Productivity Spillovers and Characteristics of Foreign Multinational Plants in Indonesian Manufacturing 1990-1995

Sadayuki Takii
Research Assistant Professor, ICSEAD

Working Paper Series Vol. 2001-14 (revised)
June 2001

The International Centre for the Study of East Asian Development, Kitakyushu

Productivity Spillovers and Characteristics of Foreign Multinational Plants in Indonesian Manufacturing 1990-1995 ⋆

Sadayuki Takii *

The International Centre for the Study of East Asian Development, Kitakyushu
11-4 Otemachi, Kokurakita, Kitakyushu, 803-0814 Japan

Abstract

This paper examines productivity spillovers derived from the existence of foreign multinational plants. The empirical evidence, first suggests the existence of positive spillovers. Second, results indicate that the extent of spillovers was positively related to the share of foreign-owned plants in employment. Third, the results suggest that the magnitude of spillovers tended to be smaller in industries where the share of majority-foreign plants was relatively large or industries where technological gaps between foreign- and locally-owned plants were relatively large. These results imply that encouraging foreign direct investment does not necessarily promote spillovers, especially in technologically backward industries.

JEL classification: F23; O30
Keywords: Multinational corporations; Foreign direct investment; Joint venture; Technology; Spillovers

⋆ This paper was completed as a part of ICSEAD's project "Foreign Multinational Corporations and Host-Country Labor Markets in Asia". The author would like to acknowledge the helpful comments from Chikayoshi Saeki, Masakatu Tamaru and Hitoshi Osaka. The author would also like to thank Robert E. Lipsey, Fredrik Sjöholm, Eric D. Ramstetter and other participants at an ICSEAD seminar. Any errors are the author's responsibility.
* Corresponding author.
Address: 11-4 Otemachi, Kokurakita, Kitakyushu, 803-0814, Japan.
Tel: +81-93-583-6202; Fax: +81-93-583-4602.
Email address: takii@icsead.or.jp (Sadayuki Takii).

1 Introduction

There has been a large inflow of foreign direct investment (FDI) to East Asian economies, including Indonesia, since the late-1980's. This inflow has been both a cause and a result of the remarkable economic growth achieved during the period. For example, Indonesia's economy grew an average of 8.2 percent annually in 1988–1996 while inward FDI increased from US$0.6 billion in 1988 to US$6.2 billion in 1996 before the Asian crisis hit the country (ICSEAD, 2001). FDI in foreign affiliates of multinational corporations (MNCs) is generally thought to contribute to the economic growth of host countries by increasing capital accumulation, productive capacity, labor demand, the demand for intermediate goods, and sometimes exports. In addition to these direct effects, the entry of foreign firms in host economy has indirect effects on existing locally-owned firms. One possible indirect effect is increased competitive pressure, which motivates locally-owned firms to improve efficiency. Another is diffusion of more sophisticated technology transferred by foreign firms. These indirect effects are often called spillovers in the literature.

This paper examines spillovers in a large panel of Indonesian manufacturing plants in 1990–1995 and is organized into 6 sections. Section 2 reviews the literature on spillovers. Section 3 reviews previous empirical analysis on spillovers and describes the methodology used in this study. Section 4 describes the data and descriptive statistics related to spillovers. Section 5 then reports the results of estimating the relationships between spillovers and foreign ownership shares and the relationship between spillovers on the one hand, and industry- and firm-specific factors, on the other. Finally, Section 6 summarizes the conclusions emerging from these analyses.

2 Technology Diffusion and Spillovers

Blomström and Kokko (1997) suggest that when affiliates are established by foreign multinational corporations, they should be distinguished from local firms in the host country. This is because MNCs transfer proprietary technology to their affiliates, giving those affiliates a competitive advantage relative to local firms. Thus, the entry of the MNC affiliates disturbs the existing equilibrium in the market and forces local firms to modify their behavior in order to protect market shares and profits. Correspondingly, it is important to measure the effects that the entry of MNCs' affiliates imparts on local firms. The effects are generally called productivity spillovers (Blomström et al., 2000).

The effects of technology transfer by MNCs are also especially important in less developed countries (LDCs). One major reason is that most of the world's advanced technology is controlled by MNCs based in a few advanced countries (Blomström and Kokko, 1997). Another important and related reason is that markets for technology are often non-existent because of the asymmetry that exists between buyers and sellers about technology (Markesen, 1995). More specifically, potential sellers know more about the technology for sale than potential buyers, but they are reluctant to share that information with the buyers for fear of losing the technology. Therefore, local firms in LDCs often have no choice but to obtain technology directly from MNC affiliates or through spillovers from MNC affiliates. In short, productivity spillovers may be one of the most important effects that foreign MNCs impart on local firms in LDCs.

Spillovers are at least partially determined by the endogenous actions of foreign investors. The question of why firms undertake investment abroad in spite of possessing less information on foreign markets compared with local firms provides a starting point for analysis. Dunning (1993) points out three factors that affect this decision, ownership advantages, location advantages, and internalization advantages. Firms undertake investment abroad when these advantages more than make up for the disadvantages accompanied by operating abroad. Firms invest abroad or transfer proprietary knowledge to their affiliates operating in foreign countries when they can enhance the value of their knowledge by operating in a particular foreign location or by internalizing markets. In other words, FDI can be thought of as a tool to enhance and materialize the value of firm-specific knowledge in the MNC. However, MNCs can't always prevent leakage of their knowledge when investing abroad. For example, when a firm undertakes investment abroad with a local partner, the firm has to share a part of its specific knowledge with the partner, and the partner may use that knowledge for other projects. When MNCs employ local labor in important positions (for example in management or engineering), they may resign and undertake other business and use the knowledge obtained while working in the MNC affiliate. Therefore, MNCs may prefer to control their affiliates so they can prevent the leakage of firm-specific knowledge.

On the other hand, when MNCs cannot sufficiently control the leakage of knowledge, they may limit the nature technology transferred to their affiliates because the costs of technology leakage increase with the sophistication of the technology transferred. In this situation another question arises. Does the transfer of less sophisticated technology to MNC affiliates imply a lower magnitude of spillovers to local firms? Alternatively, when technology gaps between MNC affiliates and local firms are large, is the speed of technology diffusion fast or slow? Findlay (1978) constructed a simple dynamic model to capture some aspects of technology diffusion. In the model, the growth rate of technological efficiency in a backward region was assumed to be an increasing function of the technological gap with an advanced region. This assumption is based on the idea that pressures for change within the backward region are positively correlated with the backlog of technological opportunities in the advanced region. Wang and Blomström (1992) also assumed the rate of technological progress in a relatively backward region to be an increasing function of the technological gap. In a cross section of twenty manufacturing sectors in Mexico, Blomström and Wolff (1994) found that the rate at which local plants catch up to MNCs is higher in sectors with relatively large disparity in productivity levels in the initial year. In some contrast, Kokko (1994) found that large productivity gaps and large foreign market shares together impede spillovers in the Mexican samples.

In the former case, the magnitude of spillovers derived from MNCs appears to have been smaller because of stricter control by the parent MNCs. In the latter case, the change in the magnitude of spillovers appears to depend on the appropriateness of technology in MNCs. If the technological capability of local firms has not reached a certain level, then it is likely that higher foreign ownership shares will be negatively correlated with the magnitude of spillovers. [1]

3 Measuring the Magnitude of Spillovers

This section reviews previous empirical studies on spillovers and then describes the methodologies to measure the magnitude of spillovers used in this study. Early empirical analyses of spillovers were undertaken by Caves (1974),

[1] The empirical results in Takii (2002) indicate that wholly-foreign plants tended to have higher technology levels than other foreign-owned plants after accounting for age of each plant.

Globerman (1979), and Blomström and Persson (1983).[2] In these models, the dependent variable was defined as the ratio of total value added in locally-owned plants in an industry to total employment engaged in the plants. The key independent variable was a measure of the foreign share, for example the share of foreign-owned plants in total employment or value added.[3] Other variables affecting average labor productivity in the industry were also included as independent variables. These studies interpreted the coefficient on the foreign share variable as an indication of the magnitude of spillovers. According to Findlay (1978, p. 3), "technical innovations are most effectively copied when there is personal contact between those who already have the knowledge of the innovation and those who eventually adopt it". This implies larger foreign shares are positively correlated with the opportunities for locally-owned plants to interact with foreign-owned plants. This interaction then facilitates the spread of sophisticated technology from MNCs to locally-owned plants. Therefore, if the coefficient on the foreign share variable is statistically significant and positive, positive spillovers are thought to exist.

Following these analyses, a lot of papers have examined spillovers empirically as well as theoretically. However, there is no general consensus about the scope of spillovers, partially because a number of factors affect the magnitude of spillovers. The review of the literature on spillovers in Blomström and Kokko (1997) suggests that the magnitude of spillovers depends on both host country characteristics and MNC characteristics. In order to account for the impact of these characteristics on the magnitude of spillovers, Kokko

[2] Caves (1974) examined 22 industries in Australia in 1966, Globerman (1979) examined 60 industries in Canada in 1972, and Blomström and Persson (1983) examined 215 industries in Mexico in 1970.

[3] Caves (1974) and Blomström and Persson (1983) used the foreign share of employment, while Globerman (1979) used the foreign share of value added.

(1994) used the following methodology to study 215 industries in Mexico in 1970. First, he classified industries into two groups based on three technological characteristics of the industries, average payments of patent fees per employee, average capital intensity of foreign affiliates, and the labor productivity gap between local and foreign firms in each industry. Next, he estimated the relationship between spillovers and the foreign share in each group, and then compared the magnitude of the coefficients on foreign share variable indicating the magnitude of spillovers. The major result was the indication that large productivity gaps and large foreign shares together impede spillovers. Sjöholm (1999) adapted this methodology to plant-level data for Indonesian manufacturing in 1980 and 1991. He examined the relationships between spillovers and productivity gaps between spillovers and the level competition in industries (measured by the Herfindahl index and effective rate of protection). The results indicated that spillovers were larger for locally-owned plants in industries with a high degree of competition and industries where technology in local firms is far behind technology in MNCs.

In addition to the characteristics of industries, the characteristics of foreign-owned plants are also thought to affect on the magnitude of spillovers. Blomström et al. (1999) argue that spillovers are at least partly endogenously determined by the actions of foreign investors. In this context, Blomström and Sjöholm (1999) compared spillovers from foreign-owned plants grouped by ownership share in Indonesian manufacturing for 1991 and concluded that local participation with MNCs does not facilitate technology diffusion and that the type of ownership of foreign-owned plants is not a determinant of the degree of spillovers. Blomström and Sjöholm (1999) also examined the relationship between spillovers and exports of plants, the results suggesting that non-exporters benefited from spillovers, while exporters already facing competition in world markets did not.

More recent analyses are primarily based on plant-level data (Sjöholm, 1999 and Blomström and Sjöholm, 1999) and some studies use panel data instead of cross-sectional data. For example, Haddad and Harrison (1993) and Aitken and Harrison (1999) examined plant-level panel data for Morocco in 1985–1989 and for Venezuela in 1976–1989 respectively. The use of panel data is beneficial because more information is available compared to simple cross sections. For example, when the efficiency levels (intercepts in production function) differ among plants and these differences are not accounted for in the model, it is known that ordinary least square (OLS) estimators of slope variables are downwardly biased. This problem can be solved when panel data is used.

This paper also empirically examines spillovers in a panel of Indonesian manufacturing plants for 1990–1995 and examines the factors affecting the magnitude of spillovers (The panel dataset will be explained in next section.). First of all, for generality, the production function of locally-owned plants is assumed as a following translog-type:

$$\begin{aligned}\ln(V_{ijt}) = A_{ijt} &+ \alpha_L \ln(L_{ijt}) + \beta_K \ln(K_{ijt}) + \alpha_{LL}\{\ln(L_{ijt})\}^2 \\ &+ \beta_{KK}\{\ln(K_{ijt})\}^2 + \gamma_{LK}\{\ln(L_{ijt})\}\{\ln(K_{ijt})\}, \qquad (1)\end{aligned}$$

where V is value added and L and K are the number of workers and capital stock respectively.[4] The subscripts i, j and t refer to the i th locally-owned plant in the j th industry at time t. A_{ijt} refers to the efficiency level of a

[4] L and K are each divided by its mean value. The translog production function can be regarded as a second-order approximation of arbitrary production function at one point. When estimating the translog production function, it is common to use the approximation at point $(L, K) = (1, 1)$. In this paper, the approximation at point (mean of L, mean of K) is used instead of point $(1, 1)$, because it appears to yield a better approximation.

locally-owned plant. At first, the efficiency is assumed to be decomposed into three components, foreign share in the j th industry at time t, plant-specific factors (α_i: the so-called individual effects) and year-specific factors ($\boldsymbol{YD}_t$: a 1×5 vector of relative year-specific effects in 1990–1994 relative to effects in 1995, which has one as the t th element and zero as other elements, e.g. if year = 1990, the first element of the vector is one).[5] Therefore, Eq. (1a) below is the first regression model estimated:

$$\begin{aligned}\ln(V_{ijt}) = {} & \beta_{FS} FS_{jt} + \alpha_i + \boldsymbol{\delta}'\boldsymbol{YD}_t \\ & + \alpha_L \ln(L_{ijt}) + \beta_K \ln(K_{ijt}) + \alpha_{LL}\{\ln(L_{ijt})\}^2 \\ & + \beta_{KK}\{\ln(K_{ijt})\}^2 + \gamma_{LK}\{\ln(L_{ijt})\}\{\ln(K_{ijt})\}. \end{aligned} \tag{1a}$$

In this model, the foreign share, FS_{jt}, is the ratio of employment in foreign-owned plants to total employment in the j th industry at time t.[6] This is called the labor share of foreign-owned plants below. The model was estimated following a usual panel procedures. First, a test of whether individual effects exist or not is conducted. Second, if individual effects exist, a specification test is conducted to determine whether the individual effects are fixed or random. Based on the results of these tests, a fixed effects model was chosen. Therefore, Eq. (1a) is equivalent to the dummy variable least square model, which includes a vector of plant-specific effects in the model. This vector has one as the i th element and zero as other elements, instead of α_i. If the regression results show that the coefficient on FS_{jt} is significantly positive,

[5] When the database was constructed, plants that belonged to n (> 1) industries were regarded as n distinct plants. For example, a plant that belonged to textile industry in 1990–1992 and that belonged to apparel industry in 1993–1995 appears on two records in the database. On one record the plant appears in textile industry in 1990–1992 and on another record it appears in apparel industry in 1993–1995. Therefore, we don't need to include industry dummy variables in estimated models because the effect is incorporated into the plant-specific (fixed) effects.

[6] Thus, β_{FS} gives the percentage change in a plant's value added per percentage "point" change in the ratio of employment in foreign-owned plants to total employment in the industry the plant belongs to.

we can reject the null hypothesis that the existence of foreign-owned plants has no effect on the efficiency of locally-owned plants, after accounting for plant-specific factors (α_i) and year-specific factors ($\boldsymbol{YD}_t$).

Next, the model in Eq. (1a) is extended to include other characteristics of foreign-owned plants in order to examine the effects of these characteristics on spillovers. As described in Section 2, the magnitude of spillovers may depend on the degree of foreign ownership because this may affect the MNC's willingness to transfer technology to its affiliates. In other words, the efficiency level of a locally-owned plant could depend on the share of plants with high foreign ownership shares in the industry. In addition, the entry of a new foreign-owned plant may lead to a relatively large increase in competitive pressure that motivate locally-owned plants to improve their efficiency. On the other hand, a new foreign-owned plant might not reach to its technological potential, and the diffusion of technology from the plant might be small. Furthermore, plants with relatively high foreign ownership shares might be relatively new. If so, the effects of the foreign ownership share on spillovers cannot be measured properly without accounting for plant age. In order to examine these aspects, three new variables are introduced into the model as follows. HFS_{jt}^{50} is the ratio of the number of workers in majority-foreign (plants with foreign ownership shares of 51 percent or more) to the number of workers in all foreign-owned plants in the industry. HFS_{jt}^{100} is the ratio of the number of workers in wholly-foreign (plants that are 100 percent foreign-owned) to the number of workers all foreign-owned plants in the industry. NFS_{jt} is the ratio of the number of workers in new foreign-owned plants to the number of workers in all foreign-owned plants in the industry, where new plants are defined as plants that had been operating for less than two years.[7] Using these variables, following the three extensions of Eq. (1a) are defined in Eq. (1b), (1c), and (1d).

$$\ln(V_{ijt}) = X_{ijt} + \beta_{FS}FS_{jt} + \beta_{50}HFS^{50}_{jt} \quad (1b)$$
$$\ln(V_{ijt}) = X_{ijt} + \beta_{FS}FS_{jt} + \beta_{50}HFS^{50}_{jt} + \beta_{100}HFS^{100}_{jt} \quad (1c)$$
$$\ln(V_{ijt}) = X_{ijt} + \beta_{FS}FS_{jt} + \beta_{50}HFS^{50}_{jt} + \beta_{100}HFS^{100}_{jt} + \beta_{N}NFS_{jt}, \quad (1d)$$

where

$$X_{ijt} = A_{ijt} + \alpha_i + \boldsymbol{\delta' Y D}_t + \alpha_L \ln(L_{ijt}) + \beta_K \ln(K_{ijt}) + \alpha_{LL}\{\ln(L_{ijt})\}^2 + \beta_{KK}\{\ln(K_{ijt})\}^2 + \gamma_{LK}\{\ln(L_{ijt})\}\{\ln(K_{ijt})\}.$$

If β_{50}, which is the coefficient on HFS^{50}_{jt} is statistically significant in Eq. (1d), then we can reject the null hypothesis that the magnitude of spillovers does not depend on the foreign ownership share after accounting for the age of foreign-owned plants. In addition, if β_{100}, which is the coefficient on HFS^{100}_{jt} is statistically significant in Eq. (1c) and (1d), we can reject the null hypothesis that the magnitude of spillovers derived from wholly-foreign plants (defined as plants with 100 percent foreign ownership share) is different from that derived from other majority-foreign plants.[8]

In order to account for the characteristics of locally-owned plants that might affect efficiency level but are not accounted for in the vector of the plant-specific factors α_i, a plant's export propensity, import propensity, and a proxy for its skill intensity, the ratio of non-production workers to all workers are added as explanatory variables to Eq. (1a–1d). The export propensity is the

[7] This variable is defined using the year reported by the surveyed plants. In some cases, plants reported starting up in year t but actually reported production in some earlier year $t - s$. The cause is unclear but appears to be related to changes in ownership in some cases.

[8] Although there might be correlation ship among the four variables, FS, HFS^{50}, HFS^{100} and NFS, the maxim correlation coefficient of 6 varieties of combinations was 0.33. Hence, there seems to be no serious problems.

ratio of exported production to total production and the import propensity is the ratio of imported materials to total raw materials used during the year. Although the relationships between the trade propensities and efficiency are somewhat ambiguous, it is often thought that exporting plants might have greater incentives to improve efficiency because they face international competition and imports from advanced countries are also thought to be a major channel through which technology and related information are diffused. The share of non-production workers in total employment (also called the share of white collar workers in total employment) is a proxy for skill intensity or labor quality that is also thought to affect efficiency. Adding these variables to Eq. (1a–1d) yields Eq. (1e–1h) below.

$$\ln(V_{ijt}) = X_{ijt} + Z_{ijt} + \beta_{FS} FS_{jt} \tag{1e}$$
$$\ln(V_{ijt}) = X_{ijt} + Z_{ijt} + \beta_{FS} FS_{jt} + \beta_{50} HFS^{50}_{jt} \tag{1f}$$
$$\ln(V_{ijt}) = X_{ijt} + Z_{ijt} + \beta_{FS} FS_{jt} + \beta_{50} HFS^{50}_{jt} + \beta_{100} HFS^{100}_{jt} \tag{1g}$$
$$\begin{aligned} \ln(V_{ijt}) = {} & X_{ijt} + Z_{ijt} + \beta_{FS} FS_{jt} \\ & + \beta_{50} HFS^{50}_{jt} + \beta_{100} HFS^{100}_{jt} + \beta_N NFS_{jt}, \end{aligned} \tag{1h}$$

where

$$\begin{aligned} X_{ijt} = {} & A_{ijt} + \alpha_i + \boldsymbol{\delta}' \boldsymbol{Y} \boldsymbol{D}_t + \alpha_L \ln(L_{ijt}) + \beta_K \ln(K_{ijt}) \\ & + \alpha_{LL} \{\ln(L_{ijt})\}^2 + \beta_{KK} \{\ln(K_{ijt})\}^2 \\ & + \gamma_{LK} \{\ln(L_{ijt})\}\{\ln(K_{ijt})\}, \\ Z_{ijt} = {} & \zeta_x Z^x_{ijt} + \zeta_m Z^m_{ijt} + \zeta_{np} Z^{np}_{ijt}. \end{aligned}$$

Following Kokko (1994), other determinants of the magnitude of spillovers are examined by partitioning the samples and comparing estimates for three sets subsamples, (i) technological gaps between locally-owned and foreign-owned plants, (ii) size and capital intensity of each locally-owned plant, and (iii) expenditures on employee training and research and development activity (R&D) in locally-owned plants. Technological gaps among plants can be defined in various ways and two measures of technological gaps, the average wage gap and the average labor productivity gap, are used here. One possibly important cause of spillovers occurs when locally-owned plants woo employ skilled workers away from foreign-owned plants by offering a relatively high wage. If the wage gap between locally- and foreign-owned plants is large, it is difficult for locally-owned plants to entice skilled workers to leave foreign-owned plants because they cannot offer a large wage premium and hence spillovers are likely to be small. Wage and average labor productivity gaps are calculated at the industry level using initial year (1990) data and industries are sorted by the size of the gap measured. Industries are then classified into a low-gap group (LW or LP), which consists of the 10 industries with the smallest gaps, and a high-gap group (HW or HP), which consists of all other industries.[9] After dividing plants into low- and high-gap groups Eq. (1a) and (1b) are estimated for each group and the results are compared.

Plant size and capital intensity are plant characteristics closely related to productivity and wages that are also thought to influence the ability of locally-owned plants to benefit from spillovers. To examine the roles of these factors samples are again divided into low and high groups and results of estimating Eq. (1a) and (1b) for the two groups are compared. Plant size was measured as average output per plant in each industry and plants that were smaller than the industry average in 1990 are classified into the small group LS and other plants are classified into large group HS. Capital intensity is measured

[9] For wage gap calculations, the industries classified in the low-gap group (LW) are, in order, footwear (324), furniture (332), leather (323), iron and steel (371), garments (322), paper products (341), other manufacturing products (390), wood products (331), other non-metallic minerals (369), and rubber products (355). For average labor productivity calculations, the in the low-gap group (LP) are, in order, leather (323), iron and steel (371), other non-metallic minerals (369), furniture (332), footwear (324), wood products (331), rubber products (355), garments (322), printing and publishing (342), and other manufacturing products (390).

as fixed assets per employee for each plant in 1990 and then averaged for each industry. Plants with capital intensity that was below the industry average in 1990 are classified into the low-capital intensity group LK and other plants are classified into the high-capital-intensity group HK.

Finally, relationships between spillovers and expenditures on employee training and R&D in locally-owned plants are examined. Plants engaging in employee training or R&D are thought to have relatively large incentives to absorb new technology and improve efficiency and these plants may benefit more from the presence of foreign-owned plants than other plants. Furthermore, these plants may also tend to have relatively high technological capabilities precisely because they engage in R&D and employee training, and are thus likely to benefit disproportionately from spillovers. Unfortunately, data on employee training expenditures is available only for 1994 and 1995 and data on R&D expenditures is only available for 1995. Therefore, plants with positive employee training expenditures in 1995 are classified into the high-training group (HT) and plants with R&D expenditures in 1995 are classified into the high-R&D group HR. Other plants are classified into the low-training (LT) or low- R&D (LR) groups.

4 Data and Foreign Affiliates in Indonesia

4.1 Data

Indonesia's Central Bureau of Statistics conducts industrial surveys or censuses annually covering plants with 20 or more workers (Central Bureau of Statistics, various years) and maintains two very detailed databases on based on these surveys/censuses. One database consists of cross sections for each year containing information reported by surveyed plants and is called the raw dataset. The other database attempts to estimate a small number of variables for the numerous plants that do not reply to surveys/censuses and are thus omitted from the raw datasets. This is called the backcast dataset and a new backcast is created for each year. The raw datasets have frequently been used to investigate the performance of Indonesian manufacturing,[10] while only a few studies have utilized the backcast datasets.[11] The dataset used in this study was newly constructed from these datasets.

The raw and backcast datasets have several important characteristics relevant to this study. First, the backcast datasets appear to contain more comprehensive and reliable information on the few variables included. Second, the backcast datasets exclude information on a number of variables used in this study such as foreign ownership share and capital stocks. Therefore, without information from the raw datasets, it is impossible to estimate Eq. (1a–1h) above. Third, data for capital stocks in the raw datasets are only available from 1988 forward. Fourth, it is possible to combine data from the raw and the backcast datasets into a panel that contains the variables necessary for this study. Fifth, there are several outliers and apparently incorrect data entries in both the raw and the backcast, though these problems appear to be relatively minor in the backcast. For example, the average capital intensity of locally-owned plants in glass products (362) was 601.5 million rupiah in 1992, while 11.7 million rupiah in 1991 and 11.3 million rupiah in 1993 (calculated from Central Bureau of Statistics, various years b). Apparently incorrect data entries such as the ones resulting the strange trend noted above are especially for data on capital stock and value added, but these problems appear to be

[10] For example, Blomström and Sjöholm (1999), Hill (1988, 1999a,b), Pangestu (1996), Sjöholm (1999).

[11] For example, Aswicahyono et al. (1995), Takii and Ramstetter (2000).

rather minor in data on employment. Sixth, Indonesia's industrial classification changed in 1990.

In view of the above points the dataset used in this study was constructed as follows. First, the sample was limited to 1990–1995 in order to insure a consistent industrial classification and because 1995 was the most recent year for which capital stock data were available when the research was begun. Second, plants reporting the data on capital stocks and foreign ownership were included in the sample for the year or years these variables were reported. Third, when data were reported in both the raw dataset and the 1996 backcast dataset (e.g., employment, value added, output), data from the backcast datasets were used.[12] Fourth, in order to weaken the influence of outliers and inappropriate data entries on the results, outliers were eliminated as follows: (a) calculate value added per worker for each plant; (b) sort plants by value added per worker for each industry and a year; (c) eliminate plants in the top $\frac{1}{64}$ and in the bottom $\frac{1}{64}$ of the sorted sample for each industry; (d) repeat steps (a) to (c) using fixed assets per worker instead of the value added per worker; (e) repeat steps (a) to (c) using value added per unit of capital instead of value added per worker; (f) repeat steps (a) to (c) using $T \equiv V/(L^{0.25}K^{1-0.25})$, where T can be thought of as an index of total factor productivity assuming constant returns to scale and a labor share of 0.25.[13] The remaining sample was used to estimate Eq. (1a–1h) and to divide the sample by average labor productivity, wages, capital intensity, size, R&D expenditures, and expenditures on employee training. However, the entire samples were used to calculate foreign

[12] Note that the ratio of non-production workers to all worker was calculated from the raw dataset and is not affected by the use of employment estimates from the backcast dataset.

[13] The labor share value is an arbitrary approximation based on regression results. However, there were no large differences in the set of plants remaining in the sample if when other values close to 0.25 were tried.

shares of industry employment (FS, HFS^{50}, HFS^{100}, NFS), because eliminating outliers could bias foreign shares and because the outlier problem seems rather minor in data for employment.

4.2 Trend of Foreign Affiliates in Indonesian Manufacturing

As mentioned in the introduction, FDI inflows increased dramatically in Indonesia during the period under study. Table 1 shows that foreign MNC presence in Indonesia's manufacturing industries also increased rapidly in 1988–1995. For example, the number of foreign-owned plants in manufacturing sectors increased from 494 in 1988 to 1194 in 1995 and the share of foreign-owned establishments in total manufacturing employment rose from 8.9 percent to 17.2 percent during the same period. In addition, the average foreign ownership share of foreign-owned plants gradually increased from 64.6 percent in 1990 to 71.3 percent in 1995 and the share of majority-foreign plants in employment by all foreign-owned plants also rose from 66.0 percent in 1990 to 71.2 percent in 1995. The number of new foreign-owned plants entering Indonesian manufacturing also increased sharply from 27–31 in 1988–1989 to over 126 or more in each year for 1991–1995. Thus, the increase in foreign presence was largely a result of increases in new plants and majority-foreign plants.

However, the data in Table 1 also indicate that there was considerable variation in levels and trends of foreign shares in employment across industries. For example, foreign shares were relatively large in footwear (324), non-electric machinery (382), beverages (313) and electric equipment (383) and foreign shares in footwear (324) and electric equipment (383) increased sharply to reach to 47.3 percent and 50.0 percent in 1995, respectively. Shares in professional equipment (385) and other manufacturing (390) also increased sharply to high levels in 1995, 48.3 percent and 40.1 percent, respectively, but these shares were lower than the average for all manufacturing in 1988–1989.

5 Regression Results

5.1 Spillover Effects and Foreign Ownership Share

Eq. (1a) was first estimated in order to investigate the relationship between efficiency in locally-owned plants and the labor share of foreign-owned plants in the industry (Table 2). β_{FS}, the coefficient on the foreign share variable, was positive and statistically significant at the 5 percent level, which indicates that the null hypothesis of non-positive spillovers should be rejected.

Table 2 also shows the results of estimating the extensions of Eq. (1a) that were specified in Eq. (1b–1h). In Eq. (1b–1d), β_{50} was negative and statistically significant and β_N was positive and statistically significant, while β_{FS} remained positive and significant. These results indicate that spillovers were lower in industry-year combinations for which the shares of majority-foreign plants were relatively high, and that spillovers were higher in industry-year combinations for which the shares of new foreign-owned plants were relatively high, in addition to the existence of positive spillovers. On the other hand, there was apparently no statistically significant relationship between the magnitude of spillovers and the share of wholly-foreign plants because β_{100} was not significant. Furthermore, estimates Eq. (1e–1h) suggest that these major results still obtain after accounting for the possibility of a relationship between trade propensities and the share of non-production workers in employment on the one hand, and efficiency on the other. These results also suggest positive and statistically significant relationships between import propensities and efficiency as well as between the share of non-production workers in employment and efficiency but no significant relationship between export propensities and efficiency.[14]

5.2 Spillovers, Industry-Specific Factors and Plant-Specific Factors

As described above, the magnitude of spillovers may be affected by (i) technological gaps between locally-owned and foreign-owned plants, (ii) size and capital intensity of each locally-owned plant, and (iii) expenditures on employee training and research and development activity in locally-owned plants. In this subsection regression results for different subsamples that have been grouped by these factors examined using the methodology of Kokko (1994) are presented.

The left side of Table 3 shows the results estimating Eq. (1a) and (1b) for samples distinguished by average wage gaps. The estimated coefficient on the foreign share variable in the low-wage-gap group LW, β_{FS}^{LW} (The superscript LW refers to group LW) is significantly positive and greater than the same coefficient for the high-wage-gap group HW (The superscript HW refers to group HW) in Eq. (1a). A Wald test was used to test the hypothesis that these two coefficients are equal and this hypothesis was rejected at the 5 percent significance level.[15] The results of estimating Eq. (1a) thus indicate that the magnitude of spillovers was larger in industries with relatively small wage gaps than in industries with relatively large wage gaps. When Eq. (1b) was estimated in the same manner, β_{50} was negative and statistically significant only for the high-wage-gap group and HW. β_{FS} remains significantly posi-

[14] When the same models were estimated in cross sections for 1995, the only change in sign and significance appeared in the estimate of the coefficient, β_{100}, which became negative and statistically significant.

[15] The Wald test and other test statistics were calculated using the formulae given in White (1980) and Davidson and Mackinnon (1993) because heteroskedasticity was assumed to exist in these samples.

tive for both groups, and the coefficient was larger for low-wage-gap group LW than for the high-wage-gap group, HW. The null hypothesis that this coefficient is equal for the two groups, $\beta_{FS}^{LW} = \beta_{FS}^{HW}$, could not be rejected at the 5 percent level, though it was rejected at the 10 percent level. Thus, the evidence suggesting differences between high- and low-wage-gap groups is somewhat weaker in Eq. (1b).

Results of estimating Eq. (1a) and (1b) in samples classified by the size of average labor productivity gaps are shown on the right side of Table 3. In both equations, β_{FS}^{LP}s were greater than β_{FS}^{HP}s. Furthermore, the null hypothesis that these two coefficients are equal was rejected at the 5 percent significance level in both models. Thus, these results suggest that the extent of spillovers were smaller in industries with relatively large technological gaps in the initial year (1990).

Table 4 shows the results of estimating Eq. (1a) and (1b), after dividing the sample by plant size (left side) and capital intensity (right side). For all of these equations, coefficients on the foreign share in the low-gap groups (β_{FS}^{LS}s and β_{FS}^{LK}s were larger than corresponding coefficients in the high-gap groups (β_{FS}^{HS} and β_{FS}^{HK}). However, the hypotheses that these coefficients are equal ($\beta_{FS}^{LS} = \beta_{FS}^{HS}$ and $\beta_{FS}^{LK} = \beta_{FS}^{HK}$) could not be rejected even at the 10 percent significance level. Thus, these results indicate that the magnitude of spillovers was not related to the size and capital intensity of locally-owned plants in the initial year (1990).

Finally, the relationships between spillovers and employee training activity (left side) and between spillovers and R&D activity (right side) were examined and Table 5 shows the results of estimating Eq. (1a) and (1b) after distinguishing plants that are engaged in these activities and those that are not.

Estimates of β_{FS}^{HT} were greater than β_{FS}^{LT} in both equations, but the hypothesis that $\beta_{FS}^{HT} = \beta_{FS}^{LT}$ cannot be rejected. Thus, employee training activity in locally-owned plants does not appear to affect the magnitude of the spillovers they receive. In some contrast, β_{FS}^{HR} was greater than β_{FS}^{LR} and the difference between these two coefficients was statistically significant at the 10 percent significance level. There is thus some weak evidence suggesting that spillovers were larger for locally-owned plants engaged in R&D in 1995 than for other locally-owned plants. In addition, it is interesting that the estimated coefficient, β_{50} for group HR was positive though not significant. Thus, there does not appear to be a negative relationship between the share of majority-foreign plants and the size of spillovers for locally-owned plants with R&D activity. However, caution is necessary when interpreting this result because the classification of plant by R&D status was done for the last year in the sample, creating a potential causality problem.

6 Conclusion

In this paper spillovers from foreign affiliates of MNCs to local plants, relationships among the magnitude of spillovers and characteristics of foreign-owned plants, and relationships between the size of spillovers and characteristics of locally-owned plants were examined for in Indonesian manufacturing during 1990–1995. The empirical results suggested that positive productivity spillover effects existed but that spillovers were generally smaller in industry-year combinations in which the foreign ownership shares of foreign-owned plants were relatively high. One possible interpretation of this result is that majority-foreign plants are able to control the diffusion of their firm-specific assets or technology better than other foreign-owned plants, and hence the magnitude of the spillovers from these plants was smaller. The results also indicated that spillovers tended to be relatively large in industries where technological gaps between foreign and locally-owned plants were relatively small in the initial year (1990). This result implies that technological levels in local firms were not high enough in some industries to facilitate large spillovers from foreign-owned plants. There is also some weak evidence that spillovers were larger for locally-owned plants with R&D activity and that for this group, the presence of foreign-owned plants with relatively high foreign ownership shares did not reduce the magnitude of spillovers.

Indonesia experienced a large inflow of foreign direct investment in the late 1980s and early- to mid-1990s and the shares of foreign-owned plants in Indonesian manufacturing, especially plants with relatively high foreign ownership shares, increased during this period. The results described above suggest that positive spillovers existed but that the extent of spillovers depended on characteristics of foreign-owned plants and locally-owned plants. These results have important policy implications because they suggest that encouraging foreign direct investment by foreign multinational corporations does not necessarily promote spillovers, especially in technologically backward industries.

References

Aitken, B. and A. Harrison, 1999. Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela, American Economic Review, 89 (3), 605–618 (June).

Aswicahyono, H.H., K. Bird, and H. Hill, 1995. What Happens to Industrial Structure When Countries Liberalize? Indonesia Since the Mid-1980s, Economics Division Working Paper SEA 95/2, Research School of Pacific

Studies, Australian National University, Canberra.

Blomström, M., S. Globerman, and A. Kokko, 1999. The Determinants of Host Country Spillovers from Foreign Direct Investment: Review and Synthesis of the Literature, Working Paper Series in Economics and Finance, 339, Stockholm School of Economics, Stockholm.

Blomström, M. and A. Kokko, 1997. How Foreign Investment Affects Host Countries, Working Paper Series 1745, World Bank.

Blomström, M., A. Kokko and M. Zejan, 2000. Foreign Direct Investment: Firm and host Country Strategies, Macmillan Press, London.

Blomström, M. and H. Persson, 1983. Foreign Investment and Spillover Efficiency in an Underdeveloped Economy: Evidence from the Mexican Manufacturing Industry, World Development, 11 (6), 493–501.

Blomström, M. and F. Sjöholm, 1999. Technology Transfer and Spillovers: Does Local Participation with Multinationals Matter? European Economic Review, 43 (4–6), 915–923 (April).

Blomström, M. and E. Wolff, 1994. Multinational Corporations and Productivity Convergence in Mexico, in Baumol, W., R. Nelson and E. Wolff (eds.), Convergence of Productivity: Cross-National Studies and Historical Evidence, Oxford University Press, Oxford, pp. 263–284.

Caves, R. E., 1974. Multinational Firms, Competition, and Productivity in Host Country Markets, Economica, 41, 176–193 (May).

Central Bureau of Statistics, various years. *Large and Medium Manufacturing Statistics*, various issues. Central Bureau of Statistics, Jakarta.

Central Bureau of Statistics, 1998. Raw datasets underlying industrial surveys for 1990–1995 and the 1996 backcast dataset. Data provided by e-mail. Central Bureau of Statistics, Jakarta.

Davidson, R., and J. G. MacKinnon, 1993. Estimation and Inference in Econometrics, Oxford University Press, New York.

Dunning, J. H., 1993. Multinational Enterprises and the Global Economy, Addison-Wesley, Wokingham.

Findlay, R., 1978. Relative Backwardness, Direct Investment, and the Transfer of Technology: A Simple Dynamic Model, Quarterly Journal of Economics, 92 (1), 1–16 (February).

Globerman, S., 1979. Foreign Direct Investment and Spillover Efficiency Benefits in Canadian Manufacturing Industries, Canadian Journal of Economics, 12 (1), 42–56 (February).

Haddad, M. and A. Harrison, 1993. Are the Positive Spillovers from Direct Foreign Investment? Evidence from Panel Data for Morocco, Journal of Development Economics, 42 (1), 51–74 (October).

Hill, H., 1988. Foreign Investment and Industrialization in Indonesia, Oxford University Press, Singapore.

Hill, H., 1990a. Indonesia's Industrial Transformation PART I, Bulletin of Indonesian Economic Studies, 26 (2), 79–120 (August).

Hill, H., 1990b. Indonesia's Industrial Transformation PART II, Bulletin of Indonesian Economic Studies, 26 (3), 75–109 (December).

International Centre for the Study of East Asian Development, 2001. Recent Trends and Prospects for Major Asian Economies, East Asian Economic Perspectives, 12, International Centre for the Study of East Asian Development, Kitakyushu.

Kokko, A., 1994. Technology, Market Characteristics, and Spillovers, Journal of Development Economics, 43 (2), 279–293 (April).

Markusen, J. R., 1995. The Boundaries of Multinational Enterprises and the

Theory of International Trade, Journal of Economic Perspectives, 9 (2), 169–189 (Spring).

Pangestu, M., 1996. Economic Reform, Deregulation and Privatization, The Indonesian Experience, Centre for Strategic and International Studies, Jakarta.

Sjöholm, F., 1999. Technology Gap, Competition and Spillovers from Direct Foreign Investment: Evidence from Establishment Data, Journal of Development Studies, 36 (1), 53–73 (October).

Takii, S. and E. D. Ramstetter, 2000. Foreign Multinationals in Indonesian manufacturing 1985–1998: Shares, relative Size, and relative Labor Productivity, ICSEAD Working Paper Series, 2000–18, International Centre for the Study of East Asian Development, Kitakyushu.

Takii, S., 2002. Productivity Differentials between Local and Foreign Plants in Indonesian Manufacturing, 1995, ICSEAD Working Paper Series, 2002–02, International Centre for the Study of East Asian Development, Kitakyushu.

Wang, J. Y. and M. Blomström, 1992. Foreign Investment and Technology Transfer: A Simple Model, European Economic Review, 36, 137–155.

White, H., 1980. A Heteroskedasticity-Consistent Covariance Matrix Estimator and A Direct Test for Heteroskedasticity, Econometrica, 48 (4), 813–838 (May).

Table 1
The entry of foreign-owned plants and their share of labor

Year	1988	1989	1990	1991	1992	1993	1994	1995
a) The number of foreign-owned plants								
	494	491	596	731	892	994	1123	1194
b) The Average foreign ownership share (of foreign-owned plants, %)								
	64.7	63.6	64.6	65.7	66.8	66.9	67.7	71.3
c) The majority-for. plants' share of total employment in foreign-owned plants*								
	63.7	62.5	66.0	66.8	68.1	70.5	71.1	71.2
d) The number of new majority-foreign plants*								
	31	27	80	126	156	134	127	139
e) The foreign-owned plants' share of employment** (%)								
All Ind.	8.9	8.4	10.1	11.7	14.1	15.1	17.1	17.2
by ISIC: Indonesian Standard Industry Classification								
311	7.3	4.6	5.0	5.9	6.7	6.2	9.5	8.3
312	7.1	3.8	6.9	6.3	7.5	6.3	7.9	10.1
313	20.2	17.8	19.4	22.1	22.8	21.5	22.1	15.7
314	3.0	2.0	1.2	0.7	0.0	0.0	0.9	0.7
321	11.2	10.0	10.5	10.9	12.5	12.8	12.5	12.7
322	3.7	3.0	6.9	12.0	16.9	19.8	20.0	22.1
323	0.0	5.1	3.1	11.6	27.2	25.0	14.8	10.9
324	21.3	25.9	32.3	36.2	47.7	47.2	49.4	47.3
331	7.7	7.9	7.3	7.3	8.3	8.0	8.0	7.9
332	5.9	7.0	6.4	6.9	4.7	5.8	6.0	5.4
341	9.5	10.6	16.4	13.6	13.8	10.7	14.9	23.5
342	2.9	3.5	0.6	2.4	3.4	4.7	4.4	4.7
351	8.8	7.6	16.1	15.3	17.8	16.8	16.2	19.2
352	18.9	19.7	20.4	17.7	17.8	18.3	18.2	20.7
355	14.0	10.9	18.7	17.8	12.2	14.1	15.7	14.6
356	1.8	2.3	3.2	3.4	5.7	5.5	11.6	12.8
361	12.1	11.7	17.0	16.1	16.9	14.7	20.5	16.9
362	8.8	0.0	0.0	0.5	12.1	4.8	5.6	11.0
363	10.2	10.5	9.9	6.2	11.9	12.3	9.0	13.2
364	1.2	0.0	0.0	0.0	2.8	0.0	0.0	0.0
369	0.0	0.0	1.4	1.9	3.7	3.8	6.1	3.6
371	11.5	20.4	20.6	13.3	11.4	13.4	13.4	14.5
372	0.0	0.0	37.5	16.3	32.6	37.4	31.3	29.3
381	16.4	17.0	15.4	14.0	17.2	17.8	25.3	23.6
382	20.5	17.7	12.6	13.9	14.0	20.4	20.2	20.6
383	19.6	22.8	24.1	30.8	36.5	42.6	52.1	50.0
384	7.9	12.5	16.8	20.2	17.6	15.4	18.5	23.3
385	4.8	3.5	10.7	9.2	10.4	22.9	32.9	48.3
390	6.1	6.3	16.2	35.5	32.1	41.5	42.8	40.1

* The new plants are defined as plants that had been operating for less than two years and the majority-foreign plants are defined as plants with 51 percent or more foreign ownership share.

** The employment share of foreign plants was calculated as the ratio of employment in foreign-owned plants to total employment

Table 2
Regression results for spillover effects

Est. Eq.	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)
β_{FS}	0.70 (7.3)	0.74 (7.6)	0.74 (7.6)	0.79 (7.8)	0.70 (7.1)	0.73 (7.3)	0.73 (7.3)	0.78 (7.5)
β_{50}		−0.12 (−4.1)	−0.12 (−4.0)	−0.11 (−3.8)		−0.11 (−3.7)	−0.11 (−3.6)	−0.11 (−3.4)
β_{100}			0.01 (0.4)	−0.00 (−0.1)			0.01 (0.3)	−0.01 (−0.1)
β_N				0.05 (2.1)				0.04 (2.0)
ζ_x					0.16 (1.5)	0.16 (1.5)	0.16 (1.5)	0.16 (1.5)
ζ_m					0.29 (2.1)	0.29 (2.1)	0.29 (2.1)	0.29 (2.1)
ζ_{np}					0.02 (3.2)	0.02 (3.2)	0.02 (3.2)	0.02 (3.2)
α_L	0.59 (32.5)	0.59 (32.5)	0.59 (32.5)	0.60 (32.5)	0.59 (31.7)	0.59 (31.6)	0.59 (31.6)	0.59 (31.7)
β_K	0.20 (18.9)	0.20 (18.9)	0.20 (18.9)	0.20 (18.9)	0.20 (18.3)	0.20 (18.3)	0.20 (18.3)	0.20 (18.3)
α_{LL}	−0.04 (−4.8)	−0.04 (−4.8)	−0.04 (−4.8)	−0.04 (−4.8)	−0.04 (−4.8)	−0.04 (−4.8)	−0.04 (−4.8)	−0.04 (−4.8)
β_{KK}	0.01 (5.2)	0.01 (5.2)	0.01 (5.2)	0.01 (5.2)	0.01 (5.0)	0.01 (5.0)	0.01 (5.0)	0.01 (5.0)
γ_{LK}	−0.02 (−2.8)	−0.02 (−2.9)	−0.02 (−2.9)	−0.02 (−2.8)	−0.02 (−2.8)	−0.02 (−2.8)	−0.02 (−2.8)	−0.02 (−2.8)
δ_{90}	−0.14 (−13.0)	−0.15 (−13.5)	−0.15 (−13.3)	−0.15 (−13.4)	−0.14 (−13.1)	−0.15 (−13.5)	−0.15 (−13.3)	−0.15 (−13.4)
δ_{91}	−0.09 (−9.3)	−0.10 (−9.9)	−0.10 (−9.8)	−0.11 (−10.0)	−0.09 (−9.1)	−0.10 (−9.7)	−0.10 (−9.6)	−0.11 (−9.7)
δ_{92}	−0.05 (−5.6)	−0.06 (−6.1)	−0.06 (−6.1)	−0.06 (−6.4)	−0.05 (−5.6)	−0.06 (−6.0)	−0.06 (−6.0)	−0.06 (−6.3)
δ_{93}	−0.02 (−2.3)	−0.03 (−3.0)	−0.03 (−2.9)	−0.03 (−3.4)	−0.02 (−2.3)	−0.03 (−2.9)	−0.03 (−2.9)	−0.03 (−3.3)
δ_{94}	0.01 (0.7)	0.00 (0.2)	0.00 (0.3)	−0.00 (−0.1)	0.01 (0.7)	0.00 (0.3)	0.00 (0.3)	−0.00 (−0.1)
n	38106	38106	38106	38106	36834	36834	36834	36834
$\bar{R}^2$	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93

Note. t-statistics within parentheses are based on White's adjustment for heteroskedasticity (White, 1980 and Davidson and Mackinnon, 1993)

Table 3
Regression results for spillover effects and technological gaps

Classification	average wage gap				average labor productivity gap			
Eq.	(1a)		(1b)		(1a)		(1b)	
Group	LW	HW	LW	HW	LP	HP	LP	HP
β_{FS}	0.97 (6.9)	0.54 (3.8)	0.94 (6.7)	0.60 (4.2)	1.03 (7.1)	0.52 (3.7)	1.00 (6.8)	0.57 (4.1)
β_{50}			−0.08 (−1.5)	−0.09 (−2.6)			−0.06 (−1.3)	−0.09 (−2.1)
α_L	0.59 (19.5)	0.59 (25.1)	0.59 (19.4)	0.59 (25.1)	0.59 (20.1)	0.59 (25.0)	0.59 (20.0)	0.59 (25.0)
β_K	0.23 (11.0)	0.19 (15.3)	0.23 (11.1)	0.19 (15.3)	0.23 (11.7)	0.19 (14.7)	0.23 (11.8)	0.19 (14.7)
α_{LL}	−0.02 (−1.8)	−0.04 (−4.4)	−0.02 (−1.7)	−0.04 (−4.4)	−0.03 (−2.2)	−0.04 (−4.1)	−0.03 (−2.2)	−0.04 (−4.1)
β_{KK}	0.01 (3.0)	0.01 (4.2)	0.01 (3.1)	0.01 (4.2)	0.01 (3.2)	0.01 (4.1)	0.01 (3.2)	0.01 (4.1)
γ_{LK}	−0.03 (−2.4)	−0.02 (−2.0)	−0.03 (−2.5)	−0.02 (−2.0)	−0.03 (−2.5)	−0.02 (−1.9)	−0.03 (−2.5)	−0.02 (−1.9)
δ_{90}	−0.06 (−2.7)	−0.18 (−13.7)	−0.07 (−3.0)	−0.18 (−13.9)	−0.06 (−3.1)	−0.18 (−13.5)	−0.07 (−3.4)	−0.18 (−13.6)
δ_{91}	−0.05 (−2.5)	−0.12 (−9.4)	−0.05 (−2.8)	−0.12 (−9.7)	−0.05 (−3.2)	−0.12 (−9.1)	−0.06 (−3.4)	−0.12 (−9.3)
δ_{92}	−0.04 (−2.4)	−0.06 (−5.3)	−0.04 (−2.4)	−0.07 (−5.7)	−0.04 (−2.3)	−0.06 (−5.5)	−0.04 (−2.4)	−0.07 (−5.7)
δ_{93}	−0.01 (−0.8)	−0.03 (−2.6)	−0.01 (−0.6)	−0.04 (−3.2)	−0.02 (−1.2)	−0.03 (−2.4)	−0.02 (−1.1)	−0.03 (−2.9)
δ_{94}	−0.01 (−0.4)	0.01 (1.0)	−0.01 (−0.4)	0.01 (0.5)	−0.01 (−0.9)	0.01 (1.2)	−0.01 (−0.9)	0.01 (0.8)
n	11171	26935	11171	26935	12124	25982	12124	25982
$\bar{R}^2$	0.93	0.93	0.93	0.93	0.93	0.94	0.93	0.94
Wald test for $H_0: \beta^L_{FS} = \beta^H_{FS},\ H_1: \beta^L_{FS} \neq \beta^H_{FS}$								
p-value	0.03		0.09		0.01		0.03	

Note. t-statistics within parentheses are based on White's adjustment for heteroskedasticity (White, 1980 and Davidson and Mackinnon, 1993)

Table 4
Regression results for spillovers and plant size and capital intensity

Classification	plant size				plant capital intensity			
Eq.	(1a)		(1b)		(1a)		(1b)	
Group	LS	HS	LS	HS	LK	HK	LK	HK
β_{FS}	0.73 (7.0)	0.66 (2.8)	0.76 (7.2)	0.69 (2.9)	0.76 (7.3)	0.55 (2.5)	0.80 (7.6)	0.58 (2.6)
β_{50}			−0.10 (−3.3)	−0.14 (−2.1)			−0.11 (−3.6)	−0.12 (−1.8)
α_L	0.65 (25.7)	0.54 (15.3)	0.65 (25.7)	0.54 (15.3)	0.60 (23.9)	0.60 (21.4)	0.60 (23.8)	0.60 (21.4)
β_K	0.22 (15.3)	0.18 (9.3)	0.22 (15.3)	0.18 (9.3)	0.21 (14.2)	0.19 (12.1)	0.21 (14.3)	0.19 (12.1)
α_{LL}	−0.01 (−1.3)	−0.04 (−2.7)	−0.01 (−1.3)	−0.04 (−2.6)	−0.04 (−4.1)	−0.03 (−2.4)	−0.04 (−4.1)	−0.03 (−2.4)
β_{KK}	0.02 (6.1)	−0.00 (−0.1)	0.02 (6.2)	−0.00 (−0.1)	0.01 (4.7)	0.01 (0.9)	0.01 (4.8)	0.01 (0.9)
γ_{LK}	−0.02 (−2.6)	0.01 (0.6)	−0.02 (−2.6)	0.01 (0.6)	−0.02 (−2.3)	−0.01 (−0.9)	−0.02 (−2.3)	−0.01 (−0.9)
δ_{90}	−0.17 (−14.8)	0.01 (0.2)	−0.18 (−15.2)	−0.00 (−0.2)	−0.15 (−12.7)	−0.11 (−4.5)	−0.16 (−13.2)	−0.12 (−4.8)
δ_{91}	−0.12 (−11.1)	0.01 (0.5)	−0.13 (−11.5)	0.00 (0.0)	−0.12 (−10.3)	−0.04 (−1.7)	−0.12 (−10.8)	−0.05 (−2.0)
δ_{92}	−0.07 (−6.5)	−0.00 (−0.1)	−0.07 (−6.9)	−0.01 (−0.4)	−0.08 (−7.6)	0.02 (1.0)	−0.08 (−8.0)	0.02 (0.7)
δ_{93}	−0.03 (−2.8)	0.01 (0.4)	−0.03 (−3.4)	0.00 (0.1)	−0.02 (−2.3)	−0.02 (−0.8)	−0.03 (−2.9)	−0.02 (−1.1)
δ_{94}	0.00 (0.2)	0.02 (1.1)	−0.00 (−0.1)	0.01 (0.8)	0.01 (0.7)	0.01 (0.3)	0.00 (0.3)	0.00 (0.1)
n	29153	8953	29153	8953	28370	9736	28370	9736
$\bar{R}^2$	0.89	0.93	0.89	0.93	0.93	0.92	0.93	0.92
Wald test for $H_0: \ \beta^L_{FS} = \beta^H_{FS}, \ H_1: \ \beta^L_{FS} \neq \beta^H_{FS}$								
p-value	0.78		0.78		0.39		0.37	

Note. t-statistics within parentheses are based on White's adjustment for heteroskedasticity (White, 1980 and Davidson and Mackinnon, 1993)

Table 5

Regression results for spillovers and human development and R&D activity

Classification	human development				research and development			
Eq.	(1a)		(1b)		(1a)		(1b)	
Group	LT	HT	LT	HT	LR	HR	LR	HR
β_{FS}	0.64	1.07	0.68	1.09	0.63	1.32	0.67	1.28
	(6.3)	(3.5)	(6.6)	(3.6)	(6.3)	(3.9)	(6.7)	(3.8)
β_{50}			−0.12	−0.09			−0.14	0.12
			(−3.9)	(−1.0)			(−4.8)	(1.3)
α_L	0.60	0.56	0.60	0.56	0.59	0.60	0.58	0.60
	(29.2)	(12.2)	(29.2)	(12.2)	(30.0)	(10.1)	(29.9)	(10.2)
β_K	0.22	0.18	0.22	0.18	0.20	0.19	0.20	0.19
	(17.3)	(8.1)	(17.3)	(8.1)	(17.0)	(7.2)	(17.1)	(7.2)
α_{LL}	−0.04	−0.01	−0.04	−0.01	−0.04	0.01	−0.04	0.01
	(−4.8)	(−0.7)	(−4.8)	(−0.7)	(−5.3)	(0.4)	(−5.2)	(0.3)
β_{KK}	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	(5.5)	(0.1)	(5.5)	(0.1)	(5.2)	(0.0)	(5.3)	(0.0)
γ_{LK}	−0.02	−0.03	−0.02	−0.03	−0.02	−0.01	−0.02	−0.01
	(−2.1)	(−1.5)	(−2.1)	(−1.5)	(−2.9)	(−0.3)	(−3.0)	(−0.3)
δ_{90}	−0.15	−0.11	−0.15	−0.12	−0.15	−0.09	−0.16	−0.08
	(−12.9)	(−3.1)	(−13.4)	(−3.2)	(−13.2)	(−2.1)	(−13.8)	(−1.9)
δ_{91}	−0.10	−0.03	−0.11	−0.04	−0.11	0.00	−0.11	0.01
	(−9.8)	(−0.9)	(−10.4)	(−1.1)	(−10.1)	(0.1)	(−10.8)	(0.3)
δ_{92}	−0.06	−0.00	−0.06	−0.01	−0.06	0.01	−0.07	0.02
	(−6.1)	(−0.1)	(−6.5)	(−0.2)	(−6.2)	(0.4)	(−6.8)	(0.5)
δ_{93}	−0.02	−0.01	−0.03	−0.01	−0.03	0.03	−0.03	0.04
	(−2.5)	(−0.3)	(−3.1)	(−0.4)	(−2.9)	(0.9)	(−3.7)	(1.1)
δ_{94}	0.01	0.00	0.00	0.00	0.00	0.06	−0.00	0.06
	(0.7)	(0.1)	(0.2)	(0.0)	(0.1)	(1.8)	(−0.5)	(1.9)
n	34092	4014	34092	4014	34814	3292	34814	3292
$\bar{R}^2$	0.93	0.92	0.93	0.92	0.93	0.92	0.93	0.92
Wald test for $H_0:\ \beta^L_{FS} = \beta^H_{FS},\ H_1:\ \beta^L_{FS} \neq \beta^H_{FS}$								
p-value	0.19		0.21		0.05		0.08	

Note. t-statistics within parentheses are based on White's adjustment for heteroskedasticity (White, 1980 and Davidson and Mackinnon, 1993)