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Productivity spillovers from FDI in Turkey: Evidence from quantile regressions

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Abstract. *This paper, using firm-level data for Turkey's manufacturing firms for the period 2003-2012, explores the role of firms' absorptive capacity in determining the magnitude of possible benefits from FDI. The empirical analysis is based on conditional quantile regression to allow for different effects of FDI on firms located at different quantiles of productivity. This enables one to take better account of the large and persistent heterogeneity in productivity dynamics across firms. The empirical evidence reveals that absorptive capacity plays an important role in capturing the positive productivity spillovers from FDI, especially for the firms that have medium and high TFP growth rates.*

Keywords: foreign direct investment, productivity spillovers, absorptive capacity, quantile regressions.

JEL Classification: F21, F23.

1. Introduction

Until 1980, the total foreign investment allowed into Turkey came to less than $250m in total. Within the framework of export-oriented trade policy, the inflow of foreign direct investment (FDI) into Turkey accelerated in the early 1980s (Mercul, 2001). Following the reforms to the existing investment law, Turkey experienced a considerable increase in foreign capital investments. In part due to economic and political stability over the past decade, Turkey has made notable progress and sustained a confident economic environment, and in this context FDI inflows to the country increased dramatically. While the country attracted only about USD 15bn. in FDI, in total, through 2002, FDI inflows totalled to USD 155bn. in the period 2003-2015. The number of companies with foreign capital, which was only 6,700 in 2003, rose to 44,000 by 2015. According to the 2015 World Investment Report of the United Nations Conference of Trade and Development (UNCTAD), FDI inflows into Turkey were $12.1 billion in 2014, making the country the 22nd most popular spot for investors in the world, 12th among emerging countries, and first in the Western Asia region.

Attracting and embedding FDI has become an important component of development strategies, and most host countries spend considerable attention and resources to attract FDI and design their policies accordingly to stimulate inward flows. This is based on the fact that multinational enterprises (MNEs) and their affiliates are seen as important sources of international capital and technology, and vehicles for an inflow of marketing and management expertise which may, through so called spillover effects, improve the productivity of domestic industries.

Spillovers can take place both within the same industry (intra-industry) and at an inter-industry level. In the former case, local firms may benefit from the presence of foreign firms in their industry (horizontal spillovers) through channels such as demonstration effects, competition effects and labour mobility. In the latter case, spillovers occur through linkages between foreign firms and domestic firms that are not in the same industry (vertical spillovers). Vertical spillovers may take place when foreign firms interact with either local suppliers in upstream industries (backward spillovers) or local customers in downstream industries (forward spillovers) (Javorcik, 2004).

In this paper, we investigate whether the spillover effects of FDI on domestic firms' productivity growth rates differ across domestic firms that locate at different quantiles of the productivity growth distribution. In other words, we study the role of absorptive capacity in determining whether or not domestic firms that differ in their productivity growth rates benefit from FDI spillovers. We calculate absorptive capacity as the gap in total factor productivity (TFP) between the domestic establishment and the "industry leader". In this sense, our analysis is similar to Girma and Gorg (2005), who utilize establishment level data for the UK and examine the role of absorptive capacity in determining spillovers from FDI by using conditional quantile regression. Using quantile regression techniques, as Girma and Gorg (2005) postulate, allows for large and persistent heterogeneity in productivity dynamics across firms.

For our purpose, we use a recent dataset on Turkish manufacturing firms over the period 2003-2013. The data come from the Annual Industry and Service Statistics (AISS) obtained from the Turkish State Institute of Statistics (TURKSTAT). Details of the dataset are provided in section 3.

The remainder of this paper is organized in the following way: section 2 reviews the literature on the role of absorptive capacity for spillovers from FDI. Section 3 discusses the data, and sections 4 and 5 set out the econometric methodology and the quantile regression estimation methods respectively. Section 6 contains the empirical results, and section 7 concludes the paper.

2. Literature review

Starting with the pioneering studies for Australia by Caves (1974), for Canada by Globerman (1979), and for Mexico by Blomstrom and Persson (1983), in the last two decades, there has been a large volume of studies exploring the existence, direction and magnitude of FDI-generated horizontal and vertical spillovers (for a comprehensive literature review, see Meyer, 2003; Gorg and Greenaway 2004; Smeets 2008; and Havranek and Irsova 2011). These earliest studies focused solely on horizontal spillovers using cross-sectional industry-level data, and all conclude that spillovers are significant. However, these studies were criticized in that they were unable to control for firm heterogeneity and time effects due to the shortcomings of cross-sectional industry-level data. Therefore, the literature shifted to using firm-level panel data estimation methods. Nonetheless, in this context, the literature provides mixed results.

For example, Aitken and Harrison (1999), using panel data on Venezuelan plants, show that foreign investment negatively affects the productivity of domestically-owned plants because of the market stealing effect of foreign firms. They also note that foreign equity participation is positively correlated with plant productivity (the “own-plant” effect), meaning that the gains from foreign investment appear to be entirely captured by joint ventures. Kathuria (2000), on the other hand, reports results indicating negative productivity spillovers from FDI on large Indian domestic firms. Konings (2001) uses firm-level panel data to investigate empirically the effects of foreign direct investment on the productivity performance of domestic firms in Bulgaria, Romania and Poland. The results show that foreign firms perform better than firms without foreign participation only in Poland. Moreover he observes, on average, negative horizontal spillovers to domestic firms in Bulgaria and Romania but no horizontal spillovers to domestic firms in Poland. He argues that this suggests that a positive technology effect is dominated by a negative competition effect.

On the other hand, there are some other studies indicating positive horizontal spillovers from FDI but with the condition of there being adequate absorptive capacity (Kokko on Mexico 1994; Kinoshita on the Czech Republic, 2001; Barrios and Strobl on Spain, 2002; Haskel et al. on the UK, 2002; Castellani and Zanfei on Spain, France, and Italy, 2003;

Girma on the UK, 2005; Keller and Yeaple on the U.S., 2009). The term “absorptive capacity” was first coined by Cohen and Levinthal (1989), who defined it as “the ability to identify, assimilate, and exploit knowledge from the environment”. They argue that the extent of spillovers depends on the concept of “absorptive capacity”, implying that the technological capabilities of firms are crucial for them to benefit from the spillover effects of FDI (Cohen and Levinthal, 1989). In the microeconomic literature, absorptive capacities mainly refer to the (i) technology gap between domestic and foreign firms, (ii) export status of the domestic firms, and (iii) size of the domestic firms.

Kinoshita (2001), using firm-level panel data on Czech manufacturing firms between 1995 and 1998, finds an insignificant horizontal spillover effects, but argues that technology spillovers from FDI occur for firms that are more R&D intensive.

Castellani and Zanfei (2003) define the absorptive capacity of the domestic firms as the technology gap between foreign and domestic firms. They find evidence of positive spillovers in Italy, negative spillovers in Spain, and no evidence of horizontal spillovers in France. They argue that high technology gaps (low absorptive capacity), implying a catching up effect, along with high levels of foreign productivity, are the main sources of positive productivity spillovers from FDI towards domestic firms.

Barrios and Strobl (2002) find that only exporting Spanish firms benefit from FDI spillovers since they are more likely to absorb foreign technology by being exposed to international competition.

Keller and Yeaple (2009), using U.S. firm level data, show that multinationals generate statistically significant horizontal spillovers, and note that firms in high-tech industries with intensive R&D activities enjoy stronger spillovers from FDI. Their findings also indicate no significant spillovers towards low-tech firms.

Recently, the attention of researchers has moved towards the hypothesis that knowledge and technology spillovers are more likely to be found in vertical linkages rather than horizontal linkages. This is due to the fact that multinational firms typically try to prevent knowledge leakage to local competitors while they provide assistance to their local suppliers to get high quality inputs at lower prices and ensure on-time delivery of inputs. Foreign firms, as input suppliers to local firms, may also provide higher-quality products to the local firms in downstream industries (Javorcik, 2004). In this context, the literature provide ambiguous results although the studies generally have been more successful at finding empirical evidence of vertical spillovers, especially backward spillovers, than horizontal spillovers.

Schoors and van der Tol (2002), using Hungarian firm level data over the period 1997-1998, analyze the impact of FDI on the labor productivity. They find evidence of positive horizontal and forward spillovers but negative backward spillovers.

Javorcik (2004), utilizing firm-level data from Lithuanian manufacturing industry covering the period 1996-2000, and finds only backward spillovers from FDI, with no evidence of horizontal spillovers. Her results also indicate negative forward spillovers.

Mervelede and Schoors (2005) argue that, in the case of horizontal spillovers, the technology gap is not a source of heterogeneity. They also show that backward spillovers are positive and high if the technology gap is low enough or high enough. Their findings also suggest positive productivity effects through forward linkages, as the absorptive capacity of domestic firm increases (technology gap decreases).

Sasidharan and Ramanathan (2007), focusing on the Indian manufacturing industry, provide evidence of negative vertical spillover effects and no evidence of horizontal spillovers, while Yudaeva et al. (2003) find negative backward and forward linkage effects but strong evidence of horizontal spillovers in Russia over the period 1992-1997.

In the context of Turkey, the empirical evidence provides contradictory results. Aslanoglu (2000), using survey data from 1993 on the largest 500 firms collected by the Istanbul Chamber of Commerce (ISO), finds no evidence of a horizontal spillover effect from FDI on the average labor productivity of domestic firms. Similarly, Lenger and Taymaz (2006) find that there is no contribution of FDI to the productivity of Turkish firms.

Pamukçu and Taymaz (2009) use Turkish plant-level data over the period 1983-2001 and show that there are negative horizontal spillovers from foreign-owned firms. Koymen and Sayek (2010) use an unbalanced panel data of Turkish manufacturing firms over the period 1990-2001 and focus on the role of human capital in horizontal and vertical spillovers from FDI. Their results indicate that only the firms that have a share of skilled employees above a certain threshold are able to benefit from horizontal spillovers. Their findings also suggest that firms' human capital does not play any role in limiting absorptive capacity when it comes to the realization of vertical linkages.

For the purposes of our study, it is important to mention the following papers. Girma, Greenaway and Wakelin (2001) use firm-level manufacturing panel data from the UK to examine productivity spillovers. Under the assumption that spillovers are homogeneous across different types of domestic firms, they provide no evidence of spillovers on average. However, their results reveal evidence of spillovers to firms with a low technology gap, which is the difference between the firm's productivity level and the industry frontier productivity level (high absorptive capacity). On the other hand, using the same dataset, Girma (2002) uses threshold regression techniques to quantify the significance of absorptive capacity, whereas Girma and Gorg (2005) allow for different effects of FDI on establishments located at different quantiles of the productivity distribution by using conditional quantile regression techniques. Both papers show that only firms with some level of absorptive capacity benefit from productivity spillovers.

Overall, it is clear from the literature that the majority of the panel data studies report either negative or insignificant spillovers while cross-sectional studies report positive horizontal spillover effects. Gorg and Strobl (2001), in their review of studies on spillover effects, conclude that research design can crucially affect the analysis of productivity spillovers. In particular, they argue that “panel studies, using data on a firm rather than on an industry level, appear to be the most appropriate to determine the true extent of productivity spillovers”. This is due to the facts that, as they point out, (i) it is possible to follow the development of productivity of domestic firms over a longer time period through panel data studies rather than studying only one data point in time in cross-sectional data; and (ii) panel data allow researchers to study in more detail whether spillovers exist, by controlling other factors. However, cross-sectional data, especially if they are aggregated at the sectoral level, fail to control for time-invariant differences in productivity across industries that might be correlated with, but not caused by, foreign presence. Coefficients estimates may be biased if such time-invariant factors exist and are not properly controlled for. For example, foreign firms may be attracted into the industries with higher productivity, and if cross-sectional data are employed one would find a positive and statistically significant relationship between productivity and the level of foreign investment, even though foreign investment is not the reason for the high levels of productivity but rather was attracted by them. Instead, panel data, ideally at a firm level, need to be employed to control properly for such unobservable constant differences in productivity across industries (Gorg and Greenaway, 2001). Gorg and Strobl (2001) also find that the definition of the foreign presence variable included in the studies may affect the results. Furthermore, they suggest that the condition of host countries, such as the technological capability of domestic firms, affects the potential positive spillovers to domestic firms.

3. Data

For our purpose in this study, we use a recent enterprise-level dataset on Turkish manufacturing firms over the period 2003-2013. In the database, “enterprise” is the statistical unit and defined as “the smallest combination of legal units that is an organizational unit producing goods and services, which benefits from a certain degree of autonomy in decision making, especially for the allocation of its current resources. An enterprise carries out one or more activities at one or more locations” (We will use the terms “firm” and “enterprise” interchangeably in this paper). This unbalanced panel dataset is based on two different sources of data collected by the Turkish State Institute of Statistics (TURKSTAT): The Annual Industry and Service Statistics (AISS) and the Foreign Trade Statistics (FTS). The datasets are available under a confidential agreement by which all the computations can only be conducted at the Microdata Research Centre of TURKSTAT.

AISS contains data on output, revenues, value added, intermediate input costs, and employment, along with capital ownership structure over the period 2003-2013. It is a census for the whole population of enterprises with more than 19 employees, while it is a representative survey for enterprises with less than 20 employees.

In 2010, economic industry classification was changed from NACE Rev.1.1 to NACE Rev.2 and accordingly the dataset was reclassified using NACE Rev.2, so that NACE Rev.1.1 standard codes are not available after 2009, while NACE Rev.2 standard codes are available for most of the firms over the whole period. However, for the sake of employing I-O table (2002), in which firms are classified by NACE Rev.1.1, in order to calculate spillover variables, we opted to convert the industry codes of firms over the period 2010-2013, for which we only observe a NACE Rev.2 code, to NACE Rev.1.1. To do so, we simply used the most recent code. Although a 4-digit code is available, we mostly rely on 2-digit (or slightly more aggregated) industry classifications for practical implementation (spillover variables estimation for example).

Our estimation sample is limited to firms operating in the manufacturing industry with more than 19 employees. This is motivated by the fact that, as mentioned above, AISS is a census for the whole population of firms with more than 19 employees whereas it is a representative survey for firms with less than 20 employees. Furthermore, we also impose the restriction of at least 4 consecutive time-series observations for each firm, with the number of years of observations on each firm varying between 4 and 11. This is mainly motivated by the initial capital stock estimation method we employ in this paper, which is based on Harberger (1978), who uses three-year growth averages to construct a more stable initial capital stock for firms (see appendix for the calculation of capital stock series). Therefore, this produces an unbalanced sample of manufacturing firms, which mitigates possible selection and survivor bias, as Levinsohn and Petrin (1999) argue, by allowing for both entry and exit. All nominal values are deflated using 2-digit NACE price indices with the base year of 2010. For capital goods, we use an aggregate investment deflator provided by the Ministry of Development. In this study, foreign firms are defined as those firms in which the equity share held by a foreign investor is at least 10 per cent in accordance with the definitions of the OECD and the IMF.

4. Empirical analysis

The approach usually adopted in the empirical literature, examining the influence of foreign investment on firms' productivity or productivity growth, is regressing the productivity of domestic firms, most frequently measured as either labor or total factor productivity (TFP), on a number of covariates assumed to have an effect on productivity, including a measure of the extent of presence of foreign firms in an industry. As Girma and Gorg (2005) argue, this implies that productivity spillovers is constrained to be the same for all firms. However, when heterogeneity across firms is considered, spillover effects may be varied across firms. Accordingly, following Girma and Gorg (2005), we allow the spillover effects to vary across firms according to their level of absorptive capacity. In this paper, absorptive capacity is proxied by the technology gap between a firm and the industry leader. The assumption here is that the lower the technology gap (higher levels of absorptive capacity), the greater the benefit from FDI, as a firm has the necessary technological ability to assimilate the knowledge available from foreign firms.

For our purpose in this study, we estimate the spillover effects on productivity growth, considering absorptive capacity of firms. Specifically, we examine the effects of a change in horizontal, backward, and forward linkages, and the sectoral competition level, on firm-specific productivity growth.

As discussed earlier, FDI spillovers can occur through both horizontal and vertical linkages between domestic and foreign firms. Following Javorcik (2004), Kneller and Pisu (2007) among others, we construct spillover variables using the firm-level panel and Turkish input/output table (I/O table) for 2002 prepared by TURKSTAT. Specifically, the horizontal spillover variable (H_{jt}) is the share of total output of foreign-affiliated plants operating in Turkey (Y_{jt}^{f}) in industry j at time t in total output of industry *j* (Y_{jt}), and captures the intra-industry spillovers from foreign multinationals to domestic firms in the same industry. H_{jt} is calculated as:

$$H_{jt} = \frac{\sum_{i\epsilon j}(f_{ijt} * Q_{ijt})}{\sum_{i\epsilon j} Q_{ijt}} = \frac{Y_{jt}^{f}}{Y_{jt}} \qquad (1)$$

where f_{jt} denotes the foreign ownership share of firm *i* in industry *j* at time t and is represented by a variable whose value is either 0 or 1, where zero implies a fully-domestically-owned firm, and 1 depicts a fully-foreign-owned firm. Plants with at least 10% foreign ownership shares are defined as foreign-affiliated firms. Q_{ijt} is the total output of firm *i* in industry *j* at time *t*.

Vertical linkages can be divided into forward or backward categories. The variable for backward spillovers (B_{jt}) captures the spillovers from foreign firm operating in downstream industry to domestic firm operating in upstream industry (the domestic firm is an input supplier of the foreign firm). B_{jt} is calculated as:

$$B_{jt} = \sum_{m \text{ if } m \neq j} \alpha_{jm} H_{mt} \qquad (2)$$

where α_{jm} is the share of industry *j*'s output supplied to industry *m* in total output of industry *j*.

The forward variable (F_{jt}) captures the spillovers from foreign firm operating in upstream industry to domestic firm operating in downstream industry (the foreign firm is an input supplier of the domestic firm). F_{jt} is calculated as:

$$F_{jt} = \sum_{n \text{ if } n \neq j} \beta_{jn} H_{nt} \qquad (3)$$

where β_{jn} denotes the share of material inputs purchased by industry *j* from industry *n* in total inputs sourced by industry *j*.

We derive both the coefficients α_{jm} and β_{jn} following Javorcik (2004). The calculation of these coefficients require an integration with the Input-Output (I/O) table, which is available only for 2002 and at the 2-digit International Industrial Classification (ISIC) level.

The Herfindahl index captures the concentration level in an industry. Blomstrom and Kokko (1998), as referred to by Javorcik (2004), argue that the entry of multinational firms results in more severe competition and forces domestic firms to use their resources more efficiently or to search for new technologies, which may increase the productivity of domestic firms. The Herfindahl index is defined as the squared sum of the market shares of the largest 50 firms, and may be written as follows, where x_{ijt} is the sales of the firm i in industry j at time t and X_{jt} is the total sales of industry j.

$$HERF_{jt} = \sum_{i=1}^{50} \left(\frac{x_{ijt}}{X_{jt}}\right)^2 = \sum_{i \in j} s_i^2 \qquad i = 1,2,\dots,50 \tag{4}$$

where s_i is a market share of a firm *i* in industry *j* and $X_{jt} = \sum x_{ijt}$

For our purpose, we use the following total factor productivity (TFP) specification:

$$\Delta lnTFP_{ijt} = \mu\Delta H_{jt} + \omega\Delta B_{jt} + \phi\Delta F_{jt} + \alpha(abs\_cap)\Delta H_{jt} + \beta(abs\_cap)\Delta B_{jt} + \gamma(abs\_cap)\Delta F_{jt} + abs\_cap_{ijt} + \phi HHI_{jt} + v_j + v_t + \varepsilon_{it} \tag{5}$$

where *i*, *j*, and *t* index firm, two-digit industries, and time respectively. Spillover variables, H_{jt} , B_{jt} , and F_{jt} depict horizontal, backward, and forward linkages respectively, whereas HHI_{jt} represents two-digit industry concentration (Herfindahl Index). The variable abs_cap (absorptive capacity) is included individually in addition to the interaction terms to account for its own influence on TFP growth. Since the firm-specific TFP might also be driven by unobserved industry-specific and macroeconomic shocks, we include industry and time dummy variables. Time dummy variables also account for the average change of productivity that is not due to the spillovers. ε is a random error term.

Furthermore, the coefficient on the spillover variables in Equation 2.5 is explicitly made to depend on absorptive capacity (abs_cap). This reflects the idea that if absorptive capacity matters for the pattern of FDI-induced TFP growth, the spillover regression functions will not be identical across all domestic firms. Here, abs_cap is defined as (Girma and Gorg, 2005):

$$abs\_cap_{it} = {TFP_{it}} \Big/ {max_{industry}(TFP_{jt})} \tag{6}$$

that is, firm *i*'s TFP relative to the maximum TFP in the two-digit industry (the "industry leader").

Tables 1 and 2 provide the definitions and summary statistics of the variables used in this study respectively.

Table 1. *Definition of the variables*

Variables	Acronym	Definition
Herfindahl Index	hhi	the concentration level in an industry (the squared sum of the market shares of the largest 50 firms)
TFP	TFP	estimated by using a semi-parametric regression method constructed by Levinsohn and Petrin (2003)
Horizontal Linkage	horizontal	the linkage between domestic firm and foreign firm when both are in the same sector
Backward Linkage	backward	the linkage between domestic firm and foreign firm when the domestic firm is the input supplier of the foreign firm
Forward Linkage	forward	the linkage between domestic firm and foreign firm when the foreign firm is the input supplier of the domestic firm
Absorptive capacity	abs_cap	the difference between firms' productivity level and industry frontier productivity level

Source: TURKSTAT (The Annual Industry and Service Statistics and the Foreign Trade Statistics).

Table 2. *Summary Statistics of the key variables (All firms)*

Variables	Obs.	Mean	Min	Max
Herfindahl Index	146830	0.022	0.002	0.959
ln(TFP)	146830	6.180	0.064	10.245
Horizontal Linkage	146830	0.179	0.0000	0.966
Backward Linkage	146830	0.107	0.0110	0.361
Forward Linkage	146830	0.138	0.0003	0.848
Absorptive capacity	146830	0.040	0.0001	1

Source: TURKSTAT (AISS).

5. Quantile regression

Recently, studies on firm level productivity dynamics have sought to identify the sources of the large dispersions in productivity across firms, which are fairly persistent through time, even within narrowly defined industries. On the other hand, a parallel strand of research reveals that the amount of change in the productivity distribution is noteworthy (Bartelsman and Doms 2000). Girma and Gorg (2005) argue that this has an important implication for productivity growth empirics: "standard OLS or GMM techniques which concentrate on the conditional mean function of the dependent variable are unlikely to be adequate analytical tools". On the other hand, quantile regressions allow us to take better account of the large and persistent heterogeneity in productivity dynamics across establishments. It is more appropriate and interesting to examine the productivity dynamics at different points of the distribution rather than average properties (i.e. conditional means) (Girma and Gorg, 2005). In this context, we employ the conditional quantile regression introduced by Koenker and Bassett (1978) in their seminal article. This is due to the fact that quantile regression allows us to consider the impact of a covariate on the specific quantiles of the dependent variable rather than only its conditional mean.

The quantile regression model can be written as:

$$TFP_{it} = Z'_{it}\beta_{\theta} + \varepsilon_{\theta it}\ , Quant_{\theta}(TFP_{it}|Z_{it}) = Z'_{it}\beta_{\theta} \qquad (7)$$

where Z is the vector of independent variables specified in Equation 2.5 and $\mathrm{Quant}_\theta(\mathrm{TFP}_{it}|Z_{it})$ denotes the conditional quantile of TFP. The distribution of the error term ε_θ is left unspecified, so the estimation method is essentially semiparametric. The quantile regression estimator for quantile q minimizes the objective function (Buchinsky, 1998):

$$Q(\beta_\theta) = \sum_{i,t:\mathrm{TFP}\geq z'\beta} \theta \left| \mathrm{TFP}_{it} - Z'_{it}\beta \right| + \sum_{i,t:\mathrm{TFP}\leq z'\beta} (1-\theta) \left| \mathrm{TFP}_{it} - Z'_{it}\beta \right| \quad (8)$$

β_θ can be estimated by minimizing this non-differentiable function with respect to β_θ via the simplex method, which is guaranteed to yield a solution in a finite number of iterations (Cameron and Trivedi, 2005); i.e.

$$min_\beta \frac{1}{n} \left\{ \sum_{i,t:TFP\geq z'\beta} \theta \left| TFP_{it} - Z'_{it}\beta \right| + \sum_{i,t:TFP\leq z'\beta} (1-\theta) \left| TFP_{it} - Z'_{it}\beta \right| \right\} \quad (9)$$

Since θ varies from 0 to 1, one can trace the entire conditional distribution of TFP, conditional on the set of independent variables. Thus quantile regression allows different slope coefficients to be estimated for different quantiles of the conditional productivity distribution, and helps us answer questions like 'what are the spillovers from FDI to firms below the 10th percentile of TFP growth?' The answer to this question may have important implications as different responses to FDI may be expected from firms at different points of the productivity growth distribution (Girma and Gorg, 2005).

Similar to Girma and Gorg (2005), we consider regression estimates at five different quantiles, namely, the 10th, 25th, 50th (median), 75th and 90th percentiles of the TFP distribution.

6. Empirical results

Table 3 presents the results of productivity spillover estimations of equation (1) and the results for estimations of the 10^{th}, 25^{th}, 50^{th} (median), 75^{th}, and 90^{th} quantile of the TFP growth distribution.

And, Table 4 reports the results for the regression without the absorptive capacity interaction terms. In particular, the results in Table 4 indicate negative and highly significant horizontal spillovers for the 25^{th} and 50^{th} (median) quantiles and negative and weakly significant horizontal and backward spillovers for the 75^{th} quantile of the TFP growth distribution. Furthermore, there are negative forward spillovers to domestic firms at the 50^{th} and 75^{th} quantiles. Table 4 also shows that there no kind of spillover to domestic firms that have the highest and lowest TFP growth rates. In short, the regression results, without the absorptive capacity interaction terms, show either insignificant-negative or significant-negative evidence for spillovers.

Table 3. *Spillover Effects from FDI on Productivity of Domestic Firms (with absorptive capacity)*

(Dependent Variable: ∆lnTFP)					
Variables	q10	q25	q50 (median)	q75	q90
Constant	-0.424***	-0.149***	0.026***	0.158***	0.316***
	(0.023)	(0.012)	(0.008)	(0.010)	(0.019)
∆horizontal	-0.162*	-0.132***	-0.185***	-0.207***	-0.165**
	(0.097)	(0.050)	(0.034)	(0.044)	(0.080)
∆horizontal_abs	2.130**	1.481***	2.354***	3.309***	2.219***
	(0.927)	(0.484)	(0.329)	(0.421)	(0.769)
∆backward	-0.309	-0.157	-0.377***	-0.509***	-0.022
	(0.348)	(0.182)	(0.123)	(0.158)	(0.288)
∆backward_abs	8.362	3.793	7.640***	9.375***	-3.949
	(5.883)	(3.076)	(2.086)	(2.675)	(4.881)
∆forward	0.167	-0.079	-0.173***	-0.152**	-0.298**
	(0.153)	(0.080)	(0.054)	(0.070)	(0.127)
∆forward_abs	-2.110	0.502	2.869***	3.113***	6.150***
	(2.372)	(1.240)	(0.841)	(1.079)	(1.968)
hhi	-0.156	-0.700***	-0.800***	-0.625***	-0.243
	(0.419)	(0.219)	(0.148)	(0.190)	(0.347)
abs_cap	3.399***	2.767***	2.901***	4.361***	6.170***
	(0.095)	(0.050)	(0.034)	(0.043)	(0.079)
Number of obs.	121429				

Notes: Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%; regressions include time and industry dummies.

Table 4. *Spillover Effects from FDI on Productivity of Domestic Firms (w/out absorptive capacity)*

(Dependent Variable: ∆lnTFP)					
Variables	q10	q25	q50 (median)	q75	q90
Constant	-0.325***	-0.068***	0.104***	0.302***	0.538***
	(0.022)	(0.012)	(0.008)	(0.011)	(0.021)
∆horizontal	-0.111	-0.119***	-0.081***	-0.067*	-0.069
	(0.081)	(0.042)	(0.029)	(0.039)	(0.074)
∆backward	-0.014	-0.035	-0.108	-0.229*	-0.213
	(0.241)	(0.124)	(0.085)	(0.117)	(0.221)
∆forward	-0.029	-0.108*	-0.095**	-0.036	-0.058
	(0.114)	(0.059)	(0.040)	(0.055)	(0.105)
hhi	-0.640	-0.995***	-0.985***	-1.122***	-0.845**
	(0.415)	(0.213)	(0.147)	(0.201)	(0.380)
Number of obs.	121429				

Notes: Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%; regressions include time and industry dummies.

However, when accounting for firms' absorptive capacity, the results are more interesting for domestic firms across all quantiles. Due to the inclusion of the interaction terms, we have to compute the marginal effect of an increase in the growth of spillovers to understand the economic magnitude of the spillover effects from FDI at the different quantiles for a given level of absorptive capacity. The marginal effects, which are presented in Tables 5 – 7, are evaluated at different levels of absorptive capacity; 0.3, 0.6, and 0.9. For example, the figures in the Table 5 show that, for a firm in the 10th percentile of the TFP distribution, a 1 percentage point increase in the growth of horizontal spillover will lead to a 0.477 percentage point increase in the growth of TFP for the level of 0.3 of absorptive capacity. This effect is much larger for firms with higher TFP growth rates, where a 1 unit increase in the growth of horizontal spillover is estimated to lead to 0.52, 0.79, and 0.50 percentage point increases in the growth of TFP of firms located at 50th, 75th, and 90th percentile of the TFP growth distribution respectively. The largest marginal effects are apparent for the 50th and 75th quantiles. This suggests that domestic firms with medium and high productivity growth rates are set to benefit more from horizontal spillovers than firms in the highest or lowest range of the distribution. Therefore, the results from Tables 3 – 5 suggest that, as the firms become more productive and improve their absorptive capacity, they are able to benefit from positive horizontal spillovers by, for example, imitating the technology of foreign firms, and with the help of mobility of workers across firms, which outweigh the negative competition effect, allowing them to enjoy higher TFP growth rates.

Table 5. *Marginal effect of increase in horizontal spillovers, evaluated at different levels of abs_cap*

	0.3	0.6	0.9
10th quantile	0.477	1.116	1.755
25th quantile	0.3123	0.7566	1.2009
median	0.5212	1.2274	1.9336
75th quantile	0.7857	1.7784	2.7711
90th quantile	0.5007	1.1664	1.8321

Note: Table gives the effect of a one unit increase in FDI on TFP growth, evaluated for different levels of absorptive capacity.

Regarding the backward spillovers, the findings in Table 6 suggest that the domestic firms with medium and high TFP growth rates benefit from FDI. Table 6 also suggests that local firms with lower and highest TFP growth rates do not benefit from FDI through backward linkages. Interestingly, firms in the middle range of the distribution benefit most from backward spillovers for the level of 0.6 of absorptive capacity. This implies that local firms benefit most as they increase their absorptive capacity up to a certain level of absorptive capacity.

Table 7 shows the marginal effect of increase in forward spillovers. The results reveal that the largest marginal effects are apparent for the 90th percentile of the TFP growth distribution. The firms with medium and high TFP growth rates also benefit from FDI as they increase their absorptive capacity and close the technology gap, whereas absorptive capacity does not play any role in determining the forward spillovers to the firms in lower range of the distribution.

Table 6. *Marginal effect of increase in backward spillovers, evaluated at different levels of abs_cap*

	0.3	0.6	0.9
10th quantile	2.1996	4.7082	7.2168
25th quantile	0.9809	2.1188	3.2567
median	1.915	7.863	6.499
75th quantile	2.3035	5.116	7.9285
90th quantile	-1.2067	-2.3914	-3.5761

Note: Table gives the effect of a one unit increase in FDI on TFP growth, evaluated for different levels of absorptive capacity.

Table 7. *Marginal effect of increase in forward spillovers, evaluated at different levels of abs_cap*

	0.3	0.6	0.9
10th quantile	-0.466	-1.099	-1.732
25th quantile	0.0716	0.2222	0.3728
median	0.6877	1.5484	2.4091
75th quantile	0.7819	1.7158	2.6497
90th quantile	1.547	3.392	5.237

Note: Table gives the effect of a one unit increase in FDI on TFP growth, evaluated for different levels of absorptive capacity.

Positive and significant marginal effects reported in Tables 6 and 7 signify that the higher the absorptive capacity, the greater the vertical spillovers to the firms located higher range of the TFP growth distribution. In other words, as domestic firms increase their productivity and close the technology gap with multinationals, they may benefit from their linkages with foreign suppliers and from their interaction with foreign firms as their suppliers. Forward spillovers can be negative if the products are too technologically complex for domestic firms to use and less adapted to the domestic market or more expensive (Javorcik, 2004). If domestic firms increase their productivity and close the technology gap, they may enjoy positive forward spillovers as they are able to use the higher quality inputs from multinationals more efficiently.

7. Conclusion

In this paper, we examine the role of absorptive capacity in determining the existence of possible productivity spillovers from FDI through horizontal (intra-industry) and vertical (inter-industry) linkages. To do so, we utilize quantile regression, which might allow us to see the difference in the spillover effect on enterprises located at different quantiles of the productivity growth distribution. Using quantile regression techniques, as Girma and Gorg (2002) point out, allows for large and persistent heterogeneity in productivity dynamics across firms. For our purpose we use a recent dataset on Turkish manufacturing firms for the period 2003-2013. The data come from the Annual Industry and Service Statistics (AISS) obtained from Turkish State Institute of Statistics (TURKSTAT).

The empirical analysis reveals that, when the absorptive capacity of firms is not taken into account, there are either insignificant-negative or significant-negative evidence for spillovers. Domestic firms are able to benefit from positive spillovers only if they improve their absorptive capacity and closing the technology gap. Specifically, with reference to horizontal spillovers, regardless of quantile firms locate at, all firms benefit from positive spillovers, but with the condition of there being adequate absorptive capacity. This finding suggests that domestic firms are able to benefit from positive spillovers by improving their absorptive capacity and closing the technology gap; this outweighs the negative competition effect, allows them to enjoy higher TFP growth rates. We should also note that horizontal spillovers are much larger for firms with higher TFP growth rates, especially for those located at 50^{th} and 75^{th} quantile of the TFP growth distribution.

Regarding the vertical spillovers, our findings suggest positive spillovers to firms with adequate absorptive capacity and especially to those that have medium and high TFP growth rates.

Overall, absorptive capacity seems to be important to capture the positive productivity spillovers from FDI, especially for the firms located in the middle and higher range of the TFP growth distribution.

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Appendix

Capital Stock Estimation

The perpetual inventory method is a simple method of producing a capital stock series from data on investment flows. The capital stock in period t is equal to the capital stock in the previous period after accounting for depreciation plus new additions to the capital stock in terms of net-investment.

$$K_t = (1-\delta)K_{t-1} + I_t \quad (A.1)$$

where K_t represents the capital stock at time t, δ the geometric depreciation rate, and I_t is investment.

In order to be able to apply the Perpetual Inventory Method to calculate the current capital stock, we need (i) a time series of investment data, (ii) information on the initial capital stock at the time when the investment time series starts, and (iii) information on the rate of depreciation of the existing capital stock.

(i) Time series of investment data

The basic ingredient to the perpetual inventory method is the investment information provided in the AISS. The AISS distinguishes between 4 types of investment:
1. Machinery and equipment
2. Buildings and civil engineering structures
3. Other tangible goods
4. Computer software

After calculating capital stock series for each one of these asset types, these series are aggregated to obtain the total capital stock series of the firm.

(ii) Initial capital stock

The implementation of the perpetual inventory method varies with respect to the way the initial capital stock is constructed. In this paper we employ the steady state approach to estimate the initial capital stock, which is based on the neoclassical growth theory whereby the economy is assumed to be at its balanced growth path (Harberger, 1978). This translates into firms operating at their steady state at a micro level. Hence, output grows at the same rate as the capital stock which implies constant capital-output over the long run. Therefore, denoting the initial year of the firm with "0", considering K_0 as initial capital stock of firm i and δ as depreciation rate, initial capital stock is constructed as follows:

$$K_{i1} = (1-\delta)K_{i0} + I_{i0} \quad (A.2)$$

Dividing both sides of equation with K_{i0}, we get

$$\frac{K_{i1}}{K_{i0}} = (1-\delta) + \frac{I_{i0}}{K_{i0}} \quad (A.3)$$

Since we assume that firms are at their balanced growth path

$$\frac{K_{i1}}{K_{i0}} = \frac{Y_{i1}}{Y_{i0}} = 1 + g_i \quad \text{(A.4)}$$

so

$$1 + g_i = (1 - \delta) + \frac{I_{i0}}{K_{i0}} \quad \text{(A.5)}$$

then

$$K_0 = \frac{I_0}{g_i + \delta} \quad \text{(A.6)}$$

where g is the growth rate of the firm and calculated as growth of deflated production value.

An obvious problem of the Steady State Approach is that the estimate of the initial capital stock depends crucially on the investments and the growth rate of output in a single year. While this is unproblematic if the economy under consideration is in fact in equilibrium, a short-term investment shock in the first period of the available time-series of investments would lead to a strongly biased initial capital stock estimate. To counter this problem, Harberger (1978) uses three year averages to construct a more stable and reliable initial capital stock for firms (Berlemann and Wesselhoft, 2012). As a rendition to this, we use average investment and average growth rate of output of firms that appear in at least four years to construct our initial capital stock.

The steady state approach can generate negative value for initial capital stock if the average growth rate in output is negative and greater than the depreciation rate. This method can also generate zero value for initial capital stock in case the firms report zero investment for the first year they appear in the dataset. For firms that report zero investment at their initial year, it is assumed that they cannot be producing without capital. Therefore initial capital stock is calculated at the year that they report positive investment and this amount is iterated back to the beginning year by dividing each type of capital stock by (1-δ) for each former year.

(iii) The rate of depreciation of the existing capital stock

Ozler and Yılmaz (2007), utilizing Turkish micro level data from 1983-1996, assumed depreciation rates of 5%, 10%, 20% and 30% for building and structure, machinery and equipment, transportation equipment and computer and programming respectively. However, these depreciation rates are quite high compared to those in the literature. Furthermore, the methodology of the data covering the period 2003-2013 is quite different from the previous years. Therefore, motivating from the literature, we assume the following depreciation rates: 2.5 percent for building and civil engineering structures; 5 percent for transportation vehicle, machinery and equipment, and computers; 10 percent for other tangible goods; and 15 percent for computer software.

Given the initial capital and depreciation rates, perpetual inventory method is used for following years where we assume that capital stock is predetermined and evolves according to,

$$K_t = (1 - \delta)K_{t-1} + I_t \quad \text{(A.7)}$$

Total Factor Productivity (TFP) Estimation

The earlier literature investigating the spillover effects from FDI estimate the production function using traditional methods, i.e. by applying ordinary least squares (OLS) to a panel of (continuing) firms. However, OLS estimation of TFP create several methodological issues. OLS technique assumes that production inputs are uncorrelated with omitted unobservable variables even though productivity and input choices are likely to be correlated. Hence, OLS estimation of firm-level production functions introduces a simultaneity or endogeneity problem and thereby results in inconsistent and biased estimates of production function. Moreover, a selection bias will emerge if no allowance is made for entry and exit (van Beveren, 2010)

In response to these methodological issues, several estimators have been proposed in the literature. The main contributions to measuring firm level TFP are by Olley and Pakes (1996) and Levinsohn and Petrin (2003). The key difference between the two methods is that Olley and Pakes (1996) use investment whereas Levinsohn and Petrin (2003) introduce material inputs as a proxy into the estimation procedure.

Levinsohn and Petrin (2003a) (LP) point to the evidence from firm-level datasets that there are substantial adjustment costs related to the investment. They argue that it is less costly to adjust material inputs than to adjust investment in response to the productivity shocks. If this is the case, the investment proxy may not smoothly respond to the productivity shock, violating the consistency condition. On the other hand, firms generally report positive material inputs whereas large number of zero observations in investment series are observed (Petrin et al., 2004).

In this paper we use Levinsohn and Petrin (2003) (LP) methodology to estimate firm level production function. Specifically, we estimate Cobb-Douglas production function by expressing value added as a function of capital and labor costs, using materials and energy usage as a proxy for unobserved productivity shocks:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + \beta_e e_{it} + \omega_{it} + \eta_{it} \qquad \text{(A.8)}$$

where y_t is the logarithm of the firm's output, measured as value added in this study; l_{it}, m_{it} and e_{it} are the logarithm of labor, material and energy usage respectively; and k_t is the logarithm of the state variable capital. ω_{it} denotes productivity of the firm and η_{it} stands for measurement error in output, which is uncorrelated with input choices. See Levinsohn and Petrin (2003) for a detailed description of the estimation procedure and the derivation of the TFP.