# Technology Gap, Competition and Spillovers from Direct Foreign Investment: Evidence from Establishment Data

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*Direct foreign investment (DFI) has been argued to be an important channel for international technology diffusion. This has led to extensive liberalisation of DFI regimes in many developing countries, including in Indonesia. Using detailed micro-data from the Indonesian manufacturing sector, we examine the effect on productivity from DFI. The results show DFI to benefit locally-owned establishments, but the effect differs between groups of industries. Spillovers from DFI are found in sectors with a high degree of competition. Moreover, it seems that the larger the technology gap between domestic and foreign establishments, the larger the spillovers.*

## I. INTRODUCTION

Direct foreign investment (DFI) is presumably an important channel in international diffusion of knowledge and technology. Multinational companies conduct most of the world's R&D, and knowledge transferred from the parent firms to the affiliates might leak out to the host country. This externality is called the spillover effect from DFI. Various channels for the spillover have been suggested: labour turnover from multinationals to domestic firms, technical assistance and support to suppliers and customers, and demonstration effects on domestic firms in issues such as choice of technology, export behaviour, managerial practices, etc.[1]

There are a number of studies examining spillovers from DFI. Positive spillovers are found in Australia [*Caves, 1974*], Canada [*Globerman, 1979*] and Mexico [*Blomström and Persson, 1983*]. No spillovers are found in

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Morocco [*Haddad and Hendersson, 1993*] and Venezuela [*Aitken and Harrison, 1991*].

The different results concerning spillovers from DFI suggest that such effects are not automatic but are affected by various economic and technological factors. Economic literature has identified some circumstances that enhance domestic firms' ability to benefit from DFI. Findlay [*1978*] constructs a dynamic model of technology transfer through DFI from developed to developing countries. The technology is hypothesised to spill over to the developing country. Findlay uses Gerschenkron's [*1952*] catching-up hypothesis of a positive connection between the distance to the world's technological frontier and the rate of economic growth. The wider the technology gap between the developed and the developing country, the larger is the potential for technological imitation, which will spur economic growth. Moreover, Findlay assumes the technology to be transferred through personal contacts, which are accomplished through DFI. The result from Findlay's model is that, for a given amount of foreign presence, spillovers are larger the larger the technology gap between the foreign and domestic firms. Accordingly, for a given technology gap, the spillovers increase with the degree of foreign presence. It has also been argued, however, that large technology gaps may constitute an obstacle to spillovers.[2] Technologies developed in the industrialised world may be less suited for conditions in developing countries, which prevents any useful technology spillovers.

Wang and Blomström [*1992*] construct a model of strategic interaction between the multinationals' subsidiaries and the domestic firms. In addition to Findlay's assumption of a positive relationship between the technology gap and spillovers, they stress the importance of competition. High competition forces the foreign subsidiaries to bring in relatively new and sophisticated technologies from the parent company in order to retain their market shares. The technology that is transferred to the subsidiaries might leak out to the domestic firms and thereby increase the competition facing the subsidiaries even more. The conclusion is that the tougher the competition, the more technology will be brought in by the MNC affiliate and the larger will the potential for spillovers be.[3]

Kokko [*1994, 1996*] examined the effect of DFI on levels of productivity in different manufacturing sectors. A high technology gap in combination with a low degree of competition was found to prevent spillovers. As pointed out by Aitken and Harrison [*1991*], however, there is an identification problem in examining levels of productivity, as foreign firms may locate in highly productive sectors. One could then, for instance, conclude that there are positive spillovers from DFI even if such do not exist. One possible way to avoid the causality problem could be to examine growth rates – instead of levels – of productivity, at a micro-level.

The purpose of this article is to examine spillovers from DFI in the Indonesian manufacturing sector. The study will be restricted to examine intra-industry spillovers. Hence, spillovers from support of linkage industries will not be captured. The article will contribute to the existing literature in several respects. First, we examine the effect on spillovers from competition and productivity gaps on an establishment level. Using micro-data enables us to construct an industry specific variable on technological differences between domestic and foreign establishments. Moreover, previous studies have concentrated on domestic competition but we will also examine competition from abroad. Finally, in examining the relation between spillovers, competition and technology gaps, we will examine not only levels of productivity but also growth in productivity. By using different model specifications we are less likely to draw conclusions from fragile results.

The econometric results show spillovers from DFI to have positive effects on productivity growth. The effects differ between different groups of industries. Spillovers are found in industries with high degree of competition and, possibly, in industries with high technology gaps.

In section II of the article, we discuss DFI and technological development in Indonesia. The empirical models, data and variables are presented in section III. The results from the econometric estimations are shown in section IV and discussed in section V. Conclusions are presented in section VI.

## II. DFI AND TECHNOLOGY DEVELOPMENT IN INDONESIA

### *(1) Direct Foreign Investment*

The half-century of Indonesia's post-colonial history has seen large changes in the policies towards DFI. Until 1966 there were basically no foreign investments in Indonesia, because of the political and economic instability and the nationalisation of foreign owned firms. The 'New Deal' was initiated in 1967, including deregulation of trade and foreign investments. Foreign firms were given tax holidays for up to six years, exemptions from duty on import of capital goods were made together with guarantees on profit and capital repatriations.[4]

Following on the prevalent export pessimism in the seventies and because of nationalistic sentiments mistrusting foreign involvement, a more restrictive policy was announced in 1974/75. A large number of sectors were – for so-called strategic reasons – closed off to foreign investors. Furthermore, foreign ownership was limited to 80 per cent of a company which was to decrease to 49 per cent within ten years, and employment of foreign personnel was restricted. The restrictive policy for foreign investments continued until the beginning of the 1980s, when the drop in oil prices forced the country on to another development path. A substantial phase of deregulation started in 1986. The reforms included reductions in import licensing restrictions, relaxation of foreign investment rules, replacement of nontariff barriers with tariffs as well as a reduction in tariffs.[5] In 1989 import licences were further liberalised and the required minimum foreign investment was lowered from US$ one million to US$250,000. However, the emergence of China as a host of DFI and more favourable investment environment in other parts of Southeast Asia, forced Indonesia to continue the liberalisation. Hence, in 1992 foreign investors were allowed to possess 100 per cent of the equity in certain projects and in 1994 the number of such projects was enlarged together with an abolishment of the mandatory reinvestment policy. The severe economic crisis, starting in 1997, has led to further liberalisation and deregulation of the Indonesian economy. For instance, the Indonesian government has, under pressure from IMF, opened new sectors of the economy to foreign firms. The policies for DFI are now as liberal as they were in the late 1960s and are broadly in line with the ones in most other countries in the region.

The structure of the Indonesian manufacturing sector in 1980 and 1991 is shown in Table 1. Figures on the important oil and gas industry (ISIC 353) were, unfortunately, not available. There is no industry at a three-digit level of ISIC that is dominated by foreign ownership, that is, where the foreign share of gross output exceeds 50 per cent.[6] Naturally, one reason could be that the division at a three-digit level of ISIC is rather aggregated and that the foreign firms specialise and dominate industries within these broad categories. However, the empirical evidence does not support this hypothesis since an examination at a five-digit level of ISIC revealed that the foreign share of gross output exceeds 50 per cent only in seven per cent of the total number of industries. Around 40 per cent of the industries do not have any foreign presence at all. The potential for spillovers is likely to be relatively large when foreign establishments locate in industries with domestic establishments. If foreign firms were to locate in isolated segments, their technologies would be of less interest to domestic firms.

Tobacco, food and textiles were the three largest industries in 1980. These three industries constituted around 45 per cent of the total Indonesian manufacturing gross output at that time. By 1991, the industry structure had changed. Most notable are the sharp decline in the tobacco industry and the large increase in wood products. The overall concentration of Indonesian manufacturing gross output seems to have declined by 1991. The three largest industries, food, textiles and wood, made up around 37 per cent of the total Indonesian manufacturing gross output in 1991.

The absolute amount of DFI in Indonesia increased substantially between 1980 and 1991. The number of newly approved DFI projects, for instance, was 20 in 1980 and 376 in 1991.[7] The foreign share of gross output has, however, fallen because of the considerable increase in gross output of domestically owned firms. We see in table 1 that the share of gross output in foreign owned establishments has declined from 19.7 per cent in 1980 to 13.8 per cent in 1991. In 1980, sectors such as beverages, other chemicals, glass, cement, metal products, machinery, electrical goods and other manufactures had a large foreign share of gross output. Hill [*1988: 89–91*] discusses the reasons for DFI in Indonesia in some detail. Brand names are, according to Hill, the main reason for a large foreign share in beverages, where the brewery industry is dominated by three big joint ventures with foreign firms. In the other sectors, technological advantage is the main explanation for a large foreign presence in 1980. In 1991 footwear and professional goods were, together with machinery and other manufactures, the sectors with the largest foreign shares of gross output. Both technological advantages and ownership of brand names are of significance for DFI in professional goods.[8] The large foreign ownership in the footwear industry can be explained by a large inflow of firms from countries such as Hong Kong, Singapore and Taiwan. High wage increases in these countries have forced firms in labor intensive industries to move to countries such as Indonesia. The foreign share of gross output is small in sectors such as printing, clay, nonmetal products, leather, wood, tobacco and glass.

*(2) Technology Development*

The liberalisation of DFI has been accompanied by an impressive growth of the economy. Manufacturing output, for instance, grew with an average annual rate of around 12 per cent between 1965 and 1991. Much of this growth has been driven by accumulation of labor and capital but also through improved technologies. Technological development has been achieved through a combination of increased domestic innovative capacity and inflows of foreign technology. Increased educational attainment, rising employment of scientific personell and increasing R&D expenditures contributed to increased domestic technological capability [*Hill, 1995*]. However, Indonesia is still lagging behind most other East Asian countries and the country is dependent on inflows of foreign technologies. Case studies have found various sources, such as trade contacts, licensing arrangements and DFI to be important in transfering technology to Indonesia. For instance, Thee and Pangestu [*1994*] interview company directors and find trade contacts and DFI to be channels for technology transfer. In the textile industry, Japanese trading houses frequently help the Indonesian firms with technical assistance, advice for purchase of capital

TABLE 1

SECTOR WISE DISTRIBUTION OF INDONESIAN MANUFACTURING GROSS OUTPUT (%).

| Sector | ISIC | Share of total manufacturing gross output 1980 | 1991 | Foreign share of gross output 1980 | 1991 |
|---|---|---|---|---|---|
| All sectors | | 100 | 100 | 19.7 | 13.8 |
| Food products | 311/12 | 15.0 | 14.5 | 17.6 | 7.7 |
| Beverages | 313 | 1.2 | 0.7 | 43.6 | 23.6 |
| Tobacco | 314 | 18.0 | 6.9 | 8.2 | 3.0 |
| Textiles | 321 | 12.2 | 12.3 | 18.3 | 14.3 |
| Clothing | 322 | 0.4 | 3.3 | 3.7 | 10.3 |
| Leather products | 323 | 0.3 | 0.5 | 1.2 | 5.0 |
| Footwear | 324 | 0.5 | 1.5 | 0.0 | 34.0 |
| Wood products | 331 | 5.5 | 10.9 | 8.0 | 5.0 |
| Furniture | 332 | 0.1 | 1.1 | 11.5 | 9.6 |
| Paper products | 341 | 1.6 | 3.8 | 21.6 | 14.1 |
| Printing | 342 | 1.2 | 1.2 | 6.6 | 1.2 |
| Industrial Chem. | 351 | 4.8 | 5.6 | 7.7 | 23.0 |
| Other chemicals | 352 | 5.6 | 5.1 | 55.9 | 26.1 |
| Coal products | 354 | 0.0 | 0.2 | 0.0 | 6.6 |
| Rubber products | 355 | 8.1 | 3.8 | 20.5 | 18.8 |
| Plastic products | 356 | 1.1 | 2.3 | 24.1 | 5.5 |
| Pottery | 361 | 0.2 | 0.6 | 13.3 | 12.5 |
| Glass products | 362 | 0.7 | 0.6 | 33.2 | 0.1 |
| Cement | 363 | 3.3 | 2.1 | 30.6 | 8.0 |
| Clay products | 364 | 0.1 | 0.1 | 0.0 | 0.0 |
| Non-metal products | 369 | 0.1 | 0.4 | 0.0 | 3.4 |
| Iron and steel | 371 | 3.5 | 5.3 | 20.7 | 8.8 |
| Non-ferrous metals | 372 | 0.0 | 1.5 | 0.0 | 22.4 |
| Metal products | 381 | 4.2 | 3.3 | 32.7 | 16.9 |
| Machinery | 382 | 1.1 | 1.6 | 37.1 | 29.4 |
| Electrical goods | 383 | 5.8 | 3.7 | 39.3 | 25.0 |
| Transport equipm. | 384 | 4.9 | 6.5 | 4.8 | 27.0 |
| Professional goods | 385 | 0.03 | 0.1 | 0.0 | 35.0 |
| Other manufactures | 390 | 0.4 | 0.5 | 47.2 | 29.5 |

*Source*: Indonesian Central Bureau of Statistics.

equipment, construction of the plants, quality controls, etc. Technical assistance was also received from suppliers of capital goods (sewing machines) from Singapore. In the electronics industry, some technology could possibly have been transferred to domestic firms through recruitment of personnel with experience from American-owned firms. Moreover, Thee [*1990*] documents frequent training programs of local staff in foreign subsidiaries, including employment in the MNC's plants abroad. Such training programs can be important channels of technology diffusion since employees in foreign firms occasionally start up their own establishments.[9]

The government has taken part in the technological development indirectly by for instance providing education, allowing DFI and open up for trade, but also more directly in several controversial 'high-tech' projects. Such projects, including manufacturing of ships and aircrafts, have been conducted in an attempt to leap-frog from natural and labour-intensive production to more skill and technology-intensive. The projects have received significant government support in the forms of exemptions on tariffs, direct subsidies, granting of monopolies, etc. The support has generally been motivated by infant industry arguments and by the supposedly important externalities in 'high-tech' production. However, empirical studies generally fail to find any significant effect from these projects on Indonesia's industrialisation and growth.[10]

## III. DATA AND EMPIRICAL MODELS

The empirical analyses are based on industrial data supplied by the Indonesian Central Bureau of Statistics (Biro Pusat Statistik). An industrial survey is conducted yearly and covers all Indonesian establishments with more than 20 employees. An establishment in Indonesian data is a plant rather than a firm.[11] Data for two years – 1980 and 1991 – were supplied. We define domestically-owned establishments as plants where the share of domestic ownership is above 85 per cent.[12] Our sample consists of 8,086 establishments (7,760 domestically-owned) in 1980 and 16,382 establishments (15,671 domestically-owned) in 1991. Furthermore, figures on 2,892 domestic establishments are available for both 1980 and 1991. This group is used in our growth estimations. The establishments are divided into 329 industries at a five-digit level of ISIC.

As previously noted, we will use two different model specifications in our empirical analyses. First, we will examine the effect of foreign presence on the level of labour productivity in domestic establishments. All establishments which operated in 1980 and/or 1991 are used and all variables are in nominal terms. The drawback with this specification is that the causality between DFI and productivity levels is not clear. There is a possibility that foreign firms are located in sectors with high productivity. Our second model specification examines growth in productivity. Growth in productivity is measured in those establishments that are operating in both 1980 and 1991. One problem with this method could be that establishments which operated in 1980 but have left the market, or establishments which have entered the market after 1980 are not in the sample. To sum up, there are drawbacks and potential biases connected with both methods, but by including both we can reduce the risk of drawing conclusions on spurious results.

We start by examining the effect on levels of labour productivity from DFI. To ensure comparability with previous studies, we follow Caves [*1974*], Globerman [*1979*], Blomström and Persson [*1983*] and Kokko [*1994, 1996*] and estimate labour productivity in domestically owned establishments as a function of various factors, including DFI. Labour productivity in establishment $i$ in sector $j$ at time $t$ is expressed as:

$$\frac{VA_{ijt}}{L_{ijt}} = f\left\{\frac{I_{ijt}}{L_{ijt}}, SCALE_{ijt}, DFI_{jt}, Z_{ijt}\right\}. \quad (1)$$

The dependent variable is value added per employee. Data on capital stocks are, unfortunately, not available. *I/L* is total investment per employee and is constructed to control for capital intensities. We would expect a positive coefficient for *I/L* in the econometric estimation. *DFI* is the share of foreign gross output at a five-digit level of ISIC. The larger the share of foreign ownership the larger is the scope for spillovers. We expect a positive coefficient for *DFI* if there are positive spillovers. *SCALE* is measured as the ratio between an establishment's production and the average production in the same sector. The variable is included to control for increasing returns to scale: if there are scale economies present, the coefficient for *SCALE* will be positive and statistically significant. *Z* finally, is a set of additional variables, which may affect labour productivity. All variables are measured in nominal terms and will be estimated in log forms. Descriptive statistics of the included variables are shown in the appendix.

In addition to the level model, which has been used in most previous work on spillovers from DFI, we will investigate the effect on growth in productivity.[13] We start with a simple production function with two factors of production:

$$Y_{ijt} = A_{ijt}\, f(L_{ijt}, K_{ijt}), \quad (2)$$

where $Y_{it}$ is value added in establishment $i$ in sector $j$ at time $t$, and $A$, $L$ and $K$ are the level of productivity, the number of employees and the capital stock. Assuming a Cobb-Douglas type of production function and taking total derivatives of equation (2), one gets:

$$\dot{Y}_{ijt} = \dot{A}_{ijt} + \beta_1 \dot{L}_{ijt} + \beta_2 \dot{K}_{ijt}, \quad (3)$$

where a dot over a variable indicates its growth and where $\beta_1$ and $\beta_2$ are the elasticity of output with respect to $L$ and $K$. Since capital stocks are not available, we replace $dK$ with total investment, I, which enables us to write equation (3) as:

$$\dot{Y}_{ijt} = \dot{A}_{ijt} + \beta_1 \dot{L}_{ijt} + \alpha_2 \frac{I_{ijt}}{Y_{ijt}}. \quad (4)$$

where $\alpha_2$ is the marginal product of capital.[14] We assume that productivity growth can be expressed as a function of spillovers from DFI:

$$\dot{A}_{ijt} = f(DFI_{jt}, Z_{ijt}) + e_{ijt}. \tag{5}$$

Thus, combining equation (5) and equation (4) we end up with the following equation to be estimated:

$$\dot{Y}_{ijt} = \beta_0 + \beta_1 \dot{L}_{ijt} + \alpha_2 \frac{I_{ijt}}{Q_{ijt}} + f(DFI_{jt}, Z_{ijt}) + e_{ijt}, \tag{6}$$

where $Q$ is gross output and $e$ is a residual. Growth in value added and employment is between 1980 and 1991. We choose to estimate investment as a share of gross output rather than as a share of value added. Figures on investment as a share of gross output are from 1980. An establishment's investment is, hence, assumed to be constant over the period. We will also try alternative measures on capital. *DFI* is measured as the average foreign share of a sector's gross output between 1980 and 1991. We expect a positive coefficient for growth in labour, investment and *DFI*.

We will estimate different samples of our observations in order to examine if technology gap and competition affect spillovers from DFI. Kokko [*1994*] uses three different measures on the technology gap: first, the different industries' capital intensities; secondly, the amount of patent fees in different industries; and finally the difference in labour productivity between foreign and domestic establishments. The first two measures capture expected differences in technology rather than observed differences. Capital-intensive industries as well as industries with a large amount of patents are assumed to have high levels of technology. Moreover, the higher an industry's level of technology, the larger is the assumed difference between the technology level in domestic and foreign firms. The last measure, differences in labour productivity, is based on observed differences between domestic and foreign firms. However, this measure suffers from the possibility that the cause is attributed to differences in capital intensities or scale of production rather than differences in technologies.

We propose an alternative measure on technology differences. Since we have micro-level data, we can estimate the difference in labour productivity between domestic and foreign establishments for each industry, after accounting for capital intensities and scale of production. We estimate the following expression for each industry at a three-digit level of ISIC:

$$\frac{Y_{ijt}}{L_{ijt}} = \beta_0 + \beta_1 SCALE_{ijt} + \beta_2 \frac{I_{ijt}}{L_{ijt}} + fordummy + T + e_{ijt}. \tag{7}$$

The expression is estimated in nominal terms and with all observations in 1980 and 1991. *T* is a dummy variable for time with the value one for 1991 and *fordummy* is a dummy variable with the value one for foreign owned establishments. The coefficient for *fordummy* is a measure on the difference in technology. Industries with high values on *fordummy* experience a large difference between domestic and foreign establishments' technology. The sample of establishments has been divided in two. The median value for the coefficient on *fordummy* over all industries is used as the selection criteria. Industries with coefficients on *fordummy* above (below) the median have been included in the group with high (low) technology difference.

TABLE 2

SECTOR SPECIFIC DIFFERENCES IN TECHNOLOGY BETWEEN DOMESTIC AND FOREIGN ESTABLISHMENTS

| | Sector (ISIC) | Technology differences |
|---|---|---|
| | Footwear (324) | -0.40 |
| | Clothing (322) | -0.08 |
| | Furniture (332) | 0.08 |
| | Other manufactures (390) | 0.10 |
| | Plastic products (356) | 0.12 |
| Low technology differences | Professional goods (385) | 0.26 |
| | Glass products (362) | 0.42 |
| | Leather products (323) | 0.45 |
| | Wood products (331) | 0.51 |
| | Rubber products (355) | 0.52 |
| | Industrial chemicals (351) | 0.55 |
| | Electrical goods (383) | 0.58 |
| | Printing (342) | 0.67 |
| | Textiles (321) | 0.73 |
| | Iron and steel (371) | 0.83 |
| | Metal products (381) | 0.84 |
| | Paper products (341) | 0.85 |
| | Transports Equipment (384) | 0.99 |
| | Non-ferrous metals (372) | 1.00 |
| | Pottery (361) | 1.08 |
| High technology differences | Machinery (382) | 1.08 |
| | Food products (311) | 1.20 |
| | Other chemicals (352) | 1.26 |
| | Non-metal products (369) | 1.68 |
| | Beverages (313) | 1.84 |
| | Tobacco products (314) | 2.53 |
| | Cement (363) | 2.79 |
| | *Coal products (354)* | 3.86 |

*Note*: The technology differences are estimated as the value on *fordummy* from equation (7).

The estimated differences in technology between domestic and foreign establishments are shown in Table 2. Foreign establishments have a higher technology level in all industries except for two – footwear and clothing. The difference is relatively small in industries such as furniture, other manufactures, plastic products, professional goods, and relatively large in coal, cement, tobacco, beverages and non-metal products. As previously mentioned, capital intensity has been used as a proxy variable on technology differences in previous studies. There seems to be a relationship between capital intensities and differences in technology in labour-intensive industries: footwear, clothing, furniture, leather and wood products are all relatively labour-intensive. This type of industry has often standardised off-the-shelf technologies, which is relatively easy to apply. However, the most capital-intensive industries such as chemicals, nonferrous metals, iron and steel are not the ones with the largest differences in technology, which instead occurs in industries with intermediate capital intensities.

One problem with our measure on technology differences is that it may, to some extent, capture the effect of brand names.[15] Foreign firms with brand names may exhibit higher value added and therefore be estimated to have a relatively superior technology. We will therefore use differences in investment ratios as an alternative measure of the technology gap. A large difference in investment per employee indicates a large difference in capital intensities and, presumably, in technologies.

We will also examine whether the effect from DFI differs between sectors with different degrees of competition. It is desirable to incorporate both the degree of competition on the domestic market as well as the degree of competition from abroad. We use the Herfindahl index to measure the degree of concentration in different industries and the ERP to measure the degree of openness to foreign competition. Our measure of competition is constructed as an interaction term between the Herfindahl index and the rate of effective protection. We construct *Competition* for each industry *j* at a five-digit level of ISIC as:

$$Competition_j = ERP_j{}^{*}\ Herfindahlj,\ \forall ERP_j\ > 0 \qquad (8)$$

$$Competition_j = \frac{\mathrm{ERP_j}}{\mathrm{Herfindahl_j}},\ \forall ERP_j\ < 0$$

where ERP is the effective rate of protection and Herfindahl is the Herfindahl index.

The Herfindahl index is equal to the sum of squared establishments' shares of the industry's total gross output. Unfortunately, we cannot control for the possibility that the same firm owns many establishments. It is likely, however, that there is a positive correspondence between the number of establishments and the number of firms in a certain industry. A high value on Herfindahl means a high concentration of an industry's gross output. The

Herfindahl index is calculated for 1980 as well as for 1991. Figures on the degree of ERP are for the years 1987 and 1989 and are taken from Fane and Phillips [*1991*] and from Wymenga [*1991*]. The former year is used for calculating competition for 1980 and the latter for 1991. The advantage with these figures is that they use international price comparisons to take in to account non-tariff barriers. Ideally, one would prefer protection figures for an earlier year, at least for the calculations for 1980. However, no major reform of the protective regime was conducted between 1980 and 1987 according to Hill [*1996: 157*], which makes our figures reasonable as a proxy variable for 1980. The figures on ERP are calculated for 119 industries, broadly in line with a four-digit level of ISIC.

The median value on *Competition* has been used to divide our sample in industries with high and low degree of competition. Industries with a value above (below) the median value have been included in the sample with low (high) competition. The average value on *Competition* between 1980 and 1991 are used in the growth estimation.

TABLE 3

THE DEGREE OF COMPETITION IN DIFFERENT INDUSTRIES

| Year | High Competition Sector (ISIC) | Value on *Competition* | Low Competition Section (ISIC) | Value on *Competition* |
|---|---|---|---|---|
| 1980 | Sawmills (33111) | −1094.8 | Misc. Leather (32330) | 371.0 |
| | Animal feeds (31290) | −721.1 | Slaughtering (31111) | 324.7 |
| | Tauco (31242) | −639.5 | Process. of Meat (31112) | 243.4 |
| | Soya Sauce (31241) | −504.0 | Cleaning of Seed (31164) | 2227.7 |
| | Printing (34200) | −377.9 | Footwear (32400) | 173.7 |
| 1991 | Sawmills (33111) | −1486.4 | Smoked Fish (31143) | 600.0 |
| | Leather tanneries (32312) | −776.5 | Misc. Furniture (33230) | 536.0 |
| | Preserved leather (32311) | −269.4 | Clean. of Roots (31166) | 529.0 |
| | Cooking oil (31151) | −210.6 | Starch (31219) | 444.0 |
| | Herbal medicines (35523) | −169.5 | Motorcycles (38442) | 367.7 |

*Note*: The value on Competition is estimated from equation (8). Misc. – Miscellaneous. Clean. – Cleaning.

The values on Competition for the five industries with most and least competition in 1980 and 1991 are found in Table 3. A few interesting features can be observed from the figures. First, different types of food products are among the industries with the highest as well as the lowest degree of competition in both 1980 and 1991. Moreover, different sorts of leather products were among the industries with the highest competition in 1991, but there was low competition in a similar industry in 1980. Hence, the heterogeneity of industries within aggregate sectors suggests that it is important to use highly disaggregated data in examining the effect of competition. Furthermore, there is a significant change in the degree of competition since it is not the same industries that show the highest (lowest) competition in 1980 and in 1991. The one exception is sawmills, which has the highest degree of competition in both years.

One drawback with our measure on competition is that industries with negative ERP will always have lower values on *Competition* than industries with positive ERP, irrespective of the value on the Herfindahl index. Around 12 per cent of the observations are in industries that have a negative ERP. We will conduct our estimations both including and excluding the observations with negative values to examine the sensitivity of our results to the construction of *Competition*. Furthermore, we will examine the effect from domestic concentration and ERP separately. The latter method enables us to see if there is a different effect on spillovers from domestic and foreign competition.

## IV. EMPIRICAL RESULTS

We start by examine if there are positive spillovers from DFI in the total Indonesian manufacturing sector. Pre-testing revealed heteroscedasticity; consequently, all variance–covariance matrixes have been estimated according to White's [*1980*] method. The estimated effect from a high share of foreign production on the level and growth in productivity is shown in Table 4. All variables have statistically significant coefficients with the expected signs and provide some support for our prior hypotheses regarding the direction of effects. The coefficient for growth in labour is above unity. One possible reason is that we only account for the quantity of labour and not the quality. The coefficient is therefore likely to incorporate the effect of human capital. The three estimations give a positive and statistically significant coefficient for *DFI*, although the size of the coefficient is rather low in the level estimations. We conclude that there are positive effects, spillovers, on domestic establishments from foreign presence within the sector. Finally, the growth model seems from the relative high R-square to be better than the level models in describing the data.[16]

We continue by examining if spillovers are affected by the size of the technology gap. The empirical results in Table 5 support the hypothesis that domestic establishments lagging far behind foreign technologies benefit relatively much from DFI. Although the coefficient for DFI is statistically significant in five out of six regressions, F-tests revealed statistically larger coefficients in the sample with a high technology gap in the level estimation for 1991 as well as in growth estimation. There was no statistically significant difference between the coefficients in the level estimation for

TABLE 4

SPILLOVERS FROM DFI

| *Variables* | *Level estimation* 1980 (dependent variable)– value added per employee) | *Level estimation* 1991 (dependent variable) – value added per employee) | *Growth estimation* 1980–1991 (dependent variable – growth in value added) |
|---|---|---|---|
| Constant | 6.55<br>(177.86)*** | 8.01<br>(196.84)*** | 31.44<br>(12.72)*** |
| Investment per empl. | 0.03<br>(20.88)*** | 0.02<br>(29.50)*** | — |
| Growth in employment | — | . | 1.09<br>(29.78)*** |
| *Investment / output* | — | — | 0.11<br>(3.11)*** |
| Scale | 0.08<br>(16.88)*** | 0.09<br>(28.78)*** | — |
| DFI | 0.01<br>(4.89)*** | 0.03<br>(19.73)*** | 0.54<br>(2.97)*** |
| R-square adjusted | 0.12 | 0.15 | 0.36 |
| Number of observations | 7760 | 15670 | 2892 |

*Note*: t-statistics within brackets are based on White's [*1980*] adjustment for heteroscedasticity.
*** Significant at the one per cent level.

1980. The results were stable to the inclusion of the measure of technology gap.

The measure of technology gap was estimated with the inclusion of all observations in both 1980 and 1991. The size of the technology gap may have changed, however, during the period. Therefore, we estimated and used the technology gap for 1980 and 1991 separately, but this did not have any major effect on the results. Furthermore, excluding footwear and clothing, where domestic establishments have a relatively high technology, did not change the empirical results; high technology gaps increased the degree of spillovers.

We also tried the alternative measure of technology gap, that is, differences in investment ratios. As previously mentioned, a large difference in investment per employee indicates a large difference in capital intensities and technologies. Unlike the previous measure of technology, there was no clear pattern of whether high or low differences in investment ratio increase or decrease spillovers from DFI.

Kokko [*1994*] made an interaction term with the degree of foreign presence and various proxies of technology gaps. Large foreign shares, in combination with a high technology gap, were found to prevent spillovers. We conducted a similar estimation with an interaction term on DFI and technology gap, but found no clear results.

TABLE 5

TECHNOLOGY GAP AND SPILLOVERS

| | Level estimation 1980 (dependent variable – value added per employee) | | Level estimation 1991 (dependent variable – value added per employee) | | Growth estimation 1980–1991 (dependent variable – growth in value added) | |
|---|---|---|---|---|---|---|
| Variables | Small technology gap | Large technology gap | Small technology gap | Large technology gap | Small technolgy gap | Large technology gap |
| Constant | 6.79<br>(227.5)*** | 6.65<br>(171.3)*** | 8.08<br>(119.7)*** | 8.15<br>(144.8)*** | 28.03<br>(6.17)*** | 34.22<br>(10.69)*** |
| Investment per empl. | 0.03<br>(16.86)*** | 0.04<br>(18.06)*** | 0.02<br>(17.68)*** | 0.04<br>(26.39)*** | — | — |
| Growth in employment | — | — | — | — | 1.13<br>(26.20)*** | 1.01<br>(20.41)*** |
| Investment / output | — | — | — | — | 0.21<br>(4.27)*** | 0.09<br>(2.20)** |
| Scale | 0.08<br>(15.23)*** | 0.11<br>(11.87)*** | 0.09<br>(30.06)*** | 0.12<br>(14.83)*** | — | — |
| DFI | 0.02<br>(5.18)*** | 0.01<br>(1.71)* | 0.01<br>(1.99)** | 0.02<br>(11.87)*** | 0.34<br>(0.93) | 0.68<br>(3.19)*** |
| R-square adjusted | 0.18 | 0.15 | 0.17 | 0.18 | 0.39 | 0.31 |
| Number of observations | 3928 | 3943 | 8360 | 7365 | 1279 | 1542 |

*Note*: t-statistics within brackets are based on White's [*1980*] adjustment for heteroscedasticity.
* Significant at the ten per cent level;
** Significant at the five per cent level;
*** Significant at the one per cent level.

We continue our analyses in Table 6 by examining the effect of competition on spillovers from DFI. The level estimation for 1980 and the growth estimation show statistically significant effects from DFI only in sectors with a relatively high competition. Moreover, F-tests revealed a statistically significant difference in the size of the coefficient for DFI in the level estimations for 1980 and 1991.

As previously stated, *Competition* is asymmetric in the respect that industries with negative ERPs always have a lower value than industries with positive ERPs, irrespective of the value of the Herfindahl index. We therefore excluded industries with negative effective rates of protection, but a high degree of competition was still found to increase spillovers. Moreover, we included the variable *Competition* in the regressions as a further test of the stability, but this did not change our results. The different estimations suggest that competition has a positive effect on spillovers from DFI.

As previously mentioned, the measure of competition incorporates both the degree of domestic concentration and protection from international competition. We also divided our sample of establishments according to either domestic concentration or ERP. It is domestic concentration rather than protection from imports that is important for spillovers. DFI was positive and statistically significant in all estimations in the sample with low concentration, but in none of the estimations with high concentration. There was no clear pattern of how ERP affects spillovers from DFI.

TABLE 6

COMPETITION AND SPILLOVERS

| | Level estimation 1980 (dependent variable – value added per employee) | | Level estimation 1991 (dependent variable – value added per employee) | | Growth estimation 1980–1991 (dependent variable – growth in value added) | |
|---|---|---|---|---|---|---|
| Variables | Low Compet. | High Compet. | Low Compet. | High Compet. | Low Compet. | High Compet. |
| Constant | 6.67<br>(124.5)*** | 6.55<br>(150.6)*** | 8.18<br>(165.5)*** | 7.96<br>(136.5)*** | 30.43<br>(6.68)*** | 31.43<br>(10.49)*** |
| Investment per empl. | 0.03<br>(19.91)*** | 0.03<br>(18.09)*** | 0.02<br>(14.39)*** | 0.02<br>(25.70)*** | — | — |
| Growth in employment | — | — | — | — | 1.17<br>(16.59)*** | 1.04<br>(26.27)*** |
| Investment / output | — | — | — | — | 0.16<br>(2.76)*** | 0.10<br>(2.49)** |
| Scale | 0.06<br>(7.16)*** | 0.09<br>(15.90)*** | 0.11<br>(13.71)*** | 0.09<br>(25.42)*** | — | — |
| DFI | 0.00<br>(0.34)*** | 0.02<br>(6.62)*** | 0.02<br>(10.21)** | 0.03<br>(18.88)*** | 0.34<br>(1.26) | 0.70<br>(2.86)*** |
| R-square adjusted | 0.13 | 0.12 | 0.18 | 0.15 | 0.41 | 0.34 |
| Number of observations | 1581 | 6179 | 3653 | 12017 | 816 | 2076 |

*Note*: t-statistics within brackets are based on White's [*1980*] adjustment for heteroscedasticity. ** Significant at the five per cent level; *** Significant at the one per cent level.

One limitation of the study has been the use of investment ratio as a proxy for growth in capital stock. Clearly, there are potential biases in our empirical results if 1980 and 1991 were not in the same cyclical phase. Instead of using investment figures from 1980 in the growth estimations, we experimented with using the average figures between 1980 and 1991 and including sector specific (at a five-digit level of ISIC) figures on energy consumption. The results did not change to any significant extent. Moreover, we also examined the effect from DFI on labour productivity, that is, excluding all variables capturing capital. The results were in accordance with the previous ones and, hence, showing a positive effect on spillovers from competition and technology gap.

## V. DISCUSSION

Our empirical results suggest that competition increases the degree of spillovers from DFI. One explanation could be that the higher the competition for foreign firms the more frequent technology has to be brought in to make them competitive, and the larger the scope is for spillovers. Hence, our result is in accordance with Blomström *et al.* [*1994*] who found that competition spurs technology transfers to affiliates, and with Kokko [*1996*] who found some support of a positive effect from competition on spillovers.

We found no effect from the ERP on the degree of spillovers. One explanation could be that in sectors with high tariffs, foreign firms chose to serve Indonesia through DFI rather than through export. Our result may be biased if the ERP is a determinant of DFI, and if high tariffs are caused by the will to protect weak domestic establishments, which may have difficulties in absorbing foreign technologies.

Local establishments in sectors lagging behind foreigners in technology seem to be grasping the benefits of spillovers. However, one should note that using an alternative measure on technology gap, differences in investment ratios, made the results less clear. We believe the regressions with our estimated technology difference to be superior to the investment gap for two reasons. First, the investment figures may fluctuate over the years and thereby be poor proxies of capital intensities and technology. Secondly, using investment differences is more of an indirect measure of technology gap in comparison to observed differences in output after controlling for various inputs.

Contrary to our results Kokko [*1994*] found a negative effect on spillovers from the size of the technology gap in combination with a high degree of foreign presence. One possible explanation to our different results could be different methodologies. Another explanation could be a bias caused by omitted variables. For instance, it is likely that institutional factors affect the results. As previously discussed, there are restrictions on localisation of foreign affiliates in Indonesia. An important issue for further research is to examine whether the institutional framework affects spillovers. Moreover, it seems reasonable to expect the relationship between technology gap and spillovers to be non-linear. Obviously, some technology gap is required for spillovers and at an initial stage the degree of spillovers may rise with the size of the technology gap. However, at a certain level the gap may be so large that it will be impossible for the domestic firms to absorb foreign technologies with their existing experience, educational level and technological knowledge.

There are some obvious policy implications following on our results. A country may increase spillovers from DFI by increasing the degree of competition. Indonesia's economy has traditionally been regulated through cartels, price controls, entry and exit controls and exclusive licensing, leading to a highly concentrated ownership of the economy [*Robison, 1997*]. The deregulation of the Indonesian economy since the mid-1980s is likely to affect positively the degree of technological diffusion and economic growth. The state-led programmes of technological leap-frogging may be a less suitable path for further development. These programmes include, for instance, granting of monopolies to domestic actors and restrictions on foreign entrance. Again, restrictions on foreign presence will decrease technology diffusion and restrictions on competition will decrease spillovers from those foreign establishments that may be present. Moreover, it is establishments in industries that lag furthest behind foreign technologies which are the ones benefiting most from DFI. It suggests that protection of 'infant' industries or of 'high-tech' industries from domestic competition as well as from DFI may not be a desirable policy.

## VI. CONCLUDING REMARKS

A number of studies have examined spillovers from DFI. Spillovers are found only in some countries, suggesting that they are not automatic but affected by various factors. We have examined if spillovers are affected by competition and by technology gaps between domestic and foreign establishments, and contributed to the existing literature in some respects. First, we examined the issues at hand at an establishment level using both levels and growth of productivity. Secondly, we examined the effect from domestic competition as well as competition from imports. Finally, we used observed differences on technology rather than proxy variables measuring the expected differences.

Our results show high competition to increase the degree of spillovers from DFI, suggesting that the degree of competition affects the choice of technology transferred to the multinationals' affiliates and, hence, the potential for spillovers. Moreover, it seems to be domestic competition rather than competition from imports that affects spillovers from DFI. Our results concerning the effect of technology gaps suggest that high technology differences give rise to large spillovers, although the result is sensitive as to how we measure the technology gap.

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## NOTES

1. See, for example, Blomström and Kokko [*1998*].
2. See Lapan and Bardhan [*1973: 585*].
3. Blomström *et al.* [*1994*] find in an empirical study on Mexico that various proxies for competition are positive related to the amount of technology brought in by foreign firms.
4. Sumantoro [*1982: 34–9*], Poot *et al.* [*1992: 85–121*].
5. See, for example, Guillouet [*1990*], and Thee and Pangestu [*1994*].
6. The foreign share has been calculated by taking the foreign share of each establishment times the same establishment's gross output. Hence, if an establishment is equally shared by foreign and domestic owners, 50 per cent of the gross output will be characterised as foreign.
7. Indonesian Financial Statistics.
8. Professional goods includes such industries as scientific equipments and cameras.
9. For an overview see Hill [*1995*].
10. See, for instance, McKendrick [*1992*].
11. The Indonesian definition of an establishment is: 'A production unit engaged in a certain location, keeping a business record concerning the production and cost structure, and having a person or more that bears the responsibility or the risk of that activity' [*Statistik Industri, 1991*].
12. It should be noted that prior to 1986, a lot of firms were effectively foreign controlled without much foreign equity. We therefore let definitions of a domestic establishment vary between 80 and 100 per cent domestic ownership, but it dit not have any major impact on the results.
13. See Haddad and Harrison [*1993*] for a study on spillovers with growth in productivity as the dependent variable.
14. Replacing $dK$ with $I$ is a standard procedure in empirical work on growth when one is lacking data on capital stocks. See, for example, Feder [*1983*], Ram [*1987*], and Dollar [*1992*]. However, it should be noted that going from equation (1) to equation (2), we implicitly assume that the marginal products of labour and capital are fixed.
15. This problem is also present when one use differences in labour productivity as a measure on technology gap.
16. One reason to the relative better performance of the growth model could be that we are examining a period when many of the variables have been growing quickly as a whole.

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## APPENDIX

TABLE A1

DESCRIPTIVE STATISTICS, LEVEL 1980

| Variable | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Value Added | 306643 | 3280966 | 49 | 233309890 |
| Investment | 57601 | 701233 | 0 | 47255674 |
| Employment | 121 | 511 | 10 | 31385 |
| Scale | 1 | 3 | 0 | 121 |
| DFI | 0.13 | 0.17 | 0 | 0.79 |

TABLE A2

DESCRIPTIVE STATISTICS, LEVEL 1991

| Variable | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Value Added | 1821100 | 20322477 | 6 | 1923910000 |
| Investment | 774362 | 10597207 | 0 | 877386136 |
| Employment | 181 | 601 | 20 | 42649 |
| Scale | 1 | 4 | 0 | 265 |
| DFI | 0.08 | 0.12 | 0 | 1 |

TABLE A3

DESCRIPTIVE STATISTICS, GROWTH 1980–91

| Variable | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Growth in Value Added | 0.62 | 1.31 | –7.00 | 11.03 |
| Growth in Employment | 0.23 | 0.71 | –3.28 | 5.21 |
| Investment/Gross Output | 0.10 | 0.70 | 0 | 16.37 |
| DFI | 0.10 | 0.12 | 0 | 0.57 |