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**THE CONCENTRIC-CIRCLE MODEL
OF FDI SPILLOVER EFFECTS
ESTIMATION USING HUNGARIAN PANEL DATA**



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IN LIEU OF A SUMMARY*

A new empirical model is presented in this paper with respect to the productivity spillover effects of foreign direct investment (FDI) by focusing on the concentric-circle structure of industrial organizations arising from sectoral differences among firms. In this model, the market presence of horizontal FDI in a host country is expressed using multiple variables with a nested structure corresponding to the aggregated level of industrial classification in order to identify its spillover effects on the productivity of domestic firms according to the industrial sector with different depth. We estimated the model using large-scale firm-level data from Hungary and confirmed horizontal FDI spillover effects simultaneously taking place in sectors with different depth that cannot be captured with the conventional model having a single horizontal variable.

JEL classification numbers: D24, F21, F23, L16, L60, L80, O19, P23

Key words: foreign direct investment, spillover effects, concentric-circle model, Hungary

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INTRODUCTION

Foreign direct investment (FDI) draws attention as a driving force of economic growth in recipient countries mainly due to two factors. One is its macroeconomic effect of boosting the effective demand of a given host country owing to the intensive capital investment and employment activity carried out by incoming foreign firms. This aspect of inward FDI has such critical significance for developing countries and post-socialist transitional states suffering from serious capital shortages that plenty of studies have been conducted on this subject. The other factor is its external effects on domestic firms, that is, FDI spillovers arising from the new entry into the production market of host countries and subsequent business expansion of multinational enterprises (MNEs) that have superior management know-how and advanced production technology. Because the FDI spillover effects represent a unique social phenomenon, economists have been paying considerable attention to this characteristic of FDI from theoretical and empirical perspectives. In fact, the issues concerning the relationship between MNEs and domestic firms in the host countries raised in the 1960s witnessing the advent of the age of internationalization by Brash (1966) and Katz (1969) are still stimulating many researchers today, as is obviously demonstrated by the fact that a number of microeconomic research works that empirically examine FDI spillover effects have been published in recent years with the remarkable enhancement of firm-level datasets worldwide (Görg and Strobl, 2001).

Many economists agree that domestic firms in recipient countries gain positive externalities from FDI via the five main routes that follow. The first one is the imitation of the management system and pro-

duction of MNEs. One transmission mechanism often mentioned in this regard is reverse engineering. Nowadays, industrial espionage is also considered to be an extreme form of imitation. The second route is the intermediate input of goods and services supplied by MNEs, which contributes to quality improvements and cost reductions in in-house products. The third route is the feedback of marketing information and transfer of techniques for quality control, inventory, and standardization through the provision of goods and services to MNEs. These foreign customers tend to actively encourage local suppliers in the form of sending experts to the latter, implementing joint research projects, and holding joint drills. The fourth route is the provision of training and education to the employees of domestic firms by foreign managers and experts, as is typically seen in joint-venture projects. The fifth route is the acquisition of human capital in the form of movement of experienced managers, engineers, and other skilled workers from MNEs to domestic firms, including not only voluntary career changes but also the active recruitment and headhunting of talent by local competitors that are quite common especially in countries with a poor market for skilled labour. Now that the role of intangible assets and tacit knowledge is becoming increasingly important, the latter three routes have the same degree of significance as the former two in order for FDI to make positive productivity spillovers to domestic firms.

On the other hand, many researchers unanimously assert that FDI can also have a negative impact on domestic firms in the recipient countries, namely crowding-out effects, which may surpass its positive competitive effect by breaking down ineffective, monopolized domestic markets and improving the managerial discipline of indigenous companies. This is especially true when MNEs strategically attempt an all-out effort to gain a significant share in the production markets of host countries with relatively closed economies, where the level of management skills and production tech-

nology of domestic firms is significantly poorer by international standards. In this way, FDI has pros and cons for domestic firms. Thus, substantial direct capital inflows from abroad do not necessarily guarantee positive spillover effects for domestic companies.¹

It is easy to imagine that post-socialist transitional countries met almost all of the above conditions to generate negative externalities from inward FDI. There have been a wide variety of empirical studies carried out regarding FDI productivity spillover effects in transition economies, including those on Hungary referred to later, as well as those by Kinoshita (2001) on the Czech Republic, Dries and Swinnen (2004), Jensen (2004), and Marcin (2008) on Poland, Altomonte and Pennings (2005) and Javorcik and Spatareanu (2008) on Rumania, Sinai and Meyer (2004) on Estonia, Javorcik (2004) on Lithuania, Yudaeva *et al.* (2003) on Russia, Lutz *et al.* (2008) on Ukraine, Hu and Jefferson (2002), Liu (2002), and Wang and Yu (2007) on China, and Konings (2001), Sabirianova *et al.* (2005), Gorodnichenko *et al.* (2007), and Kravtsova (2008) focusing on the international comparison of several transitional countries. Nevertheless, these studies do not share the same conclusion regarding the roles of FDI in the restructuring process of domestic firms, probably because, in many transition economies, former socialist enterprises suffer an enormous amount of damage from fierce competition with foreign companies.

The studies listed above presented different but interesting conclusions by turning their attention to such factors as the level of market orientation and the type of business of foreign companies (depending on whether they were foreign-owned subsidiaries or joint-venture firms), the ownership

structure and the technology absorption capability of domestic firms, the geographical relationship between MNEs and domestic firms, and the market concentration, labour intensiveness, and other characteristics of each target industry in an attempt to investigate why statistically significant spillover effects cannot be detected from the estimations of baseline models. On the other hand, these studies do not consider any relationship between the internal structure of horizontal FDI and its productivity spillover effects, which are the focus of this paper. To the best of our knowledge, the same can be said for preceding studies on industrialized and developing economies.

This paper aims to present a new empirical model regarding the productivity spillover effects of horizontal FDI and to estimate the model using large-scale panel data of Hungarian firms of the early 2000s. We argue that it is not necessary for domestic firms to treat all foreign firms that come under the same category of the 2-digit level of industrial classification in a homogenous manner. The market relationship between a domestic firm and foreign counterparts has a multilayered structure arising from the sectoral differences among firms according to the lower levels of the classification. In contrast to the conventional model to capture the market presence of horizontal FDI using a single variable, the empirical model proposed in this paper is designed to identify horizontal spillover effects on the productivity of domestic firms according to the industrial sector with different depth by expressing the FDI presence using multiple variables with a nested structure corresponding to the aggregated level of industrial classification.² We confirmed the horizontal spillover effects in Hungary simultaneously taking place in sectors with different depth that cannot be captured with

¹ We do not go into the details of this issue, on which many researchers have been working for years. For more details, see excellent survey articles by Blomström and Kokko (1998) and Görg and Greenaway (2004) as well as thorough literature reviews by Javorcik (2004), Sinani and Meyer (2004), Halpern and Muraközy (2007), and Kneller and Pisu (2007).

² It is noteworthy that Haskel *et al.* (2007) found that the differences in the aggregate level of horizontal FDI resulted in a remarkable gap between the estimation results of individual productivity spillover effects. Differently from the approach taken in this paper, however, they do not pay attention to the nested structure of the industrial classification.

the conventional model. In this sense, our empirical evidence may suggest new insights both for the studies of industrial organization and transnational investment.

The remainder of this paper is structured as follows: Section 1 examines the relationship between the concentric-circle structure of industrial organizations and productivity spillover effects of horizontal FDI. Section 2 specifies the objective and period of empirical analysis. Section 3 describes the data employed for this study. Section 4 discusses the empirical methodology. Section 5 presents the estimation results. Section 6 summarizes the major findings and concludes the paper.

1) CONCENTRIC-CIRCLE STRUCTURE OF INDUSTRIAL ORGANIZATIONS AND PRODUCTIVITY SPILLOVER EFFECTS OF HORIZONTAL FDI

To examine the productivity spillover effects of inward FDI to Hungary, we propose a new analytical framework, the essence of which is to refine the empirical methodology for estimating the externalities of horizontal FDI on the productivity of domestic firms by taking into account the concentric-circle structure of industrial organizations arising from the sectoral differences among firms within an industry at the 2-digit classification level. The fundamental concept is based on our interview surveys of company managers and other executive officers of Central and Eastern European enterprises conducted in recent years in the framework of our Hungary–Japan joint research project and others. The empirical model developed through this study reflects our heuristics that domestic firms tend to have a substantially different scope of management interest and attitude towards MNEs operating in the same industry according to the 2-digit industrial classifica-

tion, if these foreign counterparts are distinguished at a lower level of classification.³

Using census-type data of Hungarian firms,⁴ we provide a concrete example of the concentric-circle structure of industrial organizations as we assume it to be. In *Figure 1*, we focus on a manufacturing firm (hereinafter “Company A”) that is categorized as a manufacturer of plastics in primary forms according to Code 2416 of the General Industrial Classification of Economic Activities within the European Communities (NACE2416). Company A is a typical medium-sized Hungarian enterprise with 16 employees, a total turnover of 640 million Hungarian forints (HUF), total assets of 3,200 million HUF, and 57.1% of its equity capital came from foreign investors as of 2003.

As Figure 1 shows, Company A is surrounded by 41 firms that are also categorized as manufacturers of plastics in primary forms, of which 13 are foreign firms, including 7 fully foreign-owned companies. These firms are hereinafter collectively referred to as “Enterprise Layer I” for brevity. The total assets, number of employees, and turnover for Enterprise Layer I, excluding Company A, are 203 billion HUF, 3,055 employees, and 173 billion HUF, and firms with foreign participation account for 25.7%, 23.1%, and 33.5% of these figures, respectively. These 42 firms engaged in the manufacture of plastics in primary forms, including Company A, are encompassed by “Enterprise Layer II,” which consists of 125 firms involved in the manufacture of basic chemicals (NACE241). Of these 125 firms, 25 are foreign, which account for 78.7%, 48.6%, and 68.9% of the total assets, number of employees, and turnover for Enterprise Layer II, respectively. These percentages are much larger than those for firms

³ We also received important suggestions from field studies conducted by other researchers with respect to former state-owned enterprises privatized by Western MNEs and other foreign investors in transition economies. See Estrin *et al.* (2000) and Stephan (2006) for instance.

⁴ We describe the details of the data in Section 4.

engaged in the manufacture of plastics in primary forms. Furthermore, Enterprise Layer II is also externally surrounded by “Enterprise Layer III,” consisting of 328 firms categorized as manufacturers of chemicals and chemical products (NACE 24). Of these 328 firms, 78 are foreign firms, which account for 60.7%, 56.5%, and 60.2% of the total assets, number of employees, and turnover for firms engaged in the manufacture of chemicals and chemical products, respectively, excluding those in the manufacture of basic chemicals.

As of 2003, Company A was involved in the manufacture of chemicals and chemical products in Hungary, together with 378 domestic firms and 116 companies with foreign participation. As indicated in Figure 1, however, the industrial-organizational proximity between Company A and these 494 enterprises involves clear boundaries differentiating the industrial groups by sector. It is also clear that the FDI presence in Enterprise Layers I, II, and III, surrounding Company A in a concentric-circle fashion, is quite diverse.

The industrial-organizational proximity of MNEs and domestic firms is closely related with the degree of competitiveness between the two in the product market and with the probability of the technology and knowledge transfer from the former to the latter even focusing solely on the relationship between the two operating in the same sector (*Table 1*). The closer the industrial sector of a domestic firm is to that of an MNE, the fiercer the market competition between the two will be, but, at the same time, the greater the possibility for the domestic firm to improve its productivity by acquiring good human resources through voluntary career changes and headhunting of the employees hired by the foreign firm as well as by imitating its industry-specific technology and knowledge. On the other hand, the more remote the industrial sector of a domestic firm is to that of an MNE, the more moderate the competition between the two will be, but, at the same time, the lesser the possibility for the domestic firm to gain

industry-specific technology and knowledge and transfer of human capital from the foreign firm. Nevertheless, it may be possible for a domestic firm to significantly improve its productivity by imitating the general technology and knowledge of a sectorally remote MNE if its technology and knowledge are high level and can be utilized for wider applications to company management compared to those of domestic enterprises. To sum up, the spillover effects of horizontal FDI on the productivity of domestic firms emerge as the complex agglomeration effects of all of these factors.

In the real world, the market relationships and the industrial linkages between MNEs and domestic firms are quite diverse and vary from country to country as well as industry to industry. Therefore, domestic firms may receive different productivity spillover effects from horizontal FDI with different degrees of industrial-organizational proximity. It is quite difficult, however, to theoretically predict the direction and the degree of such external effects, and the issue has been the subject of empirical studies.

2) OBJECTIVE AND PERIOD OF EMPIRICAL ANALYSIS

In this section, we specify the objective and period of our empirical analysis by overlooking inward FDI to Hungary during the transition period and reviewing the preceding studies on the FDI productivity spillovers in the country.

Hungary is well known for having received a comparatively large amount of direct investment from abroad for its economic scale since the very first stage of its systemic transformation to a market economy. In fact, Hungary received the largest FDI among the Central and Eastern European (CEE) countries on an accumulated total amount basis from 1990 through 1997 due to such factors as its proactive open

market policy, privatization of state-owned enterprises focusing on direct sales to strategic foreign investors, and geographical approximation to Western markets. Although Hungary was overtaken by Poland as the largest FDI-recipient country in the region from 1998 onward, it received 62.7 billion USD, or 17.8% of the total FDI that flowed into the ten CEE countries in the period from 1990 to 2007, and its per-capita cumulative FDI for that 18-year period was 9,711 USD, the second highest after the 9,923 USD for the Czech Republic among these ten countries.⁵

This vast influx of FDI led to the emergence of a mega foreign sector within the Hungarian economy. The number of firms with foreign participation almost tripled from 9,117 to 27,180, and the total amount of FDI invested in those companies jumped from 215 billion HUF to 14.833 trillion HUF over the period from 1991 to 2007. *Figure 2* illustrates the time series changes in the number of foreign firms and the total amount of prescribed capital by foreign investors and their composition by sector. As shown in this figure, foreign capital actively participated not only in the manufacturing sector but also in the service sector.⁶ In 2007, the manufacturing sector had 3,264 foreign firms, or 12% of the total number of foreign firms in all industries, and attracted 5.451 trillion HUF from foreign investors, or 36.8% of the total prescribed capital amount contributed by foreign investors in all industries, whereas the service sector had 21,015 foreign firms (or 77.3% of the total) and attracted 6.436 trillion HUF (or 43.4% of the total). According to panel (b) of *Figure 2*, the total prescribed capital contributed by foreigners has continued to rise each year, whereas, as panel (a) of the same fig-

ure shows, the number of foreign firms has stayed almost the same since the late 1990s. This is due to the fact that many joint-venture agreements between foreign investors and domestic firms as a business form of entered firms have been terminated one after another as well as to the well-known fact that pattern of FDI shifts from new entry to profit reinvestment (Kiss, 2007). In fact, the proportion of paid-up capital by foreign investors in the total equity capital substantially increased from 45.2% in 1991 to 71.7% in 2007.

As discussed above, inward FDI to Hungary has contributed to the emergence of many foreign companies in a relatively short time, especially those in the manufacturing and services industries. The investment and business mode for MNEs has also continued to evolve over the years. This movement may have had a significant impact on the direction and degree of the external effects of FDI on the productivity of domestic firms along with the dynamic changes in the presence of foreign companies in the domestic market and their relationship with domestic counterparts.

Meanwhile, most researchers negatively evaluate the relationship between MNEs and domestic firms in Hungary by looking at the considerable disparities in financial standing and technological levels between the two and low local procurement rate of entering firms (Farkas, 2000; Fink, 2006; Ács *et al.*, 2007). The results of quantitative analyses concerning FDI spillover effects are also used to back up such negative assessments. As far as we surveyed with regard to this issue, 11 papers have been published in the past either devoted solely to the case study of Hungary or reporting empirical results limiting the scope of any estimation of Hungary as part of international comparative research. *Table 2* contains a summary of empirical methods and estimation results in these research works. It is difficult to determine from this table that the preceding studies as a whole strongly suggest the positive spillover effects of inward FDI to Hungary on the productivity of domestic firms

⁵ Authors' calculation based on UNCTAD official data (<http://stats.unctad.org/fdi/>).

⁶ Those industries refer to wholesale and retail trade; repair of motor vehicles, motorcycles, and personal and household goods (NACE 50, 51, and 52), hotels and restaurants (NACE 55), transport, storage, and communication (NACE 60 through 64), and real estate, renting, and business activities (NACE 71 through 74).

since the estimation results of the proxies for the market presence of FDI, that is, the spillover variables representing the comparative business scale of foreign companies within each industrial sector they belong to, are mixed. There is no denying that the non-uniformity of the empirical results is largely dependent upon the differences not only in the structure of the regression models and dataset used but also in the estimation period applied, because the presence of FDI and the relationship between MNEs and domestic firms in Hungary are considered to have changed dynamically at each stage of the transition to a market economy from the 1990s to the early 2000s.

With this in mind, we reexamine FDI productivity spillover effects in Hungary only for the early 2000s, during which the business activity of foreign firms entered its mature, stable stage. It is highly likely that positive FDI spillover effects during this period exceed crowding-out effects for two reasons: first, the business activity of many MNEs has taken greater root in local communities, and their alliance with domestic firms has achieved larger scale and depth through parts supply and outsourcing than before; second, many domestic firms have improved their management practices, and the weaker ones have been forced out of business through severe market competition over the past 15 years.⁷ We also pay great attention to the service industry, which has been completely ignored in previous studies, because, as we reported above, the presence of foreign companies in services is just as remarkable as they are in the manufacturing industries and, hence, we expect that a significant amount of technology and knowledge has been transferred from MNEs to domestic firms in the service industry.

⁷ The studies suggesting this possibility include those by Inzelt (2008), Mako *et al.* (2009), and Sass *et al.* (2009).

3) DATA

The data underlying our empirical analysis are annual census-type data of Hungarian firms, which were compiled from financial statements associated with tax reporting submitted to the National Tax Authority in Hungary by legal entities performing accounting and tax procedures by double-entry bookkeeping. The observation period is the four years from 2002 through 2005. The data cover all industries, including manufacturing and service industries, and contain basic information for each sample firm, including the NACE 4-digit codes, annual average number of employees, total assets, turnover, and other financial indices. In addition, the locations of the sample firms are identifiable to the extent that they are divided into the capital region, the western region, and the eastern region.⁸

Information about the ownership structure includes the total amount of equity capital (prescribed capital) at the end of the term and its share of state, domestic, and foreign private investors. Thus, the data allow us to know whether a given sample firm is a fully domestically owned or a foreign firm and, when it is a foreign firm, whether it is a foreign joint-venture firm or a fully foreign-owned firm according to the ownership share of foreign investors in the total amount of subscribed equity.

All nominal values are deflated with the base year being 2002 to use the data.⁹ As

⁸ The individual regions consist of the following city and counties, respectively: The capital region consists of Budapest and Pest County. The western region consists of the following nine counties: Győr-Moson-Sopron; Komárom-Esztergom; Vas; Veszprem; Fejer; Zala; Somogy; Tolna; and Baranya. The eastern region also consists of nine counties: Nógrád; Bács-Kiskun; Csongrád; Békés; Jász-Nagykun-Szolnok; Hajdu-Bihar; Szabolcs-Szatmár-Bereg; Borsod-Abaúj-Zemplén; and Heves.

⁹ Unless otherwise specified, the unit used for the price data is 1,000 HUF.

Sgard (2001) and Claessens and Djankov (2002) indicate, firm-specific price deflators, which are the most desirable for deflation, are not available in Hungary. Hence, following the steps taken by these two studies, the consumer price index, the industrial producer price index, and the investment price index reported by the Hungarian Central Statistical Office are used as alternative deflators in this paper. In addition, for using the data, samples including unrealistic and inconsistent input and missing values that pose an impediment to our empirical analysis are removed, and cleansing procedures are performed with due attention.

The data form an unbalanced panel with the new entry and exit of enterprises during the observation period. All of the effective data values concerning these newly entering and exiting firms are used for the computation of industry-level aggregated values, such as FDI spillover variables and Herfindahl indices reported later. The observations used for our empirical analysis are limited to those concerning companies with an average number of employees of five or more and to those available in the data at least for two terms in the analysis period in order to control firm's individual effects using panel data estimators and to exclude so-called "one-man companies" and micro firms from our estimation.

The original data include almost the same number of sample firms as the official statistics. As a result of data cleaning and the exclusion of small-scale companies, with respect to 2003, 8,505 manufacturing firms and 17,232 service firms were left out in our dataset. According to official statistics, the proportions of these sample firms in the total number of employees for 2003 account for 58.4% (540,146 employees) for manufacturing firms and 44.9% (567,078 employees) for service firms. Furthermore, the sample of manufacturing firms includes 1,520 foreign firms (of which 886 are fully foreign-owned firms), and that for service firms includes 1,825 foreign firms (of which 994 are fully foreign-owned firms). The proportion of these foreign firms in the

total number of samples (13.0%) is almost identical to that of the official statistics if the company size is taken into consideration. The same has also been confirmed for the observations for the other years. In other words, the panel data used for our empirical analysis consist of samples representative for the manufacturing and service industries in Hungary.

4) EMPIRICAL METHODOLOGY

In this section, an empirical model is developed on the basis of the discussions in Section 1 regarding the relationship between the concentric-circle structure of industrial organizations and the spillover effects of horizontal FDI on the productivity of domestic firms. The model is designed to estimate multiple variables representing the market presence of horizontal FDI according to the degree of difference in the industrial-organizational proximity to a domestic firm to be analyzed. In our empirical analysis, the presence of FDI in the manufacturing and service industries of Hungary is calculated at three different classification levels for each industry, and the productivity of the i -th firm is then regressed into these horizontal spillover variables using a panel data estimator. More specifically, if the i -th firm belongs in NACE with sector P for the 4-digit level, sector Q for the 3-digit level, and sector R for the 2-digit level ($P \in Q \in R$), the market presence of FDI for the i -th firm in sector P is defined as follows:

$$HORFDI_{it} = \frac{\sum_{p \in P} \alpha_{pc} \cdot FS_{pc}^{-\alpha_{pc}}}{\sum_{p \in P} \alpha_{pc}^{-\alpha_{pc}}} \quad (1)$$

where the subscript t refers to the year, x represents the business scale at the firm level, and FS stands for the ownership share held by foreign investors.

The presence of foreign firms in the 3-digit aggregated level sector Q , excluding

those categorized in the lower subsector P , is measured using the following formula:

$$HORFDI3N_{it} = \frac{\sum_{P \text{ for all } qaQ^{N_{it}} \cdot FS_{it} - \sum_{P \text{ for all } qaP^{N_{it}} \cdot FS_{it}}}{\sum_{P \text{ for all } qaQ^{N_{it}} - \sum_{P \text{ for all } qaP^{N_{it}}}} \quad (2)$$

Similarly, the presence of FDI in the highest aggregated level sector R , excluding those categorized in the lower subsector Q , is given by:

$$HORFDI2N_{it} = \frac{\sum_{R \text{ for all } raR^{N_{it}} \cdot FS_{it} - \sum_{Q \text{ for all } qaQ^{N_{it}} \cdot FS_{it}}}{\sum_{R \text{ for all } raR^{N_{it}} - \sum_{Q \text{ for all } qaQ^{N_{it}}}} \quad (3)$$

As is the case with the relationships among the three different enterprise layers drawn in Figure 1, the above horizontal spillover variables have a nested structure that varies depending on the level of aggregation. Namely, the numbers 2, 3, and 4 included in the names of the variables stand for the levels of aggregation in NACE, and N at the end denotes that the variable has a nested structure in the relationship with the lower categories. Empirical models that comprise the nested spillover variables of horizontal FDI in the right-hand side of the estimation equation are hereinafter called “concentric-circle models” to distinguish them from the models with a single horizontal variable.

To compare the estimation results from the two different empirical approaches, we also estimate an additional horizontal spillover variable without giving any consideration to the concentric-circle structure of industrial organizations. Specifically, the productivity variable of the i -th firm is regressed into the market presence of FDI in sector R as a whole, which is expressed in the following formula:

$$HORFDI2_{it} = \frac{\sum_{R \text{ for all } raR^{N_{it}} \cdot FS_{it} - \alpha_{it} \cdot FS_{it}}{\sum_{R \text{ for all } raR^{N_{it}} - \alpha_{it}}} \quad (4)$$

Furthermore, as Schoors and van der Tol (2002) and Damijan *et al.* (2003b) do, we also pay attention to the externalities of vertical FDI, which consist of the backward

and forward spillover effects generated by downstream industries and upstream industries, respectively. The backward spillover variable for the i -th firm takes the presence of the foreign firms as its value after being weight-averaged by the share of each downstream industry in the total inputs supplied from sector R as follows:

$$BACFDI2_{it} = \sum_{S \text{ if } S \in R} \alpha_{SR} \cdot \left[\frac{\sum_{S \text{ for all } saS^{N_{it}} \cdot FS_{it}}{\sum_{S \text{ for all } saS^{N_{it}}}} \right] \quad (5)$$

where α_{SR} represents the proportion of sector R 's output supplied to downstream industry S at the 2-digit aggregated level. Likewise, the values of the forward spillover variable ($FORFDI2_{it}$) are calculated by weight-averaging the market presence of FDI with the proportion of each upstream industry in the total inputs of sector R .¹⁰

We adopt four indices for the i -th firm's productivity as the dependent variables of our regression models. As summarized in Table 2, the estimation results of the previous studies suggest the possibility that FDI has a different impact on productivity of a different nature. In this paper, we make a detailed evaluation of this point. The first productivity variable is the output scale (Y) measured using the natural logarithm of the total annual turnover. The second productivity variable is a proxy for labour productivity (Y/L) using the natural logarithm of the total turnover per employee. The third productivity variable is the total factor productivity (TFP) obtained as the residual of OLS estimation in the following log-linear transformation of a Cobb-Douglas production function:

$$Y_{it} = \alpha + \beta_K K_{it} + \beta_L L_{it} + \beta_M M_{it} + \varepsilon_{it} \quad (6)$$

where K , L , and M stand for the natural logarithms of a firm's total assets, annual average number of employees, and total intermediate inputs, which represent produc-

¹⁰ These backward and forward spillover variables are computed using the input-output table for 2005 compiled by the Hungarian Central Statistical Office (HCSO, 2009).

tion input of capital, labour, and materials, respectively. ε is the error term.

The fourth productivity variable is the residual of a Cobb-Douglas production function (LP) estimated using the semi-parametric method first contrived by Olley and Parks (1996) and then developed by Levinsohn and Petrin (2003). Although the technical details are not given here due to space limitations, the Levinsohn-Petrin estimator is accepted as the means to accurately measure total factor productivity since it treats simultaneous bias arising from the endogenous relationship between factor inputs and productivity by adopting intermediate inputs as the firm-specific proxy of the productivity shock, which is unobservable for econometricians.¹¹ It is argued, however, that the theoretical background hypothesizing short-term profit maximization and flexible factor markets is slightly too strong for companies in post-socialist transitional countries with an underdeveloped market system. We, therefore, use both the TFP and LP to test the statistical robustness of estimation results obtained from our regressions, as performed by Halpern and Muraközy (2007) and Javorcik and Spatareanu (2008).

FDI spillover effects on the productivity of domestic firms are generated on the condition that MNEs have significantly better productivity than domestic firms. Table 3 shows the results of univariate analysis regarding the productivity gap between different company groups in terms of ownership structure in the manufacturing and service industries using the above four productivity variables. We confirm that, as of 2003, foreign firms are superior to fully domestically owned firms in both sectors and in all of the four productivity variables with statistical significance at the 1% level. Moreover, the results of the analysis of variance and the Scheffe multiple comparison of the three company groups indicate that fully foreign-owned firms are superior

to foreign joint-venture firms in terms of productivity in general. In the manufacturing industry, however, no statistically significant differences are evident between fully foreign-owned firms and foreign joint-venture firms in terms of TFP and LP , both of which represent the proxy for total factor productivity. The same applies to the relationship between the two in the service industry in terms of LP . Almost the same results as those shown in Table 3 are obtained from the analysis using 2004 and 2005 observations. Hence, we predict that FDI in Hungary had considerable potential for generating positive productivity spillover effects on domestic firms in the early 2000s.

The observations in our regressions are limited to those of fully domestically owned firms and foreign joint-venture firms since we focus on FDI productivity spillover effects on firms established by domestic investment. To avoid possible endogeneity between firm-level productivity and the market presence of FDI that may cause the simultaneous bias on estimation results, the total asset at the end of year $t-1$ preceding the production activity for year t is used as the business scale index at the firm level, on the basis of which the FDI spillover variables are calculated. Table 4 reports the correlation matrices of six FDI spillover variables computed using the formula mentioned earlier. We confirm from the table that the maximum correlation coefficient among the nested horizontal spillover variables of $HORFDI2N$, $HORFDI3N$, and $HORFDI4$ is 0.230, suggesting that it is unlikely for the simultaneous estimation of these three variables to bring about serious multicollinearity to the estimation results. On the other hand, as panel (a) of Table 4 shows, the correlation coefficient for the manufacturing industry among the vertical spillover variables of $BACFDI2$ and $FORFDI2$ is 0.779, which is greater than the threshold of 0.700 for possible multicollinearity (Lind *et al.*, 2004). Therefore, these vertical FDI spillover variables are estimated one by one. The correlation coefficient of vertical FDI spillover variables for the service industry is

¹¹ Petrin *et al.* (2007) describe how to estimate LP using econometric software.

0.246. Although it is not necessary to follow the same estimation procedure as that for the manufacturing industry, we estimate the vertical spillover variables separately for the service industry in order to compare the estimation results of the two types of industry.

Along with FDI spillover variables, we introduce three independent variables representing the input of capital stock (K), labour (L), and materials (M) into the right-hand side of the regression model taking production scale as the dependent variable and the capital-labour ratio (K/L) into that of the regression model taking labour productivity as the dependent variable. In addition to these input variables, we also adopt the firm's foreign ownership share (FS), government ownership share (GS), Herfindahl index at the NACE 4-digit level as the proxy for the market concentration of the sector the firm belongs to (HHI), export propensity (export/total turnover) ($EXPPRO$), location fixed-effects, and year fixed-effects for all regression models as the control variables. We expect that factor inputs, foreign ownership, and the linkage with the international market through export activity have a positive impact on the firm's productivity, whereas state ownership and higher market concentration of the industry the firm belongs to are negatively related to its productivity.¹²

To control the firms' individual effects, we used three panel data estimators: pooling OLS, random-effects, and fixed-effects estimators. The selection of the estimation results reported in this paper is carried out in accordance with the results of two model specification tests. One is the Breusch-Pagan test to examine the null hypothesis that the variance of the individual effects is zero, and the other is the Hausman test to exam-

ine the random-effects assumption (Greene, 2008). For all model specifications, we report White's heteroskedasticity-consistent standard errors.

5) ESTIMATION RESULTS

The estimation results using all observations are shown in *Table 5*. The definitions and the descriptive statistics of the variables used for estimation are listed in the Appendix. Table 5 contains the 32 regression models to deal with all combinations of the two industrial sectors, the four dependent variables, and the four sets of the FDI spillover variables. Both the Breusch-Pagan and the Hausman tests rejected the null hypothesis in all cases at the 1% significance level.¹³ Therefore, the regression results using the fixed-effects estimator are exclusively reported in Table 5.

The concentric-circle model succeeds in identifying the horizontal spillover effects originating from the different depths of the industrial sector that cannot be captured with the model having a single horizontal variable. For example, Model [1], which adopts the conventional empirical approach, detects no statistically significant horizontal effects. The coefficient of $HORFDI2$ is positive, but its significance is not at the 10% level or below. On the other hand, when using Figure 2 mentioned earlier as the basis for the explanation, the estimation results of Model [2], which gives consideration to the concentric-circle structure of industrial organizations, demonstrate that positive horizontal effects are observed for Enterprise Layers I ($HORFDI4$) and III ($HORFDI2M$) at the 10% or less significance level, whereas negative horizontal effects are generated at intermediate Enterprise Layer II ($HORFDI3M$) with significance at the 10% level. This outcome demonstrates

¹² Girma *et al.* (2004) examine the causality between the export activity of British firms and their productivity and confirm that export is an important channel for improving the productivity of domestic firms. Iwasaki *et al.* (2008) verify the superiority of foreign ownership over domestic private ownership and the inferiority of government ownership compared to domestic private ownership in terms of productivity using the same data in this paper.

¹³ These specification test results apply to all the other estimation results reported in this paper.

that the offset phenomenon between different enterprise layers is one of the main reasons that no significant spillover effects can be captured with the market presence of horizontal FDI aggregated at the NACE 2-digit level. Similar offset effects are evident in the estimation results of Models [9] through [16] regarding horizontal spillover effects on the total factor productivity of manufacturing firms. The estimation results of Models [5] through [8] suggest that, although the overall horizontal FDI has significant and positive spillover effects on the labour productivity of manufacturing firms at the NACE 2-digit level, their effect for each Enterprise Layer is positive but insignificant.¹⁴

As indicated in panel (b) of Table 5, horizontal FDI spillover effects on service firms are generated in a completely different pattern from those on manufacturing firms. We found that foreign competitors generally have negative impacts on the production scale and total factor productivity of domestic firms in the same sectors they belong to, whereas in all Enterprise Layers, they have strong positive spillover effects on labour productivity of domestic firms. These estimation results are quite interesting as they suggest that the market behaviour of MNEs may have diverse impacts on the production performance of indigenous companies in recipient countries.

With regard to vertical FDI spillover effects, our regression analysis detects no statistically significant backward spillover effects on manufacturing firms, whereas it confirms significantly negative effects on the production scale and total factor productivity of service firms and significantly positive effects on their labour productivity. As for forward FDI spillovers, negative effects are detected on the labour productivity of both

manufacturing and service firms at the 1% significance level.

Our estimations, as has been confirmed in many studies, have produced positive and significant coefficients on the input variables. Among the control variables, *EXPPRO* shows positive and robust estimates, suggesting that exporting goods overseas is a crucial channel for Hungarian domestic firms to improve their productivity. In most of the pooling OLS and random-effects models (not reported), the ownership variables of *FS* and *GS* are significantly estimated, and their signs correspond with our expectations. Nevertheless, their statistical significance is remarkably eliminated when the firm individual effects are controlled using the fixed-effects estimator as shown in Table 5. *HHI* is negative in almost all specifications, but its significance never reaches the 10% level.

Table 6 shows the estimation results when classifying the observations into those for fully domestically owned firms and those for foreign joint-venture firms. The estimates reported in this table are those for FDI spillover variables only using the regression models with the backward variable on the right-hand side. Table 6 reveals that fully domestically owned firms are the main recipients of external effects originating from inward FDI, whether they are positive or negative. We presume that, on average, the chances of a Hungarian foreign joint-venture firm acquiring the technology and knowledge from other MNEs are greatly diminished due to the existence of foreign ownership as a direct endogenous channel for improving its productivity and due to the relatively small productivity gap with fully foreign-owned firms, as confirmed in Table 3.

As explained in the preceding section, the FDI spillover variables estimated in Table 5 are calculated based on total assets. In most previous studies, however, the market presence of FDI is expressed using an index other than assets. With this in mind, we also estimate the FDI spillover variables using the next four indices: (a) total turnover, (b) total added-value, (c) total equity capital, and (d)

¹⁴ In some cases, such as Models [5] through [8] in Table 5, insignificant estimation results can be obtained if the horizontal effects are dissolved for each enterprise layer. Thus, it would be desirable to estimate conventional models as well and compare their results with the estimation results of concentric-circle models.

annual average number of employees. *Table 7* shows the results. The table reveals that there are certain differences among individual estimation results in terms of how FDI spillover effects are generated. For instance, according to the estimation results for manufacturing firms, productivity spillover effects of horizontal FDI are stronger within the external enterprise layers (*i.e.*, at the Enterprise Layer II and III) than within the sector of the firms to be analyzed when turnover and added-value are used as the basic indices for computation of FDI spillover variables. On the other hand, when equity capital and the number of employees are used as the basis to calculate the market presence of FDI, the horizontal effects generated closer (*i.e.*, at the Enterprise Layer I) to the firms to be analyzed are emphasized. As for the service industry, there are significant differences in the statistical evaluation of the spillover effects on labour productivity between cases where turnover and added-value are used as the basic indices and where equity capital and number of employees are used. Different management indices capture different aspects of firm activity. The regression results reported in *Table 7* indicate that the empirical evaluation of FDI spillover effects on the productivity of domestic firms greatly differs depending on what aspect of the activity of MNEs the researcher focuses on most, suggesting that careful attention should be given to the selection of the proxy variable for the market presence of FDI in the recipient country as well as to the productivity indices of domestic firms.

As discussed above, our estimation results are sensitive to the selection of the indices as the basis for computation of FDI spillover variables. Yet the signs of the FDI spillover variables estimated at the 10% or less significance level are completely the same among the different estimation results reported in *Tables 5* and *7*. Therefore, we can safely say that the FDI spillover effects repeatedly detected in different model specifications with the 10% or less significance level are highly robust estimates.

6) CONCLUSIONS

It is not necessary for domestic firms to treat all foreign companies that come under the same category of industrial classification in a homogenous fashion. In fact, local company managers are looking at the structure of their industries in a more multilayered manner and paying strong attention to how close or how far their firms are to and from foreign counterparts in the context of industrial organizations. This is our conviction acquired through several field surveys, and it provides the basic concept for this study.

Previous empirical works on the spillover effects of inward FDI have given significant attention to the differences between horizontal and vertical FDI, whereas they have not given sufficient consideration to the internal structure of horizontal FDI itself. In this paper, a new empirical framework is presented by looking at the concentric-circle structure of industrial organizations arising from the sectoral differences among firms. The essence is that the market presence of horizontal FDI, which has been traditionally treated using a single variable, is expressed as multiple variables with the nested structure corresponding to the depth of industrial classification in order to identify the horizontal spillover effects on domestic firms by enterprise layer illustrated in *Figure 1*. As explained in *Section 5*, our empirical methodology is simple and can be used for a wide range of applications.

We estimated the new empirical model using large-scale panel data of Hungarian manufacturing and service firms for the early 2000s and succeeded in detecting FDI horizontal effects that could not be captured with the conventional model. Our estimation results strongly suggest that foreign firms in Hungary have statistically significant spillover effects on the productivity of domestic firms in the same industry, but

their direction and degree differ greatly between individual enterprise layers. It is impossible for the single spillover variable, which is aggregated at a certain industrial classification level, to capture such complex effects of horizontal FDI.

Moreover, this paper presents the following estimation results. First, FDI productivity spillover effects are generated in patterns that are completely different between different industries, that is, manufacturing and service industries, even during the same period in the same country. Secondly, FDI exhibits different spillover effects on productivity of a different nature. Thirdly, the estimation of productivity spillover effects is sensitive to the selection of business scale indices as the basis for calculating the market presence of FDI. We conclude on the basis of the above empirical results that the transfer of technology and knowledge from MNEs to domestic firms in a recipient country occurs on the basis of a very complex economic mechanism. Therefore, careful attention should be given to the selection of variables and the model specifications so that they will fit well into the scope of a micro-economic empirical examination of FDI spillover effects.

The empirical evidence presented in this paper also reveals that the productivity gap is still significant between foreign firms and fully domestically owned firms in Hungary, leaving ample room for indigenous companies to acquire technology and knowledge from MNEs. There is no doubt that private firms would need to harness their own capacities to solve this problem. However, appropriate industrial policies should be established by the Hungarian government and the EU to relax the productivity gap between the two groups of companies. Researchers working on the Hungarian economy have long insisted, and still do, that sufficient progress is not visible in either of these two aspects (Szanyi, 2004; Iwasaki, 2007; Rugraff, 2008). Both the private sector and the government should take necessary steps to completely eliminate the “technological economic dualism” (Farkas,

2000) in Hungary that has been an issue since the 1990s.

* * * * *

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APPENDIX

Definitions and descriptive statistics of the variables used for empirical analysis

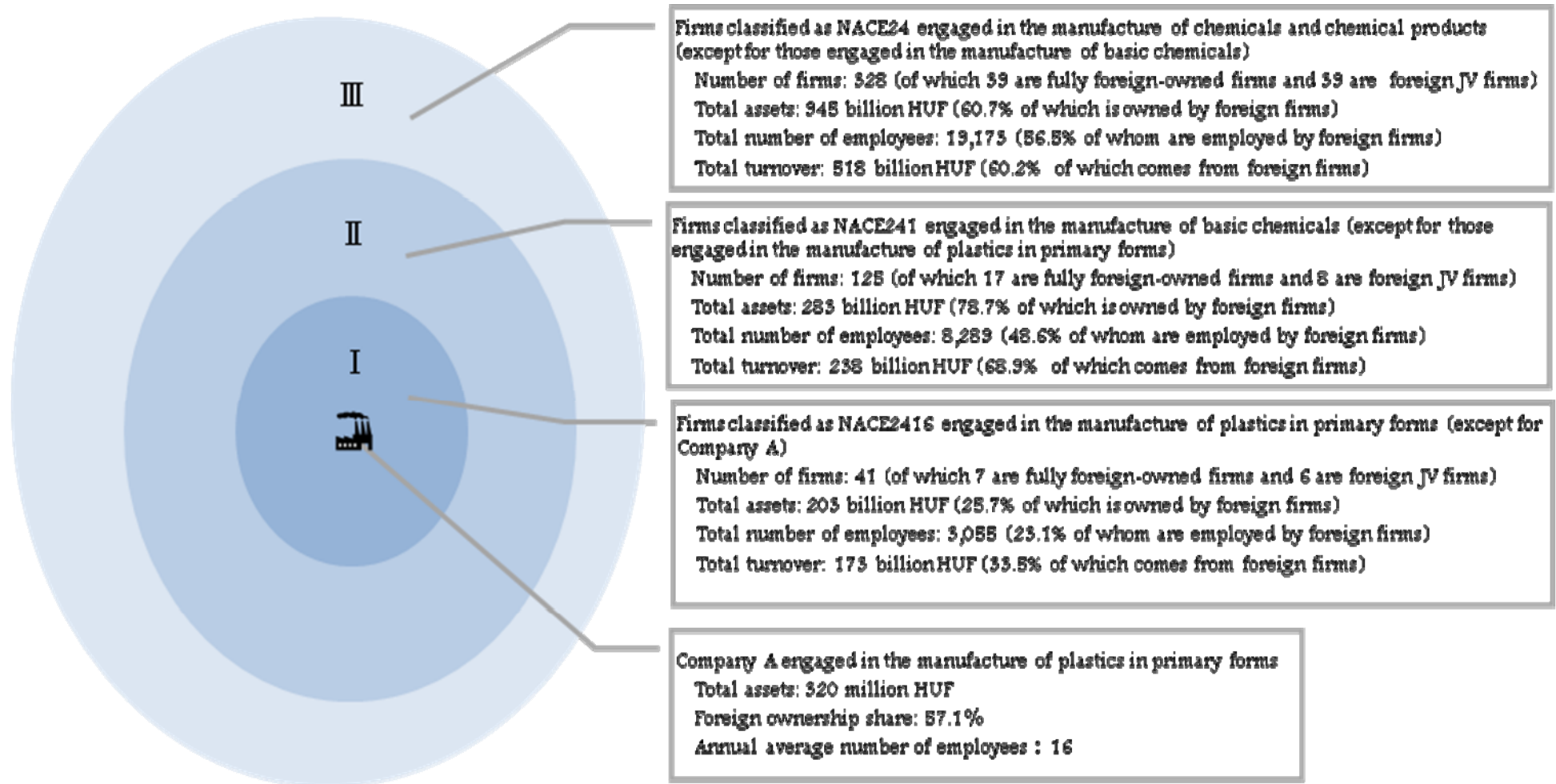
Variable name	Definition	Descriptive statistics					
		Manufacturing			Services		
		N	Mean	S. D.	N	Mean	S. D.
Productivity variable (dependent variable)							
<i>Y</i>	Annual total turnover (natural logarithm)	22762	11,795	1,399	48720	11,927	1,365
<i>Y/L</i>	Turnover per employee (natural logarithm)	22815	8,856	0,872	48740	9,422	1,053
<i>TFP</i>	Total factor productivity (OLS estimation method)	22755	0,001	0,226	48691	0,003	0,243
<i>LP</i>	Total factor productivity (Levinsohn-Petrin semi-parametric estimation method)	22755	0,012	0,203	48691	0,014	0,202
Spillover variable							
<i>HORFDIO2</i>	Share of foreign capital in assets ownership in the industry the firm belongs to (NACE 2-digit level)	22815	0,499	0,127	48783	0,356	0,128
<i>HORFDIO2N</i>	Share of foreign capital in assets ownership in the industry the firm belongs to (NACE 2-digit level: nested variable)	22815	0,520	0,170	48783	0,345	0,154
<i>HORFDIO3N</i>	Share of foreign capital in assets ownership in the industry the firm belongs to (NACE 3-digit level: nested variable)	22815	0,347	0,251	48783	0,203	0,223
<i>HORFDIO4</i>	Share of foreign capital in assets ownership in the industry the firm belongs to (NACE 4-digit level)	22815	0,384	0,230	48783	0,265	0,191
<i>BACFDIO2</i>	Share of foreign capital in assets ownership in downstream industries (NACE 2-digit level)	22815	0,453	0,086	48783	0,408	0,049

Variable name	Definition	Descriptive statistics					
		Manufacturing			Services		
		N	Mean	S. D.	N	Mean	S. D.
<i>FORFDIO2</i>	Share of foreign capital in assets ownership in upstream industries (NACE 2-digit level)	22815	0,441	0,129	48783	0,367	0,053
<i>HORFDIO2TN</i>	Share of foreign capital in turnover in the industry the firm belongs to (NACE 2-digit level: nested variable)	22815	0,492	0,183	48783	0,290	0,122
<i>HORFDIO3TN</i>	Share of foreign capital in turnover in the industry the firm belongs to (NACE 3-digit level: nested variable)	22815	0,332	0,250	48783	0,178	0,199
<i>HORFDIO4T</i>	Share of foreign capital in turnover in the industry the firm belongs to (NACE 4-digit level)	22815	0,366	0,242	48783	0,243	0,173
<i>BACFDIO2T</i>	Share of foreign capital in turnover in downstream industries (NACE 2-digit level)	22815	0,421	0,083	48783	0,362	0,045
<i>HORFDIO2VN</i>	Share of foreign capital in added-value in the industry the firm belongs to (NACE 2-digit level: nested variable)	22815	0,490	0,171	48783	0,307	0,143
<i>HORFDIO3VN</i>	Share of foreign capital in added-value in the industry the firm belongs to (NACE 3-digit level: nested variable)	22815	0,346	0,256	48783	0,205	0,225
<i>HORFDIO4V</i>	Share of foreign capital in added-value in the industry the firm belongs to (NACE 4-digit level)	22815	0,364	1,413	48783	0,258	0,184
<i>BACFDIO2V</i>	Share of foreign capital in added-value in downstream industries (NACE 2-digit level)	22815	0,440	0,083	48783	0,380	0,045
<i>HORFDIO2EN</i>	Share of foreign capital in equity capital in the industry the firm belongs to (NACE 2-digit level: nested variable)	22815	0,572	0,194	48783	0,385	0,199
<i>HORFDIO3EN</i>	Share of foreign capital in equity capital in the industry the firm belongs to (NACE 3-digit level: nested variable)	22815	0,406	0,286	48783	0,218	0,241
<i>HORFDIO4E</i>	Share of foreign capital in equity capital in the industry the firm belongs to (NACE 4-digit level)	22815	0,405	0,245	48783	0,280	0,227
<i>BACFDIO2E</i>	Share of foreign capital in equity capital in downstream industries (NACE 2-digit level)	22815	0,475	0,101	48783	0,397	0,052
<i>HORFDIO2WN</i>	Share of foreign capital in employment in the industry the firm belongs to (NACE 2-digit level: nested variable)	22815	0,337	0,167	48783	0,156	0,077
<i>HORFDIO3WN</i>	Share of foreign capital in employment in the industry the firm belongs to (NACE 3-digit level: nested variable)	22815	0,219	0,189	48783	0,112	0,128
<i>HORFDIO4W</i>	Share of foreign capital in employment in the industry the firm belongs to (NACE 4-digit level)	22815	0,259	0,189	48783	0,140	0,114
<i>BACFDIO2W</i>	Share of foreign capital in employment in downstream industries (NACE 2-digit level)	22815	0,311	0,078	48783	0,247	0,043

Variable name	Definition	Descriptive statistics					
		Manufacturing			Services		
		N	Mean	S. D.	N	Mean	S. D.
Input variable							
<i>K</i>	Total assets (natural logarithm)	22774	11,326	1,517	48738	11,185	1,450
<i>L</i>	Annual average number of employees (natural logarithm)	22815	3,030	1,045	48783	2,609	0,836
<i>M</i>	Total amount of intermediate materials (natural logarithm)	22769	11,354	1,523	48713	11,590	1,529
<i>K/L</i>	Total assets per employee (natural logarithm)	22809	8,385	1,027	48674	8,673	1,162
Control variable							
<i>FS</i>	Ownership share of foreign investors	22815	0,047	0,182	48783	0,027	0,136
<i>GS</i>	Government ownership share	22815	0,006	0,070	48783	0,006	0,072
<i>HHI</i>	Herfindahl index (NACE 4-digit level)	22815	0,106	0,152	48783	0,038	0,062
<i>EXPPRO</i>	Proportion of exports in total turnover	22815	0,124	0,261	48783	0,035	0,142

Source: Authors' compilation.

Figure 1
 Concentric-circle structure of industrial organizations: Example of company A engaged in the manufacture of plastics in primary forms for 2003



Source: Authors' illustration. See text for details.

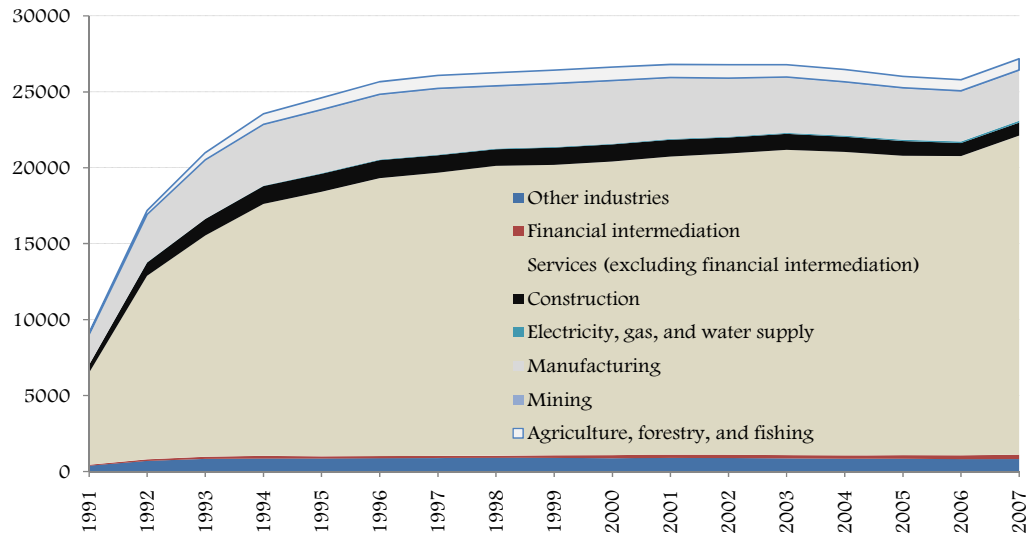
Table 1
 Relationship between industrial-organizational proximity and degree of competitiveness between MNEs and domestic firms in product markets and probability of technology/knowledge transfer from MNEs to domestic firms

Industrial-organizational proximity	Degree of competitiveness between MNEs and domestic firms in product markets	Probability of technology/knowledge transfer from MNEs to domestic firms		
		Probability of the transfer of human capital	Probability of the transfer of industry-specific technology and knowledge	Probability of the transfer of general technology and knowledge
Close	Strong	High	High	
Moderate	Moderate	Moderate	Moderate	Homogenous
Far	Weak	Low	Low	

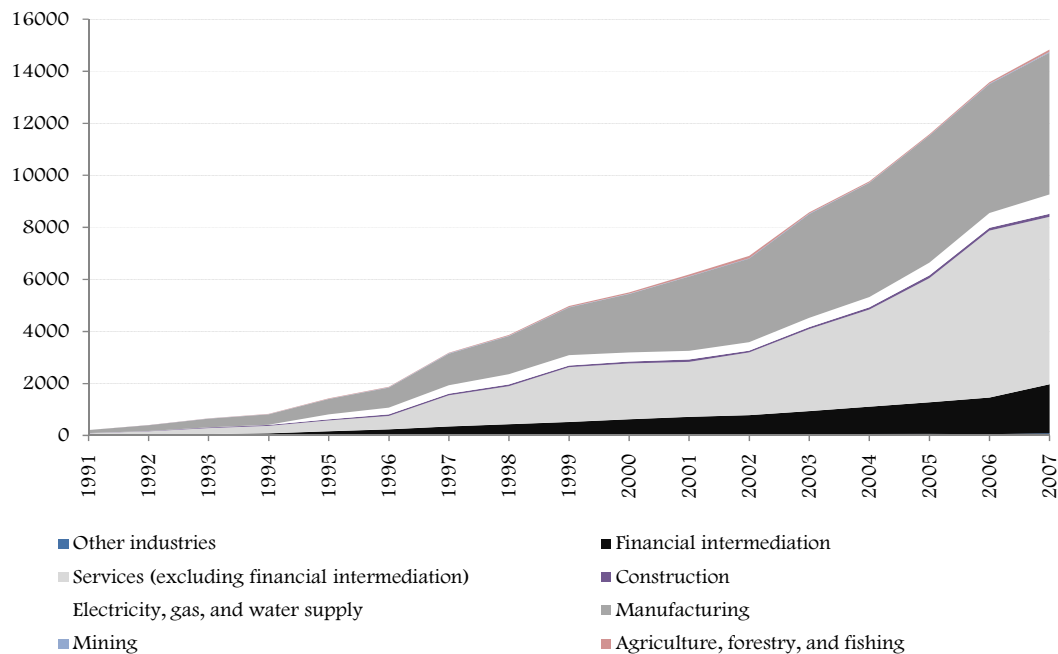
Source: Authors' compilation. See text for details.

Figure 2
Sectoral composition of the number of foreign firms and the total amount of prescribed capital by foreign investors in Hungary, 1991–2007

(a) Number of foreign firms



(b) Total amount of prescribed capital by foreign investors (billion HUF)



Source: Authors' illustration based on HCSO, the Statistical Year Book of Hungary (various years), and the official statistics of the Hungarian Central Statistical Office available at: <http://www.ksh.hu/>.

Table 2
Empirical studies on FDI productivity spillover effects in Hungary

Author	Sector	Period	Data	Productivity variable (dependent variable)	FDI spillover variable		Estimation result ^a			Control variables and their estimation results ^a
					Basic index for computation	Aggregation level	Horizontal effects	Vertical effects		
								Backward effects	Forward effects	
Bosco (2001)	NA	1993-1997	Panel	Turnover	Turnover	NACE2	no	NA	NA	Employment (+), capital (+), foreign ownership share (+)
Sgard (2001)	Manufacturing/construction	1992-1999	Panel	Turnover	Capital/turnover	NACE2	no/+	NA	NA	Employment (+), capital (+), intermediate material (+), foreign ownership share (+)
Schoors and van der Tol (2002)	All industries	1997-1998	Cross-sectional	Labor productivity	Turnover	NACE2	+	-	+	Tangible assets to labor ratio (+), intangible assets to labor ratio (-), turnover to industrial average ratio (+), square of turnover to industrial average ratio (-), credit interest (-), foreign ownership share (+)
Damijan et al. (2003a) ^b	Manufacturing	1994-1998	Panel	Turnover	Turnover	NACE2	no	NA	NA	Employment (no), capital (+), intermediate material (+), R&D expenditure (no)
Damijan et al. (2003b) ^b	Manufacturing	1995-1999	Panel	Turnover	Turnover	NACE2	no	no	no	Employment (results not reported), capital (results not reported), intermediate material (results not reported), FDI dummy (+), dummy for firms dominated by foreign investors (no), R&D expenditure (+)
Torlak (2004)	Manufacturing	1994-2000	Panel	Turnover	Turnover	NACE2	+	NA	NA	Employment (+), capital (+), intermediate material (+)
Halpern and Muraközy (2005)	Manufacturing	1996-2001	Panel	Added-value	Turnover	NACE2	+	+	no	One-term lag in added-value (+), employment (results not reported), capital (results not reported), intermediate material (results not reported)

Author	Sector	Period	Data	Productivity variable (dependent variable)	FDI spillover variable		Estimation result ^a			Control variables and their estimation results ^a
					Basic index for computation	Aggregation level	Horizontal effects	Vertical effects		
								Backward effects	Forward effects	
Békés et al. (2006)	Manufacturing	1992-2003	Panel	TFP (Olley and Parks estimator)	Turnover	NACE2	+	no	no	Herfindahl index (-), private ownership share (+)
Muraközy (2007)	Manufacturing	1995-2003	Panel	Price-cost margin	Turnover	NACE2	-	+	no	Herfindahl index (-), market share (no), capital productivity (no), employment (-), share of imports by industry (no)
Halpern and Muraközy (2007)	Manufacturing	1996-2003	Panel	Added-value, TFP (Levinson and Petrin estimator)	Turnover	NACE2	no/no	+/+	no/no	Employment (results not reported), capital (results not reported)
Görg et al. (2009)	Manufacturing	1992-2003	Panel	Added-value, TFP (Levinson and Petrin estimator)	Turnover	NACE4	-/-	NA	NA	Employment (+), capital (+)

Notes: ^a Results are obtained from the estimation of baseline models, which include a single linear-term variable on the right-hand side of the regression equation and have no sample constraints. "+" denotes that the estimated results are positive and statistically significant. "-" denotes that the estimated results are negative and statistically significant. "no" denotes that the estimated results are not significant. "NA" denotes that no estimation is made.

Table 3
Univariate analysis of productivity gaps among different types of firm ownership, 2003

Industrial sector	Manufacturing				Services			
Productivity variable	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>
All firms	11,966 (11,736)	8,917 (8,849)	0,186 (-0,001)	0,025 (0,005)	11,997 (11,924)	9,486 (9,471)	0,020 (0,002)	0,025 (0,005)
Fully domestically owned firms	11,714 (11,554)	8,831 (8,779)	0,005 (-0,011)	0,016 (-0,001)	11,891 (11,834)	9,419 (9,403)	0,013 (-0,005)	0,021 (0,003)
Foreign firms	13,144 (13,115)	9,310 (9,279)	0,082 (0,048)	0,065 (0,039)	12,900 (12,911)	10,059 (10,109)	0,083 (0,073)	0,059 (0,029)
Foreign joint-venture firms	12,806 (12,749)	9,203 (9,121)	0,070 (0,032)	0,064 (0,031)	12,652 (12,585)	9,901 (9,924)	0,061 (0,041)	0,054 (0,023)
Fully foreign-owned firms	13,390 (13,363)	9,389 (9,386)	0,090 (0,061)	0,066 (0,048)	13,106 (13,165)	10,191 (10,320)	0,101 (0,103)	0,064 (0,033)
N	8505	8465	8461	8461	17232	17227	17211	17211
Comparative analysis between fully domestically owned and foreign firms								
<i>t</i> test on the equality of means	-36,342***	-18,920***	-12,053***	-8,769***	-29,818***	-24,236***	-11,689***	-7,517***
Wilcoxon rank-sum test	-29,933***	-16,625***	-11,701***	-9,366***	-25,889***	-22,264***	-14,423***	-8,786***
Analysis of variance of the three company groups								
ANOVA (<i>F</i>)	698,280***	187,350***	74,130***	38,470***	470,770***	310,990***	74,570***	28,760***
Bartlett test (χ^2)	179,823***	124,436***	105,774***	33,230***	210,567***	107,873***	132,048***	235,091***
Kruskal-Wallis test (χ^2)	933,501***	286,522***	144,257***	88,913***	698,953***	518,074***	227,617***	78,999***
Scheffe multiple comparison of the three company groups								
Differences between fully domestically owned firms and foreign JV firms	1,092***	0,371***	0,065***	0,048***	0,762***	0,482***	0,048***	0,033***

Industrial sector	Manufacturing				Services			
Productivity variable	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>
Differences between fully domestically owned firms and fully foreign-owned firms	1,676 ^{***}	0,558 ^{***}	0,085 ^{***}	0,050 ^{***}	1,215 ^{***}	0,772 ^{***}	0,088 ^{***}	0,043 ^{***}
Differences between foreign JV firms and fully foreign-owned firms	0,584 ^{***}	0,186 ^{***}	0,020	0,002	0,453 ^{***}	0,290 ^{***}	0,040 ^{***}	0,010

Notes: The upper values are means, and the lower values in parenthesis are medians. ^{***}, ^{**}, and ^{*} denote statistical significance at the 1%, 5%, and 10% level, respectively.

Source: Authors' estimation. For definitions and descriptive statistics of the variables, see Appendix.

Table 4
Correlation matrices of FDI spillover variables

(a) Manufacturing (N=22815)

	<i>HORFDI2</i>	<i>HORFDI2N</i>	<i>HORFDI3N</i>	<i>HORFDI4</i>	<i>BACFDI2</i>	<i>FORFDI2</i>
<i>HORFDI2</i>	1,000					
<i>HORFDI2N</i>	0,738	1,000				
<i>HORFDI3N</i>	0,085	-0,028	1,000			
<i>HORFDI4</i>	0,514	0,230	-0,085	1,000		
<i>BACFDI2</i>	0,239	0,214	-0,182	0,257	1,000	
<i>FORFDI2</i>	0,263	0,261	-0,126	0,198	0,779	1,000

(b) Services (N=48783)

	<i>HORFDI2</i>	<i>HORFDI2N</i>	<i>HORFDI3N</i>	<i>HORFDI4</i>	<i>BACFDI2</i>	<i>FORFDI2</i>
<i>HORFDI2</i>	1,000					
<i>HORFDI2N</i>	0,752	1,000				
<i>HORFDI3N</i>	0,283	-0,015	1,000			
<i>HORFDI4</i>	0,291	-0,047	0,094	1,000		
<i>BACFDI2</i>	-0,395	-0,323	-0,490	-0,002	1,000	
<i>FORFDI2</i>	0,013	-0,062	-0,111	0,018	0,246	1,000

Source: Authors' calculation. For definitions and descriptive statistics of the variables, see Appendix.

Table 5
Panel data analysis of FDI productivity spillover effects: Comparison of the conventional model and the concentric-circle model

(a) Manufacturing

Dependent variable	Y				Y/L			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Model ^a								
Spillover variable ^b								
<i>HORFDI2</i>	0,0168 (0,015)		0,0167 (0,015)		0,0582* (0,031)		0,0606* (0,031)	
<i>HORFDI2N</i>		0,0237* (0,013)		0,0231* (0,013)		0,0416 (0,027)		0,0427 (0,027)
<i>HORFDI3N</i>		-0,0202* (0,012)		-0,0196 (0,012)		0,0068 (0,025)		0,0110 (0,025)
<i>HORFDI4</i>		0,0229** (0,010)		0,0232** (0,010)		0,0106 (0,021)		0,0123 (0,021)
<i>BACFDI2</i>	0,0096 (0,030)	0,0135 (0,030)			-0,0134 (0,061)	-0,0114 (0,061)		
<i>FORFDI2</i>			-0,0230 (0,035)	-0,0218 (0,035)			-0,1567** (0,071)	-0,1589** (0,071)
Input variable								
<i>K</i>	0,1328*** (0,004)	0,1327*** (0,004)	0,1329*** (0,004)	0,1327*** (0,004)				
<i>L</i>	0,1515*** (0,004)	0,1515*** (0,004)	0,1515*** (0,004)	0,1515*** (0,004)				
<i>M</i>	0,7007*** (0,003)	0,7008*** (0,003)	0,7006*** (0,003)	0,7007*** (0,003)				
<i>K/L</i>					0,5131*** (0,006)	0,5131*** (0,006)	0,5131*** (0,006)	0,5131*** (0,006)
Control variable								
<i>FS</i>	-0,0123 (0,018)	-0,0124 (0,018)	-0,0124 (0,018)	-0,0124 (0,018)	0,0057 (0,035)	0,0051 (0,035)	0,0066 (0,035)	0,0059 (0,035)

Dependent variable	Y				Y/L			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
<i>GS</i>	-0,0340 (0,023)	-0,0341 (0,023)	-0,0340 (0,023)	-0,0340 (0,023)	-0,0239 (0,047)	-0,0237 (0,047)	-0,0242 (0,047)	-0,0239 (0,047)
<i>HHI</i>	-0,0090 (0,017)	-0,0158 (0,017)	-0,0096 (0,017)	-0,0164 (0,017)	-0,0344 (0,034)	-0,0353 (0,034)	-0,0372 (0,034)	-0,0384 (0,034)
<i>EXPPRO</i>	0,0436*** (0,010)	0,0437*** (0,010)	0,0436*** (0,010)	0,0437*** (0,010)	0,1317*** (0,020)	0,1318*** (0,020)	0,1316*** (0,020)	0,1317*** (0,020)
Const.	1,8525*** (0,047)	1,8466*** (0,047)	1,8667*** (0,048)	1,8619*** (0,048)	4,4805*** (0,061)	4,4809*** (0,061)	4,5402*** (0,061)	4,5409*** (0,061)
Location fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	22755	22755	22755	22755	22809	22809	22809	22809
R ²	0,974	0,974	0,973	0,974	0,596	0,596	0,595	0,595
Ftest ^c	6145,85***	5330,15***	6146,01***	5330,23***	663,52***	561,31***	664,18***	561,88***
Breusch-Pagan test ^d	11490,47***	11475,39***	11419,66***	11391,80***	14146,63***	14132,20***	14193,23***	14171,35***
Hausman test ^e	146,09***	156,14***	157,12***	177,96***	621,51***	621,40***	600,08***	608,07***

(Continued)

(a) Manufacturing(continued)

Dependent variable	<i>TFP</i>				<i>LP</i>			
Model ^a	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
Spillover variable ^b								
<i>HORFDI2</i>	0,0164 (0,015)		0,0168 (0,015)		0,0237 (0,014)		0,0232 (0,014)	
<i>HORFDI2N</i>		0,0231* (0,013)		0,0230* (0,013)		0,0233* (0,012)		0,0227* (0,012)
<i>HORFDI3N</i>		-0,0201* (0,012)		-0,0194 (0,012)		-0,0178 (0,011)		-0,0180 (0,011)
<i>HORFDI4</i>		0,0227** (0,011)		0,0230** (0,011)		0,0287*** (0,010)		0,0286*** (0,010)
<i>BACFDI2</i>	-0,0003 (0,030)	0,0035 (0,030)			0,0089 (0,028)	0,0116 (0,028)		
<i>FORFDI2</i>			-0,0275 (0,035)	-0,0264 (0,035)			0,0112 (0,033)	0,0117 (0,033)
Input variable								
<i>K</i>								
<i>L</i>								
<i>M</i>								
<i>K/L</i>								
Control variable								
<i>FS</i>	-0,0127 (0,018)	-0,0127 (0,018)	-0,0126 (0,018)	-0,0127 (0,018)	-0,0013 (0,017)	-0,0016 (0,017)	-0,0014 (0,017)	-0,0017 (0,017)
<i>GS</i>	-0,0335 (0,023)	-0,0335 (0,023)	-0,0335 (0,023)	-0,0335 (0,023)	-0,0060 (0,022)	-0,0060 (0,022)	-0,0059 (0,022)	-0,0059 (0,022)

Dependent variable	<i>TFP</i>				<i>LP</i>			
	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
<i>HHI</i>	-0,0090 (0,017)	-0,0156 (0,017)	-0,0095 (0,017)	-0,0162 (0,017)	-0,0129 (0,016)	-0,0198 (0,016)	-0,0128 (0,016)	-0,0197 (0,016)
<i>EXPPRO</i>	0,0397*** (0,010)	0,0398*** (0,010)	0,0397*** (0,010)	0,0398*** (0,010)	0,0445*** (0,009)	0,0446*** (0,009)	0,0445*** (0,009)	0,0446*** (0,009)
Const.	-0,0203 (0,016)	-0,0267 (0,017)	-0,0089 (0,017)	-0,0142 (0,017)	-0,0151 (0,015)	-0,0207 (0,016)	-0,0157 (0,016)	-0,0200 (0,016)
Location fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	22755	22755	22755	22755	22755	22755	22755	22755
R ²	0,008	0,010	0,003	0,005	0,013	0,014	0,015	0,016
<i>F</i> test ^c	14,99***	13,34***	15,05***	13,38***	14,17***	12,91***	14,17***	12,90***
Breusch-Pagan test ^d	11445,41***	11431,41***	11379,01***	11351,64***	11019,47***	11022,43***	10888,26***	10879,70***
Hausman test ^e	83,98***	91,76***	84,77***	103,70***	75,50***	71,80***	69,01***	76,65***

(continued)

Table 5 (continued)

(b) Services

Dependent variable	Y				Y/L			
	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]
Spillover variable ^b								
<i>HORFDI2</i>	-0,0394 ** (0,020)		-0,0357 * (0,020)		0,1108 ** (0,045)		0,1126 ** (0,045)	
<i>HORFDI2N</i>		-0,0253 * (0,015)		-0,0226 (0,015)		0,0851 *** (0,033)		0,0786 ** (0,033)
<i>HORFDI3N</i>		0,0040 (0,008)		0,0062 (0,008)		0,0910 *** (0,019)		0,0793 *** (0,019)
<i>HORFDI4</i>		-0,0057 (0,009)		-0,0058 (0,009)		0,0447 ** (0,020)		0,0531 *** (0,021)
<i>BACFDI2</i>	-0,0954 ** (0,046)	-0,0907 ** (0,046)			0,2700 *** (0,104)	0,3375 *** (0,106)		
<i>FORFDI2</i>			-0,0478 (0,039)	-0,0479 (0,039)			-0,2784 *** (0,089)	-0,2759 *** (0,089)
Input variable								
<i>K</i>	0,1064 *** (0,002)	0,1064 *** (0,002)	0,1064 *** (0,002)	0,1064 *** (0,002)				
<i>L</i>	0,1398 *** (0,003)	0,1398 *** (0,003)	0,1398 *** (0,003)	0,1398 *** (0,003)				
<i>M</i>	0,7336 *** (0,002)	0,7336 *** (0,002)	0,7335 *** (0,002)	0,7335 *** (0,002)				
<i>K/L</i>					0,4809 *** (0,004)	0,4810 *** (0,004)	0,4812 *** (0,004)	0,4813 *** (0,004)
Control variable								
<i>FS</i>	-0,0149 (0,015)	-0,0146 (0,015)	-0,0147 (0,015)	-0,0145 (0,015)	0,0129 (0,034)	0,0124 (0,034)	0,0106 (0,034)	0,0098 (0,034)

Dependent variable	<i>Y</i>				<i>Y/L</i>			
	[17]	[18]	[19]	[20]	[21]	[22]	[23]	[24]
<i>GS</i>	0,0262 (0,018)	0,0261 (0,018)	0,0260 (0,018)	0,0260 (0,018)	0,0257 (0,039)	0,0264 (0,039)	0,0250 (0,039)	0,0256 (0,039)
<i>HHI</i>	-0,0316 (0,022)	-0,0306 (0,023)	-0,0298 (0,022)	-0,0283 (0,023)	-0,0179 (0,051)	-0,0110 (0,051)	-0,0154 (0,051)	-0,0138 (0,051)
<i>EXPPRO</i>	0,0420*** (0,009)	0,0421*** (0,009)	0,0427*** (0,009)	0,0427*** (0,009)	0,1164*** (0,020)	0,1173*** (0,020)	0,1143*** (0,020)	0,1147*** (0,020)
Const.	1,9116*** (0,034)	1,9056*** (0,034)	1,8899*** (0,031)	1,8858*** (0,031)	5,0519*** (0,058)	5,0050*** (0,058)	5,2547*** (0,050)	5,2368*** (0,050)
Location fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	48691	48691	48691	48691	48647	48647	48647	48647
R ²	0,967	0,967	0,967	0,967	0,522	0,527	0,532	0,536
<i>F</i> test ^c	17015,38***	14745,61***	17013,65***	14744,39***	1222,00***	1037,01***	1222,40***	1036,95***
Breusch-Pagan test ^d	29879,48***	29490,47***	29420,93***	29183,47***	35678,21***	35519,83***	35101,39***	34894,83***
Hausman test ^e	579,91***	717,37***	707,16***	786,71***	1400,11***	1363,16***	1619,65***	1636,13***

(continued)

(b) Services (continued)

Dependent variable	<i>TFP</i>				<i>LP</i>			
	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]
Spillover variable ^b								
<i>HORFDI2</i>	-0,0415** (0,020)		-0,0379* (0,020)		-0,0414** (0,018)		-0,0377** (0,018)	
<i>HORFDI2N</i>		-0,0258* (0,015)		-0,0235 (0,015)		-0,0180 (0,013)		-0,0151 (0,013)
<i>HORFDI3N</i>		0,0070 (0,008)		0,0087 (0,008)		-0,0076 (0,008)		-0,0051 (0,008)
<i>HORFDI4</i>		-0,0049 (0,009)		-0,0046 (0,009)		-0,0115 (0,008)		-0,0117 (0,008)
<i>BACFDI2</i>	-0,0801* (0,046)	-0,0730 (0,047)			-0,0990** (0,042)	-0,1011** (0,042)		
<i>FORFDI2</i>			-0,0574 (0,040)	-0,0578 (0,040)			-0,0449 (0,036)	-0,0454 (0,036)
Input variable								
<i>K</i>								
<i>L</i>								
<i>M</i>								
<i>K/L</i>								
Control variable								
<i>FS</i>	-0,0150 (0,015)	-0,0147 (0,015)	-0,0149 (0,015)	-0,0147 (0,015)	-0,0071 (0,013)	-0,0069 (0,013)	-0,0070 (0,013)	-0,0068 (0,013)
<i>GS</i>	0,0259 (0,018)	0,0259 (0,018)	0,0258 (0,018)	0,0258 (0,018)	0,0198 (0,016)	0,0197 (0,016)	0,0196 (0,016)	0,0196 (0,016)

Dependent variable	<i>TFP</i>				<i>LP</i>			
	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]
<i>HHI</i>	-0,0344 (0,023)	-0,0332 (0,023)	-0,0326 (0,023)	-0,0311 (0,023)	-0,0032 (0,020)	-0,0024 (0,021)	-0,0014 (0,020)	0,0001 (0,021)
<i>EXPPRO</i>	0,0397*** (0,009)	0,0397*** (0,009)	0,0402*** (0,009)	0,0402*** (0,009)	0,0342*** (0,008)	0,0342*** (0,008)	0,0349*** (0,008)	0,0349*** (0,008)
Const.	0,0373* (0,020)	0,0286 (0,020)	0,0245 (0,015)	0,0188 (0,015)	0,0579*** (0,018)	0,0548*** (0,018)	0,0331** (0,014)	0,0292** (0,014)
Location fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	48691	48691	48691	48691	48691	48691	48691	48691
R ²	0,001	0,016	0,001	0,001	0,001	0,001	0,001	0,001
<i>F</i> test ^c	43,31***	36,09***	43,22***	36,07***	29,72***	24,71***	29,31***	24,37***
Breusch-Pagan test ^d	29792,28***	29431,90***	29333,02***	29107,49***	26708,61***	26225,71***	25881,81***	25534,76***
Hausman test ^e	149,88***	274,82***	315,05***	385,60***	153,77***	319,94***	382,18***	482,80***

Notes: ^a All models are estimated using the fixed-effects estimator. White's heteroskedasticity-consistent standard errors are reported in parenthesis beneath the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

^b Lagged variable.

^c Null hypothesis: All coefficients are zero.

^d Null hypothesis: The variance of firm independent effects is zero.

^e Null hypothesis: The random-effects estimation is effective and consistent.

Source: Authors' estimation. For definitions and descriptive statistics of the variables, see Appendix.

Table 6
Estimation results by differentiating observations between fully
domestically owned firms and foreign joint-venture firms

(a) Fully domestically owned firms

Industrial sector	Manufacturing				Services			
Dependent variable	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>
<i>HORFDI2N</i>	0,0244 [*] (0,014)	0,0455 (0,029)	0,0241 [*] (0,014)	0,0222 [*] (0,013)	-0,027 5 [*] (0,015)	0,0696 ^{**} (0,034)	-0,0293 [*] (0,015)	-0,0185 (0,014)
<i>HORFDI3N</i>	-0,024 9 ^{**} (0,013)	0,0047 (0,026)	-0,025 1 ^{**} (0,013)	-0,0197 (0,012)	0,0081 (0,009)	0,0996 ^{***} (0,020)	0,0113 (0,009)	-0,0055 (0,008)
<i>HORFDI4</i>	0,0285 ^{***} (0,011)	0,0229 (0,023)	0,0284 ^{***} (0,011)	0,0335 ^{***} (0,010)	-0,007 6 (0,009)	0,0395 [*] (0,021)	-0,0069 (0,009)	-0,0114 (0,008)
<i>BACFDI2</i>	0,0138 (0,031)	0,0043 (0,064)	0,0068 (0,031)	0,0111 (0,030)	-0,086 5 [*] (0,049)	0,3005 ^{***} (0,111)	-0,0717 (0,049)	-0,0897 [*] (0,044)
N	20969	20978	20969	20969	46357	46306	46357	46357
R ²	0,973	0,582	0,009	0,012	0,966	0,523	0,002	0,002

(b) Foreign joint-venture firms

Industrial sector	Manufacturing				Services			
Dependent variable	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>
<i>HORFDI2N</i>	0,0564 (0,044)	0,0821 (0,077)	0,0495 (0,044)	0,0579 (0,037)	-0,016 4 (0,067)	0,3741 ^{**} (0,174)	0,0204 (0,069)	0,0050 (0,063)
<i>HORFDI3N</i>	0,0047 (0,041)	-0,0223 (0,071)	0,0080 (0,042)	-0,0080 (0,035)	-0,022 6 (0,032)	-0,0032 (0,078)	-0,0224 (0,033)	-0,0338 (0,030)
<i>HORFDI4</i>	-0,009 3 (0,036)	-0,0314 (0,062)	-0,007 9 (0,037)	-0,0106 (0,031)	-0,011 3 (0,041)	0,1294 (0,099)	-0,0037 (0,042)	-0,0369 (0,039)
<i>BACFDI2</i>	-0,149 1 (0,111)	-0,3201 [*] (0,195)	-0,123 7 (0,113)	-0,0213 (0,095)	-0,032 2 (0,165)	0,5114 (0,410)	0,0027 (0,171)	-0,0909 (0,156)
N	1786	1831	1786	1786	2334	2341	2334	2334
R ²	0,971	0,671	0,001	0,001	0,971	0,504	0,004	0,003

Notes: All models are estimated using the fixed-effects estimator. FDI spillover variables are lagged variables. For brevity, the coefficient estimates of other independent variables are not reported here. All specifications include a constant, location, year, and firm fixed-effects. White's heteroskedasticity-consistent standard errors are reported in parenthesis beneath the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Source: Authors' estimation. For definitions and descriptive statistics of the variables, see Appendix.

Table 7

Estimation results of FDI spillover variables computed using total turnover, total added-value, total equity capital, and annual average number of employees

(a) Total turnover

Industrial sector	Manufacturing				Services			
Dependent variable	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>
<i>HORFDI2TN</i>	0,0267** (0,013)	0,0085 (0,027)	0,0242* (0,013)	0,0243** (0,012)	-0,0329** (0,015)	0,0788** (0,034)	-0,0366** (0,015)	-0,0306** (0,014)
<i>HORFDI3TN</i>	-0,0172 (0,012)	0,0049 (0,025)	-0,0176 (0,012)	-0,0157 (0,011)	0,0041 (0,009)	0,1028*** (0,021)	0,0074 (0,010)	-0,0050 (0,009)
<i>HORFDI4T</i>	0,0100 (0,011)	0,0207 (0,021)	0,0121 (0,011)	0,0182* (0,010)	0,0044 (0,010)	0,0291 (0,023)	0,0034 (0,010)	0,0012 (0,009)
<i>BACFDI2T</i>	-0,0060 (0,029)	-0,0186 (0,058)	-0,0160 (0,029)	-0,0094 (0,027)	-0,0431 (0,041)	0,5523*** (0,094)	-0,0158 (0,042)	-0,0722* (0,038)
N	22755	22809	22755	22755	48691	48647	48691	48691
<i>R</i> ²	0,974	0,596	0,007	0,011	0,967	0,524	0,001	0,003

(b) Total added-value

Industrial sector	Manufacturing				Services			
Dependent variable	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>
<i>HORFDI2VN</i>	0,0300** (0,012)	0,0187 (0,024)	0,0264** (0,012)	0,0263** (0,011)	0,0077 (0,013)	0,1990*** (0,030)	0,0116 (0,013)	-0,0039 (0,012)
<i>HORFDI3VN</i>	-0,0267*** (0,009)	0,0078 (0,018)	-0,0243*** (0,009)	-0,0223*** (0,009)	0,0079 (0,008)	0,1283*** (0,017)	0,0128* (0,008)	0,0012 (0,007)
<i>HORFDI4V</i>	-0,0036 (0,009)	-0,0150 (0,018)	-0,0021 (0,009)	0,0015 (0,008)	0,0046 (0,009)	0,0511*** (0,020)	0,0062 (0,009)	-0,0056 (0,008)
<i>BACFDI2V</i>	0,0240 (0,029)	0,0333 (0,059)	0,0135 (0,029)	0,0134 (0,027)	-0,0441 (0,045)	0,4941*** (0,102)	-0,0145 (0,046)	-0,0670 (0,041)
N	22755	22809	22755	22755	48691	48647	48691	48691
<i>R</i> ²	0,973	0,596	0,006	0,011	0,967	0,531	0,003	0,001

(c) Total equity capital

Industrial sector	Manufacturing				Services			
Dependent variable	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>
<i>HORFDI2EN</i>	0,0202 (0,013)	0,0327 (0,027)	0,0159 (0,014)	0,0160 (0,013)	-0,0262** (0,011)	0,0356 (0,026)	-0,0300*** (0,011)	-0,0233** (0,010)
<i>HORFDI3EN</i>	-0,0103 (0,011)	0,0054 (0,022)	-0,0092 (0,011)	-0,0082 (0,010)	-0,0030 (0,008)	0,0158 (0,018)	-0,0012 (0,008)	-0,0084 (0,007)
<i>HORFDI4E</i>	0,0297*** (0,009)	0,0445** (0,019)	0,0281*** (0,009)	0,0286*** (0,009)	-0,0086 (0,008)	0,0246 (0,018)	-0,0087 (0,008)	-0,0149** (0,007)
<i>BACFDI2E</i>	-0,0525 (0,032)	-0,0948 (0,065)	-0,0702** (0,032)	-0,0525* (0,030)	-0,1074*** (0,042)	0,1231 (0,095)	-0,0993** (0,042)	-0,1062*** (0,038)
N	22755	22809	22755	22755	48691	48647	48691	48691
<i>R</i> ²	0,973	0,597	0,003	0,006	0,967	0,526	0,003	0,010

(d) Annual average number of employees

Industrial sector	Manufacturing				Services			
Dependent variable	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>	<i>Y</i>	<i>Y/L</i>	<i>TFP</i>	<i>LP</i>
<i>HORFDI2WN</i>	0,0172 (0,018)	0,0465 (0,036)	0,0155 (0,018)	0,0115 (0,017)	0,0139 (0,021)	0,1848*** (0,047)	0,0199 (0,021)	-0,0050 (0,019)
<i>HORFDI3WN</i>	-0,0245* (0,015)	-0,0016 (0,030)	-0,0256* (0,015)	-0,0211 (0,014)	-0,0076 (0,015)	0,0372 (0,034)	-0,0083 (0,015)	-0,0112 (0,013)
<i>HORFDI4W</i>	0,0328** (0,014)	0,0291 (0,028)	0,0300** (0,014)	0,0359*** (0,013)	0,0242* (0,015)	0,0195 (0,033)	0,0198 (0,015)	0,0030 (0,013)
<i>BACFDI2W</i>	-0,0093 (0,038)	0,0795 (0,078)	-0,0246 (0,039)	-0,0223 (0,036)	-0,1561*** (0,048)	0,1470 (0,108)	-0,1531*** (0,048)	-0,1568*** (0,044)
N	22755	22809	22755	22755	48691	48647	48691	48691
<i>R</i> ²	0,974	0,595	0,008	0,011	0,967	0,528	0,001	0,002

Notes: All models are estimated using the fixed-effects estimator. FDI spillover variables are lagged variables. For brevity, the coefficient estimates of other independent variables are not reported here. All specifications include a constant, location, year, and firm fixed-effects. White's heteroskedasticity-consistent standard errors are reported in parenthesis beneath the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Source: Authors' estimation. For definitions and descriptive statistics of the variables, see Appendix.

