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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 through the entry of multinational firms can be particularly beneficial to domestic firms because of their technological superiority. Yet, the importance of foreign firm's spillovers might depend on two key features of domestic firms: their productivity level and its export status. In line with theories and empirical evidence 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.

JEL: F23, F14, D21, R12, R30

Keywords:

FDI, multinationals, productivity, spillover, regions

A termelékenység átterjedése multinacionális vállalatoktól heterogén hazai vállalatok felé: Magyarországi eredmények

Gábor Békés - Jörn Kleinert - Farid Toubal

Összefoglaló

A vállalatok telephelyválasztási döntéseikben figyelembe veszik a közelségből fakadó technológiai és információs externáliákat. A hazai tulajdonú cégek a jellemzően magasabb technológiai szintet képviselő multinacionális vállalatoktól átterjedő magasabb termelékenységből húzhatnak hasznot. Ugyanakkor az átterjedési hatások jellege a hazai cégek két fontos jellemzőjétől, a termelékenységi szinttől és az exportáló státusztól függ. Az abszorpciós kapacitás elmélete alapján és az eddigi empirikus eredményekkel összhangban a magyar vállalatok vizsgálata azt mutatta, hogy a nagyobb és termelékenyebb vállalatok jobban ki tudják aknázni a termelékenységi átterjedési hatásokat. Az exportáló státusz szerepe ugyanakkor a vártnál kisebb.

Tárgyszavak:

FDI, multinacionális nagyvállalatok, termelékenység, átterjedési hatások, régiók

1 Introduction

The large number of bilateral investment treaties between Central and Eastern European countries and OECD countries agreed on during the 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.

Domestic firms can benefit from the presence of multinationals *in the same* industry through *horizontal* spillovers that might for instance arise 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: backward spillovers are generated through serving customers in downstream industries; forward spillovers are generated through sourcing from upstream industries.

Spillovers from foreign firms are measured through foreign firms' effect on domestic firms' total factor productivity (TFP). The TFP of a firm is the firm-specific component of the firm's technology. A higher TFP of a firm is the result of several factors, such as better use of inputs, more sophisticated sales methods, superior internal organizational structure or simply more knowledge and information. When explaining TFP by spillovers, we make the assumption that the presence of foreign firms creates additional 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 or an increase in productivity for a domestic firm, it may also lead to increased competition and to the exit of domestic firms[1].

The empirical literature on FDI spillovers finds mixed support for the positive impact of multinational entry on domestic firms' TFP (Görg and 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, and find some evidence for

[1] See Kosova (2006) for a study on the impact of FDI on exit of Czech firms

positive spillovers only for Romania. For other countries, the spillover effect is either statistically insignificant or negative. Bosco (2001) analyzes the direct and spillover effects of foreign ownership on firms' TFP in Hungary for the period 1992-1997. She finds that horizontal spillovers are either insignificant, or negative. According to Aikten and Harrisson (1999) and Konings (2001), negative horizontal spillovers arise when multinational firms attract demand away from domestic firms. This lack of sizable horizontal spillovers from multinationals to domestic firms might be explained by the lack of absorptive capacity (i.e. the ability to assimilate and apply new knowledge) of the latter (Girma *et al.* (2001)). Domestic firms may be unable to learn from multinational firms if the technological gap between the two groups is wide.

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 and Gertler (2003) find the same evidence using Indonesian plant-level data. Driffield *et al.* (2002) 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. There are however no statistically significant effects from horizontal spillovers or from backward linkages.

In this paper, we examine the impact of multinational firms' presence on local firm productivity and size. We assume that the presence of multinational firms generates spillovers which are more important when geographical distance between multinational and domestic firms is small (Audretsch, 1998). For Hungarian firms, this stance is supported by Halpern and Muraközy (2005) who found strong positive spillovers that operate only on small distances (i.e. broadly at the county level) for domestic-owned firms. At the national level, backward spillovers are found significantly positive suggesting that foreign customers make domestically owned firms more productive (Halpern and Muraközy (2005)).

More specifically, we analyze whether more productive and larger firms are able to reap more benefit from spillovers of multinational firms. The spillovers effect might also differ with respect to the export status of the domestic firm. Exporters' experience in export markets might explain why they deal better with the spillovers of foreign multinational firms. However, it might also be that the foreign multinationals' spillovers at home are less important to exporters, because they also learn from firms in the foreign market.

We use a large and extensive data set on Hungarian manufacturing firms. The data set crucially entails information on domestic and export sales as well as ownership. 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 three variables which have to be constructed in a first step. (i), we compute the TFP of domestic firms using the semi-parametric Olley and Pakes (1996) methodology. (ii), we construct the horizontal and vertical spillovers variables following Javorcik (2004). We depart from her analysis by taking the extreme view that spillovers from multinationals can only be reaped by domestic firms located in the same county. (iii), we quantify the net effects of spillovers by controlling for the degree of competition. Therefore, we construct a Herfindahl index at sectoral and county level.

We then estimate the effect of multinationals' spillovers on the *average* domestic firm's TFP using a firm fixed-effects panel model. The firm specific effects allow the control of the firm's technology and the isolation of the sectoral spillovers effects. Finally, we are interested in the difference in the effect of spillovers on firms that differ in productivity. We therefore estimate simultaneous quantile regressions.

The remainder of this paper is structured as follow. In Section 2, we provide information on the Hungarian dataset and the descriptive statistics. In Section 3, we present the estimation strategy. In Section 4, we discuss our results. We conclude in Section 5.

2 Descriptive Statistics

In this section we present the data and analyze Hungarian firms' productivity. Our analysis is limited to manufacturing firms that meet the data requirements that will be described in the first subsection. In the second subsection, we discuss 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 exporters. Hence, it is possible that Hungarian firms (non-exporter and exporter) learn from more productive foreign multinational firms. In the third subsection, we therefore have a first look at our main interest: the relationship of TFP and the number of foreign multinational firms active in a particular Hungarian county.

2.1 Data

We use a Hungarian corporate dataset, which is based on annual balance sheet data submitted to APEH, the Hungarian Tax Authority [2] . 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.

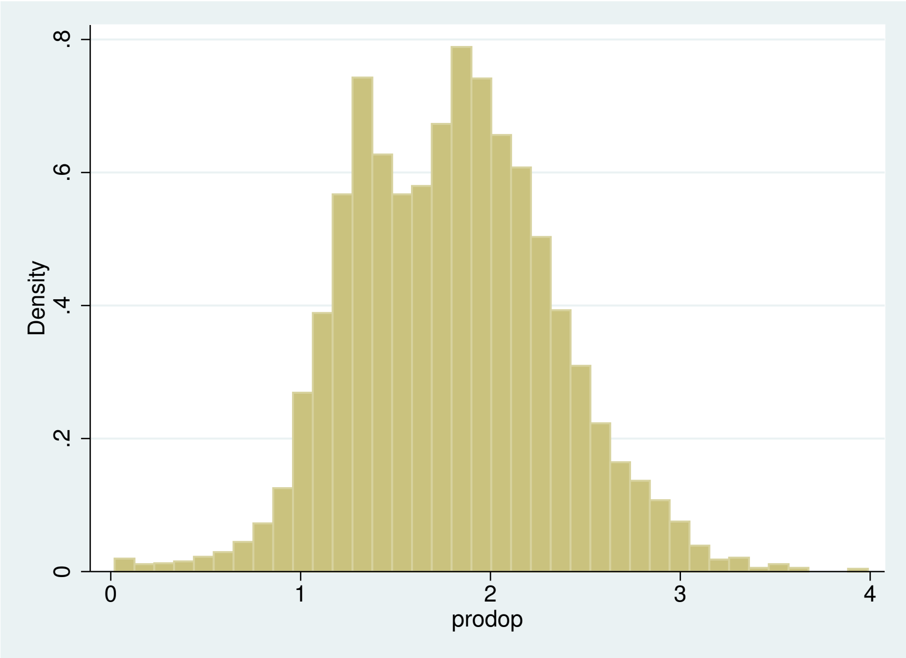
In Hungary, economic transition has lead to the entry of new domestic and foreign firms. The number of firms has risen substantially from 55,213 in 1992 to 226,072 in 2003. The sample used in this study is less comprehensive than the original APEH data for two reasons. First, we concentrate on manufacturing firms. Second, very small firm data are unreliable and no complete information exists on employment and fixed assets, which are required to compute the TFP variable. As a result, this sample contains 108,541 observations over 12 years, rising from 6,003 firms in 1992 to 11,208 in 2003. The dataset covers 42% of the total number of manufacturing firms and 73% of total turnover. We use the subsample of domestically-owned firms. It includes 66,470 observations from 11,767 firms for the period from 1993 to 2002. Table (5) of the Appendix shows the summary statistics for all domestically-owned firms in our sample.

2.2 Total Factor Productivity, Domestic and International Activities

The data at hand allows discrimination 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 (hence domestic firms), domestic exporters, foreign-owned non-exporting firms and foreign-owned exporters. We use the foreign ownership information to compute our horizontal and vertical spillover variables (see section 3.1) and focus on the impact of multinationals' spillovers on the productivity and size of domestic

[2] See details in the Appendix

Fig. 1. Distribution of Hungarian firms' TFP



Source: APEH, authors' computation.

firms. 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.

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, as domestic firms with foreign capital are responsible for 76.6% of total sales in our sample (total sales of foreign firms reached about 28.6 billion euros compared with about 8.7 billion euros by domestically owned ones).

Figure (1) shows that the distribution of Hungarian firms' TFP is right skewed. It is, however, not too far from log-normal. We have a closer look at the heterogeneity of Hungarian firms using the results of Table (1). 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.

Table (1) shows two interesting facts. First, the most productive firms are not necessarily the largest with respect to sales. For both the fifth and the forth interval, the share of the interval sales in total sales is below their shares 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 mea-

Table 1
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)

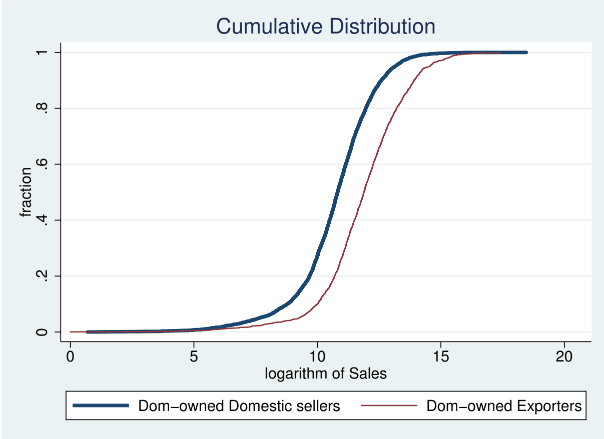
sured in export sales instead of number of exporters. Both measures suggest that exporters are more productive than non-exporting domestic firms. The qualitative results of Table (1) are robust to change in interval borders.

In Figure (2), we show the cumulative distribution of TFP and sales of Hungarian firms according to their export status. Panel (a) of Figure (2) points to first-order stochastic dominance of exporters with respect to sales. Exporters are selling more than domestic firms over the whole distribution. The first-order stochastic dominance of exporters with respect to TFP is, however, not obvious from Panel (b) of Figure (2).

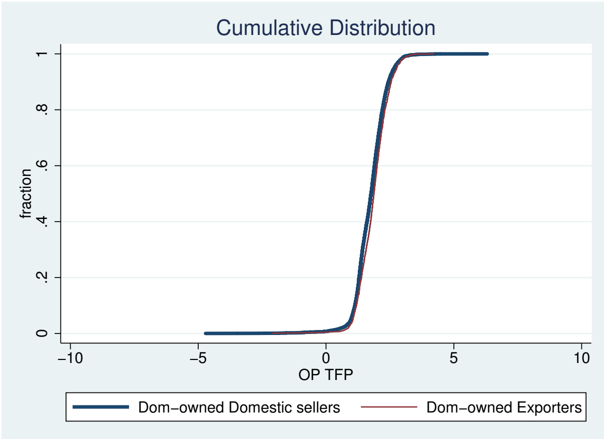
We use the non-parametric Kolmogorov-Smirnov test (KS-test) to determine whether the sales and TFP distributions between the two groups differ significantly. The KS-test calculates the largest difference between the observed and expected cumulative frequencies, which is called D-statistics. These statistics are compared against the critical D-statistic for the sample size. The results of the two-sided KS-test are shown in Table (2).

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 accept 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 dis-

Fig. 2. Cumulative Distribution of:



(a) Sales



(b) Total Factor Productivity

Source: APEH, authors' computation.

tribution 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[3].

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

2.3 TFP and Spillovers

Having documented that exporters are more productive than domestic firms, we now turn to the most productive firms in Hungary: foreign multinational firms. We are interested to see whether Hungarian firms (non-exporters and exporters) can learn from foreign multinational firms or use their proximity in another way to increase their productivity. We therefore first look at the productivity gap. A productivity gap is the first necessary condition for positive spillovers. Then we look at multinationals' geographic location relative to Hungarian firms. Geographic proximity is the other necessary condition for spillovers.

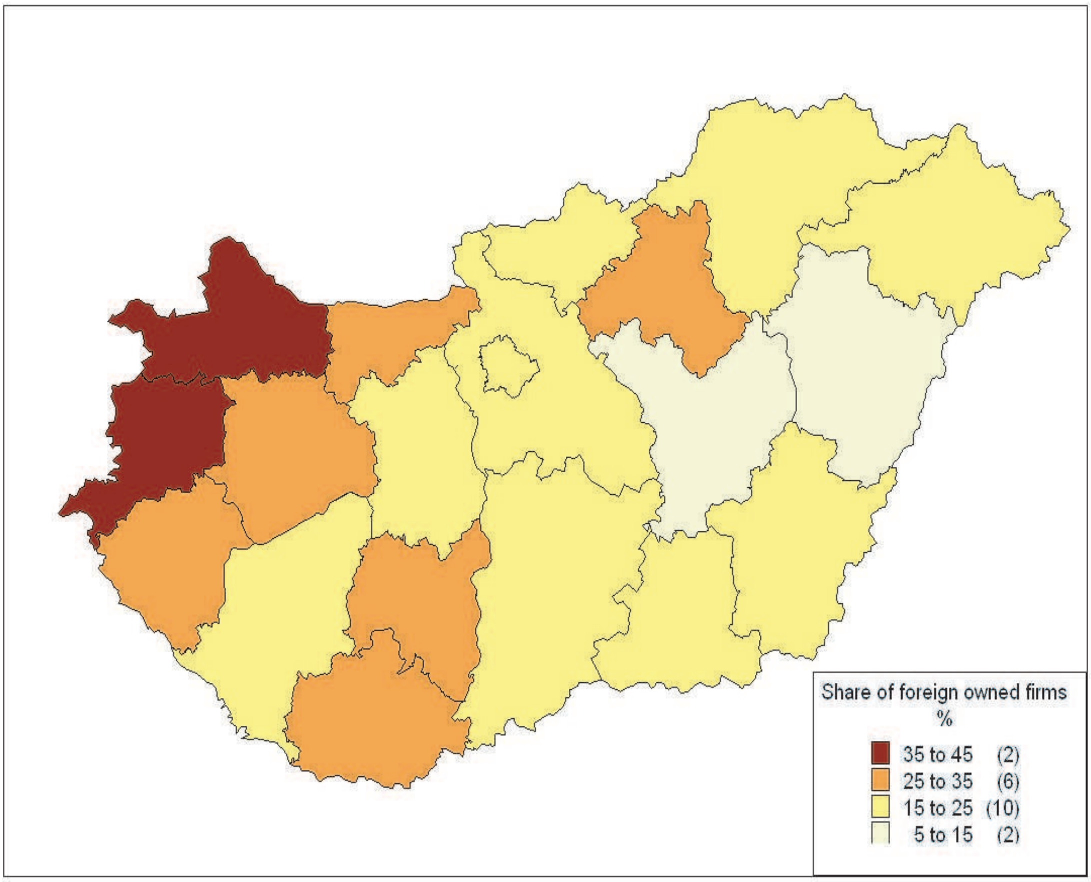
We use again the KS-test to determine whether the sales and TFP distributions of foreign owned and domestically owned firms differ significantly. We present the comparison of foreign owned firms and the group of Hungarian exporters, which are more productive than Hungarian non-exporters. The results of the two-sided KS-test are shown in Table (3). The KS-test reveals that the size of the distribution of foreign multinational firms stochastically dominates those of Hungarian exporters. Thus, the first necessary condition for positive spillovers is met. Concerning the second necessary condition, we look at the regional distribution of foreign owned firms. Figure (3) shows that Western counties have a higher share of foreign firms, while the Eastern and South-Eastern counties have a rather low share of foreign owned firms.

Next, we look at the relationship of the share of multinational firms in total firms in a particular county and the TFP of Hungarian firms in that county. We regress the logarithm of firm level TFP of domestic firms on the share of

Table 2
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

Fig. 3. Regional distribution of foreign owned firms, share in percent



Source: APEH, authors' computation.

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

$$TFP_{it} = 0.0692^{***} N_{jlt} + \nu_j + \nu_l + \nu_t \quad (1)$$

From this very crude first inspection, we find a positive correlation between a higher share of multinational firms and firm-level TFP. The share of multinational firms and the fixed effect explains 49.67% of the TFP's cross variation.

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

3 Empirical Analysis

In this section, we describe measurement of productivity, detail the spillover variables and give an account of our estimation strategy.

3.1 Horizontal and Vertical Spillovers

The total factor productivity of a firm reflects its own 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 spillovers, of backward and 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}, as follows

$$TFP_{ijlt} = \alpha H_{jlt} + \beta_1 B_{jlt} + \beta_2 F_{jlt} + \gamma C_{jlt} + \chi Psh_{it} + \nu_i + \nu_j + \nu_t \qquad (2)$$

TFP_{ijlt} has been computed using the semi-parametric estimation suggested by Olley and Pakes (1996). The methodology is developed 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 spillovers, local Backward and Forward linkages and local and sectoral Competition, respectively.[4] 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 (that may 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 sectoral 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

[4] Competition as an influential force on productivity was used e.g. in Nickell (1996).

to an increase in productivity of domestic firms active in the *same* industry. This results, for instance, in 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 each firm's share in sectoral output. We proxy horizontal spillovers by H_{jlt} defined as

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

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 occur when multinational firms' presence in backward or forward industries increases the efficiency of a firm through vertical input-output linkages with suppliers and customers. We calculate the backward linkage with multinational firms as

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

where θ_{jk} is the proportion of industry j's output shipped to sector k. This information is taken from the 1998 input-output table at two-digit NACE level. As in Javorcik (2004), the output delivered within the sector is not included in the computation since this effect is already captured by the horizontal spillovers variable.

The forward linkage is defined as the weighted foreign share in output in the supplying industries.

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

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 approximate 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.

3.2 Estimation Strategy

The heterogeneity in the firm-level data is large. This suggests that we must take it explicitly into account when studying the effects of multinational spillovers on domestic firms. We deal with this large heterogeneity 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 the fixed-effects specification, heteroscedasticity and serial correlation are always potential problems. The 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) to estimate the fixed-effects model. Cluster-sample methods are a generalization of White's (1980) robust covariance matrices (Arellano, 1987). 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 compared to the number of groups (Wooldridge, 2002, 2003). The fixed effects panel estimation allow to control for the unobserved domestic firm heterogeneity 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.

As we have shown in Section 2.2, exporting firms are more productive than non-exporters. That might on the one hand decrease the 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. Hence, 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.

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 firms in each group are affected identically by spillovers and by competition. 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 and Hallock, 2001). Hence, we test whether spillovers and competition have different impact in different groups. We estimate a simultaneous quantile regression model, which is specified as

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

where X_{ijlt} is the vector of independent variables specified in equation (2) 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 and Basset (1978), introducing this technique, show that β_{Θ} can be estimated by

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

The main advantage of the quantile regression approach is that it allows different slope coefficients for different quantiles of the conditional distribution of the TFP variable to be estimated. 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 and Görg (2005), 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]

4 Results

Discussion of the estimation strategy is now followed by a presentation of main results attained by both fixed effect panel and quantile regressions.

4.1 Average Impact of Spillovers on Domestic Productivity

First, 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 (2) 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 domestic firms and exporters. In the second specification (S2), the relative average impact of spillovers on TFP with respect to the exporting status of the firm is analyzed. 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, *Exp*, and an interaction term between the spillovers variables and a non-exporter dummy variable, *Dom*.

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 overwhelms the competition effect that arises from the multinational presence. The average impact of forward spillovers is positive but remains statistically insignificant. 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

[5] The Shapiro and Francia (1974) test, 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.

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 (specification (S2) of Table (4)). We do not find any statistically significant impact 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

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

	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
R-squared		78.70	79.00

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.

significant. For backward linkages, the average impact is positive and statistically significant for the exporters only. thus, while the results for Hungarian exporters are similar to Javorcik's findings. The results for non-exporters, in contrast, differ.

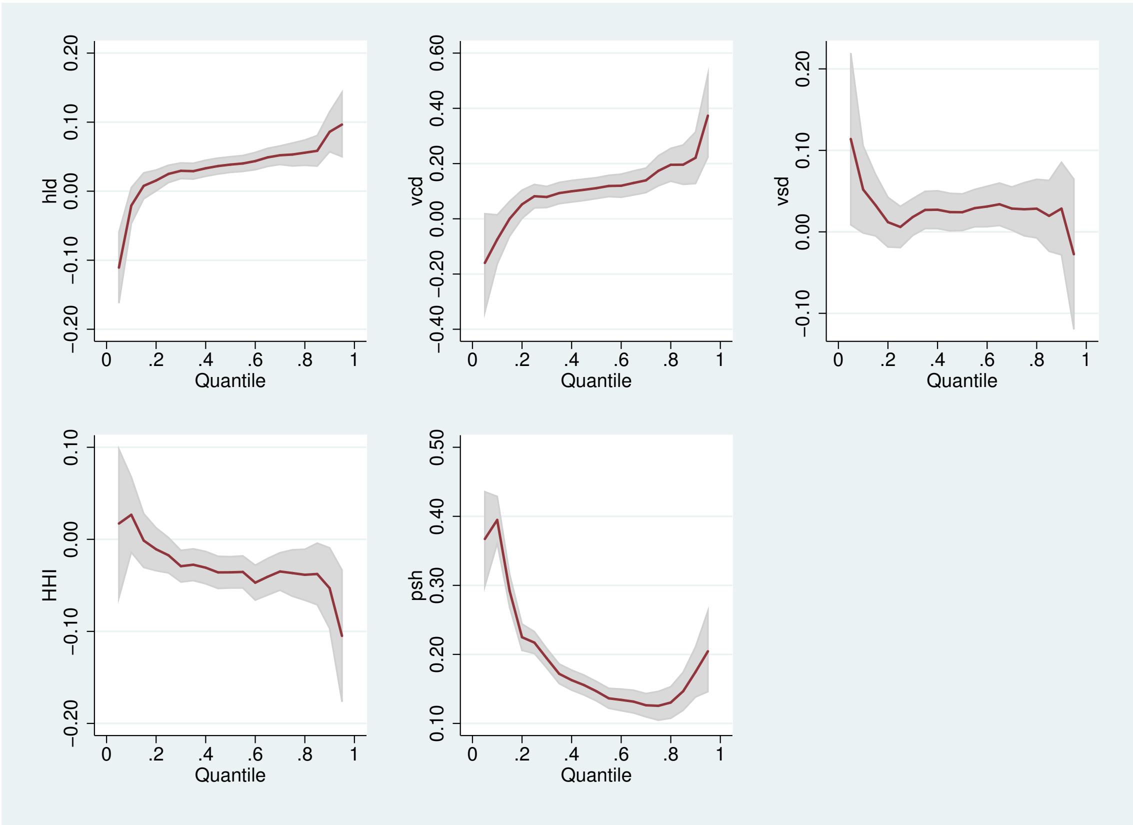
4.2 Impact of Spillovers on Heterogenous Domestic Firms

The results of the fixed effects estimation suggest that no vertical spillovers exist from multinational firms to domestic firms. A close look at domestic firm-level heterogeneity might reveal that spillovers from multinationals affect different firms differently depending on their productivity. 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 (4). 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.

The results show that horizontal spillovers have a negative impact on the least productive firm. This impact is, however, positive and significant for the most productive firm. Moreover, the impact is larger, the more productive is the domestic firm. There are two reasons for this finding. First, the negative effect on the least productive firm stems from their low level of absorptive capacity. Second, competition from multinational firms, which leads to exit of the least productive firms, stimulate innovation among domestic firms that have high level of productivity (Aghion *et al*, 2005). 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.

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 a higher incentive to transfer knowledge to more productive firms in their downstream sectors in order to obtain higher sales through higher quality or less expensive goods. Moreover, the increase in foreign presence in the upstream sectors redirects intermediate inputs supply to the downstream sectors away from least productive firms toward more productive firms in the downstream sector. This

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.

explains the negative coefficient of backward spillovers on the TFP of least productive firms. The increasing horizontal and backward spillovers with domestic firms' productivity is in line with Girma and Görg's (2005) 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.

Turning to the Herfindahl index, it has a positive but insignificant impact on the least productive firms and a negative impact on TFP of more productive firms. Finally, the data 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.

4.3 Impact of Spillovers on Exporters and Non-exporters

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 an interaction term between the spillovers variables and non-exporter dummy variable.

The results are reported in Figure (6). The upper panel of Figure (6) show that the coefficients of spillovers from multinational firms to all domestic firms are mainly driven by spillovers to non-exporting firms. Figure (4) and the upper panel of Figure (6) are very similar. 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.

As for backward linkages, non-exporters gain from positive spillovers if their productivity places them at least in the third decile. The 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 categories, slightly positive or zero, for both groups.

The productivity advantage of exporters which we reported in Section 2 therefore does not result from higher spillovers that exporters as such receive from multinational firms relative to non-exporters.

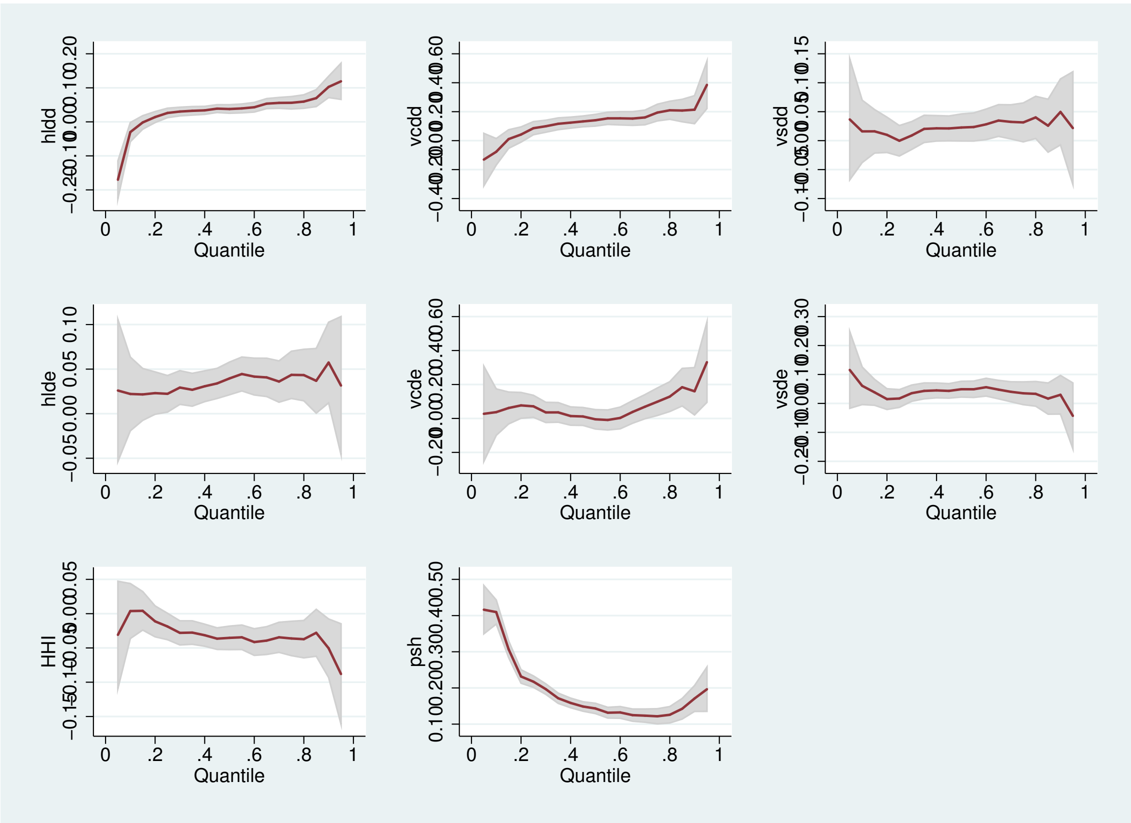
In line with the results from the fixed effects regression, the quantile regressions revealed no larger spillovers for exporters than for non-exporting domestic firms. Hence, larger spillovers from multinational firms are not part of the explanation why exporters have higher total factor productivity. Thus, while exporters might receive additional spillovers in the foreign market which increases their TFP, we did not find support for higher spillovers received by exporters at home.

There are three 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. Second, exporters might receive additional spillovers in the foreign market which increase their TFP. Third, exporters might learn from foreign owned firms active in the Hungarian wholesale sector because they share a common "*trade technology*".

For the first two points have been examined in literature, we now test the validity of the third assertion by looking at the impact of the share of foreign-owned firms in the Hungarian wholesale sector. Therefore, we construct a wholesale spillover variable, W_{jlt}, that is the share of foreign ownership among firms that operate in the wholesale sector and are exporters, $W_{jlt} = \left[\sum_{i\in j,exp=1,l} share_{it} * Y_{it}\right] / \sum_{i\in j,exp=1,l} Y_{it}$.

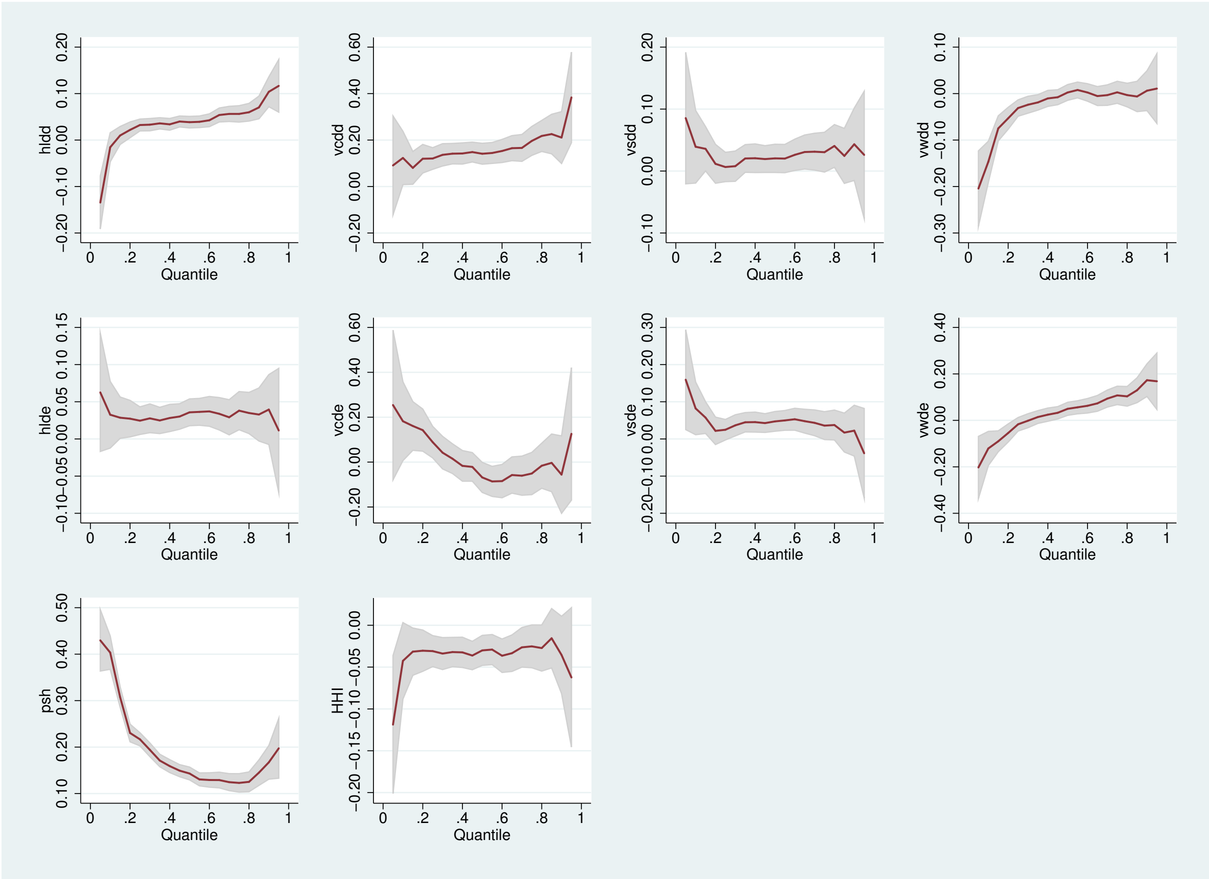
We find a strong negative impact of foreign-owned importers on the least productive domestic firms whereas this impact is positive and significant for most exporters. While domestic firms might suffer from import competition, exporters might benefit from foreign-owned importers' trade knowledge.

Fig. 5. 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.

Fig. 6. 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.

5 Conclusions

We examined the impact of the presence of foreign multinational firms in local Hungarian markets on Hungarian firms' productivity. 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, the spillover effects are average effects over all firms which 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 analyze 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.

There is a second obvious characteristic in which firms differ: their export status. Export status is not independent of productivity since only more productive firms generate profits in the export market. We expected export status to have an effect for two reasons. First, as argued above, exporters are more productive. That might increase the spillovers reaped since the absorptive capacity is larger or decrease the spillover effect because the gap to the most efficient firm is smaller. Second, exporters are used to interact with foreign firms and therefore 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.

Overall, we found that heterogeneity in terms of productivity influences domestically owned firms' capacity to absorb knowledge and achieve higher productivity. This finding may have policy implications regarding FDI subsidies, a point left for future research.

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7 Appendix

7.1 Summary statistics

In table (5), summary statistics for all domestically-owned firms in our sample are presented.

Table 5
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

7.2 TFP Measurement methodology

We use the Olley and 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 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

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.

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.

7.3 Data

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 and 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 and Wolf (2004, 2006) 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:

$$K_{i,t} = K_{i,t-1} * (1 - Depreciation_{i,t}) + Investment_{i,t} \tag{3}$$

Description of variables are as follows.

Table 7
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

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