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ANALYSIS OF FOREIGN OWNERSHIP, R&D AND SPILLOVERS IN DEVELOPING COUNTRIES: EVIDENCE FROM TURKEY

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Abstract

In the past few decades globalization enabled a new playing field for emerging economies. With the falling costs of information and communication technologies, multinational companies (MNCs) from the developed world first took advantage of the low labor costs in the developing economies. However, recognizing the lower cost of skilled manpower in the same countries, MNCs started to take advantage of scientists and engineers as well. Therefore, Foreign Direct Investment (FDI) has been recognized as a major means of knowledge transfer mechanism from the developed to the developing world. It is the purpose of this paper to examine the impact of FDI on the R&D activities of Turkish manufacturing firms. Using firm-level data, this study examines the 2003-2007 period when new legislation favoring FDI inflow had been enacted and when the government started to pursue strategic science and technology policies. Our findings indicate that there is a negative impact of foreign ownership on the R&D intensity of local enterprises. As for the geographical knowledge spillover from foreign firms, we find yet another significant negative effect which may be attributable to the competition effect born by the presence of foreign firms in the market.

ملخص

في العقود القليلة الماضية ، أتاحت العولمة حقلا جديدا للاقتصادات الناشئة. فمع انخفاض تكاليف تكنولوجيا المعلومات والاتصالات ، استفادت الشركات متعددة الجنسية من العالم المتقدم من انخفاض تكاليف الايدى العاملة في الاقتصادات النامية. ومع ذلك، و مع التسليم بإنخفاض تكلفة الايدى العاملة الماهرة في البلدان نفسها، بدأت الشركات متعددة الجنسية الاستفادة أيضا من العلماء والمهندسين ولذلك، تم الاعتراف بالاستثمار الأجنبي المباشر (FDI) بوصفه وسيلة رئيسية لنقل المعرفة من البلدان المتقدمة إلى العالم النامي . و من هذا المنطاق تسعى هذه الورقة الى دراسة تأثير الاستثمار الأجنبي المباشر على أنشطة البحث والتطوير في شركات التصنيع التركية و ذلك باستخدام بيانات الشركات فى الفترة من 2003-2007 عندما سنت تشريعات جديدة تزيد من تدفق الاستثمار الأجنبي المباشر وعندما بدأت الحكومة في متابعة السياسات الإستراتيجية العلمية و التكنولوجية . و تشير النتائج التي توصلنا إليها إلى أن هناك تأثير سلبي للملكية الأجنبية على كثافة البحث وتطوير المؤسسات المحلية. أما بالنسبة لنشر المعرفة جغرافيا من قبل الشركات الأجنبية، نجد ان هناك تأثيرا سلبيا آخر قد يرجع إلى اثر المنافسة للشركات الأجنبية في السوق.

1. Introduction

R&D as a contributor to the knowledge accumulation of the firm is a process that should be carried out internally[1] but due to rapid technological change and increased global competition; firms feel the need to lower the cost of their innovation activities. Skilled labor force, the essential ingredient in innovation generation, happens to be one of the highest cost factors. However industrialized nations have a hard time providing firms with the skilled labor force at competitive cost due to reasons such as aging population and the loss of interest of new generations in scientific disciplines. On the other hand, developing nations which have abundant skilled labor at much lower cost than industrialized countries provide an opportunity for multinational companies to take advantage at a much needed time. Making use of the new ICTs, MNCs relocate some parts of their R&D activities to a limited number of developing countries. (UNCTAD 2005) The host country firms are affected directly and indirectly from the incoming foreign firms. The literature on the effect of FDI on host economy identifies various channels through which the productivity of domestic firms are affected but hardly examines the spillover effects from the R&D activities of foreign firms. Thus R&D-related FDI spillovers in developing countries are an area that needs to be studied. It is the purpose of this paper to study the R&D related FDI spillovers for the case of Turkey in a period when FDI flows have increased considerably and R&D expenditures have reached unprecedented levels in the country.

2. Stylized Facts

Globalization of economic activity has been ongoing at least since the early sixties. The spread of production activities around the globe has been mainly attributed to the activities of the multinational corporations (MNCs) in the developed nations as a result of worldwide liberalization of economic activities[2] and rapid technological change since the eighties. Increased flows of foreign direct investment (FDI) all around the world has been the evidence of accelerated globalization movement as presented in Figure 1. An interesting feature of these international flows over the period 1980-2008 is the accompanying rise in the share of developing regions receiving these flows. By the end of 2008, developing economies have received one third of the world total FDI flows. The FDI figures below are the outcome of greenfield investments, merger and acquisitions as well as of expansions implemented by existing foreign firms.

Beginning in the nineties, the globalization of manufacturing function of MNCs – accompanied by that of marketing & sales –was followed by the offshoring of their R&D activities, pointing to the spread of innovation activities of MNCs all around the world. Although data supporting globalization of R&D is scarce, available evidence points to the increasing importance of this phenomenon. For instance, Table 1 below shows that over the period 1995-2004 the share of the total R&D budget of Western European MNCs allocated to their affiliates located outside Europe increased from 25.7% to 43.7%, almost a 20 percentage point increase. For North American MNCs, a similar evolution is observed with the aforementioned share rising from 23.2% in 1995 to 35.1% in 2004. Data for Japan indicates a similar scenario although its degree of R&D globalization is much smaller than the other two regions.

Figure 2 relates to R&D flows between the European Union (EU), USA and Japan. When R&D expenditures made by the enterprise sector only is taken into consideration, it can be observed that the main flows in 2002 took place between EU and USA whereas R&D flows

[1] Narula and Zanfei (2005), OECD (2006) and Carlsson (2006).

[2] This was made possible especially through the opening up of the economies of developing nations to the world market and creation of WTO.

both to and from Japan were less important. When *both* incoming and outgoing R&D flows are taken into account, the degree of internationalization of R&D amounts to 23.4% for the EU and 15.5% for the US in the year 2002.

Finally, Table 2 below informs us about the evolution of the geographical distribution of R&D expenditures carried out by affiliates of US MNCs over the period 1995-2005. The total amount of R&D expenditures of US affiliates abroad increased by 133%, from 12.8 billion USD in 1995 to 28.3 billion USD in 2005. The proportion of these R&D expenditures carried out in the EU went down from 70.4% to 61.0% while that in the Asia-Pacific region increased from 14.8% to 18.2%, which is largely due to the increasing share directed to China rising from 0.1% in 1995 to 2.5% in 2005. On the other hand, Japan's share decreased significantly over the same period from 10.2% to 6.2%.

The analysis of data presented above confirms the increasing trend towards globalization of R&D activities[3]. This evolution leads to the following question: How can R&D activities of firms be off-shored to such an extent although they are considered to be the least internationalized enterprise activity[4]? The factors that led many researchers to believe that R&D activities of MNCs would hardly be part of the globalization process will be examined below.

The rest of the paper proceeds with a discussion of the internationalization of R&D in the second section and the evolution of the FDI and R&D expenditures in the Turkish economy in the third section. The determinants of R&D expenditures, at the firm and sector specific levels are reviewed in the fourth section, which is followed by the presentation of data and methodology in the fifth section. The sixth section presents the econometric results and finally the seventh section concludes the paper.

3. Internationalization of R&D: Determinants and Policies

Several reasons can be mentioned as to why R&D or more generally innovative activities of firms should be carried out within the firm, rather than contracted to external actors – other firms or research laboratories[5].

Firstly, a successful or efficient innovation process often requires intense interaction between different departments–R&D, design, manufacturing, marketing and sales – within the firm[6]. The need for interaction is motivated by the largely tacit nature of the knowledge created during the innovation process and by the need to circulate it within the firm. Furthermore strategic factors such as secrecy of the R&D process and its outcome may force a firm to keep its R&D activities in-house. The prospect of leakages occurring in the R&D activity may lead firms to use relatively less external actors for this activity.

Secondly, at a more aggregated level of economic activity, i.e. at the national- or sector-level innovation activities of firms occur within the framework of networks involving different types of agents. The identification of appropriate agents and the formation of useful linkages with them are costly in monetary terms as well as in time devoted to the generation and management of these networks. At the macro level, all the links established and interactions occurring between the actors involved in the innovation process constitute the national

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[3] Note that all the indicators used here are based on R&D expenditures. Another indicator of globalization of innovation activities of MNCs is foreign ownership of domestic *patents*, indicating to what extent MNCs are the owner of patents taken by their affiliates abroad: see OECD (2008).

[4] Patel and Pavit (1991).

[5] Narula and Zanfei (2005), OECD (2006) and Carlsson (2006).

[6] Kline and Rosenberg (1986).

innovation system (NIS)[7]. Firms are *embedded* in these networks, meaning that it is extremely difficult and costly for them to reproduce the same set of relationships with similar actors outside their national borders. This situation leads very often to a situation of *path dependency* with respect to the NIS of a country, i.e. its structure; links between its actors and its outcome evolves rather gradually with time. Of course, a situation of *lock in* can appear if at least some parts of the NIS has to change for a country to remain competitive at the international level but cannot due to *inertia* of different nature – institutional, political or technological.[8].

Therefore, in order to examine the issue raised earlier, i.e. the analysis of factors responsible in the globalization of R&D activities of MNCs, we must first identify the changes occurring at the economic environment, which mitigated the relative importance of aforementioned factors in R&D location decisions[9].

First of all, the new economic era is characterized by a rapid pace of technological change and increased competition on all markets (national and international) due to the liberalization and deregulations of markets all over the world. One major way for firms to confront the intensified competition on their markets is through innovating, i.e. by offering new or better products on the market or the same products at a lower price or both. The critical point here is that consumers are not willing to pay significantly higher prices for the new products that come as a result of the innovation process. Therefore, in a highly competitive environment firms are struggling to maintain the cost of the innovation through different means.

The situation described above coincides with problems related to the availability and the high cost of skilled workforce in industrialized nations, due to an aging population and a loss of interest of new generations in scientific disciplines. Therefore, since it becomes rather difficult and costly to recruit people for R&D activities in their country of origin (NIS), MNCs turn their attention to those developing or emerging economies where the labor force with appropriate skills and knowledge exist in sufficient numbers and good quality. By the help of the new ICTs, this process has resulted in the delocalization of some parts of R&D activities of MNCs towards a limited number of developing countries, with China and India being at the top of the list[10]. Table 3 summarizes the mains factors influencing the internationalization of R&D activity of MNCs.

In fact, empirical findings and theoretical research indicate that offshoring of R&D activities by MNCs obey to two different forces. If we define MNCs as owners of intangible proprietary assets, the act of carrying out R&D activities abroad can enable them either to use those assets to obtain a competitive advantage or to benefit from the research infrastructure and skilled labor of those host countries at competitive prices. This is particularly important if their NIS is unable to provide them at home[11].

The first type of R&D activity (abroad), part of what is called *asset-exploiting FDI,* is observed in emerging or developing economies and is usually aimed at adapting products or production processes -conceived, designed in and manufactured for the markets of developed nations- to the new environments in emerging economies. They thus tend to be of an incremental kind and are carried out with the requirements of the domestic market in mind

[7] Lundvall (1992) and Edquist (2005).

[8] Narula (2003).

[9] Criscuola (2005).

[10] See UNCTAD (2005) for a discussion of the determinants of attractiveness of R&D activities for MNCs and a list of countries ranked by the CEOs of largest MNCs in the world.

[11] On the determinants of different types of FDI, see European Commission (2007), OECD (2006) and UNCTAD (2005).

(preferences and tastes of consumers, lower per capita income levels, peculiarities of the climate and physical infrastructure). Recently, R&D activities of MNCs have been changing in nature. Rather than being merely adaptive and domestic market oriented, more innovative R&D practices are taking place with a target of a region or the world market. However their link with the production activities still remains. Furthermore a final stage in the R&D activities of MNCs in emerging countries emerges. MNCs that have not had any previous manufacturing presence in a developing country do not hesitate to invest in those countries with the sole purpose of R&D and with the world market as the main target[12].

The second type of R&D activity –linked to the asset-augmenting FDI– is observed in developed nations and is usually carried out by foreign firms in order to access the scientific and research capability of the host country. A well known example of this type of R&D activity is the R&D investment made by the European pharmaceutical firms in the USA during the last ten years in order to take advantage of the strengths of USA in this field and to make up for the gap observed in Europe in this field. The outcome of such investments in R&D is in general products or services offered to the world market. In fact, R&D activities abroad aimed at mitigating the deficiencies of the NIS of MNCs' home countries constitute the first wave of globalization of R&D and has been going on for quite a while since the sixties.

Following the classification of the different types of R&D activity conducted by MNCs abroad, recent research on the internationalization of R&D point to three different kinds of R&D units implemented by MNCs' affiliates: Local development center, global development center and global research laboratory. The local development center pursues adaptive, incremental R&D mainly aiming for domestic and possibly the regional market, global development center carries out innovative research targeting the world market and global research laboratory performs world class research and generates genuine innovative products for the world market. Table 4a presents the supply- and demand-side factors impacting the innovation activities of these entities.

What are the effects exerted by R&D activities of foreign firms on the host economy? Through which channels do these effects – positive or negative – materialize? To which extent and through which policies and related instruments can governments maximize the amount of positive effects?

Although FDI flows[13] can influence positively the level of investment in machinery and equipment, foreign exchange earnings and employment in the host country – a developing or emerging economy in our case –the most important and durable effect of FDI on the host economy in the long term is its positive impact on the pace of productivity growth. Different channels such as technological and organizational innovations, imitation, reverse engineering, informal and formal transfers of knowledge, must be examined to elucidate how FDI affects the host economy positively.

In general, two effects of the activity of foreign firms on the performance of the host economy are identified[14].

The first one is the *direct* effect exerted solely by the presence of foreign firms on the host economy. Due to the proprietary intangible assets they possess, we expect foreign firms to perform better than domestic firms – a fact confirmed by the empirical studies. Therefore, the

[12] Recent R&D activities of MNC affiliates in the ICT sector in China – resulting from greenfield investment with no prior production experience –are of this kind. See UNCTAD (2005).

[13] By 'foreign firm', we refer here mainly to foreign affiliates of MNCs.

[14] Blomstrom and Kokko (1998), Gorg and Greenaway (2003), Saggi (2005) and Smeets (2008).

mere establishment of foreign firms in a developing country will exert a positive effect on its productivity level. However, what counts when the positive effects of FDI on the host economy is analyzed, is the multiplier effect they can exert through their positive effects on the performance of domestic firms. These *indirect* effects are called *FDI-related knowledge* or *technology spillovers*, and their existence and magnitude condition to a large extent the benefits host countries can obtain from FDI.

There are three main channels through which FDI can affect the productivity of domestic firms[15]. The first one is called the *demonstration effect* and occurs when foreign firms with advanced technologies enter a local market and introduce newer technologies to the industry. Through direct contact with foreign affiliates of multinationals, local firms can watch and imitate the way foreigners operate and can become more productive – by reverse engineering, for instance. The second channel of FDI spillovers is though *labor mobility*: skills or human capital acquired by employees in foreign firms can be transmitted to new or existing local firms through mobility of the workforce; *Third*, the entry of foreign firms may lead to more intense competition in the local industry and domestic firms are forced to use more efficiently existing technologies and resources by reducing their inefficiencies. Domestic firms may also be forced to acquire and introduce new technologies in order to maintain their market shares. Increased competition may be able to eliminate monopolistic profits and enhance the welfare of a country. However, there is also a possibility that the competition effect is harmful to domestic firms.

Note that the FDI spillovers examined above are called horizontal or intra-industry spillovers in contrast to vertical or inter-industry spillovers, which occur between firms located in different industries. Vertical spillovers are as important as horizontal spillovers.[16]

The literature on FDI spillovers examined above includes hardly any reference to R&D activities of foreign firms and thus does not analyze spillovers that might arise from their R&D activities. Such an approach is not erroneous in itself since many developing nations stand far behind the technology frontier in many sectors. However, a number of factors lead to the fact that R&D departments of foreign firms may now become the new source of FDI-related spillovers. Following the widespread codification of knowledge through the use of ICT, the relative share of formal innovation activities has been increasing in the two last decades with respect to informal ones. This development underlined the importance of the R&D departments of firms. Secondly, the role of innovation activities of firms in their competitive strategies is much more prevalent today than two decades earlier.

The available evidence as well as the conceptual framework used for the analysis of R&D-related FDI spillovers is less developed than the one on the classical FDI spillovers examined previously. However, the distinction between direct and indirect effects remains: indeed, it is necessary to distinguish between the direct contribution made by the R&D activities of foreign firms to nation-level performance from the indirect contribution it exerts through its impact on *domestic* firms performance, especially by means of a positive effect on R&D expenditures of *domestic* firms.

Attracting FDI-based R&D and materializing its benefits through R&D spillovers from foreign to domestic firms is a sophisticated process involving many actors with different motives and making use of a number of policies not all related to FDI promotion, a challenge which Figure 3 below presents.

[15] Pamukçu et al. (2006).

[16] Javorcik (2004).

This figure illustrates the importance of the following factors for enhancing benefits from FDI in R&D: (i) existence of a strong scientific and technological infrastructure (ii) promotion of linkages and formation of networks between domestic and foreign firms (iii) constitution of clusters around foreign firms in domains where domestic firms enjoy comparative advantage and (iv) strengthening the institutional framework for innovation through designing and implementing appropriate policies in the field of competition, human resources and IPR regulation. Notwithstanding the validity of these generic policies for the developed world, the FDI related R&D policies of the developing countries would certainly be different [17].

4. Evolution of FDI and R&D Expenditures in the Turkish Economy

The history of FDI in Turkey dates back to 1954, when the first law of foreign capital was enacted. Although this law was initiated with the intention of providing a more attractive environment to the foreign investors than before, due to its restrictive measures such as permit and minimum capital requirements, it could only partially serve its purpose. Thus from 1950 to 1980 the cumulative authorized FDI has only reached to 229 million USD[18]. Other reasons that contributed to the relatively poor FDI performance had been red tape[19] and import substitution industrialization strategy. After experiencing a severe balance of payments crisis in 1979, the government initiated a stabilization program, which paved the way to a liberal, open economy that welcomed international trade. The legislative background was also reorganized to eliminate favoritism among foreign investors, requirements for local investors and restrictions on transfer of capital and profits[20].

In addition to changes in the regulatory framework privatization, liberalization of the financial system, elimination of restrictions on foreign exchange, foundation of a capital market and heavy investment in telecommunications technology contributed to the development of a favorable environment for FDI throughout the 1980s. As a result, by 1990 the annual FDI flow reached $ 684 million. However, FDI flows remained rather stable in the 1990s. Two major economic crises in the years 1994 and 1999 and heavy reliance on short term capital flow have been attributed as main reasons for this relatively poor FDI performance compared to the previous decade. When we look at the 2000's, we see a much more favorable environment for foreign investors with a strongly regulated financial system, a reduced inflation rate and the establishment of a Coordination Council for Improving the Investment Climate. Following the enactment of the new foreign capital law, Law 4875, in June 2003, minimum capital requirements and permits were eliminated, ownership of property without any restrictions, the right to international arbitration and employment of expatriates were granted.

Figure 4 presents the evolution of the FDI to GDP (Gross Domestic Product) ratio over the period 1998-2008. Except for 2001, this ratio was less than 1% until 2005 and increased onwards to attain 5% in 2006. Comparative data on FDI flows towards other emerging economies, presented in Appendix 1, point to the satisfactory performance of Turkish economy in this field.

This increasing trend in FDI flows was accompanied by significant changes in the sectoral distribution of these flows: indeed, a gradual reorientation from manufacturing to services sector is observed over the period 2002-2009 (Appendix 2).

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17 Narula and Guimon (2010).

18 Öniş (1994).

19 Erdilek (1982).

20 Erdilek (1986) and Akpınar (2001).

On the other hand, a similar evolution is observed for the R&D /GDP ratio in Turkey, with the value of this ratio rising from 0.38% in 1998 to 0.72% in 1998 (Figure 5). The proportion of this increase in R&D expenditures performed in and funded by the enterprise sector increases as well during this period: the proportion of R&D expenditures performed by the higher education sector decreased from 61.1% to 44.2% from 1998 to 2008 whereas the corresponding share of the business sector increased from 31.6% to 43.8% over the same period. A similar evolution is observed for the funding of R&D expenditures in Turkey. Data presented in Table 4b for OECD countries point to an "R&D gap" problem Turkey has to deal with in order to catch up with developed nations. Data about the degree of internationalization of R&D activities in Turkey for 2003 and 2007 are presented in Figure 6 along with data for other OECD countries.

The proportion of R&D expenditures performed by foreign firms in the Turkish manufacturing sector increased from 16 % in 2003 to 36% in 2007, a twenty percentage point increase over five years. Along with Poland, Turkey is one of the two countries where the role played by foreign firms in R&D increased most over the examined period. It seems to us that this evolution by itself requires the analysis of the impact such R&D activities on the Turkish national innovation system.

In Table 5 the first column for each year relates to the share of foreign firms in each sector's total R&D expenditures[21]. The second column in Table 5 provides the share of each sector in *total* R&D expenditures of the Turkish economy. Two sectors, motor vehicles (NACE 34) and radio, TV and communication equipment (NACE 32) are responsible for more than 50% of all R&D expenditures in the country and foreign firms perform a significant part of these expenditures over the period 2003-2007.

Finally, data presented in Appendix 3 confirm that there is a significant association between the share of foreign firms in R&D expenditures in different manufacturing industries and their share in total sales of these same industries. This may point to the adaptive nature of the R&D expenditures undertaken by foreign firms in Turkey.

5. Determinants of R&D Expenditures of Firms

5.1 Firm-Specific Determinants of R&D

Among numerous firm-specific factors, size, by far, is the most used explanatory factor of R&D in the empirical literature. Following Schumpeter's (1950) claim that firm size is an important determinant of R&D, most researchers have included sales as an indicator of size[22]. Availability of internal resources as a means of internal financing, the ease of access to capital markets as a means of external financing are listed as two advantages large firms hold over small ones.[23] Economies of scale and economies of scope are the other two advantages enjoyed by large firms.[24] Notwithstanding these theoretical expectations of a positive relationship between R&D expenditures and firm size, empirical evidence yields contradictory results. Some studies find a U-shaped relationship between size and R&D intensity suggesting that very small firms and very large firms have high R&D expenditures, but the ones in between have lower R&D expenditures.[25] Others find small firms perform

21sectors in Table 5 are those nine sectors where this share is most important.

22 Gustavsson and Poldahl (2003), Pamukçu (2003) Kumar and Aggarwal (2005), Ogawa, 2007; Parameswaran (2008) and Ortega-Argiles (2009).

23 Hertog and Thurik (1993).

24 Piga and Vivarelli (2003) and Czarnitzki and Toole (2007).

25 Kumar and Aggarwal (2005) and Mishra (2007).

large amounts of R&D[26] whereas others claim firm size has no significant power in explaining R&D expenditure.[27]

Profit margin turns out to be the second most frequently used determinant of R&D expenditures. Assuming firms with high profits have more internal resources to finance R&D, some studies expect a positive relationship with the profit margin and R&D expenditures[28], emphasizing therefore capital market imperfections. While some find a significant and positive effect of profits on R&D, other studies find the effects of profit to be either insignificant[29] or significantly and negatively related with R&D intensity[30]. As a result, we cannot claim that a certain relation is documented in the literature between R&D and profits, which remains an empirical issue.

As a measure of human capital, skilled labor is assumed to be a major contributor to R&D. In the absence of educational data on skilled labor, most researchers prefer using wages or salaries as a proxy for the skill level of the workforce, which should hence contribute positively to the R&D activities of the firm. While some studies find a significant and positive relation between wages and R&D, others indicate wages may not necessarily have a positive impact on R&D expenditures[31].

The fact that a firm participates in international trade through exports is used as an indicator of the fiercer competition it faces compared to its domestically trading counterparts. An exporting firm thus is expected to have higher R&D expenditures, everything else equal[32]. In addition to being an indicator of the intensity of competition, exports are also believed to be a means of international knowledge spillover. As such, exporting firms are expected to benefit from that knowledge and use it in their R&D activities, thus increasing their R&D expenditures. Exports also enable firms to produce on a large scale and enjoy increasing returns to scale. If R&D is performed with the purpose of product differentiation or the development of a new product for a small domestic market, then exports enable the firm to realize economies of scale in the production of this new good. Therefore, exports may lead firms to make the required R&D investments to this end.

Regarding the relation between the degree of foreign ownership of a firm and its R&D expenditures, the evidence is mixed. Some studies underline the significant depressing effect of foreign ownership on R&D[33]. These studies claim that a foreign-owned firm relies on knowledge generated by the parent firm, thus does not carry out much R&D in the host country. However, others claim that foreign ownership may induce the firm to undertake R&D if the knowledge from the parent needs to be adapted to local conditions or if specific projects require collaboration with the foreign owner[34]. In addition to possible positive or negative effects of foreign ownership on R&D, yet a third category is the neutral impact[35]. Therefore, as far as the impact of foreign ownership on R&D is concerned, we can assert that

26 Ogawa (2007)

27 Hertog and Thurik (1993).

28 Kumar (1987), Hertog and Thurik (1993), Tan and Hwang (2002) and Parameswaran (2008).

29 Kumar (1987) ,Hertog and Thurik (1993), Un and Cazurra (2008) and Parameswaran (2008).

30 Kumar and Aggarwal (2005).

31 Hertog and Thurik (1993), Mishra (2007), Un and Cazurra (2008) and Tan and Hwang (2002).

32 Cohen and Levinthal (1989), Gustavsson and Poldahl (2003), Kumar and Aggarwal (2005), Mishra (2007), Parameswaran (2008) and Un and Cazurra (2008).

33 Veugelers and Vanden Houte (1990), Kumar (1987), Tang Un and Cazurra (2007), Ortega-Argiles (2009) and Fang and Mohnen (2009).

34 UNCTAD (2003), Lin and Yeh (2005), Parameswaran (2008) and Becker and Pain (2008).

35 Kumar and Aggarwal (2005) and Dachs and Ebersberger (2009).

most of the literature finds a significant negative effect, although this is not an undisputed fact due to the presence of conflicting findings.

Kumar (1987) argues that technology licensing is an essential means of advancement for developing countries because, as opposed to developed countries, developing ones have fewer resources to invest in R&D and therefore they prefer to learn from those countries that already have such technology. While he finds a significant positive relation between technology licensing and R&D in India, Parameswaran (2008) indicates the positive relation is present only for supplier-dominated industries, where firms need to work on the adaptation of the licensed technology towards local circumstances. However the finding of Lee (1996) that technology imports produce a substitution effect rather than a complementary effect yields a questionable relation between technology licensing and R&D.

Following Aghion and Howitt (1998) within the context of endogenous growth theory showing that capital is an important determinant of R&D, capital intensity is used to capture its effect on R&D. Particularly in developing countries capital intensity is seen as a form of embodied technology transfer from the developed world.[36] Studying capital intensity as an explanatory variable of R&D expenditures Gustavsson and Poldahl (2003) find evidence of a positive impact, yet there are others who find no significant relation[37].

5.2 Sector-Specific Determinants and Spillover Effects of R&D

Competition is identified as a significant factor among the determinants of the R&D expenditures of a firm. However, its effect on R&D is not easily specifiable. When foreign firms enter a domestic market, they may change the market structure and competition in two ways. If the market is an already concentrated one, the new firm's entry may dilute this concentration and thus increase competition. Thereafter, two effects may be in action. Due to lower returns to innovation following a fall in the market share, R&D expenditures may be curbed, or due to an increased need for survival, R&D expenditures may increase[38]. On the other hand, if the foreign firm entering the market has firm-specific assets and more advanced technology than those of its local competitors, the domestic rivals may be driven out of the market. As a result, concentration may increase, but due to higher market shares, competition may decrease, as there are higher monopoly rents to enjoy. The effect of such lower competition on R&D is again not easily determined[39]. While some find that competition boosts R&D[40], others claim that competition and market structure are not significant determinants of R&D[41]. Still, others report competition reduces R&D. Such mixed results render competition a puzzling variable as far as explaining R&D is concerned.

Enterprises' intention to carry out R&D is closely related to the channels they receive knowledge from. Knowledge spillover channels are divided into two main groups: local knowledge spillovers and international knowledge spillovers. As far as local knowledge channels are concerned, belonging to a group and being geographically close to R&D performers are found to be factors that allow the diffusion of knowledge[42]. On the other hand, more than one mechanism may be at work when we examine international knowledge

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36 Kannebley and Sekkel (2010).

37 Czarnitzki and Toole (2007) and Hertog and Thurik (1993).

38 Gorodnichenko et. Al (2008).

39 Lundin et al. (2007).

40 Mishra (2007).

41 Lee and Hwang (2003), Lundin et al. (2007), Czarnitzki and Toole (2007) and Gustavsson and Poldahl (2003).

42 Gustavsson and Poldahl (2003), Todo (2006), Barbosa and Faria (2008), Aiello and Cardamone (2008) and Aldieri and Cincera (2009).

spillover mechanisms. There are three types of spillover effects that impact on the behavior of local firms and which are due to the presence of MNCs in the host country. First is the demonstration effect: when a foreign firm comes into a market and succeeds as an enterprise, the local ones witness this success, decide to follow it and thus avoid the risk of trying out something new. Secondly, there is the labor turnover effect. People in foreign firms learn from them and after a while either decides to set up their own firms or move to local companies, carrying their knowledge wherever they go. Thus, local firms benefit from the knowledge spilled over from the foreign entity. Next, there are horizontal and the vertical spillover effects. The horizontal spillovers happen when local firms, threatened by the entry of a foreign enterprise, take the challenge and try to improve their conduct of business in various ways. On the other hand, vertical spillovers occur when the suppliers of a foreign firm strive to meet the foreign client's standard and thus improve themselves technologically. The empirical evidence suggests a robust positive vertical spillover effect[43].

Growth opportunities of the industry present a positive environment for firms' R&D efforts to increase. In industries that are at an initial stage of growth, there may be no accepted standard product design, which leads firms to search for that design. On the other hand, in industries in declining stages, firms may be induced to collaborate so that their researchers may accomplish larger research projects[44]. Empirical studies find that certain industries such as engineering or chemicals are found to have higher R&D intensities than others with less technological advancement propensity[45]. Furthermore, industries with high entry and exit rates are assumed to present more technological opportunities than those with smaller rates. Using firm turnover rate as a proxy for technological opportunity, Gustavsson and Poldahl (2003) find that technological opportunity stimulates R&D expenditures while Griffiths and Webster (2004) claim that ceteris paribus, firms in "*fast moving technological areas tend to undertake more R&D*".

6. Data, Methodology and Econometric Findings

This study uses two separate data sets collected by the Turkish Institute of Statistics (Turkstat): Structural Business Statistics Survey (SBS) and R&D Survey. SBS covers both private and public enterprises and comprises about 80,000 enterprises each year. R&D Survey, prepared in compliance with the Frascati Manual, covers only those enterprises that do carry out R&D. The total number of firms covered in the R&D survey for each year for 2003-2007 is 2495. On an annual basis the proportion of firms in the R&D survey does not surpass 10% of the number of firms in the SBS survey. After these two databases are merged and only the manufacturing sector firms with 20 or more employees are selected, our total number of observations for the five-year period comes down to 10,070. However due to data limitations in some of our independent variables, the final sample size in different models ranges between 6119 and 8639 in 2007.

The independent variables are taken from the SBS for the years 2005, 2006 and 2007. The dependent variable, R&D intensity, defined as firm-level R&D expenditures divided by sales, is generated by the data from the R&D survey of 2007. Regressions are performed on a cross sectional basis. The absence of a time lag between the dependent and independent variables may lead to a possible endogeneity problem. That is, the factors that are deemed to influence R&D activities may themselves be affected by R&D activities. Using lagged data is one way to get around this problem. The expectation is that activities undertaken in the years 2005-2007 would affect R&D expenditures in 2007. Furthermore, Ravenscraft and Scherer (1982)

43 Saggi (2005).

44 Hertog and Thurik (1993).

45 Kumar and Aggarwal (2005).

claim that the R&D gestation lag, the time elapsing between the initiation of the project and its completion, is about two years. Therefore the lag used here is in line with the proposed structure in the literature.

Most of the observations of our dependent variable have zero value, which indicates that we are facing a censored data problem, an issue that is addressed in the literature by using the Tobit model.[46]

Tobit model is used when *y*, the dependent variable, is observed for positive values but not observed for negative values or zero. The standard Tobit model is defined as in the following:

$$y_i^* = x_i\beta + e_i$$

$$y_i = y_i^* \qquad \text{if } y_i^* > 0$$

$$y_i = 0 \qquad \text{if } y_i^* \leq 0$$

where y_i^* is the unobserved latent dependent variable, y_i is the observed dependent variable, x_i is the vector of regressors, β is the vector of coefficients, and the e_i s are assumed to be independently normally distributed: $e_i \sim N(0,\sigma)$

The zeros in the dependent variable could either indicate \`true\` value of zero, or censored data. In the context of R&D expenditures, it is most likely that the zeros are censored values because we never know whether the firms that report zero for R&D do not conduct R&D or choose not to report their R&D expenditures. In the presence of such a censored dependent variable, OLS is not a good choice of an estimator because it produces biased results.[47].

Instead the estimation of the Tobit by maximum likelihood solves the problem. Assuming *f(.)* and *F(.)* represents the density and cumulative density functions respectively for the latent variable, the probabilities of observing a positive *y* and a zero *y* are *f(y)* and $F(0) = p(y^*<0)$.

$$\ln L = \sum_{y_i>0} \ln f(y_i) + \sum_{y_i=0} \ln F(0)$$

Since the e_i s are normally distributed, y_i^* s are also normally distributed. Thus in terms of the normal distribution's density function $\phi(.)$ and the cumulative density function $\Phi(.)$, the log likelihood function can be written as follows:

$$\ln L = \sum_{y_i>0}\left(-\ln\sigma + \ln\phi\left(\frac{y_i - x_i\beta}{\sigma}\right)\right) + \sum_{y_i=0}\ln\left(1-\Phi\left(\frac{x_i\beta}{\sigma}\right)\right)$$

Using the above likelihood function, the maximum likelihood estimation yields consistent coefficient estimates.

We use a dummy variable to study the effect of *foreign ownership* on R&D intensity for those firms whose captial is 10% or more foreign owned. The aim here is to test whether being a foreign firm increases or reduces R&D expenditures with respect to being a locally owned firm – which is the omitted category in our model.

The spillover effects generated by the presence of foreign firms at the sector level are taken account of via three different spillover variables:

The *FDI-related R&D spillover indicator at the province level* is defined as a ratio of two differences: First we subtract the firm's R&D expenditure from the sum of the foreign R&D

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46 Benavente (2006), Czarnitzki and Toole (2007), Mishra (2007), Un and Cazurra (2008), Parameswaran (2008), Narayanan and Bhat (2009), Deng (2009) and Fang and Mohnen (2009).

47 Cameron and Trivedi (2005).

expenditures in the province. This difference yields the numerator of the variable. Next we take the sum of the R&D expenditures of all firms in the province and subtract from that the firm's R&D expenditure – this gives us the denominator. When we divide the numerator with the denominator, we get the FDI-related R&D spillover at the province-level. This variable indicates the knowledge spillover from foreign firms to local ones located in the same province.

Another FDI-related R&D spillover variable is used to capture industrial knowledge, namely the *FDI-related R&D spillover at the sector level*. This is also defined as the ratio of two differences. First we take the sum of each sector's foreign R&D expenditures and subtract the firm's R&D expenditure from that. Next, we take the sum of each sector's R&D expenditures and subtract the firm's R&D expenditure. The ratio of the first difference to the second difference yields the FDI-related R&D spillover variable at the sector level. This variable reflects the knowledge spillover from foreign firms to local ones in the same industry regardless of their geographical proximity.

The last spillover variable, *FDI spillover*, is defined as the ratio of foreign employment to total employment in a sector. This variable is used to evaluate the impact of foreign presence due to demonstration effects, labor mobility and competition. It is *a priori* unrelated to R&D activities of foreign firms.

As an indicator of *size*, the natural logarithm of employees is used. The hypothesis follows that of Schumpeter (1950), which states the larger a firm is, the higher is its expected R&D expenditures.

To gauge the contribution of the *skill level* of the workforce to R&D activity, the natural logarithm of the average wage is utilized. The effect of disembodied knowledge use from abroad is accounted for with a dummy variable for all those firms with licensing expenditures.

The Herfindahl index is used to describe the surrounding *market structure*. In an oligopolistic setting, a concentrated market may induce a firm towards more R&D as it tries to differentiate its products in a non-price competition framework. However, if collusion takes place and limits competition, a reverse effect could be observed where concentration may lead to less R&D. In the latter case, however, a more concentrated market may indicate larger volumes of output for the dominant firms and the disappearance of the smaller ones or a reduction in their market shares[48]. Assuming constant sales at the sector level, higher market shares would allow these firms to achieve higher efficiency in their activities through an increase of their R&D expenditures. If R&D expenditures increase to a lesser extent than sales, this will result in a lower R&D intensity. Therefore a negative coefficient of the Herfindahl index may indicate an improvement in the efficiency of dominant firms due to an increase in market concentration rather than market collusion, or both – in which case it is the *net* effect, which is important[49]. Thus, the effects of market structure on R&D are not easily predictable. The Herfindahl index is calculated at the industry level as the sum of squared market share of each firm.

Two more variables are used to study the effects of international competition: *firm-specific exports and imports at the sector level*. As exports allow a firm to compete in new markets,

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48 Indeed, assuming a constant volume of output at the sector level, an increase in the Herfindahl index of concentration amounts to a shift of output toward large firms.

49 We would like to thank Dr. Azzeddine Azzam for bringing this issue to our attention. For modeling the trade-off between market power and efficiency following an increase in concentration, see Azzam (1997). Note that the fall in the R&D intensity might occur without an increase in R&D but rather through scale economies enjoyed by large firms.

exporting firms enjoy benefits of economies of scale and face fiercer competition, which poses a challenge to their success. Thus as a means of survival they may choose to undertake more R&D. Therefore, with a dummy variable for exporting firms the effect of exports on R&D are tracked. The same argument holds for imports as a source of competition but now on the domestic market. Assuming imports exert competitive pressure on domestic firms, an open market induces firms to engage in R&D with the aim to improve their products and compete with those foreign goods. Import penetration, a sector-level variable defined as the ratio of imported goods to total supply (imports *plus* sales), is utilized to examine the impact of sector-level import competition on R&D.

Capital intensity is calculated as the ratio of capital stock per employee. As a proxy for capital stock we use the end-year value of the capital allowances (depreciation). In light of the empirical evidence we expect a positive relationship between capital intensity and R&D.

Following the literature started by Cohen and Levinthal (1989) who claim that those firms that are closer to the most productive firms are more likely to benefit from knowledge spillovers and are more likely to undertake R&D themselves, we introduce a variable to stand for *technology gap*. The distance of each firm's value added to the productivity leader in the industry is used as our measure of technology gap. We expect this variable to have a negative sign because the smaller is the distance to the most productive firm; the more should be the R&D capability of our firm in question.

Finally, *industry dummies* are used in order to capture technological opportunity at the sector level. We utilize the NACE[50] two-digit codes to define the sectors. As the number of firms in some industries is too small for carrying out an econometric analysis at the two digit NACE level, to study technological opportunities in a different way, we classify the firms into three classes of technology: high technology, medium technology and low technology firms. Then, we merge the first two categories into one and introduce a dummy variable for it and use the second category (low technology) for reference purposes. The expectation is that in high technology industries there may be more emphasis on R&D than in other industries, given the existence of more ample technological opportunities to be tapped through R&D activity.

Before we move on to present the econometric findings, we need to mention that our goal in this paper is not to test any specific model but rather explore R&D activities of firms and their determinants with particular interest on the impact of MNCs in this field.

In Table 6, we present the results of the Tobit estimation for the entire sample including domestic and foreign firms in 2007. In this table, dependent variable -R&D intensity- and explanatory variables are measured by their 2007 values. Dummy variables at the two-digit NACE (revision 1.1) sector level are added to R&D equation in order to take into account technological opportunities, which certainly differ between sectors. Six different Tobit models are estimated. The first model -column 1 in Table 6- examines solely the impact of firm-specific variables on R&D expenditures.

Firm size exerts a positive impact on R&D intensity as well as the skill level of the workforce. Being an exporter has a positive influence on the dependent variable while being a foreign firm – with at least 10% of the capital belonging to foreigners – exerts a negative effect on R&D intensity, everything else equal. Therefore, being a foreign firm leads to less R&D expenditures with respect to domestic firms, a finding also obtained in other econometric studies[51]. The statistically significant coefficient of the technology gap variable points to the fact that firms close to the productivity level of the industry leader do carry out

50 NACE stands for « Nomenclature Générale des Activités Economiques dans les Communautés Européennes ».

[51] For similar findings for other countries, see UNCTAD (2005) and Un and Caturra (2007).

more R&D per unit of sales. However, firms that transfer technology from abroad do not increase their R&D intensity with respect to firms that do not. This indicates the absence of any type of relationship between R&D and technology transfer. Finally, capital intensity does not seem to influence R&D intensity in any statistically significant way.

In the remaining five Tobit models, we introduced, besides firm-level variables, sector-specific determinants of R&D intensity. Of the three sector-level variables introduced in model 2 only the coefficient of the Herfindahl index of sales concentration is statistically different from zero, at the 5% significance level. All else equal, a more concentrated market tends to go in tandem with a low R&D intensity of firms. This might indicate the negative impact of collusion on R&D expenditures or the efficiency effect of increased concentration overriding that of collusion. The import penetration rate, however, introduced to examine the impact of import competition on R&D activity of firms does not seem to have any statistically significant effect on R&D.

The three remaining sector-specific variables measure FDI spillovers. These indicators of FDI spillovers were defined in the previous section. We first introduced (model 2) only the FDI spillovers indicators constructed at a very detailed sector level (four-digit NACE level), which may occur even in the absence of R&D activities of foreign firms[52]. This variable has a positive coefficient which is not, however, statistically different from zero. In model 3, we introduce only the FDI-related R&D spillover indicator constructed at the four-digit NACE level. The coefficient associated with this variable is negative but not statistically different from zero[53]. Finally, we introduce in model 4 only the province-level indicator of FDI-related R&D spillover: its coefficient is negative and statistically different from zero at 1% significance level. In other words, the more R&D expenditures are conducted by foreign firms in the vicinity of a firm, the less its R&D intensity will be important. This negative effect seems to be robust to the simultaneous inclusion of the two other FDI spillover indicators (model 5) or to the inclusion of only the other FDI-related R&D spillover at the sector level. How should such a robust negative effect of the spatial indicator of FDI-related R&D spillovers be interpreted? One possible explanation could be the presence of a substitution effect. Firms that are close to foreign firms conducting R&D may be relying on foreign R&D instead of conducting their own. Another possibility is a kind of competition effect where R&D activities of foreign firms might simply crowd out other firms' R&D efforts in the market through, for instance, labor poaching. Whatever the valid explanation, the impact of foreign R&D spillovers on R&D intensity is negative.

In Appendix 4 and 5, firm- and sector-specific explanatory variables are measured at their 2006 and 2005 values, respectively. These lagged values are introduced to mitigate a possible endogeneity problem and also to take into account the fact that the explanatory variables may affect R&D expenditures with a lag. Previous findings on the foreign R&D spillovers do not change but all firm-specific control variables with an insignificant effect in Table 6 – except the import penetration rate– are now significant, especially if the values of the year 2005 are used in regressions. Technology transfer has a positive effect on R&D intensity (complementarity effect) as well capital intensity of firms, pointing to a possible positive effect of a more elaborate division of labor. Herfindahl index of concentration has a negative coefficient, which is significant now at the 1% level. This finding may indicate *either* the negative effect of collusion on R&D expenditures *or* the effect that on average an oligopolistic market structure increases the market shares of large firms, which become more

[52]They reflect the demonstration, competition and labor mobility effects associated with foreign enterprise activity in the host country.

[53]The reason for introducing these two indicators of FDI spillovers separately is that they are highly correlated, as indicated in Appendix 3.

efficient in their activities and their R&D expenditures tend to fall with respect to their sales. The net effect of an increase in concentration discussed in section 5.1 might be that the efficiency effect more than compensates increased market power or collusion between large firms. As for the foreign ownership effect, its coefficient is still negative and significant at the 1% level, pointing to a depressing effect of being a foreign affiliate on R&D intensity.

In order to obtain more insight about the ownership effect, we run a model by distinguishing between majority- and minority-owned affiliates: the first one is defined as those firms where foreigners own at least 50% of the equity while the second category includes firm with less than 50% of capital. Estimation results[54] show that only being a majority-owned affiliate exerts a negative effect on firm-level R&D intensity while the impact of minority-ownership is not statistically significant. Possessing the majority of equity might lead foreign affiliates to transfer more knowledge from their headquarters – which of course remains an empirical issue – but apparently in our case this does not increase R&D intensity.

In order to check for the robustness of findings on FDI spillovers, we run a number of alternative models. First, in an attempt to test an alternative measure of technological opportunities - instead of industry dummies at the two-digit NACE level- we use a dummy variable taking the value of 1 if a firm operates in a high-medium technology industry with the omitted category of those firms in low-technology industries. The coefficient associated with this dummy variable is positive and significant at the 1% level, which is a result we expected. With respect to the previous findings, one major change is that along with a negative and significant effect of FDI-related R&D spillover variable at the province-level, the coefficient of the sector-level FDI spillover variable unrelated to R&D activities of foreign firms is now positive and statistically significant. This finding indicates that FDI spillovers may influence R&D activities of firms through the demonstration, competition and labor mobility effects previously discussed, without necessarily being associated by R&D activities.

We also estimate two separate models, one only for firms operating in high-medium technology industries, and the other for those located in low-technology industries. Findings on FDI spillovers for the first model are similar to those obtained previously –i.e. only the R&D-related provincial spillovers are significant and exert a negative effect on R&D intensity – whereas in the model for low technology firms this negative effect disappears and is replaced with a similar negative effect for the FDI-related R&D spillover at the sector-level, significant, however, only at the 5% level. Finally, when we run Tobit models only for small firms, neither FDI spillover variables nor the foreign ownership turn out to be statistically significant.

What about the impact of FDI spillover variables on the R&D intensity of *domestic* firms only? As indicated in Table 7 below only a minority of firms in the Turkish manufacturing sector is owned by foreign capital, as opposed to the case of some Latin American countries and transition countries in the Central and Eastern Europe. As a result, estimation results obtained for the sample – presented in Table 8 and in Appendix 6 and 7 – including only domestic firms do not differ significantly from those obtained for the whole sample as presented in Table 6.

Our empirical findings point then to the absence of positive FDI spillovers originating from R&D activities of foreign firms in Turkey over the period examined. A robust result is that a negative effect is obtained for this last spillover effect at the province-level. The Turkish

[54] From now on, to save space, estimation results pertaining to the sample with all firms (domestic and foreign) will not be reported. They are available from the authors upon simple request.

national system of innovation seems to be unable to benefit from the existing R&D activities of foreign firms in order to accelerate its catch up process with the developed nations.

7. Conclusion

As a consequence of worldwide liberalization and rapid technological change, globalization has become an undisputed fact of life since the eighties. Although the developed countries have been on the frontline among the most affected parties from this phenomenon, in the past decade, developing countries have also been receiving a higher share of FDI inflows.

As major actors of global flows of capital, MNCs have been carrying out manufacturing, marketing and sales activities abroad. However since the nineties MNCs have also started to offshore their R&D sections. With the expectation of lower costs of skilled labor and R&D infrastructure MNCs have been relocating their R&D activities to developing countries. In the meanwhile host country firms have been influenced from the increased presence of foreign activities, directly and indirectly through various spillovers.

Turkey, a developing country has not been immune to FDI flows, and for the period of 2002-2009 has been witnessing an increased inflow of FDI. At the same time Turkey has been experiencing a similar rise in its R&D expenditures carried out by the business enterprise sector. In this paper, we analyzed the impact of foreign capital on the R&D activities in Turkey for 2005-2007 in the form of consecutive cross-sectional regressions.

Our findings indicate that having a foreign owner has a negative impact on a firm's R&D expenditures in the Turkish manufacturing industry. In other words, *ceteris paribus* foreign firms do undertake less R&D activities then their domestic counterparts for the period under scrutiny in this study. This is a finding supported by other empirical research done on Turkey. In a qualitative study on the automotive sector, Celikel (2009) claims that *until* local partners prove to the foreign partner via strong sales of a new design or a new product that they possess an R&D capability, the foreign partner does not support R&D activities of the local partner. Another study on the R&D activities of foreign firms in Turkey indicates that there is almost no genuine R&D carried out by foreign firms in the pharmaceutical sector and very little foreign R&D is done in the electrical and electronics sector (Erdil and Pamukcu, 2010). Thus our finding regarding the effect of foreign ownership on R&D activity seems to be in line with other researchers' findings.

R&D intensity of foreign firms may be lower than that of domestic firms due to the existence of joint ventures including a local partner. In this case, the foreign partner may be unwilling to share its intangible proprietary assets with the local partner, leading the foreign partner to bring simple or outdated technologies with very low R&D potential to the host country. In this case, observed low R&D intensity of the foreign firm is to be explained not so much by the preferences of the foreign partner but rather by the fact that it is bringing less productive assets to the joint venture[55]. The higher is the share of the local partner in the firm equity, the more likely is the aforementioned behavior to take place. This possibility can be tested by using two different dummy variables for measuring the degree of foreign ownership: one dummy variable taking the value of 1 for minority-owned foreign firms and another one taking the value of 1 for minority-owned foreign firms. Such an exercise can be implemented in the future with the datasets used in this study.

Furthermore, a rather robust finding about foreign R&D at the province-level reveals those firms in Turkey reduce their R&D activities if they are located close to a R&D performer foreign firm. This could be attributable to a substitution effect or a crowding out effect. Firms could substitute the knowledge they receive from the R&D activities of nearby foreign firms

[55] Once again, we would like to thank Dr. Azzeddine Azzam for bringing this possibility to our attention.

or they may back away from the competitive pressure exerted by the R&D capability of the foreign firm. Either way, we do not observe significant positive knowledge spillovers from foreign firms to others in the same province or in the same sector.

Our findings are in line with the literature on FDI-related spillovers[56]. As indicated by Narula and Guimon (2010), in the absence of proper IPR standards and other infrastructural R&D investments, domestic firms substitute their own R&D efforts with the knowledge spillovers accruing from foreign firms. Therefore, before expecting spontaneous R&D activities on the part of the domestic firms, it seems imperative for the government to build a strong R&D infrastructure aimed to embed foreign firms in the host country's National Innovation System, which might lead to the emergence of positive knowledge spillovers originating from the activity of foreign firms.

As far as research that should be performed based on the findings of this paper is concerned, we should indicate that R&D is only one instrument towards innovation and innovation is carried out with the aim of higher productivity. Therefore, a natural sequel of this work could be the integration of innovation data to the present dataset with the aim to carry out a study similar to the one conducted in Crépon et al. (1998), where modeling is done to test first the impact of R&D on innovation and then to focus on the effect of innovation on productivity – this is called the CDM (Crépon-Duguet-Mairesse) Model in the innovation literature.

Finally, since both the numerator (*R&D expenditures*) and the denominator (*sales*) of the dependent variable used in the econometric exercise are endogenous variables, a two-equation model can be estimated with appropriate techniques with the dataset used in this paper.

[56] Djankov and Hoekman (1998), Aitken and Harrison (1996), Haddad and Harrison (1993) and Damijan (2005).

References

Aghion, P. and Howitt, P. (1998), *Endogeneous Growth Theory*, MIT Press, Cambridge.

Aiello, F. and Cardamone, P. (2008), "R&D spillovers and firms' performance in Italy Empirical Economics", *Research Policy*, 34, 143-166.

Aitken, B. J. and Harrison, A. E. (1999), "Do domestic firms benefit from Direct Foreign Investment? Evidence from Venezuela", *American Economic Review,* 89, 605-618.

Akpınar, A. (2001), "Turkey's Experience with Bilateral Investment Treaties", paper presented at the *OECD Investment Compact Regional Roundtable*, Dubrovnik, May 28–29.

Aldieri, L. and Cincera, M. (2009), "Geographic and technological R&D spillovers within the triad: micro evidence from US patents", *The Journal of Technology Transfer*, 34, 196-211.

Azzam, A. (1997), "Measuring market power and cost-efficiency effects of industrial concentration", *The Journal of Industrial Economics*, 45, 377-386.

Barbosa, N. and Faria, A.P. (2008), "Technology Adoption: Does Labour Skill Matter? Evidence from Portuguese firm-level data", *Empirica*, 35, 179-194.

Becker B. and Pain, N. (2008), "What Determines Industrial R&D Expenditure in the UK?", *The Manchester School*, 76, 66-87.

Benavente, J.M. (2006), "The Role of Research and Innovation in Promoting Productivity in Chile", *Economics of Innovation and New Technology*, 15, 301-315.

Blomstrom, M. and A. Kokko (1998), "Multinational corporations and spillovers", *Journal of Economic Surveys*, 12, 1-31.

Cameron, A.C. and Trivedi, P.K. (2005) *Microeconometrics: Methods and Applications*, Cambridge University Press, New York.

Carlsson, B. (2006), "Internationalization of innovation systems: A survey of literature", *Research Policy*, 35, 56-67.

Celikel T. A. (2009) *Factors Affecting Research and Development Collaboration of Multinational Enterprises and Their Local Partner Firms: A Case Study of Turkish Automotive Industry*, unpublished PhD dissertation, Isik University, Istanbul.

Cohen, W.M. and Levinthal, D.A. (1989), "Empirical Studies of Innovation and Market Structure", in R. Schmanlensee, and R.D. Willig, (eds) *Handbook of Industrial Organization*, (Elsevier), 1060-1107.

Crépon, B., E. Duguet and J. Mairesse (1998), "Research, Innovation, and Productivity: an Econometric Analysis at the Firm Level", *Economics of Innovation and New Technology*, 7, 115-158.

Criscuolo, P. (2005), *Internationalization of corporate R&D: A survey of literature*, SPRU - University of Sussex & MERIT- University of Maastricht, mimeo.

Czarnitzki, D. and Toole, A. (2007), "Business R&D and the Interplay of R&D Subsidies and Product Market Uncertainty", *Review of Industrial Organization*, 31, 169-181.

Dachs, B. and Ebersberger, B. (2009), "Does foreign ownership matter for the innovative activities of enterprises?" *International Economics and Economic Policy*, 6, 41-57.

Damijan, J. (2005), *Transfer of Technology through FDI to New Member States: How Important are Direct Effects, Horizontal and Vertical Spillovers?*, retrieved from: http://ec.europa.eu/economy_finance/events/2005/workshop0605/doc6en.pdf .

Deng, P.D. (2009), *Three Essays on China's Productivity Growth and Technology Development in International Perspective*, PhD dissertation, Brandeis University.

Djankov, S. and Hoekman, B. (1998*) Avenues of Technology Transfer: Foreign Investment and Productivity Change in the Czech Republic*, retrieved from: http://www.feem.it/userfiles/attach/Publication/NDL1998/NDL1998-016.pdf .

Edquist, C. (2005), "Systems of Innovation: Perspectives and Challenges", In J. Fagerberg, D. Mowery, ve R. R. Nelson (der.), *The Oxford handbook of innovation*. Oxford: Oxford University Press.

Erdil, E. and Pamukcu, T. (2010), *Analysis of R&D activities of foreign firms in the Turkish economy* (in Turkish), report prepared for the *International Investors Association of Turkey*, 350 pages.

Erdilek, A. (1982), *Direct Foreign Investment in Turkish Manufacturing*, J.C.B. Mohr, Tübingen.

Erdilek, A. (1986), "Turkey's New Open-Door Policy of Direct Foreign Investment: A Critical Analysis of Problems and Prospects", *METU Studies in Development* 13, 171–191.

European Commission (EC)(2007), *Europe in the Global Research Landscape*, EC, Brussels.

Fang, C. and Mohnen, P. (2009), *FDI, R&D and Innovation Output in the Chinese Automobile Industry*, UNU-MERIT Working Paper No 2009-044, UNU MERIT, Maastricht.

Gorg, H. and Greenaway, D. (2003), *Much Ado About Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment?*, IZA Discussion Paper Series, No. 944.

Gorodnichenko, Y., Svejnar, J. and Terrell, K. (2008), *Globalization and Innovation in Emerging Markets*, IZA Discussion Paper Series, No. 3299.

Griffiths, W. and Webster, E. (2004), *The Determinants of Research and Development and Intellectual Property Usage among Australian Companies, 1989 to 2002*, retrieved from: http://ideas.repec.org/p/iae/iaewps/wp2004n27.html .

Gustavssohn, P. and Poldahl, A. (2003), *Determinants of Firm R&D: Evidence from Swedish Firm Level Data*, FIEF Working Paper Series, Stockholm.

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.

Hertog, R.G. and Thurik, A.R. (1993) “Determinants of Internal and External R&D: Some Dutch Evidence”, *De Economist*, 141, 279-289.

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, 605-627.

Kannebley, S. and Sekkel, J. (2010), “Economic Performance of Brazilian Manufacturing Firms: A Counterfactual Analysis of Innovation Impacts”, *Small Business Economics*, 34, 339-353.

Kline, S. J. and Rosenberg N. (1986), “*An overview of innovation”,* in R. Landau and N. Rosenberg (eds), *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. Washington, DC, National Academy Press**,** 275-305.

Kumar, N. (1987), “Technology Imports and Local Research and Development in Indian Manufacturing”, *The Developing Economies*, 25, 220-233.

Kumar, N. and Aggarwal, A. (2005), “Liberalization, Outward Orientation and in-house R&D Activity of Multinational and Local Firms: A Quantitative Exploration for Indian Manufacturing”, *Research Policy*, 34, 441-460.

Lee, J. (1996), “Technology Imports and R&D Efforts of Korean Manufacturing Firms”, *Journal of Development Economics*, 50, 197-210.

Lee, M.H. and Hwang, I. J. (2003), “Determinants of Corporate R&D Investment: An Empirical Study Comparing Korea’s IT Industry with its Non-IT Industry”, *ETRI Journal*, 24, 258-265.

Lin, H. and Yeh, R.S. (2005), “The Interdependence between FDI and R&D: an application of an endogenous switching model to Taiwan’s electronics industry”, *Applied Economics*, 37, 1789-1799.

Lundin, N., F. Sjoholm, P. and He, J.Q. (2007), *FDI, Market Structure and R&D Investments in China*, IFN Working Paper No. 708, Stockholm:

Lundvall, B.A. (1992), *National Systems of Innovation: Towards A Theory of Innovation and Interactive Learning*, Pinter, London.

Mishra, V. (2007), “The Determinants of R&D Expenditure of Firms: Evidence From a Cross-section of Indian Firms”, *Economic Papers*, 26, 237-248.

Narayanan, K. and Bhat, S. (2009), “Technology sourcing and its determinants: A study of basic chemical industry in India”, *Technovation,* 29, 562–573.

Narula, R. (2001), “Choosing between internal and non-internal R&D activities: some technological and economic factors”, *Technology Analysis & Strategic Management*, 13, 365-387.

Narula, R. and J. Guimon (2010), *The R&D activity of multinational enterprises in peripheral economies: evidence from the EU new member states*, UNU-MERIT Working Paper No 2010-048, UNU-MERIT, Maastricht.

Narula, R. and A. Zanfei (2005), "Globalization of Innovation: The Role of Multinational Enterprises", Fagerberg, J., Mowery D.C. and R.R. Nelson (eds.), *The Oxford Handbook of Innovation*, Oxford University Press, 318-337.

OECD (2006), "The internationalization of R&D", in *OECD Science, Technology and Industry Outlook*, OECD, Paris, 121-147.

OECD (2008), *The Internationalisation of Business R&D: Evidence, Impacts and Implications*, OECD, Paris.

Ogawa, K. (2007), "Debt, R&D Investment and Technological Progress: A Panel Study of Japanese Manufacturing Firms' Behaviours During the 1990s", *Journal of Japanese International Economies*, 21, 403-423

Ortega-Argilés, R. and Moreno, R. (2009), *Evidence On The Role of Ownership Structure On Firms' Innovative Performance*, IREA Working Papers, 2009/09, University of Barcelona, Research Institute of Applied Economics, Barcelona.

Önis, Z. (1994), "Liberalization, Transnational Corporations and Foreign Direct Investment in Turkey: The Experience of the 1980s", in: F. Senses (ed.) *Recent Industrialization Experience of Turkey in a Global Context*, Westport, Connecticut Greenwood, 91–109.

Pamukçu, T. (2003), Trade Liberalization and Innovation Decisions of Firms: Lessons from Post-1980 Turkey, *World Development*, 31, 1443-1458.

Pamukçu, T., L. Bertinelli and E. Strobl (2006), "Technology Spillovers due to Foreign Ownership and Productivity of Domestic Firms: Analyzing the Evidence" in *Selected Papers from the 13th International Conference of ERF*, Economic Research Forum (ERF), Egypt, 187-230.

Parameswaran, M (2008) *International Trade and R&D Investment: Evidence from Manufacturing Firms in India*, retrieved from: http://www.isid.ac.in/~pu/conference/dec_08_conf/Papers/MParameswaran.pdf .

Patel, P. and Pavitt K. (1991), "Large firms in the production of the world's technology: an important case of non-globalization", *Journal of International Business Studies*, 22, 1-21.

Piga, C. and Vivarelli M. (2003), "Sample Selection in Estimating the Determinants of Cooperative R&D", *Applied Economics Letters*, 10, 243-246.

Ravenscraft, D. and Scherer, I. (1982), "The Lag Structure of Returns to Research and Development", *Applied Economics*, 14, 603-620.

Sachwald, F. (2008), "Location choices within global innovation networks: the case of Europe", *Journal of Technology Transfer*, 33, 364–378

Saggi, K. (2005), "FDI, Spillovers and Linkages" in B. Hoekman, and B.S. Javorcik (eds) *Global Integration and Technology Transfer*, Palgrave and Macmillan, 51-65.

Schumpeter, J.A. (1950), *Capitalism, Socialism and Democracy*, 3rd edition, Harper, New York.

Smeets, R. (2008), "Collecting the Pieces of the FDI Knowledge Spillovers Puzzle", *The World Bank Research Observer*, 23, 107-138.

Tan, L. and Hwang, A. R. (2002), "Imported Technology and R&D in the Taiwanese Electronic Industry", *Review of Development Economics*, 6, 77-90.

Todo, Y. (2006), "Knowledge spillovers from foreign direct investment in R&D: Evidence from Japanese firm-level data", *Journal of Asian Economics*, 17, 996-1013.

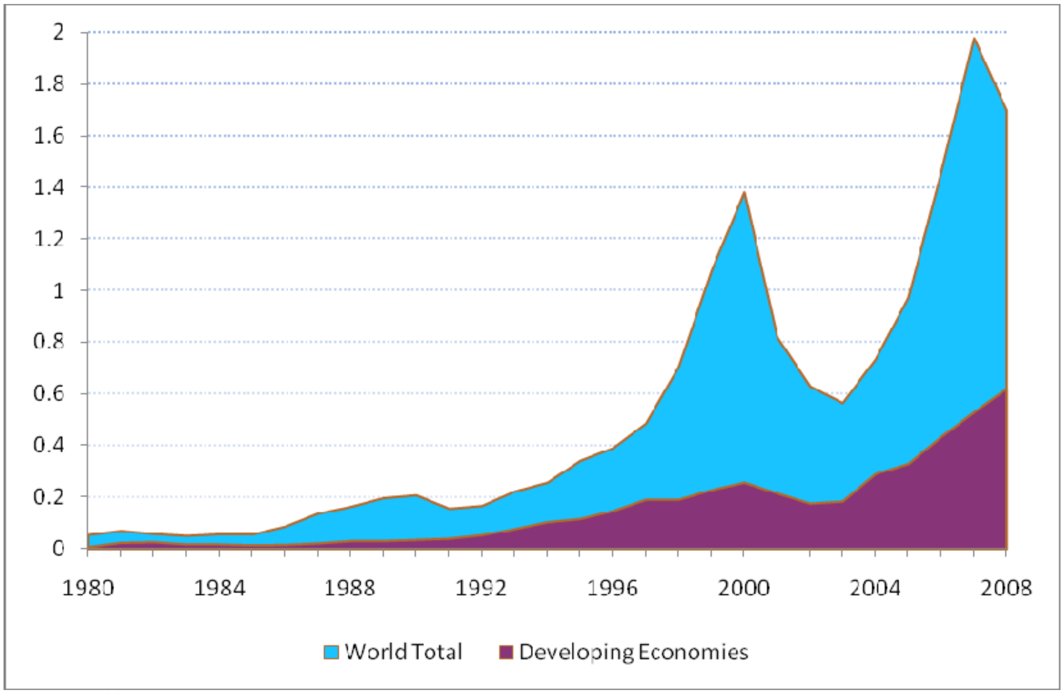
Un, C. A. and Cuervo-Cazurra, A. (2008), "Do subsidiaries of foreign MNEs invest more in R&D than domestic firms?", *Research Policy*, 37, 1812-1828.

UNCTAD (United Nations Conference on Trade and Development) (2003), *World Investment Report*: *FDI Policies for Development: National and International Perspectives*, United Nations, New York and Geneva.

UNCTAD (2005), *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D*, United Nations, New York and Geneva.

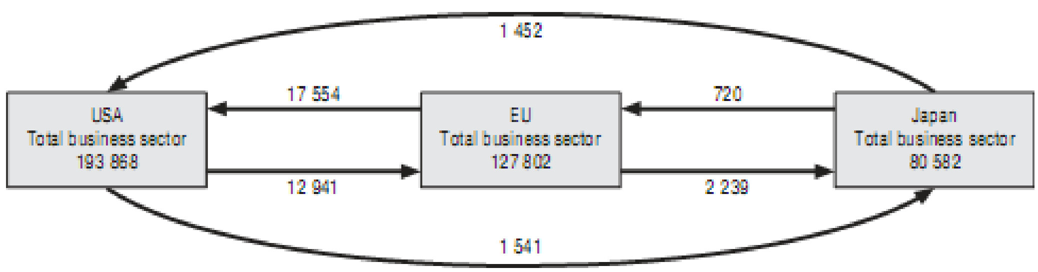
Veugelers, R. and H.P. Vanden Houte (1990), "Domestic R&D in the presence of multinational enterprises", *International Journal of Industrial Organization*, 8, 1-15.

Figure 1: Evolution of FDI Flows: 1980-2008 (trillion dollars)



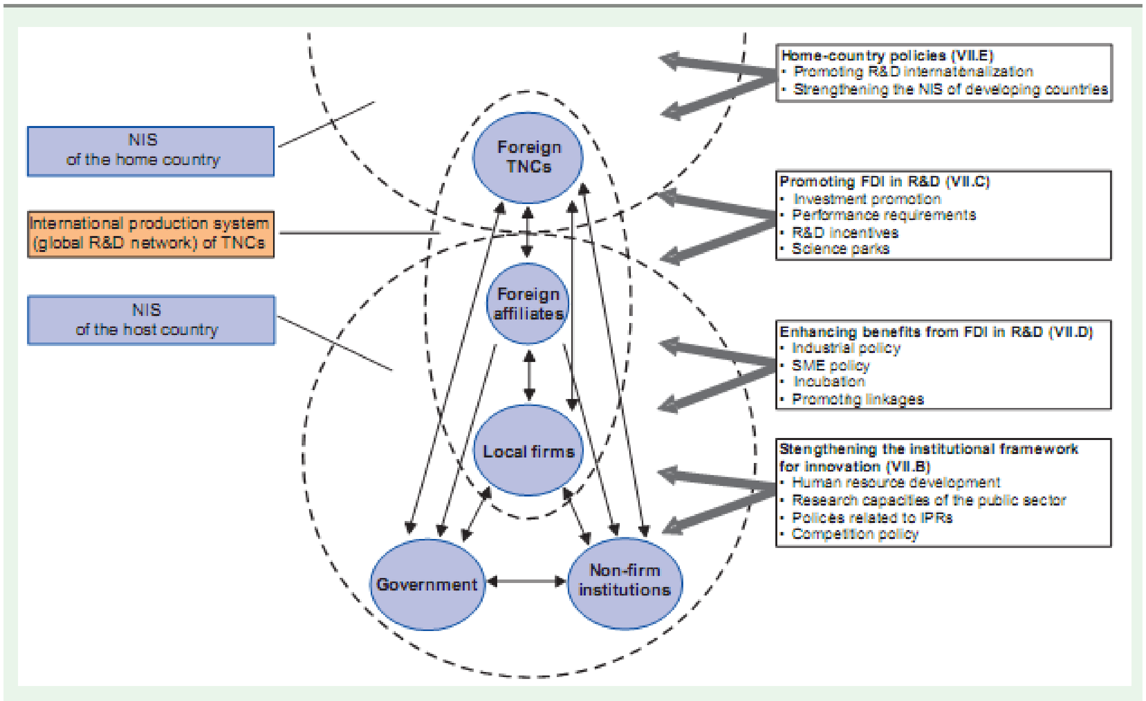
Source: World Investment Report 2010.

Figure 2: R&D Flows between EU, US and Japan in 2002 (millions of USD)



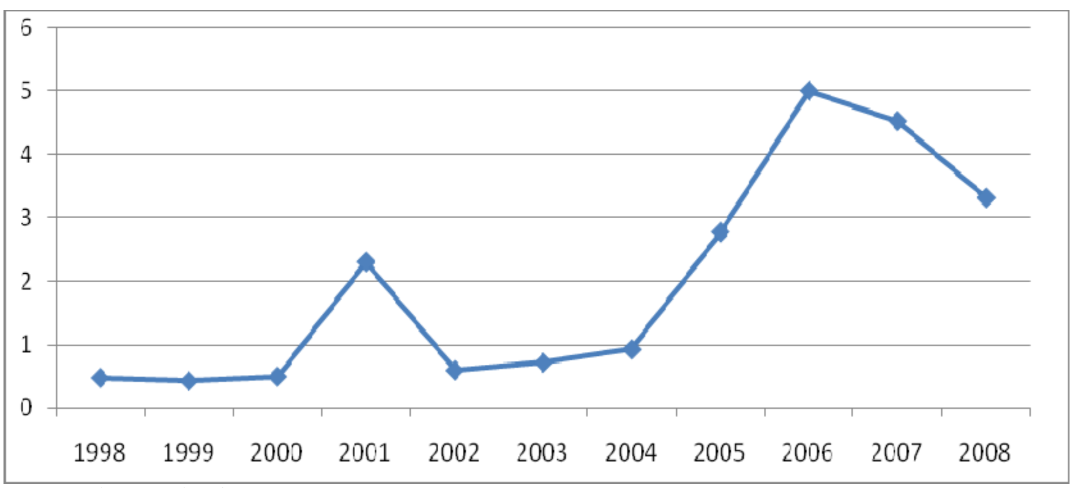
Source: OECD (2006).

Figure 3: National Innovation Systems and FDI in R&D



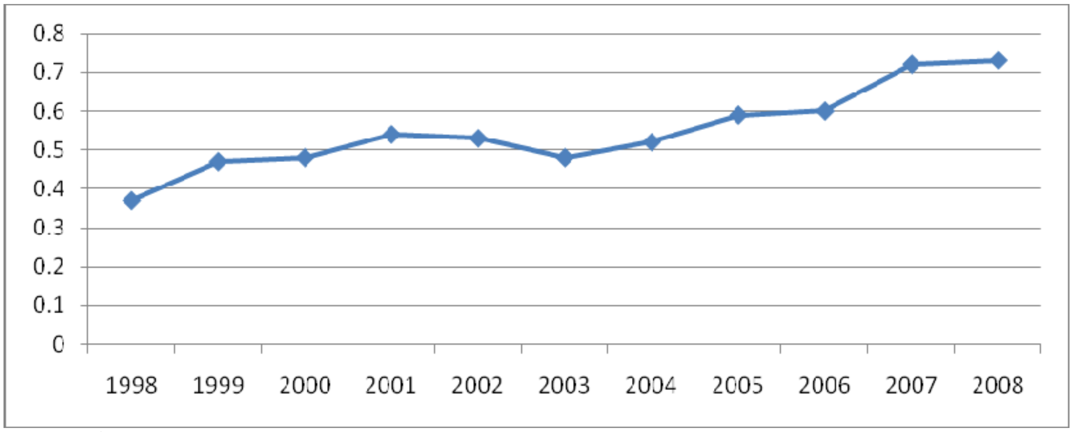
Source: UNCTAD (2005).

Figure 4: Evolution of the FDI/GDP Ratio in Turkey: 1998-2008 (%)



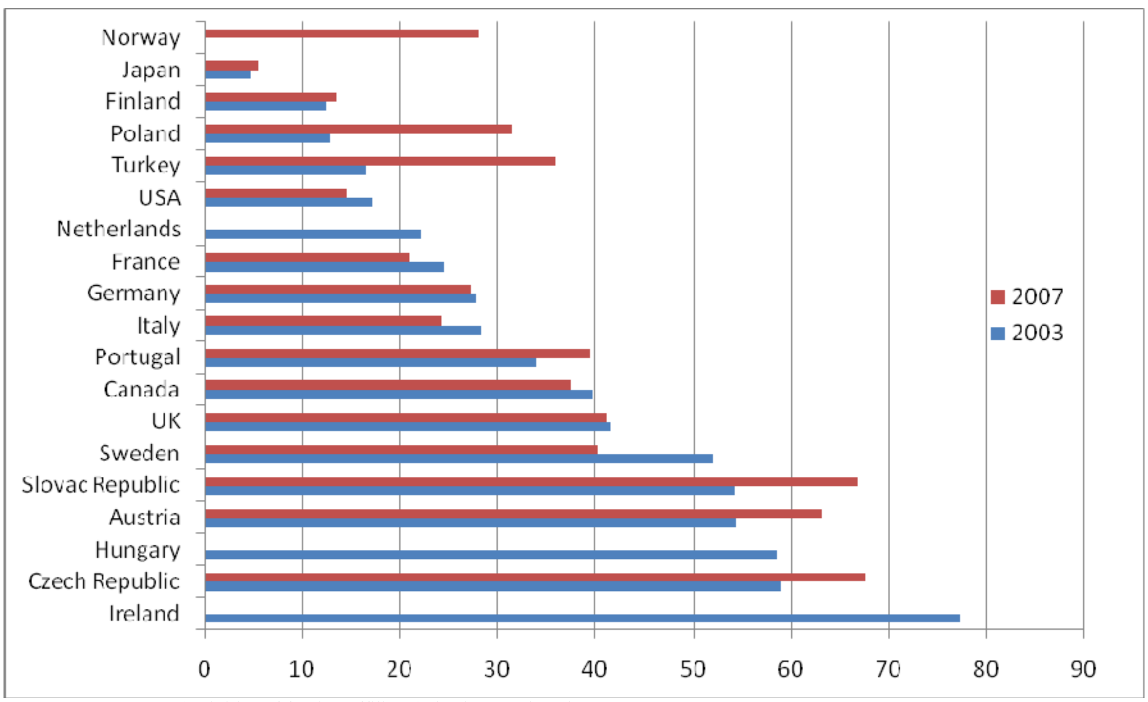
Source: Undersecretariat of Treasury.

Figure 5: Evolution of the R&D / GDP Ratio in Turkey: 1998-2008 (%)



Source: Turkstat, R&D surveys.

Figure 6: Share of Foreign Firms in the R&D Expenditures of the Manufacturing Sector in OECD Countries: 2003 and 2007 (%)



Source: OECD, AFA (activities of foreign affiliates) database and Turkstat, R&D surveys.

Table 1: Proportion of R&D Budget of MNCs Spent outside their Country/Region of Origin (%)

	1995	1998	2001	2004*
Western Europe	25.7	30.3	33.4	43.7
Japan	4.7	7.0	10.5	14.6
North America	32.2	28.4	31.7	35.1

Notes: * forecast
Source: World Investment Report 2005

Table 2: Geographical Distribution of R&D Expenditures of US MNCs Abroad, 1995-2005 (%)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Canada	8.5	11.1	12.5	11.9	9.3	11.4	10.8	10.8	11.0	10.6	10.2
European Union (15)	70.4	66.9	66.4	68.6	65.6	61.0	58.8	61.4	61.5	62.1	61.0
Eastern Europe	0.1	0.3	0.3	0.5	0.3	0.4	0.2	0.3	0.3	…	0.5
Latin America	3.1	3.9	4.5	5.1	3.4	3.2	2.9	3.7	3.1	2.8	3.2
Brazil	2.0	2.5	3.0	3.0	1.6	1.2	1.0	1.4	1.5	1.4	1.5
Africa	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Middle East	0.8	1.2	1.4	1.0	2.1	3.1	3.7	3.5	3.1	3.4	3.7
Asia-Pacific	14.8	14.8	12.8	10.9	17.8	19.2	21.3	18.0	18.2	17.8	18.2
Japan	10.2	9.5	7.5	6.6	8.4	8.0	7.6	7.3	7.4	6.3	6.2
China	0.1	0.2	0.2	0.4	1.8	2.5		3.1	2.5	2.2	2.5
Australia	2.3	2.9	2.5	2.0	1.6	1.7	1.5	1.5	1.9	1.8	1.8
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Total in billion USD	12,582	14,039	14,593	14,664	18,144	20,457	19,702	21,063	22,328	25,840	28,316

Source: OECD (2008)

Table 3: Supply and Demand-Related Factors in the Internationalization of R&D

Factors	Characteristics of S&T supply	Characteristics of demand
Centralization in the home country	• Strong S&T capabilities at the home country • Economies of scale in R&D	• Home country is a lead market
International dispersion	• Attractive centers of excellence abroad • Low cost talent pool: increasing supply of scientist and engineers in emerging countries	• Adaptation to foreign markets and local production conditions • New lead markets abroad

Source: adapted from Sachwald (2008)

Table 4a: Determinants of the Location of R&D Units

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Attractive local characteristics</td></tr>
<tr><td>Scientific and technological supply</td><td>Demand</td></tr>
<tr><td rowspan="3">Type of R&D unit</td><td>Local development center</td><td>Quality of training (engineers, technicians …) and local technological infrastructure</td><td>Large local market
(size, purchasing power)</td></tr>
<tr><td>Global research center</td><td>Excellence centers, good relations between research and industry</td><td>Lead market</td></tr>
<tr><td>Global development center</td><td>Good cost/efficiency ratio for some R&D activities</td><td>---</td></tr>
</table>

Source: Sachwald (2008)

Table 4b: R&D/GDP Ratios for OECD Countries: 2000-2008 (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
EU-27	1.74	1.75	1.76	1.75	1.73	1.74	1.76	1.77	…
Turkey	**0.48**	**0.54**	**0.53**	**0.48**	**0.52**	**0.59**	**0.58**	**0.72**	**0.73**
Hungary	0.79	0.92	1.00	0.93	0.87	0.94	1.00	0.97	…
Poland	0.56	0.54	0.56	0.57	0.56	0.57	0.56	0.57	0.60
Romania	0.37	0.39	0.38	0.39	0.39	0.41	0.45	0.52	0.59
Spain	0.91	0.92	0.99	1.05	1.06	1.12	1.20	1.27	1.35
Korea	2.30	2.47	2.40	2.49	2.68	2.79	3.01	3.21	…
Mexico	0.34	0.36	0.40	0.40	0.40	0.41	0.39	0.38	…

Source: OECD Main S&T Indicators database, 2009/1.

Table 5: Share of Foreign Firms in the Sector-Level R&D Expenditures (*For*) and Sectoral Distribution of Total R&D Expenditures (*Total*) in the Turkish Manufacturing Sector (%)

NACE		2003		2004		2005		2006		2007	
		For	Total	For	Total	For	Total	For	Total	For	Total
15	Food, beverages and tobacco	4,07	10,19	2,79	3,17	25,58	2,73	29,42	2,68	34,48	3,00
21	Paper, printing and publishing	69,45	6,94	28,46	0,15	71,32	0,16	75,57	0,16	78,54	0,12
24	Chemical and chemical products	43,40	10,16	9,07	10,56	28,77	8,76	41,09	7,41	25,93	8,51
25	Rubber and plastic products	57,60	2,97	45,30	2,04	57,52	1,80	53,22	1,72	51,19	1,65
29	Machinery and equipment	11,98	14,47	7,08	12,46	18,85	11,64	12,45	11,65	18,05	11,35
31	Electrical machinery and apparatus	0,83	12,01	1,96	3,17	59,85	3,73	63,07	2,92	57,54	2,03
32	Radio, TV and communication eq.	47,40	2,17	15,96	18,80	29,42	20,97	26,21	19,70	20,72	23,88
34	Motor vehicles	17,63	3,63	20,43	26,91	52,46	26,95	74,02	31,73	66,84	27,19
35	Other transport equipment	57,10	0,17	0,00	0,30	54,02	2,97	58,69	3,42	24,79	4,63

Source: Turkstat, R&D surveys (various years).

Table 6: Determinants of R&D Intensity (R&D/sales) of Firms (domestic and foreign) in the Turkish Manufacturing Sector (explanatory variables measured in 2007)

	(1)	(2)	(3)	(4)	(5)	(6)
Size	0.017	0.022	0.021	0.021	0.020	0.020
(log employee)	(9.19)**	(10.88)**	(10.18)**	(10.80)**	(9.95)**	(10.04)**
Skill level	0.038	0.024	0.024	0.025	0.025	0.025
(log wage rate)	(10.34)**	(6.35)**	(6.13)**	(6.52)**	(6.31)**	(6.32)**
Foreign ownership	-0.014	-0.017	-0.018	-0.015	-0.016	-0.016
(dummy if foreign equity share >= 10%)	(-2.15)*	(-2.51)*	(-2.71)**	(-2.28)*	(-2.25)*	(-2.35)*
Technology transfer	0.008	0.006	0.008	0.006	0.007	0.008
(dummy for licensing agreement)	(1.83)	(1.50)	(1.74)	(1.52)	(1.72)	(1.73)
Capital intensity	-0.001	0.000	0.000	0.000	0.000	0.000
(log depreciation)	(-0.70)	(0.30)	(0.37)	(0.16)	(0.20)	(0.20)
Exporter	0.029	0.024	0.024	0.024	0.024	0.024
(dummy for exporters)	(5.77)**	(4.73)**	(4.72)**	(4.73)**	(4.68)**	(4.69)**
Technology gap	-0.011	-0.009	-0.010	-0.009	-0.010	-0.010
(distance with respect to the productivity leader in the sector)	(-4.87)**	(-3.70)**	(-4.04)**	(-3.63)**	(-4.01)**	(-4.02)**
Herfindahl	---	-0.106	-0.146	-0.110	-0.148	-0.149
(Herfindahl concentration index)		(-2.10)*	(-2.33)*	(-2.21)*	(-2.33)*	(-2.38)*
Import penetration	---	0.005	0.006	0.006	0.007	0.007
(imports/ (production+imports))		(1.10)	(1.32)	(1.22)	(1.38)	(1.38)
FDI-related R&D spillover (*sectoral*)	---	---	-0.011	---	-0.010	-0.010
(see paper)			(-1.19)		(-1.13)	(-1.14)
FDI spillover (*unrelated to R&D + sectoral*)	---	0.067	---	---	0.008	---
(see paper)		(0.48)			(0.05)	
FDI-related R&D spillover (*province level*)	---	---	---	-0.023	-0.022	-0.022
(see paper)				(-3.42)**	(-3.22)**	(-3.22)**
Constant	-0.542	-0.497	-0.473	-0.485	-0.472	-0.471
	(-14.65)**	(-10.94)**	(-10.98)**	(-11.67)**	(-10.06)**	(-10.96)**
Pseudo R^2	0.5989	0.8367	0.8899	0.8608	0.9203	0.9142
Number of observations	7905	7905	6587	7335	6119	6119

Notes: * significant at 5% level; ** significant at 1% level (industry dummies included). Absolute value of t-statistics in parentheses

Table 7: Proportion of Foreign (For) and Domestic (Dom) Firms in the Total Number of Firms in the Turkish Manufacturing Sector (%)

NACE		2003		2004		2005		2006		2007	
		For	**Dom**	**For**	**Dom**	**For**	**Dom**	**For**	**Dom**	**For**	**Dom**
15	Food, beverages and tobacco	4,07	95,93	3,12	96,88	4,20	95,80	4,35	95,35	4,40	95,60
21	Paper, printing and publishing	5,69	94,31	6,60	93,40	6,40	93,60	7,80	92,20	6,99	93,01
24	Chemical and chemical products	15,94	84,06	6,65	93,35	15,59	84,41	16,53	83,47	16,92	83,08
25	Rubber and plastic products	5,00	95,00	7,58	92,42	4,47	95,53	4,81	95,19	4,52	95,48
29	Machinery and equipment	2,98	97,02	4,04	95,96	3,61	96,39	3,60	96,40	3,92	96,08
31	Electrical machinery and apparatus	7,04	92,96	7,04	92,06	6,90	93,10	6,87	93,13	5,70	94,30
32	Radio, TV and communication equipment	4,62	95,38	3,13	95,87	6,67	93,33	5,08	94,92	3,92	96,08
34	Motor vehicles	14,45	85,55	6,65	93,35	14,75	85,25	14,24	85,76	14,29	85,71
35	Other transport equipment	6,96	93,04	1,74	98,26	6,67	93,33	7,63	92,37	6,86	93,14

Source: Turkstat, Structural Business Statistics (various years)

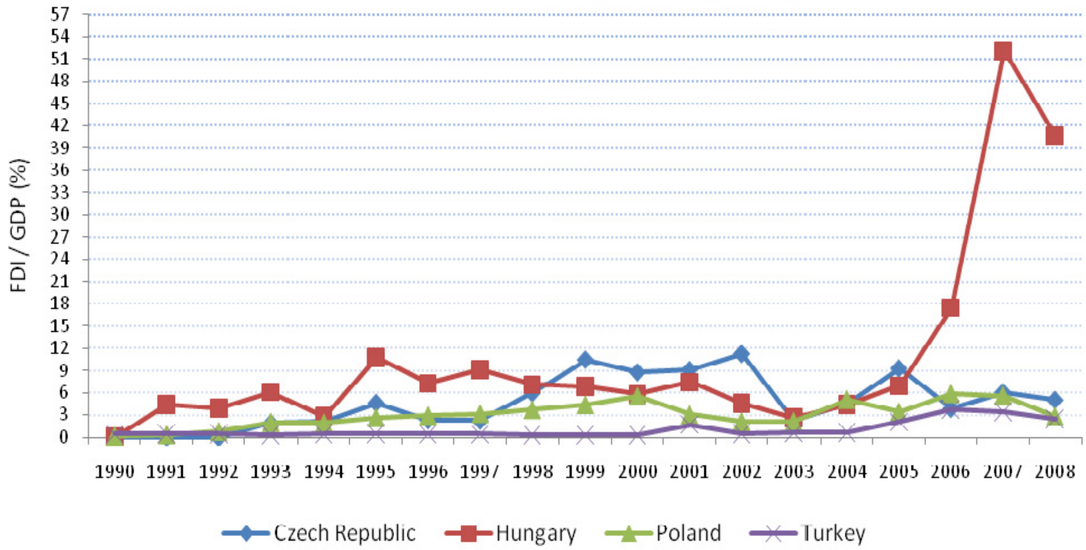
Table 8: Determinants of R&D Intensity (R&D/sales) of Domestic Manufacturing Firms (explanatory variables measured in 2007)

	(1)	(2)	(3)	(4)	(5)	(6)
Size	0.017	0.023	0.022	0.023	0.021	0.021
(log employee)	(8.37)**	(10.18)**	(9.55)**	(10.01)**	(9.38)**	(9.37)**
Skill level	0.039	0.025	0.024	0.026	0.026	0.025
(log wage rate)	(9.54)**	(5.81)**	(5.56)**	(5.98)**	(5.82)**	(5.78)**
Technology transfer	0.009	0.008	0.009	0.008	0.009	0.009
(dummy for licensing agreement)	(1.80)	(1.62)	(1.78)	(1.63)	(1.79)	(1.78)
Capital intensity	-0.001	0.000	0.000	-0.000	-0.000	-0.000
(log depreciation)	(-0.77)	(0.12)	(0.08)	(-0.04)	(-0.10)	(-0.11)
Exporter	0.031	e0.024	0.024	0.024	0.024	0.024
(dummy for exporters)	(5.61)**	(4.36)**	(4.34)**	(4.34)**	(4.34)**	(4.33)**
Technology gap	-0.014	-0.011	-0.012	-0.011	-0.012	-0.012
(distance with respect to the productivity leader in the sector)	(-5.31)**	(-4.07)**	(-4.41)**	(-4.06)**	(-4.40)**	(-4.40)**
Herfindahl	---	-0.068	-0.099	-0.067	-0.102	-0.100
(Herfindahl concentration index)		(-1.18)	(-1.40)	(-1.16)	(-1.45)	(-1.43)
Import penetration	---	0.004	0.006	0.004	0.006	0.006
(imports/ (production+imports))		(0.70)	(1.04)	(0.84)	(1.16)	(1.15)
FDI-related R&D spillover (*sectoral*)	---	---	-0.008	---	-0.006	-0.007
(see paper)			(-0.73)		(-0.58)	(-0.68)
FDI spillover (*unrelated to R&D + sectoral*)	---	-0.098	---	---	-0.217	---
(see paper)		(-0.43)			(-0.91)	
FDI-related R&D spillover (*province level*)	---	---	---	-0.028	-0.027	-0.026
(see paper)				(-3.73)**	(-3.49)**	(-3.46)**
Constant	-0.556	-0.503	-0.485	-0.508	-0.462	-0.483
	(-13.43)**	(-9.77)**	(-10.03)**	(-10.61)**	(-9.02)**	(-10.01)**
Pseudo R^2	0.5419	0.7706	0.8185	0.7945	0.8481	0.8471
Number of observations	7560	7560	6296	6999	5837	5837

Notes: Absolute value of t-statistics in parentheses (industry dummies included). * significant at 5% level; ** significant at 1% level.

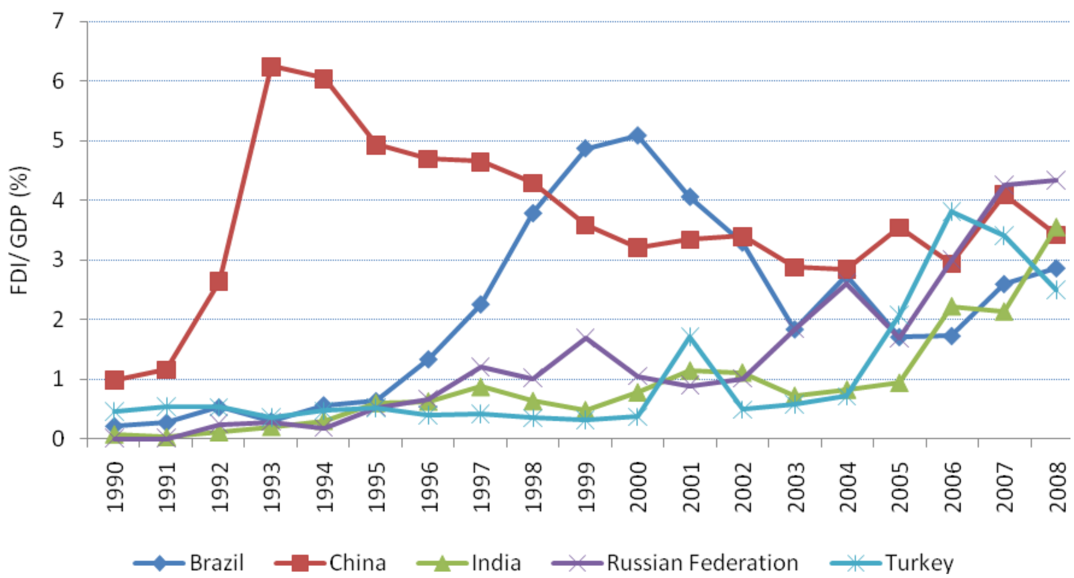
Appendix 1

The Share of FDI in Total GDP for Czech Republic, Hungary, Poland and Turkey (%) 1990-2008



Source: World Development Indicators database

The Share of FDI in Total GDP for BRICs countries (%)1990-2008



Source: World Development Indicators database

Appendix 2

Sectoral Distribution of FDI flows to the Turkish economy. 2002-2009 (million USD)

	2002	2003	2004	2005	2006	2007	2008	2009
Agriculture	0	1	4	5	5	6	23	42
Fishery	0	0	2	2	1	3	18	1
Mining	2	13	73	40	122	337	152	213
Manufacturing (total)	**95**	**440**	**190**	**785**	**1.866**	**4,211**	**3,931**	**1,713**
Food, beverages and tobacco	14	249	78	68	608	766	1.252	214
Textile and wearing apparel	5	2	9	180	26	232	189	78
Chemicals and chemical products	8	9	38	174	601	1.109	200	339
Machinery and equipment	13	16	6	13	54	48	226	223
Electrical and optical equipment	2	4	2	13	53	117	236	58
Transport equipment	34	145	27	106	63	70	77	233
Manufacturing n.e.c.	19	15	30	231	461	1.869	1.751	568
Electricity, gas and water	68	86	66	4	112	568	1.068	1.648
Construction	0	8	3	80	222	285	331	343
Trade	75	58	72	68	1.166	165	2.084	403
Hotels and restaurants	0	4	1	42	23	33	24	48
Transport and communication services	1	1	639	3.285	6.696	1.117	170	382
Financial institutions	246	51	69	4.018	6.957	11.662	6.069	497
Real estate	0	3	3	29	99	560	656	561
Health and social services	4	21	35	74	265	177	149	101
other	80	10	33	103	105	13	58	49
TOTAL	**571**	**696**	**1.190**	**8.535**	**17.639**	**19.137**	**14.733**	**6.001**

Source: Under secretariat of Treasury.

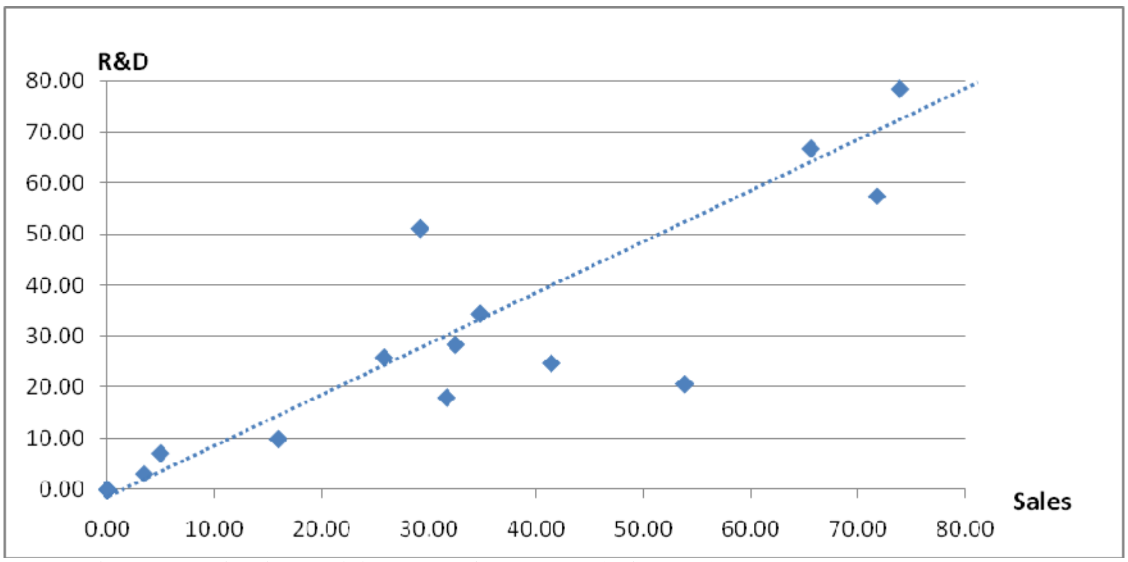
Appendix 3

Share of Foreign Firms in R&D Expenditures (*R&D*) and in Sectoral Sales (*Sales*) at the Sector Level in the Turkish Manufacturing Sector: 2003-2007 (%)

NACE		2003		2004		2005		2006		2007	
		R&D	Sales	R&D	Sales	R&D	Sales	R&D	Sales	R&D	Sales
15	Food, beverages and tobacco	4,07	28,40	2,79	5,40	25,58	31,67	29,42	34,15	34,48	34,74
21	Paper, printing and publishing	69,45	25,83	28,46	37,84	71,32	73,53	75,57	62,06	78,54	73,85
24	Chemical and chemical products	43,40	33,17	9,07	10,37	28,77	33,11	41,09	32,72	25,93	25,78
25	Rubber and plastic products	57,60	37,35	45,30	27,37	57,52	29,07	53,22	28,21	51,19	29,15
29	Machinery and equipment	11,98	29,97	7,08	3,80	18,85	28,75	12,45	24,49	18,05	31,61
31	Electrical machinery and apparatus	0,83	65,22	1,96	2,45	59,85	58,70	63,07	65,68	57,54	71,73
32	Radio, TV and communication eq.	47,40	9,80	15,96	6,74	29,42	48,09	26,21	50,60	20,72	53,79
34	Motor vehicles	17,63	83,00	20,43	37,11	52,46	37,29	74,02	77,50	66,84	65,56
35	Other transport equipment	57,10	78,90	0,00	0,00	54,02	41,99	58,69	47,68	24,79	41,37

Source: TurkStat, Structural Business Statistics Survey and R&D surveys (various years).

Share of Foreign Firms in R&D Expenditures (*R&D*) and in Sales (*Sales*) at the Sector Level in the Turkish Manufacturing Sector: 2003-2007 (%)



Source: TurkStat, Structural Business Statistics Survey and R&D surveys (various years).

Appendix 4

Determinants of R&D Intensity (R&D/Sales) of Firms (Domestic and Foreign) in the Turkish Manufacturing Sector (Explanatory Variables Measured in 2006)

	(1)	(2)	(3)	(4)	(5)	(6)
Size	0.013	0.017	0.016	0.016	0.016	0.015
(log employee)	(9.88)**	(11.88)**	(11.23)**	(11.76)**	(11.14)**	(11.12)**
Skill level	0.028	0.017	0.017	0.017	0.017	0.017
(log wage rate)	(10.99)**	(6.48)**	(6.42)**	(6.66)**	(6.44)**	(6.52)**
Foreign ownership	-0.013	-0.014	-0.015	-0.014	-0.012	-0.013
(dummy if foreign equity share >= 10%)	(-2.66)**	(-2.99)**	(-3.10)**	(-3.00)**	(-2.47)*	(-2.79)**
Technology transfer	0.006	0.004	0.004	0.005	0.005	0.005
(dummy for licensing agreement)	(1.97)*	(1.56)	(1.52)	(1.69)	(1.57)	(1.61)
Capital intensity	0.000	0.001	0.001	0.001	0.001	0.001
(log depreciation)	(0.61)	(1.43)	(1.59)	(1.46)	(1.61)	(1.61)
Exporter	0.016	0.012	0.012	0.012	0.012	0.012
(dummy for exporters)	(4.93)**	(3.69)**	(3.80)**	(3.63)**	(3.64)**	(3.67)**
Technology gap	-0.007	-0.007	-0.006	-0.006	-0.006	-0.006
(distance with respect to the productivity leader in the sector)	(-4.90)**	(-4.25)**	(-4.02)**	(-4.01)**	(-3.92)**	(-3.88)**
Herfindahl	---	-0.009	-0.026	-0.016	-0.021	-0.029
(Herfindahl concentration index)		(-0.24)	(-0.59)	(-0.44)	(-0.48)	(-0.67)
Import penetration	---	0.007	0.006	0.007	0.006	0.006
(imports/ (production+imports))		(2.02)*	(1.89)	(2.12)*	(1.84)	(1.85)
FDI-related R&D spillover (*sectoral*)	---	---	-0.006	---	-0.007	-0.006
(see paper)			(-0.94)		(-1.02)	(-0.90)
FDI spillover (*unrelated to R&D + sectoral*)	---	0.130	---	---	0.111	---
(see paper)		(1.26)			(1.02)	
FDI-related R&D spillover (*province level*)	---	---	---	-0.013	-0.011	-0.011
(see paper)				(-2.85)**	(-2.52)*	(-2.51)*
Constant	-0.397	-0.361	-0.335	-0.345	-0.346	-0.333
	(-15.58)**	(-11.64)**	(-11.75)**	(-12.26)**	(-10.91)**	(-11.69)**
Pseudo R^2	0.7549	1.0867	1.1739	1.1243	1.2257	1.2139
Number of observations	8511	8511	7225	7968	6775	6775

Appendix 5

Determinants of R&D Intensity (R&D/Sales) of Firms (Domestic and Foreign) in the Turkish Manufacturing Sector (explanatory variables measured in 2005)

	(1)	(2)	(3)	(4)	(5)	(6)
Size	0.010	0.014	0.014	0.014	0.014	0.014
(log employee)	(8.89)**	(11.35)**	(10.77)**	(11.29)**	(10.68)**	(10.70)**
Skill level	0.026	0.016	0.016	0.017	0.016	0.014
(log wage rate)	(10.66)**	(6.34)**	(6.22)**	(6.57)**	(6.32)**	(6.36)**
Foreign ownership	-0.012	-0.012	-0.012	-0.012	-0.012	-0.012
(dummy if foreign equity share >= 10%)	(-2.48)*	(-2.60)**	(-2.65)**	(-2.65)**	(-2.44)*	(2.57)*
Technology transfer	0.017	0.014	0.015	0.014	0.015	0.015
(dummy for licensing agreement)	(4.81)**	(4.22)**	(4.27)**	(4.08)**	(4.18)**	(4.27)**
Capital intensity	0.001	0.001	0.001	0.001	0.001	0.001
(log depreciation)	(2.11)*	(2.38)*	(2.39)*	(2.24)*	(2.21)*	(2.26)*
Exporter	0.014	0.010	0.010	0.010	0.010	0.010
(dummy for exporters)	(5.01)**	(3.61)**	(3.58)**	(3.56)**	(3.49)**	(3.43)**
Technology gap	-0.006	-0.004	-0.005	-0.004	-0.005	-0.005
(distance with respect to the productivity leader in the sector)	(-4.35)**	(-3.01)**	(-3.29)**	(-2.96)**	(-3.33)**	(-3.28)**
Herfindahl	---	-0.091	-0.131	-0.093	-0.132	-0.139
(Herfindahl concentration index)		(-2.53)*	(-2.72)**	(-2.61)**	(-2.74)**	(-2.90)**
Import penetration	---	0.003	0.003	0.003	0.004	0.004
(imports/ (production+imports))		(1.06)	(1.18)	(1.19)	(1.26)	(1.25)
FDI-related R&D spillover (*sectoral*)	---	---	-0.008	---	-0.008	---
(see paper)			(-1.57)		(-1.44)	
FDI spillover (*unrelated to R&D + sectoral*)	---	0.048	---	---	0.034	-0.017
(see paper)		(0.48)			(0.33)	(-3.85)**
FDI-related R&D spillover (*province level*)	---	---	---	-0.018	-0.017	
(see paper)				(-3.94)**	(-3.66)**	
Constant	-0.366	-0.331	-0.312	-0.325	-0.313	-0.292
	(-15.73)**	(-11.88)**	(-11.72)**	(-12.33)**	(-11.10)**	(-11.41)**
Pseudo R^2	0.7760	1.1215	1.2314	1.1706	1.2935	1.2849
Number of observations	8639	8639	7734	8216	7359	7359

Notes: Absolute value of t-statistics in parentheses; * significant at 5% level; ** significant at 1% level (industry dummies included)

Appendix 6

Determinants of R&D Intensity (R&D/Sales) of Domestic Manufacturing Firms (explanatory variables measured in 2006)

	(1)	(2)	(3)	(4)	(5)	(6)
Size	0.013	0.018	0.017	0.017	0.017	0.017
(log employee)	(8.84)**	(10.94)**	(10.41)**	(10.82)**	(10.28)**	(10.28)**
Skill level	0.030	0.018	0.018	0.019	0.019	0.019
(log wage rate)	(10.33)**	(6.23)**	(6.12)**	(6.44)**	(6.31)**	(6.30)**
Technology transfer	0.007	0.005	0.005	0.006	0.005	0.005
(dummy for licensing agreement)	(2.10)*	(1.56)	(1.48)	(1.67)	(1.58)	(1.60)
Capital intensity	0.000	0.001	0.001	0.001	0.001	0.001
(log depreciation)	(0.42)	(1.20)	(1.28)	(1.24)	(1.31)	(1.31)
Exporter	0.017	0.012	0.013	0.012	0.012	0.012
(dummy for exporters)	(4.68)**	(3.43)**	(3.51)**	(3.35)**	(3.40)**	(3.40)**
Technology gap	-0.010	-0.008	-0.008	-0.008	-0.008	-0.008
(distance with respect to the productivity leader in the sector)	(-5.42)**	(-4.62)**	(-4.44)**	(-4.47)**	(-4.31)**	(-4.32)**
Herfindahl	---	0.014	0.003	0.013	-0.001	-0.000
(Herfindahl concentration index)		(0.31)	(0.07)	(0.30)	(-0.01)	(-0.00)
Import penetration	---	0.007	0.007	0.007	0.007	0.007
(imports/ (production+imports))		(1.87)	(1.90)	(1.99)*	(1.91)	(1.91)
FDI-related R&D spillover (*sectoral*)	---	---	-0.003	---	-0.002	-0.002
(see paper)			(-0.35)		(0.26)	(-0.30)
FDI spillover (*unrelated to R&D + sectoral*)	---	0.052	---	---	-0.046	---
(see paper)		(0.32)			(-0.27)	
FDI-related R&D spillover (*province level*)	---	---	---	-0.017	-0.015	-0.015
(see paper)				(-3.32)**	(-2.97)**	(-2.97)**
Constant	-0.421	-0.381	-0.362	-0.375	-0.356	-0.361
	(-14.39)**	(10.30)**	(10.96)**	(11.45)**	(-9.63)**	(-10.95)**
Pseudo R^2	0.6529	0.9591	1.0254	0.9923	1.0652	1.0651
Number of observations	8138	8138	6910	7607	6471	6471

Notes: (industry dummies included)

Appendix 7

Determinants of R&D Intensity for Domestic Manufacturing Firms (explanatory variables measured in 2005)

	(1)	(2)	(3)	(4)	(5)	(6)
Size	0.011	0.015	0.015	0.015	0.014	0.014
(log employee)	(8.16)**	(10.73)**	(10.23)**	(10.63)**	(10.13)**	(10.12)**
Skill level	0.028	0.017	0.017	0.018	0.017	0.017
(log wage rate)	(10.21)**	(6.04)**	(5.84)**	(6.20)**	(6.03)**	(5.98)**
Technology transfer	0.019	0.017	0.017	0.017	0.017	0.017
(dummy for licensing agreement)	(4.74)**	(4.28)**	(4.37)**	(4.29)**	(4.38)**	(4.38)**
Capital intensity	0.001	0.001	0.001	0.001	0.001	0.001
(log depreciation)	(2.09)*	(2.26)*	(2.22)*	(2.09)*	(2.06)*	(2.04)*
Exporter	0.014	0.010	0.010	0.009	0.010	0.010
(dummy for exporters)	(4.68)**	(3.27)**	(3.22)**	(3.10)**	(3.15)**	(3.11)**
Technology gap	-0.006	-0.004	-0.005	-0.004	-0.005	-0.005
(distance with respect to the productivity leader in the sector)	(-4.30)**	(-2.90)**	(-3.26)**	(-2.94)**	(-3.29)**	(-3.31)**
Herfindahl	---	-0.081	-0.120	-0.080	-0.125	-0.124
(Herfindahl concentration index)		(-2.06)*	(-2.20)*	(-2.04)*	(-2.31)*	(-2.29)*
Import penetration	---	0.003	0.003	0.003	0.004	0.004
(imports/ (production+imports))		(0.82)	(1.06)	(0.92)	(1.21)	(1.18)
FDI-related R&D spillover (*sectoral*)	---	---	-0.005	---	-0.004	-0.004
(see paper)			(-0..86)		(-0.58)	(-0.72)
FDI spillover (*unrelated to R&D + sectoral*)	---	-0.134	---	---	-0.183	---
(see paper)		(-0.87)			(-1.15)	
FDI-related R&D spillover (*province level*)	---	---	---	-0.020	-0.019	-0.019
(see paper)				(-3.93)**	(-3.74)**	(-3.69)**
Constant	-0.392	-0.344	-0.337	-0.350	-0.321	-0.333
	(-14.87)**	(-10.97)**	(-11.10)**	(-11.59)**	(-10.25)**	(-10.99)**
Pseudo R^2	0.6421	0.9644	1.0442	1.0053	1.0974	1.0958
Number of observations	8284	8284	7416	7870	7049	7049