based on comparative advantage in labour intensive and low-tech lines of production. In a later stage, a process of technological upgrading commenced characterised by shifts into high technology sectors, use of skilled labour and the importance of learning (Amsden 1989).

Indonesia differs from East Asia due to her resource-abundance, especially oil and gas, and on account of the much later timing of the shift from import substitution to export orientation.

Until the mid-eighties, Indonesia 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 manufactured 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 (Appendix Table A.2.). Industrial policy during the "new order" regime of General Suharto 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.[1] However, the most important sectors were resource intensive sectors such as food, beverages & tobacco and rubber (Table 1). These sectors also accounted for bulk of the exports from manufacturing until the mid-eighties (Table 2).

Given the prevailing ownership and incentive structures, big enterprises did not have to fulfil any export commitments, in contrast to their Korean counterparts. Again, unlike in Korea, the Indonesian industry faced the constraint of limited technological and human capability (Hill 1995). These may explain the failure of such ambitious endeavours like, for example, the aerospace and automobile projects.

During the liberal era (1986---present), manufacturing exports became the top priority of economic policies, similar in spirit to those in Korea and Taiwan. By 1998, the share of manufacturing in GDP had risen in current prices to 27% from a meagre 8% in 1960 (Fane 1999). Our own data in constant 1983 prices show an increase from 11 per cent in 1975 to 27 per cent in 2000 (Appendix Table A.1.)

During the initial years of reform during the eighties, the thrust has been on labour intensive and low-technology sectors, as was the case in the early stages of export orientation in Korea and Taiwan. Compared to the import substitution period, there was a process of "down grading" in the direction of labour intensive, low-tech and resource intensive sectors in which Indonesia had a comparative advantage. Till the early nineties manufacturing exports were largely concentrated in three sectors – wood and furniture, garments & leather and textiles –, which accounted for more than half of the total manufacturing exports.

From the nineties onwards a more diversified pattern started to emerge, with electronics, electrical goods, office equipment, etc, making substantial inroads into export markets (Table 2). The key question is to what extent the process of upgrading is comparable to that in East Asian economies.

[1] In spite of the trend towards liberalisation from the mid-eighties, these industries, which either were in the public sector or in the private sector controlled by military personnel, continued to receive protection from foreign competition until the economic crisis of 1997 (Dhanani 2000).

Table 1. Pattern of Structural Change in Indonesian Manufacturing: 1975–2000

Sectoral composition of Value Added						
Sector	1975	1980	1985	1990	1995	2000
Food, beverages & tobacco	58.7	45.8	36.2	35.1	35.2	29.1
Wood products & furniture	2.1	5.4	8.8	11.8	6.7	6.2
Rubber & rubber products	6.2	7.2	5.5	4.1	3.3	4.2
Non-metallic mineral products	2.9	4.1	5.1	2.7	2.9	3.3
Resource Intensive Manufacturing	69.8	62.6	55.7	53.7	48.2	42.7
Garments & leather	4.2	4.3	3.4	5.1	6.3	8.2
Other manufacturing	0.4	0.5	0.7	0.4	0.6	0.6
Labour Intensive Manufacturing	4.6	4.8	4.0	5.5	6.9	8.8
Textiles	4.0	4.2	6.5	8.4	10.3	9.1
Paper, paper products & printing	2.9	2.0	3.1	4.7	5.2	6.1
Industrial chemicals	4.2	4.7	6.1	4.9	4.9	4.5
Iron & steel	0.3	1.6	3.7	3.4	3.5	1.8
Non-ferrous metals	0.9	1.0	2.9	3.3	2.7	2.0
Shipbuilding & repairing	0.7	1.0	1.3	0.6	0.3	0.2
Other transport	0.1	0.1	0.1	0.0	0.0	0.0
Motor vehicles	5.9	5.4	3.2	3.7	4.6	6.5
Aircraft	0.4	0.2	0.6	0.4	0.2	0.2
Scale Intensive Manufacturing	19.3	20.3	27.6	29.4	31.6	30.5
Metal products	2.2	2.4	3.2	2.1	1.9	2.7
Non-electrical machinery	2.1	4.0	3.2	4.8	3.4	3.3
Differentiated Manufacturing	4.3	6.5	6.3	6.9	5.3	6.0
Drugs & medicines	0.5	1.2	1.6	1.1	0.9	0.8
Plastics	0.4	0.9	1.9	0.9	2.0	2.4
Electrical apparatus, nec	0.0	0.5	0.5	0.2	0.3	0.9
Radio, TV & comm. equipment	0.7	2.6	2.2	2.0	3.7	6.9
Professional goods	0.4	0.6	0.3	0.3	1.1	0.9
Science Based Manufacturing	2.0	5.9	6.4	4.5	8.0	11.9
Total Manufacturing	100.0	100.0	100.0	100.0	100.0	100.0

Source: Input-Output tables; Statistik Industri, various issues, BPS, Jakarta.

Table 2. Pattern of Structural Change in Indonesian Manufacturing: 1975–2000

Sectoral composition of Exports						
Sector	1975	1980	1985	1990	1995	2000
Food, beverages & tobacco	27.2	19.5	7.5	13.1	8.3	6.9
Wood products & furniture	0.1	11.2	27.0	26.8	17.2	11.1
Rubber & rubber products	31.0	35.1	20.8	8.1	5.6	3.3
Non-metallic mineral products	0.0	0.9	0.6	1.5	1.0	1.9
Resource Intensive Manufacturing	58.4	66.7	55.9	49.6	32.2	23.2
Garments & leather	0.2	3.3	8.8	17.6	19.1	14.5
Other manufacturing	0.0	0.1	0.1	0.5	1.2	1.1
Labour Intensive Manufacturing	0.2	3.4	8.8	18.1	20.3	15.6
Textiles	0.2	1.9	6.2	10.1	13.1	13.3
Paper, paper products & printing	0.7	0.2	0.6	1.7	4.3	7.1
Industrial chemicals	29.8	2.1	5.8	4.3	4.1	4.7
Iron & steel	0.0	0.5	0.8	1.4	0.9	0.9
Non-ferrous metals	7.9	19.5	16.4	9.5	8.4	5.2
Shipbuilding & repairing	0.1	1.3	1.1	1.0	0.7	0.3
Other transport	0.0	0.0	0.0	0.0	0.0	0.0
Motor vehicles	0.0	0.2	0.0	0.3	1.1	0.9
Aircraft	0.7	0.2	0.1	0.2	0.2	0.1
Scale Intensive Manufacturing	39.3	25.8	31.0	28.4	32.8	32.6
Metal products	0.2	0.3	0.1	0.7	1.3	1.8
Non-electrical machinery	0.8	0.2	0.4	0.3	2.9	7.4
Differentiated Manufacturing	1.0	0.4	0.5	1.0	4.2	9.3
Drugs & medicines	0.1	0.4	0.3	0.1	0.1	0.1
Plastics	0.0	0.0	0.5	0.8	0.6	1.1
Electrical apparatus, nec	0.0	0.0	0.0	0.1	0.6	2.1
Radio, TV & comm. equipment	0.9	3.2	2.2	1.3	7.3	14.4
Professional goods	0.1	0.1	0.8	0.7	1.8	1.5
Science Based Manufacturing	1.0	3.7	3.7	3.1	10.5	19.3
Total Manufacturing	100.0	100.0	100.0	100.0	100.0	100.0

Source: same as Table 1

The steep fall in oil prices, first in 1982 and thereafter in 1986, led to the initiation of economic reforms and the adoption of an export-oriented industrialisation strategy (Hill

The export-orientation of the post-reform phase has been helped by a surge in investment from the four Asian NICs —South Korea, Taiwan, Hong Kong and Singapore— and Japan; the latter had been the single largest foreign investor during the inward oriented phase of industrialisation with most of the investment going into the textile and garment industry. By the 1990s three quarters of FDI approvals were from the four NICs, of which Korea was the most important in terms of the number of projects (Hill 1991). The foreign investments of the late eighties led to the rapid growth in industries like textiles, garments, footwear and electronics. However, unlike in the "tigers" Indonesian high-technology manufacturing is still in low-value added activities, most of which resulted from the relocation of these activities from the NICs, where labour costs were rising, according to the flying geese model[2].

A moot question at this point is what has been 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 (Lall 1998). This raises the question whether Indonesia was able to profit from international inflows of technology through FDI, imported inputs and capital goods.[3] Available evidence is mixed on the question of FDI related technology spillovers. While econometric investigations demonstrate the presence of technology spillovers from foreign investment, albeit with varying levels of impact at different degrees of foreign ownership, (Sjöholm 1999), case studies by Hill (1988) and Thee (1991) fail to find any strong evidence for such spillovers.[4]

A crucial aspect that has not been sufficiently investigated, in our view, is the role of foreign technology spillovers through imports. Given the high proportion of manufacturing imports—about three quarters of total imports—and especially of capital goods imports, the spillover-generating role of imports warrants careful scrutiny. It is unlikely that concerted learning efforts from imported inputs could have taken place in Indonesia on the same scale, as in Korea. However, technology-spillovers from imports merit closer attention, 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 new-growth literature and the spillover literature, and develop a measure for capturing north-south spillovers. In the

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[2]Flying Geese model of development: In the Pacific region, the United States developed first as the lead country. Beginning in the late 19th century, Japan began to play catch-up development in the nondurable consumer goods, durable consumer goods, and capital goods sectors in that order. The Asian nics first and the ASEAN countries afterwards are following in Japan's footsteps (see http://www.grips.ac.jp/module/prsp/FGeese.htm).

[3] Technology contracts between domestic and foreign firms are an important channel of north-south technology diffusion. For Indonesia, these data are not available.

[4] Hill and Thee (1998) and Hill (1996) provide elaborate account of Indonesia's industrial technology landscape.

[5] Technology contracts between domestic and foreign firms are an important channel of north-south technology diffusion. For Indonesia, these data are not available.

[6] Hill and Thee Kian Wie (1998) and Hill (1996) provide elaborate account of Indonesia's industrial technology landscape.

following section, we discuss some of the conceptual and empirical issues pertaining to spillovers.

3: The Model and Conceptual Issues

The starting point of our analysis is the following augmented Cobb-Douglas production function similar to Romer (1987).

$$Y_i = A_i K_i^a KS_i^b L_i^V \tag{1}$$

where Y_i represents the output of sector i, K and L represent capital and labour inputs respectively and KS_i the international knowledge stock available in sector i. There is very little expenditure or R&D in the domestic private sector and data are only available for some plants for a few years in the 1990s. We have therefore not included this variable in the estimation.[7] The theoretical model assumes that the production function exhibits constant returns to scale in capital and labour and increasing returns when the international R&D stock (international knowledge stock, which is a measure of externalities deriving from foreign investments in R&D) is included as a third factor. From (1), we derive an equation of labour productivity of the following type.

$$y_i - l_i = a_i + a(k_i - l_i) + hl_i + b\,ks_i \tag{2}$$

In the above equation, lower case letters represent natural logarithms of variables, and h denotes the returns to scale parameter equal to $(a+V)-1$. As the returns to scale coefficient is determined econometrically, the assumption of constant returns to scale in capital and labour will be empirically tested. The knowledge stock variable is designed to indicate the importance of international knowledge spillovers.

The following section provides a background to our notion of international knowledge spillovers and proposes a method for measuring it.

3.1. 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

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[7] The public research laboratories, in contrast to other asian NIEs, undertake bulk of the R&D spending in Indonesia. However, the R&D undertaken in these research laboratories has been for product certification, training and testing activities than R&D proper (see Thee 1998, for a vivid description of the science and technology policy, public R&D research, etc.)

research efforts. This can be by means of licensing[8], reverse engineering, the exploitation of knowledge from academic and trade journals, turnover of researchers etc. Griliches (1979) calls this form of technology diffusion as knowledge spillovers (`true' externalities), and distinguishes it from rent spillovers. Rent spillovers arise when quality improvements due to R&D are not reflected in the prices at which goods and services are sold by upstream suppliers to down stream producers/customers due to competition in the product market. Thus, from the perspective of an individual economy, rent spillovers amount only to an unwanted measurement problem as productivity improvements in one industry shows up in the productivity statistics of a downstream industry.

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 (Scherer 1982;Scherer 1984;Terleckyj 1974;Verspagen 1997) and its role in generating social returns to R&D that compared well or exceeded private returns (Bresnahan 1986;Jaffe 1986;Mansfield et al. 1977;Trajtenberg 1990). Studies have also underlined the importance of knowledge spillovers between firms, industries as well as countries as an important component of technological progress.[10]

The North-South diffusion of technology too has been the subject of extensive investigations with studies focusing on different channels of technology. 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. For Indonesian manufacturing, Sjöholm (1999) found evidence for technology spillovers from MNCs to domestic plants. In their analysis at the aggregate level, Coe, *et. al*, (1999), found that imports of machinery from advanced countries, especially the USA has been an important contributor to domestic TFP growth for a sample 77 developing countries.

We now come back to the distinction between rent and knowledge spillovers. This distinction assumes importance mainly with respect to spillovers from imports. The embodied product technology in imports affects productivity of the user sector directly as a result of rent spillovers. At the same time imported inputs could generate knowledge spillovers in the form of reverse engineering and learning by using. Furthermore, 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, as they do not occur between competitors.

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[8] Like purchase of technology-embodied inputs, licensing can generate knowledge spillovers only if the purchaser is able to *add-on* to the technology or knowledge that is licensed through complementary research effort.

[10] For a review of literature that examine studies on technology spillovers in general and rent and knowledge spillovers in particular, see Los (1998).

While the conceptual distinction between rent and knowledge spillovers is clear, distinguishing the effect of one from the other is a difficult empirical problem. In the following subsection we discuss the construction of a spillover measure that we believe could be used as a proxy for the actual stock of *knowledge* from imports in the Indonesian manufacturing.

3.2. Deriving the International Knowledge Stock

Since knowledge spillovers take place between entities that are close to each other in a technological sense, empirical studies have attempted to develop measures that capture what is called technological distance (Jaffe 1986;Verspagen 1997). While we use this notion of technoloigcal distance in deriving the international R&D stock, we also introduce a new measure to account for inter-country differences in sectoral structures/technology.

We derive the *international knowledge stock in Indonesia*, which results from international technology spillovers, in four steps. First, sectoral R&D stocks are calculated for each trading partner of Indonesia using the perpetual inventory method (PIM). Second, we weight sectoral R&D intensity (R&D stock per unit of output) in the advanced exporting countries by the volume of their exports to Indonesia. Third, we weight the resulting figure by an index of technological distance between the sector of origin and the sector of destination. Finally, we weight the result with an index of technological congruence between the same sector in the advanced economy and Indonesia.

Step 1: Sectoral R&D Stock of Partner Countries

The starting point in constructing the international R&D stock available in the Indonesian manufacturing is the construction of sectoral R&D stocks for countries that export to Indonesia. We consider 10 major trading partners of Indonesia in the OECD.[12] The countries considered are Australia, Canada, Denmark, France, Germany, Great Britain, Italy, Japan, the Netherlands and the USA. We derive sectoral R&D stock for each country in constant prices using PIM (with the benchmark year taken as 1973) assuming an initial growth of 5% and a depreciation rate of 0.15.

Step 2: International R&D Stocks

The contribution of an advanced country's sectoral R&D stock to the International R&D stock depends on its exports to Indonesia. Therefore, the contribution of an OECD trading partner to the international R&D stock in Indonesia is calculated by weighting the country's sectoral R&D intensities (R&D stock divided by output) by sectoral exports to Indonesia as follows.[13]

[12] Note that OECD countriues account for more than 80 percent of the global R&D.
[13] For a discussion of the use of trade weights, see Lichtenberg and van Pottelsberghe (1998)

$$ERD_{ci} = RD_{ci}E_{ci} \tag{3}$$

where

ERD_{ci} is the export-weighted international R&D stock from sector *i* in country *c* to Indonesia

RD_{ci} is the ratio of the R&D stock to output of sector *i* in country *c*

E_{ci} is the volume of exports from sector *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 sectors. 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 sectors. 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 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 sector and the supplementary technology class is assumed to represent knowledge-receiving sector. 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 sectors. These two classes of sectors can be linked with the 'emitting' sectors in the rows and the 'receiving' sectors 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 sector *i* to sector *j*. We weight the international R&D stocks with the technological distance between sectors to derive a sectoral stock concept, which represents the *potential knowledge stock* in each of the Indonesian economic sectors.

This potential knowledge stock can be expressed as follows.

$$PKS_{cj} = \sum_{i} ERD_{ci}P_{ij} \tag{4}$$

where,

PKS_{cj} is the potential knowledge stock in sector *j* of Indonesia associated with imports from all sectors *i* of country *c*

Whereas ERD_{ci} is used to capture the flow of International R&D stock through trade from sector *i* in country *c* to Indonesia, the patent flow matrix *P* is used to distribute this R&D stock across sectors.

Step 4: Actual International Knowledge stock: using the Structural congruence Index as weight

An obvious weakness of the indicator resulting from step 3 is that it assumes that inter-sectoral technology flows are the same across countries. This is even more problematic when comparing manufacturing sectors 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 structural congruence to account for inter-country differences between sectors. Our notion of structural congruence is linked to the Abramovitzian notion that domestic 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). Structural congruence also provides an indication of the absorptive capacity of a sector in a developing country. The greater the structural 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 structural congruence index by comparing the input structure (column vector of sectoral input coefficients) of an Indonesian sector with that of each of her 10 trading partners in the OECD. This measure allows us to distinguish the potential knowledge stock in a given sector (as derived from technological-distance measure) from the actual technology spillover to that sector.[14] This implies that given the level of potential knowledge stock in a sector from imports, an increase in the sector's structural congruence with the same sector in the country from which it imports will increase the extent of knowledge spillovers.

Incorporating the structural congruence measure into equation 4 yields the following.

$$KS_j = \sum_c PKS_{cj} S_{cj} \qquad (5)$$

where KS_j is the realised knowledge stock resulting from international knowledge spillovers in sector j of Indonesian manufacturing from all sectors of each trading partner country.

S_{cj} is the technological distance weight between the sector j of Indonesia and the same sector of her partner country c.[15] It can be written as follows.

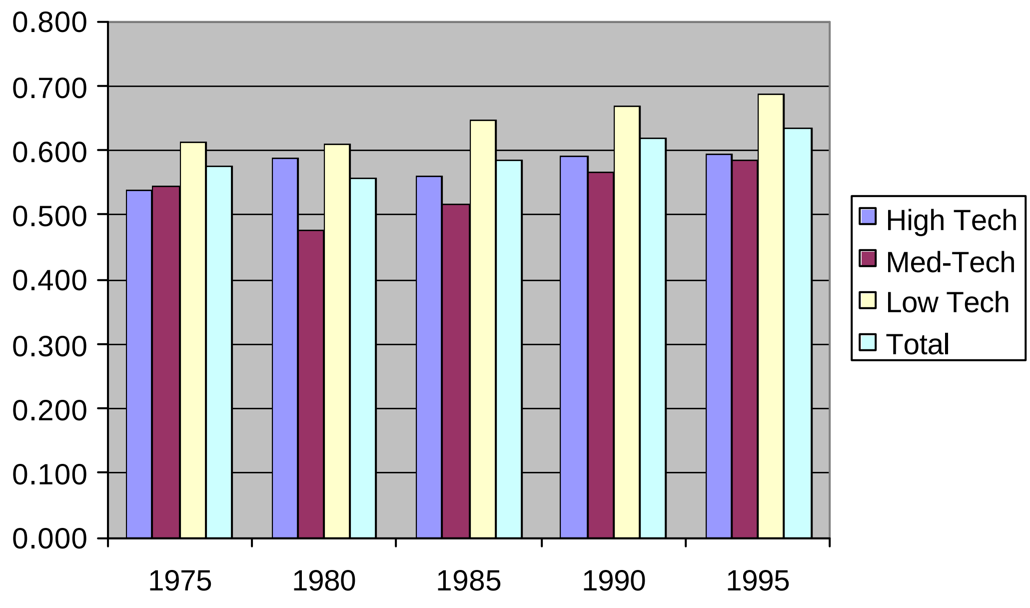
[14] van Meijl & van Tongeren (1999) show that a higher technological embodiment can be counter-balanced by the structural differences between the receiving and supplying entities.

[15] The input coefficient vector of an industry derived from total intermediate input vectors can be argued to represent the technology of that sector. See Los (1998) on the appropriateness of using input coefficient vectors to measure technological closeness.

$$S_{cj} = \sum_{j} \min(A_{dj},\ A_{cj}); \quad 0 \le S_{cj} \le 1 \tag{6}$$

where, $A_{.j}$ represents the share in the column sum of each cell of the input coefficient vectors of Indonesia *(d)* and the trading partner *(c)*. S_{cj} takes a value of 1 if the two sectors are perfectly similar and zero in the case of perfect dissimilarity between them.

Chart 1. Structural Similarity in manufacturing: Indonesia and the US



In the above chart we plot the structural similarity between the Indonesian and the US manufacturing sectors as average for three technology groups and total manufacturing for 1975, 1980, 1985, 1990 and 1995 (see section 4.4 for discussion on the data used). We see that sectoral structures of Indonesia have been becoming increasingly similar to those of the US over the years. Among the three technology groups, low technology group has the highest similarity, followed by high and medium technology groups.

3.3. Expanded model

We now expand equation (3) to include other theoretically important variables that can influence labour productivity, namely foreign ownership, sectoral concentration, policy period and time, as follows.

$$y_i - l_i = a_i + a\,(k_i - l_i) + hl_i + b\,KS_i + \rho\,(KS \times hn)_i + \delta f_i + g\,T + \varpi d \tag{7}$$

where hn is the Herfindahl index of sectoral concentration
f is the share of foreign controlled plants in output
T is a time trend
d is a dummy for liberalisation

The term $ks \times hn$ represents an interaction variable between the international knowledge stock and a measure of domestic market structure. The latter is the h*erfindahl* index of concentration, normalised for the number of plants and is defined as;

$$Hn = \frac{nS - 1}{n - 1}, \ \ 0 \leq Hn \leq 1$$

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

The conditional causal effect of spillovers on labour productivity is now given by *ß+?(hn).* We assume that some degree of concentration is conducive for learning and innovation from the perspective of *Schumpeterian process of growth*.

Variable f in the equation is the average output-share of foreign-controlled plants in an industry.[16] This variable is meant to capture the contribution of knowledge spillovers from MNCs to their subsidiaries and local firms. We have included a time trend T in the equation, which captures exogenous factors contributing to productivity. The final variable d is a dummy that takes a value log(1) for the pre-liberalisation phase and log(2) for the post-liberalisation phase. This variable assesses the effect of liberalisation on the intercept of the regression equation.

4: The Data

Our study combines Indonesian datasets on production and input-output transactions with the R&D, export-to-Indonesia and Output data of 10 major OECD countries that trade with Indonesia. The dataset used in the statistical analysis consists of observations on 19 Indonesian sectors and 16 years between 1980 and 1996. This results in a panel dataset with 323 observations. All variables are measured at constant 1990 international PPP dollars.

The following table shows the 19 sectors used in the study. The final column shows the technology class to which each sector belongs.

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[16] 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 by the foreign investor is not required.

[17] The public research laboratories, in contrast to other asian NIEs, undertake bulk of the R&D spending in Indonesia. However, the R&D undertaken in these research laboratories has been for product certification, training and testing activities than R&D proper (see Thee 1998, for a vivid description of the science and technology policy, public R&D research, etc.)

Table 3. Sectoral Classification

No.	Sector	ISIC Revision 2	Technology class*
1	Food, beverages & tobacco	31	3
2	Textiles, apparel & leather	32	3
3	Wood products & furniture	33	3
4	Paper, paper products & printing	34	3
5	Industrial chemicals	351+352-3522	2
6	Drugs & medicines	3522	1
7	Rubber & plastic products	355+356	2
8	Non-metallic mineral products	36	3
9	Iron & steel	371	3
10	Non-ferrous metals	372	3
11	Metal products	381	3
12	Non-electrical machinery	382	2
13	Electrical apparatus, nec	383-3832	2
14	Radio, TV & communication equipment	3832	1
15	Shipbuilding & repairing	3841	2
16	Other transport	3842+3844+3849	2
17	Motor vehicles	3843	2
18	Professional goods	385	1
19	Other manufacturing	39	3

*1-High technology, 2-Medium Technology, and 3-Low technology sector

In the following subsections we discuss, the adjustments made to the data and the derivation of some key variables.

4.1. The Indonesian Data

We use the plant-level data sets of Statistik Industri (SI) and backcast data of Badan Pusat Statistik, (BPS) to construct all the sectoral variables, other than the variable referring to the international knowledge stock. This involved substantial data screening at micro level.

The advantage of the backcast data is that it covers a larger sample of plants, especially prior to 1985. As disadvantage is that it only provides information on a few variables such as gross value added, employment and output (see Jammal, 1993 for details of the backcasting procedure). We merged the backcast data with the SI data in order to be able to profit from the greater detail reported in the latter source (among which data on investment and foreign ownership are of relevance for this paper).

First, we merged plants in both data sets that have identical output, value added and labour. Second, those observations could not be matched in the first stage were merged using plant-identification codes.[18] Finally, the non-matched backcast observations, which represent newly discovered plants not included in the regular SI data, have been added to the matched-data set. In this way, we were able to eliminate erroneous observations from the SI data.[19]

4.2. Construction of Capital Stock Series:

One of the problems with the new data, and especially with investment series is the large number of missing values. To generate investment series for all plants, we applied the average value added-investment ratio at the five-digit level, to the value added data of the plant for years in which no investment data were available. This exercise was undertaken for four types of investment—building, machinery, transport equipment and other assets.

For 1996, no investment data was available. (The database does contain an estimate of the total gross capital stock data. But this was not used due to problems of comparability). We generated a proxy investment series for this year applying comparing the incremental sectoral capital to value added ratio for 1995 to the change in gross value added from 1995 to 1996.

We converted investment series into constant 1990 prices using three types of price indices published in *Indikator Ekonomi*: the price index of non-residential and residential building for deflating investment in building, the price index of imported machinery for machinery and equipment, and the price index of imported transport equipment for vehicles and for other investment.[20] The deflated series have been divided with the PPP 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 International Standard Industrial Classification (ISIC) Revision 2) from 1975 to 1999. In the absence of a benchmark capital stock data, we used the ratio of the average investment-value added change (incremental capital value added ratio, ICVAR) for 1976-80 (see Dasgupta, Hanson, & Hulu 1995; Osada 1994 and Timmer 2000). The ICVAR was multiplied with gross value added of 1975 to derive the benchmark capital stock for 1975. Based on this benchmark, we constructed capital stock for the remaining years using the PIM. Following the survey findings of (Goeltom 1995), we used depreciation rates of 0.033 for buildings, 0.10 for machinery and equipment, and 0.20 for vehicles and other fixed capital.

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[18] We followed this two-step merging procedure instead of stage two alone, because the plant-identification code is not completely accurate.

[19] The two plant-level data sets are beset with problems like duplicate observations, and even duplicate plant-identification codes. Most of these result from the BPS practice of accounting for the missing data of plants that do not report data for some years using the data of plants with similar characteristics. We removed observations with same variables for output, value-added and labour.

[20] Aswicahyono (1998) and Timmer (2000) follow the same approach.

4.3. The OECD Data

In constructing the knowledge stock measure we used the datasets on output, R&D and exports to Indonesia for 10 OECD countries, used in Jacob and Meister (2004). These data are derived from the OECD databases STAN, BITRA and ANBERD respectively.

4.4. The Input-Output Data

To construct our measure of structural congruence, we used the input-output (IO) total 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 most disaggregated tables published by the BPS, available approximately at 170-sector levels — with minor variations in the number of sectors over time. The OECD tables have been taken from the OECD Input-Output database available at http://www1.oecd.org/dsti/sti/stat-ana/stats/eas_io.htm. It should be noted that for some of the 10 OECD countries, IO tables were not available for all five-year intervals. Where a table for a particular year was not available, we used the IO table of the nearest preceding or the following year. We consolidated the IO tables into 19 sectors.

For explaining the structural change in Indonesia (Tables 1, 2, A.1 & A.2), we used the Indonesian IO tables from 1975 to 2000 in constant 1983 prices. Here we followed an elaborate scheme of aggregation involving 22 manufacturing sectors. The same aggregation scheme could not be followed for measuring structural congruence index, because the OECD IO tables were of a higher degree of aggregation.

5: Estimation

The final data set used in the study covers the period 1980-1996 for 19 manufacturing sectors. To estimate equation 7, we employ a panel-corrected standard error estimation method that accounts for heteroskedastic errors. We estimate three models, a Total model, a Within Model and a Between model. The total model is a matrix weighted average of the within- and the between-sector estimates. The between model shows the deviation of sector means from the overall mean and thus portrays the long-run dimensions of the influence of independent variables on the dependent variable. The within-sector model is estimated with sector dummies, thus accounting for the effect of sector-specific influences. A *Hausman* test showed that sector specific effects are indeed correlated with the regressors, suggesting the appropriateness of the within model. Also, among the three panel estimation models, the within estimates provide a greater fit to the regression equation. We therefore report results from this model only (see Tables 5, 6 & 7). In the appendix, we report the estimation results after excluding the interaction term $ks \times hn$, foreign ownership dummy f, and time trend T (Appendix tables A.3 to A.5), as well as after omitting only the interaction term $ks \times hn$ (Appendix tables A.6 to A.8).

We make separate estimations for pre- and post-liberalisation phases. Although the economic reforms began on a large scale from 1986 onwards, we consider the data til 1987 as belonging to the pre-liberalisation phase. This is because of the lag with which polices take effect. A *Chow test* showed that there had indeed been a significant difference in the slope coefficients of the regression equations during 1980-87 and 1988-96.[21] 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 divide the sample into low, medium and high technology sectors. The estimation is therefore done for the full period, the pre- and post-liberalisation phases, across all sectors as well as high-, medium-, and low-tech sample. The summary statistics are provided in table 4.

Table 4. Summary Statistics (means, standard deviations in brackets)

	Observations	log *Q*	log *Q/L*	log *L*	log *K/L*	log *KS*	log *KS*× log *Hn*	log *F*
Full period, 1980-96								
Total	323	9.34	-1.49	10.83	0.64	10.20	-31.04	2.90
		(1.49)	(0.78)	(1.41)	(0.99)	(1.32)	(11.18)	(2.31)
High-Tech	51	7.91	-1.77	9.68	0.20	11.17	-30.06	2.20
		(1.70)	(0.57)	(1.16)	(0.97)	(0.59)	(9.62)	(4.58)
Med-Tech	119	9.30	-1.31	10.61	0.52	10.76	-29.92	2.83
		(0.99)	(0.65)	(0.89)	(0.61)	(1.39)	(10.42)	(2.24)
Low-Tech	153	9.86	-1.54	11.40	0.89	9.44	-32.23	3.19
		(1.43)	(0.90)	(1.53)	(1.16)	(0.98)	(12.13)	(0.54)
Pre-Liberalisation Phase, 1980-87								
Total	152	8.67	-1.79	10.45	0.38	9.98	-29.50	2.61
		(1.39)	(0.69)	(1.38)	(0.94)	(1.29)	(10.13)	(3.22)
High-Tech	24	7.15	-2.10	9.25	-0.13	10.96	-28.82	0.51
		(1.61)	(0.46)	(1.17)	(0.93)	(0.42)	(8.81)	(6.31)
Med-Tech	56	8.72	-1.60	10.31	0.38	10.55	-28.40	2.58
		(0.69)	(0.43)	(0.79)	(0.60)	(1.33)	(8.24)	(2.97)
Low-Tech	72	9.13	-1.84	10.97	0.56	9.22	-30.58	3.33
		(1.37)	(0.85)	(1.54)	(1.09)	(0.99)	(11.77)	(0.52)
Post-Liberalisation Phase, 1988-96								
Total	171	9.95	-1.23	11.17	0.87	10.39	-32.41	3.16
		(1.31)	(0.77)	(1.35)	(0.99)	(1.32)	(11.89)	(0.89)
High-Tech	27	8.59	-1.48	10.07	0.50	11.36	-31.16	3.70
		(1.50)	(0.51)	(1.03)	(0.93)	(0.65)	(10.33)	(0.48)
Med-Tech	63	9.81	-1.05	10.86	0.65	10.96	-31.28	3.06
		(0.94)	(0.70)	(0.91)	(0.59)	(1.42)	(11.93)	(1.25)
Low-Tech	81	10.50	-1.28	11.78	1.18	9.63	-33.70	3.06
		(1.14)	(0.86)	(1.43)	(1.16)	(0.93)	(12.34)	(0.53)

[21] Indeed the calculated *F-statistic* is the highest when the cut-of year is 1987 instead of 1985, 1986 and 1988.

6: Findings

Among the three panel estimation models, the within estimates provide a better fit to the regression equation. This is line with the results of earlier studies that found that unit specific factors - country, industry etc. - play an important role in influencing the factors contributing to productivity, especially technology spillovers (Fagerberg & Verspagen 2000). We therefore focus mainly on the results from the within model. The results of the total and between models are presented in the appendix.

In general, the results show that knowledge spillovers have been an important contributor to productivity even surpassing the contribution of capital and labour. There are, however, important differences across industry-groups and between policy-regimes.

Table 5. Determinants of Labour Productivity, 1980-96 (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.245	0.351	-0.026	0.134
	(0.070)**	(0.132)**	(0.183)	(0.080)
k-l	0.034	0.066	0.036	0.027
	(0.027)	(0.051)	(0.075)	(0.029)
ks	0.148	0.281	0.231	-0.028
	(0.042)**	(0.124)*	(0.055)**	(0.051)
ks×hn	0.023	0.016	0.022	0.022
	(0.003)**	(0.007)*	(0.006)**	(0.005)**
f	-0.006	0.005	-0.023	0.021
	(0.007)	(0.012)	(0.016)	(0.068)
T	0.042	0.012	0.057	0.062
	(0.009)**	(0.015)	(0.017)**	(0.009)**
d	0.029	0.130	0.064	-0.004
	(0.102)	(0.161)	(0.143)	(0.088)
Constant	-5.904	-7.720	-3.658	-3.113
	(0.914)**	(1.096)**	(1.607)*	(1.115)**
Observations	323	51	119	153
Number of sectors	19	3	7	9
R-squared	0.92	0.89	0.86	0.95
Wald chi2	66773.11	402.72	851.96	8272.75

Standard errors in parentheses
* significant at 5%; ** significant at 1%

For the complete sample (table 5), international knowledge stock variable turns out to be the second most important contributor to manufacturing productivity, after returns to scale. The conditional spillover effect is also highly significant. Thus not only have international knowledge spillovers been significant on their own, but their contribution has been greater at higher levels of domestic market concentration. This result is interesting with regard to the distinctive roles of domestic and external competition in the East Asian industrial landscape. As has been argued in the *heterodox literature* discussed in the introduction, promoting domestic competition has hardly been a priority in industrial policy.

Among the industry groups, high and medium technology groups (the capital goods industries) show the highest significance for the spillover variables. In low-technology sectors, spillovers have been significant only conditional on higher levels of concentration.

The contribution of the capital-labour ratio, though positive was not statistically significant. Our results with regard to the share of foreign owned firms in output do not confirm the received wisdom that foreign ownership contributes to productivity spillovers. The time trend capturing exogenous productivity increases made significant contributions to productivity, especially in the medium-technology sector.

Table 6. Determinants of Labour Productivity: Pre-Liberalisation Phase, 1980-87 (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.448	1.397	-0.035	-0.236
	(0.177)*	(0.661)*	(0.341)	(0.270)
k-l	0.248	0.290	0.406	0.200
	(0.038)**	(0.166)	(0.110)**	(0.038)**
ks	-0.027	-0.006	-0.033	-0.055
	(0.055)	(0.165)	(0.077)	(0.059)
ks×hn	0.019	0.018	0.006	0.036
	(0.007)**	(0.021)	(0.007)	(0.008)**
f	-0.019	-0.012	-0.027	0.045
	(0.007)*	(0.023)	(0.011)*	(0.105)
T	-0.011	-0.079	-0.007	0.070
	(0.013)	(0.031)*	(0.027)	(0.023)**
Constant	-7.162	-14.973	-1.449	2.152
	(2.439)**	(6.629)*	(4.029)	(3.609)
Observations	152	24	56	72
Number of sectors	19	3	7	9
R-squared	0.94	0.90	0.88	0.97
Wald chi2	1208.14	151.73	3157.53	8084.31

Standard errors in parentheses
* significant at 5%; ** significant at 1%

The difference between the pre- and post-liberalisation phases provide important insights into the Indonesian industrialisation process. During the pre-liberalisation phase (table 6) contributions to productivity came mainly from capital. Only in the low-technology sector did factors other than capital – conditional knowledge spillovers and exogenous productivity change — exert positive influence. These findings demonstrate that the inward-oriented policy regime has not been conducive to technological progress and knowledge spillovers.

During the post-liberalisation phase (table 7), the opposite is the case. We note an increase in the contribution of spillover related variables and a decline in the contribution of capital, of which the coefficient becomes non-signficant. The knowledge stock variable generated the highest contributions to labour productivity in all but the low technology group, indicating that international knowledge spillovers have been important. The interaction variable between market concentration and knowledge stocks also had a higher significance in this phase. The results also suggest that some degree of concentration is helpful for learning (in the Schumpeterian sense), especially when the policy environment is open and market-oriented. Note in this context that exogenous productivity change (as proxied by the time trend variable) also improved its contribution during this phase. The coefficient of foreign investment remains statistically insignificant in all sectors, indicating the foreign investment as such did not contribute to increased productivity growth.

Table 7. Determinants of Labour Productivity, Post-Liberalisation Phase, 1988-96. (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.218	0.359	-0.640	0.113
	(0.100)*	(0.126)**	(0.335)	(0.118)
k-l	-0.013	0.033	0.004	-0.080
	(0.032)	(0.041)	(0.087)	(0.030)**
ks	0.212	0.463	0.262	0.088
	(0.069)**	(0.185)*	(0.086)**	(0.107)
ks×hn	0.034	0.039	0.056	0.024
	(0.004)**	(0.009)**	(0.008)**	(0.005)**
f	0.076	0.130	0.112	-0.003
	(0.068)	(0.107)	(0.101)	(0.111)
T	0.057	0.029	0.127	0.066
	(0.012)**	(0.030)	(0.032)**	(0.018)**
Constant	-5.704	-9.181	4.764	-3.267
	(1.205)**	(1.689)**	(4.015)	(1.438)*
Observations	171	27	63	81
Number of sectors	19	3	7	9
R-squared	0.93	0.91	0.91	0.96
Wald chi2	4976.90	314.32	1670.33	640833.54

Standard errors in parentheses
* significant at 5%; ** significant at 1%

7: Conclusions

In this paper we set out to examine the importance of import-induced knowledge spillovers from advanced partner-countries for productivity performance and catch up in Indonesian manufacturing industries. We developed a measure of international knowledge stock from imports taking into consideration the concepts of technological closeness and structural congruence. It is however, difficult to assume that our measure solely represents pure spillovers, as a transaction involving user-producer relationship inevitably generates other forms of spillovers, especially of a pecuniary nature. Given these caveats, we draw the following conclusions from the study:

1. There is a strong association between technological learning and policy regime. This is indicated by the differences in the influence of international knowledge stock variables on productivity in the pre- and post liberalisation phases.
   - An export-oriented policy regime provides a suitable incentive structure for technological learning.
   - When the policy regime is inward –looking, the bulk of the improvements in labour productivity derives from capital deepening.
2. The contribution of technological learning differs across sectors that vary in their technological opportunities.
   - Medium and high technology sectors present the greatest opportunities for technological learning compared to low-technology sectors.
3. Concentration in the domestic market has a favourable impact on growth in the Schumpeterian sense; i.e., by facilitating innovation and learning.
4. The absence of a significant relationship between changes in the output share of foreign owned firms and labour productivity indicates that FDI does not necessarily generate technology spillovers.
5. Our results provide support for an assimilationist interpretation of the recent industrial experience of Indonesia.

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APPENDIX TABLES

1. Pattern of Structural Change in Indonesia

Table A.1. Pattern of Structural Change in Indonesia: 1975–2000

Sectoral composition of Value Added						
Sector	1975	1980	1985	1990	1995	2000
Primary	27.7	20.6	22.2	16.7	11.6	7.9
Oil, Gas & Mining	20.5	26.3	14.2	14.6	9.8	17.6
Petroleum Refinery	0.6	0.3	5.0	3.2	2.0	5.5
Resource Intensive Mfg	7.6	7.0	7.3	10.2	11.8	11.6
Labour Intensive Mfg	0.5	0.6	0.5	1.1	1.8	2.5
Scale Intensive Mfg	2.1	2.3	3.6	5.6	7.8	8.2
Differentiated Mfg	0.5	0.7	0.8	1.3	1.3	1.6
Science Based Mfg	0.2	0.6	0.8	0.8	1.9	3.2
Total Manufacturing	10.9	11.2	13.1	19.0	24.5	27.0
Electricity Gas & Water	0.3	0.3	0.4	0.6	0.6	0.5
Construction	5.0	5.0	6.6	5.8	6.7	4.0
Trade	11.4	11.3	11.8	11.8	12.1	11.1
Restaurant & Hotels	1.2	2.0	2.4	3.2	4.0	2.7
Transport & Services	4.6	4.6	4.7	5.6	5.5	3.9
Communication	0.2	0.3	0.5	0.7	1.0	1.5
Finance & Insurance	2.4	2.0	2.6	3.8	4.1	4.1
Real Est. & Busc. Servs	3.8	4.3	4.3	3.7	7.1	2.9
Public Administration	11.4	11.8	12.2	11.2	10.9	11.3
Total Services	35.0	36.3	38.5	40.0	44.7	37.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: same as Table 1

Table A. 2. Pattern of Structural Change in Indonesia: 1975–2000

Sectoral composition of Exports						
Sector	1975	1980	1985	1990	1995	2000
Primary	6.0	6.7	6.1	2.3	1.1	0.8
Oil, Gas & Mining	73.9	70.8	40.6	27.9	17.3	16.2
Petroleum Refinery	1.0	6.8	23.7	14.4	7.5	13.3
Resource Intensive Mfg	5.5	4.9	10.0	19.1	16.4	12.8
Labour Intensive Mfg	0.0	0.2	1.6	7.1	10.8	8.8
Scale Intensive Mfg	3.7	1.9	5.6	10.9	16.8	17.9
Differentiated Mfg	0.1	0.0	0.1	0.4	2.1	5.1
Science Based Mfg	0.1	0.3	0.6	1.0	5.0	10.5
Total Manufacturing	9.4	7.3	17.9	38.5	51.1	55.1
Electricity Gas & Water	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0
Trade	2.7	4.3	4.8	7.5	7.6	5.7
Restaurant & Hotels	0.8	0.3	0.9	1.9	4.3	2.1
Transport & Services	5.9	3.4	3.5	3.9	5.9	4.3
Communication	0.0	0.1	0.1	0.1	0.4	0.1
Finance & Insurance	0.0	0.2	2.3	3.0	3.3	1.3
Real Est. & Busc. Servs	0.0	0.0	0.0	0.1	0.5	0.2
Public Administration	0.3	0.0	0.0	0.6	1.0	0.9
Total Services	9.7	8.4	11.7	17.0	23.0	14.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: same as Table 1

2. Within-Sector Estimations after omitting ks×hn, f and T

Table A.3. Determinants of Labour Productivity, 1980-96 (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.368	0.322	0.374	0.399
	(0.064)**	(0.100)**	(0.136)**	(0.069)**
k-l	0.044	0.093	0.079	0.037
	(0.024)	(0.045)*	(0.067)	(0.028)
ks	0.110	0.209	0.208	-0.071
	(0.048)*	(0.089)*	(0.065)**	(0.050)
d	0.337	0.302	0.332	0.354
	(0.096)**	(0.108)**	(0.153)*	(0.109)**
Constant	-7.737	-7.241	-7.903	-6.524
	(0.823)**	(0.841)**	(1.265)**	(0.977)**
Observations	323	51	119	153
Number of sectors	19	3	7	9
R-squared	0.90	0.88	0.82	0.93
Wald chi2	77155.77	410.93	854.61	11961.26

Standard errors in parentheses
* significant at 5%; ** significant at 1%

Table A.4. Determinants of Labour Productivity, 1980-87 (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.384	0.041	-0.217	0.531
	(0.134)**	(0.263)	(0.228)	(0.130)**
k-l	0.225	0.200	0.370	0.201
	(0.037)**	(0.160)	(0.079)**	(0.045)**
ks	-0.005	-0.002	0.001	-0.113
	(0.061)	(0.149)	(0.077)	(0.067)
Constant	-7.188	-2.130	0.071	-8.162
	(1.982)**	(2.982)	(3.101)	(2.007)**
Observations	152	24	56	72
Number of sectors	19	3	7	9
R-squared	0.93	0.87	0.86	0.96
Wald chi2	5700.39	110.23	30585.95	5041.97

Table A.5. Determinants of Labour Productivity, 1988-96 (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.239	0.129	0.430	0.185
	(0.115)*	(0.164)	(0.254)	(0.136)
k-l	-0.001	0.042	0.197	-0.065
	(0.027)	(0.044)	(0.082)*	(0.023)**
ks	0.314	0.544	0.264	0.240
	(0.083)**	(0.165)**	(0.128)*	(0.075)**
Constant	-7.617	-8.561	-10.141	-6.160
	(1.063)**	(0.751)**	(2.293)**	(1.396)**
Observations	171	27	63	81
Number of sectors	19	3	7	9
R-squared	0.90	0.86	0.84	0.95
Wald chi2	3365.36	266.09	1607.91	27953.85

3. Within-Sector Estimations after omitting ks×hn

Table A.6. Determinants of Labour Productivity, 1980-96 (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.136	0.246	-0.160	0.022
	(0.072)	(0.140)	(0.196)	(0.066)
k-l	0.034	0.079	-0.018	0.035
	(0.027)	(0.050)	(0.075)	(0.028)
ks	0.095	0.241	0.223	-0.129
	(0.041)*	(0.123)	(0.060)**	(0.047)**
f	-0.006	0.006	-0.021	0.029
	(0.009)	(0.012)	(0.018)	(0.076)
T	0.044	0.012	0.064	0.065
	(0.009)**	(0.016)	(0.019)**	(0.009)**
d	0.059	0.217	0.017	0.046
	(0.094)	(0.154)	(0.153)	(0.081)
Constant	-4.786	-6.878	-2.654	-1.548
	(0.920)**	(1.109)**	(1.712)	(0.930)
Observations	323	51	119	153
Number of sectors	19	3	7	9
R-squared	0.91	0.88	0.84	0.95
Wald chi2	41946.98	410.29	983.87	5661.07

Standard errors in parentheses
* significant at 5%; ** significant at 1%

Table A.7. Determinants of Labour Productivity, 1980-87 (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.562	1.596	-0.074	0.258
	(0.179)**	(0.641)*	(0.341)	(0.253)
k-l	0.245	0.341	0.390	0.197
	(0.040)**	(0.168)*	(0.112)**	(0.043)**
ks	-0.056	-0.043	-0.043	-0.089
	(0.053)	(0.145)	(0.074)	(0.066)
f	-0.024	-0.026	-0.027	0.005
	(0.007)**	(0.018)	(0.011)*	(0.117)
T	-0.017	-0.081	-0.006	0.032
	(0.013)	(0.030)**	(0.027)	(0.023)
Constant	-8.976	-17.293	-1.129	-4.936
	(2.428)**	(6.529)**	(4.035)	(3.250)
Observations	152	24	56	72
Number of sectors	19	3	7	9
R-squared	0.94	0.90	0.88	0.96
Wald chi2	1297.11	133.47	5141.08	3438.04

Table A.8. Determinants of Labour Productivity, 1988-96 (Within Model)

	Full-Sample	High-tech	Med-tech	Low-tech
l	0.012	0.148	-0.443	-0.082
	(0.120)	(0.188)	(0.369)	(0.138)
k-l	-0.019	0.037	0.020	-0.068
	(0.029)	(0.046)	(0.119)	(0.027)*
ks	0.178	0.475	0.188	0.032
	(0.086)*	(0.178)**	(0.104)	(0.120)
f	0.034	-0.091	0.043	0.072
	(0.080)	(0.078)	(0.120)	(0.121)
T	0.054	0.017	0.105	0.061
	(0.012)**	(0.045)	(0.034)**	(0.019)**
Constant	-3.653	-7.752	1.004	-1.129
	(1.437)*	(2.484)**	(4.228)	(1.716)
Observations	171	27	63	81
Number of sectors	19	3	7	9
R-squared	0.91	0.86	0.86	0.96
Wald chi2	5845.32	290.67	1200.47	24497.84