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REGULAR ARTICLE

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To innovate or to transfer?

A study on spillovers and foreign firms in Turkey

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Abstract FDI has been considered by many development economists as an important channel for transfer of technology to developing countries. It is suggested that modern, advanced technologies introduced by multinational firms can diffuse to domestic firms through spillovers. In this paper, we study innovation and technology transfer activities of domestic and foreign firms in Turkish manufacturing industries, and the impact of horizontal, vertical and labor spillovers on these activities. Our analysis shows that foreign firms are more innovative than their domestic counterparts, and transfer technology from abroad (mostly from their parent companies). Horizontal spillovers from foreign firms seem to be insignificant. The effects of foreign firms on technological activities of other firms in vertically related industries are ambiguous. High-tech suppliers tend to have a high rate of innovation when the share of foreign users is high, but the opposite is true for users: high-tech users supplied mainly by foreign firms tend to have a lower rate of innovation. Labor turnover is found to be the main channel of spillovers. Our findings reiterate the importance of tacitness of knowledge, and confirm that technology cannot easily be transferred through passive mechanisms.

Keywords FDI · Innovation · Technology transfer · Spillovers · Productivity

JEL Classification O14 · O33 · O31 · F23

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1 Introduction

There are two strands of the literature in development economics that have attracted substantial interest in the last couple of decades: the importance of technological change for long term economic growth and the role of foreign direct investment (FDI) in the process of economic development. Studies on technological change emphasize the fact that innovation (the development of new products, processes and organizations) is basically an interactive process. Recent advances in science and technology have led to, on the one hand, an increase in the knowledge content of products and processes, and, on the other hand, an appreciation of the importance of generic technologies that can be used in various products and processes. These two processes, which form two sides of the same coin, have increased the need to extend the knowledge base of industrial firms. As Rosenberg suggested 20 years ago, the process of innovation cannot fit into the boundaries of a single firm. Firms can now innovate only within an intensive web of interactions with other firms (suppliers, buyers, and, even, competitors), consumers, research institutions, etc, i.e., they can be innovative, and, thus, competitive, only if they can form and be part of innovation networks (for a small group of studies, see Lundvall 1988; Nelson and Rosenberg 1993; Smith 1995; OECD 1999, 2000).

FDI has been considered by many development economists as an important channel for the transfer of technology to developing countries. It is suggested that modern, advanced technologies introduced by multinational firms can diffuse to domestic firms through spillovers (imitation, demonstration effects, training local labor, vertical technology transfers, etc.). However, empirical studies show that the net benefits the host country can enjoy from FDI depend on host country characteristics, such as industry and the policy environment (Blomström and Kokko 1998), the level of human capital stock (Borensztein et al. 1998; Noorbakhsh et al. 2001), and the absorptive capacity of domestic firms (Kinoshita 2001).

This paper contributes to the existing literature by presenting new evidence on the interactions between domestic and foreign firms engaged in technological activities in Turkish manufacturing industries. The aim of this paper is to analyze technology acquisition decisions and to test the impact of various types of spillovers on technological activities (innovation and technology transfer activities).

First, we model and estimate the determinants of two types of technology acquisition, innovation and technology transfer, and test whether foreign ownership matters for technology decisions. We study the determinants of technology transfer because policy-makers in Turkey since the early 1980s have consistently claimed that FDI is an important channel for transfer of technology from abroad, and have introduced various measures to attract foreign capital. However, there is no comprehensive study that analyzes the contribution of foreign firms in transferring technology from abroad, and its subsequent diffusion within the manufacturing industry through spillovers. In this paper, we test whether foreign firms are more likely to transfer technology from abroad, and whether they have any impact on the technology transfer decisions of domestic firms. Since earlier studies have shown that innovative activities by domestic firms are essential to building technological capabilities and to becoming competitive in international markets (for the Turkish case, see Özçelik and Taymaz 2004), we also look at the determinants of innovative activities, and test the hypothesis that foreign firms tend to be more innovative than domestic firms.

Second, we identify the effectiveness of different types of spillovers in enhancing domestic firms' innovative and absorptive (technology transfer) capability (see also, Reger 1998; Smith 1995). We focus on three types of spillovers:

– *Horizontal spillovers* (spillovers from foreign firms to others operating in the same industry or in the same region)
– *Vertical spillovers* (spillovers from foreign firms to others operating in vertically related industries, i.e., from foreign suppliers to domestic users, and from foreign users to domestic suppliers, all located in Turkey)
– *Labor spillovers* (spillovers through labor turnover, i.e., employment by domestic firms of workers who worked for foreign firms)

Following Pavitt's warning on the importance of inter-sectoral differences in technological activities (see Pavitt and Patel 1999), we analyze the effects of spillovers for low-technology and medium- and high-technology industries separately.

Finally, we estimate productivity equations for low-technology and medium/high-technology industries to observe the impact of innovation and technology transfer activities on productivity in these two types of industries.

The paper is organized as follows: the second section provides background information on FDI in Turkey, and presents the data on productivity differentials between foreign and domestic firms in low-technology and medium/high-technology industries. The differences in innovativeness between foreign and domestic firms are analyzed as a possible factor behind productivity differentials. The data source, variables and models used to test the impact of spillovers on innovation and technology transfer activities are explained in Section 3. Estimation results are presented in Section 4. The last section summarizes basic findings and implications of our analysis.

2 Foreign direct investment and productivity differentials

Turkey introduced the first legislation governing foreign investments in the early 1950s. The Foreign Capital Law, enacted in 1954, and the related Decree of the Council of Ministers remained in force until the late 1980s. Although this early legislation provided a liberal framework designed to create a favorable environment for FDI, the cumulative FDI authorized from 1950 to 1980 reached only 229 million USD (Öniş 1994). Restrictive bureaucratic practices were blamed for the low level of FDI in Turkey in the pre-1980 period (see, for example, Erdilek 1982).

Turkey had to abandon the import substitution industrialization strategy followed in the 1960s and 1970s after the severe balance of payments crisis in the late 1970s. On January 24, 1980, the Turkish government announced a stabilization program that was implemented under the military regime after September 1980. The new program was based on an outward-oriented trade strategy and foreign trade, product, and, later, capital markets were liberalized to a large extent (for a comprehensive overview of the Turkish economy, see Kepenek and Yentürk 2000). The administrative system regulating FDI was reorganized in the early 1980s and all discriminatory treatment of foreign investors, requirements on local equity participation, and restrictions on the transfer of earnings were gradually eliminated (Erdilek 1986; Akpınar 2001).

The share of foreign firms[1] in the total number of private firms in the manufacturing industry was about 1% in 1983, but it increased continuously up to 2% in 1999, and 3.5% in 2000 through acquisitions and entry.[2] The share of foreign firms in private manufacturing employment was about 6%, with 50 thousands people employed by foreign firms in 1983. The employment share of foreign firms increased gradually, especially after 1988, and reached 11% in 2000.

Foreign firms prefer to invest in medium- and high-technology industries:[3] their share in value added increased continuously from about 25% in the mid-1980s to almost 50% in the late 1990s (see Fig. 1). On the other hand, the share of foreign firms in low-tech industries increased gradually until the mid-1990s and stabilized at around 13–15% afterwards. In other words, the increase in foreign investment in manufacturing since the mid-1980s is mainly due to the attractiveness of high-tech industries.[4]

Foreign firms are on average more productive than domestic firms, and the productivity[5] differential is much wider in low-tech industries: foreign firms in low-tech industries have been 2.5–3 times more productive than their domestic counterparts (Fig. 2). High-tech foreign firms in Turkey have been two times more productive, but the productivity differential has widened in recent years and reached 150% (2.5 times) in 2000.

We use US productivity data in order to compare the productivity of foreign firms with the "best practice" productivity. It is interesting to observe that low-tech foreign firms in Turkey are as productive as US firms, but high-tech foreign firms in Turkey lag behind their US counterparts.

Why are foreign firms more productive than domestic firms? Technological differences between foreign and domestic firms can explain a part of this productivity differential.[6] If foreign firms use superior technologies and if they are more innovative so that they maintain their technological superiority over domestic firms, persistent productivity differentials may arise.

[1] Following the usual convention, "foreign firms" are defined as those joint ventures in which foreign ownership is 10% or more. If the foreign share is less than 10%, it is considered to be portfolio investment. Joint ventures with more than 50% foreign ownership are "majority-owned foreign firms."

[2] The data refers to all private establishments employing ten or more people, and all public establishments. The statistical unit is the "establishment" which is the main decision-making unit.

[3] We use OECD's definition of low-, medium- and high-technology industries. Since the number of firms operating in high-technology industries is small, medium- and high-technology industries are grouped together, and defined as "high tech."

[4] After the elimination of local equity participation and minimum export requirements in 1986 (Öniş 1994: 96), majority-owned foreign firms realized a rapid growth in their valued added share. Therefore, all the expansion in value added share since the late 1980s was achieved by majority-owned foreign firms, whereas minority-owned foreign firms (with equity participation within the 10–50% range) kept their shares almost constant. Cieslik and Ryan (2002) also found a similar shift from minority-owned joint ventures in Central and Eastern Europe in favor of wholly-owned foreign firms.

[5] Productivity is defined as "labor productivity," i.e., value added per employee. Current exchange rate is used for currency conversion.

[6] Another important reason behind the productivity differential between domestic and foreign firms is the size differential. Foreign firms are, on average, 2.5 times larger than domestic ones. Note that the productivity differential between large (employing at least 150 people) and small (employing 10–149 people) firms in low-tech industries was about 60% in the late 1990s whereas the same rate was almost 150% in high-tech industries.

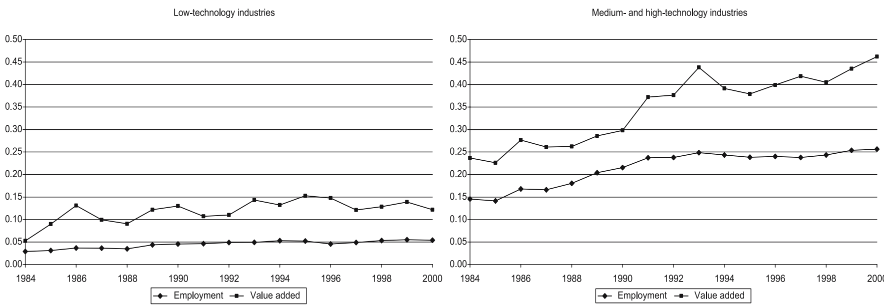

Fig. 1 Share of foreign firms in manufacturing employment and value added in Turkey, 1984–2000

Table 1 summarizes the data on the innovativeness of domestic and foreign firms in the periods 1995–1997 and 1998–2000 for low-tech and high-tech industries. It is interesting to observe that there is almost no difference in terms of product innovations between domestic and foreign firms in low-tech industries. For example, only 11.2% of domestic firms introduced any product innovation in the period 1995–1997, whereas the proportion of foreign firms that introduced product innovations in the same period is even slightly lower (9.1%). The proportion of innovative firms has increased in the second time period (1998–2000), but the difference between domestic and foreign firms is not significant. Foreign firms in low-tech industries seem to have become more successful in process innovations than their domestic counterparts in the second time period.

Firms operating in the high-tech industries are almost two times more innovative than firms operating in low-tech industries, and foreign firms in these industries are undoubtedly superior to domestic firms in innovativeness. The data provide strong evidence that support the argument that domestic firms are technologically weaker than foreign firms in high-tech industries.

The relative importance of product and process innovations differs in low-tech and high-tech industries, and the ownership of the firm matters for the type of innovation. Process innovations are more common than product innovations in low-tech industries. Moreover, foreign firms put more emphasis on process innovations than do domestic firms. Since low-tech industries tend to have "mature" product technologies, process innovations are likely to play a more important role for productivity and competitiveness, where foreign firms seem to have a com-

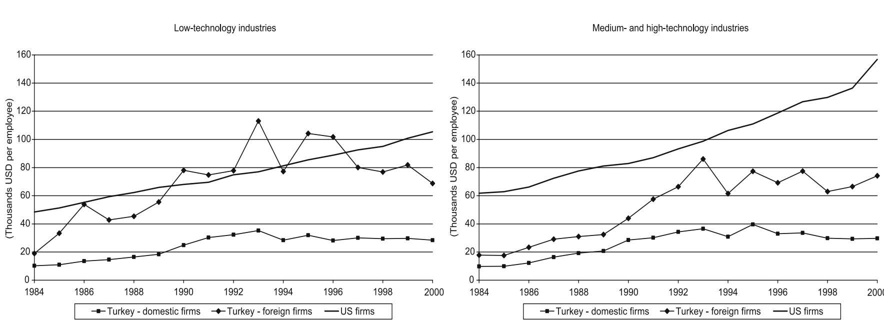

Fig. 2 Labor productivity, domestic and foreign firms in Turkey, and US firms, manufacturing industries, 1984–2000

Table 1 Innovativeness of domestic and foreign firms, 1995–1997 and 1998–2000 (proportion of innovative firms)

	1995–1997		1998–2000	
	Domestic firms	Foreign firms	Domestic firms	Foreign firms
Product innovations				
Low tech	0.112	0.091	0.143	0.162
Medium and high tech	0.278	0.526	0.325	0.601
Process innovations				
Low tech	0.159	0.163	0.193	0.387
Medium and high tech	0.280	0.453	0.279	0.483
Innovative (product and/or process innovations)				
Low tech	0.191	0.169	0.250	0.425
Medium and high tech	0.378	0.563	0.419	0.680
Product/process innovators ratio				
Low tech	0.704	0.558	0.741	0.419
Medium and high tech	0.993	1.161	1.165	1.244
n				
Low tech	1301	68	1391	83
Medium and high tech	646	79	770	94

Source: SIS, Innovation Surveys, 1995–1997 and 1998–2000

petitive advantage over domestic ones. The product/process innovator ratio is much higher in high-tech industries than in low-tech industries, and foreign firms have an even higher ratio of product-to-process innovations. This finding supports the perception that high-tech industries play a leading role in developing new products.

Since foreign firms, on average, are more innovative than domestic firms and they are more productive (possibly due to their superior technologies), there could be spillovers from foreign to domestic firms. We identify three types of (or mechanisms for) spillovers: horizontal, vertical and labor.

Horizontal spillovers flow between firms operating in the same industry or in the same region. Horizontal spillovers arise as a result of imitation (demonstration effects, reverse engineering, etc) or competitive pressure exerted by foreign firms. Horizontal spillovers can be observed in the same industry (for example, in the case of industry-specific technologies), or in the same region if geographical proximity is important.

Vertical spillovers refer to the transfer of technology through the transfer of embodied technology, information exchange (disembodied technology) or imitation between vertically related firms (suppliers/users). They can flow from suppliers to users when the supplier provides new or improved machinery, equipment or intermediate goods that enable product and/or process changes. However, competent, demanding users can also provide valuable technological information to suppliers, and can force them to improve technologically (for an early study on information flows between users and suppliers, see Lundvall 1988).

Labor spillovers take place when technology is transferred from one firm to another through the employment relationship. If a worker, employed in a technologically superior firm, moves to another one, he can transfer, at least, a part of that technology. Labor turnover could be an important mechanism for spillovers especially when the technology is tacit, so that it is difficult to be imitated and transferred through other means.

3 Technological activities and spillovers: the model

As noted in the previous section, foreign firms in Turkish manufacturing industries are more productive and innovative than their domestic counterparts. Differences in foreign and domestic firms may lead to spillovers in various forms. In this section, a model for estimating the impact of horizontal, vertical and labor spillovers on technological activities is presented. The analysis takes into account two types of technological activities: in-house innovative activities and technology transfer (from abroad).

The choice to be innovative and to transfer technology depends on a number of firm- and sector-specific factors:

$$INNO_{it} = \alpha_0 + \sum \alpha_j x_{ijt} \tag{1}$$

$$TECHNO_{it} = \beta_0 + \sum \beta_j x_{ijt} \tag{2}$$

$$i = 1, \ldots, n, \ j = 1, \ldots, m$$

where x's are m variables that determine innovativeness (INNO) and technology transfer (TECHNO); t denotes the time period (1995–1997 or 1998–2000); INNO and TECHNO are dummy variables that take the value 1 if the firm is innovative and transferred a technology through license/know how agreement, respectively.

The data on innovativeness were collected by the State Institute of Statistics through two Innovation Surveys following the methodology set by the Oslo Manual (OECD 1997), and the Community Innovation Survey of the European Union. The first survey conducted in 1998 covers the period 1995–1997 and the second one conducted in 2002 covers the period 1998–2000. "Technological innovation" is defined in the questionnaire as "technologically new products and processes or significant technological improvements in products and processes." Innovation is explicitly defined at the firm level, i.e., "innovation occurs when a firm implements a new or improved product or process, which is technologically novel for the firm, not for the market." The response rates were more than 50% in both surveys. The SIS performed a non-response analysis and estimated sample weights for each respondent.

The data on technology transfer come from the Annual Survey of Manufacturing Industries, collected by the SIS. The TECHNO variable is defined as a binary variable, and takes the value 1 if the firm transferred any technology through license or know-how agreements in the period under consideration (1995–1997 or 1998–2000).

A number of variables are defined as proxy for horizontal, vertical and labor spillovers.

Horizontal spillovers We use three variables to capture the effects of horizontal spillovers from foreign firms: the first variable, SFDI, measures the market share[7] of foreign (FDI) firms (for variable definitions and data sources, see Table 2). If there are (sectoral) horizontal spillovers from foreign firms in the form of demonstration effects, imitation, etc., other firms in the same industry may invest in innovative activities to benefit from these spillovers. In a similar way, informational spillovers may make technology transfer more likely. If competition from foreign firms forces other firms to adopt better technologies through innovative activities and/or transferring technologies, the SFDI variable will have a positive coefficient as well. Although foreign firms are, on average, more productive than domestic firms, and, therefore, are likely to generate spillovers for domestic firms, R&D intensive foreign firms are likely to be the main source of spillovers. Therefore, we use two additional variables, SREGRD and SSECTRD, to estimate the impact of spillovers from R&D activities of foreign firms. The SREGRD variable is defined as the ratio of foreign firms' R&D expenditures to total output in the province in which the firm operates, whereas the SSECTRD variable is measured similarly at the (4-digit) industry level. Thus, the SREGRD variable captures regional foreign R&D spillovers, and the SSECTRD variable sectoral foreign R&D spillovers.

Vertical spillovers There are two variables used as proxies for the extent of vertical spillovers: SSUP and SBUY measure the weighted average of foreign market share in supplier and user industries, respectively. These variables are defined as follows:

$$SSUP_i = \sum \omega_{ij} s_j$$

$$SBUY_i = \sum \omega'_{ij} s_j$$

where s_j is the market share of foreign firms in market j, ω_{ij} the j^{th} sector's share in inputs used by the ith sector, and ω'_{ij} the share of j^{th} sector in total consumption of the ith sector's output. Thus, in a sense, SSUP measures the proportion of firm's inputs produced by foreign firms, and SBUY measures the proportion of firm's output used by foreign firms. ω and ω' variables are calculated from the 1996 Input–Output Table. If vertical relations are used to transfer knowledge from foreign firms, these two variables are expected to have a positive impact on technological activities.

Labor spillovers There is an extensive literature that emphasizes the importance of tacit knowledge in technological activities (for a recent review and extensions, see Cowan et al. 2001). Technology is, at least partly, tacit and embodied in people who develop and use it. Therefore, the transfer of workers, formerly employed by for-

[7] The "market" and "industry" are defined at the ISIC (Revision 2) four-digit level.

Table 2 Descriptive statistics (average values for the period 1995–2000)

Label	Variable definition	Unit	Low-tech industries	Medium- and high-tech industries
Innovation and technology transfer				
INNOVAT	Innovativeness	Binary (0/1)	0.25	0.44
TECHNO	Technology transfer	Binary (0/1)	0.01	0.07
FDI spillover variables				
SLABOR	Labor turnover in foreign firms	Percentage	0.01	0.02
SFDI	Market share of foreign firms	Percentage	0.10	0.31
SREGRD	Regional foreign R&D intensity	Percentage (*100)	0.06	0.06
SSECTRD	Sectoral foreign R&D intensity	Percentage (*100)	0.00	0.09
SSUP	Market share of foreign firms in supplier ind	Percentage	0.07	0.12
SBUY	Market share of foreign firms in user ind	Percentage	0.03	0.07
Foreign ownership				
FDI	Foreign-owned firm	Binary (0/1)	0.03	0.06
R&D and R&D spillovers				
RDINT	R&D intensity	Percentage (*100)	0.02	0.22
DREGRD	Regional domestic R&D intensity	Percentage (*100)	0.04	0.05
DSECTRD	Sectoral domestic R&D intensity	Percentage (*100)	0.02	0.09
Other variables				
LTURN	Labor turnover ratio	Percentage	0.14	0.15
INTERNET	Internet intensity	Percentage	0.54	0.71
GROUP	Member of a business group	Binary (0/1)	0.07	0.08
SUBIN	Share of subcontracted inputs	Percentage	0.05	0.03
SUBOUT	Share of subcontracted outputs	Percentage	0.07	0.01
SKILLED	Proportion of skilled employees	Percentage	0.16	0.20
LQ	Output (log)	Million 1997 TL	10.95	10.90
LL	Employment (log)		3.90	3.75
LM	Inputs (log)	Million 1997 TL	10.50	10.28
LE	Electricity consumption (log)	Thousands kWh	12.74	12.39

Table 2 (continued)

Label	Variable definition	Unit	Low-tech industries	Medium- and high-tech industries
LK	Depreciation allowances	Million 1997 TL	7.17	7.17
LRW	Real product wage (log)	Million 1997 TL	4.86	5.35
n	Number of observations		1978	1043

Sources: Innovation and Internet intensity variables: SIS, Innovation Surveys, 1995–1997 and 1998–200
R&D variables, SIS, Annual R&D Surveys, 1995–2000. All other variables: SIS, Annual Surveys of Manufacturing Industries, 1995–2000

eign firms, could constitute an important channel for spillovers. Since there is no data about the flow of workers between firms, we use a proxy variable, SLABOR, to measure the extent of spillovers through labor flows. The SLABOR variable is defined as the ratio of the number of separations (quits and fires) from foreign firms to the total number of employees in a given industry. Therefore, the higher the value of the SLABOR variable, the higher the probability that former employees of foreign firms would be employed by other firms operating in the same industry. If there are spillovers through labor turnover, the coefficient of the SLABOR variable will be positive.

Other variables used to explain innovativeness and technology transfer are as follows:

FDI is a dummy variable that takes the value 1 for joint ventures in which the share of foreign ownership is 10% or more. This dummy variable is used to test whether foreign firms are more innovative and/or whether foreign firms are more likely to transfer technology from abroad, possibly from their parents.[8]

The main input for innovation process is investment in R&D activities. The R&D intensity (RDINT, R&D expenditures/sales ratio) is used to determine the effect of R&D activities on innovation. Since there could be a complementarity between in-house R&D and technology transfer, it is also included in the technology transfer model. Moreover, the effects of regional and sectoral knowledge spillovers from domestic firms are captured by the R&D intensity of firms operating in the same province (DREGRD) and in the same sector (DSECTRD), respectively.

The size of the firm is considered to be one of the main determinants of innovativeness. Thus, we include the (log) number of employees (LL) to test the impact of firm size on technological activities. Moreover, the proportion of skilled employees, SKILLED, is used to test the contribution of skilled employees on innovation and technology transfer activities.

The effect of subcontracting relations on technological activities is tested by using two variables, SUBIN (the share of subcontracted inputs in total inputs) and

[8] We also experimented with a dummy for majority-owned foreign firms. Since most of the foreign firms in the sample are majority-owned foreign firms, there was not any major change in our results.

SUBOUT (the share of output subcontracted by other firms in total output). These variables are used to check whether subcontract-receiving (SUBOUT) and subcontract-offering (SUBIN) firms are more innovative/more likely to transfer technology from abroad.

Finally, there are three additional firm-specific variables: GROUP is a dummy variable that takes the value 1 if the firm belongs to a business group. This variable is used to test whether membership in a business group yields any benefit for technological activities. The variable Internet is defined by the proportion of employees who have direct access to the Internet on the job. If technological activities require extensive exchange of information (and, of course, if the Internet provides the basis for information exchange), this variable is expected to have a positive coefficient in both innovation and technology transfer models. The third variable, LTURN, is the ratio of the number of separations in a year to the average number of employees (average employment *plus* the number of separations). This variable is used to measure labor flexibility that is likely to have a negative impact on innovative activities (see Kleinknecht 1998; Michie and Sheehan 2003).

In order to test the productivity effects of innovation and technology transfer activities, we estimate a simple production function, defined as follows:

$$Q_{it} = f(A_{it}, K_{it}, L_{it}, E_{it}, M_{it}, SKILLED_{it}, LRW_{it}) \tag{3}$$

$$A_{it} = A_0 e^{\delta INNOit+\gamma TECHNOit+\lambda t} \tag{4}$$

where Q is (real) output, K, L, E and M are (real) capital, labor, energy and materials inputs. SKILLED and LRW are the share of skilled employees and real product wages, respectively. These variables are used to control for labor quality. Subscripts i and t denote firm and time period, respectively. A_0 is the base-line productivity level, and δ and γ are the effects of innovation and transferred technologies, respectively, on productivity.

Since the innovation and technology transfer variables are endogenous in the output model (Eq. 3), we first estimate Eqs. (1) and (2), and then estimate the output Eq. (3) by adding the inverse-Mills ratios (obtained from the estimation of Eqs. 1 and 2) to have unbiased estimation. Since the Innovation Surveys are available for two time periods, 1995–1997 and 1998–2000, the data for these two time periods are pooled together in the regression analysis, and a dummy variable for the second period is used to capture exogenous changes in the dependent variables over time. Moreover, dummy variables for 2-digit industries are added into all models to control for unobserved sector-specific factors.

4 Determinants of innovation and technology transfer: estimation results

Table 2 presents descriptive statistics on all variables used in the regression analysis. As noted in the previous sections, the share of innovative firms is much higher in high-tech industries than in low-tech industries. Moreover, the share of technology transferring firms is also higher in high-tech industries. Firms in high-tech industries are somewhat smaller than firms in low-tech industries, but spend proportionately much more on R&D activities. (However, note that the average R&D intensity is only 0.22% for firms in high-tech industries.) Regional R&D intensity is almost the same for both groups of firms, i.e., high-tech firms do not cluster in specific regions (provinces), but, as expected, sectoral foreign and domestic R&D intensities (SSECTRD and DESCTRD) are much higher in high-tech industries. The average market share of foreign firms is higher in high-tech industries, and foreign firms have a larger market share in supplier industries than in user industries. Finally, the possibility that a firm will employ a former employee of a foreign firm is much higher in high-tech industries than in low-tech industries because of the larger share of labor turnover in high-tech foreign firms.

Regression results summarized in Table 3 show that *labor spillovers* from foreign firms contribute significantly to the innovativeness of Turkish manufacturing firms. However, as may be expected, labor spillovers do not have any impact on the probability of technology transfer from abroad. This finding indicates that tacit knowledge, embodied in people, plays an important role for innovativeness.[9] Moreover, in supporting this argument, the skilled variable (the proportion of skilled employees) is also found to be one of the main determinants of innovativeness.

As for *horizontal spillovers*, neither the foreign presence in the industry, nor R&D spillovers, make any contribution to technological activities (neither innovation nor technology transfer). There seem to be some regional spillovers from the R&D activities of foreign firms in low-tech industries, but the coefficient of the variable SREGRD is statistically significant only at the 5% level. Economic significance of regional spillovers in low-tech industries is also low because of low level of R&D intensity.

Vertical spillovers are significant only for innovativeness in high-tech industries, but with a mixed outcome. User firms operating in industries supplied mainly by foreign firms tend to be less innovative, i.e., the higher the share of foreign firms in supplier industries, the lower the innovativeness of firms in user, high-tech industries. On the other hand, high-tech firms supplying their output mainly to foreign firms tend to be more innovative. This finding may point to the importance of users in technological activities (for the importance of "learning from users," see Carlsson and Jacobsson 1991).

Since most of the spillover variables have statistically insignificant coefficients, we estimated a number of additional models to test the robustness of our results. First, we estimated our models by excluding all but one spillover variable to eliminate possible multicollinearity among spillover variables. The results for the models including only one spillover variable are qualitatively the same as those obtained by including all spillover variables together. The only difference is that the presence of foreign firms (the SFDI variable) in high-tech industries becomes significant at the 5% level in the technology transfer model. Second, it is suggested in the literature that domestic firms can benefit from spillovers only if they are equipped with necessary technological capabilities/absorptive capacity. We used two variables, the firm size (dummy) and the share of skilled employees as mea-

[9] In a recent study on Dutch manufacturing, Brusoni et al. (2005, p. 230) found no link between the availability of codified knowledge and the level of innovativeness. Thus, they suggest that "... attempts to improve the distribution power of the innovation system by supporting codification exercises, such as computer-information networks, will have a limited impact on overall rates of innovation."

Table 3 Determinants of innovativeness, technology and productivity

	Low-tech industries						Medium- and high-tech industries					
	Innovativeness		Technology transfer		Production		Innovativeness		Technology transfer		Production	
	Coeff	Std dev	Coeff	Std dev	Coeff	Std dev	Coeff	Std dev	Coeff	Std dev	Coeff	Std dev
Labor spillovers												
SLABOR	11.45	2.88**	−6.91	22.61			7.78	3.22*	5.55	6.86		
Horizontal spillovers												
SFDI	0.22	0.33	−0.89	1.57			−0.09	0.26	0.61	0.52		
SREGRD	0.73	0.35*	0.47	3.79			−0.63	0.59	0.82	1.55		
SSECTRD	20.07	29.73	−7.03	275.59			−0.15	0.50	−0.44	1.04		
Vertical spillovers												
SSUUP	−1.64	1.09	1.98	5.97			−2.33	0.72**	0.61	1.55		
SBUY	0.61	0.94	−1.57	4.03			2.19	0.87*	3.27	2.81		
Foreign ownership												
FDI	0.05	0.19	1.81	0.48**	0.11	0.03**	0.47	0.19*	1.17	0.26**	0.05	0.03
R&D and R&D spillovers												
RDINT	25.38	9.63**	6.97	34.71			25.44	5.73**	7.31	4.06		
DREGRD	−0.40	0.46	−3.44	8.88			0.53	0.52	0.41	1.14		
DSECTRD	5.35	1.44**	1.69	7.16			−0.14	0.49	−0.09	1.10		
Other explanatory variables												
LTURN	−0.66	0.30*	−0.05	2.55			−0.46	0.37	0.27	1.07		
INTERNET	0.84	0.08**	0.35	0.49			0.99	0.13**	0.56	0.41		
GROUP	0.04	0.13	0.38	0.60			−0.03	0.20	0.58	0.27*		
SUBIN	−0.64	0.41	−0.08	2.15			−0.67	0.76	1.62	1.42		
SUBOUT	0.33	0.19	−5.23	13.61			−0.56	0.71	−0.46	2.00		
SKILLED	0.69	0.23**	−0.61	1.94	0.00	0.02	1.06	0.31**	0.61	0.77	0.23	0.05**
LL	0.17	0.03**	0.30	0.18	0.13	0.01**	0.06	0.05	0.60	0.10**	0.22	0.01**

Table 3 (continued)

	Low-tech industries						Medium- and high-tech industries					
	Innovativeness		Technology transfer		Production		Innovativeness		Technology transfer		Production	
	Coeff	Std dev	Coeff	Std dev	Coeff	Std dev	Coeff	Std dev	Coeff	Std dev	Coeff	Std dev
LM					0.68	0.00**					0.67	0.01**
LE					0.06	0.00**					0.03	0.01**
LK					0.08	0.00**					0.07	0.01**
LRW					0.00	0.00**					0.00	0.00**
INNOVAT					0.25	0.03**					0.31	0.01**
TECHNO					−0.04	0.11					0.00	0.00**
λ_{inno}					−0.12	0.02**					−0.17	0.03**
λ_{techno}					0.01	0.05					−0.02	0.04
ρINNNO TECHNO	0.072	0.274					0.065	0.141				
n	1978				1978		1042				1042	
Log-likelihood	−1007				−793		−756.25	−1595			−433	
Spillovers test	48.4**						41.3**					
Adj. R^2					0.945						0.948	

All models include sector dummies for ISIC 2-digit industries, a dummy for year 2000, and a constant term
**(*) means statistically significant at the 1% (5%) level, two-tailed test

sures for domestic firms' capabilities, and used interactions of these variables with spillover variables to test whether larger firms or firms that employ proportionately more skilled people benefit more from spillovers. Among 24 coefficients estimated for the innovation models, only one turned out to be statistically significant at the 5% level.[10] In other words, interactions with size and skill levels did not change our results.

Among other explanatory variables, foreign ownership is found to matter for innovativeness in high-tech but not for low-tech industries, i.e., foreign firms in high-tech industries tend to be more innovative than domestic firms even after controlling for all other factors. However, foreign ownership is one of the main determinants of technology transfer in both sectors: foreign firms tend to transfer technology from abroad.

Firm size has a positive impact on innovative activities in low-tech industries, and on technology transfer in high-tech industries. It seems that small firms are as innovative as large firms in high-tech industries, where innovativeness is essential for competitiveness. High-tech firms belonging to business groups tend to transfer technology, but, apparently, business groups fail to improve the innovativeness of their members. As expected, R&D intensity is correlated with innovativeness. Sectoral knowledge spillovers from domestic firms are correlated with innovativeness in only low-tech industries, but regional spillovers do not have any impact on technological activities. The access to the Internet has a positive impact on innovativeness in both sectors, and labor turnover, i.e., labor flexibility, has a negative impact on innovativeness in low-tech and high-tech industries, although the latter is not statistically significant. Subcontracting relationships do not play any role in technological activities.

Estimation results for production equations reveal a difference between low-tech and high-tech industries. Although the coefficients of input variables (except labor input variables, LL and SKILLED) are almost the same for low-tech and high-tech industries, the innovativeness variable has a somewhat larger coefficient in the high-tech industries model. It seems that what matters for productivity in high-tech industries is internally generated technological capability. Technology transferred from abroad improves productivity neither in low-tech nor in high-tech industries after controlling for all other variables. It is interesting to observe that although foreign ownership makes low-tech firms more productive, it does not have any impact on productivity in high-tech industries, where foreign firms are assumed to be in a more advantageous position. Foreign firms in high-tech industries could be more productive only if they were to become more innovative.

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[10] The interaction between the SFDI and skilled variables has a statistically significant (at the 1% level) negative coefficient in the innovation model for low-tech industries, i.e., those low-tech firms that employ more skilled people benefit less form foreign presence in their sectors. In the case of technology transfer models, only four out of 24 interaction variables had coefficients statistically significant at the 5% (size-SFDI, size-SSECTRD, and size-SBUY interactions had positive coefficients, and skilled-SSECTRD interaction had negative coefficient in high-tech industries).

5 Conclusions

FDI has been considered by many development economists as an important channel for the transfer of technology to developing countries. It has been suggested that modern, advanced technologies introduced by multinational firms can also diffuse to domestic firms through spillovers. Our analysis shows that foreign firms in Turkey are more innovative than their domestic counterparts in medium- and high-tech industries, but not in low-tech industries. However, in both industries, foreign firms tend to transfer technology from abroad (mostly from their parent companies).

The type of spillovers seems to matter: in terms of horizontal spillovers, neither the foreign presence in the industry, nor foreign R&D spillovers, make any significant contribution to technological activities (neither innovation nor technology transfer) in low- and high-tech industries. There are no vertical spillovers in low-tech industries and their effect on innovativeness of medium- and high-tech firms is ambiguous. High-tech suppliers tend to have a high rate of innovation when the share of foreign users is high, but the opposite is true for users: high-tech users supplied mainly by foreign firms tend to have a lower rate of innovation. The main channel of spillovers is labor turnover. Our findings reiterate the importance of tacitness of knowledge, and confirm that technology cannot easily be transferred through passive mechanisms (demonstration effects, reverse engineering, etc.). Therefore, the policy aimed at encouraging innovativeness should pay due attention to in-house technological activities.

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