Spillovers from Multinationals to Heterogeneous Domestic Firms: Evidence from Hungary ⋆

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Abstract

Firms cluster their economic activities to exploit technological and informational spillovers from other firms. Spillovers from multinational firms can be particularly beneficial to domestic firms especially in less developed economics, because technological superiority and management experience of foreign multinational firms yield various opportunities for learning. Yet, the importance of foreign firm's spillovers might vary with respect to two key features of domestic firms: their productivity level and its export status. In line with theories on the absorptive capacity of firms, we argue on the basis of an empirical analysis of Hungarian firms that larger and more productive firms are more able to reap spillovers from multinationals firms than smaller firms. The export status, in contrast, is of minor importance.

Keywords: FDI, multinationals, productivity, spillover, quantile regression.

JEL classification: F23, D21, D24, R12, R30

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1 Introduction

The large number of bilateral investment treaties between Central and Eastern European countries and OECD countries agreed on during the nineties and the various investment support schemes carried out since the early nineties suggests that political actors in the participating countries view multinational firms as welfare increasing and growth enhancing. It is widely believed that multinational firms increase competition, transfer technology and help to achieve more efficient allocation of resources. A major argument in this line of reasoning is that inward Foreign Direct Investment (FDI) increases domestic firms' productivity (and thus, enhances economic development) by creating linkages among domestic and foreign firms.

Most Hungarian firms are small relative to foreign-owned firms active in Hungary but quite a few have built successful relationship with these multinational firms. Such relationships have been essential for many Hungarian firms since multinational firms have often been the nucleus of successful development in Hungary. A success story from the automobile industry shall illustrate this claim. *Suzuki* has been one of the first multinationals to open a major factory in Hungary in the early nineties. The plant is situated in Esztergom, about 100km North from Budapest. This has made the county Komarom-Esztergom become home of a large motor vehicle cluster, with most SMEs situated in the industrial park by Esztergom. *Suzuki* was first followed by its Japanese suppliers (such as *Sumitomo*) but Hungarian firms such as *Tari-Prod Kft* (a hydraulics machinery producer) have also become suppliers to Suzuki or to other multinational suppliers of *Suzuki* [1]. Supplying Hungarian firms had to learn specific management procedures and were forced to apply quality management solutions.

In the paper, we argue that positive spillovers are generated by interaction with multinational firms. They are restricted to fairly small geographic area. *Spori Print V. Kft*, a printing firm that mentions its proximity to *Suzuki* (200

[1] Source: Esztergomi Ipari Park www.esztergon.hu / regioinfo.

meters) as a key advantage, can serve as an example. The firm has become *Suzuki*'s supplier of the year in 2004. *Spori Print V. Kft* has become supplier to other firms in the industrial park and after 2004, it started to export to neighboring Slovakia.

Linkages with foreign firms can create positive spillover effects on host country firms through learning, exchange of information, training, labor mobility or even technology transfer. Such spillovers from foreign firms are measured through foreign firms' effect on domestic firms' total factor productivity (TFP), which is the firm-specific component of a firm's technology. A difference in TFP between two firms can be the result of several factors, such as better use of inputs, more sophisticated sales methods, superior internal organizational structure or simply superior knowledge and information.

Explaining TFP differences by spillovers assumes that the presence of foreign firms creates additional knowledge, information and opportunities and thereby enhances this firm-specific component of domestic firms' technology. In the literature, several channels of positive spillovers have been identified, including labor mobility, supply chains, and face-to-face communication. Yet, while proximity to other producers, customers and suppliers can create a cost advantage for or raise the productivity of a domestic firm, it may also lead to increased competition and to exit of domestic firms.

The channels of spillovers certainly depend on the kind of linkages between domestic and the multinational firms. A natural differentiation divides the linkages into three different groups. First, firms *in the same* industry may benefit through *horizontal* spillovers. These might arise for instance through the movement of workers within industries. In addition, there may be *vertical* spillovers from multinationals operating *in other* industries. This type of external effect is usually attributed to buyer-supplier linkages. There are two types of vertical spillovers. Domestic firms may benefit through *backward* spillovers which are generated when serving customers in downstream industries. As the *Suzuki* example illustrated, foreign firms pass knowledge to their suppliers, in order to improve their suppliers' overall performance. The third

groups is formed by domestic firms' relationships to foreign suppliers. It has also been argued (e.g. Ethier (1982)) that access to better quality and greater variety of inputs improves a firm's performance. Hence, sourcing from foreign suppliers in upstream industries can generate *forward* spillovers. Yet, while better inputs improve the performance of a firm, an effect on this firms' TFP might be harder to find, because the measurement of TFP is based on the value added of the firm which excludes intermediate goods and services.

Empirical studies on spillovers in general have found ambiguous results. The empirical literature on FDI spillovers finds mixed support for the positive impact of multinational entry on domestic firms' TFP (Görg & Greenaway 2004). A large part of literature investigates the extent of horizontal productivity spillovers. Damijan et al. (2003), for instance, use firm level data for several transition countries, including Hungary, but find some evidence for positive spillovers only for Romania. Javorcik (2004) extends the spillover approach to backward linkages. Using firm level panel data for Lithuania from 1996 to 2000, she finds evidence of backward linkages. There is, however, no robust evidence from her analysis that domestic firms benefit from horizontal spillovers from multinational firms. Blalock & Gertler (2005) find the same evidence using Indonesian plant-level data. [2]

Certainly, firms react to foreign presence in a rather heterogenous manner. Javorcik (2004) cites surveys of Czech and Latvian firms prepared by the World Bank finding that different groups of firms emphasize different aspects of the contact to multinational firms. On the one hand, about a third of the domestic firms complained about direct losses from increased foreign presence. In total, increased competition was mentioned by 40%, and loss of market share was named by 29% of firms. On the other hand, about a quarter of respondents cited positive aspects such as learning about new technologies

[2] Further, Bosco (2001) finds horizontal spillovers either insignificant, or negative for Hungary. According to Aitken & Harrison (1999) and Konings (2001), negative horizontal spillovers arise when multinational firms attract demand away from domestic firms. Driffield et al. (2003) examine the relative importance of horizontal, backward and forward spillovers using an industry-level data for UK manufacturing during 1984 - 1992. They show evidence for positive spillovers through forward linkages.

(23%), learning about marketing (13%), or getting better employees (5%). Such effects might particularly arise if *horizontal* or *backward* linkages are strong. Czech and Lithuanian firms answered that there is little gain or pain when dealing with multinational suppliers in manufacturing. Less than 10% reported that foreign presence allowed for a better input mix. That refers to small perceived spillovers from *forward* linkages. Foreign multinational firms were asked for the local content of their sourcing. It turns out that many multinationals (46%) relied on their global suppliers. If locals are favored that is mainly due to lower costs (71%) or to proximity (30%).

We expect a similar pattern for Hungarian firms. Some can reap spillovers generated from linkages with multinational firms, other may not. That might result from different intensities of linkage or differences in the absorptive capacity of firms, i.e. their ability to learn from superior foreign firms. The competition effect, in contrast, might be felt by all firms alike. Our aim is to analyze how heterogeneity in domestic firms' productivity may affect the degree of spillovers from multinational to domestic firms. In addition, the export status of a domestic firm might be important. Arguments may work in both directions. An argument in favor of less spillovers reaped by exporters might stress that exporters have learned already in the foreign markets and do therefore not so much depend on foreign firms at home for spillovers. Contrarily, one might argue that being used to interact with foreign firms increases the ability to raise productivity when creating linkages with foreign firms also at home.

We use a large and extensive data set on Hungarian manufacturing firms. It entails information on domestic and export sales and on the ownership structure of all firms. Further, we have information on employment, capital and other firm-level characteristics that enable us to compute the TFP of each domestic firm. We work with an unbalanced panel of manufacturing firms for the period 1992-2003.

Our empirical analysis makes use of variables that have to be constructed in a first step. First, we compute the TFP of domestic firms using the semi-

parametric Olley & Pakes (1996) methodology. Second, we construct horizontal and vertical linkage variables following Javorcik (2004). Our linkage variables slightly differ from hers because we take the extreme view that spillovers from multinationals can only be reaped by domestic firms located in the same county, while she assumed country-wide spillovers.

We estimate the effect of linkages with foreign multinational firms on the *average* domestic firm's TFP using a firm fixed-effects panel model. The firm specific effects allow to control for the firm's technology, thereby isolating the spillovers effects. Then, we look at the difference in the spillover effect from linkages for firms that differ in productivity by estimating simultaneous quantile regressions. We study the differences between the spillover coefficients for groups of firms differing in their productivity.

As stated above, we assume that firms form linkages to multinational firms that are located in the same county. Thus, we assume that spillovers are only generated if geographical distance between multinational and domestic firms is small as has been suggested by Audretsch (1998). For Hungarian firms, this assumption is supported by Halpern & Muraközy (2005). They find strong positive spillovers to domestic firms that operate only on small distances (i.e. broadly at the county level).

The remainder of this paper is structured as follows. In Section 2, we ground our analysis in the literature. In Section 3, we introduce the Hungarian dataset and present some descriptive statistics. In Section 4, we present the estimation strategy. In Section 5, we discuss our results. We conclude in Section 6.

2 Spillovers and Heterogeneity

Our interest in the effect of firm heterogeneity on the ability to reap spillovers from foreign firms is first of all policy related. Since large foreign firms are often attracted using large amounts of tax payers money, it is important to analyze the conditions under which positive spillovers can be maximized and negative

effects kept as small as possible. There are different theoretical reasons to expect the extent of spillovers to vary with productivity. Unfortunately, there are theories that imply that more productive firms can reap more spillovers and those that imply less spillovers for more productive firms.

In the paper, we therefore analyze whether more productive and larger firms are able to reap more benefit from spillovers of multinational firms. Findlay (1978) denies that and argues based on a theoretical model that a greater technology gap allows for faster convergence of lagging firms to the technology frontier. This idea is widely applied in macroeconomics growth literature such as Barro & Sala-i Martin (1991). Many studies find that the potential to catch up is an important determinant of absorbed spillovers. Sjöholm (1999) for instance finds that FDI spillovers in Indonesia are greater in sectors with a high-technology gap. Griffith et al. (2004) study UK manufacturing and find support for the convergence hypothesis. Moreover, they find that a higher foreign presence within a particular industry yields more rapid convergence.

Focusing on the technological gap, i.e. the potential to catch up, assumes that reaping this potential is not the main concern. That view is challenged by research that puts learning in the center of the analysis. According to the hypothesis of a minimum absorptive capacity, some firms may be unable to learn, because their absorptive capacity is too small. *Absorptive capacity is a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability.* (Zahra & George 2002, p.186.) or using another definition, *firms ability to recognize valuable new knowledge, integrate it into the firm and use it productively* (Cohen & Levinthal 1990). We argue that identification, acquisition and exploitation may all depend on the firm's level of productivity.

(Girma et al. 2001) argue that a lack of sizable horizontal spillovers from multinationals to domestic firms might be explained by the lack of absorptive capacity of domestic firms. They may be unable to learn from multinational firms if the technological gap between the two groups is too wide. This is supported by evidence from UK establishments, where the strength of spillovers

rises in productivity (Girma & Görg 2005).

A third channel of spillovers from multinational firms runs through a competition effect. An increase in competition might encourage innovative activities. Aghion et al. (2005) argue that innovation that spurs competition is particularly important among peers. Given that innovation shall lead to higher productivity, some firms realize productivity gains. Firms that are near the technological frontier are therefore most likely to reap additional gains.

Yet, there is of course not only this indirect channel of competition, there is certainly also a direct competition from foreign multinational firms. Competition from foreign firms may affect domestic firms through the product market or the factor markets, especially the labor market. Competition in factor markets drives up factor prices while goods market competition drives down good prices. Both channels lead to a lower measure of productivity since value added falls. If economies of scale exist, lower sales reduce productivity. These effects of competition from multinational firms may be similar for all firms but the least productive. These firms might be forced to exit. See Kosova (2006) for example for a study on the impact of FDI on exit of Czech firms.

In table (1), we summarize hypothesis from theoretical considerations for three groups of firms differing with respect to productivity.

Table 1
Theoretical Considerations: Predictions.

	Least Prod.	Average	Most Prod.	Linkage type
1. Convergence	++	+	0	Hor, Vert
2. Absorptive capacity	0	0	+	Hor
3. Innovation	0	+	++	Hor, Vert
4. Competition	–	-	0	Hor, Vert

Spillover effects might also differ with respect to the export status of the domestic firm. (Kneller & Pisu 2007) looked at export spillovers using UK manufacturing data. Their results suggested that spillovers affected exporters and non-exporters in a different way. Further, it is found that export decision of domestic firms does not seem to be affected by the potential relationship between domestic and multinational firms. Yet, exporters' experience in export markets might explain why they deal better with spillovers of foreign

multinational firms (Bernard & Jensen 1999). That is particularly the case if learning is the main issue. However, it might also be possible that the foreign multinationals' spillovers at home are less important to exporters, because they also learn from firms in the foreign market. That argument holds if the catch up potential is more important.

Thus, theory does not provide unambiguous predictions on the effect, channel and importance of spillovers. Moreover, we did also not find a conclusive theoretical picture with respect to the effect of productivity of a particular firm on its ability to reap spillovers from foreign multinational firms [3]. Unfortunately, the empirical evidence on spillovers has not converged yet either ((Görg & Greenaway 2004)).

3 Descriptive Statistics

In this section, we describe the data and analyze the productivity distribution of Hungarian firms. Our analysis is limited to manufacturing firms. Moreover, we restrict the sample to those firms that meet certain data requirements that will be described in the first subsection. In the second subsection, we study the distribution of Hungarian firms with respect to size and productivity. As documented for other economies as well, exporters are larger and more productive than domestic firms over the whole size distribution. Foreign multinational firms are larger and more productive than Hungarian exporters. Hence, the necessary condition for learning is met. It is possible that Hungarian firms (non-exporter and exporter) learn from more productive foreign multinational firms. In the third subsection, we have a first look at the number of foreign multinational firms active in a particular Hungarian county.

[3] For surveys on export and productivity, see Wagner (2007) and Greenaway & Kneller (2007)

3.1 Data

We use a dataset of Hungarian firms, which is based on annual balance sheet data submitted to the Hungarian Tax Authority APEH [4]. The dataset contains information on *all* registered, double entry book-keeping firms. The data include the information of a firm's balance sheet and income statement. It entails information on sales, employment, total assets, labor costs, and equity ownership. It also includes information on each firm's sector classification (NACE rev-1, two-digit level) and on the location of the firm's headquarter. The data covers firms' activities between 1992 to 2003.

In Hungary, economic transition has lead to the entry of new domestic and foreign firms. The number of firms has risen substantially from 55,213 in 1992 to 226,072 in 2003. The sample we use in this study is smaller than the original APEH data for two reasons. First, we focus on manufacturing firms. Second, we drop very small firms because their data is unreliable and incomplete on employment and fixed assets, which are required to compute the TFP variable. That reduces the sample to 108,541 observations over 12 years. The number of firms in the sample rises from 6,003 in 1992 to 11,208 in 2003. The total dataset covers 42% of the total number of manufacturing firms and 73% of total turnover. We use a subsample that includes only the domestically-owned firms. It contains 66,470 observations from 11,767 firms for the period from 1993 to 2003. We loose the first year because calculating TFP requires data on the previous period. The summary statistics for all domestically-owned firms in our sample can be found in table (7) in the appendix.

3.2 Total Factor Productivity, Domestic and International Activities

The data allows to discriminate between firms according to their export status and their foreign ownership. We differentiate between four types of firms in the APEH database: domestic non-exporting firms, domestic exporters,

[4] See details in the Appendix

foreign-owned non-exporting firms and foreign-owned exporters. We define an exporter as a firm that exports at least 5% of its total sales and a foreign owned firm as a firm with at least 10% foreign stake. Results are robust to the choice of limits. We use the foreign ownership information to compute our horizontal and vertical spillover variables.

In 2002, the sample includes 8,650 domestically owned and 2,112 foreign owned firms. Exporters account for 27% of domestically owned firms and 74.0% of foreign owned firms. The foreign presence in Hungarian manufacturing is rather important. Foreign-owned Hungarian firms are responsible for about 28.6 billion euro (76.6% of total sales in our sample) compared with about 8.7 billion euros by domestically owned firms.

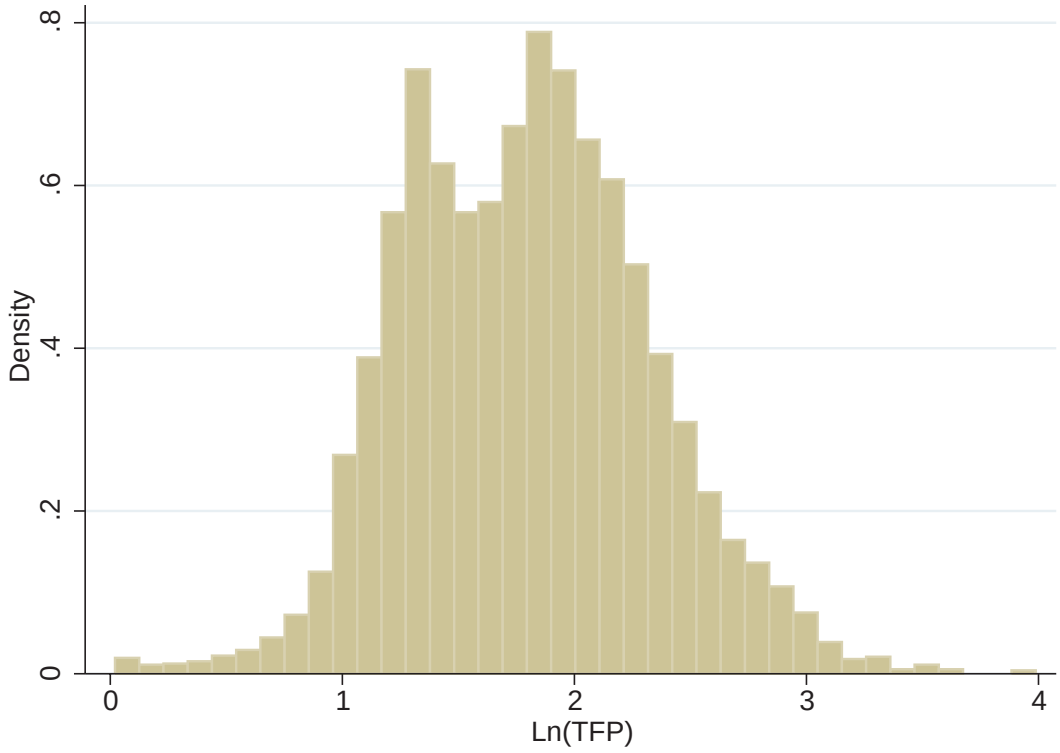
We are interested in the effect of spillovers from foreign firms on domestic firms TFP. To proxy TFP, we use the firm-level residual from a production function estimated at sector level. We use the Olley & Pakes (1996) (OP) semiparametric method to estimate firm-level TFP, a method that takes into account the endogeneity of capital input, exit of firms and unobserved permanent differences among firms. We assume a Cobb-Douglas production function

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \epsilon_{it} \tag{1}$$

and denote the logarithm of output (total sales), fixed asset capital, labor (employment) and intermediate inputs (materials) with y_{it}, k_{it}, l_{it} m_{it}, respectively. Subscripts i and t stand for the individual firm and time, ω_{it} denotes productivity, and ϵ_{it} stands for measurement error in output. For details, see the Appendix. Figure 1 shows the distribution of Hungarian firms' TFP. The distribution is right skewed. It is, however, not too far from log-normal.

For a closer look at the heterogeneity of Hungarian firms, we split the distribution of the logarithm of TFP in five intervals and report information on the corresponding number of domestic firms, export status and sales in Table 2. Table 2 shows two interesting facts. First, the most productive firms are not necessarily the largest with respect to sales. For the fifth ([2,3]) and the forth ([3,6.3]) interval, the share of interval sales in total sales is below their shares

Fig. 1. Distribution of Hungarian firms' TFP



Source: APEH, authors' computation.

in total number of firms. We expect sector differences behind this finding. Second, export participation increases with productivity. The share of exporters in total firms in the interval increases from 26.2% in the first interval to 41.2% in the fifth. The increase is even more impressive if export activities are measured in export sales instead of number of exporters. Both measures suggest that exporters are more productive than non-exporting domestic firms. The qualitative results of Table 2 are robust to changes in interval borders.

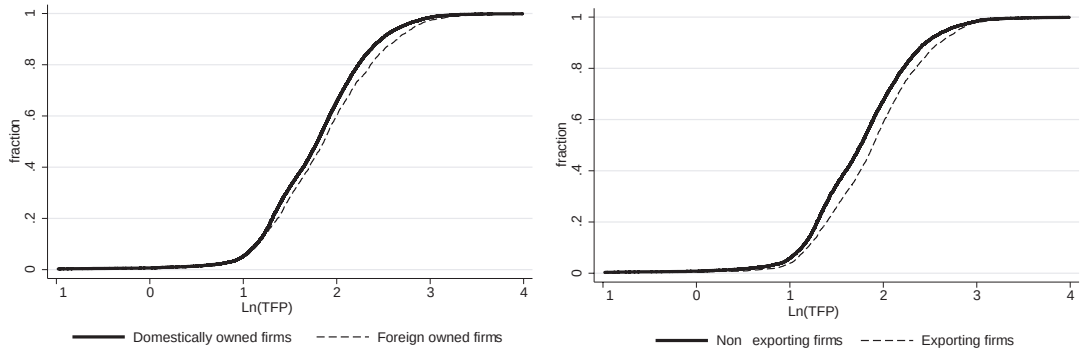
Before estimating spillover regressions, we first look at the productivity variation among groups. Taking sample means for the year 2000, foreign firms are more productive than domestically owned firms (1.88 vs 1.76), and exporters are more productive than non-exporters (1.89 vs 1.72). In Figure 2, we show the cumulative distribution of TFP for various groups. Panel (a) points to first-order stochastic dominance of foreign firms with respect to domestically owned ones, while panel (b) suggest the dominance of exporters over non-exporters.

Table 2
Breakdown of Hungarian Firms by Total Factor Productivity in 2000
(percentage into bracket)

$lnTFP_{it}$ interval	Number of firms	Number of exporters	Total Sales	Export Sales
$[-8.2, 0]$	61	16	4.E+06	6.45E+05
	(0.69)	(26.2)	(0.05)	(16.1)
$[0, 1]$	395	107	2.E+08	7.51E+07
	(4.46)	(27.1)	(2.36)	(37.5)
$[1, 2]$	5249	1738	5.E+09	3.07E+09
	(59.26)	(33.1)	(64.14)	(61.4)
$[2, 3]$	2995	1232	3.E+09	1.99E+09
	(33.82)	(41.1)	(32.49)	(66.3)
$[3, 6.3]$	157	65	8.E+07	5.90E+07
	(1.77)	(41.4)	(0.95)	(73.8)

Source: APEH, authors' computation. Sales figures in HUF million.

Fig. 2. **Cumulative Distribution of:**



(a) **Domestic vs Foreign owned** (b) **Non-exporters vs exporters**

Source: APEH, authors' computation.

In Figure 5 in Appendix B, we show the cumulative distribution of TFP and sales of domestically owned Hungarian firms according to their export status. Panel (a) of Figure 5 points to first-order stochastic dominance of exporters with respect to sales. Exporters are selling more than domestic firms over the whole distribution. A first-order stochastic dominance of exporters with respect to TFP is, in contrast, not apparent from Panel (b) of Figure 5.

We use the non-parametric Kolmogorov-Smirnov test (KS-test) to determine whether the sales and TFP distributions between the two groups differ significantly. The KS-test calculates the largest difference between the observed and expected cumulative frequencies, which is called D-statistics. These statistics

are compared against the critical D-statistic for the sample size. The results of the two-sided KS-test are shown in Table 8 in Appendix B. The KS-tests reveals that Hungarian exporters are larger and more productive than domestic firms.

3.3 TFP and Spillovers

Having documented that Hungarian exporters are more productive than domestic firms, we now turn to the most productive firms in Hungary: foreign multinational firms.

Transition countries in general, and Hungary in particular, offer a laboratory environment for studying spillover effects because the presence of foreign firms is rather impressive. Transition started before 1992 the starting point of our sample. Foreign firms entered Hungary as early as the 1989 through joint ventures and greenfield investment. The share of foreign production in manufacturing sales reached as much as 30% in 1992 already.

We examine whether domestic Hungarian firms (non-exporters and exporters) use their proximity to foreign multinational firms to learn from them or to increase their productivity in another way. We therefore first look at the productivity gap. Recall that theory proposed two opposite effects of a productivity gap on spillovers from multinational firms. First, a productivity gap is the first necessary condition for learning. The larger the gap the higher is the potential for the lagging firm. Second, the ability to reap positive spillovers from interaction with multinationals might depend positively on the firm's productivity.

We use again the KS-test to determine whether the sales and TFP distributions of foreign owned and domestically owned firms differ significantly. We present the comparison of foreign owned firms and the group of Hungarian exporters. The results of the two-sided KS-test are shown in Table 3. The KS-test reveals that the TFP distribution of foreign multinational firms stochastically dominates those of Hungarian exporters. Thus, there is a gap

between Hungarian and multinational firms with respect to TFP.

Table 3
KS-Test of Differences between foreign multinational firms and Hungarian Exporters. TFP, 2000

		TFP	
Group	Largest Difference	P-value	Corrected
$Ho: MNE - Exp \leq 0$	0.0474	0.020	
$Ho: Exp - MNE \leq 0$	-0.0111	0.809	
Combined K-S	0.0474	0.041	0.037

Yet, we expect spillovers not only to depend on domestic firms' productivity but also on the intensity of interactions with multinationals. We expect these interactions to decrease in distance and assume for our empirical analysis that interactions take place only between firms located in the same county. We therefore look at multinationals' geographic location in Hungary below.

There is substantial sectoral as well as regional heterogeneity in terms of foreign presence. Whereas in *Vas*, a Western county, foreign firms were responsible for two-third of sales in 1992, this share was just over 10% in *Hajdu-Bihar* county, in the South-East of the country. In 2002, almost 90% of manufacturing production in *Vas* was carried out by non-domestic firms, and the lowest shares of multinationals in a county rose to 42%-48% in *Bekes*, *Bacs-Kiskun*, *Veszprem*. Figure (7) in Appendix B shows that Western counties have in general a higher share of foreign firms, while the Eastern and South-Eastern counties have a rather low share of foreign owned firms. There is enough variation at the level of the county to infer effects of spillovers on firm's productivity.

The presence of multinational firms differs strongly between industries. In the production of motor vehicles, non-domestically owned firms were responsible for over 98% of output in 2002 compared with just over 17% in press, 57% in raw materials, and 65% in machinery and equipment.

In the next section, we study the relationship of the share of multinational firms in total firms of a particular industry in a particular county and the TFP of Hungarian firms in that county. For a first impression, we regress the logarithm of firm level TFP of domestic firms on the share of multinational

firms in sector j of county l, N_{jlt}.

$$TFP_{ijlt} = 0.0692^{***} N_{jlt} + \nu_j + \nu_l + \nu_t \tag{2}$$

We find a positive correlation between the share of multinational firms in a county and the average firm-level TFP of firms located in that county. The share of multinational firms and the fixed effect explains 49.7% of the TFP's cross variation.

4 Empirical Analysis

We want to explain systematic variation in firms' TFP by spillovers from multinational firms which are not observable. We expect spillovers to stem from linkages with foreign multinational firms and proxy therefore the potential of spillovers by the share of multinational firms per county.

4.1 Horizontal and Vertical Spillovers

The total factor productivity of a firm reflects its technology. Apart from its own technology, the productivity of a firm might also be affected by sectoral linkages and local competition. In this study, we examine the effect of horizontal linkages, of backward and of forward linkages and of local and sectoral competition on firm-specific productivity. Thereby, we describe the logarithm of the TFP of a domestic firm i, in sector j located in a county l at time t, TFP_{ijlt}, by equation (3)

$$TFP_{ijlt} = \alpha H_{jlt} + \beta_1 B_{jlt} + \beta_2 F_{jlt} + \gamma C_{jlt} + \chi Psh_{it} + \nu_i + \nu_j + \nu_t \tag{3}$$

TFP_{ijlt} has been computed using the semi-parametric estimation suggested by Olley & Pakes (1996). The methodology is explained in Appendix A. It allows to take into account the endogeneity of the inputs in the production function. The endogeneity issue arises because inputs are chosen by a firm

based on its productivity.

H_{jlt}, B_{klt}, F_{klt} and C_{jlt} represent local Horizontal, local Backward and Forward linkages and local and sectoral Competition, respectively. We focus on spillovers and competition within a specific county and assume that they arise from the presence of multinational firms in the same county. The variable Psh_{it} stands for the Privatization $sh$are at firm-level (which can change year by year). Since we want to quantify the impact of spillovers at sectoral level on firm-specific total factor productivity, we control for the technology of the firm by introducing firm-specific effects, ν_i. Since the firm specific TFP might also be driven by unobserved sectoral specific shocks, we include a set of sector dummy variables, ν_j. We also assume that firm-specific TFP is affected by macroeconomic shocks and include a set of time dummy variables ν_t to control for it. In addition, the time dummy variables control for the average change of productivity that is not due to the spillovers.

Horizontal spillovers occur when entry or presence of multinational firms lead to an increase in productivity of domestic firms active in the *same* industry. They result, for instance, from intra-sectoral movement of workers who take some industry-specific knowledge with them. As in Javorcik (2004), we assume that horizontal spillovers increase with the foreign presence in sector j at time t. We assume, however, that horizontal spillovers are county-specific. We proxy the potential for spillovers by the share of multinational firms in total activities. For each county l, H_{jlt} is defined as foreign equity participation averaged over all firms in the sector, weighted by sector output in the county. Thus, we define horizontal linkages H_{jlt} as

$$H_{jlt} = \left[\sum_{i \in j,l} share_{it} * Y_{it} \right] / \sum_{i \in j,l} Y_{it} \tag{4}$$

where $share_{it}$ is the share of firm's total equity that is foreign owned. Y_{it} is the output of firm i at time t.

Vertical spillovers can arise from multinational firms' presence in backward or forward industries. Linkages with suppliers and customers might increase the

efficiency of a firm. We compute backward linkages with multinational firms (i.e. domestic firms supplying to foreign firms) as

$$B_{jlt} = \sum_{k \neq j,l} \theta_{jk} H_{klt} \tag{5}$$

where θ_{jk} is the fraction of industry j's output shipped to sector k. This information is taken from the 1998 input-output table at the two-digit NACE level. The results do not change if we the use the revised 2000 version to compute the linkage variables. As in Javorcik (2004), the output shipped within the sector is excluded in the computation since this effect is already captured by the horizontal spillovers variable.

Forward linkages (i.e. domestic firms purchase goods from foreign firms) are defined as the weighted foreign share in output in the supplying industries.

$$F_{jlt} = \sum_{m \neq j,l} \theta_{mj} H_{mlt} \tag{6}$$

θ_{jm} is the share of inputs purchased by industry j from industry m in total inputs purchased by industry j. We again exclude the input purchased within the sector because these linkages are captured by the horizontal spillovers variable.

We capture a potential competition effect by the Herfindahl index. We calculate the Herfindahl indices for all year, sector and county combinations and denote it C_{jlt}. We expect competition to exert a positive effect on TFP. The mode of ownership might also influence the TFP of domestic firms. According to Brown et al. (2006), privately owned firms are more efficient than state-owned firm. We therefore control for the mode of ownership at firm level by including the privatization share.

4.2 Estimation Strategy

The heterogeneity in the firm-level data is large. This suggests that we should not start from the assumption of a representative firm. We take therefore the

heterogeneity explicitly into account when studying the effects of multinational spillovers on domestic firms. We deal with it in our empirical analysis in two ways. First, we look at the *average* impact of spillovers and competition on domestic firms. Therefore, we use a firm fixed-effects panel model. While firm heterogeneity is collected in the firm fixed effects, coefficients of H_{jlt}, B_{jlt}, F_{jlt} and C_{jlt} give the average effects of spillovers and competition. Thus, we first ignore differences in the effect of spillovers and competition among firms. Second, we allow spillovers and competition effects to differ between well defined groups of firms but not among firms within each group. We do this by estimating a simultaneous quantile regression model. Unlike the least squares estimator that assumes covariates shifting the location of the conditional distribution only, quantile regression allows us to analyze the possible effects on the shape of the TFP distribution.

In fixed-effects specifications, heteroscedasticity and serial correlation are always potential problems. The possible bias is larger the longer the time horizon. Since we have short time-series and a large cross-section, it is appropriate to use cluster-sample methods (Wooldridge 2003, Arellano 1987) to estimate the fixed-effects model. Cluster-sample methods are a generalization of White's (White 1980) robust covariance matrices. The obtained robust variance matrix estimator is valid in the presence of heteroscedasticity and serial correlation provided that, as in our case, T is small relative to the number of groups (Wooldridge 2002, 2003). The fixed effects panel estimation allows to control for the unobserved heterogeneity among domestic firms in the sample. Since our endogenous variable is an estimate itself, we bootstrap the standard errors in a robustness check. This does not alter the significance of the estimated coefficients.

In addition to analyzing differing spillover effects on firms characterized by different levels of TFP, we examine the effect of the export status on firms TFP. As we have shown in Section 3.2, exporting firms are more productive than non-exporters. That might on the one hand decrease the exporters' potential for learning from foreign multinational firms, because more productive firms

are already closer to the most efficient technology. On the other hand, learning might be easier because the absorptive capacity of more productive firms is larger. In either way, exporters might be affected differently by foreign multinational firms' spillovers than non-exporting domestic firms. Moreover, there is a second dimension why exporters might reap spillovers to a larger degree: their international experience. Being used to interactions with partners in foreign countries might also ease interaction with foreign multinational firms at home. We therefore test whether spillovers have a different effect on exporters than on non-exporting domestic firms in a second fixed effects specification.

The simultaneous quantile regression methodology allows a closer look at the impact of the spillovers on the productivity of domestic firms. We split the firms into twenty groups sorting them with respect to their productivity. We assume that firms within each group are affected identically by spillovers and by competition while the effect between groups might vary. Hence, we test whether spillovers and competition have different impact in different groups. The bootstrapped variance-covariance matrix takes into account the errors correlation between the different quantiles and allows us to compare coefficients of the explanatory variables in the different quantiles (Koenker & Hallock 2001). We estimate a simultaneous quantile regression model, which is specified as

$$Quant_{\Theta}\left(TFP_{ijlt}|X_{ijlt}\right) = X_{ijlt}^{'}\beta_{\Theta} \tag{7}$$

where X_{ijlt} is the vector of independent variables specified in equation (3) and $Quant_{\Theta}\left(TFP_{ijlt}|X_{it}\right)$ the conditional quantile of TFP. The distribution of the error term ν_{ijlt} is left unspecified so the estimation method is essentially semiparametric. Koenker & Bassett (1978), introducing this technique, show that β_{Θ} can be estimated by

$$min_{\beta}\{\sum_{ijlt:TFP\geq X'\beta}\Theta|TFP_{ijlt}-X_{ijlt}^{'}|+\sum_{ijlt:TFP<X'\beta}(1-\Theta)|TFP_{ijlt}-X_{ijlt}^{'}| \tag{8}$$

The main advantage of the quantile regression approach is that it allows different slope coefficients to be estimated for different quantiles of the conditional

distribution of the TFP variable. Since Θ varies from 0 to 1, we trace the entire distribution of TFP conditional on the set of independent variables. As emphasized in Girma et al. (2004), quantile regressions provide a robust alternative to OLS when as in our case, the error terms are non-normal. The tests of normality of the TFP distribution, as well as a skewness and kurtosis test, reject the log-normal distribution of TFP. Tests of normality reject a log-normal distribution of establishment-level TFP for any given year and for all domestic-owned firms. [5]

5 Results

We first present the results from the fixed effects regressions discussing the effect of the particular productivity level of a firm and its export status on spillovers from multinational firms. We compare the results to Javorcik's Lithuanian study. Then, we turn to the quantile regressions also presenting results for the whole sample and domestic firms and exporters separately.

5.1 Average Impact of Spillovers on Domestic Productivity

We estimate the average impact of the spillover variables on the domestic firm using a firm fixed effects panel model. Since a firm does not change its sector and its county over time, the firm fixed-effects are perfectly collinear with the sector and county fixed-effects. We thus estimate equation (3) without introducing sector and county fixed-effects. The results are presented in Table 4. In the first specification (S1), we show the results of the average spillovers and the competition effect on Hungarian firms without separating domestic firms and exporters. In the second specification (S2), we interact the average impact of spillovers on TFP with the exporting status of the firm. We thereby

[5] The Shapiro and Francia test (Shapiro & Francia 1972), designed for a smaller sample size, yields a p-value of 0.000 to 0.013 for any given year and a p-value of 0.000 for all but two sectors, while the skewness and kurtosis test of D'Agostino et al. (1990) for the whole sample gave a p-value of 0.000.

Table 4
Firm-Level Fixed Effects Panel Regression - Dependent Variable:$lnTFP$

	Labels	(S1)	(S2)
Horizontal Spillovers	H_{jlt}	0.0411**	
		(2.41)	
Backward Spillovers	B_{jlt}	-0.0047	
		(0.10)	
Forward Spillovers	F_{jlt}	0.0392	
		(1.38)	
Herfindahl Index	C_{jlt}	-0.0684**	-0.0660**
		(2.41)	(2.34)
Privatization Share	Psh_{it}	0.0660***	0.0660***
		(4.25)	(4.26)
Horizontal Spillovers×Exporter	$H_{jlt} \times Exp$		0.0344
			(1.64)
Backward Spillovers×Exporter	$B_{jlt} \times Exp$		0.1681***
			(2.60)
Forward Spillovers×Exporter	$F_{jlt} \times Exp$		0.0181
			(0.55)
Horizontal Spillovers×Domestic	$H_{jlt} \times Dom$		0.0437**
			(2.36)
Backward Spillovers×Domestic	$B_{jlt} \times Dom$		-0.0545
			(1.10)
Forward Spillovers×Domestic	$F_{jlt} \times dom$		0.0426
			(1.44)
Time Fixed Effects	Yes	Yes	Yes
Observations		66470	66470
Number of groups		11767	11767
Within R-squared			

Robust t-statistics in parentheses.
Standard errors have been adjusted for clustering around the firm's identity.
*** denotes statistical significance at one percent level od significance.
** denotes statistical significance at five percent level of significance.
* denotes statistical significance at ten percent level of significance.

separate the effect of spillovers from multinational firms on exporters and non-exporting domestic firms.

Specification (S1) of Table (4) shows that the average impact of horizontal spillovers is positive and significant. Therefore, the potential technology transfer from multinationals to domestic firms in the same sector outweighs the competition effect that arises from the multinational presence. The average impact of forward spillovers is positive but remains statistically insignif-

icant. The coefficient of the backward spillovers variable is very close to zero and insignificant. Both the significant positive effect of horizontal spillovers and the insignificant effect of vertical spillovers differ from Javorcik's results on Lithuanian firms. Turning to the average impact of competition on total factor productivity, we find that a higher Herfindahl index reduces the productivity of domestic firms. Thus, as expected, more competition yields more productive firms. Moreover, as found in Brown et al. (2006), the firm-level privatization share has a positive and significant impact on TFP.

The coefficients of the Herfindahl index and the privatization share variables are robust to the inclusion of the interaction term between the spillover variables and the export status dummy variables in specification (S2) of Table 4. We do not find a statistically significant effect of horizontal spillovers from multinational firms to exporters, while the coefficient of the interaction term between the horizontal spillovers variable and the domestic firms is statistically significant. For backward linkages, the average impact is positive and statistically significant for the exporters only. Thus, the results for Hungarian exporters are similar to Javorcik's findings. The results for non-exporters, in contrast, differ from hers.

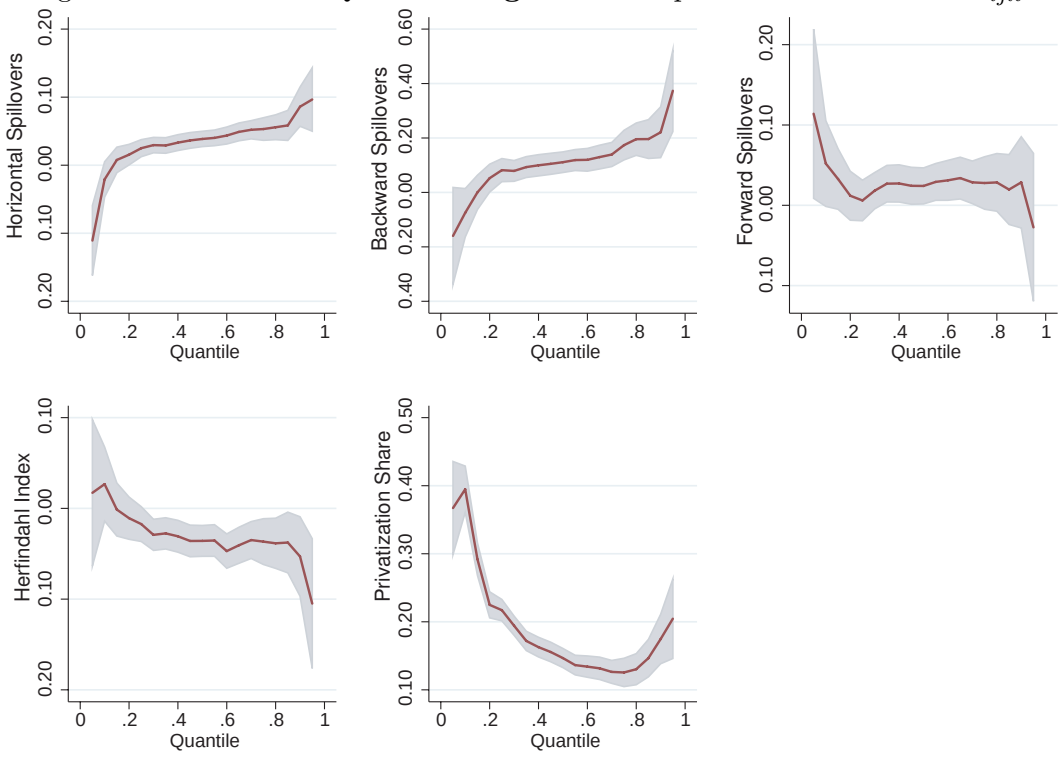
5.2 Impact of Spillovers on Heterogenous Domestic Firms

In this subsection, we employ quantile regression to study how different productivity levels affect spillovers from foreign multinational firms. The fixed effect regressions infer the average effect on a Hungarian firm. Yet, if firms ability to benefit from foreign multinationals is very different, the average might not be very informative. If the ability changes with the firms' productivity level, quantile regression allow to estimate group-specific effects.

We split the distribution of the logarithm of TFP in twenty quantiles and estimate a simultaneous quantile regression. We assume therefore that spillovers and competition effects differ between groups of firms but not within each group. The estimation results are presented in Figure (3). In each subfigure,

we present the estimated coefficient of each variable on the vertical axis and the corresponding quantile of $lnTFP_{ijlt}$ on the horizontal axis. The first quantile of the distribution contains information on the least productive firms, while the last quantile contains information on the most productive firms.

Fig. 3. **Simultaneous Quantile Regression**: Dependent Variable $lnTFP_{ijlt}$



Estimated coefficient on the vertical axis. Quantile of $lnTFP_{ijlt}$ on the horizontal axis. Source: APEH, authors' computation.

Figure 3 shows that horizontal spillovers have a negative impact on the least productive firm. The effect is significantly positive in contrast for the most productive firm. Moreover, the effect increases monotonically over the whole distribution of TFP. Based on the theoretical considerations from above, we suspect two possible reasons for this finding. First, absorptive capacity in learning is more important than catch-up potential in our analysis. The negative effect on the least productive firm stems from their low level of absorptive capacity. Second, in line with Aghion et al. (2005) competition from multinational firms stimulates innovation among domestic firms that have high level of productivity. Hence, we argue that the larger the productivity gap between the domestic and foreign firms, the less likely is the domestic firms to gain

from foreign multinational firms in its own sector.

The picture for backward spillovers looks very similar. We find a negative impact of backward spillovers on the least productive firm, whereas this impact is positive and significant for the more productive firms. The positive impact of backward linkages is increasing with the productivity of the domestic firm. Multinational firms might have stronger linkages to more productive firms in their downstream sectors. These firms are provided with knowledge in order to obtain higher quality or less expensive goods. Moreover, increasing foreign presence in the upstream sectors redirects intermediate inputs supply away from least productive firms toward more productive firms in the downstream sector. Horizontal and backward spillover effects increasing in domestic firms' productivity is in line with Girma et al. (2004) findings on UK establishment.

Contrary to Javorcik (2004), we find a positive although small impact of forward spillovers on the productivity of domestic firms. The effect is larger for the least productive firms and insignificant for the most productive firms. The positive effect might stem from a higher quality of inputs purchased from multinational firms.

The Herfindahl index has a positive but insignificant impact on the least productive firms and a negative impact on TFP of more productive firms. Finally, the results suggest a positive correlation between the privatization share and the level of productivity of domestic firms. The impact of privatization is larger the less productive the domestic firm is.

Spillovers might take time to exercise their impact on TFP. For example, an increase of output by foreign firms may lead to increased interaction with domestic firms at time t, but it is only in time $t+1$ when this relationship bears fruit. Thus, we ran our basic regression with all spillover variables lagged by one year. Results given in Figure 8 in the Appendix do not differ much. If anything, the "slope" of the backward spillover variable seems slightly stronger.

As a robustness check, we split the distribution of the logarithm of TFP in 10 deciles and run fixed effect panel regressions for each deciles. Basic results

are presented in Figure 6 of the Appendix. They confirm that more productive firms reap greater benefit from backward and to a less extent horizontal spillovers than less productive firms.

5.3 Impact of Spillovers on Exporters and Non-exporters

Finally, we separate the effect of spillovers from multinational firms on exporters and non-exporting domestic firms by additionally including an interaction term between the spillovers variables and an exporter dummy variable and a non-exporter dummy variable, respectively.

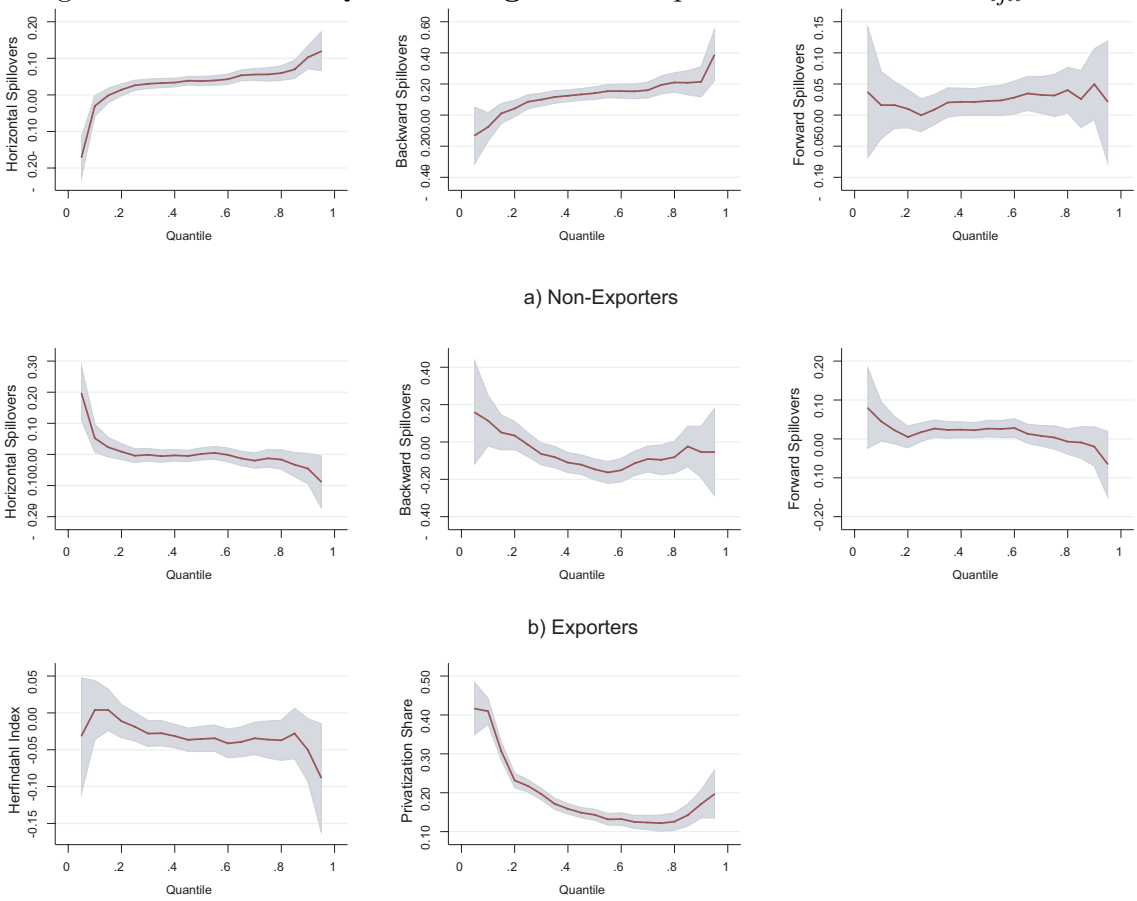
The results are reported in Figure 4. The upper panel of Figure 4 show the coefficients of spillovers from multinational firms to domestic non-exporting firms. Figure (3) and the upper panel of Figure (4) are very similar. That suggests that the effect on all Hungarian firms is mainly driven by the non-exporting firms. The middle panel shows the coefficients of the spillovers effect on exporters. The bottom panel shows the coefficients of Herfindahl index and of the privatization share variables.

We can statistically distinguish the impact of spillovers from multinational firms by the export status of domestic firms for some quantiles. Most non-exporting Hungarian firms receive horizontal spillovers from multinational firms. The effect of spillovers on TFP increases in productivity.

With respect to backward linkages, the panel in the second column show that non-exporters gain from positive spillovers if their productivity places them at least in the third decile. Exporters' pattern has a slight u-shape, but significant gain from productivity takes place in the upper third of the distribution only. Forward spillovers are very similar for the two groups. They are slightly positive or zero.

The productivity advantage of exporters that we reported in Section 3 does therefore not result from higher spillovers that exporters as such receive from multinational firms relative to non-exporters.

Fig. 4. **Simultaneous Quantile Regression**: Dependent Variable $lnTFP_{ijlt}$



Estimated coefficient on the vertical axis. Quantile of $lnTFP_{ijlt}$ on the horizontal axis. Source: APEH, authors' computation.

Supporting the results from the fixed effects regression, the quantile regressions revealed no larger spillovers for exporters than for non-exporting domestic firms. Hence, larger spillovers from multinational firms are not a reason for the higher TFP of exporters. Thus, exporters might receive additional spillovers in the foreign market which increases their TFP, but we did not find support for higher spillovers received by exporters at home.

There are two possible explanations for these findings. First and probably most important, the higher TFP of exporting firms relative to non-exporters is explained by the fact that more productive firms self-select into exporting (as in Melitz 2004) Thus, exporting status *per se* gives no reason for a difference in the effect of spillovers in addition to the higher TFP level of exporters. Second, exporters might receive additional spillovers in the foreign market which increase their TFP but do not show up in above average spillovers in

Hungary.

6 Conclusions

We examined the impact of the presence of foreign multinational firms in a particular Hungarian county on the productivity of Hungarian firms in the same county. We searched for horizontal spillovers from multinational firms in the same sector, backward spillovers from multinationals that are customers of Hungarian firms and forward spillovers from multinationals that are input suppliers. We used a sample of 11,767 Hungarian firms and their activities between 1993 and 2002. For this sample, we found significant horizontal spillovers in a firm level fixed effect regression but no evidence of backward and forward spillovers.

Yet, average spillover effects over all firms might not be very informative if Hungarian firms are very heterogeneous and this heterogeneity affects the size of the spillovers. We documented great heterogeneity among Hungarian firms with respect to their productivity and size and analyzed whether more productive and larger firms are able to reap more benefit from spillovers of multinational firms than less productive smaller firms. We used simultaneous quantile regression to analyze group specific effects with groups defined with respect to productivity. We found significant differences among the groups with more productive firms receiving more horizontal and backward spillovers from foreign multinational firms but less forward spillovers than less productive firms.

We studied a second obvious characteristic in which firms differ: their export status. The export status is not independent from productivity since only more productive firms start exporting to foreign market. We expected export status to have an effect for two reasons. First, exporters are more productive, and second, exporters are used to interact with foreign firms and therefore possibly able to gain more from the presence of foreign multinational firms in Hungary. In a fixed effects regression which separates the spillover

effects on exporters and non-exporters, we found significantly positive backward spillovers of multinational firms on Hungarian exporters but no effect on Hungarian non-exporters. Horizontal spillovers in contrast were only significant for non-exporting firms. In line with the results from the fixed effects regression, the quantile regressions revealed no larger spillovers for exporters than for non-exporting domestic firms.

We argued that several theories have been put forward to motivate differing effects for heterogeneous firms. We found that the most productive firms gain the most, while the least productive are actually negatively affected by proximity to foreign firms. This supports the idea of an absorptive capacity necessary to reap positive spillover effects. The role of peer pressure on innovative activities of most productive firms is also supported. Convergence of the *least* productive firms, in contrast, does not receive support by our data.

Overall, we found that heterogeneity in terms of productivity affects domestically owned firms' capacity to absorb knowledge and achieve higher productivity.

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7 Appendix

In the appendix, data cleaning is described in detail, and productivity estimation is discussed.

7.1 Data cleaning

First note, that the APEH data provide information of firms with non-consolidated accounts. Thus, a manufacturing firm can mostly be considered as an establishment: i.e. a headquarter and a plant. For details, see Békés (2005).

This version of the dataset comes from the Central European University - Labor Project and is based on a dataset managed by the Magyar Nemzeti Bank. Several steps have been made to improve the consistency of the dataset. The initial dataset were exhaustively cleaned by the CEU Labor Project and the authors.

Non-surprisingly in a transition economy, firms frequently changed their attributes. First, we had to define manufacturing firms and their sector classification to avoid firms appearing/disappearing based on their statistical status. A sector was defined based on the NACE 2-digit code a firm most often used. A firm was kept in manufacturing if it spent 75% of its time in the sample as a manufacturer. Second, longitudinal links for firms had to be improved using data provided by Hungarian statistics office KSH on corporate entry and exit. These are cases, when a firm changes its identification code but remains basically the same. This is especially frequent phenomenon in transition economies such as Hungary, see Brown et al. (2006). Other longitudinal links were investigated where firms did not simply appear under a new code but actually split up into several firms or were formed via a merger. These allowed keeping track of most but not all of firms under transformation. Further, small firms (ones that never had as many as 5 employees) had to be dropped for the well-documented lack of reliable data (see Katay & Wolf (2006)) We discarded 58% of firms for missing or unreliable data. Otherwise, no outliers were dropped.

We made several fixes, too. Obvious typing errors were corrected. In order to ensure that small firms are not dropped for missing data in employment or fixed assets, for missing years we replaced these variables with the mean of their (t-1) and (t+1) values. This was the case for 1175 occasions for employment and 206 cases for fixed assets. Ownership also had to be cleaned for the

large number of missing observations (filled in case of equality of the (t-1) and (t+1) values) and typos.

The capital variable was created and corrected following suggestions in Katay & Wolf (2004). Importantly, capital was recalculated by the perpetual inventory method (PIM). The reason for this is that capital stock should be registered at market prices. This is not the case in Hungary, where the stock enters the balance sheet on the book value. Without information on the composition of the capital, actual data represents a mixture of various kinds of assets in terms of age and readiness to use. Hence, the need to recompose the capital stock by the PIM using an initial condition (i.e. first year of investment) and a capital accumulation equation to reconstruct the stock of capital. As a result, investments are deflated by the investment price deflator, and then, the rate of depreciation is used to get K, the capital stock. Thus:

$$K_{i,t} = K_{i,t-1} * (1 - Depreciation_{i,t}) + Investment_{i,t} \tag{9}$$

Description of variables are presented in table 5.

Note that one may consider various other variables for the productivity estimation, such as using labor productivity of output instead of TFP. However, a meta analysis of Diebel & Wooster (2006) suggests that there is no great difference in terms of results, with TFP being the hardest to find significance with. In terms of measuring foreign share, employment as a weight is more likely to yield higher impact than output (used here).

7.2 TFP Measurement

We use the Olley & Pakes (1996) (OP) semiparametric method to estimate firm-level TFP. This method allows robust estimation of the production function. It takes into account the endogeneity of some inputs, the exit of firms as well as the unobserved permanent differences among firms. The main assumption the OP technique relies on, is the existence of a monotonic relationship between investment and firm-level unobserved heterogeneity. Table (6) gives an account of estimated coefficients.

We consider the following Cobb-Douglas production function

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \omega_{it} + \epsilon_{it}$$

and denote the logarithm of output, capital, labor and intermediate inputs

Table 5
Description of variables

Variable	Details	Source
Output	Net sales by the firm, deflated by sectoral PPI deflators	APEH:income statements
Capital	Fixed assets capital generated and corrected by the perpetual inventory method, following suggestions in Katay and Wolf (2004, 2006)	APEH: income statements
PPI	Producer price deflator, sectoral level	KSH
Ownership	Foreign-owned firms: at least 10% of equity capital is owned by non-residents. (NB. Distribution of the status is bimodal, and results are insensitive to the threshold.)	APEH:balance sheets
Private share	Share of equity capital owned privately (i.e. non-state and non-municipal owners	APEH: balance sheets
Export status	Exporter firm is defined if net export sales reached at least 5% of total net sales. (NB. Distribution of the status is bimodal, and results are insensitive to the threshold.)	APEH:income statements
Investments	Change in fixed assets, reduced by a sector specific depreciation rate calculated from the data, deflated by investment input prices. (NB. Results robust to flat depreciation rate)	APEH: income statements
Investment price deflator	Estimated by authors based on 80% machinery and 20% property price deflators	KSH, authors
Depreciation rate	Directly is estimated from the APEH data. To see robustness of the APEH data, an average of 20% was used, without sizeable impact	authors calc.
Labor	Average annual employment in the given year	APEH:income statements
Materials	All materials, calculated following Katay-Wolf (2006) who advised on how to take care of changes in the accounting law in 2001.	APEH:income statements

with y_{it}, k_{it}, l_{it} m_{it}, respectively. Subscripts i and t stand for firm and time, ω_{it} denotes productivity, and ϵ_{it} stands for measurement error in output. It is assumed that ω_{it} follow an exogenous first order Markov process:

$$\omega_{it+1} = E[\omega_{it+1}|\omega_t] + \eta_{it+1}$$

where η_{it} is uncorrelated with the productivity shock. The endogeneity problem stems from the fact that k_{it} and l_{it} are correlated with the ω_{it}. This makes β_{OLS} to be biased and inconsistent. Given that investment is strictly monotonic, it can be inverted as:

$$\omega_{it} = h(i_{it}, k_{it})$$

and substituting this function in the production function leads to

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \Phi(i_{it}, k_{it}) + \epsilon_{it}$$

where $\Phi(i_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + h(i_{it}, k_{it})$. Since the functional form of $\Phi(\cdot)$ is not known, we cannot estimate the coefficients of the capital and labor variable directly. Instead, we use a linear model that includes a series estimator using a full interaction term polynomial in capital and investment to approximate $\Phi(\cdot)$. From this first stage, the consistent estimates of the coefficients on labor and material inputs as well as the estimate of the polynomial in i_{it} and k_{it} are obtained.

The second stage takes into account the survival of firms. These probabilities are given by

$$\begin{aligned} Pr\{\chi_{t+1} = 1 | \underline{\omega}_{t+1}(k_{t+1}), Jt\} &= Pr\{w_{t+1} \geq \underline{\omega}_{t+1}(k_{t+1}) | \underline{\omega}_{t+1}(k_{t+1}), \omega_t\} \\ &= \varphi\{\underline{\omega}_{t+1}(k_{t+1}), \omega_t\} \\ &= \varphi(i_t, k_t) \\ &= P_t \end{aligned}$$

The probability that a firm survives at time $t+1$ conditional on its information set at time t, J_t and ω_{t+1}. This is equal to the probability that the firm's productivity is greater than a threshold,$\underline{\omega}_{t+1}$, which in turn depends on the capital stock. The survival probability can be written as a function of investment and capital stock at time t. Thus, we estimate a probit regression on a polynomial in investment and capital controlling for year specific effects. Now, consider the expectation $y_{t+1} - \beta_l l_{t+1}$ conditional on the information at time t and survival at $t+1$.

$$\begin{aligned} E[y_{t+1} - \beta_l l_{t+1} | k_{t+1}, \chi_{t+1} = 1] &= \beta_0 + \beta_k k_{t+1} + E[\omega_{t+1} | \omega_t, \chi_{t+1} = 1] \\ &= \beta_k k_{t+1} + g(\underline{\omega}_{t+1}, \omega_t) \end{aligned}$$

ω_{it} follow an exogenous first order Markov process. We substitute the productivity shock in the above equation using the result from the first stage.

$$y_{t+1} - \beta_l l_{t+1} = \beta_k k_{t+1} + g(P_t, \Phi_t - \beta_k k_t) + \eta_{t+1} + \epsilon_{it}$$

The third step takes the estimates from β_l, Φ_t, and P_t and substitutes them

for the true values. The series estimator is obtained by running a non-linear least squares on the equation

$$y_{t+1} - \beta_l l_{t+1} - \beta_m m_{t+1} = c + \beta_k k_{t+1} + \sum_{j=0}^{s-m} \sum_{m=0}^{s} \beta_{mj} (\hat{\phi}_t - \beta_k k_t)^m \hat{P}_t^j + e_t$$

where s is the order of the polynomial used to estimate the coefficient on capital.

Table 6
Productivity function coefficients

Sector	Observations	Labor	Materials	Capital	Scale
17	4883	0.32	0.66	0.07	1.05
18	6526	0.45	0.59	0.05	1.09
19	2857	0.41	0.57	0.07	1.04
20	6209	0.19	0.82	0.03	1.04
21	1523	0.15	0.83	(0.02)	0.99
22	9010	0.18	0.80	0.06	1.04
24	2978	0.14	0.86	0.03	1.02
25	6097	0.20	0.78	0.06	1.04
26	4100	0.21	0.79	0.07	1.07
27	1501	0.13	0.83	0.06	1.02
28	15736	0.26	0.73	0.05	1.04
29	12104	0.26	0.73	0.02	1.01
30	662	0.42	0.60	0.17	1.19
31	3369	0.27	0.70	0.09	1.06
32	2568	0.27	0.74	0.07	1.08
33	3571	0.26	0.78	0.05	1.09
34	1466	0.28	0.75	0.02	1.05
35	558	0.35	0.78	(0.00)	1.13
36	5762	0.26	0.72	0.07	1.04

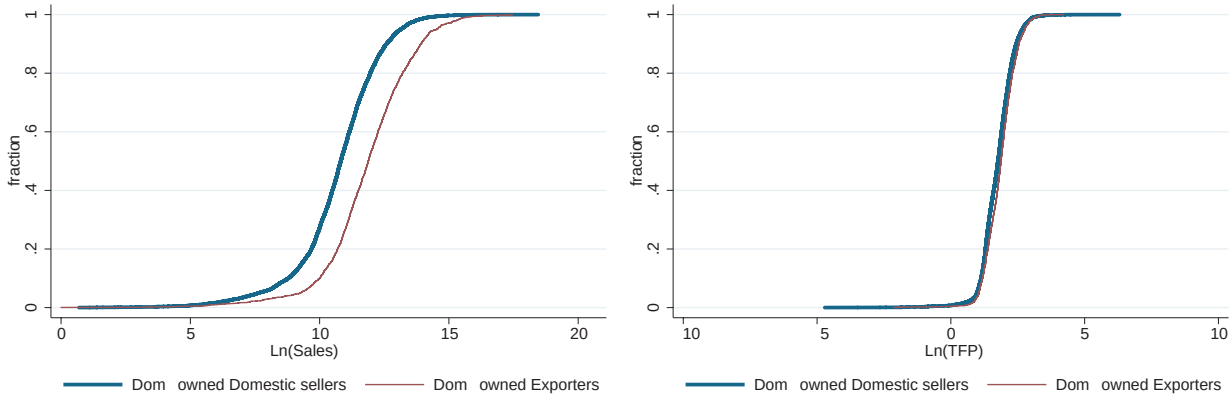
NB Figures in brackets are not significant at one percent level of significance.

8 Appendix B

Table 7
Summary statistics of variables. Domestically-owned firms only

	Mean	Std. Dev.
Fixed assets (log)	8.324	1.967
Sales (log)	10.78	1.547
Materials (log)	9.468	1.579
Employment (log)	2.848	1.242
Domestic Sales (log)	10.80	1.562
Export Sales (log)	9.660	2.357
Export share	0.114	0.249
Exporter status (dum)	0.253	0.435
Horizontal Linkage	0.330	0.224
Backward Linkage	0.145	0.088
Forward Linkage	0.260	0.242
$R\&D$ Linkage	0.119	0.117
Wholesale linkage	0.262	0.192
Herfindahl index	0.137	0.152
Private share	0.974	0.149
TFP (log)	1.815	0.598

Fig. 5. **Cumulative Distribution of:**



(a) **Sales** (b) **Total Factor Productivity**

Source: APEH, authors' computation.

Table 8
KS-Test of Differences between Exporters and Domestic firms, Sales and TFP, 2000

		Sales	
Group	Largest Difference	P-value	Corrected
$Ho: Exp - Dom \leq 0$	0.3034	0.000	
$Ho: Dom - Exp \leq 0$	-0.0005	0.999	
Combined K-S	0.3034	0.000	0.000
		TFP	
Group	Largest Difference	P-value	Corrected
$Ho: Exp - Dom \leq 0$	0.0918	0.000	
$Ho: Dom - Exp \leq 0$	-0.0014	0.995	
Combined K-S	0.0918	0.000	0.000

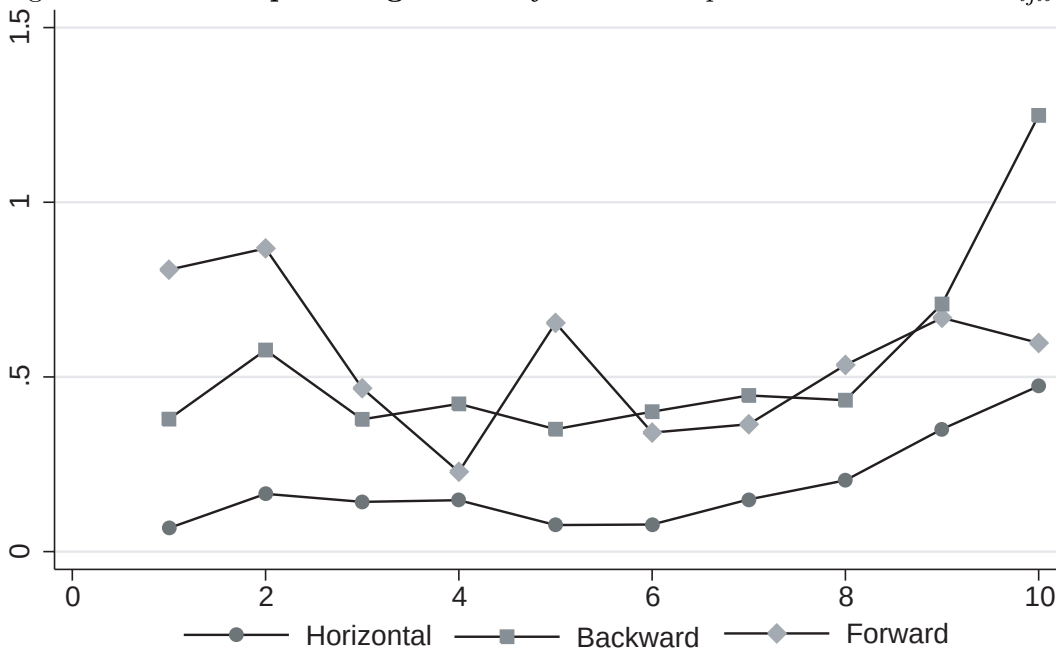
Concerning the sales distribution, the largest difference between the distribution functions is 0.3034, which is statistically significant at 1%. Thus, the null hypothesis that both sales distributions are equal is rejected. From the left hand-side of the KS-test we can reject the hypothesis that domestic firms are larger than exporters with respect to their sales. The largest difference between the distributions functions is 0.3034, which is statistically significant at 1% level of significance. From the right hand-side of the KS-test, we can not reject the hypothesis that exporters are larger than domestic firms. The largest difference between the distributions functions is -0.0005, which is not significant. Therefore, we cannot reject the stochastic dominance of exporters' sales

distribution over domestic firms' sales distribution. However, we can reject the stochastic dominance of domestic firms' sales distribution over exporters' sales distribution.

We find qualitatively similar results using the TFP distributions. Exporters' TFP cumulative distribution with respect to TFP dominates stochastically domestic firms' TFP cumulative distribution. As result, the KS-test of stochastic dominance suggests that exporters are more productive than domestic firms and larger in size. [6]

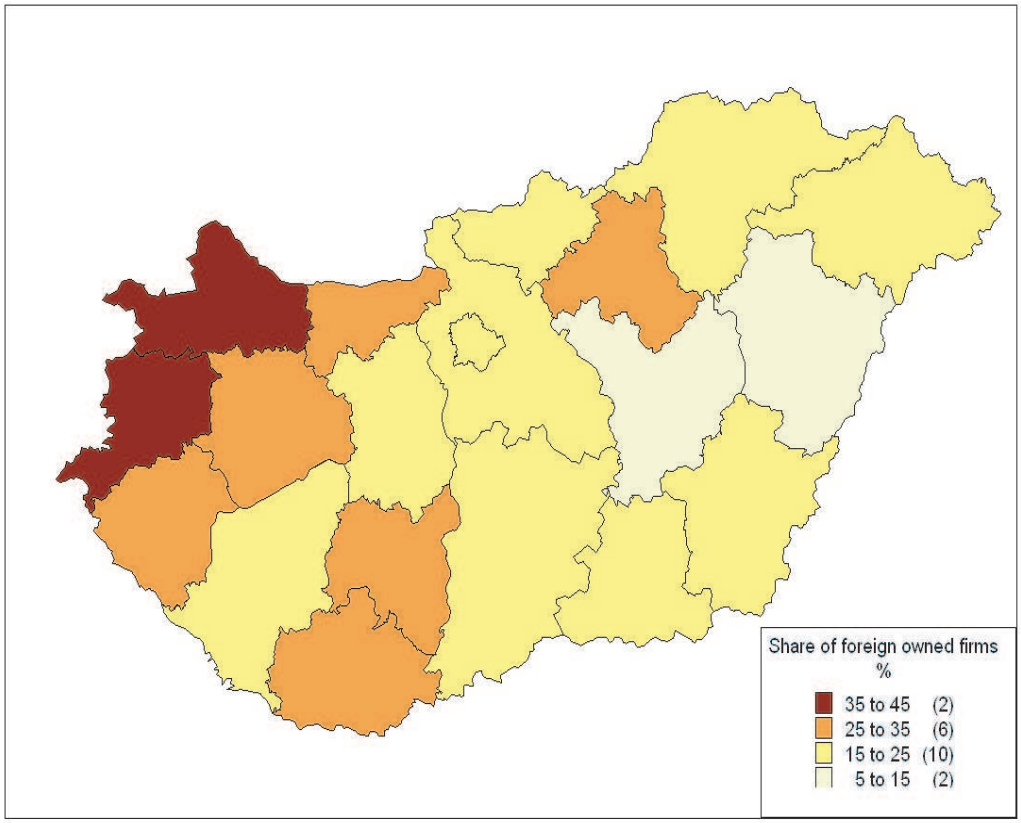
[6] Note that the KS-test results are qualitatively similar for each year of the sample.

Fig. 6. **Fixed effect panel regression by deciles**: Dependent Variable $lnTFP_{ijlt}$



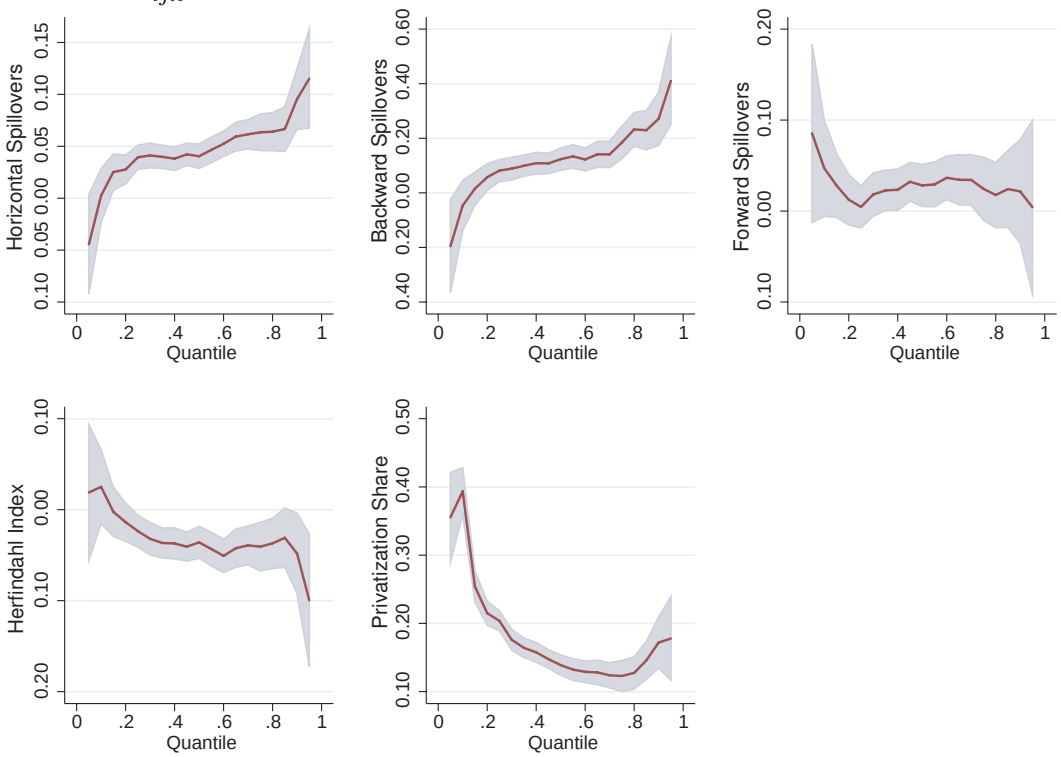
Estimated coefficient on the vertical axis. Quantile of $lnTFP_{ijlt}$ on the horizontal axis. Source: APEH, authors' computation.

Fig. 7. **Regional distribution of foreign owned firms**



Source: APEH, authors' computation, share in percent.

Fig. 8. **Simultaneous Quantile Regression, lagged spillover:** Dependent Variable $lnTFP_{ijlt}$



Estimated coefficient on the vertical axis. Quantile of $lnTFP_{ijlt}$ on the horizontal axis. All spillover variables are lagged one year. Source: APEH, authors' computation.