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KNOWLEDGE DIFFUSION FROM MULTINATIONAL ENTERPRISES: THE ROLE OF DOMESTIC AND FOREIGN KNOWLEDGE-ENHANCING ACTIVITIES

by

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PREFACE

The main theme for the programme of work 2001-02 at the Development Centre is *Globalisation and Governance*. Multinational enterprises (MNEs) are a key actor of globalisation and also raise numerous governance issues. Accordingly, their role in poor countries has always interested the development community.

The Development Centre has contributed to the debate by organising a forum entitled "FDI, Human Capital and Education in Developing Countries" in December 2001 in Paris. During this, a number of experts including policy makers, researchers and civil society specialists from around the world gathered to discuss how MNEs and government policies can be mobilised to promote human capital formation and hence economic growth. Ironically, one of the main conclusions from the conference was our lack of knowledge with respect to the human capital development activities of the MNEs.

This research by Koji Myamoto, a young professional at the Centre, and Yasuyuki Todo, from Tokyo Metropolitan University, addresses the question of whether or not MNEs facilitate knowledge diffusion to domestic firms and, if so, under what conditions. The approach takes into account aspects that had been neglected in past empirical literature. In particular, it highlights enterprise activities that mobilise technology transfers to domestic firms — *knowledge enhancing activities* — such as research and development (R&D) and human resource development by both MNEs and domestic firms.

Indonesia is an interesting case study, owing to the history of activities by MNEs as well as to the diversity of regions and cultural backgrounds in which they operate.

The authors find that, contrary to the conclusions of a number of recent works on technology transfers, MNEs do have a positive and significant contribution to knowledge diffusion to domestic firms. However, this does not happen automatically. It is only when MNEs and domestic firms make efforts to invest in R&D and/or human resource development that knowledge diffusion occurs.

While the conditions under which such investment might occur are not spelled out, the specific link between globalisation and governance becomes more apparent thanks to this study.

Jorge Braga de Macedo
President
OECD Development Centre
22 August 2002

RÉSUMÉ

De nombreux travaux de recherche ont utilisé des données au niveau des entreprises pour évaluer la diffusion de compétences depuis les firmes multinationales vers les entreprises nationales dans les pays moins développés. Cependant, ces travaux n'ont pas permis de dégager un consensus sur l'existence ou non de retombées. Ces résultats contradictoires peuvent peut-être s'expliquer par une mauvaise prise en compte des efforts de diffusion tant nationaux qu'étrangers. Ce Document technique inclut donc les activités de R&D et le développement des ressources humaines initiés par les multinationales et par les entreprises locales afin d'examiner si ces activités renforcent la diffusion du savoir à partir des multinationales. Pour ce faire, les auteurs ont utilisé des données au niveau des entreprises du secteur manufacturier indonésien. Il en ressort que les activités des multinationales en R&D et développement des ressources humaines favorisent la diffusion du savoir vers les entreprises locales, et qu'il n'y a pas de retombées en leur absence. En outre, les activités de R&D des entreprises locales sont également favorables à la diffusion des connaissances des multinationales vers les firmes en question. Ce résultat varie toutefois en fonction des spécifications de l'estimation. On peut donc conclure que la diffusion du savoir des multinationales nécessite des efforts en R&D et développement des ressources humaines de la part des multinationales et des entreprises locales.

SUMMARY

Many existing works using firm-level data sets have examined whether or not knowledge spills over from MNEs to domestically owned firms in a less developed country, but the literature has not come to a general consensus on the presence of spillovers. A possible reason for the mixed results is that they do not adequately address domestic and foreign efforts for active diffusion. The present paper thus incorporates R&D activities and human resource development conducted by MNEs and domestic firms to investigate whether these activities enhance knowledge diffusion from MNEs, using establishment-level panel data for the Indonesian manufacturing sector. We find that R&D activities and human resource development conducted by MNEs stimulate knowledge diffusion from MNEs to domestic firms, while knowledge diffusion from MNEs without such activities is absent. Moreover, R&D activities by a domestic firm are also found to promote knowledge diffusion from MNEs to the firm, although this result is sensitive to estimation specifications. It is thus suggested that knowledge diffusion from MNEs requires domestic or foreign efforts in R&D and human resource development.

I. INTRODUCTION

Knowledge diffusion, sometimes rephrased as technology transfer[1], from multinational enterprises (MNEs) to domestically owned firms of a less developed country, is often regarded as a major source of its technical progress and productivity growth. Particularly, many recent empirical studies have examined the presence of knowledge spillovers from MNEs to domestic firms, estimating the magnitude of the effect of foreign presence represented by, for example, the foreign share in employment in an industry of a less developed country on productivity of domestic firms in the same industry. If the effect is positive, it is suggested that the presence of MNEs contributes to productivity improvement in domestic firms through knowledge spillovers.

However, these empirical studies provide inconclusive results. For example, Kokko (1994) and Chuang and Lin (1999) find that foreign shares have a positive and significant effect on the labour productivity of domestic firms in firm-level data for the Mexican and Taiwanese manufacturing industries, respectively. Blomström and Sjöholm (1999) and Sjöholm (1999) also find significant knowledge spillovers from MNEs in Indonesian data[2]. However, Haddad and Harrison (1993) show that a higher level of foreign presence was not associated with higher growth in total factor productivity of domestic firms in Morocco. Kinoshita (2001) also finds insignificant spillovers from MNEs among Czech firms. Moreover, the results from panel data on Venezuelan plants in Aitken and Harrison (1999) demonstrate that foreign presence in fact negatively affects the productivity of domestic plants[3].

A possible reason for these mixed results is that their foreign presence variable amalgamates two distinct modes of knowledge diffusion from MNEs, one that occurs through costly activities conducted by domestic firms and MNEs such as R&D and human resource development, and the other that can spontaneously arise without such activities. To understand the difference between the two, suppose that a MNE is engaged in R&D activities in the host country. Then, domestic workers in the MNE gain a greater deal of knowledge through R&D activities than those in MNEs without R&D, and hence knowledge diffuses from the MNE to domestic firms relatively easily through work-related discussions and job turnovers. Although knowledge may diffuse from MNEs without R&D, its magnitude is likely to be small. Also, knowledge diffusion can be strengthened when domestic firms put efforts to R&D activities, since these efforts would enable domestic firms to absorb advanced knowledge from the MNEs. Similarly, human resource development conducted by domestic firms and MNEs may have positive effects on knowledge diffusion similar to those of R&D.

This paper attempts to account for the differences between the two modes of knowledge diffusion[4] neglected in the literature, which we distinguish as costly and cost-

less diffusion, using establishment-level panel data for the Indonesian manufacturing sector. As channels of costly knowledge diffusion, we focus on R&D activities and human resource development conducted by both domestic firms and MNEs which will hereafter be referred to as *knowledge-enhancing activities*.

Specifically, to examine whether a greater deal of knowledge diffuses from MNEs through their own knowledge-enhancing activities, our estimation specification distinguishes MNEs with such activities from MNEs without them. To the authors' best knowledge, this is the first attempt to investigate the difference between the two types of MNEs. Also, to test whether R&D activities of a domestic firm promote knowledge diffusion from MNEs to the firm, we incorporate the interaction term between expenditures of each domestic firm on R&D and the magnitude of the industry-wide foreign capital, which has been included in regressions in Kinoshita (2001). Effects of human resource development by domestic firms cannot be investigated because of limitations of our data.

The main results from our panel analysis are as follows. First, the amount of industry-wide foreign capital invested by MNEs engaged in either R&D activities or human resource development has a positive and significant impact on labour productivity of domestic firms. MNEs without any knowledge-enhancing activity, however, show no significant effect. Second, the effect of the interaction term between domestic R&D and industry-wide foreign capital is found to be positive. The direct effect of domestic R&D is, by contrast, insignificant, implying that domestic R&D is effective only when MNE is present in the same industry so that domestic firms can absorb knowledge from MNEs through R&D. We therefore conclude that knowledge-enhancing activities by domestic firms and MNEs indeed promote knowledge diffusion from MNEs while advanced knowledge of MNEs does not spill over without such efforts.

Part of our results are closely related to the argument that the degree of diffusion depends on the absorptive capacity of domestic firms that can be expanded by domestic R&D activities. This idea is theoretically developed by Griffith *et al*. (2001) and empirically supported by Griffith *et al*. (2000) and Kinoshita (2001). Yet our finding suggests one more important source of knowledge diffusion: R&D activities and human resource development conducted by MNEs. Since we find that the positive role of domestic R&D in promoting knowledge diffusion is sensitive to estimation specifications while the role of knowledge-enhancing activities by MNEs is robust, the latter may be fundamental whereas the former is secondary.

Another contribution of the present paper is to provide theoretically justified econometric specifications. The existing works have used a number of specifications, each of which differs slightly from another. For example, some works use as the dependent variable the *level* of output or value added per worker or total factor productivity (Kokko, 1994; Aitken and Harrison, 1999; Chuang and Lin, 1999) and others employ its *growth rate* (Haddad and Harrison, 1993; Sjöholm, 1999), although they all include the share of MNEs in an industry as an independent variable to represent the industry-wide foreign presence. However, the literature does not clarify whether the foreign share affects the level or the growth rate of domestic productivity. It is *ex-ante* not obvious whether the share of foreign capital or its absolute level more suitably captures foreign presence. The present paper employs a simple R&D-based endogenous growth

model that incorporates knowledge diffusion from MNEs to generate econometric specifications. The model suggests that the logarithm of output per worker should be regressed on the summation of the absolute level of foreign investment in previous and current years, rather than its current share. The distinction between these two specifications, one using shares and the other using levels, should not be ignored, because from our Indonesian data set we achieve an insignificant effect of the foreign share while finding a positive and significant impact of the level of foreign capital.

The rest of the paper is organised as follows. The next section derives econometric specifications, while Section III explains the data set examined and variables employed in the regressions. Estimation results are demonstrated in Section IV, and Section V concludes.

II. EMPIRICAL FRAMEWORK

The empirical specification tested in the present paper is based on the producers' side of R&D-based endogenous growth models originally developed in Romer (1990). The basic structure of the present model is directly taken from Jones (2001, Ch. 6) to incorporate knowledge diffusion from MNEs to domestically owned firms of a less developed country.

Suppose each domestic firm produces a final good using labour and a variety of capital goods. Each capital good embodies a certain type of knowledge, and no capital good can be employed without understanding its embodied knowledge. This implies that the number of types of capital goods employed by a firm represents the magnitude of its knowledge stock. The production function of the final good for firm *i* at time *t* is given by

$$Y_{it} = \left(\int_0^{A_{it}} X_{it}(a)^{\alpha} da \right) H_{it}^{1-\alpha},$$

where $0 < \alpha < 1$. Y_{it} is the output of the final good, and $X_{it}(a)$ is the amount of capital good *a* used for the production. Capital goods are continuously indexed so that good *a* is utilised by firm *i* if and only if $0 \leq a \leq A_{it}$, and hence A_{it} denotes the number of types of capital goods employed by the firm. H_{it} denotes the efficiency units of labour, defined as

$$H_{it} = \int_0^{\infty} e^{\psi u} l_{it}(u) du, \qquad (1)$$

where $l_{it}(u)$ is the number of workers in firm *i* with *u* years of formal schooling. This equation implies that every additional year of schooling improves the efficiency of labour by ψ. We assume ψ = 0.1, taking its average figure for 43 countries in Psacharopoulos (1994)[5].

Assuming that capital goods are indexed so that the price of each capital good, and hence its demand are equivalent, we can simplify the production function to

$$Y_{it} = A_{it}^{1-\alpha} K_{it}^{\alpha} H_{it}^{1-\alpha} \qquad (2)$$

where $K_{it} \equiv A_{it} X_{it}$, or K_{it} is the total amount of capital stock of firm *i* at time *t*. Equation (2) implies that A_{it}, that denotes the knowledge stock of firm *i*, is directly related to its total factor productivity.

A firm has several potential channels to introduce a new capital good for its production. R&D-based endogenous growth theory suggests R&D activities as a potential channel. Grossman and Helpman (1991, Ch. 11) in particular claim that firms in a less developed country conduct R&D activities to imitate foreign products, rather than to innovate new goods. R&D activities are also required for adaptation of foreign

products and technologies to the local conditions of the recipient country. For example, technologies innovated in industrial countries are likely to be capital intensive and hence should be modified to be more labour intensive. Teece (1977) finds that such costs of adaptation are large for MNEs, and this should be applicable to domestic firms when they import advanced technologies from abroad. In addition to R&D activities, human resource development within a firm through training of its employees enables the firm to learn new knowledge and hence to employ a new capital good. Particularly, if the knowledge embodied in a capital good is less advanced, R&D activities may not be required for its use and learning it through human resource development may be sufficient.

Moreover, diffusion of advanced knowledge from MNEs helps the introduction of new capital goods to a domestic firm. Since Jaffe *et al.*（1993), Jaffe and Trajtenberg (1996; 1999), and Keller (2002) find that knowledge diffusion is geographically localised, a greater deal of advanced knowledge of industrial countries is likely to diffuse to a less developed country with the presence of MNEs than otherwise. The present model thus focuses on three channels of knowledge diffusion from MNEs: cost-less diffusion and diffusion through efforts undertaken by MNEs and domestic firms.

First, less advanced knowledge of MNEs may diffuse to domestic firms with little effort through turnovers of employees, domestic engineers' visits to plants of MNEs, and discussion between domestic and foreign engineers over lunch[6]. This type of knowledge diffusion is cost-less in nature and does not require efforts such as R&D and human resource development activities for either MNEs or domestic firms.

By contrast, more advanced knowledge may not diffuse in a cost-less manner. Indeed, knowledge of MNEs is likely to be a black box to domestic workers (Kim and Ma, 1997), and hence they can attain operational capability from MNEs but do not understand the principles of knowledge of MNEs (Lall, 2000). If this is the case, domestic firms cannot benefit from employing former employees of MNEs or visiting their plants and hence knowledge diffusion requires active efforts. Thus, the second potential channel of knowledge diffusion is knowledge-enhancing activities, R&D and human resource development, conducted by domestic firms. For example, even though a domestic worker without any experience in research or training may not benefit from lunch with foreign engineers, its outcome should be different if he or she were an experienced engineer or a well-trained manager. In other words, the coexistence of domestic knowledge-enhancing activities and advanced knowledge of MNEs promotes knowledge diffusion from MNEs. Therefore, the number of new capital goods introduced to a domestic firm is positively affected by the interaction term between its own expenditures on knowledge-enhancing activities and the amount of industry-wide foreign knowledge.

Third, knowledge-enhancing activities by MNEs may also lead to knowledge diffusion from themselves. When an MNE is engaged in R&D activities or human resource development, domestic workers of the MNE are in a better position to understand the principles of its advanced knowledge. These workers with advanced foreign knowledge should be clearly distinguished from those who only know operational skills of foreign machinery. By employing these workers with advanced knowledge, a domestic firm is likely to be able to introduce new capital goods and hence improve its

productivity. Therefore, knowledge embedded in MNEs engaged in knowledge-enhancing activities is more likely to diffuse to domestic firms than the knowledge of MNEs without such activities. The two types of MNEs should thus be distinguished in the production function for the knowledge stock.

It is further assumed that the number of types of new capital goods that can be introduced to a domestic firm by the channels above is also linearly affected by its current knowledge stock A_{it} and that knowledge diffusion occurs only within each industry. Therefore, the production function for the knowledge stock of firm *i* at time *t* is given by

$$\frac{\dot{A}_{it}}{A_{it}} = \lambda_1 KE_{it} + \lambda_2 KE_{it} \cdot MNE_{j(i)t} + \lambda_3 MNE^{KE}_{j(i)t} + \lambda_4 MNE^{noKE}_{j(i)t} + \lambda_5 D_t \qquad (3)$$

where λs are constant parameters. KE_{it} represents expenditures on knowledge-enhancing activities conducted by firm *i* at time *t*. To estimate whether or not domestic knowledge-enhancing activities promote knowledge diffusion from MNEs, KE_{it} is multiplied by the magnitude of new knowledge of MNE in industry *j* to which firm *i* belongs, $MNE_{j(i)t}$. We assume that $MNE_{j(i)t}$ can be represented by the total amount of foreign direct investment (FDI) in industry *j* at time *t* because FDI is likely to be associated with new knowledge. $MNE^{KE}_{j(i)t}$ and $MNE^{noKE}_{j(i)t}$ are magnitudes of new knowledge of MNEs with and without knowledge-enhancing activities, respectively, which are also captured by the amount of FDI. The former shows how knowledge-enhancing activities by MNEs affect knowledge diffusion, while the latter tests the presence of cost-less knowledge diffusion.

Integrating (3) with respect to time, combining it with (2), and denoting the first year of the sample period by t_0, we obtain the following equation to be tested:

$$\ln y_{it} = \beta_{0i} + \alpha \ln k_{it} + \underbrace{\beta_1 \sum_{\tau=t_0}^{t} KE_{i\tau}}_{\substack{\text{direct effects of}\\ \text{knowledge-enhancing}\\ \text{activities of domestic firm } i}} + \underbrace{\beta_2 \sum_{\tau=t_0}^{t} KE_{i\tau} \cdot MNE_{j(i)\tau}}_{\substack{\text{knowledge diffusion from MNEs}\\ \text{through knowledge-enhancing activities}\\ \text{of domestic firm } i}}$$
$$+ \underbrace{\beta_3 \sum_{\tau=t_0}^{t} MNE^{KE}_{j(i)\tau}}_{\substack{\text{knowledge diffusion}\\ \text{from MNEs engaged in}\\ \text{knowledge-enhancing activities}}} + \underbrace{\beta_4 \sum_{\tau=t_0}^{t} MNE^{noKE}_{j(i)\tau}}_{\substack{\text{knowledge diffusion}\\ \text{from MNEs not engaged in}\\ \text{knowledge-enhancing activities}}} + D_t + \varepsilon_{it}, \qquad (4)$$

where $y_{it} = Y_{it} / H_{it}$, $k_{it} = K_{it} / H_{it}$, and D_t is the time dummy for time *t*. Constant term β_{0i} is firm-specific, which may include industry-specific effects, and given by

$$\beta_{0i} = (1-\alpha) \sum_{\tau=t_{i0}}^{t_0-1} (\lambda_1 KE_{i\tau} + \lambda_2 KE_{i\tau} \cdot MNE_{j(i)\tau} + \lambda_3 MNE^{KE}_{j(i)\tau} + \lambda_4 MNE^{noKE}_{j(i)\tau}) + \mu_i .$$

where t_{i0} is the time when firm *i* is established, and μ_i denotes effects that are specific to firm *i* but unobservable. Other coefficients in (4) relate to (2) and (3) as $\beta_i = (1-\alpha)\lambda_i$ for *i* = 1, 2, 3, 4.

Note that if the expenditure on knowledge-enhancing activities for a firm in a survey year is zero, the firm is unlikely to have been engaged in any knowledge-enhancing activity in the previous years. This implies that when KE_{it} is zero for any t during the survey years, β_{0i} tends to be low and hence that the individual specific constant term and some of the independent variables are correlated. To account for this potential correlation, we adopt a fixed-effects model throughout the paper.

Although the main contribution of this empirical specification is to incorporate costly knowledge diffusion, it differs from the existing ones in the construction of independent variables. To test the existence of knowledge spillovers from MNEs, most existing specifications use the share of foreign firms in an industry in capital stock (Haddad and Harrison, 1993; Chuang and Lin, 1999), in employment (Kokko, 1994; Aitken and Harrison, 1999; Kinoshita, 2001), or in output (Sjöholm, 1999). The present specification, however, suggests using the absolute amount of FDI, rather than its share, in equation (4). It is the magnitude of knowledge of MNEs unknown to a domestic firm that determines the amount of knowledge diffused to the firm and improves its knowledge stock. The amount of FDI is likely to be a better proxy for the magnitude of MNEs' new knowledge than the foreign share.

It is also suggested that when the level of output per worker (or per efficiency unit of labour) is used as the dependent variable, as is the case in this paper, the *summation* of each variable in (3) in previous and current years, or its "stock", should be used as an independent variable. This provides another justification for the use of the absolute amount of FDI, rather than its share, because the summation of shares over time has less intuitive implication. Moreover, using summations of previous and current values alleviates possible endogeneity problems, because previous values are predetermined.

Thus, this paper suggests to employ summations of the absolute amounts of R&D expenditures and FDI, rather than their shares. We will later show that using shares leads to intuitively less plausible results.

III. THE INDONESIAN MANUFACTURING SURVEY

III.1. Description of Data

The data set examined in the present paper are based on annual surveys conducted by the Central Bureau of Statistics of Indonesia. The survey covers all Indonesian manufacturing establishments with 20 or more employees. A manufacturing establishment is defined as "a production unit located in a building or in a certain location," and therefore a firm may contain more than one establishment. This paper examines panel data from 1995 to 1997, because data for expenditures on R&D activities and human resource development are only available for the three-year period. Since knowledge diffusion from MNEs to domestic firms is our interest, our sample for regressions only includes domestic establishments defined as those with a foreign capital share of 20 per cent or less[7]. To estimate the magnitude of intra-industry knowledge diffusion from MNEs within each industry, we define each of nine ISIC 2-digit industries in the manufacturing sector as an "industry" in our analysis. Also, establishments whose data are not available for at least one of the three years are excluded in building a balanced panel[8], although industry-wide variables are constructed from the original data set. Since the time period of our panel data is not long, the selection bias due to entries and exits of establishments may not be substantial. After dropping establishments with zero output or capital stock, we obtain 9 695 establishments for each year.

III.2. Description of Variables

The dependent variable of our regressions is the logarithm of value added per efficiency unit of labour for each domestic firm. Efficiency units of labour are obtained from equation (1) using reported data for the number of employees classified by each level of formal education. Value added is deflated by the wholesale price index for each 2-digit industry. The value of capital stock is estimated from the reported book value of capital stock in 1995 and the present discounted values of investment in 1996 and 1997 with the depreciation rate of 5 per cent per annum. This is divided by efficiency units of labour to obtain one of our independent variables, which will be denoted as *Estimated logk* in the tables for regression results later.

$KE_{i\tau}$ in equation (4) represents expenditures on knowledge-enhancing activities spent by domestic firm i at time τ. Since the Indonesian data set distinguishes between expenditures on R&D and those on human resource development, we may incorporate each of them. We have found, however, that the data for human resource development

expenditures are not reliable. In addition to human resource development expenditures, the data for 1996 report whether or not any employees were exposed to training in each establishment. Since training is the main part of human resource development, it is expected that firms where employees were exposed to training are more likely to have spent positive expenditures on human resource development. However, among the 3 538 firms including both MNEs and domestic firms that have reported positive training incidence, only 1 165 reported a positive expenditure on human resource development. We suspect that many firms do not consider the opportunity costs of training (e.g. wages of in-house trainers and forgone wages of workers) as part of their human resource expenditures. Moreover, when the reported expenditure on human resource development is employed in regressions, its estimated effect is substantially sensitive to estimation specifications. Hence, we do not incorporate the reported expenditures on human resource development into our analysis[9], and instead focus on R&D activities as knowledge-enhancing activities by domestic firms. Accordingly, $\sum_{\tau=t_0}^{t} KE_{i\tau}$ in equation (4) is the summation of previous and current R&D expenditures (*R&D* in the tables for regression results), while $\sum_{\tau=t_0}^{t} KE_{i\tau} \cdot MNE_{j(i)\tau}$ is the product of R&D expenditures and industry-wide FDI summed over time (*R&D*FDI*).

When the total FDI is disaggregated into two types, FDI with knowledge-enhancing activities, $MNE_{j(i)\tau}^{KE}$ in equation (4), and FDI without them, $MNE_{j(i)\tau}^{noKE}$, we employ two classification measures. First, we classify MNEs according to whether or not they are engaged in R&D activities. Thus, $\sum_{\tau=t_0}^{t} MNE_{j(i)\tau}^{KE}$ is the summation of previous and current FDI in industry *j* invested by MNEs with positive R&D expenditures (*FDI with R&D*), while $\sum_{\tau=t_0}^{t} MNE_{j(i)\tau}^{noKE}$ is that with zero R&D expenditures (*FDI without R&D*). Second, focusing on the presence of human capital development, we represent $\sum_{\tau=t_0}^{t} MNE_{j(i)\tau}^{KE}$ by the summation of industry-wide FDI invested by MNEs engaged in training (*FDI with HRD*: *HRD* stands for human resource development) and $\sum_{\tau=t_0}^{t} MNE_{j(i)\tau}^{noKE}$ by that without training (*FDI without HRD*)[10]. These two classifications cannot be integrated in a single regression, because inclusion of the four variables above leads to perfect multicollinearity. Therefore, we test two baseline specifications, one focusing on R&D activities by MNEs and the other on their human resource development. Finally, we also include the percentage of capacity utilisation reported by each firm (*Capacity*) as well as year dummies (*Year 96* and *Year 97*) in each regression[11].

III.3. Summary Statistics

Table 1 reports differences between domestic and foreign establishments in labour productivity and in the degree of knowledge-enhancing activities. Although only 7.5 per cent of manufacturing establishments are foreign, their total value added is approximately half of the total value added generated by domestic firms. The average value added per worker among foreign establishments, 31.7 million rupiahs, is substantially higher than that of domestic establishments, 19 million. We also find that expenditures on R&D activities by foreign establishments are 0.32 per cent of value added on average, which is higher than the figure for domestic establishments, 0.26 per cent. Moreover, 57.1 per cent of foreign establishments are engaged in human resource

development[12], while its share for domestic establishments, 31.9 per cent, is significantly lower. Therefore, it is concluded that MNEs exceed domestic establishments with respect to both labour productivity and the intensity of knowledge-enhancing activities.

Table 1 also describes regional differences. Although Indonesia can be divided into six regions, we focus on Java and Sumatra because approximately 80 per cent of domestic and foreign establishments are located in Java and 10 per cent in Sumatra. It is indicated that while value added per worker of foreign establishments in Sumatra is higher than that in Java, establishments in Sumatra spend substantially less on R&D than those in Java. Relatively more establishments in Sumatra, however, are engaged in human resource development than in Java. This suggests that there can be regional differences in the impact of knowledge-enhancing activities on productivity, which necessitates a cross regional analysis. Hence, we will later incorporate the regional differences and consider interregional diffusion of knowledge.

Table 1. **Comparing Domestic Firms and MNEs**

	Number of establishments		Value added (billion rupiahs)		Value added per worker (million rupiahs)		R&D expenditures (% of value added)		Share of establishments engaged in human resource development (%)	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Java	7 490	617	84 925	37 372	19.4	30.5	0.28	0.38	28.7	53.5
Sumatra	1 136	113	13 478	7 738	19.5	41.6	0.19	0.07	37.6	69.9
Total	9 695	784	107 297	46 831	19.0	31.7	0.26	0.32	31.9	57.1

The summary statistics for each industry in the upper left block of Table 2 demonstrate large variances in the average value added per worker of domestic establishments, which ranges between 9.6 million rupiahs in the textile and garments industry and 157.1 million in the metal industry. The total amount of FDI in the three-year period in each industry and its ratio to industry-wide value added are shown in the upper-right block of Table 2. The amount of FDI is divided according to whether FDI is associated with R&D or human resource development. We find that FDI with R&D is smaller than that without R&D in most industries. The last row shows that on average, the ratios of FDI with and without R&D to the total value added in the whole manufacturing sector are 0.79 per cent and 2.13 per cent, respectively. Also, FDI with human resource development accounts for 1.28 per cent of the total value added, while FDI without it is 1.64 per cent. In some industries such as chemicals, petroleum and rubber, however, more than half of FDI is associated with human resource development.

The second part of Table 2 reports the average statistics by each year. It indicates that neither labour productivity, expenditures on R&D activities, nor FDI was substantially affected by the Asian financial crises that hit Indonesia in the second half of 1997. This reduces the possibility of biased results due to the inclusion of 1997 data.

Table 2. **Summary Statistics of the Indonesian Manufacturing Sector from 1995 to 1997**

(Billion rupiahs unless otherwise noted; Percentages of value added in parentheses)

Classified by		Domestic establishments					Total in each industry/year/region				
		Number of establish-ments	Total value added	Value added per worker (million rupiahs)	R&D expendi-tures	Share of establishments engaged in human resource development (%)	FDI	FDI with R&D	FDI without R&D	FDI with human resource development	FDI without human resource development
2-digit industry	Food, beverages, and tobacco (31)	2 075	29 378	26.5	18 (0.06)	24.3	365 (1.12)	150 (0.46)	215 (0.66)	217 (0.67)	147 (0.45)
	Textile, garments, and leathers (32)	2 223	16 396	9.6	26 (0.16)	34.4	1 266 (5.08)	152 (0.61)	1 114 (4.47)	385 (1.55)	881 (3.54)
	Wood, bamboo, and rattan (33)	1 481	10 801	10.9	12 (0.11)	36.1	117 (0.95)	22 (0.18)	95 (0.77)	60 (0.49)	57 (0.46)
	Paper, printing, and publishing (34)	496	4 258	17.8	15 (0.34)	42.1	111 (1.71)	7 (0.10)	104 (1.61)	38 (0.59)	73 (1.13)
	Chemical, petroleum, and rubber products (35)	1 224	13 005	18.3	43 (0.33)	38.8	848 (3.71)	353 (1.54)	495 (2.17)	532 (2.33)	316 (1.38)
	Nonmetallic mineral products (36)	1 043	3 986	14.3	14 (0.36)	16.4	395 (5.93)	6 (0.09)	389 (5.83)	146 (2.19)	249 (3.74)
	Metal (iron, steel, nonferrous) (37)	75	11 603	157.1	99 (0.85)	42.7	240 (1.64)	147 (1.00)	93 (0.63)	160 (1.09)	80 (0.55)
	Fabricated metal products, machinery and equipment (38)	1 078	17 871	33.9	50 (0.28)	37.1	1 148 (3.40)	377 (1.12)	771 (2.28)	430 (1.27)	718 (2.13)
Year	95	9 695	33 808	17.9	89 (0.26)	31.9	1 252 (2.68)	370 (0.79)	882 (1.89)	569 (1.22)	683 (1.46)
	96	9 695	38 527	20.3	85 (0.22)		1 349 (2.48)	420 (0.77)	929 (1.71)	625 (1.15)	723 (1.33)
	97	9 695	34 962	18.8	103 (0.29)		1 888 (3.56)	424 (0.80)	1 464 (2.76)	774 (1.46)	1 115 (2.10)
Region	Java	7 490	84 925	19.4	237 (0.28)	28.7	3 769 (3.08)	1 120 (0.92)	2 649 (2.17)	1 401 (1.15)	2 368 (1.94)
	Sumatra	1 136	13 478	19.5	26 (0.19)	37.6	664 (3.13)	79 (0.37)	586 (2.76)	512 (2.41)	153 (0.72)
Total		9 695	107 297	19.0	276 (0.26)	31.9	4 489 (2.91)	1 213 (0.79)	3 276 (2.13)	1 968 (1.28)	2 521 (1.64)

IV. ESTIMATION RESULTS

IV.1. Baseline Results

Throughout the present paper, the fixed-effects model is applied to our panel data owing to possible correlation between the individual constant term and some of the independent variables, as mentioned in Section II. As a benchmark, we start off with a simple regression model adopted in the literature, ignoring knowledge-enhancing activities and instead using the share of foreign capital stock in each industry as the key independent variable. Column (1) of Table 3 reports that this specification leads to an insignificant effect of foreign presence on labour productivity of domestic firms[13]. This result implies no knowledge diffusion from the MNEs, as is the case in many empirical results in the literature (Haddad and Harrison, 1993; Kinoshita, 2001). However, incorporating domestic and foreign knowledge-enhancing activities provides completely different conclusions, as we will demonstrate.

We now replace the foreign share with the summation of the absolute levels of previous and current FDI, as Section II suggests, and incorporate R&D activities conducted by each domestic firm and its interaction term with the industry-wide FDI. Column (2) of Table 3 shows that FDI has a positive and significant effect on labour productivity of domestic firms. Moreover, although the direct effect of domestic R&D (denoted as *R&D* in the tables for regression results) is insignificant, the interaction term (*R&D*FDI*) positively affects domestic productivity. These results imply that domestic R&D activities are effective only when MNEs are present in the same industry and that the degree of the effect increases as the amount of FDI rises. In other words, R&D activities by a domestic firm promote knowledge diffusion from MNEs and thus improve its productivity.

Furthermore, to test whether or not R&D activities by MNEs promote knowledge diffusion from themselves, we disaggregate FDI into that with and that without R&D. The result in column (3) of Table 3 clearly indicates that FDI with R&D has a positive impact on domestic productivity while FDI without R&D has no significant effect. Also, to examine the role of human resource development by MNEs in knowledge diffusion, the effect of each of FDI with and without human resource development is estimated. The results reported in column (4) are similar to the case of R&D: FDI with human resource development (*FDI with HRD*) positively affects domestic productivity while the effect of FDI without it (*FDI without HRD*) is insignificant.

Table 3. **Baseline Results**

	(1)	(2)	(3)	(4)
Estimated logk	0.105 (0.007)**	0.105 (0.007)**	0.104 (0.007)**	0.105 (0.007)**
Share of foreign capital	0.112 (0.062)			
R&D		-0.035 (0.019)	-0.034 (0.019)	-0.034 (0.019)
R&D*FDI		0.269 (0.121)*	0.257 (0.121)*	0.262 (0.121)*
FDI		0.073 (0.021)**		
FDI with R&D			0.412 (0.083)**	
FDI without R&D			0.029 (0.023)	
FDI with HRD				0.238 (0.071)**
FDI without HRD				0.034 (0.026)
Capacity	0.244 (0.041)**	0.249 (0.041)**	0.249 (0.041)**	0.250 (0.041)**
Year 1996	0.035 (0.008)**	0.023 (0.009)*	0.011 (0.009)	0.013 (0.010)
Year 1997	0.019 (0.009)*	-0.012 (0.013)	-0.032 (0.014)*	-0.031 (0.016)*
N	9 695	9 695	9 695	9 695
R-squared	0.19	0.19	0.19	0.18
Bhargava *et al.* Statistics		1.72	1.72	1.72

Notes: Standard errors in parentheses. * significant at 5 per cent; ** significant at 1 per cent.

To summarise, knowledge diffusion from MNEs can be promoted by R&D activities and human resource development conducted by domestic firms and MNEs. At the same time, it is suggested that knowledge does not diffuse from MNEs without domestic or foreign efforts. Therefore, using "stock" variables and incorporating domestic and foreign knowledge-enhancing activities provide deeper insights to the process of knowledge diffusion to less developed countries than the existing literature using only the share of MNEs suggests.

IV.2. Specification Tests

To check the robustness of the baseline results in the previous subsection, a number of alternative specifications using different methods, samples and variables are examined. First, because the industrial-organisation literature has pointed to the two-way relationship between FDI and domestic R&D (Petit and Sanna-Randaccio, 2000, among many others), we investigate the possible endogeneity between them in the right-hand side of our baseline regression, although using the summation of previous and current values should alleviate this problem, as mentioned earlier. Specifically, we instrument

R&D, *R&D*FDI*, *FDI with R&D*, and *FDI without R&D* (*FDI with HRD*, and *FDI without HRD* when we focus on human resource development by MNEs) by their lagged values in addition to other independent variables to obtain the two-stage least-squares fixed-effects estimators. Table 4 demonstrates that the results from 2SLS are qualitatively the same as those from the baseline fixed-effects model except for the insignificant effect of the interaction term between domestic R&D and FDI[14]. Namely, the positive effects of knowledge-enhancing activities by MNEs on promoting knowledge diffusion survive when endogeneity bias is accounted for, while the impact of domestic R&D may not be robust.

Table 4. **Two-Stage Least-Squares Estimators**

	(1)	(2)
Estimated logk	0.119 (0.007)**	0.100 (0.007)**
R&D	-0.026 (0.020)	-0.026 (0.020)
R&D*FDI	0.213 (0.123)	0.217 (0.123)
FDI with R&D	0.382 (0.088)**	
FDI without R&D	0.044 (0.025)	
FDI with HRD		0.211 (0.075)**
FDI without HRD		0.051 (0.028)
Number of establishments	9 640	9 640
R-squared	0.18	0.18

Notes: Standard errors in parentheses. * significant at 5 per cent; ** significant at 1 per cent.
Instrumented: *R&D, R&D*FDI, FDI with R&D, FDI without R&D, FDI with HRD, FDI without HRD.*
Instruments: One-year lags of the instrumented variables.

In addition to the endogeneity, serial correlation may lead to biased results. Therefore, we test the existence of serial correlation using the extended Durbin-Watson statistics developed in Bhargava *et al.* (1982). As the last row in Table 3 shows, the statistics are 1.72 in any of the baseline specifications, which suggests no serial correlation in our data set.

Next, we employ two different samples for further robustness checks. First, we exclude outliners with respect to the relation between value added and capital stock per efficiency unit of labour using the method developed in Hadi (1992; 1994) with the "significance" level at 30 per cent. Accordingly, 93 establishments are dropped from the sample. Second, we allow entries and exits of establishments during the three-year period examined to generate an unbalanced panel. This modification raises the number of establishments from 9 695 to 11 073 while increasing the number of total observations from 28 920 to 30 463. The results from the two key regressions using the two alternative samples in Table 5 exhibit no qualitative deviation from the baseline results in Table 3 except for the insignificant effect of *R&D*FDI* in the case without outliners.

Table 5. **Specification Tests Using Alternative Samples**

	Without outliners		Unbalanced panel	
	(1)	(2)	(3)	(4)
Estimated logk	0.127 (0.007)**	0.128 (0.007)**	0.104 (0.007)**	0.105 (0.007)**
R&D	0.089 (0.081)	0.089 (0.081)	-0.034 (0.019)	-0.034 (0.019)
R&D*FDI	-0.048 (0.229)	-0.043 (0.229)	0.257 (0.121)*	0.262 (0.121)*
FDI with R&D	0.404 (0.096)**		0.412 (0.083)**	
FDI without R&D	0.038 (0.022)		0.029 (0.023)	
FDI with HRD		0.178 (0.082)*		0.238 (0.071)**
FDI without HRD		0.049 (0.026)		0.034 (0.026)
Number of observations	28 806	28 806	30 463	30 463
Number of establishments	9 602	9 602	11 073	11 073
R-squared	0.23	0.23	0.19	0.18

Notes: Standard errors in parentheses. * significant at 5 per cent; ** significant at 1 per cent.

Finally, different independent variables are used for robustness checks. First, we replace the logarithm of the estimated value of capital stock per efficiency unit of labour (*Estimated logk*) with the log of its value reported by each establishment divided by efficiency units of labour and deflated by the current price level (*Reported logk*). A justification of using the latter is that the reported amount of investment is often less reliable than the reported amount of capital stock in firm-level surveys. Note, however, that *Reported logk* does not reflect the true value of capital stock because investment in previous years is deflated by the current price level. Moreover, our data set does not include the reported values of capital stock in 1996 so that we should drop all observations in that year when using *Reported logk*. Columns (1)-(2) in Table 5 indicate results showing that the effects of knowledge-enhancing activities by MNEs are still positive and significant, while the estimated coefficient of the interaction term between domestic R&D and FDI becomes insignificant.

We also consider alternatives for other independent variables. Section II suggests that the degree of knowledge diffused from MNEs should depend on the magnitude of their knowledge unknown to domestic firms. The baseline specification assumes that this can be represented by the amount of FDI because FDI is likely to be associated with new knowledge. However, this representation has two potential problems. First, it implicitly assumes that all new ideas associated with FDI in the current year diffuse to domestic firms so that diffusion of knowledge embodied in the past FDI is ruled out. Second, the amount of FDI is likely to fluctuate more over time than other variables in regressions such as value added and capital stock. The magnitude of new foreign knowledge, however, should not show a great deal of variation over time. Thus, it may be misleading to assume the amount of yearly FDI in industry *j* to represent $MNE_{j(i)t}$ in equation (4).

Therefore, as an alternative we introduce foreign capital stock, rather than flows, to denote $MNE_{j(i)t}$ and its derivatives. Foreign capital stock is obtained by multiplying the reported share of foreign capital by the estimated capital stock. A possible disadvantage of this specification is that the summation of previous and current foreign capital stock has no intuitive explanation. The results reported in columns (3) and (4) of Table 6 using this alternative variable show that MNEs with human resource development (*Foreign K with HRD*) still have a positive and significant effect on domestic labour productivity, although MNEs without it (*Foreign K without HRD*) do not seem to improve productivity. However, column (3) indicates that the effect of MNEs with R&D activities (*Foreign K with R&D*) is insignificant. Moreover, we again find that the interaction term between domestic R&D and FDI (*R&D*Foreign K*) is not associated with improvement in domestic productivity.

Table 6. **Specification Tests Using Alternative Variables**

Using reported values of capital stock			Using summation of foreign capital stock		
	(1)	(2)		(3)	(4)
Reported logk	0.088 (0.008)**	0.088 (0.008)**	Estimated logk	0.105 (0.007)**	0.105 (0.007)**
R&D	-0.032 (0.023)	-0.032 (0.023)	R&D	-0.015 (0.018)	-0.017 (0.018)
R&D*FDI	0.259 (0.147)	0.265 (0.147)	R&D*Foreign K	0.004 (0.004)	0.004 (0.004)
FDI with R&D	0.418 (0.103)**		Foreign K with R&D	0.0022 (0.0013)	
FDI without R&D	0.021 (0.028)		Foreign K without R&D	0.0003 (0.0012)	
FDI with HRD		0.249 (0.092)**	Foreign K with HRD		0.030 (0.006)**
FDI without HRD		0.018 (0.035)	Foreign K without HRD		-0.008 (0.002)**
R-squared	0.15	0.14	R-squared	0.19	0.18

Using ratios of foreign investment		
	(5)	(6)
Estimated logk	0.105 (0.007)**	0.106 (0.007)**
R&D/VA	-1.061 (0.311)**	-1.057 (0.311)**
(R&D/VA)*(FDI/K)	1.011 (10.973)	1.004 (10.981)
FDI with R&D/K	2.411 (0.636)**	
FDI without R&D/K	-1.014 (0.372)**	
FDI with HRD/K		0.411 (0.436)
FDI without HRD/K		-0.201 (0.566)
R-squared	0.19	0.18

Notes: Standard errors in parentheses. * significant at 5 per cent; ** significant at 1 per cent.

One may also argue that the absolute levels of R&D expenditures and industry-wide FDI may not capture characteristics of firms because of the variation in the size of each establishment or industry. In fact, most existing works use the share of foreign capital or employment, rather than its absolute level, to represent foreign presence[15]. We argued in Section II, by contrast, that growth in total factor productivity of a domestic firm is more likely to be correlated with the level of foreign investment, not its share. Similarly, the absolute amount of R&D expenditures should affect the growth rate of total factor productivity, because $1 spent by a firm on R&D may generate a certain amount of knowledge, regardless of the output level of the firm.

Nevertheless, we check the results using shares and ratios, rather than levels: R&D expenditures are divided by value added of the individual establishment (*VA* in columns 5 and 6 of Table 6), and the amount of FDI is by the total investment in each industry (*K*). Column (5) of Table 6 demonstrates that a positive and significant effect of FDI with R&D survives while a negative effect of FDI without R&D emerges. Combined with the result in column (1) of Table 1 that the share of total FDI exhibits no significant effect, this confirms that whether or not MNEs are engaged in R&D activities affects the degree of knowledge diffusion from them. However, the significant effect of FDI with human resource development found in the baseline results cannot be seen in column (6) of Table 6. Moreover, the direct effect of domestic R&D is found to be negative and significant, while its interaction term with FDI has an insignificant effect. Since these results imply that R&D activities by a domestic firm is harmful in any event, it is suggested that the ratios and shares may be less suitable to the present analysis than the absolute levels.

In summary, a number of alternative specifications and selection of samples confirm that R&D activities and human resource development conducted by MNEs enhance knowledge diffusion from MNEs while diffusion does not take place without such domestic and foreign efforts. By contrast, although the baseline specification finds a positive role of domestic R&D activities in stimulating knowledge diffusion from MNEs, this effect is sensitive to regression specifications.

IV.3. Interregional Diffusion of Knowledge from MNEs

Regional aspects of knowledge diffusion have drawn much attention of researchers. In the literature on knowledge spillovers from MNEs using firm-level data sets, Sjöholm (1999) and Haskel *et al.* (2002) examine whether knowledge spills over from MNEs in the same region regardless of their type of industry and find insignificant intraregional diffusion. A possible reason for this is that little knowledge in an industry can be employed in other industries. We also investigate the presence of intra regional diffusion from MNEs on our Indonesian data set, replacing industry-wide FDI with region-wide FDI. The results, not presented here for brevity, support the conclusion of Sjöholm (1999) and Haskel *et al.* (2002) that knowledge of MNEs in other industries is not helpful to domestic firms even if the MNEs are geographically adjacent.

Thus we turn to another regional issue, i.e. interregional diffusion. Aitken and Harrison (1999) distinguish between the total FDI in the same industry and FDI in the same industry in the same region to examine whether knowledge of MNEs diffuses across regions. They found no intraregional or interregional diffusion, however. Sjöholm (1999) applies similar distinction between FDI in the same region and in others to Indonesian firm-level data and obtains evidence of interregional diffusion although surprisingly finding insignificant intraregional diffusion within an industry. Using the same data source for the Indonesian manufacturing sector as in Sjöholm (1999) but for different years, we incorporate knowledge-enhancing activities and look into interregional knowledge diffusion in Indonesia more deeply.

Since Indonesia consists of many islands, it is relatively easy to define “regions” for the country. Moreover, a notable regional characteristic of the Indonesian manufacturing sector is that 80 per cent of establishments in the data set are on the island of Java, 10 per cent on the island of Sumatra, and another 10 per cent in many other islands, as we have seen in Table 2. Therefore, although principally following the method employed in Aitken and Harrison (1999) and Sjöholm (1999), we focus on the two main islands, Java and Sumatra, and investigate whether knowledge of MNEs in Java diffuses to Sumatra and vice versa.

Columns (1) and (2) of Table 7 describe results from regressions using establishments only in Java. It is shown in the first column that MNEs engaged in R&D activities in Java (*FDI with R&D, Same region*) have a positive and significant impact on productivity of domestic firms in Java while MNEs with R&D in Sumatra (*FDI with R&D, Other region*) have no significant effect. Similarly, column (2) indicates that MNEs with human resource development in Java (*FDI with HRD, Same region*) improve domestic productivity, but those in Sumatra (*FDI with R&D, Other region*) have in fact a negative impact. As in the baseline results, the effect of MNEs without any knowledge-enhancing activity is found non-positive. These results suggest that domestic firms in Java benefit from knowledge diffusion from MNEs with knowledge-enhancing activities in Java, but knowledge does not seem to diffuse from MNEs in Sumatra to Javanese firms in even if MNEs are devoted to R&D or human resource development. As some alternative specifications find, the coefficient of the interaction term between R&D and FDI is insignificant, regardless of whether R&D is multiplied by FDI in Java (*R&D*FDI in the same region*) or by FDI in Sumatra (*R&D*FDI in the other region*).

Table 7. **Diffusion between Java and Sumatra**

	Java		Sumatra	
	(1)	(2)	(3)	(4)
Estimated logk	0.103	0.104	0.123	0.126
	(0.008)**	(0.008)**	(0.022)**	(0.022)**
R&D	-0.042	-0.042	0.169	0.165
	(0.022)	(0.022)	(0.211)	(0.211)
R&D*FDI in the same region	0.306	0.317	1.031	0.515
	(0.186)	(0.186)	(5.666)	(5.662)
R&D*FDI in the other region	0.177	0.153	-1.089	-0.958
	(0.425)	(0.426)	(2.623)	(2.624)
FDI with R&D				
Same region	0.722		-3.083	
	(0.113)**		(3.039)	
Other region	-0.644		0.854	
	(0.802)		(0.351)*	
FDI without R&D				
Same region	-0.007		0.171	
	(0.027)		(0.726)	
Other region	-0.792		-0.162	
	(0.189)**		(0.107)	
FDI with HRD				
Same region		0.491		1.001
		(0.100)**		(0.670)
Other region		-0.458		0.476
		(0.207)*		(0.349)
FDI without HRD				
Same region		-0.020		-2.050
		(0.032)		(1.224)
Other region		-0.454		-0.185
		(0.361)		(0.126)
Number of establishments	7 490	7 490	1 136	1 136
R-squared	0.21	0.18	0.19	0.18

Notes: Standard errors in parentheses.* significant at 5 per cent; ** significant at 1 per cent.

However, the results for establishments in Sumatra are completely different. Columns (3) and (4) of Table 7 clearly demonstrate that although the presence of MNEs associated with R&D in Java (*FDI with R&D, Other region*) improves productivity of domestic firms in Sumatra, everything else including MNEs with R&D in Sumatra (*FDI with R&D, Same region*) has no significant effect.

We may thus conclude that knowledge of MNEs in Java engaged in knowledge-enhancing activities diffuses to both Java and Sumatra, while diffusion from MNEs in Sumatra to any region is unlikely. One possible reason for this puzzling result is geographical agglomeration of MNEs. As we noted, 80 per cent of MNEs are located in Java, a relatively small island the size of the state of Pennsylvania, while 10 per cent are in Sumatra, a big island the size of California. These facts imply that MNEs in Java are geographically agglomerated while those in Sumatra are scattered. This provided, our conclusion that no knowledge diffuses from MNEs in Sumatra may probably suggest that knowledge diffusion requires agglomeration of MNEs. This may also be a reason for the inconclusive results from the existing literature on knowledge spillovers from MNEs, in addition to the omission of variables representing domestic and foreign knowledge-enhancing activities, because MNEs are agglomerated in some countries but not in others. Further research is required to clarify this issue.

V. CONCLUSION

Many existing works using firm-level data sets have examined whether or not knowledge spills over from MNEs to domestically owned firms in a less developed country, but the literature has not come to a general consensus on the presence of spillovers. A possible reason for the mixed results is that they do not distinguish between two distinct modes of knowledge diffusion from MNEs, i.e. costly and cost-less diffusion, and do not adequately address domestic and foreign efforts for active diffusion. The present paper thus incorporates R&D activities and human resource development conducted by domestic firms and MNEs to investigate whether these activities enhance knowledge diffusion from MNEs, using establishment-level panel data for the Indonesian manufacturing sector during the period 1995-1997. Although the result from the conventional regression suggests no knowledge diffusion from MNEs in Indonesia, our theoretically justified specifications and variables provide different conclusions. First, R&D activities and human resource development conducted by MNEs stimulate knowledge diffusion from MNEs to domestic firms and hence improve domestic productivity. This result is robust to a number of specifications. Second, knowledge diffusion from MNEs engaged in neither R&D activities nor human resource development is absent. Third, R&D activities by a domestic firm may also promote knowledge diffusion from MNEs to the firm, although this result is sensitive to estimation specifications. It is thus suggested that knowledge diffusion from MNEs requires foreign or domestic efforts in R&D and human resource development.

This conclusion has possible impacts on growth theory and FDI policy for less developed countries. First, many growth models assume that knowledge diffusion is cost-less at least within a country. It is true that knowledge is a nonrival good, but our conclusion suggests that the use of an idea by one person, which is possible even if others are using it, still requires some efforts and costs beforehand. Accordingly, growth models may have to incorporate costly knowledge diffusion. Second, our results suggest selective FDI policy. That is, in order to benefit more from diffusion of advanced knowledge from MNEs, governments of less developed countries are advised to encourage FDI associated with R&D activities and human resource development.

NOTES

1. "Knowledge diffusion" is a concept similar to "technology transfer" often used in the existing literature. We, however, avoid use of the latter phrase since it is more likely to imply relocation of "machinery" and its "operation-methods" rather than "ideas and skills". Furthermore, the mode of relocation implied in the latter is rather "intentional" while we prefer it also to include "unintentional" flows of ideas and skills.
2. Haskel *et al.* (2002) obtain the same conclusion from data for Britain, a developed country.
3. See Keller（2001), Görg and Strobl（2001), and Saggi（forthcoming) for excellent surveys on this issue.
4. To emphasise the role of costly activities, we hereafter stick to the term "knowledge diffusion", rather than "knowledge spillovers", since "spillovers" are likely to imply cost-less flows.
5. Psacharopoulos (1994) indicates that the estimated value of ψ for Indonesia is 0.17. Using this value generates no qualitative difference.
6. Jaffe *et al.*（2000) reveal that direct communication between scientists and engineers plays a crucial role in knowledge diffusion.
7. Twenty per cent reflects the OECD definition of foreign establishment. The results, however, are not sensitive to the percentage used to classify foreign establishment.
8. We will later estimate alternative specifications using an unbalanced panel.
9. One may argue that a dummy variable showing the presence of training may be used as an alternative. However, because the data on training incidence is available only for 1996, this is not a possible option in our panel analysis.
10. Although expenditures on human resource development may be unreliable, the data for whether or not a firm is engaged in training are less so because it is easily recognised. Also, it is assumed that a MNE with positive training incidence was engaged in training in 1995 and 1997 as well. This assumption may not affect the estimation results substantially, because $\sum_{\tau=t_0}^{t} MNE_{j(i)\tau}^{KE}$ and $\sum_{\tau=t_0}^{t} MNE_{j(i)\tau}^{noKE}$ are industry-wide variables.
11. $KE_{i\tau}$'s are expressed in billion rupiahs while $MNE_{j(i)\tau}$'s in trillions and *Capacity* in raw ratios.
12. We use training incidence to determine whether or not a firm is engaged in human resource development.
13. Using data sets for the Indonesian manufacturing sector, Blomström and Sjöholm (1999) and Sjöholm (1999) find a positive and significant effect of the foreign share. However, Blomström and Sjöholm (1999) use data for only 1991 so that they do not incorporate establishment-specific constant terms that we found crucial in Section II. Also, Sjöholm (1999) uses the growth rate of value added from 1980 to 1991 as the dependent variable, and hence he drops a number of establishments that entered or exited during the 12-year period. This possible selection bias in his sample may be a reason for his different result from ours.
14. Estimates for capacity and time dummies are omitted in the rest of the tables, but can be obtained by request to the authors.
15. Haskel *et al.* (2002) examine the effect of the level of foreign employment as a robustness check to confirm their results from the use of the foreign share.

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