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The Role of Human Capital In Productivity Spillovers from FDI: An Empirical Analysis on Turkish Manufacturing Firms*

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April 6, 2010

Abstract

The importance of human capital skills in allowing for productivity spillovers from foreign direct investment (FDI) to domestic firms at the country (macro) level is well established in the literature. In this paper, using firm-level data, we decompose this effect and investigate through which channel of linkages human capital endowments of local firms act as an absorptive capacity. The dynamic nature of these spillovers and the respective role of human capital in these dynamic gains are also studied. An unbalanced panel data of Turkish manufacturing firms covering the period 1990-2001 is used. Econometric tests point to dynamic effects, where the effects of linkages are spread over two time periods. While there is no evidence for horizontal linkages affecting the local firm's productivity, backward linkages are found to negatively affect the current period productivity, while this effect is overcome with larger positive effects with one period lag. The reverse is valid for forward linkages, where the positive effects of forward linkages in the current period are overcome with larger negative effects with one period lag. A deeper investigation suggests that horizontal linkages (both in the current period and with a period's lag) matter positively only for local firms with more human capital/skilled labor. Whereas, human capital does not play a role of a limiting absorptive capacity when it comes to the realization of vertical linkages.

JEL Classification: F23, F16, J31
Keywords: Foreign Direct Investment, Productivity Spillovers, Human Capital.

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1 Introduction

The transfer of new technologies and techniques plays a key role in economic growth and development of a country. This technology diffusion may take place through different channels, among which foreign direct investments (FDIs) are considered to be very important. Multinational companies (MNCs) operate with a higher level of technology to be able to compete with domestic firms which are familiar to the local market conditions, business practices and consumer preferences (Blomström and Sjöholm, 1999). This characteristic of MNCs enable domestic firms to gain access to new technologies through imitating the products and techniques of the foreign firms or gaining access to their managing and marketing skills. Imitation, learning-by-observing or technology transfers through competition are all possible if the human capital available to the local firm is sufficiently skilled to be able to do any of these activities.

Such knowledge and technology transfers occur through three types of linkages between domestic and foreign firms. Foreign firms and domestic firms can interact and compete within the same sector or might operate in different sectors and provide inputs to each other. The first type of interaction, labelled as horizontal linkages can lead to horizontal spillovers where domestic firms benefit from foreign affiliates which are operating within the domestic firm's sector. On the other hand the latter channel of interaction, labelled as vertical linkages can lead to either backward spillovers where the domestic firm that operates as the input supplier to the sector that the multinational operates in benefits from this interaction or forward spillovers where the multinational operates as the input supplier to the domestic firm and the domestic firm benefits from this interaction.

The earlier studies have mostly found that there is very weak evidence regarding the existence of any positive horizontal spillovers.[1] Javorcik (2004), in a seminal paper, has suggested that the

[1]The earlier studies focusing solely on the horizontal spillover channels start with industry-level analysis. These studies mostly point to a positive correlation between FDI presence and average value added per worker. See, for example, Caves (1974), Mansfield and Romeo (1980), Blomström and Persson (1983), Blomström and Wolff (1994) and Blomström (1999). However, the positive correlation in these studies may arise from the reverse causality problem. To overcome the above

literature was "looking for spillovers in the wrong place". Accordingly, the findings on Lithuania reported by Javorcik (2004) documents evidence supporting positive productivity spillovers through backward linkages. Following this study a literature studying the respective roles of horizontal and vertical linkages in generating spillovers has spawned. Similar to Javorcik's (2004) results on Lithuania studies by Schoors and Tol (2001) on Hungary, Blalock and Gertler (2003) on Indonesia, Mucchielli and Jabbour (2003) on Spain and Sasidharan and Ramanathan (2007) on India have found evidence of positive backward spillovers from FDI. Indeed, Schoors and Tol (2001) and Javorcik (2004) find evidence for negative forward spillovers alongside with positive backward spillovers. We hypothesize that not only was the literature looking at the wrong channels of spillovers, but continues to ignore possible dynamic effects (i.e. lagged realization of spillovers) as well as the role played by firm level absorptive capacities in ensuring that these spillovers are realized. We especially emphasize the role of the human capital (i.e. skilled labor in the total labor force) of the firm as an important absorptive capacity for the firm. Indeed, we argue that the lack of any horizontal spillovers could be due to lack of controlling for the possible role played by firm characteristics in ensuring such spillovers to accrue. In other words, we argue that only firms with a certain human capital endowment will benefit from horizontal spillovers and analyses that do not take into account for such firm-level absorptive capacities will fail to find any positive horizontal spillovers.

There are several reasons to expect positive spillovers via horizontal linkages which may be realized through imitating the foreign technologies, techniques and managerial skills. First, to gain access to more efficient techniques, local firms may hire workers trained by multinationals and this labor turnover

defined problem, case-level studies regarding the spillovers from a specific MNC to firms in the sector MNC operates in were undertaken by Larrain et al. (2001) and Moran (2001), among others. However, the problem with these case-level studies is that their findings are specific to the multinational they focus on. Therefore, the results of these studies are limited in providing a general result on FDI spillovers. Hence the move towards firm-level panel data studies. These include the studies such as those by Haddad and Harrison (1993) on Morocco, Aitken and Harrison (1999) on Venezuela, Blomström and Sjöholm (1999) on Indonesia, Djankov and Hoekman (2000) on the Czech Republic, Konnings (2001) on Bulgaria, Romania and Poland, among developing economies, and those by Haskel et al. (2007) on the U.K. and Keller and Yeaple (2003) on the U.S, among developed economies.

could positively contribute to the productivity of the domestic firm. Second, as discussed in Blomström and Kokko (1998), the existence of a foreign affiliate in the sector may create a competition effect and domestic firms may try to catch up with multinationals through research and development activities and reallocation of resources. Finally, as pointed out in Blalock and Gertler (2003) international trade brokers, accounting firms, consultant companies and other type of professional services which multinational corporations require may become available to domestic firms.

On the other hand, the competition effect created by multinational entrance may prevent such direct horizontal spillovers from taking place. Multinationals competing with domestic firms may try to inhibit information leakages. They may impede domestic firms to gain access to their efficient technologies and techniques by using intellectual property rights and trade secrecy or by paying higher wages than domestic firms are able to pay to prevent labor turnover (Javorcik, 2004). Also, as multinationals acquire market shares in the host economy, this may divert demand from domestic firms and increase their average costs. This may further decrease the domestic firm productivity (Aitken and Harrison, 1999). Furthermore, by hiring skilled workers, multinationals may cause "brain drain" in the local sector (Blalock and Gertler, 2003).

As noted above, the findings in the literature mostly point to insignificant horizontal spillovers, where the positive and negative effects discussed here probably negate each other. It could be that if one were to take into account the dynamic nature of these linkages and the absorptive capacity role played by the human capital endowment of domestic firms this result could change. It is quite possible that the realizations of any spillovers from the horizontal (and vertical) linkages take time. There are only very few studies that have looked into the dynamic nature of spillovers. Haskel et al (2007) study the time dynamics of the effects of foreign presence in the firm's sector and in the region of operation, and although this is not their main focus of the paper they find that the foreign presence in the industry the firm operates in has spillover effects with a lag. Our analysis differs from theirs by differentiating

between the type of linkages and identifying in which sector the foreign presence occurs in. Stanck (2007) on the other hand studies the productivity spillovers in the Czech Republic, and discusses the time lag for each linkage. This is in line with our analysis; however, we also look into how these time dynamics interact with the human capital (absorptive capacity) of the firms.

Horizontal linkages can be thought of as mainly occurring through a transmission of knowledge made possible by labor mobility and competition effects. While the competition effects might be felt by the local firms very quickly and lead to a quick reorganization of resources to ensure productivity improvement, being able to imitate a product or being able to allure workers from the MNC to carry over knowledge to allow for such imitation or product improvement are phenomena that are to take longer time. As such, one would expect the productivity effects to be spread out over time, and not be necessarily realized in the current period when linkages occur.

Furthermore, domestic firms with more human capital are expected to imitate easier, to avoid the negative effects of competition from foreign firms easier via faster improvements in produtivity, and finally, to be able to reallocate resources to R&D activities with a higher probability. As such, one would expect that firms with a higher share of skilled labor will benefit positively from horizontal spillovers. On the other hand, domestic firms with higher levels of human capital may be in more competition with MNCs than domestic firms with lower levels of human capital. Although there are no formal contracts between the domestic firm and MNC that operate in the same sector, MNCs may prevent technology transfer to these high-tech firms with higher levels of human capital. Therefore, ex ante human capital is expected to play both a positive and a negative role in making positive spillovers happen. Resolving which of these effects dominate is an empirical issue, a task we undertake in this paper.

As noted above, the elusive spillovers from horizontal linkages have instigated interest in disentangling the intersectoral spillovers, i.e. backward and forward spillovers, in the literature. In the case of

backward spillovers multinationals that demand higher-quality inputs are expected to try to improve the efficiency of their local intermediate input suppliers by direct knowledge transfer. Furthermore, just because multinationals demand higher-quality inputs, to be able to sell their products to foreign affiliates local suppliers will have an incentive to improve their production techniques. Finally, entrance of a multinational into the final goods sector may create benefits of scale for domestic suppliers (Javorcik, 2004 and Blalock and Gertler, 2003). These all point to the expectation of positive backward spillovers. In addition to backward spillovers, another type of intersectoral benefits may be realized through forward linkages. Domestic firms who gain access to higher-quality intermediate inputs and to the complementary services provided for these inputs may present higher levels of productivity (Javorcik, 2004).

On the contrary, local suppliers may not be able to meet the standards of MNCs and have difficulty in supplying higher-quality inputs that foreign firms demand. This may limit the spillovers through backward channels (Mervelede and Schoors, 2005). Similarly, forward spillovers may be limited if domestic firms are not able to utilize the high-quality and more expensive inputs that are produced by MNCs. Such outcomes point to the possibility of negative vertical spillovers.

The realization of spillovers from vertical linkages could also take time to be realized. The main benefits from backward linkages are that the local firm will be required to supply a higher quality input to the MNC and will be forced to reorganize its production to ensure such productivity improvements. Similarly, the newly established forward linkages also require a reorganization within the local firm who will be using the higher quality inputs provided by the MNC. While a part of these reorganization effects might occur in the short-run some resource reallocation might require a longer time and the positive benefits of such changes would only occur over time.

As was argued for the realization of horizontal spillovers there is also a possibility that human capital does play a role as an absorptive capacity for the positive vertical spillovers. To meet the higher

standards of multinationals who are using domestic firm's input (backward) or to be able to utilize the high-quality inputs provided by the MNCs (forward) a certain human capital endowment is needed.

In order to benefit from backward spillovers, domestic firms have to be able to produce inputs that can meet the standards of MNCs. The firms that are more technologically advanced and possess high levels of human capital are more able to meet these standards. Therefore, these firms face a higher probability to interact with MNCs as suppliers and the spillovers through backward linkages on domestic suppliers with high human capital may be higher. Furthermore, this may create higher competition for domestic suppliers with low levels of human capital and these firms may realize negative spillover through backward linkages.

In the forward spillovers case, the high-tech and more expensive products of foreign firms can be used as an input by domestic suppliers with higher levels of human capital. These firms may realize productivity gains through increased quality of inputs, and hence, realize higher positive forward spillovers. Moreover, as these high-tech firms benefit from foreign presence in upstream sector, they may create a competition effect for low human capital firms. Thus, firms with low levels of human capital get hurt through forward linkages (Mervelede and Schoors, 2005).

Thus, one can argue that spillovers take time to be realized and the human capital level of domestic firms may affect the possible productivity spillovers from FDI. Therefore any productivity spillover analysis of FDI should take into account the time dynamics of linkages and the absorptive capacities of the firm, especially the skill composition of its labor force. In fact, the mixed results found in the literature on the spillovers from FDI on firm productivity may lead one to think that the net effect of these linkages should be evaluated by taking firm-specific characteristics into consideration, where the human capital of the firm acts as an indicator of the firm's capacity to absorb the better technology.

Country-level macro studies have already identified the country-level human capital endowment as critical for ensuring positive growth effects from FDI (see Borenzstein, de Gregario and Lee, 1998, and

Xu, 2001 among others). It is also of interest to decompose the channels through which the country-level absorptive capacities play a role at the firm level. More specifically, it is of interest to analyze the role played by the human capital endowment of firms in allowing the three channels of spillovers – horizontal, backward or forward– to be realized.

More recent firm-level studies have been able to disaggregate these benefits and identify through which linkages the productivity spillovers accrue. Studies by Castellani and Zanfei (2001), Mervelede and Schoors (2005), Girma et al (2003), among others, have discussed the role of the technology gap between the domestic and foreign firms and the export status of the domestic firms as an absorptive capacity of the firms to benefit from productivity spillovers. These studies are able to discuss for which linkages between domestic and foreign firms technology gap and the export status of the firm plays the role of an absorptive capacity. However, no firm-level study has looked into the role of human capital as an absorptive capacity at the firm level.[2] In this study we try to fill this void in the literature, where we look into the role of the human capital level of the domestic firms in making productivity spillovers possible and study for which linkages and over what time frame these spillovers occur.

In order to disentangle the role played by human capital in the realization of productivity spillovers from foreign firms we use a plant-level dataset from the Turkish manufacturing industry, covering the period 1990-2001. Upon estimation of the total factor productivity (TFP) of firms using the Levinsohn-Petrin (2003) methodology we search for the existence of horizontal and vertical spillovers and the correct lag structure for such spillovers. Our results show that while Turkish firms have benefited positively from foreign firms via their backward linkages (with a negative effect in the current period overcome by a positive effect with a period lag) they have been hurt via their forward linkages (this time with a positive effect in the current period overcome by a negative effect with a period lag). However, any evidence for horizontal spillovers are elusive. These findings echoe that of Javorcik (2004) for Lithuania,

[2] An exception is Lenger and Taymaz, 2006, who study spillovers among low-tech and medium-high-tech industries and show that the different levels of skilled employees across Turkish firms does not alter their results.

who also finds positive backward spillovers accompanied by negative forward spillovers and extends it to show that the effects can take time to be fully realized.

We next look into whether or not the human capital level of the domestic firm alters the results regarding the horizontal and vertical spillovers. The results support the role of human capital as an absorptive capacity. Evidence suggests that there are overall positive backward spillovers and negative forward spillovers on firm-level productivity regardless of the human capital endowment of the domestic firm. However, positive horizontal spillovers are only observed in domestic firms with human capital levels above a certain threshold level. This result suggests that Boreznstein et al's (1998) finding is mostly reflective of the horizontal spillovers being realized only in countries with a certain human capital endowment. Our results can be viewed as a disaggregation of the total productivity spillovers discussed in Borenzstein et al (1998) and as such adds value to their discussion.

The rest of the study is structured as follows: section 2 provides a discussion of the data and the variables constructed for the analysis. Section 3 discusses the estimation and empirical results. Section 4 concludes.

2 Data

The data set used in this study is on the Turkish manufacturing industry collected by the Turkish Statistical Institute (TurkStat). This data set is available at TurkStat in a machine-readable form starting from 1980. The data coverage ends in 2001 due to lack of consistent data availability.[3] In order to calculate the productivity of the firms we first have to calculate the capital stock for individual firms. As such we limit the final regression analysis to 1990-2001.[4] This time coverage is much larger

[3]While data has been collected for 2003-2007 the change in the sampling technique makes the recently collected data incompatible with the earlier panel data.

[4]Although the time period of this analysis is 1990-2001, the capital stock series is constructed from 1983 in order to reduce problems arising from the initial capital stock calculation. Firms that have 10-24 employees are excluded from the analysis due to two problem encountered in the calculation of this capital stock series. First, detailed investment series needed for capital stock calculation is only available after 1991 for the firms that have 10-24 employees. Second, for these firms, the fuel consumption is included in material inputs and cannot be extracted.

compared to previous studies and is long enough to record changes in foreign ownership of individual firms and overall macroeconomic conditions.[5] Although the Statistical Institute collects information for all establishments, regardless of their employment size, in this study we focus only on establishments with 25 or more employees simply due to the unavailability of several of the necessary variables for the establishments that have 10-24 employees.[6] [7] Finally, this study focuses only on private establishments.[8]

Total number of firms and foreign affiliated firms included in this analysis are 5578 and 265, respectively. Table 1 presents the number of firms and foreign affiliated firms for each year in the analysis. Although, the absolute number of firms and foreign firms have increased throughout the period of this study, the percentage share of foreign affiliated plants have only increased from 4.7 percent in 1992 to 5.7 in 2001.

The sectors with the highest foreign presence are industrial chemicals (351), other chemicals (352), electrical machinery (383) and transport equipment(384) as can be seen from column 3 of table 2. The sectors with the lowest foreign presence are leather products (323) and footwear (324).

Our goal is to test for the relationship between FDI and productivity, and whether this relationship depends on the human capital endowments of the local firm. For this purpose we need to calculate the TFP level for each firm and regress this productivity on industry-based linkage measures and their interaction with a firm level human capital indicator. We next discuss the data most relevant for this analysis, namely the TFP measure, linkages and human capital measures, alongside the control variables

[5]For example, Javorcik (2004) studies the period 1996-2000, Yılmaz and Taymaz (2009) study the period 1990-1996 and Mervelede and Schoors (2005) study the period 1996-2001.

[6]Information on addresses of establishments are collected in two steps. First, TurkStat conducts Census of Industry and Business Establishments (CIBE) every 10 years for every industry except agricultural industry. In the period of this analysis, CIBE is conducted only in 1992. CIBE is collected from establishments that have 1 or more employees and possess information on addresses and employment of firms. For the entry and exit of establishments that have 10 or more employees, they gather information from the chamber of industry annually. After collecting addresses, TurkStat conducts Annual Survey of Manufacturing Industries (ASMI) at establishments with 10 or more employees.

[7]TurkStat also gathers data on establishments with less than 10 employees. Until 1992 this data was collected as explained above. After 1992, the sampling method has been adopted for this type of establishments. However, these firms are not included in the following analysis.

[8]This data set is not on firms but is on establishments. However, the Turkish manufacturing industry consists mostly of single plant establishments (see Taymaz and Yılmaz, 2009).

used in the regression.

2.1 Total Factor Productivity (TFP)

The TFP for each firm is calculated using the Levinsohn-Petrin methodology. Earlier studies have used OLS estimation of the production function to calculate the TFP. However, as suggested by Griliches and Mairesse (1995), treating inputs of production as exogenous variables can create biases in the OLS estimation of the TFP. Another problem with OLS estimation of the production function is the selection bias. The selection bias is due to the fact that the capital stock, as a state variable, responds to productivity shocks with a lag. If a firm possesses large amounts of capital stock, it will expect higher returns for a given level of productivity and, therefore, it will continue to operate in the market even if it observes low levels of productivity for the next period (Olley and Pakes, 1996). On the contrary, firms with lower levels of capital may not be able to remain in the market in similar conditions. Hence, the resulting capital coefficient is an underestimate of the true coefficient.

Olley and Pakes (1996) and Levinsohn and Petrin (2003) have proposed ways of resolving these two biases. Olley and Pakes (1996) suggest to proxy productivity shocks with the investment decision of the firms and therefore eliminate the relationship between productivity shocks and variable inputs. Moreover, they incorporate an exit-entry rule into the estimation procedure to overcome the selection bias.

Levinsohn and Petrin (2003) on the other hand suggest that in data sets that include a large number of zero observations in investment series, the investment cannot be monotonically increasing in productivity. Therefore, productivity shocks cannot be proxied by investment decisions. On the other hand, firms generally report material inputs positively. Moreover, it is less costly to adjust material inputs than to adjust investment. Therefore, material inputs respond to the productivity shocks better than investment causing Levinsohn and Petrin (2003) to introduce material inputs as a proxy into the

estimation procedure.

In this study, the Levinsohn-Petrin estimation procedure is used due to large number of zero observations in investment series in the Turkish manufacturing industry dataset.[9] We could have used Olley-Pakes by using only positive investment observations in order to avoid the non-monotonicity problem. However, this causes a significant loss of observations, and hence, efficiency.

In estimating the TFP using the Levinsohn-Petrin methodology we use value added as the dependent variable rather than output. As discussed by Arnold (2005), Levinsohn-Petrin is not able to identify the coefficients for material inputs, energy, labor and capital due to the lack of variation in data when output is used as the dependent variable. We find that this is also the case for the Turkish manufacturing industry. Therefore, we use value added defined as the gross output net of intermediate inputs, as the dependent variable.[10]

Industries show statistical variation in output, employment and capital to labor ratios as can be seen in columns 4 through 7 in table 2. The variables are statistically different among sectors. The sectors that have the highest production and employment figures are industrial chemicals (351), other chemicals (352), ceramics (361), glass (362), electrical machinery (383) and transport equipment (384). The most capital intensive sectors are beverages (313), textiles (321), industrial chemicals (351), other chemicals (352), ceramics (361), glass (362) and fabricated metals (381). Finally, the highest total factor productivity is observed in the miscellaneous food (312), wood products (331), other chemicals (352), fabricated metals (381) and electrical machinery (383) sectors. These differences are important in the calculation of TFP. Since sectors differ in these production related measures it makes more sense to calculate the TFP sector by sector, rather than using the whole sample.

Table 3 presents some summary statistics for the firm characteristics for each year. It is evident that the foreign firms are larger in terms of production, number of employees and are more capital intensive

[9] 41 percent of the data on investment is composed of zero observations.

[10] The variables and data used in the Levinsohn-Petrin estimation are detailed in the Appendix.

when one compares average employment and average capital/labor with their domestic counterparts. Finally, average total factor productivity of foreign-owned firms are much higher than domestic-owned firms. All of these differences between domestic and foreign firms are statistically significant, again supporting the estimation of TFP sector by sector.

Tables 4 and 5 show the estimation results of the production function using OLS and Levinsohn-Petrin, respectively. As expected, the coefficient of labor decreases and that of capital increases when we use Levinsohn-Petrin instead of OLS.

We also calculate alternative TFP measures for robustness control purposes. In the benchmark regressions we use the TFP measure calculated using the Levinsohn-Petrin methodology, and where we use the total labor employed in aggregate form in the production function estimation. However, in the regression analysis reported in section 3 we argue that the composition of the firm's labor force plays an important role in the evolution of productivity and FDI relationship. As such, to ensure our results do not depend on how we measure the labor force in the Levinsohn-Petrin analysis we apply the Levinsohn-Petrin methodology to a disaggregate labor force data of the firm, i.e. where the skilled jobs and unskilled jobs are treated as separate inputs in the production function. Finally, we also calculate the TFP assuming constant shares for each production factor, without estimating them semiparametrically.

2.2 Linkage measures

We next discuss the calculation of the FDI indicators, namely the horizontal, forward and backward linkages. This calculation requires the input-output matrix of three-digit industries. The input-output matrix is only available for the years 1990, 1996 and 1998. Therefore, we used the 1990 matrix for the years 1990-1993, the 1996 matrix for the years 1994-1997 and the 1998 matrix for the years 1998-2001.[11]

[11] In this study linkages are measured in the traditional approach. Vacek (2009) and Taymaz and Yılmaz (2009) provide alternative product based linkage measures, whereas Barrios, Gorg and Strobl (2009) suggest using the input-output matrices of the investing country rather than the host country. These alternative measures are not preferred for comparability

The horizontal linkage that measures the relationship between domestic and foreign firms when they operate in the same sector is calculated as:

$$H_{jt} = \sum_{m \epsilon j} (f_{mt} * Q_{mt}) / \sum_{m \epsilon j} Q_{mt}$$

where f_{mt} is the foreign-ownership share of plant m at time t, Q_{mt} is the output of plant m at t. Therefore, H_{jt} can be defined as the share of the foreign affiliated plants' output in sector j in the total output of sector j. Note that, H_{jt} increases when there is an increase in foreign investment in sector j or an increase in the output of foreign-affiliated plants in sector j.

The backward linkage variable that measures the relationship between domestic and foreign firms when the domestic firm is the input supplier to the foreign firm is calculated as:

$$B_{jt} = \sum_{j \neq m} \alpha_{jm} H_{mt}$$

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

The forward linkage variable that measures the relationship between domestic and foreign firms when the domestic firm purchases inputs from the foreign firm is calculated as:

$$F_{jt} = \sum_{j \neq m} \sigma_{jm} H_{mt}$$

where σ_{jm} is the share material inputs purchased by sector j from sector m in total inputs purchased by sector j.

Hence, B_{jt} measures the foreign presence in the industries that purchases inputs from sector j. On the other hand, F_{jt} measures the foreign presence in the industries that sell inputs to sector j. Note

of findings to the existing and broad literature.

that inputs supplied in the same sector are not included in the formula since they are measured in H_{jt}.

In table 6, the summary statistics for the linkage measures are presented. The average of horizontal linkage over the years 1990-2001 is 9.7 percent. This average is close to what Taymaz and Yılmaz (2009) find for the period 1990-1996, however, much lower than what Javorcik (2004) finds on Lithuania for the period 1996-2001. The average of backward linkages is 3.7 percent in this study which is close to what Javorcik (2004) and Taymaz and Yılmaz (2009) find for Lithuania and Turkey, respectively. Finally, the forward linkage measure's average is 3.6 percent which is also close to the average that Taymaz and Yılmaz (2009) find for Turkey, but lower than what Javorcik (2004) finds for Lithuania.

The averages of these linkage variables throughout the sample period are reported in the last three columns of table 6. Here, one can see that although not statistically significantly, the averages of the three linkages have increased throughout the period of this study.[12]

2.3 Measurement of Human Capital

It is expected that firms which possess higher levels of human capital realize higher productivity levels for a given level of input. Human capital of the firm is measured by the share of skilled employees in total employees. Two alternative definitions are used to capture the extent of skilled employees in a firm. The data lacks any concrete information about the education level of the workers, however provides some information about the characteristics of their job posts. As such, in the first definition we take a narrow definition of skilled jobs and only include high-level technical personnel and management staff as skilled employees. In the second definition we broaden this concept and also include positions where on-the-job learning and experience would also create skills. The second definition adds middle technical personnel and foremen to the first definition. The analysis is conducted using both definitions, showing

[12]The correlation coefficients of all three linkage variables are found to be low and insignificant. The correlation between the horizontal and backward linkages is -0.03, between the horizontal and forward linkages is 0.21, and the correlation between the two vertical linkage measures is 0.01. These low correlations suggest that unlike Taymaz and Yılmaz (2009) we need not be concerned with a multicollinearity problem and can include all measures simultaneously in the econometric specification.

that our results are robust to the choice of skilled labor measurement. Therefore, for the rest of the paper, the results of regressions using the latter and more comprehencive definition of skilled employee are reported.

The average of skilled employee share in total employment over the whole period is 16.4 and 19.7 percent, for domestic firms and foreign firms respectively, as shown in table 6. The skilled employee share of firms on average seems to have been increasing from 1990 to 2001, although this increase is not statistically significant.

2.4 Control Variables

We also include several control variables, in line with the literature. Following Javorcik (2004), we try to distinguish the technological spillovers from benefits of scale by controlling for a variable which is defined as the demand of other sectors for sector j's products, which is calculated as:

$$Demand_{jt} = \sum_{m} a_{jm} Y_{mt}$$

where a_{jm} is the Input-Output matrix coefficient indicating that in order to produce one unit of good m a_{jm} units of sector j's goods are needed and Y_{mt} is the output of sector m at time t, deflated by three-digit sectoral price deflator. Furthermore, to be able to distinguish the competition effect from technological spillovers, again following Javorcik (2004), we use the herfindahl index as an additional regressor. The herfindahl index for sector j gives the industry concentration which takes smaller values if the industry is competitive.

3 Empirical Analysis

To test for the spillover effects, in line with Javorcik (2004) and Taymaz and Yılmaz (2009), we estimate the following regression:

$$lnTFP_{ijr,t} = \beta_0 + \beta_1 foreignshare_{j,t-1} + \beta_2 horizontal_{j,t} + \beta_3 backward_{j,t} + \beta_4 forward_{j,t} \qquad (1)$$

$$+control\ variables + \alpha_i + \alpha_r + \alpha_t + \varepsilon_{ijr,t}$$

where $lnTFP_{ijrt}$ is natural logarithm of total factor productivity of firm i, operating in sector j, in region r, at time t. $Foreignshare_{j,t-1}$ is included to control for direct effect of firm foreign ownership on TFP. $Horizontal_{j,t}$, $backward_{j,t}$ and $forward_{j,t}$ are linkage measures for industry j where firm i operates in, and α's are fixed effects.

The results are presented in tables 7 and 8 for all firms and only for domestic firms, respectively.[13] Many of the existing studies empirically first examine whether the firms acquired by multinationals are more productive than their domestic counterparts, the so-called direct effect of FDI. Most of the studies in the literature find this direct effect to be positive. These direct effects are tested for in table 7. The lagged value of foreign ownership rather than its current value is included into the regression to be able to overcome the possible endogeneity problem between foreign ownership and TFP. Contrary to our descriptive statistics there seems to be no statistically significant effect of the extent of foreign ownership on the firm's productivity. However, there seems to be cross productivity effects, where the linkages statistically affect the productivity of firms in the Turkish manufacturing industry.

Results suggest that the firms in the Turkish manufacturing industry have no significant productivity spillovers from foreign firms through their horizontal linkages. On the contrary, the vertical linkages

[13]We report the results for the benchmark measure of TFP, calculated using the Levinsohn-Petrin (LP) methodology and where labor is not disaggregated within the LP process.

seem to play a significant role in generating productivity spillovers. Firms are found to be positively and somewhat significantly benefiting from the backward linkages with multinational firms. In other words, the positive sign of the coefficient reflects the view that MNCs increase the TFP level of their suppliers, though not statistically significant at all times. The forward linkages are found to robustly matter in generating negative productivity spillovers from the MNCs to other firms. The coefficient of the forward linkage measure appears to be negative and significant at 10% and 5% significance levels in different specifications. One possible explanation for negative forward spillovers is suggested by Javorcik (2004). After acquiring domestic firms in supplying sectors, foreign owners may upgrade their production techniques and start to produce higher quality inputs which are sold at higher prices. Therefore, domestic firms may get hurt by the increasing cost. Moreover, only high technology firms are capable of utilizing higher-quality and more expensive inputs produced by MNCs. Another interpretation is that some firms, whose characteristics we are yet unable to observe at this stage of the analysis, may be unable to reorganize their production schedules upon the increased linkages in the economy, and hence lose efficiency as they try to reorganize but are unable to do so. All explanations point to forward linkages hurting the average Turkish firm. If the population of local firms is dominated by such firms who lack the capabilities of absorbing the better foreign technology might be hurt from the existence of firms who are able to absorb the technology and are capable in capitalizing on the higher-quality inputs provided by MNCs, then forward linkages might hurt the overall local economy rather than benefit it. The main hypothesis of our analysis actually serves to provide an answer to this possibility. In the next section we report our findings that suggest that the firms' human capital endowment acts as such an absorptive capacity, and allows us to identify which firms end up benefitting from FDI.

The demand variable is statistically significant in all specifications indicating that there are indeed benefits of scale effects in this sample. The negative and statistically significant coefficient of the herfindahl index on the other hand is suggestive of positive productivity effects of a competitive market

environment. The negative sign of the variable suggests that the firm level TFP decreases as the industry it operates in gets less competitive.

All of these effects, both regarding the linkages and the sector specific factors are even more pronounced when one only looks into the spillovers to domestic firms. Table 8 reports results when only domestic firms are included in the analysis, echoing the findings in table 7.

3.1 Dynamic Effects

It is possible that it could take time for such linkages to generate any meaningful spillover effects. The reorganization of resources necessary to imitate, compete with, or absorb the technology of the foreign firm requires time. We next test for the existence of any such dynamic effects of linkages. The joint lag structure test suggests that the appropriate lag structure is two periods, where the effects of the linkages are felt both in the current period and with one period lag. As such the remainder of the analysis is completed with this lag structure for all linkages.[14]

With the determined lag structure we next test for the significance of the linkages and their effects on the productivity of domestic firms in the Turkish manufacturing industry. The first three columns of table 9 use the benchmark TFP measure, LP using aggregate labor data of the firm. The results suggest that horizontal linkages are inexistent, neither immediately nor in the longer-run. However, the time structure of the vertical linkages are found to be quite important. Results suggest that the vertical spillovers are not only realized in the current period of foreign firm activity but continue to influence the local firm's productivity over time. The positive backward spillovers seem to be the result of a positive spillover effect in one year's time dominating a usually statistically insignificant negative spillover effect in the current period of foreign firm activity. On the contrary, the negative forward spillovers seem to be the result of a positive forward spillover in the current period that is dominated by a negative

[14]The likelihood ratio (LR) test for the joint significance of including both the current period and one-period lagged values of all three linkages is significant at 1% significance level ($\chi^2 = 13.53, p - value = 0.004$), whereas the joint significance of including one more lagged measure of all three linkages is statistically insignificant ($\chi^2 = 2.91, p - value = 0.41$).

forward spillover effect in one year's time.

In the remainder of the table we test for the robustness of our findings if we were to use alternative TFP measures. In columns (4)-(6) when using the Levinsohn-Petrin methodology the labor is decomposed as skilled and unskilled. Columns (7)-(9) reiterate the results using a TFP measure calculated using constant shares for the factors of production, where labor is disaggregated.[15] Regardless of the TFP calculation, results point to the lack of horizontal spillovers and possible productivity spillovers through vertical linkages. The dynamics of these spillovers are also robust to alternative measures of TFP, all pointing to the reorganization of production requiring more than a year to adjust to the new streamline of input-output relationships. While the firms' adjustment to horizontal linkages, i.e. competition in the same sector, do not seem relevant, adjustments to changes in vertical linkages, both downstream and upstream, seem to require an adjustment that takes at least one year. When adjusting to the reorganization of relationships with foreign input buyers, i.e. backward linkages, domestic firms take time but are able to adjust to their benefit. On the contrary, when adjusting to the reorganization of relationships with foreign input suppliers, i.e. forward linkages, although domestic firms take time they are unable to adjust to their benefit.

3.2 Absorptive Capacity Results

The above results of the spillover analysis which do not take absorptive capacities of domestic firms into account suggest no evidence for horizontal spillovers yet suggest evidence of vertical spillovers, i.e. positive spillovers from backward linkages and negative spillovers from forward linkages. However, as mentioned above, the firm-specific characteristics may determine the existence, direction or magnitude of spillovers and not taking them into consideration may produce insignificant results. Therefore, in this section, the results of the regressions that analyze spillover effects from FDI when human capital

[15] We assume that the shares of skilled labor, unskilled labor and capital are 0.32, 0.35 and 0.33, respectively. (See Alfaro et al. (2009))

is considered to be an absorptive capacity are presented.

We test our hypothesis that the skill composition of the local firm is an important factor that influences the realization of horizontal and forward spillovers by including a skill composition measure of the local firm in our regression analysis individually and interactively with the linkage measures. The skill composition is measured as the share of high-level technical personnel and management staff in the total labor force of the firm. We continue to keep the dynamic characteristics of the linkages that we have established in the preceding analysis.

To this end we estimate the following regression:

$$\begin{aligned} lnTFP_{ijrt} = \beta_0 + \sum_{k=0}^{1} \beta_{1+k} horizontal_{j,t-k} + \sum_{k=0}^{1} \beta_{3+k} backward_{j,t-k} + \sum_{k=0}^{1} \beta_{5+k} forward_{j,t-k} \\ + \sum_{k=0}^{1} \beta_{7+k} horizontal_{j,t-k} \times skilledemployee_{ijr,t-1-k} + \sum_{k=0}^{1} \beta_{9+k} backward_{j,t-k} \times skilledemployee_{ijr,t-1-k} \\ + \sum_{k=0}^{1} \beta_{11-k} forward_{j,t-k} \times skilledemployee_{ijr,t-1-k} + \beta_{13} skilledemployee_{ijr,t-1} \\ + controlvariables_t + \alpha_i + \alpha_r + \alpha_t + \varepsilon_{ijrt} \quad (2) \end{aligned}$$

where interaction variables are added to equation (1). These interaction variables reflect the effect of the linkage measure on productivity when firms possess different levels of skilled employees. Furthermore, the skill composition measures and its relevant interaction terms are included in the regression with a lagged structure. One could envisage a case where the skill composition of the firm's labor force may be dependent on the firm's productivity, generating endogeneity biases. In order to alleviate this problem we estimate the above regressions by including the skilled labor measures with a lag. The regressions are estimated for the sample of all domestic firms and the results are presented in table 10.

It is clear that, regardless of the TFP measure the horizontal linkages, both in the current period and with one period lag, remains insignificant. However, the interaction of horizontal linkages with the skill

composition measure is statistically significant and this finding is robust across alternative measures of the TFP. The positive sign and statistical significance of the interaction term reflects the view that domestic firms that have higher levels of human capital realize increases in TFP from a rise in foreign presence in their sector. These results suggest that only local firms that have the skill composition to allow them to imitate or compete with the MNCs are able to positively and significantly benefit from the horizontal linkages with the MNCs. This is true dynamically as well, where the benefits of horizontal linkages are reflected in higher productivity of the local firm both in the current period and one period ahead for firms with sufficient human capital endowment.

The coefficients of the backward linkage remain similar qualitatively, where it negatively affects productivity in the current period but this effect is overcome with a positive backward spillover observed within one period of time. Here the overall positive sign of the backward variable indicates that an increase in foreign presence in the downstream sector of the domestic firm increases the productivity of domestic firms. The effect of backward linkages is found to be positive and independent of the skill composition of the local firms, where the interactive term for the backward linkage is statistically insignificant for both time periods.

Similarly, human capital of the local firms does not seem to play any significant role in allowing for the forward linkages to generate productivity spillovers. However, regardless of the human capital endowment of the local firm there is an overall negative forward spillover effect, which is felt positively in the current period but eventually turns significantly negative in one period time.

Using the obtained coefficients for further interpretation we are able to get some economic insights, beyond statistical significance. In order to do such an exercise we test for the joint significance of the linkage indicator and its interactive term with the skill composition of the firm. We carry out this exercise for all the columns in the table and report them in table 11. Since the results do not vary much across columns below we only discuss the findings from column (2).

We find that the horizontal spillover and its interaction with the skill measure are jointly significant at 1% statistical significance. This suggests that firms that have a skilled labor measure above 9 percent are able to benefit positively from horizontal linkages. This means that an average firm, defined as the firm with the average skill level, benefits positively from the horizontal linkages.[16] Furthermore, we find that above 75 percent of the firms in the data sample are able to benefit positively from horizontal linkages, given their human capital endowments. This finding is of importance and adds insight to previous studies which find that horizontal spillovers do not matter. We are able to show that they do indeed matter for some firms, and the share of these firms in the Turkish manufacturing industry is quite large.

The interactive term for the backward linkage measure is insignificant and we find it to be jointly insignificant with the backward linkage measure. On the other hand, the forward linkage and its interactive term are found to be statistically significant at the 5 percent level. Economically the coefficients suggest that only firms with a share of skilled labor in their total labor force below 38% will benefit from FDI, which means 95% of the firms indeed positively benefit from forward linkages in the current period. While we find that a majority of the firms end up benefiting from forward linkages it is worthwhile discussing possible economic reasons for why higher human capital endowments mean less forward spillovers for domestic firms.

It is quite possible that the domestic firms that possess higher levels of human capital may be producing similar, yet in different sectors, products with MNCs and in the donwstream sector of MNCs. Therefore, to avoid competition, MNCs may prevent information leakages to these domestic firms. Hence, the empirical results point to the negative role played by the human capital endowment of the domestic firm where such competition effects will limit the benefits of the reallocation of resources with increased forward linkages.

[16] In our analysis, high- and medium- level technical personnel, management staff and foremen are defined as skilled labor.

Considering the joint significance tests for the lagged linkage measures we reiterate our finding for the horizontal spillovers. The benefits from horizontal spillovers prevail one period later in firms with a human capital measure that is above 8 percent according to our measure. This means 80 percent of the firms continue benefiting from horizontal spillovers even after one period. This suggests that regardless of the time frame, around 77 percent of the firms benefit from horizontal linkages, both in the current period and even after a period elapses.

The lagged backward linkage measure and its interactive term are not jointly significant, suggesting that regardless of the human capital endowment of the firm all firms positively benefit from backward linkages within one period of time. This result, along with the above finding that none of the firms benefit from backward linkages in the current period are suggestive that it takes time for the positive backward linkage effects to materialize.

On the other hand, while the lagged forward linkage measure and its interactive term are jointly statistically significant at 10% no firm in the sample seems to benefit from the forward linkages. This result, together with the current period effect of the forward linkage suggests that when one takes into account the human capital endowment of the firms the forward linkage effects are limited to the current period and are positive. These findings point to the importance of extending the analysis to study the economic significances and not just limit the discussion to statistical significance.

The three findings regarding the three linkages suggest that all linkages create positive spillover effects to the local firms, but their absorptive capacity necessities and time dynamics differ. The findings can be summarized as follows. (1) Horizontal spillovers are spread over two time periods, and only firms with sufficient human capital endowment are able to benefit from these dynamic horizontal spillovers. (2) Backward spillovers do not depend on the human capital endowment of the firms. However, it takes time for the backward linkages to materialize. Overall backward linkages create positive spillovers, but only within one period of time. (3) Forward linkages only materialize in the current period and it allows

for positive spillovers.

All three results improve our understanding of the productivity spillovers from MNCs. While earlier studies on several developing countries have found either insignificant or negative horizontal spillovers these new results suggest that the picture is not as grim. While not all domestic firms benefit from horizontal spillovers, those that have a certain share of skilled labor in their labor force are able to create positive productivity effects from horizontal linkages. It is possible that the findings for Morocco by Haddad and Harrison (1993), for Venezuela by Aitken and Harrison (1999), for Indonesia by Blomstrom and Sjoholm (1999) and many others would be different if one were to take into account the human capital of the firm as an absorptive capacity measure. Contrary to the findings regarding the horizontal spillovers the literature has reached somewhat of a consensus on the positive effects of backward linkages, including studies on Hungary by Schoors and Tol (2001), on Indonesia by Blalock and Gertler (2003) and on Lithuania by Javorcik (2004) and many other studies that have found the backward spillovers to be significant and positive. Our findings further strengthen this finding, showing that the positive effects of backward linkages are observed by all firms, regardless of their human capital. We further add to the finding that the realization of these positive backward linkages could take time, in our case up to one year. Javorcik (2004) finds that the positive backward spillovers are accompanied by negative forward spillovers. We show that while the statistical significances suggest an overall negative forward spillovers case adding dynamics to this relationship and allowing for the human capital of the domestic firm to play a threshold effect role alters the economic significance and the sign of the forward spillovers. Indeed, with this extended framework we are able to show a large share of firms also benefit from forward linkages, dominated by positive effects in the first period of linkage formation and in firms that employ a larger share of unskilled labor.

4 Conclusion

Existing studies in the literature have almost come to a consensus that while benefits from horizontal linkages are elusive, backward linkages mostly generate benefits and forward linkages might even hurt the local firms. This finding lends itself as support to policies that would attract FDI which creates a lot of backward linkages with limited forward and horizontal linkages. However, our empirical evidence suggests that these findings can change when one takes into account the dynamic nature of spillovers and the absorptive capacity role played by the human capital endowment of the local firms. Indeed, when one takes into account both the time lag effects of linkages and the skill composition of the local firm the results are altered significantly. While all linkages seem to require time for the realization of the full spillover effects, human capital plays an important role in making the elusive horizontal spillovers visible to the local firms. Horizontal spillovers occur over a two period time, backward spillovers only occur after a lag, whereas forward linkages occur instantaneously. When one takes into account the economic significance of the measures we are able to show that all three linkages create positive spillovers for Turkish local firms. The skill composition of the local firm only contributes to them benefiting positively from horizontal linkages and not vertical linkages.

Alongside our contribution to understanding the workings of productivity spillovers we are also able to decompose the absorptive capacity role played by human capital found by Borensztein et al (1998). We find that human capital plays a significant role in allowing for horizontal spillovers to occur while playing no role in allowing for backward or forward spillovers to take place. This finding suggests that the aggregate effect found in the country-level studies is indeed the end result of the role played by the human capital in allowing for intrasectoral spillovers.

The results point to the need for a careful interpretation of the lack of any horizontal spillover evidence found in the previous studies. The elusive horizontal spillovers seems to be the result of the lack of controlling for human capitals absorptive role in ensuring the realization of these spillover effects

and the dynamic nature of the spillovers.

Therefore, this study proposes that firm characteristics are important determinants of spillovers from FDI and they should be taken into consideration in the spillover analysis. However, further investigation of these characteristics should be conducted in order to analyze the net effect of linkage measures on productivity. In other words, besides human capital, other firm characteristics such as the technology level, export openness, import openness, size and financial status of the firms could be used as absorptive capacities in the regressions. This remains an issue for future research.

References

Aitken, Brian J. and Harrison, Ann E. "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela." *American Economic Review*, June 1990, 89(3), pp. 605-18.

Arnold, Jens M. "Productivity Estimation at the Plant Level: A Practical Guide" *Unpublished manuscript*, 2005.

Blalock, Garrick and Gertler, Paul J. "Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers." *Journal of International Economics*, March 2008, 74(2), pp. 402-21.

Blomström, Magnus. "Foreign Investment and Productive Efficiency: The Case of Mexico." *Journal of Industrial Economics*, September 1986, 35(1), pp. 97-110.

Blomström, Magnus and Kokko, Ari. "Multinational Corporations and Spillovers." *Journal of Economic Surveys*, July 1998, 12(2), pp. 1-31.

Blomström, Magnus and Persson, Hakan. "Foreign Investment and Spillover Efficiency in an Underdeveloped Economy: Evidence from the Mexican Manufacturing Industry." *World Development*, June 1983, 11(6), pp. 493-501.

Blomström, Magnus and Sjöholm. "Technology Transfer and Spillovers: Does Local Participation with Multinationals matter." *European Economic Review*, April 1999, 43(4-6), pp. 915-23.

Blomström, Magnus and Wolff, Edward N. "Multinational Corporations and Productivity Convergence in Mexico." in William J. Baumol, Richard R. Nelson and Edward N. Wolff, eds., *Convergence of Productivity: Cross-National Studies and Historical Evidence*, Oxford: Oxford University Press, 1994, pp. 263-84.

Borensztein, Eduardo; De Gregorio, Jose and Lee, Jong-Wha. "How Does Foreign Direct Investment Affect Economic Growth" *Journal of International Economics*, June 1998, 1986, 45(1), pp. 115-135.

Castellani, Davide and Zanfei, Antonello. "Productivity Gaps, Inward Investments and Productivity of European Firms." *International Trade Workin Papers*, July 2001.

Caves, Richard E. "Multinational Firms, Competition, and Productivity in Host-Country Markets." *Economica*, May 1974, 41(162), pp. 176-93.

Djankov, Simeon and Hoekman, Bernard. "Foreign Investment and Productivity Growth in Czech Enterprises." *The World Bank Economic Review*, 2000, 14(1), pp. 49-64.

Girma, Sourafel; Görg, Holger and Strobl, Eric. "Exports, International Investment, and Plant Performance: Evidence from a Non-Parametric Test." *Economic Letters*, June 2004, 83(3), pp. 317-24.

Griliches, Zvi and Mairesse, Jacques. "Production Functions: The Search for Identification." *Econometrics and Economic Theory in the 20th Century*, The Ragnar Frisch Centennial Symposium, Cambridge: Cambridge University Press, 1999, pp. 169-204.

Haddad, Mona and Harrison, Ann E. "Are There Positive Spillovers from Direct Foreign Investment? Evidence from Panel Data for Morocco." *Journal of Development Economics*, October 1993, 42(1), pp. 51-74.

Haskel, Jonathan E; Pereiera, Sonia C. and Slaughter, Matthew J. "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?" *The Review of Economics and Statistics*, August 2007, 89(3), pp. 482-96.

Javorcik, Beata Smarzynska. "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages." *American Economic Review*, June 2004, 94(3), pp. 605-27.

Keller, Wolfgang and Yeaple, Stephen R. "Multinational Enterprises, International Trade and Economic Growth: Firm Level Evidence From the United States." *National Bureau of Economic Research (Cambridge, MA) Working Paper No. 9504*, February 2003.

Konings, Jozef. "The Effects of Foreign Direct Investment on Domestic Firms." *Economics of Transition*, November 2001, 9(3), pp. 619-33.

Lenger, Aykut and Taymaz, Erol. "To Innovate or to Transfer? A Study on Spillovers and Foreign Firms in Turkey." *Journal of Evolutionary Economics*, April 2006, 16(1), pp. 137-53.

Levinsohn, James and Petrin, Amil. "Estimating Production Functions Using Inputs to Control For Unobservables." *The Review of Economic Studies*, April 2003, 70(2), pp. 317-41.

Mansfield, Edwin and Romeo, Anthony. "Technology Transfers to Overseas Subsidiaries." *The Quarterly Journal of Economics*, December 1980, 95(4), pp. 737-50.

Merlevede, Bruno and Schoors, Koen. "Conditional Spillovers from FDI within and between Sectors: Evidence from Romania." mimeo, October 2005.

Moran, Theodore H. "Parentel Supervision: The New Paradigm for Foreign Direct Investment and Development." *Washington D.C: Institute for International Economics*, August 2001.

Mucchielli, Jean-Louis and Jabbour, Liza. "Technology Transfer through Backward Linkages: The Case of the Spanish Manufacturing Industry." *Unpublished manuscript*, 2004.

Olley, G. Steven and Pakes, Ariel. "The Dynamics of Productivity in the Telecommunications Equipment Industry." *Econometrica*, November 1996, 64(6), pp. 1263-97.

Petrin, Amil; Poi, Brian P. and Levinsohn, James. "Production Function Estimation in Stata Using Inputs to Control for Observables." *Stata Journal*, 2004, 4(2), pp. 113-23.

Schoors, Koen and Van der Tol, Bartoldus. "Foreign Direct Investment Spillovers within and between Sectors: Evidence from Hungarian Data." *Unpublished manuscript*, 2002.

Sasidharan, Subash and Ramanathan, A. "Foreign Direct Investment and Spillovers: Evidence from Indian Manufacturing." *International Journal of Trade and Global Markets*, 2007, 1(1), pp. 5-22.

Saygılı, Şeref; Cihan, Cengiz and Yurtoğlu, Hasan. "Türkiye Ekonomisinde Sermaye Birikimi, Büyüme ve Verimlilik: 1972-2003." *State Planning Organization*, 2005, Publication Number: 2686.

Taymaz, Erol and Yılmaz, Kamil. "Foreign Direct Investment and Productivity Spillovers: Identifying Linkages through Product-based Measures." *Unpublished manuscript*, 2009.

Xu, Bin. "Multinational Enterprises, Technology Diffusion and Host Country Productivity Growth." *Journal of Development Economics*, 2000, 62, pp. 477-93.

5 Appendix: Data

In order to calculate the TFP we need a measure of output, material inputs, labor, capital stock and energy. We next detail the definitions and when relevant the calculation of these variables of interest. All variables are measured in 1990 Turkish Liras and are obtained from TurkStat.

Output is measured as the sum of the revenues from the annual sales of the firm's final products, the revenues from the contract manufacturing and the value of stock of final products at the end of the year minus the value of stock of final products at the beginning of the year, deflated by the relevant three-digit output price deflator.

Material inputs are measured as the sum of the value of purchases of intermediate inputs (except for the fuel) and the value of stock of material inputs at the beginning of the year minus the value of stock of material inputs at the end of the year. This variable is deflated by the relevant three-digit input price deflator.

Energy variable is the sum of the values of fuel purchases and electricity used in production. Electricity used in the production is calculated as the sum of the value of electricity purchased and the value of electricity produced minus the value of electricity sold. Both electricity and fuel are deflated by their own price deflators.

Labor is measured as the number of employees of the firm in a given year. Also, skill disaggregation of labor is available from the data. The employees that work in production are classified as technical personnel, foremen and workers. Furthermore, technical personnel is disaggregated into middle- and high-level technical personnel. The employees that work in management are classified as management employees, office employees and other type of employees.

Firm level data on investment in machinery and equipment, building and structure, transportation equipment and computer and programming are available. Except for computer and programming, all series are available since 1983. Computer and programming investment is reported since 1995. Since

the disaggregated investment deflator is not available, the different investment series are deflated by the aggregate investment deflator. The aggregate investment deflator is gathered from Saygılı et al. (2005).

Using these investment series, capital stock series for machinery and equipment, building and structure, transportation equipment and computer and programming are constructed applying the perpetual inventory method. Following Taymaz and Yılmaz (2009), depreciation rates of 5%, 10%, 20% and 30% are used for building and structure, machinery and equipment, transportation equipment, computer and programming respectively, to construct initial capital stock and to apply the perpetual inventory method.

For the firms that report zero investment at their initial year, it is assumed that they can't be producing without capital. Therefore, the 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 capital stock $(1 - \delta)$ each year.

After calculating capital stock series for building and structure, machinery and equipment, transportation equipment, computer and programming, these series are aggregated to form the total capital stock series of the firm.

Table 1: Summary Statistics I

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total number of plants	2944	2921	3178	3632	3764	4141	4305	4587	4867	4771	4771	4560
Number of FA plants	140	142	158	181	186	204	213	222	245	268	261	262
Percent of FA plants	4.7	4.8	4.9	4.9	4.9	4.9	4.9	4.8	5.0	5.6	5.4	5.7

Notes: Data is obtained from TurkStat. Plants with 10 percent or more foreign ownership shares are defined as foreign affiliated (FA) plants.

Table 2: Summary Statistics: Sector-based

Sector	All Plants-Years	FA Plants-Years	% of FA Plants	Avg. Output	Average Emp.	Avg. K/L	Avg. TFP
	1	2	3	4	5	6	7
311	4592	311	6.7	30.6	133	118.5	4.3
312	1255	154	12.3	26.1	92	132.3	5.9
313	408	41	10	48.9	142	209	3.4
321	9239	235	2.5	35.6	215	155.6	5.1
322	6465	257	4	15	118	42	5.5
323	568	2	0.3	19.1	68	70.6	6.1
324	583	5	0.8	9.7	79	42.8	4.2
331	800	16	2	24.3	85	92.2	6.1
332	663	11	1.7	15.6	121	47.8	3.6
341	902	80	8.9	37.1	118	126.5	4.9
351	479	94	20	121.5	252	273.6	4.3
352	1525	354	23.2	73.2	178	168.1	5.6
355	800	67	8.3	36.6	149	78.5	4.7
356	2150	138	6.4	29.3	90	125.2	5.4
361	288	9	3.1	92.1	370	154.5	3.8
362	428	29	6.8	81.3	283	154.5	5.3
369	3689	124	3.3	20.7	91	136.4	3.2
372	703	28	4	46.5	99	138.4	3.4
381	4120	216	5.2	24.6	93	210.8	6.2
382	3169	220	7	34.3	120	96.4	4.7
383	2465	361	14.6	104.2	184	133.5	6.3
384	2510	368	14.6	90.5	257	95.9	4.3
390	640	42	6.6	10	88	66	3.5

Notes: Data is obtained from TurkStat. Plants with 10 percent or more foreign ownership shares are defined as foreign affiliated (FA) plants. Output measure is in billions and both output and capital/labor ratio is measured in 1990 prices. Total factor productivity (TFP) is calculated using the Levinsohn-Petrin estimation procedure. The sectors are as follows: 311 Food, 312 Food Miscellaneous, 313 Beverages, 321 Textiles, 322 Wearing Appeal, 323 Leather Products, 324 Footwear, 331 Wood Products, 332 Furniture, 341 Paper, 351 Industrial Chemicals, 352 Other Chemicals, 355 Rubber Products, 356 Plastics, 361 Ceramics, 362 Glass, 369 Nonmetal Minerals, 372 Nonferrous Metals, 381 Fabricated Metals, 382 Non-electrical Mach., 383 Electrical Machinery, 384 Transport Equipment, 390 Other Manufacturing Products.

Table 3: Summary Statistics: Yearly

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
All Plants												
Avg. Emp.	179	165	154	141	134	133	142	148	149	142	146	144
Avg. Output	29.1	32.5	35.9	37.8	33.2	35.9	35.7	40.7	38.7	39.2	43.7	44.1
Avg. K/L	91.7	94.5	109.9	123.2	127.6	146.3	124.7	137.7	139	155.5	142.8	150.5
Avg. TFP	4.7	4.8	4.9	5	4.8	4.9	4.9	5	5	5.1	5.1	5
FA Plants												
Avg. Emp.	525	534	506	466	420	391	380	386	400	371	399	400
Avg. Output	131.6	168.3	195.4	224.1	177	193.3	182.8	224.3	206.7	199.9	242.7	238.9
Avg. K/L	115.8	128.6	122.8	128.3	142.1	161.3	172.4	197.2	181.5	217.8	224.1	246.1
Avg. TFP	5.3	5.5	5.7	5.9	5.7	5.8	5.7	5.8	5.8	5.8	5.8	5.8
Local Plants												
Avg. Emp.	162	146	135	123	119	120	130	136	135	129	131	129
Avg. Output	24.1	25.6	27.5	28.1	25.8	27.8	28.1	31.3	29.7	29.7	32.2	32.3
Avg. K/L	90.5	92.7	109.2	122.9	119.2	145.5	122.2	134.7	136.8	151.8	138.1	144.6
Avg. TFP	4.6	4.7	4.9	5	4.8	4.9	4.9	5	5	5.1	5.1	5

Notes: Data is obtained from TurkStat. Plants with 10 percent or more foreign ownership shares are defined as foreign affiliated (FA) plants. Output measure is in billions and both output and capital/labor ratio is measured in 1990 prices. Total factor productivity (TFP) is calculated using the Levinsohn-Petrin estimation procedure.

Table 4: OLS Estimates of Production Function (1990-2001)

Sector	Labor***	S.E.	Capital	S.E.	No of Obs.
	Dependent Variable: Value Added				
311 Food	1.01	0.03	0.22***	0.02	476
312 Food Miscellaneous	1.23	0.05	0.09***	0.03	1293
313 Beverages	1.35	0.14	0.19***	0.07	429
321 Textiles	0.99	0.02	0.17***	0.01	9492
322 Wearing Appeal	0.94	0.03	0.15***	0.01	6649
323 Leather Products	1.08	0.09	0.12	0.04	582
324 Footwear	1.26	0.08	0.11***	0.03	599
331 Wood Products	1.29	0.09	0.17***	0.03	828
332 Furniture	1.25	0.08	0.12***	0.04	675
341 Paper	1.22	0.12	0.25***	0.05	926
351 Industrial Chemicals	0.95	0.11	0.28***	0.06	502
352 Other Chemicals	0.98	0.06	0.30***	0.04	1600
355 Rubber Products	1.06	0.08	0.30***	0.03	827
356 Plastics	1.02	0.06	0.25***	0.03	2210
361 Ceramics	1.22	0.12	0.22***	0.05	296
362 Glass	1.13	0.09	0.25***	0.05	447
369 Nonmetal Minerals	1.28	0.05	0.31***	0.02	3806
372 Nonferrous Metals	1.15	0.09	0.18***	0.04	741
381 Fabricated Metals	1.02	0.04	0.26***	0.02	4246
382 Non-electrical Mach.	1.17	0.04	0.15***	0.02	3255
383 Electrical Machinery	1.04	0.05	0.25***	0.03	2569
384 Transport Equipment	1.11	0.03	0.19***	0.02	2579
390 Other Manufacturing Products	1.02	0.09	0.17***	0.03	666

Notes: S. E. denotes standard errors. ***, ** and * indicates the statistical significance at the 1, 5 and 10 % levels, respectively. Statistical significance indicators apply to all sectors if it is next to the variable name.

Table 5: Levinsohn-Petrin Estimates of Production Function (1990-2001)

Sector	Labor***	S.E.	Capital	S.E.	No of Obs.
	Dependent Variable: Value Added				
311 Food	0.74	0.03	0.27***	0.05	4764
312 Food Miscellaneous	0.90	0.06	0.05	0.09	1293
313 Beverages	0.67	0.12	0.40***	0.12	429
321 Textiles	0.66	0.02	0.22***	0.03	9481
322 Wearing Appeal	0.67	0.03	0.16***	0.03	6612
323 Leather Products	0.71	0.07	0.13	0.14	582
324 Footwear	0.88	0.09	0.18**	0.08	599
331 Wood Products	0.71	0.11	0.10	0.10	828
332 Furniture	0.96	0.07	0.22**	0.09	674
341 Paper	0.90	0.14	0.17	0.10	925
351 Industrial Chemicals	0.91	0.16	0.25	0.20	502
352 Other Chemicals	0.63	0.08	0.27***	0.07	1599
355 Rubber Products	0.69	0.08	0.22*	0.13	827
356 Plastics	0.65	0.06	0.23***	0.05	2210
361 Ceramics	0.79	0.13	0.32	0.20	290
362 Glass	0.99	0.09	0.10	0.13	447
369 Nonmetal Minerals	0.89	0.04	0.29***	0.09	3722
372 Nonferrous Metals	0.87	0.10	0.34***	0.09	741
381 Fabricated Metals	0.67	0.04	0.14***	0.04	4242
382 Non-electrical Mach.	0.82	0.06	0.21***	0.06	3254
383 Electrical Machinery	0.66	0.06	0.18**	0.09	2569
384 Transport Equipment	0.79	0.05	0.27***	0.06	2579
390 Other Manufacturing Products	0.74	0.08	0.34**	0.15	666

Notes: S. E. denotes standard errors. ***, ** and * indicates the statistical significance at the 1, 5 and 10 % levels, respectively. Statistical significance indicators apply to all sectors if it is next to the variable name.

Table 6: Summary Statistics: Linkage Measures

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Number of Observations	Mean 1990-2001	S
Horizontal (Hor)	0.067	0.080	0.084	0.088	0.094	0.096	0.093	0.093	0.098	0.105	0.110	0.126	48441	0.097	
Backward (Bwd)	0.023	0.027	0.030	0.033	0.037	0.039	0.039	0.039	0.038	0.039	0.040	0.046	48441	0.037	
Forward (Fwd)	0.026	0.029	0.030	0.030	0.036	0.037	0.031	0.031	0.033	0.038	0.049	0.052	48441	0.036	
HK (Domestic Firms)	0.156	0.163	0.167	0.164	0.172	0.165	0.160	0.156	0.160	0.165	0.161	0.176	48084	0.164	
HK (Foreign Firms)	0.175	0.182	0.200	0.202	0.206	0.211	0.201	0.200	0.192	0.200	0.195	0.202	48084	0.197	

*Notes:*Authors' own calculations. Horizontal, backward and forward are linkage measures that takes values from 0 to 1. Skilled employee is the share of skilled labor in total labor.

Table 7: Spillovers from FDI - All Firms

	1	2	3	4	5	6
Variable						
$Foreignshare_{t-1}$	0.02	0.02	0.03	0.02	0.03	0.02
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Hor_t	0.21	0.16			0.17	0.12
	(0.21)	(0.21)			(0.21)	(0.21)
Bwd_t			0.41	0.63*	0.37	0.60*
			(0.35)	(0.35)	(0.21)	(0.21)
Fwd_t			-0.75**	-0.55*	-0.75**	-0.56*
			(0.30)	(0.30)	(0.30)	(0.30)
$Demand_t$		0.03***		0.03***		0.03***
		(0.01)		(0.01)		(0.01)
$Herfindahl_t$		-1.30**		-1.47**		-1.49**
		(0.60)		(0.60)		(0.61)
No of observations	42033	42033	42033	42033	42033	42033
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The numbers in parenthesis denote standard errors. ***, ** and * indicates the statistical significance at the 1, 5 and 10 % levels, respectively. Sample includes data from 1990-2001. The dependent variable is ln(TFP). Subscript t denotes current period variables, and $t-k$ denotes k period lagged variables. Foreign share is the foreign ownership share of the firm. Horizontal (Hor), backward (Bwd) and forward (Fwd) are sectoral linkage measures that takes values from 0 to 1. Demand is the amount of output of the sector that is used by other sectors. Herfindahl is the usual herfindahl index.

Table 8: Spillovers from FDI - Domestic Firms

	1	2	3	4	5	6
Variable						
Hor_t	0.15	0.12			0.08	0.04
	(0.20)	(0.20)			(0.20)	(0.20)
Bwd_t			0.46	0.68*	0.44	0.67*
			(0.35)	(0.35)	(0.35)	(0.35)
Fwd_t			-1.04***	-0.83***	-1.04***	-0.83***
			(0.30)	(0.30)	(0.30)	(0.30)
$Demand_t$		0.03***		0.03***		0.03***
		(0.01)		(0.01)		(0.01)
$Herfindahl_t$		-1.56***		-1.73***		-1.74***
		(0.59)		(0.59)		(0.59)
No of observations	45948	45948	45948	45948	45948	45948
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The numbers in parenthesis denote standard errors. ***, ** and * indicates the statistical significance at the 1, 5 and 10 % levels, respectively. Sample includes data from 1990-2001. The dependent variable is ln(TFP). Subscript t denotes current period variables, and $t-k$ denotes k period lagged variables. Horizontal (Hor), backward (Bwd) and forward (Fwd) are sectoral linkage measures that takes values from 0 to 1. Demand is the amount of output of the sector that is used by other sectors. Herfindahl is the usual herfindahl index.

Table 9: Spillovers with Time Structure

	TFP-1			TFP-2			TFP-3		
	1	2	3	4	5	6	7	8	9
Variable									
Hor_t	0.31	0.30	0.32	0.41	0.40	0.42	0.24	0.23	0.25
	(0.26)	(0.26)	(0.26)	(0.28)	(0.28)	(0.28)	(0.28)	(0.28)	(0.28)
Hor_{t-1}	-0.24	-0.26	-0.28	-0.25	-0.28	-0.29	-0.14	-0.17	-0.18
	(0.26)	(0.26)	(0.26)	(0.29)	(0.28)	(0.28)	(0.28)	(0.29)	(0.29)
Bwd_t	-0.71*	-0.54	-0.50	-0.37	-0.23	-0.22	-0.59	-0.45	-0.44
	(0.42)	(0.42)	(0.42)	(0.49)	(0.49)	(0.49)	(0.50)	(0.50)	(0.50)
Bwd_{t-1}	0.98**	1.01**	0.98**	0.51	0.53	0.54	1.07**	1.09**	1.11**
	(0.44)	(0.44)	(0.43)	(0.50)	(0.50)	(0.50)	(0.51)	(0.51)	(0.51)
Fwd_t	0.64*	0.66*	0.67*	0.87**	0.90**	0.91**	0.77*	0.79*	0.81**
	(0.36)	(0.36)	(0.36)	(0.40)	(0.40)	(0.40)	(0.40)	(0.40)	(0.40)
Fwd_{t-1}	-1.40***	-1.28***	-1.29***	-1.35***	-1.26***	-1.26***	-1.20***	-1.10***	-1.10***
	(0.36)	(0.36)	(0.36)	(0.40)	(0.40)	(0.39)	(0.40)	(0.40)	(0.40)
$Demand_t$		0.02**	0.02**		0.02**	0.02**		0.02**	0.02**
		(0.01)	(0.01)		(0.01)	(0.01)		(0.01)	(0.01)
$Herfindahl_t$		-1.51**	-1.48**		-1.23**	-1.23**		-1.38*	-1.37*
		(0.65)	(0.67)		(0.72)	(0.72)		(0.75)	(0.76)
No of observations	33527	33527	33483	28585	28585	28561	28630	28630	28606
Sectoral controls	No	No	Yes	No	No	Yes	No	No	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The numbers in parenthesis denote standard errors. ***, ** and * indicates the statistical significance at the 1, 5 and 10 % levels, respectively. Sample includes data from 1990-2001. The dependent variable is ln(TFP). TFP-1 is estimated without disaggregating labor into skilled and unskilled. TFP-2 is estimated by disaggregating labor into skilled and unskilled. TFP-3 is calculated by assigning constant shares to capital, skilled labor and unskilled labor. Foreign share is the foreign ownership share of the firm. Subscript t denotes current period variables, and $t-k$ denotes k period lagged variables. Horizontal (Hor), backward (Bwd) and forward (Fwd) are sectoral linkage measures that takes values from 0 to 1. Demand is the amount of output of the sector that is used by other sectors. Herfindahl is the usual herfindahl index.

Table 10: Human Capital as an Absorptive Capacity

	TFP-1		TFP-2		TFP-3	
	1	2	3	4	5	6
Variable						
Hor_t	-0.11	-0.15	0.05	0.02	-0.06	-0.09
	(0.29)	(0.29)	(0.31)	(0.32)	(0.32)	(0.32)
Hor_{t-1}	-0.09	-0.10	-0.11	-0.11	-0.00	-0.00
	(0.31)	(0.31)	(0.34)	(0.34)	(0.34)	(0.34)
Bwd_t	-1.07**	-0.87*	-0.66	-0.51	-1.07**	-0.88
	(0.52)	(0.52)	(0.59)	(0.59)	(0.59)	(0.59)
Bwd_{t-1}	0.94*	0.99*	0.65	0.68	1.10*	1.15*
	(0.52)	(0.52)	(0.61)	(0.61)	(0.62)	(0.62)
Fwd_t	1.37**	1.35**	1.48**	1.44**	1.44**	1.41**
	(0.56)	(0.56)	(0.61)	(0.61)	(0.62)	(0.62)
Fwd_{t-1}	-0.96*	-0.82	-0.91	-0.82	-0.82	-0.71
	(0.51)	(0.52)	(0.59)	(0.59)	(0.60)	(0.60)
$Hor_t * HK_{t-1}$	1.55***	1.53***	1.32***	1.31***	1.13**	1.12**
	(0.41)	(0.41)	(0.46)	(0.46)	(0.50)	(0.50)
$Hor_{t-1} * HK_{t-2}$	1.16**	1.17**	1.17**	1.18**	1.15**	1.16**
	(0.45)	(0.45)	(0.50)	(0.50)	(0.51)	(0.51)
$Bwd_t * HK_{t-1}$	-0.21	-0.29	-0.48	-0.58	-0.10	-0.22
	(1.28)	(1.29)	(1.47)	(1.47)	(1.51)	(1.52)
$Bwd_{t-1} * HK_{t-2}$	-1.13	-1.17	-1.04	-1.03	-0.86	-0.86
	(1.44)	(1.44)	(1.68)	(1.69)	(1.67)	(1.67)
$Fwd_t * HK_{t-1}$	-3.59*	-3.61*	-3.02	-3.02	-3.52	-3.53
	(2.17)	(2.18)	(2.43)	(2.44)	(2.48)	(2.49)
$Fwd_{t-1} * HK_{t-2}$	0.12	0.06	-0.14	-0.16	0.35	0.33
	(2.24)	(2.25)	(2.43)	(2.44)	(2.46)	(2.46)
HK_{t-1}	0.01	0.02	-0.06	-0.06	-0.08	-0.07
	(0.11)	(0.11)	(0.12)	(0.12)	(0.13)	(0.12)
HK_{t-2}	-0.04	-0.03	-0.02	-0.02	-0.03	-0.03
	(0.10)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)
No of observations	27789	27789	23806	23806	23853	23853
Sectoral controls	No	Yes	No	Yes	No	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The numbers in parenthesis denote standard errors. ***, ** and * indicates the statistical significance at the 1, 5 and 10 % levels, respectively. Sample includes data from 1990-2001. The dependent variable is ln(TFP). TFP-1 is estimated without disaggregating labor into skilled and unskilled. TFP-2 is estimated by disaggregating labor into skilled and unskilled. TFP-3 is calculated by assigning constant shares to capital, skilled labor and unskilled labor. Subscript t denotes current period variables, and $t-k$ denotes k period lagged variables. Horizontal (Hor), backward (Bwd) and forward (Fwd) are sectoral linkage measures that takes values from 0 to 1. HK is the share of skilled labor in total labor Sectoral controls are demand variable and herfindahl index. Demand is the amount of output of the sector that is used by other sectors. Herfindahl is the usual herfindahl index.

Table 11: Joint Significances

	1	2	3	4	5	6
JOINT SIGNIFICANCE						
LINKAGE DYNAMICS						
Hor_t and Hor_{t-1}	...	...	...	...	...	...
Bwd_t and Bwd_{t-1}	10%	10%	...	...	10%	...
Fwd_t and Fwd_{t-1}	5%	5%	5%	5%	5%	5%
ABSORPTIVE CAPACITY ROLE OF HUMAN CAPITAL						
Significance						
Hor_t and $Hor_t * HK_{t-1}$	1%	1%	5%	5%	10%	10%
Bwd_t and $Bwd_t * HK_{t-1}$	10%	...	...	...	...	...
Fwd_t and $Fwd_t * HK_{t-1}$	5%	10%	5%	5%	10%	10%
Hor_{t-1} and $Hor_{t-1} * HK_{t-2}$	5%	5%	10%	10%	10%	5%
Bwd_{t-1} and $Bwd_{t-1} * HK_{t-2}$	...	...	...	...	...	...
Fwd_{t-1} and $Fwd_{t-1} * HK_{t-2}$	5%	10%	...	...	...	...
Threshold Human Capital						
Hor_t and $Hor_t * HK_{t-1}$	$> 7\%$	$> 9\%$	?	?	$> 6\%$	$> 8\%$
Bwd_t and $Bwd_t * HK_{t-1}$	$< 0\%$	...	...	...	...	...
Fwd_t and $Fwd_t * HK_{t-1}$	$< 38\%$	$< 38\%$	$< 49\%$	$< 49\%$	$< 41\%$	$< 41\%$
Hor_{t-1} and $Hor_{t-1} * HK_{t-2}$	$> 8\%$	$> 8\%$	$> 8\%$	$> 8\%$	$> 0\%$	$> 0\%$
Bwd_{t-1} and $Bwd_{t-1} * HK_{t-2}$	...	...	...	...	...	...
Fwd_{t-1} and $Fwd_{t-1} * HK_{t-2}$	$> 1\%$	$> 1\%$	...	...	...	...
Does the Average Firm Benefit from FDI?						
Hor_t and $Hor_t * HK_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
Bwd_t and $Bwd_t * HK_{t-1}$	No	...	...	...	...	...
Fwd_t and $Fwd_t * HK_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
Hor_{t-1} and $Hor_{t-1} * HK_{t-2}$	Yes	Yes	Yes	Yes	Yes	Yes
Bwd_{t-1} and $Bwd_{t-1} * HK_{t-2}$	...	...	...	...	...	...
Fwd_{t-1} and $Fwd_{t-1} * HK_{t-2}$	No	No	...	...	...	...
Share of Firms that Benefit from FDI						
Hor_t and $Hor_t * HK_{t-1}$	83%	75%	100%	100%	88%	80%
Bwd_t and $Bwd_t * HK_{t-1}$	0%	...	...	...	...	...
Fwd_t and $Fwd_t * HK_{t-1}$	95%	95%	95%	95%	95%	95%
Hor_{t-1} and $Hor_{t-1} * HK_{t-2}$	80%	80%	80%	80%	100%	100%
Bwd_{t-1} and $Bwd_{t-1} * HK_{t-2}$	...	...	...	...	...	...
Fwd_{t-1} and $Fwd_{t-1} * HK_{t-2}$	0%	0%	...	...	...	...

Notes: '...' means that the two variables are jointly insignificant. Subscript t denotes current period variables, and $t-k$ denotes k period lagged variables. Horizontal (Hor), backward (Bwd) and forward (Fwd) are sectoral linkage measures that takes values from 0 to 1.