Foreign Direct Investment and Productivity Spillovers: Identifying Linkages through Product-based Measures

Taymaz, Erol and Yilmaz, Kamil

Middle East Technical University, Koc University

August 2008

Foreign Direct Investment and Productivity Spillovers

Identifying Linkages through Product-based Measures

Erol Taymaz * — METU

Kamil Yılmaz † — Koç University

August 2008

Abstract

This article analyzes direct and indirect effects of foreign ownership on productivity in the Turkish manufacturing plants between 1990 and 1996. First, based on Olley-Pakes production function estimates, foreign affiliates are shown to be more productive than local plants. Using sectoral output shares of foreign affiliates and 1990 input-output matrix to identify linkages across plants, regression results show that productivity spillovers from foreign affiliates to local plants took place through horizontal and vertical linkages. However, these results mostly lose their economic and statistical significance once plant-level data on the value of output and inputs are used to obtain product-based measures of linkages across plants. The magnitude of spillover effects are much smaller than the ones obtained with industry-based measures. Statistically meaningful positive spillovers are found to be generated through backward linkages only.

JEL Classification: F2, O1, O2

Keywords: Foreign Direct Investment; Productivity; Horizontal and vertical linkages; Semi-parametric estimations

*Erol Taymaz, Department of Economics, METU, Ankara, 06531 Turkey. email: etaymaz@metu.edu.tr.

†Kamil Yılmaz (Corresponding author), Koç University, Rumelifeneri Yolu, Sarıyer 34450, Istanbul, Turkey. Tel:(90-212) 338 1458, Fax: (90-212) 338 1653. email: kyilmaz@ku.edu.tr

1 Introduction

With globalization and worldwide trade liberalization taking a hold, increased competition has forced multinational corporations (MNCs) to move production and service facilities to developing economies. As a result, inward FDI stocks of developing countries which was 12.6% of GDP in 1980 and 16.6 % in 1995, reached to 36.6 % by the end of 2002.

Along with the increased importance of MNCs for developing economies, research interest on FDI and its impact on economic development in host countries have intensified throughout since early 1990s. Furhermore, the academic research on FDI has been facilitated by the availability of plant-level micro data for developing countries for longer time spans, allowing the use of more sophisticated micro-econometric methods to obtain more conclusive results.

Because FDI involves significant ownership control as well as the transfer of embodied and disembodied technology, its impact on economic growth can take place through increased productivity, human capital accumulation, R&D activity as well as technological and productivity spillovers. In addition, the impact of MNCs on economic growth can be greater if the types of FDI that the country receives stimulate, in other words crowd-in, domestic investment activity. Having firm-specific assets, such as production technology and know-how, marketing and management techniques among others, foreign-affiliates (FAs) of MNCs are expected to be more productive than local plants. With these firm-specific assets, multinational corporations start to generate technological externalities on local plants once they invest in a country (Markusen 1995).

Unfortunately, empirical studies have not been succesful in obtaining results that would unequivocally support the theory. In Dani Rodriks words, todays policy literature is filled with extravagant claims about positive spillovers from FDI but the evidence is sobering (see Rodrik, 1999). After so many studies, the jury is still out on the presence of productivity spillovers from FAs to local plants (LPs). While many studies found evidence in favor of positive horizontal and/or vertical spillovers, there are still many others finding no support for positive spillovers or support for negative productivity spillovers in developing countries (see Grg and Strobl, 2001, and Smarzynska Javorcik, 2004). The substantial cross country variation in empirical results could be due to diverse factors, such as the differences in institutional framework, the state of development of the local manufacturing industry and the characteristics of FDI in each of the countries for which the studies are conducted.

Obtaining different conclusions could also be due to the limitations of the data sets to correctly measure intra- and inter-industry linkages through which productivity spillovers may be realized. As is the case in other areas, the empirical research on FDI spillovers first started with sector-level data. As the plant-level data has become available over time in developing countries, empirical research on investment and employment behavior, productivity and export decision among others relied more and more on micro data. (Grg and Strobl, 2001).

While empirical research on productivity spillovers also started to utilize plant level data, the most critical data that is needed to obtain measures of vertical linkages between domestic- and foreign-owned plants is still not available at the plant level. For example, recent contributions to the literature that use plant- or firm-level data, Javorcik-Smarynska (2005), Blalock (2001) and Schoors and van der Tol (2001), identify horizontal and vertical linkages across plants through the use of sector-level output shares and input-output matrices. Therefore, it is not wrong to conclude that the measurement of spillovers across plants still constitutes the major shortcoming of the empirical research on productivity spillovers.

This paper does not propose a new methodology or an approach to the analysis of FDI and productivity spillovers. Its main objective is to provide more accurate measures of horizontal and vertical linkages at the plant-level and hence, improve over the results with industry-based measures of linkages. Towards that end, we make use of a disaggregated database on products sold and inputs purchased by manufacturing plants in Turkey.

The remainder of the paper is structured as follows. In the next section, we briefly review the literature on FDI and productivity spillovers. Section III presents a brief overview of FDI flows to Turkey and describes the dataset in detail. The industry-based and product-based measures of linkages are presented and discussed in section III as well. The last part of section III outlines the Olley-Pakes approach to production function estimation that used investment as a proxy to correct for simultaneity and selection biases tht arise when OLS and other estimation methods are used. The first part of the empirical analysis of productivity spillovers is reported in section IV, using industry-based measures of linkages across plants. Section V reports the results of regressions with product-based measures and discuses the differences between the estimates using industry- and product-based measures. Section VI concludes the paper.

2 Foreign Direct Investment and Productivity Spillovers

One of the important contributions of multinational corporations and their affiliates in developing countries is to enhance the transfer and diffusion of technology to the host country. As a multinational corporation undertakes investment in a country, it brings along production technology, know-how and experience, as well as access to global production and distribution networks. Being large corporations, MNCs have access to large and low-cost investment funds that could be used to finance investment in more advanced technology than available and accessible in the host country.

The direct technology transfer effect may not be realized in all FDI projects. The impact of FDI on technology diffusion was rather limited in the import-substitution era, as the main incentive for an MNC to undertake investment was the heavily-protected domestic market. In such an environment, MNCs prefer to transfer old and outdated technology to their factories in developing countries, creating little technology diffusion.

Today, however, FDI decisions cannot focus only on the domestic market. Following the push for more liberal trade relations throughout the world, FAs of MNCs are no more immune to import competition in the host country markets. Consequently, FDI decisions by MNCs, especially in the manufacturing sector, should be made with serious consideration of international competitiveness of its FA. The FA must have the technological capability and the resulting efficiency that renders it sufficiently flexible to target export markets as well as the domestic market. Consequently, one would expect to observe higher productivity in

FAs compared to LPs.

The impact of FDI on the host country economy is not just limited to direct channels of technology transfer and diffusion. The presence of multinationals may affect the productivity of local plants through several indirect channels. (Blomstrm and Kokko, 1998) The first of these is the competition effect. As the FAs become major players in the domestic market, LPs will be forced to adopt newer and more advanced technologies and to use their existing resources more efficiently in order to succeed in the presence of technologically more advanced competitors. This channel is similar to the effect of import liberalization, even though the impact on LPs may be more significant than imports. Furthermore, as Aitken and Harrison (1999) showed for the case of Venezuelas manufacturing industry, the "competition effect" on local plants productivity can be negative as well. As a result of the entry of MNCs, domestic demand for LPs products will be diverted away, generating adverse effects on productivity.

The technology transfer may take embodied (machinery and equipment imports) and/or disembodied (know-how, knowledge, licenses) forms. LPs can easily tranfer the embodied technology from original foreign patent owners. What is more difficult is the transfer of disembodied technology, which requires absorption capacity of the receiving plant. This is where the second indirect productivity effect may be crucial. The workers and engineers employed by FAs will gain experience and accumulate knowledge through their tenure. In the medium-to-long-run, the movement of skilled employees from FAs to LPs will transfer this experience and knowledge to LPs and increase the capacity of local plants to absorb more advanced technology used by foreign-affiliated plants.

Other channels through which the presence of FAs affects local plants mostly take the form of productivity spillovers. Productivity spillovers take place when the entry or presence of MNCs increases productivity of domestic firms in a host country and the multinationals do not fully internalize the value of these benefits (Blomstrm and Kokko, 1998). An important channel through which productivity spillovers take place is the adoption of technology through imitation and copying of the technologies used by the foreign- affiliated plants. With the domestic presence of MNCs, local plants will start learning from the more-advanced practices of these companies. Even if the local plants cannot directly observe the production practices of the FAs, they can learn about these practices through a careful analysis of their products and the experience of local suppliers to FAs. Obviously, the spillover effects through imitation and learning depend very much on the sophistication of the production technology. Even then, however, it is still possible for local plants to copy technologies of foreign affiliates through hiring engineers and workers that have gained experience in the FAs. For these reasons, FAs will rely on formal and legal methods of protection of their license, know-how and other intellectual property rights.

Arms length relations provide an important channel through which local plants can learn about the products and processes of MNCs. In addition, local plants can hire workers that had worked in the MNCs from which the local plant needs to transfer knowledge. By employing skilled workers, who have some information about the products and production processes in FA plants, local plant owners can increase productivity without fully internalizing the benefits.

Unlike the studies that have mostly relied on cross-section data (industry level or plant level), most of the studies that used panel data at the plant-level had failed to produce empirical results that unambiguously support the presence of intra-industry productivity spillovers from foreign-affiliated plants to local plants in developing countries (Grg and Strobl, 2001). On the contrary, Haddad and Harrison (1993), Aitken and Harrison (1999) and Djankov and Hoekman (2000) obtained results that support the presence of negative productivity spillovers from foreign-affiliated plants to local plants in Morocco, Venezuela and the Czech Republic, respectively. In the case of industrial countries, however, Haskel, Pereira and Slaughter (2002) obtained results that support the presence of positive FDI spillovers in the UK manufacturing. In a recent paper, Keller and Yeaple (2003) find that inward FDI flows led to significant productivity gains for domestic firms in the United States. According to their estimates, spillovers from foreign-owned firms accounted for about 11% of productivity growth in U.S. firms between 1987 and 1996.

Besides horizontal spillovers, there is the possibility of vertical productivity spillovers between a supplier plant and an input user plant. Vertical spillover effects can be through backward (foreign-affiliated plant purchases some of its inputs from a local supplier) and forward linkages (foreign-affiliated plants supply intermediate inputs to a local plant) between the foreign-affiliated and local plants.

In the case of backward linkages, the fact that the FA purchases from local suppliers would imply an increase in the demand for domestic suppliers. Depending on the size (in our Turkish sample, FA are significantly larger than LP), the increased demand due to newly established FA can be quite significant and help LP reap the benefits of scale economies and become more productive. Additionally, it is possible that vertical spillovers are realized through direct technology and knowledge transfers from the FA to local suppliers. In the case of export-oriented FA, it may be more profitable to help the domestic suppliers upgrade their technology to ascertain a minimum required level of efficiency and quality, rather than importing the inputs from abroad. Under such circumstances, FA will provide the technical know-how to their local suppliers and create an externality.

The productivity spillovers through backward linkages can still be realized even in the absence of arms-length relationship between the FA and their local suppliers. Due to the fact that FAs quality and delivery standards are often higher than their local competitors, local suppliers that are striving to sell intermediate products to FA will have to improve their production and management practices. As a result, the presence of FAs as a potential purchaser of intermediate inputs and components may lead to productivity improvements in local plants.

Using plant-level data for Lithuanias manufacturing industry, Smarzynska-Javorcik (2004) shows that there are productivity spillovers from foreign affiliates to their local suppliers in upstream sectors. Smarzynska-Javorciks (2004) empirical results do not support the presence of productivity spillovers through horizontal and forward linkages. She also shows that spillover effects from domestic-market-oriented foreign affiliates are greater than the spillover effects from export-oriented foreign affiliates. This result indicates that the major impetus for local plants to increase productivity takes place if the foreign affiliates compete with the local plants in the same industry.

If the economy is undergoing a significant transformation towards an open economy, the horizontal and vertical spillover effects from FDI may not be as substantial as one would have thought. Key elements of such a transformation would be import liberalization and increased export orientation along with increased FDI inflows. As the economy becomes more involved in international trade activity, the competitive pressure on domestic firms can come from imports as well as the presence of multinational corporations. Similarly, irrespective of the presence of foreign-affiliated plants in their sectors, in downstream or upstream sectors, local plants will have to upgrade their technology and improve their production and management practices if they want to compete in export markets. Given the coexistence of different effects on the behavior of domestic firms, the trade liberalization and export-orientation of local plants have to be taken into account when one is analyzing the empirical significance of FDI spillovers.

3 FDI in Turkey, Data and Production Function Estimates

3.1 Foreign Direct Investment in Turkey

Since the efforts to open the economy to international competition in the early 1980s, Turkey has not been able to attract large sums of FDI flows. The most striking feature of the FDI flows to Turkey is their low level relative to comparator emerging market economies. Throughout the 1990s, Turkey averaged an annual FDI inflow of US$ 800 million. Between 1990 and 2000, FDI inflows to Turkey never exceeded US$ 1 billion a year. In 2000, Turkey attracted $15 of FDI per capita. The same year Poland attracted $105, Romania $50, Brazil $96, and Algeria $32.

As Dutz, Us and Yılmaz (2005) discuss in detail, there are several reasons behind this laggard performance. The first, and the foremost, is the countrys long-running fiscal problems and the ensuing macroeconomic uncertainty. Besides macroeconomic uncertainty, specific infrastructure-related weaknesses also continue to undermine Turkish governments attempts to make the country more attractive for foreign investors. However, based on the case studies Dutz, Us and Yılmaz (2005) argue that the main unaddressed obstacles to increased FDI in Turkey are governance and institutions-related problems related to the rule of law and competition.

It was hoped that the FDI inflows to Turkey would increase following the 1996 Customs Union agreement with the European Union. MNCs were to take advantage of Turkeys geographical location, low cost yet highly skilled and disciplined labor, and long experience with a market economy. Unfortunately, these expectations were not realized. Between 1997 and 2000, Turkey received only $875 million per year in FDI flows. After all, the Customs Union agreement did not entail any major change that would drastically remove some of the obstacles that prevent multinationals investing in Turkey. In contrast, Czech Republic, Hungary and Poland that had started the accession talks with EU in 1997 received 4.1, 2.0 and 7.0 billion US$ per year in FDI flows.

In terms of industrial sub-sector allocation, a majority of FDI inflows to Turkey has been directed to the tertiary sector. Over 57% of total FDI stocks in Turkey by end-2000 were dedicated to services, including 3 of the top 5 sub-sectors transport & communications, banking and other financial services, and trade & repairs. The other major recipients of FDI inflows to Turkey have been in the manufacturing sector, namely the automotive & auto parts sub-sector, and the petroleum, chemicals, rubber & plastic products sub-sector.

3.2 Data

In this study, we use a data set, collected by the Turkish Statistical Institute (TURKSTAT) for the Turkish manufacturing industry. Since 1980, TURKSTAT periodically conducts Census of Industry and Business Establishments (CIBE). In addition, TURKSTAT conducts Annual Surveys of Manufacturing Industries (ASMI) at establishments with 10 or more employees. The set of addresses used during ASMI are those obtained during CIBE years. In addition, every non-census year, addresses of newly opened private establishments with 10 or more employees are obtained from the chamber of industry. For this study, we use a sample that matches plants from CIBE and ASMI for the 1990-96 period and data on products and input use collected through CIBE. Unfortunately, not all the key variables needed for this study have been collected for establishments in the 10-24-size group. Thus our sample consists of plants with 25 or more employees. Finally, we limit the sample to only on private establishments.

We do not select the plants that were in the sample period through the entire period only and hence use an unbalanced data set. However, entry or exit each constitutes a small percentage of total number of plants within each year. In 1993, following the CIBE year 1992, the number of entering plants shows a dramatic increase, indicating the concerted effort by SIS to identify new plants. Even in that year, continuing plants constitute about 75% of the total number of plants. (See Özler and Yılmaz, 2004) We exclude those plants that had changed status from local plants to foreign affiliates through acquisitions by foreign investors and/or multinational corporations.

The data is well suited for our purposes, because it contains information on variables that are commonly used in estimation of firm level production functions. Specifically, the data includes value of sales, number of employees, values of material inputs, electricity, fuels and investment. We provide a detailed description of variable construction in the Appendix of Özler and Yılmaz (2004), but note here a couple of important features of variable construction. First, we create the plant level capital series using a perpetual inventory method. Second, sales, material inputs, energy, and capital each have their own price deflator and they are each measured in real 1990 Turkish Liras.

The dataset has its limitations. It does not cover all foreign-affiliated plants active in the Turkish manufacturing industry. While the records of the Undersecretariat of the Treasury indicate 581 plants with foreign partners to be active in the manufacturing sector in 1991 increasing to 922 by 1996, in our data set in 1990 there are 174 plants with foreign shareholders. This number increases to 252 by 1996. When we consider plants with foreign ownership exceeding 10% these numbers decrease to 152 and 225, in the respective years (see Table 1). An important reason for the missing FAs from our sample is that our data set covers only plants with 25 and more employees.

As reflected in Table 1, foreign-affiliated plants tend to be larger than domestic-owned plants. Average employment in FAs is almost 3 times the average employment in all plants.

Table 1: **Summary and descriptive statistics**

All Plants							
	1990	91	92	93	94	95	96
Total number of plants	3646	3827	3714	4350	4344	4702	4930
Number of FA plants	152	172	186	213	226	232	225
Percent of FA plants	4.2	4.5	5.0	4.9	5.2	4.9	4.6
Avg. for. ownership share	2.3	2.5	2.9	2.9	3.1	3.1	3.0
Wtd. market share of FAs	8.0	8.5	10.1	10.1	11.3	10.8	10.3
Average Employment	162	148	147	138	131	133	138
Average Output	26.5	28.3	34.5	36.3	31.6	35.0	37.7
Avg. TFP level	1.10	1.09	1.13	1.16	1.08	1.23	1.23
Avg. labor productivity	3.09	3.16	3.43	3.57	3.36	3.59	3.64
Foreign Affiliated Plants							
	1990	91	92	93	94	95	96
Avg. foreign share	54.4	56.1	57.3	58.9	59.8	62.1	65.5
Avg. employment	530	481	485	436	386	373	372
Avg. Output	138	141	178	199	153.9	181.1	201.1
Avg TFP	1.15	1.14	1.18	1.27	1.27	1.48	1.42
Avg. labor productivity	4.12	4.20	4.37	4.68	4.34	4.62	4.75
Local Plants							
	1990	91	92	93	94	95	96
Avg. employment	146	132	129	123	117	120	127
Avg. Output	21.7	23.0	27.0	28.0	24.9	27.5	29.9
Avg. TFP	1.10	1.09	1.13	1.16	1.07	1.21	1.22
Avg. labor prod.	3.04	3.11	3.38	3.51	3.30	3.53	3.58

FAs tend to be more capital intensive plants and on average produce 5-6 times the output of an average manufacturing plant. In line with the findings for other countries, in Turkish manufacturing industry FAs have higher labor and total factor productivity relative to local plants. In 1991 and 1992, the average labor productivity in FAs was 33% higher than average labor productivity in all manufacturing plants. Over time, the productivity gap between FAs and the sector average was closed slightly to 30% by 1996. These numbers show that the labor productivity gap between foreign affiliated and local plants is significant and does not vanish over time. In the case of total factor productivity, foreign affiliated plants lead over local plants has increased from 4% to 15%.

3.3 Measures of Horizontal and Vertical Linkages

In this section, we briefly define and discuss the salient features of the industry-based and product-based measures of linkages across plants. Our aim in this section to provide convincing evidence showing the shortcomings of the industry-based measures.

Table 2: **Horizontal and vertical industry-based linkage measures**

	1990	91	92	93	94	95	96
Horizontal (IB)	8	8.5	10.1	10.1	11.3	10.8	10.3
Backward (IB)	2.2	2.4	2.8	3.1	3.6	3.4	3.5
Forward (IB)	3.1	3.6	4.1	3.9	4.4	4.3	4.2

Industry-based Measures of Linkages

Sectoral output shares of foreign-affiliated plants weighted by their respective foreign ownership shares are used to identify horizontal linkages from foreign-affiliated plants:

$$H^s_{mt} = \frac{\sum_{i \in m} f_{it} Q_{it}}{\sum_{i \in m} Q_{it}} \tag{1}$$

where H^s_{it} is the industry-based measure of horizontal linkages for sector i at time t, f_{it} is the foreign owners' share in plant i at t, Q_{it} is the output of plant i.

Following Smarzynska-Javorcik (2004), intermediate input flows across 3-digit manufacturing industries (from the 1990 input-output matrix) are used to calculate industry-based measures of backward (B^s_{jt}) and forward (F^s_{jt}) linkages:

$$B^s_{jt} = \sum_{m \neq j} \alpha_{jm} H^s_{mt} \tag{2}$$

$$F^s_{jt} = \sum_{m \neq j} \sigma_{jm} H^s_{mt} \tag{3}$$

where α_{jm} is the proportion of sector js output supplied to sector m, σ_{jm} is the share of inputs purchased by industry j from industry m in industry j's total input purchases and H^s_{mt} is the measure of horizontal linkages, namely, foreign ownership weighted sectoral output shares of foreign-affiliated plants in sector m.

Industry-based measures of linkages are presented in Table 2. All three measures of industry-based linkages increased from 1990 through 1996. Backward linkages increased the fastest (from an average of 2.2% to 3.5%), followed by horizontal (from an average of 5.6 to 8.2%) and forward linkages (from an average of 3.1% to 4.2%). All three measures vary substantially across sectors. In sectors where foreign ownership share is high (SIC 352, 351, 383, 384, 312, 313), horizontal, forward and backward linkage measures are also high.

Table 3: Cross-correlations of industry-based linkage measures

	Backward	Forward	Horizontal
Backward	1	–	–
Forward	0.436	1	–
Horizontal	0.801	0.491	1

Actually, in the case of other chemicals (ISIC 352) forward linkage measure is very high compared to other sectors and as such has the potential to drive the productivity spillover regression results.

It is true that horizontal and vertical linkage measures identify different channels through which productivity spillovers can take place from FAs to LPs. While these channels are different in nature there is nothing that rules out two firms to be linked through any two or all three of these linkages. When that is the case, using them simultaneously in regressions will lead to multicollinearity. Correlation coefficients among the three variables at the industry level, presented in Table 3, warn us against using them simultaneously as explanatory variables in regressions.

Product-based Measures of Linkages

The intensity of backward linkages between a domestic supplier i of intermediate inputs and its foreign-affiliated plants is measured by B_{it}:

$$B_{it} = \sum_{k=1}^{K_i} \gamma_{kt} \frac{q^i_{kt}}{Q^i_t} \tag{4}$$

where γ_{kt} is the share of foreign-affiliated plants in the total purchases of domestic intermediate input k by all plants in year t, $\frac{q^i_{kt}}{Q^i_t}$ is the share of product k in the total value of plant i's sales in year t. Summing over all products of plant i (1 through K_i), B_{it} measures the intensity of backward linkages from FAs to the local plant i.

In similar vein, using data on the value of products sold and inputs purchased by each plant, the intensity of forward linkages between FAs and the local plant i is measured by, F_it:

$$F_{it} = \sum_{k=1}^{K_i} \lambda_{kt} \frac{m^i_{kt}}{M^i_t} \tag{5}$$

where λ_{kt} is the share of sales by FAs in total sales of domestically-produced product k in year t, $\frac{m^i_{kt}}{M^i_t}$ is the share of intermediate input k in the total value of all domestically produced intermediate inputs purchased by plant i in year t. Summing over all intermediate inputs purchased by the plant i, the product-based measure of forward linkages between FAs and the local plant i is obtained.

Using data on products sold and inputs purchased at the plant and product level on an annual basis, it is also possible to calculate measures of horizontal linkages through product and input markets. If the same product is produced and sold by foreign-affiliated and local plants, through competition and learning from the products of the foreign-affiliated plant local plants can increase their productivity. The intensity of horizontal linkages between foreign-affiliated and local plants is obtained using the following equation:

$$H^q_{it} = \sum_{k=1}^{K_i} \lambda_{kt} \frac{q^i_{kt}}{Q^i_t} \quad (6)$$

$$H^m_{it} = \sum_{k=1}^{K_i} \gamma_{kt} \frac{m^i_{kt}}{M^i_t} \quad (7)$$

where λ_{kt} is the market share of FAs in total sales of product k in year t, $\frac{q^i_{kt}}{Q^i_t}$ is the share of product k in the total value of output of all items produced by plant i in year t. Summing over all products produced by plant i, H^q_{it} measures the intensity of horizontal linkages between foreign-affiliated and local plants through the output market. In similar vein, using detailed data on the value of input purchases by foreign-affiliated and local plants it is possible to obtain a measure of horizontal linkages through the input purchases H^m_{it}.

Product-based measures of horizontal and vertical are calculated using 137,136 observations of inputs for plant-years, and 106,919 observations of products for plant-years (see Table 4). The data coverage improved and the number of products increased substantially after the 1992 census. Even though the total number of observations for inputs and products are huge, average number of inputs and products per plant, and per plant-years are not very high. On average, a manufacturing plant used 10.4 inputs and produced 8.0 products between 1990 and 1996. In a single year, on average of 2.9 inputs are used and 2.2 products are produced by manufacturing plants. The average number of inputs and products per plant and per plant-year are higher in food and beverages (312-313), chemicals and rubber

Table 4: **Data on products and material inputs**

	Number		Average Number			
	of	of	of inputs per		of products per	
sic3	inputs	products	plant	plant-year	plant	plant-year
3	137136	106919	10.4	2.9	8.0	2.2
311	16429	15917	8.9	2.6	8.3	2.4
312	6336	3189	17.0	4.1	8.4	1.9
313	1318	1156	17.9	3.8	14.0	2.8
321	16055	13925	8.3	2.3	7.6	2.1
322	15759	24147	7.6	2.3	12.7	3.7
323	1479	1502	6.9	2.2	6.7	2.2
324	2371	1294	13.8	4.4	7.4	2.3
331	2083	2124	6.5	1.8	6.3	1.8
332	3595	2599	14.0	4.7	9.1	3.1
341	2106	1401	11.7	2.9	6.4	1.9
351	1608	1009	18.3	4.1	10.2	2.4
352	4861	3520	16.1	4.2	10.4	2.4
355	3137	1377	17.4	4.1	7.4	1.7
356	4942	2728	9.5	2.8	4.9	1.4
361	1074	329	14.3	4.4	4.2	1.3
362	1174	578	11.2	3.3	5.1	1.4
369	6179	5485	7.1	1.7	6.1	1.4
371	2900	2401	7.8	2.0	6.4	1.6
372	1381	1148	8.7	2.7	6.8	2.2
381	12040	6264	11.0	3.0	5.6	1.6
382	14364	6374	15.7	4.5	6.8	1.8
383	8671	4884	18.0	4.7	8.5	2.2
384	7274	3568	14.3	3.6	6.4	1.7

products (351-356), glass and minerals (361-362) and machinery and equipment (381-384). These are the sectors where foreign presence is the highest (see Table 4).

The share of foreign affiliated plants in input use and product markets are used in calculating backward and forward linkage measures. Despite the low number of foreign affiliated plants covered by the data set, the data on products and inputs at the plant level allows the researcher to calculate measures of backward and vertical linkages. Table 5 presents foreign-affiliated plants involvement in the markets for inputs and products. Approximately, in 44% and 54% of input and product observations foreign affiliated plants have either no or very little presence. Among a 35% and 33% of inputs and products, foreign affiliated plants account for between 1% and 10% share, either as a purchaser of inputs or as a producer of products. In the remaining 21% and 13% of observations, foreign affiliated plants account for 25% or higher market share.

Table 5: Share of FAs in input and output markets

FA Share in Total Sales or Purchases	Number of Observations		% of Total Number of Observations	
	Input	Output	Input	Output
FA share ≤ 0.01	59,786	57,552	43.6	53.8
0.01 < FA share ≤ 0.10	47,933	35,303	35.0	33.0
0.10 < FA share ≤ 0.25	19,173	7,122	14.0	6.7
0.25 < FA share ≤ 0.50	8,131	5,462	5.9	5.1
0.50 < FA share ≤ 0.75	1,726	1,165	1.3	1.1
0.75 < FA share ≤ 1.0	387	315	0.3	0.3

Table 6: **Horizontal and vertical product-based linkage measures**

	1990	91	92	93	94	95	96
Hor. (Input)	3.2	2.9	4	3.2	3.7	4.5	3.8
Hor. (Output)	2	2.3	2.9	3.2	3.3	3.7	3.6
Backward (PB)	4.8	6.4	6.8	5.8	5.9	7.2	7.1
Forward (PB)	6.2	5	6.3	6.4	7.9	7.5	5.4

Annual averages of product-based measures of horizontal and vertical linkages are presented in Table 6. A comparison of Tables 2 and 6 reveal that product-based vertical linkage measures are almost twice larger in magnitude compared to industry-based measures. In addition, across sector variation in product-based measures is higher compared to industry-based measures. There is a big discrepancy between product-based and industry-based measures in especially those three-digit ISIC industries, where intra-industry input-output flows are substantial. Since these flows are not accounted for in an input-output matrix calculated for 3-digit ISIC industries, industry-based measures of vertical linkages are likely to be downward-biased. For example, in the case of automotive industry where there is substantial degree of intermediate input flows across four-digit sub-industries product-based backward linkage measure is almost twice and forward linkage is eight-times larger than the corresponding industry-based measures. Overall, input use from suppliers within the same industry accounts for 41% of the total value of inputs used in the manufacturing industry.

By definition, product-based measures of horizontal and vertical linkages can be correlated across plants. A local plant selling products that are used as intermediate inputs by some foreign-affiliated plants (backward linkages) could possibly be competing with other foreign-affiliated plants in the product market (horizontal linkages). Alternatively, foreign-affiliated plants that sell intermediate inputs to local plants (forward linkages) could possibly

Table 7: Cross-correlations of Product-based linkage measures

	1990	1991	1992	1993	1994	1995	1996
Backward							
Forward	0.073	0.142	0.182	0.077	0.073	0.119	0.113
Hor.-Input	0.165	0.185	0.217	0.197	0.178	0.165	0.176
Hor.-Output	0.252	0.365	0.558	0.578	0.435	0.402	0.459
Forward							
Hor.-Input	0.365	0.344	0.520	0.376	0.338	0.508	0.391
Hor.-Output	0.193	0.169	0.211	0.183	0.092	0.149	0.129
Horizontal Input							
Hor.-Output	0.144	0.172	0.202	0.224	0.124	0.198	0.230

be selling the same products to other foreign-affiliated plants (horizontal linkages through the input use).

Correlation coefficients for product-based linkage measures are presented in Table 7. While the cross-section time-series correlation coefficient between product-based backward and forward linkage measures is quite small (0.11), the corresponding correlation coefficients between backward and output-based horizontal measures and between forward and input-based horizontal measures are higher (0.44 and 0.41, respectively). A high correlation coefficient between horizontal and vertical linkage measures raises a flag against using them simultaneously as explanatory variables in productivity spillover regressions, a common practice in studies that use industry-based measures.

For many industries, most inputs originate from the same industry. This basic observation implies that the measures of vertical linkages should take into account intra-industry linkages through the intermediate use and provision. Industry-based measures of vertical linkages, on the other hand, are obtained from inter-industry input-output flows (equations 2 and 3). As a consequence, industry-based measures of vertical linkages can not account for all possible influences between FAs and LPs through input use. To the contrary, the industry-based measures confuse vertical linkages

3.4 Production Function Estimation

We estimate plant level productivity using Olley and Pakes (1996) approach (OP from here on).[1] In this section, we provide a brief overview of the OP method. The biases and problems of using the more traditional estimators are well known; as in the rest of the literature, we find that estimation with the most commonly used conventional methods yield the expected biases. In order to cover the whole of 1990-96 in our study of foreign direct investment, we estimate separate production functions for 23 industries using the data from 1989 to 1996.

Consider a Cobb-Douglas production function for firm i at time t (suppressing the firm index i) where all variables are represented in log-levels:

$$y_t = \beta_0 + \beta_l l_t + \beta_\iota \iota_t + \beta_k k_t + \epsilon_t \tag{8}$$

where $\epsilon_t = \omega_t + \eta_t$. OLS estimates are biased. where y_t is output, l_t is labor, k_t is the capital stock and, ι_t is the intermediate input. Plant specific error term, ϵ_t, is composed of a plant-specific productivity component, ω_t, and an i.i.d. component, η_t:$\epsilon_t = \omega_t + \eta_t$ The latter term has no impact on the firms decisions. The productivity term, , which is not observed by the econometrician, is known by the firm, and it has an impact on the firms decision rules. A simultaneity problem arises when there is contemporaneous correlation both within firm i and across time t between and the firms inputs in the firm specific sequences.[2]

To address the simultaneity problem, OP use investment to proxy for the part of the error correlated with inputs where investment demand function is then written as follows:

$$i_t = i_t(\omega_t, k_t) \tag{9}$$

[1] We prefer OP approach instead of estimating a production function that also incorporates plant characteristics including the FDI related variables (ownership as well as intra- and inter-industry linkage measures) using OLS. Since this estimation will suffer from simultaneity and selection biases OP approach aims to correct for, we do not take this route. Instead, we prefer to obtain OP estimates of the production function corrected for simultaneity and selection biases, calculate the total factor productivity measure that will be used as the dependent variable in the productivity spillover equation.

[2] As sketched out in Levinsohn and Petrin (2000), in the case of a two input production function, when both capital and labor are correlated with the productivity shock, but labor's correlation is significantly higher, and that labor and capital are correlated with each other, OLS will overestimate the labor elasticity and underestimates the capital elasticity. It is generally not possible to sign the biases of the coefficients when there are many inputs all of which potentially have varying degrees of correlation with the error term ϵ.

For positive values of investment $i_t(\omega_t, k_t)$ is inverted to yield ω_t as a function of capital and investment, $\omega_t(i_t, k_t)$.[3] Substituting this expression into equation (7) yields output in terms of observable variables:

$$y_t = \beta_l l_t + \beta_\iota \iota_t + \phi_t(i_t, k_t) + \eta_t \tag{10}$$

where $\phi_t(i_t, k_t) = \beta_0 + \beta_k k_t + \omega_t(i_t, k_t)$.[4] Consistent parameter estimates of the coefficients on the variable inputs can then be obtained using a semi-parametric estimator (for example by modeling as a polynomial series expansion in capital and investment as in OP).[5]

A separate effect of capital on output from its effect on a plants investment is obtained in a second stage by assuming that ω_t follows a first order Markov process and capital does not immediately respond to the innovations in productivity, where the innovation in productivity is defined as: $\xi_t = \omega_t - E[\omega_t|\omega_{t-1}]$

Under these assumptions consistent estimates of β_k is obtained from the estimation of the following equation:

$$y_t^* = y_t - \beta_l l_t - \beta_\iota \iota_t = \beta_0 + \beta_k k_t + E[\omega_t|\omega_{t-1}] + \eta_t^* \tag{11}$$

where, y_t^* is output net of labor's contribution and $\eta_t^* = \xi_t + \eta_t$. Since a by-product of the first stage is an estimate of ω, a consistent estimate of $E[\omega_t|\omega_{t-1}]$ can be obtained and estimation of equation (4) yields consistent estimate of β_k.[6]

The production function estimates based on OP and OLS are presented in Table 3.4 and Table 9, respectively. As can be seen in Table 3.4, in all industries the elasticity

[3]Even though we leave the firms exit decision in this exposition, OP framework accounts for exit; we present results that estimate OP with and without exit for comparisons with other methods.

[4]ϕ_t will always be used when discussing the non-parametric part of the first stage; it will always have capital, the endogenous state variable, and the proxy variable.As sketched out in Levinsohn and Petrin (2000), in the case of a two input production function, when both capital and labor are correlated with the productivity shock, but labor's correlation is significantly higher, and that labor and capital are correlated with each other, OLS will overestimate the labor elasticity and underestimates the capital elasticity. It is generally not possible to sign the biases of the coefficients when there are many inputs all of which potentially have varying degrees of correlation with the error term ϵ.

[5]An important feature of the Turkish economy relevant to our undertaking is the presence of macroeconomic boom and bust cycles during the period under consideration. This behavior is apparent in the cyclical pattern of real GNP growth rate. In our production function estimations, we take these cycles into account by using dummies for the periods of expansion and contraction. More specifically, we distinguish between four time periods: 1991 (Iraq war); 1990, 1992, 1993, 1995, 1996 (expansion); and 1994 economic crisis, 1997 and 2000 (expansion), and 1998-1999 (Russian crisis and the Marmara earthquake).

[6]Olley and Pakes (1996) use a series expansion as well as a kernel estimator for this stage. Also, note that a constant can not be identified separately from the polynomial expansion in investment and capital.

Table 8: Olley-Pakes production function estimates

		Labor		Mat. inputs		Energy		Capital	
SIC	Sector	Coef.**	S.E.[a]	Coef.**	S.E.	Coef.	S.E.	Coef.	S.E.
311	Food	0.191	0.010	0.761	0.012	0.029**	0.006	0.058**	0.007
312	Food Misc.	0.182	0.028	0.810	0.014	0.049**	0.012	0.037	0.027
313	Beverages	0.191	0.047	0.676	0.034	0.148**	0.034	0.116**	0.036
321	Textiles	0.153	0.011	0.729	0.009	0.095**	0.006	0.052**	0.010
322	Wearing App.	0.222	0.017	0.676	0.016	0.059**	0.011	0.058**	0.010
323	Leather Prod.	0.221	0.059	0.635	0.033	0.137*	0.028	0.070*	0.024
324	Footwear	0.288	0.056	0.749	0.036	0.028	0.024	0.059**	0.010
331	Wood Prod.	0.075+	0.043	0.746	0.022	0.078**	0.018	0.120**	0.012
332	Furniture	0.216	0.047	0.829	0.026	0.080**	0.025	0.039	0.028
341	Paper	0.214	0.054	0.625	0.057	0.087**	0.017	0.130**	0.014
351	Industrial Chem.	0.180	0.043	0.579	0.023	0.085**	0.019	0.075*	0.029
352	Other Chem.	0.224	0.025	0.681	0.021	0.047**	0.010	0.111**	0.013
355	Rubber Prod.	0.140	0.030	0.670	0.021	0.065**	0.020	0.089**	0.026
356	Plastics	0.220	0.020	0.722	0.021	0.073**	0.012	0.097**	0.011
361	Ceramics	0.322	0.103	0.502	0.075	0.231**	0.082	0.105**	0.011
362	Glass	0.249	0.038	0.631	0.038	0.132**	0.021	0.052**	0.011
369	Nonmetal Min.	0.245	0.023	0.548	0.011	0.210**	0.014	0.041	0.032
371	Iron and Steel	0.151	0.028	0.733	0.011	0.084**	0.014	0.054**	0.014
372	Nonferr. Metals	0.224	0.032	0.763	0.023	0.063**	0.021	0.102*	0.042
381	Fab. Metals	0.190	0.018	0.741	0.012	0.079**	0.010	0.071**	0.011
382	Non-elect. Mach.	0.208	0.024	0.738	0.015	0.009	0.014	0.141**	0.027
383	Elect. Machinery	0.126	0.022	0.768	0.015	0.055**	0.010	0.095**	0.010
384	Transport Eq.	0.229	0.024	0.650	0.016	0.100**	0.012	0.050**	0.012

[a]S.E. denotes standard errors, **, * and + indicates statistical significance at the 1, 5, and 10% levels, respectively. Statistical significance indicators apply to all sectors when included next to the variable name heading.

estimates for material inputs are the largest (averaging about 0.70 across industries). The next largest is the labor elasticity estimates, followed by energy. Note also that with the exception of capital stock elasticity almost all of the coefficients are estimated statistically significantly at standard levels of confidence and are of expected sign. We compare OP estimates with OLS estimates. In a majority of industries, the coefficient estimates change in the expected direction as we move from OLS to OP estimation: capital elasticity estimate increases in 14 sectors, while labor, energy and material input elasticity estimates decrease (or change very little) in 21, 22 and 19 industries respectively.

Table 9: OLS production function estimates

SIC	Sector[a]	Labor**	M.Inputs**	Energy**	Capital	Obs.
311	Food	<0.222	<0.768	<0.058	>0.028**	2174
312	Food Miscellaneous	>0.142	<0.860	=0.050	<0.030**	541
313	Beverages	<0.224	<0.707	<0.160	>0.039*	235
321	Textiles	<0.185	<0.737	>0.079	>0.034**	3523
322	Wearing Apparel	<0.260	<0.682	<0.063	>0.034**	2987
323	Leather Products	>0.174	<0.685	>0.130	>0.058*	301
324	Footwear	<0.352	>0.718	<0.051*	>0.014	207
331	Wood Products	<0.155	=0.751	<0.089	>0.067**	357
332	Furniture	<0.277	>0.753	<0.106	>-0.003	261
341	Paper	<0.271	<0.658	<0.113	>0.020	439
351	Industrial Chemicals	<0.186	<0.637	<0.114	<0.104**	275
352	Other Chemicals	<0.276	>0.674	=0.048	>0.101**	935
355	Rubber Products	<0.220	<0.703	<0.083	<0.103**	425
356	Plastics	=0.217	<0.761	>0.067	>0.050**	928
361	Ceramics	<0.425	<0.538	>0.175	>0.036	132
362	Glass	<0.256	>0.618	=0.134	<0.097**	221
369	Nonmetal Minerals	<0.300	>0.488	<0.272	<0.102**	1419
371	Iron and Steel	<0.187	>0.727	<0.089	>0.047**	853
372	Nonferrous Metals	=0.223	<0.785	>0.055	>0.038**	317
381	Fabricated Metals	<0.195	<0.761	<0.082	>0.065**	1599
382	Non-electrical Mach.	<0.258	=0.737	<0.023	>0.053**	1458
383	Electrical Machinery	=0.126	>0.723	<0.093	<0.100**	1194
384	Transport Equipment	<0.251	=0.644	<0.114	<0.076**	1143

[a]Standard errors for OLS estimates are not reported. Inequality signs next to OLS coefficient estimates indicate whether an OP coefficient estimate is less than (<), greater than (>) or almost equal(=) to the corresponding OLS coefficient estimate.

4 Empirical Results with Industry-based Measures

Using Olley-Pakes elasticity estimates, total factor productivity estimates are obtained at the plant-level. Even though OP estimates are obtained for plants with non-zero investment expenditures, we calculate productivity measures for all plants between 1990 and 1996. In the remainder of the empirical analysis, the level of total factor productivity will be a dependent variable. Depending on the focus of the analysis, explanatory variables will include measures of foreign ownership, measures of horizontal and vertical linkages, plant characteristics other than foreign ownership, as well as year, industry and region indicators.

5 Foreign Ownership and Productivity

The annual average values in Table 1 support the case for significant labor and total factor productivity differences between foreign-affiliated and local plants, but cannot rule out the possibility that these differences stem from plant characteristics other than foreign ownership. In the rest of this section, we report the results of total factor productivity regressions on various measures of FDI participation. Our primary objective is to understand whether or not foreign ownership helps explain productivity differences between foreign-affiliated and local plants when other plant characteristics are taken into account, in order to make more informed statements about the role of the FDI in the performance of the Turkish manufacturing industry. The regression results also shed light on whether there are spillover effects from the presence of FDI.

Four different variables are used as measures of foreign participation in ownership. The first two measures are the foreign owners share as described in equation (1). While the first one does not impose any restriction, the second measure considers foreign owners share in plants with 10% or more foreign share ownership. Productivity may not be a linear function of foreign shareholding. Third and fourth measures of foreign ownership are designed to capture differences in the impact of foreign ownership in plants with different degrees of foreign owner involvement. The impact of foreign ownership on productivity is likely to be different in joint ventures with minority foreign shareholding, in joint ventures with majority foreign shareholding and in plants under full foreign control. The difference in the productivity response to foreign ownership is captured by three dummy variables: foreign shares in plants with foreign shareholding between 10 and 50%; foreign shares in plants with foreign shareholding higher than 50% but less than 100% and finally plants fully owned by foreign investors. The fourth measure divides the foreign-affiliated plants into four groups: foreign share holding between 10 and 39.9%, between 40 and 69.9%, between 70 and 99.9%, and 100%.

In order to control for plant characteristics that are not directly related to foreign shareholding, but can also be affecting productivity, several variables are included in the productivity estimations. These variables are the share of exports in total sales, share of imported M&E in total machinery and equipment stock, amount spent on imported license purchases relative to total sales, the share of skilled labor in production, agglomeration at the provincial level, incorporated plant dummy, and firm size dummies measured by employment.

Table 10 reports the regression results. Independent of which foreign ownership measure is used, the regression results show that plants with foreign partners have a higher level of total factor productivity even after other plant characteristics, and size, region, year and industry effects are accounted for. In the first column, the estimated coefficient for the foreign owners share is 0.196, and statistically significantly different from zero. The effect of foreign owners share on productivity is economically meaningful as well. If the foreign owners share increases by 10 percentage points, total factor productivity increases by 2 percent. There is no change in the statistical significance of the regression results when the dummy variables are used as measures of differing degree of foreign participation. Nor is there any significant change in the estimated parameters of other variables when the dummy variables of foreign participation are used. The coefficient on column 2 implies that the impact of foreign ownership is negligent when the foreign share is less than 10%.

Column 3 presents the results after further refining the definition of the dummy variables. It shows that unless foreign owners have the majority stake, their presence does not have a significant impact on a plants productivity. For a plant with foreign share holding above 10% and less than 50%, foreign ownership does not affect productivity. On the other hand, in plants with foreign majority control a 10 percentage point increase in foreign ownership would increase productivity by 1.7% more productive than plants with less than 10% foreign shareholding. Foreign subsidiaries fully-owned by MNCs are on average 25 % more productive relative to the plants with less than 10% foreign shareholding.

Column 4 presents the estimations with four groups of foreign-affiliated plants. The estimation results do not change much when we include plant characteristics as the right-hand side variables. (column 5 through column 8) These results clearly support the view that unless the foreign investors have the majority control over the companys decisions, they

Table 10: Foreign ownership and productivity

	1	2	3	4	5	6
Foreign Share	0.196** (0.025)	–	–	0.171** (0.026)	–	–
$0.10 \leq$ Foreign Share	–	0.195** (0.025)	–	–	0.170** (0.026)	–
$0.10 \leq$ Foreign share < 0.50	–	–	0.094 (0.078)	–	–	-0.05 (0.080)
$0.50 \leq$ Foreign share < 1.0	–	–	0.171** (0.033)	–	–	0.157** (0.034)
Foreign Share $= 1.0$	–	–	0.244** (0.040)	–	–	0.224** (0.041)
Exports/Output (%)	–	–	–	0.020+ (0.011)	0.020+ (0.011)	0.021+ (0.011)
Imported M&E share	–	–	–	0.024* (0.011)	0.024* (0.011)	0.024* (0.011)
Imported license fees (% of total costs)	–	–	–	0.042* (0.019)	0.042* (0.019)	0.049** (0.019)
Skilled production Employees (% of total)	–	–	–	0.156** (0.021)	0.156** (0.021)	0.157** (0.021)
Agglomeration (provincial)	–	–	–	0.272** (0.028)	0.272** (0.028)	0.270** (0.028)
Incorporated plant Indicator	–	–	–	0.025** (0.006)	0.025** (0.006)	0.026** (0.006)
Size indicator - $50 \leq$ Employment < 100	0.026** (0.007)	0.026** (0.007)	0.026** (0.007)	0.020** (0.007)	0.020** (0.007)	0.020** (0.007)
Size indicator - $100 \leq$ Employment < 250	0.041** (0.007)	0.041** (0.007)	0.041** (0.007)	0.033** (0.007)	0.033** (0.007)	0.033** (0.007)
Size indicator - $250 \leq$Employment	0.016+ (0.009)	0.017+ (0.009)	0.019* (0.009)	0.004 (0.009)	0.004 (0.009)	0.006 (0.009)
No. of Observations	29513	29513	29513	29424	29424	29424
Adj. R-squared	0.531	0.531	0.531	0.535	0.535	0.535

either fail or intentionally decide not to exert effort to use firm-specific assets that will boost productivity. Given that majority foreign control makes the difference in productivity, we will need to separately analyze spillovers from majority foreign controlled plants through horizontal and vertical linkages with local plants.

These findings about the impact of foreign share ownership on productivity are consistent with the findings of Aitken and Harrison (1999) for Venezuelan manufacturing industry. They also find, however, that foreign ownership effect on productivity works only in smaller plants, plants with less than 50 employees.

5.1 Horizontal and Vertical Linkages and Productivity Spillovers

Having shown the significant impact of foreign ownership on productivity in the previous section, we now focus on horizontal spillovers using industry-based linkage measures. Productivity measures for local plants are regressed on foreign-ownership weighted output shares of FAs with different degrees of foreign ownership as well as other characteristics of local plants. Output shares of foreign affiliated plants are calculated for the FA groups defined in Table 10.

Table 11 reports regression results capturing horizontal spillover effects of FDI at the sectoral level. When all foreign affiliated plants are taken into account to calculate the measure of horizontal linkage, an estimated coefficient of 0.82 is obtained. This coefficient estimate implies that a 1 percentage point increase in the foreign-ownership weighted sectoral output shares of foreign-affiliated plants is associated with a 0.82 percent increase in the productivity of local plants. Given that the foreign-ownership weighted output share of foreign affiliates increased from 5.6% in 1990 to 8.2% in 1996, this coefficient estimate implies that due to the increased presence of foreign affiliates domestic plants productivity increased by 2.1%. This is not a negligible amount of horizontal spillovers.

It is not just assumed that all foreign affiliates generate horizontal spillovers on their competitors. In particular, it is important to analyze whether the foreign ownership share matters for the generation of horizontal spillovers. First, for each sector output share is calculated for plants with 10% or more foreign ownership. The results with this variable on the RHS are reported in columns 2 and 6. The coefficient estimates (0.79) are very close to what is obtained for the output share of all foreign affiliated plants.

In the next step, the measure of horizontal linkages is refined further. A distinction is made between foreign affiliated plants that have foreign share of more than 10% but less than majority control; plants that are under foreign majority control but falls short of full control; and plants that are under full foreign ownership. The coefficient estimates do not differ substantially when plant characteristics are included in the equation (compare columns 3 and 7). In terms of the effect of foreign presence in a sector, the resulting

Table 11: Productivity spillovers - Horizontal (industry-based)

	1	2	3	4	5	6
Output share of FA (All)	0.817** (0.113)	–	–	0.820** (0.113)	–	–
0.1 ≤ FA share	–	0.792** (0.111)	–	–	0.795** (0.111)	–
0.1 ≤ FA share < 0.5	–	–	0.721** (0.269)	–	–	0.696** (0.268)
0.5 ≤ FA share < 1.0	–	–	1.099** (0.145)	–	–	1.097** (0.144)
FA share = 1.0	–	–	0.403** (0.155)	–	–	0.406** (0.150)
Exports/Output (%)	–	–	–	0.027* (0.011)	0.027* (0.011)	0.027* (0.011)
Imported M&E share	–	–	–	0.024* (0.011)	0.024* (0.011)	0.024* (0.011)
Imported license fees (% of total costs)	–	–	–	0.048* (0.019)	0.048* (0.019)	0.048* (0.019)
Skilled production Employees (% of total)	–	–	–	0.152** (0.021)	0.152** (0.021)	0.152** (0.021)
Agglomeration (provincial)	–	–	–	0.261** (0.028)	0.260** (0.028)	0.260** (0.028)
Incorporated plant Indicator	–	–	–	0.029** (0.006)	0.029** (0.006)	0.029** (0.006)
50 ≤ Employment < 100	0.029** (0.007)	0.029** (0.007)	0.029** (0.007)	0.022** (0.007)	0.022** (0.007)	0.022** (0.007)
100 ≤ Employment < 250	0.046** (0.007)	0.046** (0.007)	0.046** (0.007)	0.034** (0.007)	0.034** (0.007)	0.034** (0.007)
250 ≤Employment	0.016+ (0.009)	0.017+ (0.009)	0.019* (0.009)	0.004 (0.009)	0.004 (0.009)	0.006 (0.009)
No. of Observations	28107	28107	28107	28105	28105	28105
Adj. R-squared	0.557	0.557	0.557	0.560	0.560	0.560

coefficient estimates form an inverted-U shape. While the productivity of local plants on average increases by 0.72% in response to one percentage point increase in the output share of plants with minority foreign control, it increases by 1.10% in response to one percentage increase in the output share of plants with majority but not full foreign control. As can be seen from a coefficient of 0.4, horizontal spillovers from fully foreign-controlled plants are less compared to plants with less than full foreign control. The inverted-U shape of the horizontal productivity spillovers is obtained when foreign affiliated plants are grouped into four groups (column 4 and 8) based on foreign ownership shares.

In sum, using the output shares of FAs to measure horizontal linkages, the regression results confirm that there are spillovers from foreign affiliates to local plants that operate in the same industry. Second, horizontal spillovers from FAs with minority foreign share holding are stronger than the spillovers from FA under the majority or full foreign ownership control.

The inverted-U shape of the horizontal spillover estimates can be due to two counteracting factors. First, as their stakes increase, especially to above the 50% threshold, foreign investors tend to bring more technology and know-how to the plant. Second, as their stakes increase towards full ownership control, foreign investors capability of preventing competitors from gathering information about the plants production and management practices increases. While majority foreign-controlled plants are also able to keep some control over their production and management practices it is nevertheless not possible to prevent spillovers above the 50% threshold and further

These two forces explain why the horizontal spillovers are higher in majority (but not full) foreign controlled plants relative to plants with minority foreign ownership or fully foreign controlled plants. Having no domestic partner, fully foreign-owned plants can prevent its competitors from gathering information about its production and management practices relatively more easily compared to plants with domestic partners. Having more solid control over the information, multinational corporations are willing to inject more advanced technology and know-how to the fully-owned subsidiary. As a result, even though they can prevent most of the information leakage to their competitors, their presence as a competitor in the market gives more reason for local plants to improve their productivity. (Saggi, 2001).

Using industry-based measures, productivity spillovers through vertical linkages are analyzed. Results of backward (equation 2) and forward (equation 3) productivity spillovers regressions are presented in Table 12. Results presented in columns 1 through 4 show that there are significant productivity spillovers through backward and forward linkages, irrespective of the inclusion of plant characteristics in the regressions. When included together in the regression (column 3), a one standard deviation (10.5 percentage points) increase in the output share of foreign-affiliated plants in the producing (sourcing) industry generates a 10 (2.6) percent increase in the productivity of local plants in the upstream

Table 12: Productivity Spillovers - Vertical (industry-based measures)

	1	2	3	4	5	6	exc. 352
Backward spillovers	1.116**	–	0.631*	0.667**	-0.007	0.025	0.257
	(0.243)		(0.251)	(0.251)	(0.26)	(0.26)	(0.259)
Forward spillovers	–	1.120**	0.982**	0.952**	0.806**	0.776**	0.267
		(0.173)	(0.180)	(0.179)	(0.179)	(0.178)	(0.199)
Horizontal spillovers	–	–	–	–	0.426**	0.428**	0.386**
(Output Share of FA)					(0.044)	(0.043)	(0.046)
Exports/Output (%)	–	–	–	0.028*	–	0.031**	0.038**
				(0.011)		(0.011)	(0.011)
Imported M&E share	–	–	–	0.025*	–	0.019+	-0.002+
				(0.011)		(0.011)	(0.011)
Imported license	–	–	–	0.047*	–	0.052**	0.059**
				(0.020)		(0.020)	(0.021)
Skilled production	–	–	–	0.152**	–	0.141**	0.133**
				(0.021)		(0.021)	(0.022)
Agglomeration	–	–	–	0.260**	–	0.272**	0.240**
				(0.028)		(0.028)	(0.028)
Incorporated plant	–	–	–	0.028**	–	0.029**	0.033**
				(0.006)		(0.006)	(0.006)
$50 \leq$ Employment < 100	0.029**	0.028**	0.029**	0.022**	0.027**	0.021**	0.020**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$100 \leq$ Employment < 250	0.046**	0.045**	0.045**	0.033**	0.041**	0.030**	0.023**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Employment < 250	0.025**	0.025**	0.025**	0.007	0.020*	0.003	-0.004
	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)
Number of Observations	28107	28107	28107	28105	28107	28105	27204
Adj. R-squared	0.556	0.556	0.556	0.559	0.558	0.561	0.574

(downstream) industry.

Once the horizontal linkage measure is included in the regressions (columns 5 and 6 of Table 12, the results change significantly. While the coefficient on forward linkage measure continues to be statistically significant, the coefficient on backward linkage measure becomes statistically insignificant. The substantial change in the estimated backward productivity spillovers is not surprising, given the rather high correlation coefficient between industry-based backward and horizontal linkage measures (see Table 3.

Horizontal spillovers as measured by the coefficient estimate on the sectoral output share of foreign-affiliated plants continue to be statistically important when considered along with vertical spillover measures. Its economic importance diminishes by almost half as the possibility of vertical productivity spillovers are taken into account. Finally, when the other chemicals industry (SIC 352) is dropped out of the sample, and the productivity equations

Table 13: Horizontal and vertical spillovers - product-based measures

Size indicators only					
	1	2	3	4	5
Horizontal spill. (via output)	–	–	0.043 (0.038)	–	–
Horizontal spill. (via input)	–	–	–	0.039 (0.036)	–
Backward spill.	0.044* (0.020)	–	–	–	0.044* (0.020)
Forward spill.	–	-0.019 (0.022)	–	–	-0.019 (0.022)
Observations	28107	28107	28107	28107	28107
Adj. R-squared	0.556	0.556	0.556	0.556	0.556
Including other plant characteristics along with size indicators					
	1	2	3	4	5
Horizontal spill. (via output)	0.042 (0.038)	–	0.03 (0.038)	0.05 (0.038)	0.042 (0.038)
Horizontal spill. (via input)	0.037 (0.036)	–	0.027 (0.036)	0.02 (0.040)	0.009 (0.040)
Backward spill.	–	0.041* (0.019)	–	0.039+ (0.020)	0.038+ (0.020)
Forward spill.	–	-0.025 (0.022)	–	-0.03 (0.023)	-0.033 (0.023)
Observations	28107	28105	28105	28107	28105
Adj. R-squared	0.556	0.559	0.559	0.556	0.559

are estimated again, forward spillovers became statistically insignificant.

6 Empirical Results with Product-based Measures

In the second part of the empirical analysis, product-based measures of backward, forward and horizontal linkages (equation 4, 5, and 6, respectively) are used to study productivity spillovers from foreign-affiliated plants to local plants. Unlike industry-based measures, product-based measures are defined at the plant level, and, therefore, allow us to measure the interaction of local plants with foreign affiliated plants both through the inputs purchased and/or products sold. Table 13 reports the first round of the results of productivity spillover regressions with product-based measures. Irrespective of the variables included in the regressions, coefficient estimates for the forward and horizontal linkages do not support the presence of productivity spillovers from foreign-affiliated plants towards the local plants.

When used alone or together with forward linkage measures, the coefficient on backward linkages indicates the presence of statistically meaningful (at the 5 percent level) productivity spillovers from FAs to local suppliers of inputs they use. Other things held constant, a one standard-deviation (an increase of 15 percentage points) increase in a local plants output share of FA-targeted products (backward linkage between the LP and FAs) leads to a 0.6% increase in the local plants productivity. Given that the average productivity growth for all local plants during 1990-1996 was approximately 12%, the contribution of backward spillovers to local plants productivity growth was not substantial. Even though it is statistically important, economically the impact of backward spillovers is quite small. A one standard deviation increase in the proportion of products that are consumed by foreign affiliates can account for only 5% of the average total factor productivity growth during 1990-1996.

The results obtained with product-based measures are drastically different from the ones obtained with industry-based measures. The product-based measures of linkages are calculated from the information provided by each plant about the value of their products and inputs. Any failure of plants in providing correct information on inputs and output can lead to serious biases in linkage measures of spillovers. For this reason, it is desirable to use measures of vertical linkages that take the history of each plants products and inputs use into account as well as the information about current product and input mix. When the value of products and inputs used in the past three years are taken into account in the calculations of backward and forward linkages the results do not change in a qualitative manner.

It is not correct to assume that all local plants are able to make use of the productivity spillovers. For example, Kokko et. al. (1996) argued that the local plants with some capability of making use of productivity spillovers should be treated separately from others. In the end, they were not able to find any significant difference among the local plants absorptive capacity of spillovers. Following the example of Kokko et. al. (1996), we estimate the productivity equations separately for four size groups (defined by the number of employees: between 25 and 49; between 50 and 99; between 100 and 250; and higher than 250). The results without and with other plant characteristics are presented in Table 14.

Table 14: LP size & Horizontal and vertical spillovers - (product-based measures)

Horizontal spillovers only				
	Size 1	Size 2	Size 3	Size 4
Horizontal spill. (via inputs)	-0.016 (0.054)	-0.176* (0.075)	0.167* (0.083)	0.059 (0.078)
Horizontal spill. (via output)	-0.023 (0.058)	-0.205* (0.083)	0.094 (0.092)	0.205* (0.084)
Vertical spillovers only				
	Size 1	Size 2	Size 3	Size 4
Backward spill.	0.085** (0.032)	-0.043 (0.038)	-0.019 (0.041)	0.013 (0.046)
Forward spill.	-0.044 (0.031)	-0.043 (0.052)	-0.064 (0.050)	0.005 (0.046)
Horizontal and vertical estimated together				
	Size 1	Size 2	Size 3	Size 4
Backward spill.	0.099** (0.033)	-0.0003 (0.039)	-0.043 (0.043)	-0.029 (0.048)
Forward spill.	-0.041 (0.033)	-0.006 (0.054)	-0.113* (0.050)	-0.024 (0.052)
Horizontal spill.	-0.004 (0.057)	-0.173* (0.080)	0.227** (0.084)	0.073 (0.087)
Horizontal spill. (via output)	-0.081 (0.060)	-0.205* (0.087)	0.118 (0.096)	0.224* (0.088)

The inclusion of other plant characteristics does not change the spillover estimates much. There are differences in the reaction of productivity of different size groups to the presence of linkages with FAs. With a coefficient of 0.083, plants with 25-49 employees enjoy productivity spillovers through backward linkages. Given that LPs can potentially interact with FAs through all three channels, FAs with a couple of hundred employees may not be concerned about their small local suppliers to benefit from their firm-specific assets.

It is also not surprising to see that the largest LPs are the ones that benefit from productivity spillovers in product market competition with FAs (with a coefficient estimate of 0.258). These plants are the most likely candidates to hire employees with work experience in the rival FAs; they are more likely to have the human resources that can learn more about the rival FAs products and their production, management and marketing techniques. According to the results in Table 14, local plants with 50-99 employees received negative productivity spillovers from the competition with FAs in the output and input markets. Local plants with 100 to 250 workers, on the other hand, had positive productivity spillovers from the presence of FAs in input markets.

7 Conclusions

Using detailed data on product sales and input purchases of plants to identify horizontal and vertical linkages among plants, this paper contributes to the analysis of the productivity spillovers from foreign affiliated plants to local plants. The empirical analysis is based on plant-level data for the Turkish manufacturing industry between 1990 and 1996.

There are several results to be reported. First, foreign affiliates are more productive than local plants. Majority foreign-owned FAs are more productive than minority foreign-owned FAs, and fully foreign-controlled plants are more productive compared to majority foreign-owned FAs. After obtaining these results, we proceed to analyze whether there are productivity spillovers from FAs to LPs. The analysis with industry-based measures of linkages supports the presence of productivity spillovers from FAs to LPs that operate in the same industry. Using vertical linkages alone, vertical spillovers are also found to be economically and statistically meaningful. When analyzed along with horizontal spillovers, the backward spillovers become statistically insignificant. Due to the presence of high correlation among them, using horizontal and vertical linkage measures simultaneously on the right hand side generates spurious results.

Empirical results with product-based measures, on the other hand, do not lend much support to the results with industry-based measures. Given the lower correlation coefficients among them, product-based measures of linkages are less likely to create the multicollinearity problem compared to industry-based measures. The presence of FAs producing similar products or using similar material inputs does not improve productivity in LPs. Furthermore, the productivity of an LP does not increase as a result of purchasing inputs that could be produced by foreign-affiliated plants. Only in the case of backward linkages, the foreign-affiliated plants generate significant productivity spillovers. Even then, productivity spillovers from FAs to local plants from which they purchase inputs are quite small.

References

Aitken, B. J. and A. E. Harrison, 1999, Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela, *American Economic Review* 89(3), 605-618.

Blalock, G. and P. Gertler, 2004, Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers, mimeo, Cornell University.

Blomstrm, M. and A. Kokko, 1998, Multinational Corporations and Spillovers, *Journal of Economic Surveys* 12(2), 1-31.

Djankov, S. and B. Hoekman, 2000, Foreign Investment and Productivity Growth in Czech Enterprises, *World Bank Economic Review* 14(1), 49-64.

Dutz, M., M. Us, and K. Yılmaz, 2005, Turkeys Foreign Direct Investment Challenges: Competition, the Rule of Law and EU Accession, in B. Hoekman and S. Togan, ed. *Turkey: Towards EU Accession*, Oxford University Press, Oxford, UK.

Grg, H. and E. Strobl, 2001, Multinational Companies and Productivity Spillovers: A Meta Analysis, *The Economic Journal* 111, 723-739.

Griliches Z. and J. Mairesse, 1995, Production Functions: The Search for Identification, *NBER Working Paper Series* No. 5067, March.

Haddad, M. and A. Harrison, 1993, Are There Positive Spillovers from Direct Foreign Investment? Evidence from Panel Data for Morocco, *Journal of Development Economics* 42, 51-74.

Haskel, J. E., S. C. Pereira and M. J. Slaughter, 2002, Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms? NBER Working Paper Series No. 8724.

Keller, W. and S. R. Yeaple, 2003, Multinational Enterprises, International Trade and Productivitty Growth: Firm Level Evidence from the United States, *NBER Working Paper Series* 9504, February.

Lenger, A. and E. Taymaz, 2006, To Innovate or to transfer? A study on spillovers and foreign firms in Turkey, *Journal of Evolutionary Economics* 16, 137-153.

Levinsohn, J. and A. Petrin, 2003, Estimating Production Functions Using Inputs to Control for Unobservables, *Review of Economic Studies* 70, pp. 317-342, April.

Markusen, J. R., 1995, The Boundaries of Multinational Enterprises and the Theory of International Trade, *Journal of Economic Perspectives* 9, 169-89.

Olley, S., and A. Pakes, 1996, The Dynamics of Productivity in the Telecommunications Equipment Industry, *Econometrica* 64, 1263-1297.

Özler, S., and K. Yılmaz, 2004, Productivity Response to Reduction in Trade Barriers: Evidence from Turkish Manufacturing Plants mimeo, Ko University.

Rodrik, Dani, 1999, "The New Global Economy and Developing Countries: Making Openness Work. *Overseas Development Council* (Baltimore, MD) Policy Essay No. 24, 1999.

Saggi, K., 2001, Trade, Foreign Direct Investment, and International Technology Transfer: A Survey, Background paper, The World Bank.

Schoors, K. And B. van der Tol, 2002, Foreign direct investment spillovers within and between sectors: Evidence from Hungarian data, Ghent University, Working Paper 2002/157.

Smarzynska-Javorcik, B. S., 2004, Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages, *American Economic Review* 94(3).