ANALYZING THE DETERMINANTS OF R&D, ITS IMPACT ON PRODUCTIVITY AND EFFICIENCY OF FIRMS IN THE TURKISH MANUFACTURING INDUSTRY

A THESIS SUBMITTED TO

THE GRADUATE SCHOOL OF SOCIAL SCIENCES

OF

MIDDLE EAST TECHNICAL UNIVERSITY

BY

ELİF KALAYCI

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE DOCTOR OF PHILOSOPHY
IN
THE DEPARTMENT OF SCIENCE AND TECHNOLOGY POLICY STUDIES

SEPTEMBER 2012

Approval of the Graduate School of Social Sciences

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ABSTRACT

ANALYZING THE DETERMINANTS OF R&D, ITS IMPACT ON PRODUCTIVITY AND EFFICIENCY OF FIRMS IN THE TURKISH MANUFACTURING INDUSTRY

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PhD., Science and Technology Policy Studies

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September 2012, 217 pages

This dissertation consists of three papers revolving around economics of R&D. The first paper analyzes the determinants of R&D expenditures with specific focus on foreign ownership and spillovers; the second paper studies the impact of R&D on productivity and the third paper analyzes whether conducting R&D enables Turkish manufacturing firms to catch up with sector leaders' as far as their productivity levels are concerned. The first contribution of the thesis is the use of newly available data from Turkish Institute of Statistics (Turkstat) . Two different surveys of Turkstat are matched at the firm level for the years 2003-2007. The second contribution is the employment of a new methodology; Heckman two-stage procedure with instrumental variables for panel data. The third contribution is collection of qualitative data via interviews with R&D performing firms. Foreign ownership has no statistically significant effect on R&D intensity. Foreign knowledge spillovers exert a negative effect on R&D, but in time their effect becomes positive. R&D subsidies and skill affect R&D intensity positively while size influences it negatively. The effect of R&D and skill on productivity is positive and significant. The effect of R&D on technical efficiency is negative but knowledge spillovers exert a positive effect on technical efficiency.

Keywords: R&D, foreign knowledge spillovers, productivity, efficiency.

ÖZ

TÜRK İMALAT SANAYİNDEKİ FİRMALARDA AR-GENİN BELİRLEYİCİLERİ,VERİMLİLİĞE VE ETKİNLİĞE ETKİSİ

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Tez Yöneticisi : Doç. Dr. M. Teoman Pamukçu

Eylül 2012, 217 sayfa

Bu tez araştırma geliştirme (AR-GE) ekonomisi üzerine üç ayrı çalışmadan oluşmaktadır.İlk çalışma AR-GE harcamalarının belirleyicileri, ikincisi AR-GE harcamalarının verimliliğe etkisi, üçüncüsü de AR-GE harcamalarının teknik etkinliğe etkisi üzerine odaklanmaktadır. İlk bölümdeki araştırma sorusu yabancı sahipliğinin ve yabancı firmalardan kaynaklanan bilgi taşmalarının AR-GE harcamalarına etkisi ile ilgilidir. İkinci bölümde AR-GE harcamalarının ve yabancı sahipliğinin emek verimliliğine etkisi incelenmektedir. Üçüncü bölümde ise AR-GE harcamalarının ve AR-GE yapanlardan kaynaklı bilgi taşmalarının teknik etkinliğe etkisi üzerinde durulmuştur. Tezin literatüre ilk katkısı Türkiye İstatistik Kurumu ’ndan (TÜİK) kullanılan yeni veri seti olmuştur. 2003-2007 yılları arasında TÜİK’in iki ayrı anketi firma bazında eşleştirilmiştir. İkinci katkı Heckman iki aşamalı prosedürünü enstrumental değişkenler ile birlikte panel veri ortamında kullanmış olmaktır. Üçüncü katkı da AR-GE yapan firmalar ile yapılmış olan mülakatlardır. Yabancı sahipliğinin AR-GE yoğunluğuna istatistiki olarak bir etkisi bulunmamıştır. Yabancı firmalardan kaynaklı bilgi taşmalarının ise AR-GEye olumsuz etkisi bulunmuştur. Fakat zamanla bu etki olumluya dönmektedir. AR-GE destekleri ve eğitimli elemanların da AR-GE yoğunluğuna olumlu etkisi varken firma büyüklüğünün AR-GE yoğunluğunu olumsuz etkilediği gözlemlenmiştir. AR-GEnin ve eğitimli elemanların verimliliğe etkisi olumlu ve istatistiki olarak anlamlıyken, AR-GEnin teknik etkinliğe etkisi olumsuzdur. Fakat yabancı firmalardan kaynaklanan bilgi taşmalarının teknik etkinliğe etkisi olumludur.

Anahtar Kelimeler: AR-GE, yabancı firmalardan kaynaklı bilgi taşmaları, verimlilik, etkinlik

To my son, Ali Dayar

ACKNOWLEDGEMENTS

I am deeply grateful to Assoc. Prof. Dr. M. Teoman Pamukçu for his invaluable academic guidance and encouragement, for supporting me at all times throughout the dissertation. From him I learned that a researcher needs to persevere, be optimistic when faced with mountains of obstacles. I am grateful to him for believing in me even when I was not sure of my pursuit.

I need to extend my heartfelt gratitude to Prof. Dr. Fikret Şenses for his insightful comments. Prof. Şenses always encouraged me and showed me the value of qualitative research. Now I know how a researcher needs to balance quantitative and qualitative methods to be as objective as possible.

My deep gratitude goes to Prof. Dr. Erol Taymaz for opening up new avenues when I felt stuck with econometrics, 'story building'and finding the proper tools. It has been a privilege to have Prof. Taymaz in my advising committee.

My thanks go to Prof. Dr. Erkan Erdil for his constructive criticism. His advice has contributed so much to the last version of the dissertation, I owe him for allowing me the opportunity to carry out the last touches on the manuscript.

I thank Assist. Prof. Dr. Yeşim Üçdoğruk for showing me alternatives to try out when I felt like I have exhausted every other option. She has been awfully kind and understanding. I am honored and glad to get to know her through this work.

This dissertation has been funded by the ARGEDA office of Atılım University. I thank Prof. Dr. Abdülkadir Erden, Selma Dölek Kandemir , Naciye Çakır from ARGEDA office of Atılım University for everything they have done to help me carry out this work. Furthermore, I need to thank Turkstat staff particularly, Nilgün Dorsan, Erdal Yıldırım, Sabit Cengiz Ceylan, İbrahim Cicioğlu for helping me with so many different issues for the last four years at Turkstat laboratory.

I thank my PhD classmates Dr. V. Sinan Tandoğan, Dilek Çetin, Derya Fındık, Dr. Berna Beyhan for their stimulating comments and sharing the agony and fun of writing a dissertation. My friends from Atılım University Assoc. Prof. Mustafa İsmihan, Assist. Prof. S. Mümin Cilasun have been of tremendous support. Assoc. Prof. Ömür Süer, Assist. Prof. Nil Demet Güngör, Assoc. Prof. Aslı Yüksel and Assist. Prof. Eminegül Karababa were my psychological support units uplifting my mood whenever it was down. I need to extend my thanks to my dear friends, Ayşegül Orhan, Reyhan Öztelcan and Ebru Doğruol for helping me out finding firms to interview.

My family has given me tremendous support for the last six years. I am indebted to Zeynep Dayar for standing by me. I thank Havva-Yurdaer Kalaycı, Hatice-Yunus Kurtoğlu, Ayşe-Halit Kurtoğlu, Sevinç-Oktay Yirmili, Hasan-Şeniz Atalay, Mustafa-Hayriye Öz, Yurdanur Elbir and Tahsin Atalay for all they have done for me.

Last but not the least, I owe so much to Ali, my son for his understanding that I had to work so much. I missed so much of time with him when I had to do my academic work, but from now on you are my priority and I hope I can learn to be a worthy opponent in chess for you.

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CHAPTER I

INTRODUCTION

Ever since the First Industrial Revolution in Britain towards the end of the 18th century and the Second Industrial Revolution about a century later in Germany and the United Sates, the role of invention, innovation and technology in economic growth has been found to be key factors (Amsden, 1989). Gerschenkron (1962) argues that while the path to industrialization in Britain relied on invention, Germany and US benefited from innovation. However later industrialized countries, namely, Bulgaria, Italy and Russia took a different road and benefited from the foreign technology of the previously industrialized nations (Gerschenkron, 1962). Studying South Korea, Japan, Taiwan, and Thailand among others as late industrialized nations, Amsden (2001) underscores the importance of ‘borrowed technology’ in the economic development of these countries. From a theoretical point of view, the role of knowledge and investments in technology has been made inter alia in the endogenous growth theory by Romer (1990) who attributed economic growth to investments in innovation and human capital. According to the endogenous growth theory long-term technological progress and productivity growth could be sustained. As knowledge accumulated and spillovers accrued to other firms in the economy, sustained growth could be achieved. Faced with opportunities in the market, firms would try to come up with innovation by investing in human capital, scientific research, and product and process innovations. The research on the effect of R&D on productivity has been by now well established (Griliches and Mairesse, 1990; Hall and Mairesse, 1995; Czarnitzki and O’Byrnes, 1999; Fagerberg et al., 2009; Criscuolo et al., 2010). Nevertheless the effect of R&D on economic growth has also been found to depend on the presence of other factors, such as economic stability, well established institutions such as intellectual property rights and a properly working national innovation system which are hard to find in developing countries (Song 2005; Kothari, 2009). In addition to R&D, other mechanisms have also been reported as affecting economic growth. In the case of late industrialized countries, Amsden (2001) argues the presence of a determined interventionist state extending subsidies to firms building technological capabilities is a vital factor. The exercise of discipline on subsidized firms to ensure their concordance with predetermined rules is also listed as another prerequisite for fighting against corruption and maximizing the likelihood of success on the part of subsidized firms. The presence of a well-educated labor force and close surveillance of the foreign know-how in the world markets are reported as other elements of economic growth based on 'learning' (Amsden, 2001). Therefore even 'borrowed learning' is reported as dependent upon certain preconditions and Amsden (1991) states that she has studied the macro conditions but micro studies are needed to be studied to find out the factors that affect firms' learning and how that knowledge can affect economic growth. Other researchers reviewing the literature on productivity and R&D conclude that "One thing we would like to know more about is the impact of increased R&D in mid-level developing countries" (Hall et al., 2010:34). As a result, we can deduce from the literature that there is a need to study the process of knowledge generation and the effects of R&D on productivity in developing countries particularly from a microeconomic perspective.

As a developing country whose R&D expenditures have been rising in the period 2003-2007, Turkey poses as a well-suited case to study from the point of view of R&D expenditures and their effects on productivity. Turkish Gross Domestic Expenditure on R&D as a percentage of GDP has been around 0,47 % at the end of the 1990s, however, in 2009 this figure had reached 0,85%. Another changing factor within the same time frame has been with the fall in government's share in total R&D expenditure and the rise in the share of the business enterprise sector's. These changes and factors underlying them were what motivated this thesis. Our main area of focus in the first chapter was to analyze the manner in which various firm-level and sector-level factors affect R&D expenditures in Turkey. Although there have been a number of studies on different aspects of Turkish R&D activities (Lenger and Taymaz 2005; Özçelik and Taymaz, 2008; Taymaz and Üçdoğruk, 2009; Pamukçu and Erdil, 2011), all these studies except for the last one were using the pre-2001 period's data. Our first contribution in this thesis happened to be the use of firm-level data from Turkish Institute of Statistics (Turkstat) that became recently available. Two different annual surveys conducted by Turkstat, the R&D survey and the Structural Business Survey were matched at enterprise level to reach a unique dataset for the period 2003 to 2007.[1]

[1] The terms *firm* and *enterprise* are used interchangeably throughout the dissertation.

After a critical review of existing studies on the determinants of R&D, we decided to focus on the effect of foreign ownership and foreign knowledge spillovers that arise at the industrial and spatial levels since FDI and knowledge spillovers have been shown to be two major mechanisms developing countries can use to draw from the global knowledge pool (Pack, 2000; Fagerberg, et. al, 2009; Narula and Guimon, 2010). Therefore our research question in the first chapter was how does foreign ownership and related foreign knowledge spillovers affect R&D expenditures in Turkey? As there were many firms with zero R&D investments in our sample, using the whole dataset would produce biased results (Cameron and Trivedi, 2009) which led us to use the Heckman selection procedure (Heckman, 1976) with panel data. Heckman selection procedure is used when a non-random sample can introduce selection bias in the study. Our use of only R&D performing firms out of all manufacturing companies created a non-random sample which required the appropriate correction for employment of such a sample. Previously, past R&D expenditures have been found to affect current R&D expenditures (Özçelik and Taymaz, 2008; Pamukçu and Tandoğan, 2011) leading to the problem of endogeneity. We employed instrumental variables technique and system GMM method to deal with this problem. Our second contribution happened to be the employment of a new methodology by Semykina and Wooldridge (2010) to correct for selection bias in the presence of endogenous variables within a panel data setting. Our third contribution was the instruments generated for the endogenous variables employed in the Semykina and Wooldridge (2010) procedure.

In the second chapter, we mainly focused on the following two questions: “How does the increase in R&D capital stock affect labor productivity?” and “How do foreign knowledge spillovers affect labor productivity?”. The literature has inconclusive evidence in the case of developing countries with respect to this question (Hall et. al 2010; Kemme et al., 2009; Sharma, 2011). We believe this is an important question to pursue for the case of Turkey, as Turkey has been drawing increased amounts of FDI inflow for the period 2003-2007. While in 2003 FDI inflow as a percentage of GDP was 0,56 %, in 2007 it had risen to 3,41%. We started out by a assuming a Cobb Douglas production function where the dependent variable was labor productivity. We constructed the physical capital stock and the R&D capital stock variables. Again we took advantage of Heckman procedure with instrumental variables in panel data context via employment of Semykina and Wooldridge (2010) procedure. To deal with endogeneity we proposed new instruments and to account for the effect of past productivity on current productivity we employed the system GMM technique.

In the third chapter we examine the impact of R&D on technical efficiency in the manufacturing sector. Particularly, we divide the sample into two as high and medium technology and low technology sectors and study the impact of R&D on technical efficiency for each of these groups. As Narula (2005) indicates “developing countries undertake less than 8% of the formal R&D activities globally…(p.47)”. Forbes and Wield (2000) on the other hand, argue that for the technology-follower countries “the future is already shaped” (p. 1098) pointing to less technical and commercial risks associated with R&D conducted in latecomer countries. Therefore, rather than pushing up the world technology frontier, the R&D activities in these countries may be most likely used to catch up with the leading technology generated by the developed world. As a developing country with rising R&D expenditures, Turkey is a suitable candidate to study this hypothesis. Particularly, “does an increase in R&D intensity affect technical efficiency in high-mid-tech sectors and low-tech sectors?” is the question that is pursued in this chapter. We use the stochastic frontier analysis method with panel data.

In addition to these econometric estimations, we have conducted semi-structured interviews with R&D performers in the Turkish manufacturing sector. As Tandoğan (2011) indicates, there is a need to collect qualitative information on R&D performers as part of the efforts to evaluate their R&D performances because of the R&D subsidies they receive. Therefore our interviews with R&D performers constitute our fourth contribution to the literature. To reach the R&D performers a convenience based sampling has been used. Convenience based sampling facilitates selection of the most easily reached subjects (Marshall, 1996). In our case the preference of convenience based sampling was justified by a lack of financial resources to access a random sample of R&D performers. We were also pressed with time to find these firms; therefore we accessed those R&D performing firms that we could find through our own network of friends and family. A total of 11 R&D performers and three organizations, KOSGEB (the small and medium enterprises development organization), OSIAD, OSTIM Industrial’s and Businessmen’s Association and Techno-entrepreneurship Enterprises R&D Association have been interviewed. We need to underline that the time frame of the econometric estimations and the cross-sectional interviews (performed in October and November of 2011) do not match. Furthermore we do not claim the results of the interviews to constitute a representative picture of R&D performers nor establish a solid link between the quantitative results; nonetheless, they still shed some light and fresh evidence on R&D activities of these firms.

CHAPTER II

HOW DOES FOREIGN OWNERSHIP AND FOREIGN KNOWLEDGE SPILLOVERS AFFECT R&D IN TURKEY?

The significance of knowledge as an essential component of economic growth is by now an accepted fact. Notwithstanding this reality for both the developed and the developing countries, the way of acquiring knowledge as well as mechanisms through which it affects growth differs according to level of development. While the developed world performs cutting edge technological research, the developing world, follows the leaders and tries to learn from them in a number of ways. Forbes and Wield (2000) state that while technology leaders in the developed world move the technological frontier forward with their R&D activities, technology followers in the developing world try to catch up with the frontier by transferring technology from them. As Forbes and Wield (2000, p. 1098) put it "for the technology follower the future is already shaped" because there is an example to follow in the form of a new product. On the other hand, it is not easy for the technology follower to learn and apply this existing technology because the leader may not be willing to provide it. Secondly, even if the technology leader is willing to supply the knowledge, as Teece (1981) argues there is a tacit component of knowledge which makes the transfer of knowledge rather difficult. There is a rather large amount of uncodified knowledge embedded in R&D outputs which requires close interaction between the supplier and the receiver to be transferred. Furthermore the absorptive capacity of the receiver also limits the absorption of such knowledge (Cohen and Levinthal, 1990). Only as much knowledge as comprehended by the receiver can be transferred therefore the accumulated knowledge of the technology follower can be a significant barrier in transferring knowledge. There are also problems stemming from the local conditions of the technology followers when they try to learn from the technology leaders. Most of the time the materials, labor and market conditions may be rather different from those which prevailed when the technology leaders generated the technology (Forbes and Wield, 2000). Sometimes absence of economic stability and institutions such as trust and transparency turn out as other problems the followers need to tackle with in the local markets (Narula, 2005; Kothari, 2009). It is here that the foreign direct investment plays an important role as a bridge connecting these two worlds and facilitates technology transfers or knowledge spillovers from the leaders to the followers. Pack (2000) points out that the successful industrial development of East Asian countries stems from their policy of being open to foreign knowledge. Knowledge transfer through FDI can occur when joint ventures are formed between domestic and multinational firms. Strategic alliances, supplier or customer relationships in supply chains can foster demonstration effects where multinational firms show certain technology and thus encourage the local firms in the backward or forward linkages to undertake their own R&D efforts (Javorcik, 2004). The advanced technology embedded in the machinery and equipment of foreign firms may also have a positive effect on the technology level of the host country (Saggi, 2006; Fu and Gong, 2011). Foreign firms may also bring new management techniques and boost the innovation efficiency of the host economy (Fu, 2008). Labor mobility is another channel through which knowledge gets transmitted from foreign firms to local ones when employees of foreign firms decide to change firms or set up their own ventures (Markusen and Trofimenko, 2009).

However, foreign firms' presence also could act as a competitive pressure in the market. They may drive some local firms out of the market via exploiting their superior technology or by employing the best skilled labor thus depriving particularly the local small firms from such strategic resources (Aitken and Harrison, 1999). Lack of access to such resources could eliminate the domestic firms' R&D activities (Gustavsson and Pohldahl, 2003). On the other hand such competitive activities might induce some local firms to conduct their own R&D to be able to compete with the foreign firm (Fagerberg et al., 2009).

From the point of view of the foreign firms, tough competition from liberalization of markets and rapid technological developments has rendered innovation an essential element for them to survive in the global arena. Facing scarcity and rising costs of skilled labor in their home countries, foreign firms have been looking into developing countries to secure this resource at lower cost. Some MNCs have relocated their R&D activities to India and China (UNCTAD, 2005). Although the changing environment can direct the MNCs' R&D activities more towards the developing world, the benefits from such activities should not be expected to arise automatically for the host country enterprises. There are certain conditions in the domestic market that need to hold before benefits can be enjoyed from foreign firms' R&D activities. Figure 1 presents the interaction of these forces.

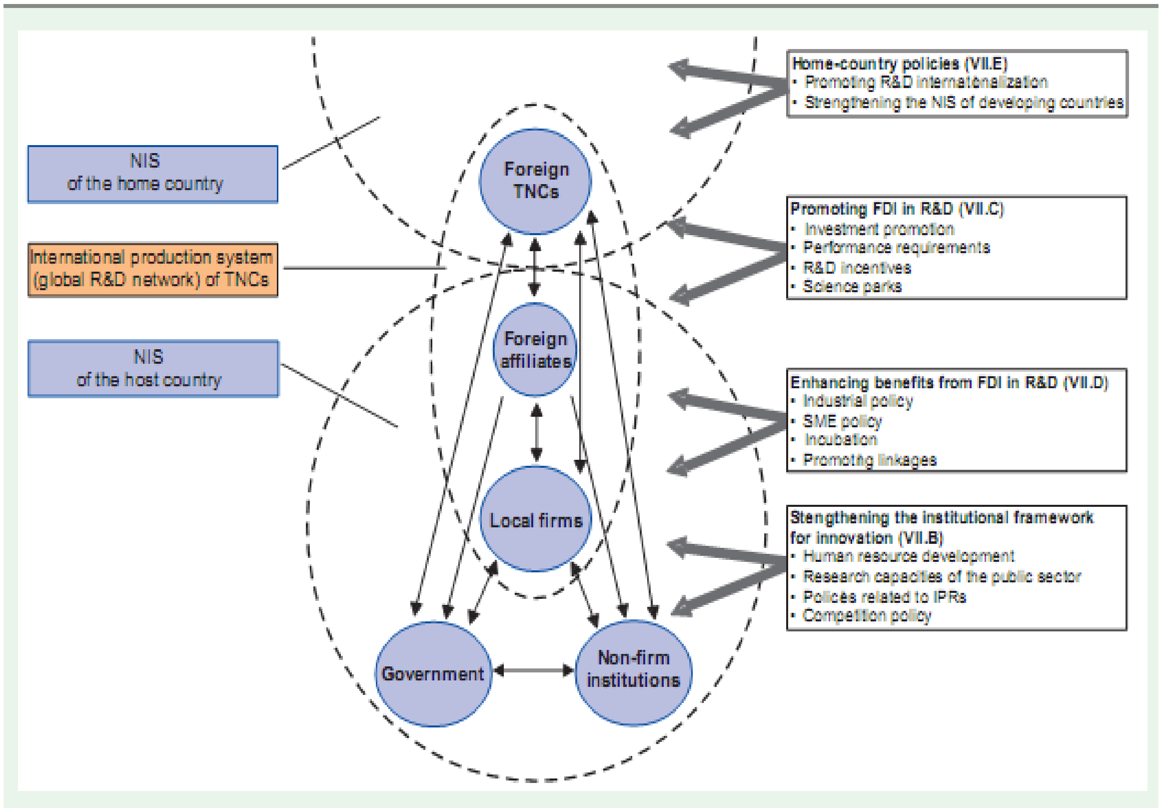

Figure 1: National Innovation Systems and FDI in R&D

Source: UNCTAD (2005)

First of all there needs to be a strong scientific and technological infrastructure in the host country. A determined public sector favoring research and development, soundly established policies towards intellectual property rights and competition are prerequisites for the host country to attract foreign firms with research agenda. Secondly, presence of linkages between foreign and domestic firms is a must. Thirdly, there needs to be clusters around foreign firms so that domestic firms can initiate formal and informal contacts. Particularly for small and medium sized firms liaisons with foreign firms are essential for the generation of clusters. However without strengthening the investment in human capital which in return is based on an established educational system geared towards equipping students with an analytical mindset, team-work ability and among others project management skills, the provision of the above stated items may not be enough to generate an environment where foreign firms can be embedded into the National Innovation System of the host country. Although these may be deemed generic policies of the developed world, the developing countries could use these as starting points in devising their own approaches (Narula and Guimon, 2010). Thus it is essential to study the impact of FDI on emerging countries to see the circumstances in their unique contexts and to come up with policy designs applicable to each case.

As a developing country, Turkey presents a case to be studied on the effects of FDI on its R&D activities. In the period from 2003 to 2007, while attracting higher inflows of foreign capital than before, Turkey also witnessed a rising share of R&D undertaken by its private sector. Seeing the parallel increase in these two areas, we wanted to study the impact of FDI on RD activities of domestic firms in Turkey. Do foreign firms undertake R&D in Turkey directly and thus contribute to the domestic R&D and/or do they generate knowledge pools local firms could draw from? These are the questions that will be tackled in this chapter.

2.1 Background information on FDI in Turkey

The history of FDI in Turkey dates back to 1950 when Law no 5583 which stated that profit transfers to home countries can take place under highly restrictive conditions was enacted (Erdilek, 2005). One year later, Law no 5821 was introduced with the aim of reducing the restrictive conditions but neither of these laws was able to generate the welcoming climate needed to attract foreign investment. In 1954, Law no 6224 titled `Law to Encourage Foreign Capital` was initiated with the intention of providing a more attractive environment for foreign investors. This law eliminated all the restrictive measures of the Law no 5821 but it did not introduce any incentives either (Erdilek, 2005). Thus, from 1950 to 1980 the cumulative authorized FDI only reached $229 million (Öniş, 1994). Other reasons that contributed to the relatively poor FDI performance were red tape (Erdilek, 1982) and the adoption of an import substitution industrialization strategy which aimed at restrictive FDI flows and the role of foreign firms in economic development. After experiencing a severe balance of payments crisis in 1979, the government initiated a stabilization program that 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 of establishing joint ventures with local investors and restrictions on transfer of capital and profits (Erdilek, 1986).

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 all contributed to the development of a favorable environment for FDI throughout the 1980s. However, in the following decade, two major economic crises in 1994 and 1999 as well as heavy reliance on short term capital flows resulted in relatively poor FDI performance. When we look at the 2000s, we see a more favorable environment for foreign investors with a strongly regulated financial system, a low inflation rate and the establishment of a Coordination Council for Improving the Investment Climate (İzmen and Yılmaz, 2009). Following the enactment of the new foreign capital law, Law 4875, in June 2003, minimum capital requirements and permits were eliminated; the ownership of property without any restrictions, the right to international arbitration and employment of expatriates were granted. As a result of these measures there happened a sharp rise in FDI from 0.56 % of GDP in 2003 to 3.8% in 2006. A major portion of the FDI in the year 2005 took place with the privatization of the 55 % of the national telecommunications service provider Turk Telekom and the sale of Telsim to a Dutch firm, Vodafone. In 2006, the sale of two Turkish banks, Denizbank and Finansbank to Belgian and Greek companies contributed to the rise in FDI inflow (Figure 2).

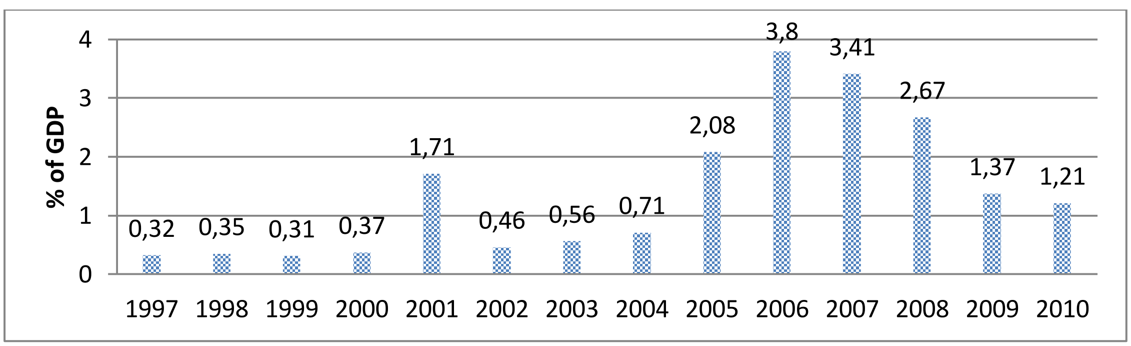

Figure 2. Foreign Direct Investment Inflows to Turkey as a Percentage of GDP,1997-2010

Source: Author's calculations from UNCTAD statistics, 2011.

As far as the sectoral decomposition of FDI inflows to Turkey are concerned, services sector has been receiving the higher portion for the most part of the 2000s. Particularly the financial intermediation sector has been receiving the lion's share from FDI inflows after 2005 (Figure 3). The manufacturing sector on the other hand has received a falling share of FDI between 2003 and 2005 but enjoyed a consistently rising share until 2009. In 2009, manufacturing sector's share from total FDI surpassed that of financial intermediation and energy. The marked decrease in FDI inflow in 2010 could be attributed to the economic recession throughout the world. We need to note that the FDI received by the manufacturing sector increased once again in 2011.

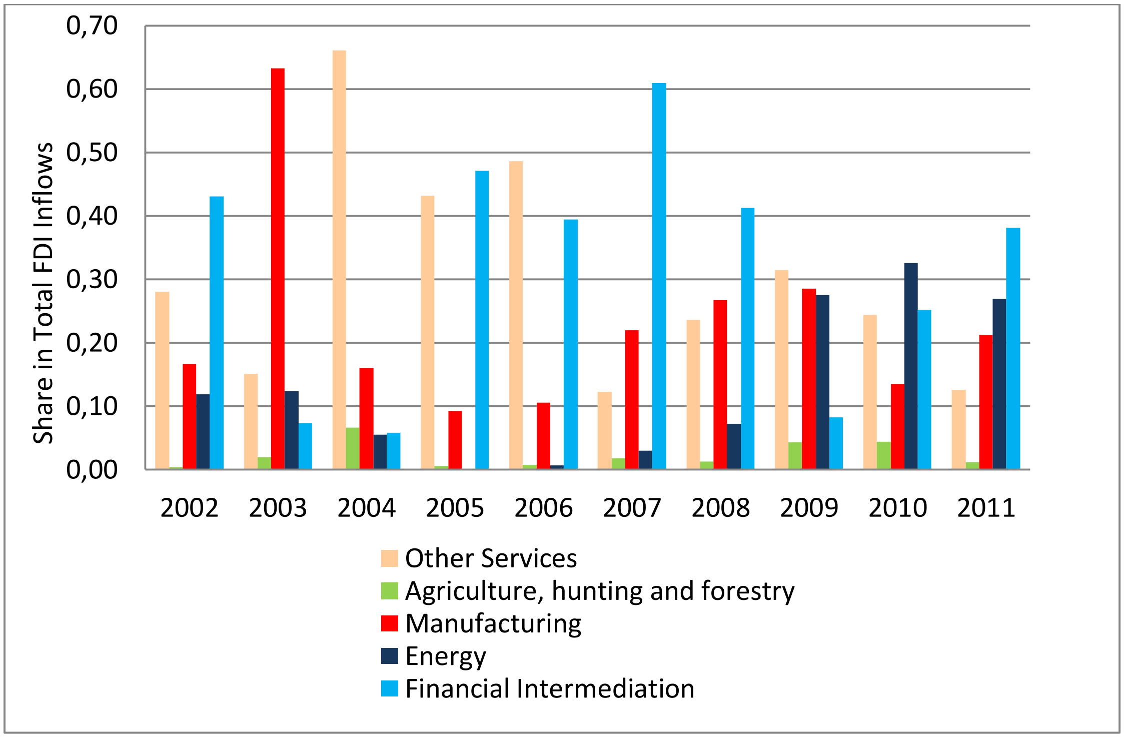

Figure 3: Share of FDI Inflows of the Industrial and Services Sectors in Total FDI inflows to the Country, 2002-2011

Source : Central Bank of Turkey, 2012

Depicting the R&D performance of Turkey in comparison to that of EU27, Figure 4 reveals that up until 2003 Turkish R&D intensity (Gross Domestic Expenditure on R&D as a percentage of GDP) was a bit less than one third of that of the EU27. However from 2003 onwards, Turkish R&D intensity followed a positive growth trend reaching 42% (0.85/2.01) of the EU27 GERD as of 2009.

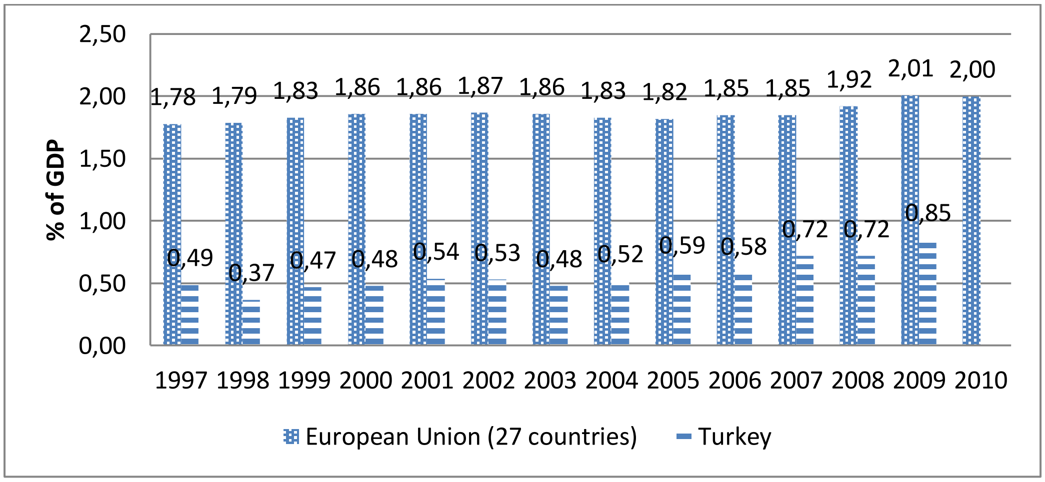

Figure 4. Gross Domestic Expenditure on R&D as a % of GDP in Turkey and the EU27, 1997-2010
Source: Eurostat

During the same time frame another interesting development occurred with respect to the R&D expenditures of the business enterprise sector. Figure 5 presents the share of R&D expenditure of the three main sectors of performance, namely the government, the business enterprise and the higher education sectors. Beginning in 2004, the role of business enterprise sector in R&D activities has increased consistently, and for the first time in 2008, the business enterprise sector began to conduct as much R&D as the higher education sector. However, after the emergence of the economic crisis, the business enterprise sector's R&D expenditures decreased in 2009 only to recover slightly in 2010.

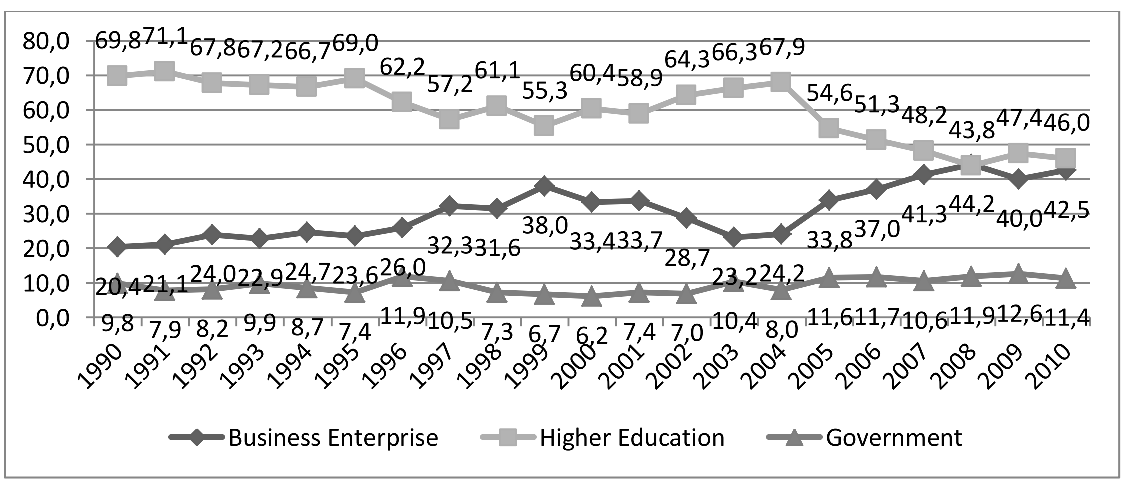

Figure 5 Shares of R&D Expenditures in Turkey by Sectors of Performance (%), 1990-2010
Source: Turkish Institute of Statistics.

The rising role of the business enterprise sector is also visible from Figure 6 where the R&D expenditures financed by the business enterprise sector is presented. While the R&D expenditure of the EU27 financed by the business enterprise sector has been quite stable around 55% of the GERD, Turkish financing by the business enterprise sector has been rising from 36% in 2003 to 48% in 2007. However, after 2007 it has started to fall reaching 41% in 2009.

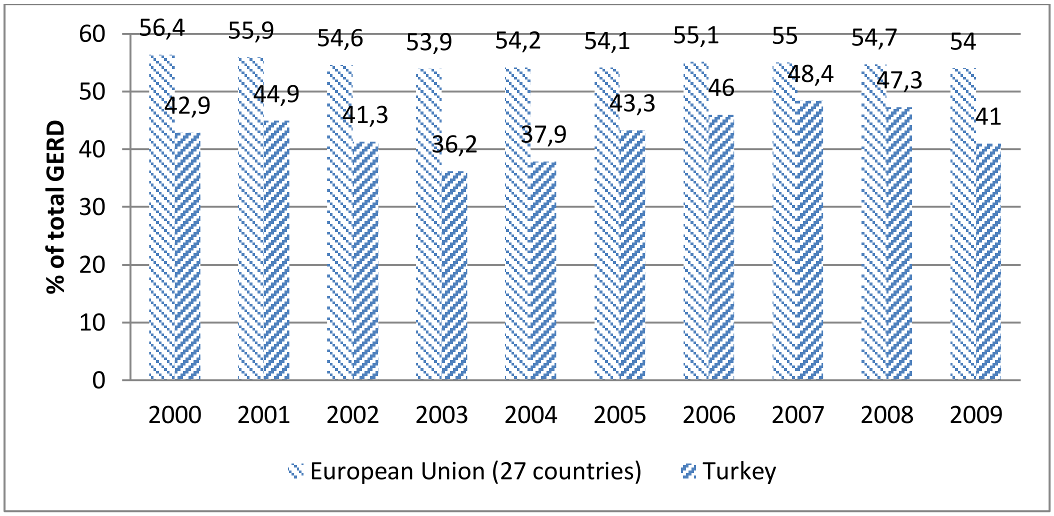

Figure 6: Gross Domestic Expenditure on R&D Financed by the Business Enterprise Sector, 2000-2009

Source: Eurostat (2012).

The rise in the R&D expenditures after 2003 coincides with the increase in the public R&D subsidies. According to Taymaz (2009), the share of public R&D subsidies in enterprise R&D has increased from 1% to 9% between 1996 and 2008. Between 2006 and 2009 the government has started fifteen new policy measures in order to increase private R&D and improve the liaison between universities and industry (Worldbank, 2009). The various subsidies and policy instruments were put to use via the four key organizations, namely, DTM (Under secretariat of Foreign Trade), TUBITAK (The Scientific and Technological Research Council of Turkey), TTGV (Technology Development Foundation of Turkey) and KOSGEB (Small and Medium-size Industry Development Organization) from 2003 to 2006 (Tandoğan, 2011). According to Tandoğan (2011) "During 2003-2006, the most important public R&D incentive was the industrial R&D projects support program that was launched by DTM and the Technology and Innovation support Programs Directorate (TEYDEB) of TUBITAK (Tandoğan, 2011:100)". As far as the rate of increase in the grants handed out by TUBITAK is concerned the acceleration has started in 2004 (Figure 7) and between 2004 and 2010, the grants grew by more than 250%.

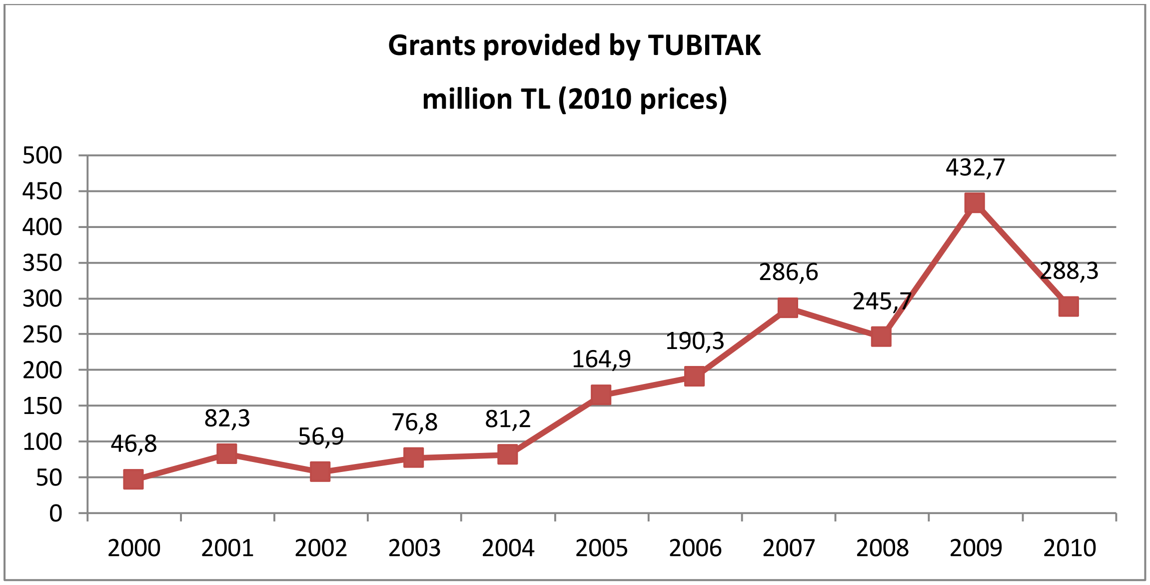

Figure 7: Grants Provided by TUBITAK, 2000-2010
Source: TUBITAK

2.2 Review of Literature on Knowledge Transfer Mechanisms from Foreign Firms

There is a wide empirical literature covering the different channels through which FDI affects local R&D (Saggi, 2006; Smeets, 2008; Fu and Gong, 2011; Narula and Guimon, 2010; Fagerberg, et al. 2009). The most frequently employed performance indicator used as a dependent variable in the econometric studies in that literature is some form of productivity (either labor or total factor productivity). Thus, that literature looks at the effect of FDI on productivity. While doing so, it also uses the different knowledge spillover or knowledge flow channels. However, our concern here is the impact of FDI on R&D activities of local firms. Therefore our performance indicator will be R&D intensity. We will scrutinize the spillovers accruing from foreign to local firms. After a thorough review of the literature Smeets (2008) claims that there are four different ways the presence of FDI contributes to the knowledge accumulation of the host country firms: foreign ownership effect, through competition effect, through knowledge transfer, and finally via knowledge spillover.

Foreign ownership effect: When foreign firms invest in a particular country, they may conduct R&D themselves and, thus, contribute to the total R&D activities of that country. This may take place with a technology-seeking motive. Thus, foreign firms coming into a country may prefer this country for its technological level of advancement which may facilitate their own learning (Kothari, 2009). In the case of developing countries, foreign firms may be conducting R&D with the goal of adapting their products to the local market. Sasidharan and Kathuria (2011) provide evidence for an R&D-promoting effect of FDI for new domestic firms, for the others they report a significantly negative effect.

Competition effect: The presence of foreign firms in the domestic market exerts a competitive pressure on the local firms. However the effect of competition[2] on innovation is not definite. According to Schumpeter (1942) increased competition leads to less R&D because higher profits attract firms to innovate. If an increase in competition lowers the gains from (post) innovation, then firms may undertake less R&D as their monopoly profits will be reduced. Gustavsson and Pohldahl (2003) provide empirical examples of reduced R&D due to competition from foreign subsidiaries. Sasidharan and Kathuria (2011) also find that in India, in low tech sectors, lower competition boosts R&D investment. On the other hand, Scherer (1980) claims competition encourages innovation. The argument rests on the assumption that if firms do not innovate, they will be forced to leave the market and a potential entrant will replace it. Mishra (2007); Sun (2010) and Tingwall and Pohdahl (2011) report empirical cases where competition boosts R&D. Yet there are other studies that claim competition is not a significant determinant of R&D (Lee and Hwang, 2003; Lundin et al., 2007; Czarnitzki and Toole, 2007). In a study on the determinants of R&D investment in the information technology industry in Korea, Lee and Hwang (2003) use the Herfindahl index as an indicator of competition and find that it is not statistically significant. Using data on 925 innovative firms in Germany, Czarnitzki and Toole (2007) study the effects of R&D subsidies on R&D investment and report that competition, measured by the Herfindahl index has no impact on R&D investment. Examining the effect of FDI on competition, measured by price-cost-margin, and the effect of competition on R&D expenditures of Chinese firms, Lundin et al. (2007) report that even though FDI increases competition, competition neither increases nor decreases R&D.

[2] Usually measured via indicators such as the Herfindahl index or the profit margin(Wiel, 2010)

Knowledge Transfer Effect: Through vertical integration with local suppliers, foreign firms get embedded in the host country business environment. When these local business partners comply with the technological demands of their foreign customer, there may occur a knowledge flow from the foreign firm to the local ones. However, what distinguishes this knowledge flow from knowledge spillovers is the fact that this flow takes place voluntarily. In other words, foreign firms choose their suppliers carefully and they expect these firms to keep up with their standards. Therefore, the knowledge flows take place nonrandomly and knowingly. Therefore Smeets (2008) claims this is not an externality because there is an intentional action here. Thus, Smeets (2008) classifies vertical knowledge movement as a 'transfer' not a 'spillover`. The empirical evidence suggests a robust positive vertical 'transfer' effect (Saggi, 2006; Javorcik, 2006; Damijan, 2005; Banri et al. 2010).

Knowledge Spillover Effect: Smeets (2008) claims knowledge spillover is an externality and takes place unintentionally. He underlines the importance of employee turnover for knowledge spillover to happen. In other words, when former employees of foreign firms leave either to move to a domestic firm or to set up their own firms, they carry the knowledge they gain from the foreign firm to the new environment. Their knowledge passes to colleagues and even complementary employees from other firms. Another way that enables knowledge spillovers to take place is the demonstration effect (Saggi, 2006). When local firms reverse engineer and imitate products of foreign firms or through personal contact with engineers, locals learn from foreign firms, unintentionally knowledge spills to these firms. Most likely this effect takes place within a sector so it can be called an intra-industry knowledge spillover effect. While some claim positive spillovers take place from FDI (Sjoholm, 1999, Aw 2001) others conclude knowledge spillovers depend on foreign firms' R&D activities in the host country, that is there are positive spillovers accruing from foreign firms to local ones, if the foreign firms are actively engaged in training their staff and employing highly educated personnel, however there is an absence of spillovers if foreign firms are not performing such activities (Marin and Bell, 2006).

In addition to these four different ways FDI contributes to local R&D, there are two more factors that are deemed as essential in the recent literature for knowledge spillovers to take place. These are absorptive capacity and spatial proximity. Absorptive capacity is created by 'investments in R&D and human capital' (Smeets 2008). There are two main approaches in the literature regarding the role of absorptive capacity or the level of technological skill with respect to the frontier knowledge of the foreign firms. Findlay (1978) claims the higher the technological distance of domestic firms from foreign firms the faster the improvement will be in their R&D because there is so much to catch-up.

The opposing view of Cohen and Levinthal (1990) claims that those firms that are more similar to the leader firms in terms of technological knowledge and skills, will undertake more R&D and will approach to the productivity level of the leaders more rapidly than others. The laggards will reduce their R&D activities. Here the assumption is that the skilled labor will be able to absorb the knowledge spilling from the foreign firm whereas the relatively unskilled labor will not be able to follow course. Some empirical evidence supports this view (Marin and Bell, 2006; Fu, 2008; Karray and Kriaa, 2009; Deng, 2009).

The significance of spatial proximity arises due to the tacit nature of knowledge. While it is rather easy for codified knowledge to travel long distances mainly due to the advancement of information and communication technologies (ICTs), tacit knowledge requires personal interaction to pass from one individual to the next. Here the assumption is that the closer a domestic firm is to a foreign firm the higher the chances of its employees to interact at social contexts and the higher the chances for knowledge to spill from the foreign firm's employees to the others'. Thus, belonging to a group and being geographically close to R&D performers are found to be factors that allow the diffusion of knowledge (Gustavsson and Poldahl, 2003; Todo, 2006; Barbosa and Faria, 2008; Aiello and Cardamone, 2010; Aldieri and Cincera, 2009).

Notwithstanding the theoretical approaches in the literature, the empirical papers on the determinants of R&D include numerous variables depending on data availability. Table 1 in Appendix A presents a sample of the literature on R&D determinants and the independent variables used in those studies.

2.3 R&D Activities of Turkish Firms and FDI

Our point of departure for this study is mostly based on the increased R&D activities in the manufacturing sector. As can be seen from Table 1, three sectors, namely motor vehicles, radio TV communication equipment and machinery and equipment have the highest share of

R&D expenditures consistently from 2003 to 2007. Particularly the R&D activities in the radio and TV and communication equipment sector and the motor vehicles sectors have risen significantly from 2003 to 2004 and then continued to stay more or less at those high levels until 2007. As a matter of fact, these two sectors together have been undertaking more than 50% of all R&D expenditures of the manufacturing industry after 2004. However in terms of growth rates, 'other transportation vehicles' sector has performed the best, starting with a share of 0,28% in 2003 and ending up with a 5,80% in 2007. On the other hand, some sectors have been performing rather poorly in this period. For instance there has been a serious fall in the shares of R&D expenditures of the 'food and beverage' and 'paper and paper products' industries in total R&D expenditures of the manufacturing sector from 2003 to 2004. While R&D expenditures of these two industries have been around 17% and 12% respectively in 2003, they have fallen to very low levels (2,83%, 0,11%) in the following years. Another sector that has had a serious change in its R&D expenditures has been 'other transportation vehicles'. However in this case the change has occurred positively. Their share of R&D expenditures in the manufacturing sector has started off from 0,28% and reached to 5,80% in 2007.

Table 1: Distribution of Total R&D Expenditures in Turkish Economy as per Different Manufacturing Sub-sectors (%)

NACE	*INDUSTRY*	*2003*	*2004*	*2005*	*2006*	*2007*
15	Food and beverage	17,31	3,58	2,14	2,71	2,83
16	Tobacco products	0,00	0,00	0,03	0,00	0,00
17	Textile products	3,35	1,33	2,82	1,64	1,48
18	Clothing ; fur processing and dying	0,82	0,11	0,45	0,17	0,25
19	Leather and leather products	1,17	0,13	0,18	0,16	0,19
20	Wood and wooden products	0,00	0,00	0,03	0,07	0,06
21	Paper and paper products	11,85	0,20	0,18	0,16	0,11
22	Printing and Xeroxing	0,55	0,01	0,00	0,00	0,00
23	Fuel, coal and nuclear fuel	1,93	0,25	0,09	0,03	0,00
24	Chemical items and products	16,24	13,20	10,56	9,03	10,02
25	Plastics and rubber products	5,07	2,43	1,94	1,72	1,58
26	Nonmetallic mineral products	6,33	2,55	2,79	2,38	1,41
27	Basic metal products	0,88	0,63	0,72	0,88	0,51
28	Fabricated metal products	3,90	0,91	0,51	0,50	0,30
29	Machinery equipment	10,69	15,51	13,21	12,19	11,56
30	Office Machinery	0,02	0,10	0,06	0,00	0,00
31	Electrical equipment	5,95	3,35	3,06	2,33	2,16
32	Radio, TV, Communication equipment	3,70	25,71	27,22	24,89	30,65
33	Medical and precision equipment	1,48	1,04	0,51	1,10	0,67
34	Motor Vehicles and trailers	5,85	27,88	29,73	35,43	29,70
35	Other transportation vehicles	0,28	0,38	3,41	4,19	5,80
36	Furniture	2,64	0,68	0,34	0,41	0,71
37	Recycling	0,00	0,00	0,02	0,00	0,00
15-37	*Manufacturing Industry*	100,00	100,00	100,00	100,00	100,00

Source: Turkstat, R&D Survey, various years

In terms of the share of foreign firms' R&D expenditures in total R&D expenditures, which is depicted in Table 2, the leader sector is paper and paper products. While the share of foreign firms' R&D in total R&D expenditures in this sector has started with a 69% in 2003, in 2007 it has reached to almost 95%. The motor vehicles and trailers, electrical equipment, plastics and rubber products sector are three other sectors where foreign firms' R&D expenditures constitute more than 50% of the sector's R&D expenditures. An interesting point to note is the fall of the share of foreign firms' R&D expenditures in total R&D expenditures in the radio, TV, communication equipment, chemical items and products, machinery and equipment and other transportation vehicles from 2003 to 2007.

Table2: Share of Foreign Firms' R&D Expenditures in Total R&D Expenditures in Turkey (%)

NACE	*INDUSTRY*	*2003*	*2004*	*2005*	*2006*	*2007*
15	Food and beverage	3,98	24,77	14,21	30,12	36,30
16	Tobacco products	0,00	0,00	0,00	0,00	0,00
17	Textile products	4,30	34,96	61,95	0,00	0,00
18	Clothing ; fur processing and dying	0,00	0,00	0,00	0,00	0,00
19	Leather and leather products	0,00	0,00	0,00	0,00	0,00
20	Wood and wooden products	0,00	0,00	0,00	0,00	0,00
21	Paper and paper products	69,49	74,55	77,44	79,71	94,82
22	Printing and Xeroxing	0,00	0,00	0,00	0,00	0,00
23	Fuel, coal and nuclear fuel	0,44	2,67	0,00	0,00	0,00
24	Chemical items and products	46,16	37,86	29,51	43,73	27,75
25	Plastics and rubber products	57,60	42,71	59,32	55,41	52,25
26	Nonmetallic mineral products	0,10	1,13	3,27	1,83	3,17
27	Basic metal products	6,76	8,31	15,96	3,81	0,00
28	Fabricated metal products	0,00	0,00	4,12	0,64	9,56
29	Machinery equipment	27,67	12,04	20,70	13,62	18,42
30	Office Machinery	0,00	0,00	0,00	0,00	0,00
31	Electrical equipment	2,73	58,55	58,01	55,33	58,89
32	Radio, TV, Communication equipment	47,51	15,78	30,99	28,98	24,38
33	Medical and precision equipment	23,90	4,99	7,93	2,28	33,47
34	Motor Vehicles and trailers	13,03	54,15	54,80	74,02	67,35
35	Other transportation vehicles	57,10	89,83	54,02	58,66	24,77
36	Furniture	5,62	9,98	18,93	11,88	7,77
37	Recycling	0,00	0,00	0,00	0,00	0,00

Source: Turkstat, R&D Survey, various years

In terms of foreign presence which is measured by the ratio of total employment in foreign firms to total employment in the manufacturing industry, the leading sector by far is the motor vehicles (Table 3). More than 50% of employment in this sector is provided by foreign firms. In the electrical equipment, radio & TV, communications equipment and chemical items industries foreign firms employ about one third of total employees. In the machinery and equipment sector there has been a slight increase in the foreign presence but overall the ratio of employment by foreign firms to all manufacturing sector employment has been around 12% from 2003 to 2007. The increase in foreign presence in the medical and precision equipment is almost 70% from 2003 to 2007, but a parallel increase in the share of R&D expenditures of this sector is not observed (Table 1).

Table 3: Ratio of Total Employment at Foreign Firms to Total Employment in Manufacturing Industry in Turkey

NACE	*INDUSTRY*	*2003*	*2004*	*2005*	*2006*	*2007*
15	Food and beverage	8,78	11,75	11,43	13,15	14,05
16	Tobacco products	15,04	8,95	9,35	38,46	31,62
17	Textile products	3,34	3,22	2,23	1,85	2,01
18	Clothing ; fur processing and dying	4,71	5,06	4,51	4,08	4,12
19	Leather and leather products	0,00	0,00	0,00	0,00	0,00
20	Wood and wooden products	1,62	0,95	1,65	1,30	1,15
21	Paper and paper products	13,78	17,12	17,10	18,11	19,81
22	Printing and Xeroxing	1,97	1,71	0,25	1,35	1,27
23	Fuel, coal and nuclear fuel	83,73	1,27	1,28	1,46	1,44
24	Chemical items and products	31,70	35,19	33,00	36,28	35,16
25	Plastics and rubber products	19,36	20,27	18,76	18,40	15,82
26	Nonmetallic mineral products	5,64	5,60	4,88	5,00	6,67
27	Basic metal products	7,29	6,75	6,79	10,24	6,55
28	Fabricated metal products	5,14	5,50	3,87	5,55	6,90
29	Machinery equipment	12,37	9,99	12,25	11,45	14,51
30	Office Machinery	18,53	16,34	0,00	0,00	0,00
31	Electrical equipment	30,49	32,21	33,96	29,08	30,12
32	Radio, TV, Communication equipment	32,90	30,79	33,39	34,90	36,98
33	Medical and precision equipment	7,79	10,04	5,85	6,43	13,02
34	Motor Vehicles and trailers	39,66	57,32	48,37	54,24	50,29
35	Other transportation vehicles	24,76	26,58	9,98	11,98	10,54
36	Furniture	8,41	10,11	9,29	9,32	9,43
37	Recycling	0,00	0,00	0,00	0,00	0,00

Source: Turkstat, Structural Business Survey, various years

If we measure foreign presence via share of foreign firms' sales in total manufacturing sector's sales, then the leading sector is once again motor vehicles. (Table 4). Radio & TV, communications equipment and tobacco products are the next two sectors with a high share of foreign sales, but as there is no R&D in the tobacco products sector (Table 1), we might as well not take that sector into account. Chemical items and products and electrical equipment sectors are also sectors where foreign firms seem to have considerable share of total sales. Other transportation vehicles sector has a falling share of foreign firms' sales and a rising share of medical and precision equipment and last but not the least the motor vehicles sector is dominated by foreign firms' sales in the market. However, in these descriptive measures as we can observe only relative figures via percentages, the absolute size of these industries and the effects of foreign firms' R&D practices on domestic R&D performers are not taken into account. Therefore a deeper analysis than this simple description is necessary to draw conclusions on the effect of foreign ownership and particularly foreign knowledge spillovers and that is what we will be pursuing in the rest of the dissertation.

Table 4: Share of Foreign Firms' Sales in Total Sales in Turkey (%)

NACE	*INDUSTRY*	*2003*	*2004*	*2005*	*2006*	*2007*
15	Food and beverage	15,80	21,39	17,56	21,96	21,56
16	Tobacco products	50,87	40,12	42,14	68,75	71,06
17	Textile products	3,39	4,57	3,65	1,81	1,84
18	Clothing ; fur processing and dying	5,75	5,67	5,72	5,86	5,45
19	Leather and leather products	0,00	0,00	0,00	0,00	0,00
20	Wood and wooden products	0,80	0,37	1,05	1,01	0,76
21	Paper and paper products	25,49	32,68	31,71	33,01	36,09
22	Printing and Xeroxing	3,85	3,68	0,27	3,32	3,07
23	Fuel, coal and nuclear fuel	98,10	0,11	0,13	0,09	0,10
24	Chemical items and products	37,35	42,73	44,63	42,23	40,87
25	Plastics and rubber products	33,51	33,94	31,89	31,04	28,87
26	Nonmetallic mineral products	13,55	11,67	10,81	11,70	15,11
27	Basic metal products	13,44	13,01	11,34	13,29	11,46
28	Fabricated metal products	14,41	12,25	9,58	14,75	17,42
29	Machinery equipment	28,61	17,38	23,03	19,69	27,53
30	Office Machinery	5,27	4,63	0,00	0,00	0,00
31	Electrical equipment	38,63	47,06	43,72	42,19	42,75
32	Radio, TV, Communication equipment	63,85	46,18	49,56	54,35	60,39
33	Medical and precision equipment	12,15	13,96	9,91	9,65	19,29
34	Motor Vehicles and trailers	68,10	83,08	61,42	79,62	75,57
35	Other transportation vehicles	27,10	27,56	14,84	20,44	12,49
36	Furniture	15,72	16,64	16,70	13,90	13,45
37	Recycling	0,00	0,00	0,00	0,00	0,00

Source: Turkstat, R&D Survey, various years

Before looking at how foreign ownership affects local R&D, one needs to look at the motives of foreign capital to be in the host country in the first place. According to Izmen and Yilmaz (2009), until 1990s, the main motive for foreign business enterprises to come to Turkey was to take advantage of the large domestic market and the cheap unskilled labor. However, in the second half of the 2000s, there has been a change in the motives of FDI in Turkey; realizing the success of the local R&D activities and an increase in the absorptive capacity of domestic partners, some MNEs started to support the local R&D activities and eventually changed their target market from domestic to export. (Çelikel-Tuncay, 2009; Pamukçu and Erdil, 2011)

Thus, we assume that there are two stages in the relationship between FDI and R&D in Turkey. The first stage covers the generation of production capabilities where the local firm goes through a long learning curve which may take decades (Castellani and Zanfei, 2006). During this time, the foreign partner discourages the local partner from undertaking R&D and wants to focus on production only (Celikel- Tuncay, 2009). At this stage, the local firm focuses on production capability and supplier network building which requires significant capital investment. At this stage, main channels of knowledge transfer could be through vertical linkages, via licensing and/or through labor turnover. There is no contribution of the foreign partner to the local subsidiary in terms of R&D capacity building at this stage. Hence, at this phase, predominantly non-R&D-related spillover and transfer channels are in action.

Upon competitive pressures from global markets, the local firms feel the need to start R&D efforts (Castellani and Zanfei, 2006). To augment the knowledge capabilities the local subsidiaries establish links with universities and other domestic research institutions (Castellani and Zanfei, 2006). This marks the beginning of the second stage. After investing decades and resources in their own R&D attempts, the local firms reach a point where their activities are sound enough for the mother firm to acknowledge its absorptive capacity. At this point when the MNE considers the cost of skilled labor of its local partner vis-a-vis its productivity, the domestic government incentives, and the trust built over decades of partnership, it may decide to work with the local partner in R&D projects. It is at this stage that a two-way knowledge sharing takes place (Castellani and Zanfei , 2006); the foreign firm benefits from the local partner's R&D activities and its knowledge of local elements and the local partner learns from the mother firm's knowledge (Celikel Tuncay, 2009; Marin and Sasidharan, 2010)

There are few studies conducted on the determinants of R&D activities of Turkish firms. Using a panel dataset at the establishment level from 1998 to 2007 Üçdoğruk (2009) examines the effect of size on R&D intensity. While she finds that "small firms tend to have higher R&D intensity" (Üçdoğruk, 2009, p.8) she also reports that foreign ownership has no significant effect on R&D intensity. According to her results being an exporter has a negative significant effect on R&D intensity and receiving subsidy has also a positive effect on R&D intensity. In another panel data study Taymaz and Üçdoğruk (2009) use establishment level data for the period 1993-2001 where they focus on the impact of size on R&D activities of manufacturing firms. They find that foreign ownership has no significant effect on R&D intensity and small firms have higher R&D intensity. Furthermore they report that capital intensity, age, skilled labor share and exporting status have no significant effect on R&D intensity. R&D performers' market share has a positive significant effect on R&D intensity. Taymaz and Üçdoğruk (2009) also report that subsidy has a positive significant effect on R&D intensity. Analyzing the effect of R&D support programs in the Turkish manufacturing sector for the period 1993-2001, Özçelik and Taymaz (2008) report that public R&D support affects private R&D investment positively and significantly. Their results also indicate that small firms' benefit more from R&D support and they spend more on R&D investments. Technology transfer comes out to have a positive effect on R&D intensity and lagged R&D intensity also emerges as a significant determinant of R&D intensity. In an unpublished PhD dissertation, Tandoğan (2011) scrutinizes the determinants of R&D intensity of the Turkish manufacturing firms for the years 2003-2006. He reports that foreign ownership has a significant negative effect on R&D intensity. Pamukçu and Erdil (2011) take a qualitative approach and conduct interviews with foreign firms located in Turkey. They aim to find out about the different factors affecting the R&D activities of foreign firms. They report that foreign firms are not integrated enough with their environment in Turkey and they have difficulty in finding skilled staff. Pamukçu and Erdil (2011) conclude that the policies towards foreign capital and R&D are not developed and harmonized considering one another.

2.4 Variable Definitions

As mentioned before, when dealing with R&D firms, there is a selection problem. Since not all firms in the manufacturing sector perform R&D, if we include only the R&D performing firms into our sample we run the risk of choosing a biased sample. Therefore, in order to avoid the selection bias problem, we need to apply Heckman's two stage procedure (Heckman, 1979). First we need to take all firms in the sample to carry out probit regression estimations, in order to study the factors that will be influential on a firm when it decides to conduct R&D or not. Secondly, we need to take only the R&D performers and carry out the second stage regressions to observe the factors that affect a firm's decision on the amount of R&D intensity.[3]

Therefore we have two sets of regressors. Below when we define each variable, those in the selection equation will be depicted with a superscript of S and those in the R&D intensity equation will be depicted with a superscript of O.

[3] A more elaborate description of the Heckman two stage procedure is provided in section 2.6.

Foreign Ownership[s,o]: This variable indicates the amount of foreign capital share in total capital. It is defined as the ratio of foreign capital in total share capital. Our expectation is uncertain, because foreign ownership could have a negative effect, a positive effect or no effect at all on R&D. In case the local affiliate is at production stage under the name of the parent firm, we expect a negative relationship (Tandoğan, 2011), but if it has started R&D activities, the foreign owner may back it up and we could see a positive relationship (Lin and Yeh, 2005, Karray and Kriaa 2009, Kathuria, 2010).

Foreign knowledge spillovers[s,o]**:** Foreign firms' R&D activities create a knowledge pool for those local ones around them. Particularly for those firms in the same sector, the foreign knowledge pool may have a positive effect on local R&D if a number of conditions are met (Fu, 2008). This variable is defined at the four digit sector level. As it is intended to capture the knowledge spillovers from foreign enterprises, the sum of the R&D expenditures of all foreign firms in the market is taken. In order to prevent double counting, firm i's R&D expenditure is deducted from the sum. Then the difference is divided by the sum of all enterprises' R&D expenditures in the sector.

Geographical spillovers[s,o]: Foreign firms located in the same province as the local ones, constitute a source of knowledge which turns into a local knowledge pool from which the firms located within that province can benefit. Inventory management technique is a good example to this type of spillovers. This is also a variable defined at the more aggregate level, which is the province. The sum of all foreign enterprises' R&D expenditures in a province is taken. Then firm i's R&D expenditure is subtracted from this sum to prevent double counting. The resulting difference is divided by the sum of total R&D expenditures at the province. We expect a positive relationship between this variable and R&D because it is easier for knowledge to travel short distances particularly if it is a rather uncodified knowledge (Aiello and Cardamone, 2010; Cincera, 2005)

Absorptive capacity[s,o]: Absorptive capacity indicates the ability of the local firm to learn from the knowledge surrounding it. This variable is defined in terms of a ratio. The maximum value added per employee of the firm j in the sector (at the four digit level) is divided by the value added per employee of the firm i. Then the natural logarithm of this ratio is taken. Since this variable is defined as a distance to the leader in the firm in terms of value added per employee, we expect a negative relationship with this variable and R&D intensity. In other words, as the distance to the leader decreases, the similarity of the firm to the leader increases and we expect a higher R&D intensity from such a firm. (Fu, 2008; Karray and Kriaa, 2009; Deng, 2009; Marin and Bell, 2006; Bogliacino and Pianta, 2010a)

Skill^{S,O}: As an indicator of skill, following the literature, the natural logarithm of the average wage rate is used (Mishra, 2007). The assumption we are making in using wage rate as the proxy for skill is that highly skilled people demand higher wages. Thus, ceteris paribus, higher wages indicate higher skills which may in turn generate higher R&D expenditures. Therefore, a positive relationship is expected (Sun, 2010).

Herfindahl Index^{S,O}: Market structure is an important determinant of R&D because it acts as an indicator of competitive pressure on the firm. Herfindahl index of sales is an indicator of market concentration. (Tingvall and Poldahl, 2011; Sasidharan and Kathuria, 2011; Sun, 2010). Herfindahl index is defined as the sum of the squared market shares of firms in the sector at the four digit level. A low level of market concentration indicates high competition because it shows that there are many firms in the market. In other words, an increase in Herfindahl index means a fall in competition (Wiel, 2010). An increase in competition could induce the firms towards higher R&D expenditures out of fear that they will be driven out of the market if they do not innovate (Tingvall and Pohldahl, 2011; Sun, 2010). On the other hand, higher competition could also lead the firm to reduce its R&D activities (Sasidharan and Kathuria, 2011). This happens if the expected profits from innovation are lower due to the entry of new firms into the market. Thus we do not have a priori expectation regarding the Herfindahl index.

Sector's export ratio^{S,O}: If a firm exports, then it has to face fiercer competition than the non-exporters do. This extra competition motivates the firm to improve its abilities therefore exporters are expected to have more R&D expenditures. However, Sasidharan and Kathuria (2011) and Kumar and Aggarwal (2005) claim exports and R&D could be endogenous. More R&D-intensive firms may self-select in exporting. Therefore to avoid this endogeneity issue, we take export intensity at the four digit sectoral level.

Size^{s,o}: Following the Schumpeterian hypothesis that R&D is a significant sum to incur and large firms can gain economies of scale by engaging in R&D there may a positive relationship between size and R&D. Assuming firms use self-financing for uncertain investment such as R&D, size is certainly an advantage. On the other hand, from the point of view of Pavitt (1984), there may be a negative relationship between size and R&D in certain sectors such as the science-based and specialized suppliers. According to Pavitt (1984) in science-based sectors such as pharmaceuticals and electronics small firms can benefit from the R&D activities of universities and large firms and thus, can create highly R&D intensive products and processes. Specialized suppliers such as high-tech precision instrument manufacturers can also be small in size, but have high R&D expenditures triggered by customer orders. Firms in the scale-intensive sectors tend to be large such as the automotive or the consumer durables sectors due to the high barriers to entry in these sectors. Small firms also lie in supplier-dominated sectors such as textile. Therefore, expecting a certain relationship between size and R&D depends on the type of sector a firm is located in and it is difficult to state a general expectation for the manufacturing sector as a whole.

Capital Intensity^{s,o}: Knowledge may also be embodied in capital and firms buying new machinery and equipment can, thus, gain access to embodied technology. The higher the capital intensity of a firm, the higher could be the R&D expenditures.

Subsidy^{o}: The role of public incentives is certainly very important for developing countries (Karray and Kriaa 2009). The natural logarithm of R&D subsidies received by the firm is used to define the subsidy variable. However, there may be an endogeneity effect of firms receiving subsidy and conducting R&D (Özçelik and Taymaz, 2008). Therefore in order to deal with this endogeneity issue, we make use of two instruments which are introduced at the selection stage: total subsidy in the sector and the technology transfer.

Total Subsidy in the Sector^{s}: Defined as the natural logarithm of the sum of the total subsidy received by all firms in a sector (at the two digit level), this variable is used as an instrument for the firm level subsidy variable. The intuition behind this variable is that as firms in a sector apply for R&D subsidy, those who do not conduct R&D may feel tempted to follow course. This is a result we found in our interview with OSIAD, OSTIM Industrialist's and Businessmen's

Association representative who stated that when firms in OSTIM witnessed other firms receiving R&D subsidies, they felt like they were being left behind. For reasons such as benefiting from the financial support of the grant, firms have applied for R&D subsidies. Although this result can by no means be generalized, it still gives an idea as to how firms are affected from their environment when it comes to decide whether or not to apply for a subsidy and conduct R&D.

Technology transfer[S]: Technology transferring from foreign firms is depicted as one way firms can get access to knowledge. Via licensing foreign technology, firms may try to acquire the knowledge in disembodied form. Such spending includes expenditure on importing product design, processing technologies, blueprints, receipts, patents, etc.. The example of LG as presented in Forbes and Wield (2003,p.114) is a perfect case where licensing seeds R&D capability:

> Although LG had accumulated radio and design and production experience for several years, it was beyond the firm's capability to reverse engineer TVs… thus in 1965 LG found it necessary to enter into a licensing agreement with Hitachi… The agreement included not only assembly processes but also product specifications, production know-how, parts/components, training, and technical experts, transferring a significant volume of explicit and tacit knowledge… [LG] sent seven experienced engineers and technicians to Hitachi for… assimilating and mastering TV production technology…. The engineers held group discussions every evening, reviewing and sharing the literature… their observations, and their training, facilitating rapid learning by the team; they played a pivotal role on their return home.
>
> The next step was to master production technology for color TVs, especially to compete in export markets. After being turned down by foreign firms for licensing technology, LG and two other major firms decided to enter into a joint research contract with the Korea Institute of Science and Technology. The R&D team worked round the clock for two years, searching and mastering foreign literature, reverse engineering foreign color TVs. LG finally developed a working model of its own color TV and mass production began a year later.

One might argue this is a single case study, and, therefore would not be enough to support our argument. However Müftüoğlu and Haliloğlu (2011) cite the case of Sarar, a Turkish textile firm that used know-how from Germany to improve their production technology. After years of learning, Sarar decided to start its own branded product. Today, Sarar exports to many countries and is a leader firm in the domestic market as well. Pack (2000) is another study who states that in Korea and Taiwan the role of foreign technology licensing and the knowledge of citizens abroad who have worked in multinationals are among the key variables of R&D capability building. Based on these findings we claim licensing technology and know-how takes firms through a learning process which gives the firms the courage to undertake R&D themselves, and therefore they may want to apply for R&D subsidy.

Location^{S}: Sasidharan and Kathuria (2011) use a location variable for industrial provinces as an additional variable in the R&D decision function (Sasidharan and Kathuria, 2011). Location is a dummy if the firm is located in İstanbul, İzmir, Ankara, Bursa and Kocaeli and Sakarya and zero otherwise. These are the industrial provinces in general. The reasoning for incorporating such a variable is that if firms are in an industrial province they may have a more favorable environment for an R&D decision since the probability of meeting other R&D performing firms in the province is higher as opposed to less-industrialized provinces.

As sectors are different from one another in terms of the technological opportunities presented due to their underlying knowledge bases; for example chemicals provide higher opportunities for R&D than textiles we take account of these factors by using technological opportunity dummies namely, high-mid tech and low tech dummies. [4] However, we have assumed that a firm belongs to one industry throughout the course of this study; hence these dummies present stable characteristics of each firm. As such, these dummies get incorporated in the fixed effects which prevent us from using them in the fixed effects estimations. Therefore we used these dummies only in the system GMM estimations. Time is another factor capturing the effects of technological advancement and macroeconomic factors affecting all firms. Therefore, their impact is captured by time dummies.

2.5 Data Matching, Cleaning and Data Description

Two surveys from Turkish Institute of Statistics have been used in this study. The R&D and Structural Business Surveys (SBS) from Turkstat are matched at an enterprise level. The data on R&D from the R&D survey is compiled according to the Frascati Manual which defines R&D as

[4] The classification of the manufacturing industries as high-tech, med tech and low tech has been performed following the OECD(2003) definition. A table of the OECD(2003) classification is provided in Appendix B. As there were not enough firms in the high-tech sectors among the R&D performers, we have included the med tech and high-tech category as one versus the low tech category.

“creative work undertaken on a systematic basis in order to increase the stock of knowledge of man and society, and the use of this stock in order to devise new applications” (OECD, 1993, page 29).

The data from the R&D survey was provided by Turkstat for each year on a different file. Therefore before matching the R&D survey with the SBS we first had to link the different years in the R&D survey data to one another on an enterprise basis. In the key provided by Turkstat to link the R&D data files to one another, the identifier for each firm was called ‘BultenNo’. Until 2005 each firm was followed by a different BultenNo, but after 2005 there was a systematic identifier for each firm. When we used this key to match different years’ observations of the same firm within the R&D survey, we saw that firm A in 2003 did not match with firm A in 2005 but matched with another firm in 2005. In other words, using Turkstat’s key to trace R&D performers throughout the years to get a panel data, we ran into a problem of mismatching. A sample of the key provided by Turkstat to identify each R&D firm in the five consecutive R&D data files is presented in Table 5 to indicate this problem better:

Table 5: R&D survey’s key from Turkstat

Bulten07	Bulten06	Bulten05	Bulten04	Bulten03
271735	1735	1631	1381	1381
60273	273	158	215	215
60305	305	549	226	226
342568	2568	3097	1996	1996
342581	2581	2996	2001	2001
354719	4719	4547	3602	3602
354890	4890	5634	2898	2898
343817	3817	1911	2913	2913
10042	42	41	41	41

In the above table the first row lists the BultenNos or identifier numbers for each firm from 2003 to 2007. If we take the second row and read it from right to left, it states that the firm identified as 1381 in 2003 is identified as 1381 in 2004 and 1631, 1735 and 271735 respectively in the following years. In other words, we expect each row to identify a single R&D firm uniquely.

Using this key, we expect to trace each firm in the R&D survey data files from 2003 to 2007. The R&D survey data files are provided separately from 2003 to 2007. In each data file, in addition to the R&D survey data, we also observe a BultenNo for the other years so that each firm can be linked to other years' R&D data files. Table 6 lists two samples from the data files of the R&D survey for 2003 and 2004. To save space we have excluded the data columns and presented only the BultenNo information. As we scrutinize Table 6 under the section with the heading R&D 2003 data file, we see three BultenNos for 2003, 2004 and 2005 respectively. The Bulten03 is the identifier for the year 2003 and Bulten04 indicates that if we go to the R&D data file for 2004, we can find this very firm under the identifier Bulten04. The Bulten05 indicates that if we go to the R&D data file for 2005, we can find this firm under the identifier Bulten05. For instance a firm identified with a Bulten03 as 1381 should be found in R&D 2004 data file under the Bulten04 as 1381 again. Also this same firm can be found in the R&D 2005 data file under the Bulten05 4077. This is where we encounter the matching problem. Following the key in Table 5 taking the firm with Bulten03 as 1381, we expect to see this firm listed as 1381 in the R&D data file of 2004. However, when we look for a 1381 in Bulten04 in the R&D data file of 2004 which is provided in the three columns listed under the heading R&D 2004 data file in Table 6, we cannot find such a firm. Taking another firm from Table 5 with Bulten03 of 3602, which has a Bulten04 of 3602 and Bulten05 of 4547, we expect to find it listed in Table 6 with a Bulten04 as 3602, but cannot find it. However, we realize that there is a firm with a Bulten05 of 4547 in Table 6 and it corresponds to another firm with a Bulten03 of 3515. Thus, there is a mismatching problem in between the R&D data files when we use the key provided by Turkstat.

Table 6: Firm Identifiers as Listed in the R&D Data Files

R&D 2003 data file				R&D 2004 data file		
Bulten03	Bulten04	Bulten05		Bulten03	Bulten04	Bulten05
1381	1381	4077				
219	219	158		-	219	158
236	236	549		236	236	549
1919	1919	3097		1919	1919	3097
1931	1931	2996				
3515	3515	4547		3515	3515	4547
2830	2830	5634		2830	2830	5634
2843	2843	1911		2843	2843	1911

Therefore, the key provided by Turkstat to link the R&D data files could not be employed, however, as we had the different years' BultenNos in the R&D data files, we assumed they were correct. Therefore using those identifiers we generated another key. We took the identifiers for each firm from each year's R&D data file and used the year 2005 as the common identifier to pass from one year's file to another and thus came up with a new key. Anytime one needs to link a data between different years, one needs to have a common identifier in each year's data. Otherwise, the different years cannot be matched correctly. In our case we asked Turkstat which year's identifier would be the best one to use and they stated that 2005 would be the best one. Thus we picked 2005 as the common identifier to pass from one year to the next in the R&D data files. In order to test the validity of our key, we added the number of employees from each year because the number of employees seemed to be a variable with the least variation from one year to the next. Based on these rules, we came up with a key a part of which is provided in Table 7 for information purposes.

Table 7: The New Key Generated from the Firm Identifiers Listed in the R&D Data Files

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2003	2003	2003	2003	2004	2004	2004	2005	2005	2005	2006	2006	2006	2007	2007	2007	2007
emp03	B03	B04	B05	*emp04*	B04	B05	*emp05*	B05	B06	*emp06*	B06	B07	emp07	B07	B06	B05
370	3515	3515	4547	*370*	3515	4547	*310*	4547	4719	*307*	4719	354719	*314*	354719	4719	4547
41	1255	1255	1631	*65*	1255	1631	*69*	1631	1735	*36*	1735	271735	*47*	271735	1735	1631
970	41	41	41	*903*	41	41	*851*	41	42							41
				74	219	158	*97*	158	273	*82*	273	60273	*103*	60273	273	158
22	236	236	549	*37*	236	549	*34*	549	305	*67*	305	60305	*79*	60305	305	549
1264	1919	1919	3097	*1591*	1919	3097	*29*	3097	2568	*3060*	2568	342568	*1629*	342568	2568	3097
250	1931	1931	2996	*256*	1931	2996	*253*	2996	2581	*266*	2581	342581	*280*	342581	2581	2996
4281	2830	2830	5634	*3967*	2830	5634	*3690*	5634	4890	*3794*	4890	354890	*3546*	354890	4890	5634
319	2843	2843	1911	*324*	2843	1911	*298*	1911	3817	*271*	3817	343817	*290*	343817	3817	1911

The new key comprises both firm identifiers and number of employee data for the years from 2003 to 2007. The first row has been numbered from 1 to 17 to indicate the different columns in the table. The columns from 1 to 4 belong to year 2003, columns 5 to 7 belong to year 2004, columns 8 to 10 represent year 2005, columns 11 to 13 stand for year 2006 and finally columns 14 to 17 belong to year 2007. If we take a look at the first four columns, the column number 1 indicates the number of employees in year 2003. B03 is the BultenNo in year 2003, then B04 is the BultenNo of the same firm in 2004 and B05 is the BultenNo in year 2005. Thus, in each year's section the first column lists the number of employees then the identifier numbers are listed.

If we study Table 7 from left to right, we realize that in the first four columns there are only identifier numbers for the years 2003, 2004 and 2005. In the columns from 5 to 7, only identifiers for 2004 and 2005 are provided. However in the columns from 8 to 10 identifiers for years 2005 and 2006 are listed. Moving on to the columns 11 to 13 again, identifiers for the years 2006 and 2007 are presented and in the last four columns identifiers for the years 2005, 2006 and 2007 are provided. Thus studying the table from left to right, it can be observed that BultenNo05 is present in the 2003, 2004 and 2005 columns. Then the year 2005 is used as the bridge linking the first three years to the last two. In other words, year 2007 and year 2006 have the common BultenNo06 information and that BultenNo06 is also present in year 2005. Therefore, using this key, one can first match 2003, 2004 and 2005 with each other. Then 2005 is used to tie 2006 and 2007 with the first three years' data.

Using the new key in Table 7 we again take the firm with the identifier B05 in 2005 as 4547 and see that it matches with the firm identified as 3515 in 2003. The employee figure which is provided under the columns titled emp03-emp07 indicates that the number of employees vary from 370 in 2003 and in 2004 to 310 in 2005, 307 in 2006 and 314 in 2007. Taking the next firm with B03 of 1255 in 2003, we see that its employee figures range from 41 to 65, 69, 36 and 47. Then the next firm with B03 of 41 has a number of employee figure which is ranging from 970 to 851 in the years 2003 to 2005. We also realize there is no information for this firm in years 2006 and 2007. Thus, the pattern in the number of employees is rather stable as we move from one firm to the next throughout the years which to some extent verifies that our key is correct. However, in order to triangulate the correctness of our key, we performed another check.

Turkstat had prepared another key for data users that have started later than we did. We made a random check of our firms with their key and found that all our random check results matched their key. Therefore, we verified that our own key is correct.

Having completed this part, we matched the data with the second key provided by Turkstat to link the R&D survey to the SBS. We added this key to both the R&D data and the SBS data, then using the common identifier in both we matched the two datasets on a year by year basis. At this point we had a total of 92456 observations for the five year period from 2003 to 2007. Since our objective was to study the manufacturing sector only, we eliminated the nonmanufacturing enterprises and lost 43473 observations. Next, we dropped those firms that had less than 20 employees because Turkstat does not visit every firm with less than 20 employees and instead interpolates some observations using the ones collected. In order to be able to use original data, we lost 3565 observations by dropping the ones with less than 20 employees.

The aim with data cleaning is to reach a sample free of outliers so that the sample is as representative as possible of the population. To accomplish this goal, we followed the data cleaning procedures presented in the literature using firm-level data. First of all, following Hall and Mairesse (1995), we dropped those observations that had sales growth rate of more than 3 and less than -0.9. This eliminated a total of 297 observations. Dropping those firms with a value added growth rate of more than 3 and less than -0.9 caused a loss of 4767 observations. Next we got rid of the observations which had a profit margin of less than -1 and greater than 4. This resulted in the elimination of 54 observations. Again following Hall and Mairesse (1995) we tracked those firms with employee growth rate of more than 2 and less than -0.5 and decided to drop these as well which cost us 489 observations. Hall and Mairesse (1995) indicate that this cleaning procedure allows one to include those firms that grow naturally and not via mergers or acquisitions. Next following Aldieri and Cincera (2009) we take a closer look into our variable of interest, the R&D expenditures. We divide R&D expenditures by sales and drop those observations that have an R&D to sales ratio of less than 0,0002 and greater than 0.5. Although these cut off points can be debated, the idea is to follow those firms that can sustain their R&D expenditures. For instance in the data there are such high R&D to sales ratios as 55. Such a high figure especially in manufacturing industry surely casts doubt on its reliability. On the other hand assuming this is a typo, there are still very high figures such as 7 or 5, which are still too high to be sustained throughout the years to come. Therefore although we lose a total of 69 firms due to the cleaning procedure of the R&D expenditure, we are confident that the data left in the sample reflects firms that can represent the population of the R&D performing firms. There is possibly no way one can ever be sure of what the population is like however, if the sample consists of R&D performers, in our opinion one needs to make sure that the R&D to sales ratio is as sustainable as possible. With figures higher than 50% of sales which is already a very high figure itself, it is very difficult for firms to sustain R&D expenditures at this level. Therefore, we believe a maximum of 0.5 as the cutoff point of R&D to sales ratio seems reasonable.[5] The last step that causes us to drop some observations is the lack of the province identifier for 2 observations. At this point we were left with 39740 observations out of which 2278 belong to R&D performers. In Table 8: the data cleaning process is presented for the entire data set and for the R&D performing firms only.

Table 8: Data Cleaning Process I

Total number of observations at the beginning	92456	2499	*Total number of observations for R&D performers at the beginning*
Nonmanufacturing firms	43473		
Firms with number of employees<20	3565		
Sales growth rate <-0.9 or >3	297	7	Sales growth rate <-0.9 or >3
Value added growth rate <-0.9 or >3	4767	124	Value added growth rate <-0.9 or >3
Gross profit margin <-1 or >4	54	2	Gross profit margin <-1 or >4
Employee growth rate <-0.5 or >2	489	19	Employee growth rate <-0.5 or >2
R&D expenditures/Sales <-0.5 or >2	69	69	R&D expenditures/Sales <-0.5 or >2
Missing provincial code	2		
	39740	**2278**	

[5] When we make scatterplot diagrams of the variables with which we apply data cleaning procedures, we can see the outliers easily. These diagrams are presented in Appendix H.

Now we need to mention the other issues that came about due to other variables in the data set. For one thing we had some firms with an export to sales ratio greater than 1. Since such values were not possible we replaced those figures with 1 and saved some data from being lost if we dropped them. The ratio of foreign capital to total capital had figures that were also greater than 1. Following Mairesse and Mohnen (2003), we assigned a value of 1 to these firms as well.

The sector dummy variables were generated following the NACE (Nomenclature générale des Activités économiques dans les Communautés Européennes" (Statistical classification of economic activities in the European Communities) revision 1.1 classification. However, we realized that an enterprise was listed in a number of industries in the same year. Although this is quite a natural result as an enterprise does not necessarily need to operate only in one sector, this was going to cause extra variation in fixed effects regressions. Since a firm usually does not switch industries easily in time, the different industry codes would have caused spurious variation for each firm. Therefore, we took the mode of the two-digit industry codes listed for each firm and assigned the firm to the mode of those industries it was listed at. This ensured that the firm was operating in a single industry and eliminated the spurious variation in fixed effects model. 1623 observations were listed as 'changed' as a result of this action.

Following the literature (Banri et. al 2010), the nominal values such as R&D expenditures, and value added have been deflated by the producers' price index at the four digit NACE level. Only depreciation which was used to calculate capital intensity has been deflated by the capital deflator of the State Planning Organization for the manufacturing sector which is provided as an aggregate deflator for the whole manufacturing sector. As will be described in the methodology section in detail, we will be employing a two-staged approach in the estimations. In the first stage, all firms in the sample will be used, and in the second stage only R&D performers will be included. Therefore we have two sets of descriptive statistics tables. Table 9 and Table 10 present the number of observations and descriptive statistics of the variables used in the first stage and Table 11 and Table 12 provide the outcome stage variables' number of observations and descriptive statistics. As observed from Table 10 R&D performers constitute between 4-7% of all manufacturing firms throughout the period from 2003 to 2007. As the size variable is depicted in natural logarithm terms, taking the antilogs of the figures listed in Table 10, we can say that on the average the manufacturing firms have 60-69 employees from 2003-2007. We can also observe that the average size of a firm grows in this period. Skill level as represented in the forms of natural logarithm of average wage is also rising in the same period. Foreign ownership in all manufacturing firms seems rather stable. The amount of licensing, copyright expenditures on average are on the rise as seen by the technology transfer variable. The decrease in absorptive capacity indicates that firms in the manufacturing sector are approaching to the sector leaders in terms of per person value added. The rise in capital intensity also signals these firms are investing more in capital equipment. The location dummy is an indicator for the ratio of firms located in İstanbul, Ankara, İzmir, Sakarya and Kocaeli. Thus, for the whole manufacturing firms in our sample, we can state about 72 % of them are located in these industrial provinces. As for the sector level variables, we can observe that the mean of the foreign knowledge spillover has been rising signaling the availability of more accumulated knowledge at sector level attributable to foreign firms in the market. Geographic spillover also presents an increasing availability of foreign knowledge at the province level. Manufacturing sectors' export ratio has been rather stable and so is the Herfindahl index, representing the competitiveness in the industries. However, the average amount of total R&D subsidy available to the sectors has increased significantly for the period under study.

When we study the descriptive statistics for R&D performers only (Table 12), we observe that from 2003 to 2007 R&D intensity is on the rise. As this variable is computed in natural logarithm, when we take the antilog, we can see the average per person R&D expenditure of the R&D performing firm ranges between 975 Turkish Lira in 2003 to 1180 Turkish Lira in 2007. The size variable is also in terms of natural logarithm, so after we take the antilog, we can observe that the average size of the R&D performing firm ranges between 152 to 250 people. The average skill level of an R&D performing firm is higher than that of an average manufacturing firm which is rather expected. The mean level of foreign ownership ranges around 10% for R&D performers which is much higher compared to manufacturing firms in the entire sample. The amount of R&D subsidy received by R&D performers also rises for the period of the study. As for absorptive capacity, the R&D performing firms seem to be closer to the sector leaders as opposed to manufacturing firms in general and in time, the distance between the R&D performing firms and the sector leader reduces. In terms of capital intensity, the average R&D performer seems to be larger than the average manufacturing firm, but in time the average R&D performer is also investing in capital equipment just as the average manufacturing firm does. The rise in both foreign knowledge spillovers and geographic spillovers indicate there is increasing amount of accumulated knowledge in the foreign firms in the sector and in the province. R&D performers' sector's export ratio is also stable but at a somewhat higher level than that of the manufacturing firms' average. The Herfindahl index for the R&D performer reveals a stable competitive environment for the average firm in the sample.

Table 9: Selection Stage Variables' Definitions and Number of Observations for All Manufacturing Firms (2003-2007) for Determinants of R&D

Variable	*Definition*	*2003*	*2004*	*2005*	*2006*	*2007*	Total
		Number of observations					
R&D dummy	1 for R&D performers, 0 for others	9208	7808	7772	7618	7334	39740
Size	Ln(employees)	9208	7808	7772	7618	7334	39740
Skill	Ln(wage per employee)	9208	7808	7772	7618	7334	39740
Foreign Ownership	Share of foreign capital in total capital	9208	7808	7772	7618	7334	39740
Technology Transfer	Ln(Licensing expenditures)	9208	7808	7772	7618	7334	39740
Absorptive capacity	Ln(Max value added per worker in the sector/value added per worker of the firm i)	9208	7808	7772	7618	7334	39740
Capital Intensity	Ln(Depreciation/Employee)	9208	7808	7772	7618	7334	39740
Location dummy	Dummy=1 for İstanbul, Ankara, İzmir, Bursa, Sakarya, Kocaeli 0 otherwise	9208	7808	7772	7618	7334	39740
Foreign Knowledge Spillover	[(sum of R&D expenditures of foreign firms in the sector-firm i's R&D expenditures)/sum of R&D exp. in the sector]	9208	7808	7772	7618	7334	39740
Geographic Spillover	[(sum of foreign firms' RD expenditures in the same province as firm *i*- firm i's R&D expenditures)/sum of R&D exp. in the province]	9208	7808	7772	7618	7334	39740
Sector's export ratio	(Total exports in the sector calculated from micro data)/(Total sales of the sector)	9208	7808	7772	7618	7334	39740
Herfindahl	Sum of the squared market shares of firms for the sector	9208	7808	7772	7618	7334	39740
Total R&D Subsidy	Ln(Total R&D subsidies in the sector)	9208	7808	7772	7618	7334	39740

Table 10: Selection Stage Variables' Descriptive Statistics for All Manufacturing Firms (2003-2007) for Determinants of R&D

Variable		*2003*	*2004*	*2005*	*2006*	*2007*
R&D Dummy	Mean	.04	.06	.07	.06	.06
	Standard Deviation	.21	.23	.26	.23	.23
Size	Mean	4.09	4.19	4.23	4.27	4.33
	Standard Deviation	.93	.97	.97	.98	.99
Skill	Mean	8.52	8.73	8.80	8.85	8.87
	Standard Deviation	.55	.52	.53	.54	.55
Foreign Ownership	Mean	.03	.04	.03	.04	.04
	Standard Deviation	.16	.17	.16	.17	.17
Technology Transfer	Mean	.48	.60	.62	1.88	1.82
	Standard Deviation	2.04	2.31	2.37	4.05	4.03
Absorptive capacity	Mean	2.72	2.21	2.13	2.04	1.99
	Standard Deviation	2.39	1.46	1.40	1.33	1.35
Capital Intensity	Mean	5.19	6.19	6.63	6.57	6.40
	Standard Deviation	3.69	3.25	2.77	2.96	3.13
Location Dummy	Mean	.72	.73	.72	.73	.72
	Standard Deviation	.45	.45	.45	.44	.45
Foreign Knowledge Spillover	Mean	.08	.13	.12	.10	.11
	Standard Deviation	.21	.26	.25	.23	.24
Geographic Spillover	Mean	.18	.31	.33	.37	.34
	Standard Deviation	.18	.24	.26	.30	.28
Sector's Export Ratio	Mean	.28	.28	.29	.27	.27
	Standard Deviation	.18	.18	.18	.16	.16
Herfindahl	Mean	.01	.01	.01	.01	.01
	Standard Deviation	.04	.05	.05	.05	.05
Total Subsidy of the Sector	Mean	3.35	4.25	4.67	3.56	5.07
	Standard Deviation	5.29	5.64	5.82	5.54	5.91

Table 11: Outcome Stage Variables' Definitions and Number of Observations for R&D Performers (2003-2007) for Determinants of R&D

Variable	*Definition*	*2003*	*2004*	*2005*	*2006*	*2007*	Total
		Number of observations					
R&D Intensity	Ln(R&D expenditures/employees)	405	464	575	424	410	2278
Size	Ln(employees)	405	464	575	424	410	2278
Skill	Ln(wage per employee)	405	464	575	424	410	2278
Foreign Ownership	Share of foreign capital in total capital	405	464	575	424	410	2278
Subsidy	Ln(R&D subsidies received)	405	464	575	424	410	2278
Absorptive capacity	Ln(Max value added per worker in the sector/value added per worker of the firm i)	405	464	575	424	410	2278
Capital Intensity	Ln(Depreciation/Employee)	405	464	575	424	410	2278
Sector Level Variables							
Foreign Knowledge Spillover	[(sum of R&D expenditures of foreign firms in the sector- firm i's R&D expenditures)/sum of R&D exp. in the sector]	405	464	575	424	410	2278
Geographic Spillover	[(sum of foreign firms' RD expenditures in the same province as firm *i*- firm i's R&D expenditures)/sum of R&D exp. in the province]	405	464	575	424	410	2278
Sector's export ratio	(Total exports in the sector calculated from micro data)/(Total sales of the sector)	405	464	575	424	410	2278
Herfindahl	Sum of the squared market shares of firms for the sector	405	464	575	424	410	2278

Table 12: Outcome Stage Variables' Descriptive Statistics for R&D Performers (2003-2007) for Determinants of R&D

Variable		*2003*	*2004*	*2005*	*2006*	*2007*
R&D Intensity	Mean	6.88	6.79	6.69	6.93	7.07
	Standard Deviation	1.60	1.40	1.42	1.46	1.42
Size	Mean	5.02	5.21	5.27	5.48	5.52
	Standard Deviation	1.22	1.32	1.30	1.34	1.34
Skill	Mean	9.14	9.32	9.35	9.51	9.52
	Standard Deviation	.72	.69	.69	.70	.70
Foreign Ownership	Mean	.09	.10	.10	.11	.12
	Standard Deviation	.26	.26	.27	.28	.29
Subsidy	Mean	1.88	1.69	2.18	2.52	3.47
	Standard Deviation	4.23	4.15	4.58	4.91	5.43
Absorptive capacity	Mean	1.63	1.42	1.43	1.20	1.27
	Standard Deviation	1.48	.96	1.18	1.01	1.23
Capital Intensity	Mean	7.13	7.83	8.07	8.17	8.01
	Standard Deviation	3.23	2.58	1.76	1.86	2.09
Sector Level Variables						
Foreign Knowledge Spillover	Mean	.11	.17	.17	.18	.17
	Standard Deviation	.22	.26	.27	.26	.25
Geographic Spillover	Mean	.20	.31	.33	.39	.36
	Standard Deviation	.18	.23	.26	.30	.28
Sector's export ratio	Mean	.25	.25	.25	.26	.27
	Standard Deviation	.16	.15	.15	.16	.17
Herfindahl	Mean	.02	.02	.02	.02	.02
	Standard Deviation	.09	.08	.08	.09	.07

2.6 Methodology

The first observation one makes when we scrutinize the data is related with the dependent variable. R&D intensity, the dependent variable has too many zeros. This happens because only a subsample of the manufacturing firms conduct R&D which causes what is termed as a selection bias. Selection bias arises due to the nature of the R&D performing process. First a firm needs to decide whether to conduct R&D or not, then it needs to determine the size of its R&D expenditures. Sample selection emerges when some component of the R&D decision is related to the R&D intensity. If the relationship between the decision and the outcome is due to observable factors, then with the inclusion of appropriate variables in the outcome equation, this effect can be controlled for. However if there are unobserved factors affecting the R&D decision and if they are correlated with the unobservable factors affecting the R&D intensity, then there is a relation between the decision and intensity. Only considering the observed factors affecting the R&D intensity would not be enough as there is the additional process affecting the R&D intensity, namely the R&D decision process. Hence, the sample selection bias acts through unobservables and the correlation between the unobservables and the observables.

Thus, first we apply a Heckman selection procedure (Cameron and Trivedi, 2009). Essentially two regressions are performed, one for the R&D decision and the other for the R&D outcome because R&D activities of firms are modeled in two steps. First firms decide whether or not to conduct R&D and in the second step, they decide on the amount for R&D. The decision to undertake R&D is assumed to be a function of expected profits. Those that have positive expected profits are also expected to have R&D investment. Therefore if we assume X to be a vector of regressors that represent the factors influencing the expected profits of a firm, we can model R&D decision. However, the downside of this model is that expected profits are unobservable. On the other hand, what can be observed are realized R&D activities. In other words, we can only observe positive R&D expenditures for those firms that expect positive profits. Thus, we expect significant correlation between R&D and expected profits. Thus, R&D expenditures act as a proxy for expected profits. This means, if our aim is to make a statement about all firms, not only R&D conductors, we need to take into consideration the ones that do not report R&D as well. Let's assume the following:

$$y_i^* = x_i'\beta + \varepsilon_i \, ; i = 1, \ldots\ldots, N \qquad (1.1)$$

$$d_i^* = z_i'\gamma + v_i \;\; ; i = 1, \dots\dots, N \qquad (1.2)$$

$$d_i = 1 \text{ if } d_i^* > 0 \; ; \quad d_i = 0 \text{ otherwise} \qquad (1.3)$$

$$y_i = y_i^* * d_i \;\; ; \qquad (1.4)$$

where y_i^* is a latent variable and y_i is the observed part of y_i^*. d_i^* is also a latent variable and d_i is its indicator function. While N stands for the total sample size, n denotes the subsample when $d_i = 1$. The indicator function indicates when the primary dependent variable is observed or not. In our case, the indicator function signals if a firm performs R&D or not. Equation 1.1 is the primary equation and equation 1.2 is the equation reflecting sample selection; x_i and z_i are exogenous variables. β and γ are unknown parameter vectors, ε_i and v_i are error terms with $E[\varepsilon_i|v_i] \neq 0$. The unobserved error terms ε_i and v_i are assumed to follow a bivariate normal distribution with zero means and variances σ_ε^2 and σ_v^2 and a covariance $\sigma_{\varepsilon v}$. In other words, the unobserved error terms from the primary and selection equations are correlated. Estimation of β only for the subsample with OLS creates inconsistent estimates as x_i and ε_i are correlated because of the correlation between the unobserved error terms ε_i and v_i. Maximum likelihood or two stage estimation procedures are two ways to solve this problem. In the two step estimation the conditional expected value of the primary equation can be written as

$$E[y_i|d_i = 1] = x_i'\beta + E[\varepsilon_i|d_i = 1]; \quad i = 1, \dots\dots.., n. \qquad (1.5)$$

$$= x_i'\beta + E[\varepsilon_i|v_i > -z_i'\gamma]$$

$$= x_i'\beta + \frac{\sigma_{\varepsilon v}}{\sigma_v^2} E[v_i|v_i > -z_i'\gamma] \qquad (1.6)$$

$$= x_i'\beta + \frac{\sigma_{\varepsilon v}}{\sigma_v^2} \left\{ \frac{\phi(z_i'\gamma)}{\Phi(z_i'\gamma)} \right\} \qquad (1.7)$$

Where $\phi(.)$ and $\Phi(.)$ represent the probability density function and the cumulative distribution functions of the standard normal distribution. In other words, the probability density function is said to be “the height of the normal curve evaluated at a certain point” and the probability distribution function is referred to as “the area under the normal curve evaluated at a certain value” (Stolzenberg and Relles, 1997). Thus, the second term in the Equation 1.7 introduces the probability for an observation to be included in the selected sample. The term in the brackets in equation 1.7 is called the inverse Mills ratio (IMR), also known as Heckman’s lambda because Heckman (1979) denoted this variable as $\lambda(z_i'\gamma)$ (Verbeek, 2000). In our case as not every firm performs R&D, IMR reflects the chances of a firm being included among the R&D performing ones. In order to compute the inverse Mills ratio, initially a probit regression is performed over the whole sample where the dependent variable is a dummy taking a value of 1 if y_i is not missing and a value of zero if it is missing. Thus ${}^{\gamma}/_{\sigma_v}$ is estimated for each data case. Then the primary equation's parameters are estimated by including an estimate of the inverse Mills ratio denoted as λ_i into the primary equation. In other words the following equation is estimated:

$$y_i = x_i'\beta + \mu\hat{\lambda}_i + \eta_i \tag{1.8}$$

Where η_i is the error term uncorrelated with the regressors with a mean of zero and $\mu = \sigma_{ev}/\sigma_v^2$. When μ =0, then this represents the absence of a selection bias because this indicates the case that there is no correlation between the unobserved error terms of the primary and the selection equation where Ordinary Least Squares is good enough as an estimator. However, when, μ ≠0 the presence of a selection bias is confirmed (Vella, 1998). To sum up and apply the theoretical explanation to our case, the dependent variable in our first step of the Heckman two stage models is unity if the firm invests in R&D and is zero otherwise. The regressors of the selection equation are the key determinants of the R&D investment decision which are chosen according to the literature on this topic . While Lee (1996) takes size, technology imports and R&D intensity of US industries in the selection stage, Lin and Yeh (2005) prefer size, profitability, sales growth rate, average wage rate, technology imports, firm's age, export intensity, Herfindahl index, market growth rate and industry dummies as the variables to affect R&D decision. Benavente (2006) assumes market share, demand pull and technology push factors, size and sector dummies are determinants of R&D decision. Aiello and Cardamone (2010) use human capital, cashflow, investments in ICT, dummy for exporters, dummy variables for location, and industry dummies as determinants of R&D decision. Cefis (2010) chooses size, age, and technological class to some proxies which reflect factors a firms needs to consider in deciding on R&D such as financial risk, market uncertainties, internal organizational issues and regulatory issues. Worter at al. (2010) employ lagged R&D decision, sales growth rate, size, age, education of employees, and industry dummies as determinants of R&D decision. Harris and Trainor (2009) use size, technological opportunity, ownership, location, absorptive capacity, attitudes and reasons for R&D as both variables that could affect R&D decision and R&D intensity. Abdelmolula and Etienne (2010) classify the factors that affect the R&D decision and intensity into two, the cost factor and the revenue factors. Among the cost factors are technological opportunities, spillovers, market structure, subsidies, size and among the revenue factors are growth in demand and appropriability present. Fang and Mohnen (2009) use dummy variables for foreign ownership and for the large and medium sized firms, market share, industry dummies and location dummies as explanatory variables of R&D decision. Therefore following this literature we choose foreign ownership, size, sector's export ratio, capital intensity, skill, foreign knowledge spillover, absorptive capacity, geographical spillover, the Herfindahl index, total amount of subsidy received by the sector, technology transfer and a location dummy as our explanatory variables for the R&D decision.

For the second stage we again review the literature and find that Gustavssohn and Poldahl (2003) assume sales, the Herfindahl index, capital intensity, human capital, export intensity, profit ratio and dummies to represent government and foreign ownership as factors that influence R&D intensity. Benavente (2006) selects previous R&D expenditures per employee, size, and demand pull and technology push factors are determinants of R&D intensity. Griffiths and Webster (2004) take size, change in industry sales, lagged company profits, lagged debt ratio, local knowledge spillovers, scientific opportunity, profit markup as determinants of R&D intensity. Cefis (2010) takes the effect of previous mergers and acquisitions as another variable that affect R&D intensity in addition to age and size. Fang and Mohnen (2009) choose the ratio of foreign capital to total capital, number of employees, market share, industry dummies, and location dummies as determinants of R&D intensity. Thus, for our second stage, we decide to use foreign ownership, size, sector's export ratio, capital intensity, skill, foreign knowledge spillovers, absorptive capacity, geographical spillovers, the Herfindahl index, subsidy received by the firm as the determinants of R&D intensity.

The number of regressors in the selection equation has to be more than that of the outcome equation because there may be an identification problem. The reasoning follows from the fact that the selection equation is nonlinear and a source of variation that is not dependent only on the regressors could arise. This could affect the probability of positive outcome, which is termed as 'identification through nonlinear functional form' (Cameron and Trivedi, 2009). To eliminate this problem, the number of regressors in the selection equation is kept higher than the number of regressors in the outcome equation. In our case, we use the location dummy variable, the sum of subsidies received in the sector and the licensing expenditures as the additional variables in the decision equation. Location dummy stands for six large industrial provinces: İstanbul, Ankara, İzmir, Kocaeli, Bursa and Sakarya. Following Sasidharan and

Kathuria (2011) we believe the R&D decision of a firm may be affected by being located in one of these large industrial centers, but their R&D intensity need not be associated with their specific locations. As for the sector's subsidies, we believe sector's R&D subsidies could be a factor that may induce a firm towards making an R&D decision for fear of lagging behind competitors. Technology transfer is assumed to be an initial step towards one's own research efforts. A firm could learn via transferring technology such as licensing or know-how and based on that knowledge it may feel courageous enough to undertake its own R&D. (Pack, 2000; Çelikel Tuncay, 2009) Thus with these three additional variables in the selection equation, we avoid the identification problem. However, the Heckman selection procedure described so far is not appropriate in our case because it does not have a time dimension. When we introduce a time dimension in panel data models, we have two main choices of estimation, one is the fixed effects and the other is the random effects. The advantage of fixed effects is that it accounts for the presence of unobserved heterogeneity in the model. In our case this happens to be firms' time-invariant characteristics such as management skills, locational advantages or other such factors which are hard to observe or quantify. Since these effects could affect the independent variables, correlation between the error term which captures the unobserved heterogeneity and independent variables is allowed for in the fixed effects model. Fixed effects model uses within variation and random effects model uses between variation among different firms but assumes no correlation between the error term and the regressors. As this is not a realistic assumption in our case, we cannot use random effects.

Yet, using fixed effects or random effects on its own falls short of employing the Heckman two-step procedure. Although Heckman's approach is widely used for cross sectional analysis, its application for panel data is rare. In the panel data version the Heckman procedure can be termed as in the following model:

$$y_{it}^{*} = x_{it}'\beta + \mu_i + \xi_t + e_{it} \tag{1.9}$$

$$d_{it}^{*} = z_{it}'\gamma + \alpha_i + \psi_t + v_{it} \tag{1.10}$$

$$d_{it} = 1 \text{ if } d_{it}^{*} > 0 \tag{1.11}$$

$$y_{it} = y_{it}^{*} * d_{it} \tag{1.12}$$

Where i, (i=1,……,N) stands for the firm and t, (t=1,…….,T) denotes the years (Vella, 1998). The dependent variable in equation 1.9 which is our primary equation is observed only when the selection rule is satisfied. Now we assume the errors in equations 1.9 ad 1.10 can be divided into an individual effect ($\mu_i$and α_i) a time effect (ξ_t and ψ_t) and an idiosyncratic effect

(e_{it} and v_{it}) where error terms are assumed to be normally distributed and correlated with the corresponding term in the other equation. The time effects are taken as fixed effects and are captured in x_i and z_i. Wooldridge (1995) proposes a way to go about this problem. For each period a probit estimation is performed with regressors z_i and the dependent variable d_{it}. The inverse Mills ratio is computed. Then the following is estimated by fixed effects over the selected sample of observations:

$$y_{it} = \zeta_i + x_{it}\beta + \rho\hat{\lambda}_{it} + \eta_{it} \quad (1.13)$$

The only other issue, we need to deal with is that of endogeneity. Among our independent variables, there is the amount of R&D subsidies a firm receives. This could be an endogenous variable because those firms that conduct R&D may be picked to receive subsidy, or subsidy receivers' R&D performance could induce the government officers to favor those R&D performers for subsidies over others (Özçelik and Taymaz, 2008; Pamukçu and Tandoğan, 2011). Instrumental variable technique can be employed to deal with the endogeneity problem, however, the instrumental variable technique on its own falls short of addressing the two intertwined problems of selection bias and endogeneity but the procedure developed by Semykina and Wooldridge (2010) addresses both of these issues for panel data. When applying Semykina and Wooldridge (2010) procedure which builds on the Wooldridge (1995) approach, one needs to make sure that the instruments used pass all the relevant tests. The first test is the underidentification test which is a Lagrange Multiplier test applied to see if the equation is identified. In other words this test tries to see if the excluded instruments are relevant or correlated with the endogenous regressor. Before describing this test, we need to introduce the variables which are endogenous, exogenous and the relevant instruments.

Let $y = X\beta + u$ where X is nxK and K_1 regressors are assumed to be endogenous and $K - K_1 = K_2$ variables are exogenous.

$$y = [X_1\ X_2][\beta_1'\ \ \beta_2']' + u \quad (1.14)$$

The instrumental variables' set is Z and is nxL. We divide the instruments into two so that L_1 of them are excluded instruments and $L - L_1 = L_2$ instruments are included instruments or exogenous regressors. The goal is to satisfy the order condition for identification which is L ≥ K. This condition states the need that there has to be at least as many excluded instruments L_1 as there are endogenous variables K_1. In other words the rank condition requires that the matrix

Q_{XZ} must have rank K. To test if the rank condition holds or not is equal to testing the rank of a matrix.

$$\text{Ho}: Q_{XZ} = (K-1) \sim \chi^2_{(L-K+1)} \quad (1.15)$$

A rejection of the null indicates that the model is identified. Failure to reject the null means the equation is underidentified (Baum et.al., 2007). However, as Baum, et al. (2007) indicates a rejection of the underidentification tests can disguise the presence of a weak identification problem. Weak identification is a problem that comes about when instruments are weakly correlated with the endogenous regressor. Estimators can perform poorly in case of weak identification. Therefore, next one has to conduct a weak identification test. This is an F version of the Kleibergen-Paap Wald statistic (Kleibergen-Paap, 2006); the null hypothesis is that the estimator is weakly identified which indicates the presence of a large bias. Therefore, one would like to reject the null in order to pass this test. The critical values for this test are the Stock-Yogo IV critical values (Stock and Yogo, 2005).

The last test is that of overidentification. If there are more exogenous variables that can act as instruments for endogenous variable then one should test if the instruments are appropriately independent of the error process and correlated enough with the endogenous variables. Therefore, this test is crucial as it facilitates the evaluation of the validity of the instruments. In this test, the residuals from an IV estimation are regressed on instruments. Under the null hypothesis all instruments are uncorrelated with the error process; the test has a large sample chi-square(r) distribution where r is the number of overidentifying restrictions. In other words, when errors from the IV regression are regressed on instruments, if the instruments are truly uncorrelated with the errors, their coefficients must not be different from zero. Therefore, one wants to fail to reject the null hypothesis. There are two versions of this test. The first one is the Sargan test which is used when error term is assumed to be independently and identically distributed. The second one, the Hansen test is employed when there is heteroskedasticity in the regression. A strong rejection of the Hansen test indicates one has reason to doubt the validity of the instruments (Baum, 2009; Mileva 2007; Baum, et. al 2003). When all these tests validate the suitability of our instruments, one can apply the Semykina Wooldridge (2010) procedure. However, that process does not allow the employment of lagged dependent variable. Yet, R&D could very likely depend on its past values (Griffiths and Webster, 2004; Aiello and Cardamone, 2010). Therefore, we feel the need to include a lagged dependent variable in the regressions. Including a lagged dependent variable introduces first order autocorrelation problem into the regression which can be defined as the correlation between the error terms and is expected to arise when a lagged dependent variable is used. Autocorrelation renders the variances of the Ordinary Least Squares estimators biased (Thomas, 1997), thus we need to look for another estimator which can address both lagged dependent variables problem and arbitrarily distributed fixed individual effects.

Both of these problems are tackled with the system GMM estimator of Blundell and Bond (1998) which is designed for small T and large N panels and suits perfectly to our case. To describe system GMM we need to assume the following model

$$y_{it} = \alpha y_{i,t-1} + \ x'_{it\beta} + u_{it} \tag{1.16}$$

$$u_{it} = \mu_i + v_{it} \tag{1.17}$$

$$E[\mu_i] = E[v_{it}] = E[\mu_i v_{it}] = 0 \tag{1.18}$$

where i indicates firms, t time and x stands for the control variables. The error term has two orthogonal parts: the fixed effects, μ_i, and idiosyncratic shocks, v_{it} . The panel has dimensions N×T, and it could be unbalanced. With difference GMM first differences are taken in order to eliminate the fixed effects and then estimation proceeds. With system GMM, in addition to the differences, levels are also used. Lagged variables in levels instrument the differences and lagged differences instrument the levels. Here one assumes that the past changes in y are not correlated with the current errors in levels, which include fixed effects. As the presence of first order autocorrelation is expected in system GMM, the important point is to be careful about the absence of second order autocorrelation in first differences. The Arellano-Bond test for AR(1) and AR(2) have the null hypothesis that there is no autocorrelation in first differences. Therefore, one needs to fail to reject the Arellano Bond test for AR(2) to be safe from second degree autocorrelation in first differences (Roodman, 2008). To summarize all the different phases of the various estimation methods we employed since the beginning of the study, we provide an illustration in Figure 8 depicting each step. A more detailed description is provided in Appendix C.

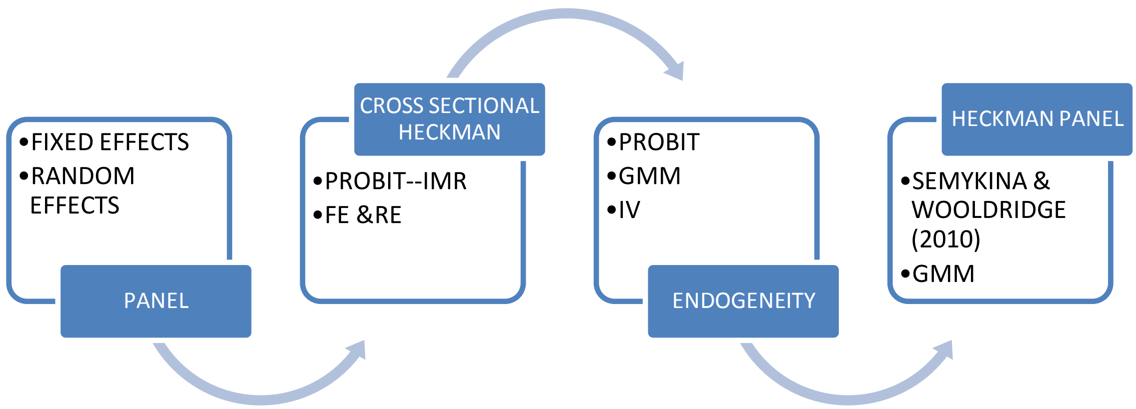

Figure 8: Different Methods Employed Since the Beginning of the Research

2.7 Estimation Results

The results in Table 13 represent the case where the selection bias is disregarded and a fixed effects regression is performed on R&D performers only. While foreign ownership does not have a significant effect on R&D intensity, a number of variables turn out to be significant determinants of R&D intensity. A highly significant negative foreign knowledge spillovers' effect for all R&D performers and for low tech R&D performers is observed but for high-mid-tech R&D performers although the coefficient is negative it is statistically not significant. Another spillover variable, the geographic spillover which captures the spillovers from foreign firms at the province is not significant at the 10% level for all R&D performers nor for the other sub-groups. Among the other variables the amount of subsidy received seems to be a significant determinant of R&D intensity at 1 %level for all R&D performers and for high-mid-tech firms but not for low tech ones.

Other factors being constant, size seems to affect R&D intensity negatively and statistically significantly for all subgroups of firms. Skill happens to be a statistically significant positive determinant of R&D for all R&D performers and for high-mid-tech ones but not for low-tech ones. A surprising result is observed with absorptive capacity. Since absorptive is constructed as the difference of the value added per employee of two firms: the industry leader and a firm in the sample, we expect a negative relation between this variable and R&D intensity. In other words, we expect that as the distance to the leader decreases, the firm bears more resemblance to the sector leader and may have higher R&D intensity. However as observed from Table 13, while our expected result emerges with low-tech-firms, the sign of the absorptive capacity variable for high-mid-tech group is positive but insignificant. This is a rather unexpected outcome. There may be a number of reasons for the unexpected results; one of them may be the ignorance of the selection bias and the endogeneity issue. Therefore next we perform an estimation with two-step Heckman procedure and use instruments for the amount of subsidy a firm receives which we believe could be endogenous with R&D intensity. The amount of subsidy received may be high because a firm already conducts R&D and/or vice versa. We use two instruments for this variable. Following the results of our interviews, we observe that firms follow others who apply for R&D subsidy we believe the total amount of R&D subsidies received by all firms in the sector (at the two digit level) could be a good instrument for firm level R&D subsidy. The second instrument is the amount of licensing expenditures incurred by the firm.

Table 13: Fixed Effects Estimation Results for Determinants of R&D

	R&D performers	High-Med R&D performers	Low Tech R&D performers
Subsidy	0.0437***	0.0526***	-0.0106
	(0.00688)	(0.00743)	(0.0180)
Absorptive Capacity	-0.0143	0.0444	-0.126**
	(0.0443)	(0.0468)	(0.0638)
Foreign Knowledge Spillover (sector level)	-0.585**	-0.401	-1.245***
	(0.257)	(0.281)	(0.453)
Capital Intensity	-0.0261	-0.0284	-0.0160
	(0.0189)	(0.0225)	(0.0346)
Size	-0.799***	-0.903***	-0.690***
	(0.152)	(0.199)	(0.214)
Skill	0.288**	0.493***	-0.271
	(0.137)	(0.153)	(0.228)
Foreign ownership	-0.235	-0.227	-0.141
	(0.251)	(0.267)	(0.638)
Sector's export ratio	-0.147	-0.568	0.888
	(0.496)	(0.543)	(1.283)
Herfindahl	3.968	2.777	10.74
	(4.144)	(4.283)	(16.78)
Geographic spillover	-0.165	-0.129	-0.526
	(0.276)	(0.294)	(0.736)
Constant	8.489***	7.082***	13.05***
	(1.648)	(1.900)	(2.706)
Observations	2,278	1,726	547
R-squared	0.085	0.112	0.129
Number of firms	746	545	200

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Time dummies included.
Dependent Variable Ln (R&D Intensity).

We need to conduct two tests to determine if the instruments we use are appropriate. The first test is the underidentification test. Stata reports the Kleibergen-Paap rk LM statistic for this test (Kleibergen-Paap, 2006). As observed from Table 14, all the Kleibergen-Paap rk LM statistics have a p-value of 0.000 which means we reject the null hypothesis that the equation is underidentified. Furthermore for the weak identification test, we need to take the Kleibergen-Paap rk Wald F statistics' values for all groups and compare them with the critical value from the tables generated by Stock and Yogo (2005). As observed from the Table 14, the values of Kleibergen-Paap rk Wald F statistics' exceed the critical value of 19.93 for all R&D performers, high-mid-tech and low-tech R&D performers. Therefore we reject the null which states there is a weak instrument problem. Finally, with the Hansen test statistics also reveal that our instruments are valid for all R&D performers, high-mid-tech ones and low-tech ones.

In Table 14 we see the results after the Semykina & Wooldridge (2010) procedure (S&W) has been applied. The lambdas are all significant for all R&D performers, for high-mid tech and low-tech firms which indicates that there is a selection bias which is corrected with the employment of the two stage Heckman procedure. Once the S&W procedure is performed[6], the absorptive capacity for all R&D performers becomes statistically significant with a negative sign in line with our expectation. A negative absorptive capacity indicates that for all R&D performers, the closer a firm is to the sector leader, the higher will be its R&D intensity. For the high-mid-tech and low-tech firms, although the sign is negative, no statistical significance is observed. Therefore we cannot draw the same conclusion for the high-mid-tech and low-tech R&D performers. The subsidy variable is still positive for all R&D performers and high-mid-tech firms, but with higher coefficients. Subsidy is observed to affect the R&D intensity of low-tech firms also which was not observed in the fixed effects results previously. The effects of size remains negative and statistically significant indicating the smaller the size the higher the R&D intensity, ceteris paribus. Moreover, skill continues to have a statistically significant positive effect at 1% level for all R&D performers and high-mid-tech R&D performers but not for low-tech firms. As with our main variables of interest, foreign ownership still stays insignificant for all groups of R&D performers and keeps the negative sign. Furthermore a negative effect of foreign knowledge spillovers at the sector level is evident at 1% significance level as well for all R&D performers and for high-mid-tech and low-tech firms. The capital intensity is not significant in any model. This is a finding that has been reported by other researchers in the literature as well (Czarnitzki and Toole, 2007; Tandoğan, 2011). The insignificance of capital intensity may be due to the fact that depreciation may be a poor indicator of physical capital investment and perhaps with the employment of a capital stock variable a better proxy could be employed to observe the effect of physical capital service.

[6] The results of the first stage regressions from the Semykina Wooldrisge (2010) estimation are provided in Appendix D.

Table 14: Panel Heckman Two Stage Estimation Results with IV

	R&D performers	High-med tech R&D performers	Low tech R&D performers
Subsidy	0.0774***	0.0818***	0.0476*
	(0.0155)	(0.0195)	(0.0270)
Absorptive Capacity	-0.0689*	-0.0298	-0.0565
	(0.0401)	(0.0421)	(0.0763)
Foreign Knowledge Spillover	-0.914***	-0.648***	-1.433***
	(0.220)	(0.234)	(0.431)
Capital Intensity	-0.0180	-0.00869	-0.0212
	(0.0191)	(0.0219)	(0.0354)
Size	-0.851***	-0.850***	-0.909***
	(0.141)	(0.177)	(0.223)
Skill	0.404***	0.502***	0.00502
	(0.123)	(0.141)	(0.220)
Foreign Ownership	-0.236	-0.0935	-0.229
	(0.250)	(0.206)	(0.598)
Sector's export ratio	-0.564	-0.905*	0.747
	(0.477)	(0.522)	(1.056)
Herfindahl	2.531	2.678	-5.011
	(4.578)	(4.887)	(16.06)
Geographic Spillover	-0.0717	-0.0687	0.0393
	(0.242)	(0.264)	(0.634)
Lambda	2.169***	1.788***	1.225***
	(0.285)	(0.304)	(0.355)
lam2	-1.225***	-1.306***	-0.665***
	(0.146)	(0.177)	(0.249)
lam3	-1.394***	-1.572***	-0.939***
	(0.151)	(0.185)	(0.266)
lam4	-1.599***	-1.849***	-0.781***
	(0.155)	(0.191)	(0.280)
lam5	-1.392***	-1.592***	-0.583**
	(0.155)	(0.185)	(0.288)
Cons	-5.372***	-2.155	-1.309
	(1.666)	(1.738)	(2.285)
Observations	2278	1726	547

Kleibergen Paap rk LM:	105.98	74.82	32.19
(P value) :	0.000	0.000	0.000
Kleibergen Paap rk Wald F stat:	109.61	75.65	39.65
(Stock and Yogo critical value)	19.93	19.93	19.93
P value of Hansen stat:	0.27	0.67	0.78

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1. Time dummies included.

Therefore next we construct a capital stock intensity variable, as a capital stock measure.[7] The results of this regression are provided in the Appendix E because although the sign of the variable changes from negative to positive, it still remains insignificant.

To see if there is an inverse U type of relationship between size and R&D intensity, we need to include a size squared variable, but the correlation between size and size squared is significantly high (99%) therefore we cannot use size squared. However, we use size dummies instead of the number of employees variable. Defining five size dummies as s1: 1 for firms with employees between 20 and 49, s2:1 for firms with employees between 50 and 99, s3:1 for firms with employees between 100 and 199, s4:1 for firms with employees between 200 and 499 and s5:1 for firms with employees more than 500, we use s1 as the reference category. The results are again presented in Appendix E because as size gets larger the negative significant relationship still prevails.

Another surprising result arises with the sector's export ratio. For the high-mid-tech firm, the sector's export ratio turns out to have a statistically negative impact on R&D intensity at the 10% level. At this point, we believe this result could be arising due to a multicollinearity between foreign knowledge spillovers and sector's export ratio which are both defined at the sector level. Thus, we take a one year lag of foreign knowledge spillovers because it takes time for knowledge to propagate in a sector. In Table 15 we report the results where foreign knowledge spillovers are introduced with a lag. When foreign knowledge spillovers are lagged, their negative significant effect on R&D intensity disappears for all R&D performers and even a positive significant effect at 10% level arises for low-tech R&D performers. As for the high-mid-tech R&D performers, the negative sign remains but it is not statistically significant. The coefficient of the sector's export ratio turns to positive with a statistical significance variable at 10% level for all R&D performers. This result indicates that as the export ratio of the sector a firm operates increases, the R&D intensity of that firm also increases. Firms in industries with high export ratios may have higher R&D intensity because their interactions with other firms in the industry may enable them to tap into the developments in the export markets which may drive them towards R&D investment. This may create a challenge for the firm to improve its

[7] We use the perpetual inventory method to construct the capital stock variable (Meinen et al. 1998). The computation of this variable has been explained in detail in section 3.2.

products even if it may not be exporting itself. Thus, being present in a sector with high export intensity can facilitate the flow of information from the rest of the world and relying on that knowledge the firm can increase its R&D intensity.

While subsidy, size and skill variables keep their coefficient's signs and significance levels, the Herfindahl index turns out to have a statistically significant positive coefficient at the 1% level only for the high-mid-tech R&D performers. This result signals that among the high-mid-tech R&D performers, less competition promotes R&D activity. In other words, concentrated market structure favors R&D intensity for high-mid-tech R&D performers.

Table 15: Panel Heckman Two-stage Estimation Results with IV with Lagged Spillovers

	R&D performers	**High-med tech R&D performers**	**Low tech R&D performers**
Subsidy	0.0393**	0.0364*	0.0151
	(0.0154)	(0.0203)	(0.0268)
Absorptive Capacity	-0.0410	0.0374	-0.101
	(0.0466)	(0.0539)	(0.0622)
Foreign Knowledge Spillover	0.0349	-0.0577	0.682*
	(0.159)	(0.165)	(0.360)
Capital Intensity	0.000364	0.0260	-0.0401
	(0.0249)	(0.0234)	(0.0578)
Size	-0.587***	-0.602***	-0.477**
	(0.147)	(0.190)	(0.229)
Skill	0.513***	0.499***	0.300
	(0.132)	(0.149)	(0.216)
Foreign Ownership	-0.0726	-0.0660	0.162
	(0.210)	(0.222)	(0.358)
Sector's export ratio	0.992*	0.801	0.572
	(0.565)	(0.613)	(1.051)
Herfindahl	-3.276	7.954***	-6.032
	(6.240)	(3.063)	(12.46)
Geographic Spillover	0.244	0.138	0.344
	(0.187)	(0.204)	(0.447)
Lambda	1.530***	0.895***	0.448
	(0.335)	(0.336)	(0.335)
lam2	-0.279**	-0.388**	-0.304*
	(0.122)	(0.159)	(0.164)
lam3	-0.495***	-0.672***	-0.141
	(0.126)	(0.166)	(0.163)
lam4	-0.343***	-0.533***	0.0661
	(0.131)	(0.162)	(0.201)
cons	-7.195***	-2.113	-1.354
	(2.106)	(1.972)	(2.316)
Observations	1807	1364	439

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Time dummies included.

So far no distinction has been made between domestic and foreign firms which are defined as firms 10% and greater share of their capital belonging to foreign firms. In order to see if there are knowledge spillovers from foreign to domestic firms we need to isolate the domestic firms. In Table 16, the results of the S&W (2010) procedure are presented for domestic R&D firms.

Table 16: Panel Heckman Two-stage Estimation Results with IV for Domestic R&D Performers

Subsidy	0.0787***	0.0357**
	(0.0161)	(0.0167)
Absorptive Capacity	-0.0621	-0.0444
	(0.0412)	(0.0491)
Foreign Knowledge Spillover	-0.835***	
	(0.237)	
Foreign Knowledge Spillover(lagged)		0.0814
		(0.171)
Capital Intensity	-0.00915	0.00269
	(0.0199)	(0.0259)
Size	-0.934***	-0.752***
	(0.150)	(0.155)
Skill	0.468***	0.567***
	(0.134)	(0.138)
Sector's export ratio	-0.753	
	(0.527)	
Sector's export ratio(lagged)		0.587
		(0.564)
Herfindahl	1.921	-4.573
	(5.096)	(6.159)
Geographic Spillover	-0.0976	
	(0.253)	
Geographic Spillover(lagged)		0.139
		(0.200)
Lambda	1.878***	1.402***
	(0.285)	(0.333)
lam2	-1.081***	-0.188
	(0.152)	(0.123)
lam3	-1.184***	-0.379***
	(0.156)	(0.121)
lam4	-1.354***	-0.223*
	(0.164)	(0.130)
lam5	-1.137***	
	(0.162)	
Constant	-3.765**	-6.310***
	(1.621)	(2.132)
Observations	1939	1538

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Time dummies included.

The first column in Table 16 represents the results of the Semykina-Wooldridge (2010) procedure for domestic firms while the second column presents the same estimation with the introduction of a one year lag for foreign knowledge spillovers and geographic spillovers. For domestic R&D performers there is a selection bias one needs to correct for which is evident from the significance of all lambdas in the first column. Subsidy seems to have a statistically significant positive effect on R&D intensity at 1% level. Although the absorptive capacity carries a negative sign, it is not statistically significant at 10% level. The effect of size keeps on having a negative effect on R&D intensity at a statistically significant level of 1% for domestic R&D performers. Skill is found to affect R&D intensity positively and statistically significantly at 1% level for domestic firms as well. However, a highly significant foreign knowledge spillover arises as a negative factor affecting R&D intensity for domestic R&D performers. Although another negatively affecting factor comes out in the form of geographic spillovers, it is not statistically significant at 10% level. On the other hand, when we take a one year lag for the spillover variables, while the signs of subsidy, skill and size continue to remain as they are, the foreign knowledge spillovers start to have a positive coefficient, though not statistically significant.

In order to see if the R&D performers that have a high absorptive capacity may benefit from the foreign knowledge spillovers positively, we interact these two variables, however, after correction of standard errors for the use of an interaction term, the result does not change. The results are exhibited in the Appendix E.

So far, we have not considered the possibility that current R&D intensity can be a determinant of future R&D intensity (Griffiths and Webster, 2004; Vakhitova and Pavlenko, 2010; Fu and Gong, 2011). Since the introduction of this variable brings in a lagged dependent variable into the model, the Heckman procedure of Semykina and Wooldridge (2010) cannot be employed to tackle this issue. Thus, we prefer to use the system-GMM approach to deal with the endogeneity of the dependent variable and the endogeneity of the other firm-level variables. Using second and further lags of the dependent variable, the R&D intensity and the firm-level variables of skill, size, absorptive capacity, foreign ownership and taking the sectoral level variables as predetermined we conduct the system-GMM regression. However, the results of the system–GMM estimation turn out rather poorly, with only the lagged value of R&D

intensity and skill as the statistically significant variables, therefore we do report them in the Appendix G.

2.8 Discussion of estimation results

Our results reveal that foreign ownership has a negative but statistically insignificant effect on R&D intensity. This is a result also supported in the literature (Pamukçu 2003, Dachs and Ebersberger,2009; Karray and Kriaa, 2009; Fu et al., 2010; Sasidharan and Kathuria, 2011). The results from our interviews reveal a glimpse of how that negative (but insignificant) effect may be arising. Although our interview results are not representative of the R&D performers' sample in any way, we believe they may offer some hints about the impact of foreign ownership on R&D. One textile manufacturer firm stated that they are the licensee of their mother firm which is foreign and their mother firm does not want them to perform R&D. Despite the unwillingness of the mother firm, the Turkish side has decided to launch R&D activities and are planning to set up a separate R&D facility in the future. They state that being a licensee and a subsidiary of a foreign company hinders their R&D process but they also foresee that without an R&D department they will not be able to compete successfully in the future. Thus, in this specific case foreign ownership seems to have prevented R&D for a while, but due to the persistence of the local firm, they have started investing in R&D and will be pursuing more in the future. Another finding in the literature also backs up our results in the interviews. Performing a qualitative study on the effect of privatization on R&D expenditures Ansal and Soyak (1999) report that two state-controlled firms which were technologically quite capable to develop new products on their own were privatized and with the new foreign owners they started to transfer technology from the parent company and perform only subcontracted R&D projects in line with the parent firm's goals. Thus, although our econometric results do not reveal a statistically significant outcome for foreign ownership, the negative sign that emerges persistently seems in line with the findings of our interview results and those of the literature (Ansal and Soyak, 1999).

Our results indicate there is a negative knowledge spillover effect from the foreign R&D conductors at the sector level to R&D performers. Domestic R&D performers also conduct less R&D when the foreign knowledge spillovers at the sector level increases. This is a finding that has also been reported in the literature. (Konings, 2001; Barrios et al, 2004; Karray and Kriaa, 2010). Such an effect can be due to the asset-exploiting intention of the foreign R&D performers in the market. As Narula and Zanfei (2005) indicate if a foreign firm aims to improve its assets' utilization in the host country conditions, then there will not be much of a positive externality in the environment. Foreign firms could undertake R&D with the goal of adapting their technologies, products or processes to the local needs which may arise due to consumer tastes or laws and regulations. Such an intention is termed as an "asset-exploiting" type of behavior (Narula and Zanfei,2005). As opposed to the "asset-augmenting" aim where the foreign firm wishes to pursue R&D activities to create a competence while benefiting from the knowledge available locally, the asset-exploiting aim does not necessitate the movement of trained R&D staff from the headquarters to subsidiaries. There is less of a need to make joint ventures with domestic firms or subcontract projects to local research institutions who could later pass on newly acquired knowledge to other domestic firms. Furthermore, according to Marin and Sasidharan (2010) asset-exploiting foreign firms are more likely to have a market-seeking goal and therefore they may have a market–stealing effect (Aitken and Harrison, 1999). This explanation seems to suit our results because when we introduce foreign knowledge spillovers with no lag structure, the negative effect prevails significantly but once the lag is introduced, the negative sign turns to positive though insignificant for all R&D performers. This finding could be due to the competitive effect exerted by the foreign firms in the market which later turns to a positive externality as the same foreign firms get embedded in the economy. Using a lag for knowledge spillovers captures the effect of time it takes for spillovers to travel from foreign firms to the others. The positive foreign knowledge spillovers' effect on R&D intensity observed for low-tech R&D performers could be attributable to the complementarity between the external and internal R&D activities in low-tech R&D performers (Nieto and Quevo, 2005; Karray and Kriaa, 2010). In our interviews with R&D performers, some stated that they look at the foreign firms 'products, get information from their publicly available materials or learn about them from customers. They also examine their test procedures and test reports. Therefore the findings of our interviews corroborate the existence of positive foreign knowledge spillovers. However, the insignificance of positive foreign knowledge spillovers in the high-mid tech sector could be attributable to the longer time it takes for knowledge to travel in this more knowledge intensive sector.

As far as geographic spillovers are concerned even though we could not find any statistically significant results, one point is worth underlining. Before the introduction of the lag, geographic spillovers had a negative sign for all sub groups of R&D performers but once the lag was introduced, the sign turned to positive. One reason for the insignificant results could be the definition of geographical regions which were administrative provinces in this study. Another reason could be the short time span. Had we had a longer time dimension to allow us to introduce further lags we may have found different results regarding geographic spillover effects. This is one area where future research can be built upon.

Skill is essential for R&D activity (Van Dijk et.al., 1997).The higher the skill level in a firm, the higher is the R&D intensity (Piga and Vivarelli, 2007). In our case this result holds true for R&D performers in general but not for low tech ones. Again, our interviews found supporting results. For instance a firm performing cutting edge research and turning it into products patented to be sold all over the world indicated that, they had trouble finding skilled labor. Most of the other interviewees stated that they solved their skilled staff problem by establishing links with university professors on a project basis or by hiring them as consultants. Thus, skilled labor is depicted as a scarce resource for R&D performers in the manufacturing industry.

Size is another variable that consistently comes up as significant and negatively related with R&D intensity. As size gets smaller, other things being constant, R&D intensity rises negating the Schumpeterian hypothesis that larger firms have higher R&D activities. This is an interesting result but there are other studies that come up with similar findings (Ogawa, 2007; Taymaz and Üçdoğruk, 2009; Lundin et al., 2007). Studying the pharmaceutical industry in Asia, Mahlich and Roediger-Schluga (2001) find evidence supporting the U-shaped relationship and explain that the 'radical improvements in R&D productivity' necessitate scientific excellence which is provided by small and highly focused firms.[8] This is a result that we find in our interviews as

[8]"p.7: Accordingly the most efficient way to currently conduct pharmaceutical R&D may be a new division of labor' in research between small, highly specialized firms conducting research and large firms focusing on the development, testing and marketing new drugs. … The relevant knowledge base becomes more and more scientific, i.e. codified. This implies that knowledge can be 'assembled' piece by piece and is tradable via market transactions which in turn affect the market structure in that it will no longer be necessary for research intensive firms to possess and master all the downstream tasks necessary to bring a drug to the market. Instead companies can make use of specialization gains and economies of scope. Indeed empirical evidence suggests that an increasing number of projects in the early research phase are contracted out by incumbent companies to young biotechnology startups.

well. An interviewee from a private R&D firm that performs several million TL worth projects ranging from autonomous underwater vehicles to inside-mouth imaging devices indicates that they use subcontractors in order to benefit from “expert knowledge”. The wide spectrum of this firm’s research areas demand knowledge from diverse backgrounds therefore they find working with subcontractors rather convenient to acquire expertise. Subcontractors could be small firms focusing on specific areas in R&D which could explain the negative effect of size on R&D intensity.

Subsidies are found to affect R&D intensity positively (Czarnitzki and Toole, 2007). Small firms with small resources need to rely on subsidies to realize their R&D activities. Most of the R&D performers interviewed indicated that they certainly needed subsidies to carry out these projects. A few claimed in the absence of subsidies, they would still carry out their projects, but it would take longer. One large firm indicated that they could not have undertaken R&D projects if they had not received subsidies as their R&D budgets started from one million lira. These results point out that the Turkish manufacturing industry is still hungry for subsidies in order to increase R&D intensity.

The export intensity of a sector has a positive effect on R&D intensity of an R&D performer. In the literature firm’s export intensity is found to have a positive association with R&D (Lee, 2003; Kumar and Aggarwal, 2005; Parameswaran, 2009; Mishra, 2007). Firms in industries with high export ratios may have an information advantage over other firms that produce and sell for the domestic market. Those firms in an exporting sector via their interactions with other firms in the industry may be informed about the developments in the export markets. This may create a challenge for the firm to improve its products. Forbes and Wield (2000) state the importance of R&D departments as knowledge-gate keepers of the firm. Thus, being present in a sector with high export intensity can facilitate the flow of information from the rest of the world and relying on that knowledge the firm can increase its R&D intensity. One of our interviewees in the machinery manufacturing sector stated that their attendance to international fairs have had tremendous impact on their learning as they had the opportunity

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Biotechnology firms succeed in supplying innovative activity while the large enterprises whose core competencies are in marketing, and in coordination and organization of the R&D networks serve ‘merely’ as developer.” (Machlich and Roediger-Schluga, 2001:7) to observe leading products and they accelerated their R&D activities in order to achieve the leading technology level. However, as our findings with size suggest, small firms tend to have high R&D intensities. It may be the case that these small firms may not feel strong enough to export so they may be relying on other exporters in the industry to benefit from their knowledge.

Past R&D intensity is a significant positive determinant of current R&D intensity. This is a result for which we find support in the interviews we conducted with some R&D performers in the manufacturing sector. They claim that when they start an R&D project, it opens up new channels of research, generates new ideas to be pursued; therefore having experience in R&D certainly boosts further R&D investment. When asked if they had any failed R&D projects, none of the firms answered affirmative. While this may be due to “not to seem unsuccessful” on the one hand, it may also be attributable the fact that they believe sooner or later these projects will pay off either in the form of new customers or as new products. Thus the R&D performers are rather optimistic about the potential outcomes of their R&D projects and therefore would like to carry on with their R&D efforts, which may explain for the increase in R&D intensity. Furthermore as two interviewees from two firms point out carrying out R&D projects have taught them how to track the paperwork of an R&D project, which essentially enables a firm to evaluate the project by pinpointing the failures and the successful trials thus indicates the path to success. This may be one of the reasons for R&D veterans to have high R&D intensities.

CHAPTER III

THE IMPACT OF R&D ON PRODUCTIVITY

The significant role of R&D activities on firm productivity is a general finding in the R&D literature (Griliches,1979; Lööf and Heshmati, 2006; Rogers, 2006; Luintel et al., 2010). What is not so well established is the way developing countries can generate R&D capabilities to create those positive effects on firm productivity. Since developing countries have an insufficient knowledge accumulation particularly in knowledge-intensive sectors, they need to rely on certain mechanisms through which they can draw knowledge from the rest of the world. As mentioned in the first chapter, FDI is one of these mechanisms. The debated issue for the case of developing countries is that should they rely on FDI to transfer technology or should they try to develop their indigenous R&D capabilities in order to increase their firm productivity? The empirical findings regarding developing countries do not present a unanimous conclusion. While some researchers find R&D efforts of firms in developing countries have no effect on productivity (Hasan, 2000; Benavente, 2006), other authors report significant positive effect (Saxena, 2009; Kemme et. al, 2009; Vakhitova and Pavlenko, 2010; Zhao and Zhang, 2010; Sharma, 2011). Turkey is a developing country which has had increased R&D expenditures which are financed increasingly by the business enterprise sector for the period 2003-2007[9]. Given this fact, investigating the question "How is the firm level productivity in Turkish manufacturing sector affected from the R&D investments?" seems timely. This question has not been studied before for the 2003-2007 period mainly because the data has recently been available for use. Therefore, our study will contribute to the literature by using new data. Secondly, while reviewing the literature we found a number of papers on productivity taking only R&D performers in their sample and disregarding the issue of the selection bias[10] (Yrkkö and Maliranta, 2006; Tsai and Wang, 2004; Parameswaran, 2009). There is also the issue of endogeneity one needs to consider when studying the impact of R&D on productivity. Therefore, both the selection bias and the endogeneity problems need to be considered in the panel data context. However, we were able to find only two studies using panel data and

[9] See Figures 5 and 6 in section 2.1.

[10] See section 2.6 for the explanation of selection bias.

addressing both issues at the same time (Damijan & Knell, 2003; Loof, 2009). Therefore, by taking into account both of these econometric procedures together, we will again be contributing to the literature.

3.1 Literature Review

Ever since the seminal paper of Griliches in 1979, the effect of R&D on productivity has been investigated by a number of researchers. Most of the time a Cobb Douglas production function has been used to study the effect of R&D on productivity:

$$Q_{it} = Ae^{\lambda t} C_{it}^{\alpha} L_{it}^{\beta} K_{it}^{\gamma} S_{it}^{\mu} e^{\varepsilon_{it}} \qquad 2.1$$

where Q represents the output, A is a constant, K physical capital stock, L labor, R R&D capital stock of the firm and S stands for the knowledge stock of the environment surrounding the firm. α, β are elasticities with respect to physical capital and labor. γ and μ are elasticities with respect to firm's own knowledge capital and the knowledge pool in the environment. λ represents disembodied technological change, *t* is the time index. ε_{it} stands for any errors in the specification. Most of the time, logs of this production function is taken to turn it into a linear form which yields

$$\ln Q_{it} = \ln A + \lambda_t + \alpha \ln C_{it} + \beta \ln L_{it} + \gamma \ln K_{it} + \mu \ln S_{it} + \varepsilon_{it} \qquad 2.2$$

In the literature a number of issues have been reported when using the production function approach in measuring the effect of R&D on productivity. One of them has to do with the measurement of outputs. Griliches (1979) claims that much of R&D is performed in industries where the product is poorly measured. He also asserts that quality improvement cannot be properly observed in the product. In defense, health and space industries, output measures are generated from input measures. For instance in space industry, R&D output is measured as man hours and the output's quality does not depend on the success of a mission where the new spaceship is used. In defense, products are sold to the government and there are no price indices that take into account the improved performance of the chips or the new warfare. In consumer goods producers, there is the additional problem of considering the competition in pricing their products. As most consumer firms are not pure monopolists, they cannot reflect the social returns to their products. Most of the time, these innovative products are introduced at slightly higher prices. Therefore, the innovating firm can only partially appropriate the return to its R&D investment. The price indices are not adjusted for the quality improvement. Thus, what is reflected in the price indices is only the private return reflected in the price. As social returns are not captured in prices, the output of R&D falls short of reflecting the full returns to R&D. As a result R&D outputs' value is underestimated. Griliches (1979) points out that there is not much to do about what he calls "the measurement of output" problem. However, as Hall et al. (2010) claim that if panel data is used with industry and time dummies, the quality problem in the measurement of output is mitigated to a certain extent. Regarding output measurement, another issue has to do with the price deflators. Most of the time aggregate price indices at the two digit level are used by researchers rather than firm level deflators. While some researchers such as Wieser (2005) find that this is not appropriate, others report very small differences between results when using sector specific versus a single deflator for the whole economy (Harhoff, 1998). In a recent literature review article Hall et.al. (2010) indicate which deflator one uses does not make much of a difference for the findings.

Another problem one needs to be careful about is termed as "doublecounting". As R&D expenditures also have capital, labor and material costs components, when one uses R&D expenditures as another factor of production one runs into the risk of counting them twice unless the capital, labor and material cost components are first cleaned from the part used in R&D. If the factors of production are not cleared from the R&D components, then incorrect input measures emerge (Wakelin, 2001). The bias can be either positive or negative (Hall and Mairesse, 1995; Harhoff, 1994).

One more point that needs to be considered with inputs is one regarding the different kinds of labor, different skills and educational levels. Hall et al. (2010) cite three studies in French[11] that obtain lower R&D coefficients when they introduce different skilled labor variables to their production functions. This is attributable to the high correlation between highly educated labor and R&D. However, this is a problem that one runs across in the cross sectional[12] dimension

[11] Mairesse and Cunéo (1985), Mairesse and Sassenou (1989), and Crépon and Mairesse (1993).

[12] Cross sectional regressions do not have a time dimesion therefore they make use of the between firm variation while within regressions are performed using deviations of the variables from individual firm means.

rather than the within dimension because quality of labor does not change much over time. Regarding the capital variable, when age is introduced to take into account the quality of capital, citing two French studies[13], Hall et.al. (2010) indicate not much improvement in the R&D coefficients take place.

Knowledge is a difficult concept to measure. Particularly the contribution of science to knowledge is extremely difficult to measure with precision. However, what has been done so far in the literature is the measurement of the contribution of industrial investment in R&D. To that end, the most frequently used method for constructing knowledge capital stock has been the perpetual inventory method as proposed by Griliches (1979).

$$K_t = RD_t + (1-d)K_{t-1} \qquad 2.3$$

where K_t is the knowledge capital at the end of year t, K_{t-1} is the knowledge capital at the end of year t-1, RD_t is the real R&D expenditure during year t and d is the depreciation rate of R&D which is assumed to be constant. According to this method current stock of knowledge is the result of present and past R&D expenditures discounted by a rate of depreciation. In this method an initial capital stock needs to be generated. The following formula is used for this purpose:

$$K_0 = \frac{RD_{t-n}}{g+d} \qquad 2.4$$

where preferably a pre-sample R&D expenditure is assumed to grow at g, a constant growth rate and also to depreciate at d, again a constant rate. Although this is a widely used formulation, there are acknowledged problems in the application of this procedure (Wieser, 2005). An important issue is that of depreciation. The depreciation rate here is assumed to be known, yet in reality it is unknown. However the literature suggests that one can assume that the private depreciation rate is higher than the social depreciation rate (Griliches, 1979). Secondly, depreciation is assumed to be constant in the perpetual inventory method. This means a portion of the R&D stock becomes obsolete every single year whether R&D is performed or not. However, this is a debatable issue according to Wieser (2005) who claims that "most economists would agree that knowledge does not depreciate in such a mechanical way" (p.592). Furthermore in the above formulation depreciation is taken as exogenous. Yet

[13] Mairesse and Sassenou (1989) and Crépon and Mairesse (1993)

Griliches (1979), Bernstein and Nadiri (1988), Capron and Cincera (1998), Hall et al. (2010) indicate that depreciation is not exogenous. It depends firstly on firm's own behavior, secondly on its competitors' behaviors and thirdly on the general progress of science and technology. This fact also adds another reason not to take the depreciation rate as constant.

When one uses a depreciation rate to construct the R&D capital stock, one also assumes a lag structure which reflects the distribution of R&D effects in time. Since it is not realistic to assume that the current R&D stock affects productivity right away, it makes sense to introduce some lags. While Ravenscraft and Scherer (1982) claim a lag structure between 4 to 6 years, Pakes and Schankerman (1984) indicate that there is a gestation lag of 1 to 2 years. Griliches and Mairesse (1984) point out that after two years, the lag effect loses its impact and lag structure does not matter much in cross sectional regressions. On the other hand, Geroski (1989) reports that innovations still have an impact on productivity growth even after three years. These findings render the use of lag structure and depreciation rather problematic. Notwithstanding these difficulties, a number of researchers have tried to find the appropriate depreciation rate by trying different rates in the construction of knowledge stock. Griliches and Mairesse (1984), Griliches and Mairesse,1990; Hall and Mairesse (1995), Harhoff (1994) and Bernstein and Mamuneas (2006), find a range of values from about 8% to 29%.

Given the aforementioned difficulties in computing the R&D capital stock, another approach has been devised to use R&D intensity rather than R&D capital stock and has been first used by Terleckyj (1974) as reported in Wakelin(2001). This approach makes sense for instance in cases where a country is at the beginning of R&D process, and it does not possess much of an R&D stock or when data on R&D expenditures have become available only recently. This approach makes use of the relationship between the elasticity of R&D investment and rate of return on R&D investment. First production function as in the following

$$q_{it} = a + \lambda_t + \alpha k_{it} + \beta l_{it} + \gamma r_{it} + e_{it} \tag{2.5}$$

where q, k, l and r represent the natural logarithms of value added, physical capital stock, labor, R&D capital stock and λ_t stands for disembodied technical change and e_{it} represents the error term is taken. Then it is restated in growth form as in the following:

$$\Delta q_{it} = \lambda + \alpha \Delta k_{it} + \beta \Delta l_{it} + \gamma \Delta r_{it} + v_{it} \tag{2.6}$$

Next making use of the definition of the elasticity of R&D investment which is

$$\gamma = \frac{\partial Q}{\partial R}\frac{R_{it}}{Q_{\ it}} \tag{2.7}$$

A transformation is performed from the elasticity to the rate of return on R&D investment by multiplying the elasticity with the growth of R&D capital investment.

$$\gamma \Delta r_{it} = \frac{\partial Q}{\partial R}\frac{R_{it}}{Q_{it}}\frac{\Delta R_{it}}{R_{it}} \tag{2.8}$$

Since the Rs cancel out, what is left is the following:

$$\gamma \Delta r_{it} = \frac{\partial Q}{\partial R}\frac{\Delta R_{it}}{Q_{it}} \tag{2.9}$$

Assuming a depreciation rate of zero for R&D investment (indicating a long patent protection which would protect R&D findings and reduce depreciation), ΔR_{it} can be replaced with one year's R&D investment. Therefore we arrive at the following:

$$\gamma \Delta r_{it} = \psi \frac{R_{it}}{Q_{it}} \tag{2.10}$$

where ψ is the rate of return on R&D investment and R_{it} is one year's R&D investment (Capron , 1992). As a result in the estimation equation, R&D capital stock is replaced by the R&D intensity :

$$\Delta(q_{it} - l_{it}) = \lambda + \Delta a_{it} + \alpha\Delta(k_{it} - l_{it}) + \psi\, R_{it}/Q_{it} + \theta\,\Delta l_{it} + v_{it} \tag{2.11}$$

Even though this approach enables one to avoid calculating the R&D capital stock, it is not free from problems of its own. For one thing, the coefficients that will be estimated are gross rates of return and in order to reach the net rate of return one still needs to estimate the depreciation rate (Kinoshita, 2000; Capron, 1992). Secondly, here the rate of return or marginal productivity is assumed to be constant and the elasticity is assumed to vary due to the ceteris paribus nature of econometric estimation whereas the reverse is assumed when the estimation is performed with the capital stock variables and elasticities (Griliches and Mairesse, 1990).

Yet, although conceptually it seems more reasonable to assume the rate of returns to be constant and then to derive the elasticities, the estimated rates of return turn out to be variable owing to the uncertainty of the R&D output. Hall et al. (2010) attribute this to the fact that before carrying out an investment, firms face ex ante expected returns which are equal to cost of capital but, what the researchers measure are the ex post returns. Thus a variance in the supposedly constant rates of returns emerges.

The nonrival, partially excludable and quasi-public nature of knowledge yields it an easily transmittable item between people and firms. Owing to poor patent protection, or other difficulties to keep innovations secret, benefits from R&D cannot be kept solely to the innovating firm. The more the codified knowledge becomes, the easier it gets for other firms to benefit from that knowledge. This generates a knowledge pool in the industry. According to Griliches (1979) there are two types of spillovers: rent spillovers and true knowledge spillovers. Rent spillovers are knowledge spillovers enjoyed by a firm as it gets involved in various activities such as purchasing new products or services from other industries, making direct investment in other firms, hiring workers from others, collaborating with research partners or getting engaged in mergers and acquisitions (Hall et al., 2010). In other words, rent spillovers accrue to a firm when it gets engaged in transactions involving goods or services. These types of spillovers are most likely to be found among firms in a supply chain and therefore are transmitted through backward and forward linkages (Javorcik, 2004). On the other hand, true spillovers are `The ideas borrowed by the research teams of industry i from the research results of industry j` (Griliches, 1979 p.104). Capron (1992, p105) attributes the emergence of true knowledge spillovers to “discoveries and innovations in an industry some of which are fruitfully borrowed by other industries to generate technological improvements of products and processes in these industries”. It is more difficult to trace true knowledge spillovers as probable beneficiaries of the new technologies are never known beforehand. Capron (1992) asserts that most likely a firm enjoys a significant portion of knowledge spillovers that arise from its own industry. Although conceptually it is easy to distinguish rent spillovers from true knowledge spillovers, empirically it is quite difficult to separate them (Mohnen, 1996). Mainly two approaches are used for modeling spillovers between industries: one of them makes use of the input-output tables and the other defines a technological proximity between industries.

The approach based on input output matrices (Wakelin, 2001, Aiello and Cardamone 2005) is regarded more likely to be a better indicator of rent spillovers. In this approach the hypothesis is that the higher the purchases of an industry from another industry, the more knowledge spillovers accrue to the purchasing industry. The other approach making use of technological proximity based on patent space (Jaffe, 1986; Cincera, 2005) is thought to be more appropriate for knowledge spillovers (Wieser, 2005). In this approach "firms' patents are distributed over patent classes to characterize their technological position. Assuming that the existence of technological spillovers implies that a firm's R&D success is affected by the research activity of its neighbors in technology space, a potential spillover pool, which is the weighted sum of other firms' R&D is measured " (Capron, 1992, p.112). There are a number of studies examining the significance of these spillovers in the literature. For instance Jaffe (1986), Griffith et al. (2006) , Ülkü (2007), and Aiello and Cardamone (2008) find the social knowledge pool have a positive impact on firm's performance.

When we review the empirical literature we see that positive impact of R&D on productivity is widely established (Griliches, 1979; Lööf and Heshmati, 2006; Rogers (2006) Luintel et al. (2010) and most of these studies are either cross country analyses or single sector analysis. Sectoral comparison studies or firm level studies are less in number. Using firm level data Griliches and Mairesse (1982) and Cuneo and Mairesse(1983) perform two of the studies that perform sectoral comparisons. Distinguishing science related sectors from others; their research finds that the elasticity of R&D for science based firms is higher than the elasticity for other firms. In another study employing OECD sector level-data Verspagen (1995) makes use of a production function and finds that R&D activities have a positive effect on productivity in high-tech sectors, but not for low-tech sectors. With a panel data of 443 manufacturing firms in Germany Harhoff (1998) studies the R&D's impact on productivity and reports that it is positive and significant for high-tech firms but not significant for low tech firms. The elasticities for low tech firms are also found to be lower than that of high tech firms. Studying 170 UK firms for the 1988-1992 period Wakelin (2001) finds that the 'net users of innovations' have higher rates of return on R&D as opposed to others. Using data from the Taiwan Stock Exchange on 156 large firms Tsai and Wang (2004) find that the R&D investments' effect on high tech and low tech firms' productivity (elasticity) was 0.3 and 0.07 respectively. Hasan (2000) utilizes panel data on a sample of Indian manufacturing firms for the ten years from 1977 to 1987. She reports that while imported technologies (both embodied and disembodied) have a positive impact on productivity, firms own R&D efforts bear no fruit as far as productivity is concerned. Applying a CDM (Crepon et al., 1998) model to Chilean panel data for the period 1995-1998, Benavente (2006) finds R&D has no significant impact on productivity. Using a panel data covering the period from 1994 to 2006 and a system GMM technique, Saxena (2009) studies the impact of R&D and knowledge spillovers in the Indian firms and finds that R&D has a positive and significant effect on productivity for technological intensive, capital intensive and nontechnological firms. Comparing the effect of foreign ownership on productivity in the information technology sector and the textiles sector in India for 2000-2006, Kemme et al. (2009) use firm level data. They report that R&D has a significant effect on productivity growth for both sectors when foreign ownership is taken as a share rather than a dummy. With a data set consisting of 783 Ukranian firms for the period 2004-2006, Vakhitova and Pavlenko (2010) implement a CDM model and finds that productivity is positively related to R&D and higher R&D breeds higher productivity. Examining the impact of R&D activities on performance in India with a firm level data for the period (1984-2006) Sharma (2011) points out that the performance of R&D conducting firms is higher than that of the non-R&D firms. Furthermore he reports that the elasticity of total factor productivity with respect to R&D is found to be a significant value of 0,15. Investigating the impact of FDI on China's industrial productivity for the 2001-2006 period, Zhao and Zhang (2010) find that R&D has a significantly positive effect on both productivity and productivity growth for both capital intensive and labor intensive industries. However, they report that the effect of foreign knowledge spillovers is observed to be higher in the capital intensive sectors as opposed to the labor intensive sectors.

There are two points we can derive from the literature review of the recent studies focusing on the effect of R&D on productivity. First is that most of the studies are conducted in developed countries and only Hasan (2000), Benavente (2006), Saxena (2009), Kemme et. al (2009), Zhao and Zhang (2010) and Sharma (2011) are on developing countries. The developed country results claim that for high tech sectors R&D has a high impact and for low tech sectors, either there is no significant impact or it is very small Harhoff (1998). However, the developing country results do not agree with that claim. While some (Hasan, 2000; Benavente, 2006) find R&D has no effect on productivity others indicate R&D does make a difference in productivity even for low tech or capital intensive sectors (Kemme, et al. 2009, Zhao and Zhang, 2010). Still others find R&D is a prominent factor affecting productivity in high tech sectors in developing countries. (Sharma, 2011). All in all there is inconclusive evidence in the case of developing countries whether R&D has any effect or any positive significant effect on productivity, particularly when taking the technological opportunities of different industries into account.

3.2 The Model

Following Kemme et al (2009) we take an augmented Cobb Douglas production function as in the following:

$$Q_{it} = Ae^{\lambda t} e^{\varpi f_{it}} e^{\phi sf_{jt}} K_{it}^{\alpha} L_{it}^{\beta} R_{it}^{\gamma} e^{\varepsilon_{it}} \tag{2.12}$$

where Q=output,

A= constant

K=physical capital stock

L= labor

R= R&D capital stock

f_{it}= foreign ownership

sf_{jt} = foreign knowledge spillover in the industry j where firm i operates

λ is the disembodied technical change, α, β, γ are elasticities with respect to physical capital, labor and knowledge capital, *t* is the time index. ϖ and ϕ are used to test the significance of the effects of direct foreign ownership and foreign knowledge spillovers on productivity. ε_{it} includes any errors in the specification and is assumed to be independently, identically and normally distributed. The physical capital and knowledge capital stocks are generated via the perpetual inventory method.

$$K_t = I_t + (1-\delta)K_{t-1} \tag{2.13}$$

where K represents the capital stock, d stands for the depreciation rate and I_t represents the annual expenditure. Here capital stock is used to proxy the total service flows from capital assets of the firm because unlike labor or other inputs which are purchased and consumed in the period when production is undertaken, capital assets are acquired once and are used in the production throughout the lifetime of the asset. The initial capital stock is calculated assuming there is permanent growth at the rate of depreciation. After the generation of the physical and knowledge capital stocks with the perpetual inventory method, we plug these into the production function and take natural logarithms which yield the following:

$$\ln Q_{it} = \ln A + \lambda_t + \varpi f_{it} + \phi sf_{jt} + \alpha \ln K_{it} + \beta \ln L_{it} + \gamma \ln R_{it} + \varepsilon_{it} \quad (2.14)$$

Using uncapitalized letters to represent the natural logarithm of the variables in equation 2.14, in order to get the labor productivity form, we subtract l and subtract and add αl and γl to both sides, to get,

$$q_{it} - l_{it} = c + \lambda_t + \alpha k_{it} + \alpha l_{it} - \alpha l_{it} + \gamma r_{it} + \gamma l_{it} - \gamma l_{it} + \beta l_{it} - l_{it} + \varpi f_{it} + \phi sf_{jt} + \varepsilon_{it} \quad (2.15)$$

After rearranging the common terms we arrive at

$$(q_{it} - l_{it}) = c + \lambda_t + \alpha(k_{it} - l_{it}) + \gamma(r_{it} - l_{it}) + (\alpha + \beta + \gamma - 1) l_{it} + \varpi f_{it} + \phi sf_{jt} + \varepsilon_{it} \quad (2.16)$$

Here by allowing $\theta = \alpha + \beta + \gamma$ we rephrase the labor productivity equation to be able to test the assumption of constant returns to scale. Thus we have

$$(q_{it} - l_{it}) = c + \lambda_t + \alpha(k_{it} - l_{it}) + \gamma(r_{it} - l_{it}) + (\theta - 1) l_{it} + \varpi f_{it} + \phi sf_{jt} + \varepsilon_{it} \quad (2.17)$$

Following Hall and Mairesse (1992), instead of λ_t which represents the disembodied technical change, we use time dummies because we believe the effect of disembodied technical change may not be constant.

The expected effect of foreign ownership on firm productivity is twofold. When a parent firm decides to invest in another country, its expectation on that investment must be higher than average return elsewhere. With their advanced technology embodied machinery and equipment, the foreign firms can raise the firm productivity in the host country. They may also practice advanced innovation management techniques and contribute to the local innovation (Fu, 2008). Therefore, the expectation in the literature is that foreign ownership should produce a positive effect on productivity. Yet, the empirical evidence is mixed. While there are positive significant effects of foreign ownership on firm productivity (Damijan et al. 2003; Zhao and Zhang, 2010), negative effects (Dillig-Hansen et al. 1999; Fu and Gong, 2011) and insignificant effects are reported as well (Chudnovsky et al. 2006). Kemme et al. (2009) find foreign ownership's effect on productivity is positive and significant for information technology sector and not significant for textile sector. Therefore, depending on the type of knowledge intensity of the sectors, different effects of foreign ownership on firm productivity may arise. As the evidence in the literature is mixed, we do not have an a priori expectation regarding this variable. This variable is defined as the share of foreign capital in total capital.

Through trained labor turnover, or via demonstration effects, or by exerting competitive pressure foreign firms can cause the accrual of knowledge spillovers to local firms. Thus, the foreign knowledge spillovers variable could have a positive effect on firm productivity. However, by attracting the best skilled labor, foreign firms may deprive local R&D performers from such strategic resources. Moreover by exploiting their superior technology they may drive out the local competitors out of the market. While in developing economies mostly insignificant or even negative horizontal spillovers are detected (Kinoshita, 2000; Damijan *et al*. 2003, Fu and Gong, 2011) there are others who find positive spillovers too. (Zhao and Zhang, 2010). Those who study different sectors also report different results as far as the foreign knowledge spillover's effect on productivity is concerned. Kemme et. al (2009) point out that there is a positive significant spillover effect in the high-tech sector of information technology but no such effect is found for the textile industry. The net effect of the positive and negative forces of foreign knowledge spillovers depends on which one overrides the other. Therefore we do not have a specific expectation regarding the foreign knowledge spillover effect. This variable is defined as the natural logarithm of the sum of all R&D expenditures belonging to the foreign firms minus the R&D expenditure of the firm.

In addition, assuming higher skilled staff contributes to higher productivity, we add skill as a control variable. Furthermore, we assume being present in an exporting sector a firm could benefit from the knowledge other firms in its industry can be drawing from the world. Therefore, we control for a firm's presence in an exporting sector. Firms that export have to survive tough competition abroad. They need to follow their international competitors closely to be able to remain competitive. When exporting they can achieve large economies of scale and keep their production costs down and also increase productivity (Kathuria, 2010). While exporting they also have the opportunity to meet challenging customer demands and to improve their production processes to satisfy those customers (Parameswaran, 2009; Vahter, 2010). Thus exporting could be an incentive to increase productivity. However while exporting can have an effect on productivity, productivity can also have an effect on exporting

(Lichtenberg and Siegel, 1989; Song, 2005; Aw et al., 2011). Therefore there may be an endogeneity between these two variables. To avoid that effect, we take the ratio of exports to sales at the sector level. We assume that it is very difficult for a single firm to affect the industry as a whole. However, if there is a high export ratio in the industry, then this will induce the firm to export too. Competing in export markets will have a positive effect on labor productivity. While there are researchers finding positive effects of exporting on productivity (Luintel et al., 2010), others find negative significant impact too (Kathuria, 2010).

3.3 Data Cleaning and Construction of Variables

We continue using the R&D and Structural Business Surveys (SBS) from Turkish Institute of Statistics. Again we start out with the 92456 observations for the whole data set. Leaving out the nonmanufacturing sectors and the firms with employees less than 20 people decreases the sample size by 43473 observations. As we need to compute both physical capital stock and R&D capital stock in this chapter, it is important to have as many nonmissing consecutive data as possible (Yrkkö and Maliranta, 2006). Therefore, first we look at the firms that do not have consecutive data for 5 years. 7733 observations are lost because of nonconsecutivity. There is one observation which has a 0 value for the provincial code, therefore we drop that observation. Next following Aldieri and Cincera (2009) we drop the firms that have a ratio of R&D expenditures to sales less than 0,0002 and greater than 0,5. This eliminates 66 observations which are deemed to be outliers. To be able to follow those organizations that do not grow via mergers and acquisitions we drop a total of 383 observations based on the criteria of Hall and Mairesse (1995), who chop off the firms with employee growth rate above 2 and below -0.5. Again following Hall and Mairesse (1995), we trim those enterprises that have value added growth of more than 3 and less than -0.9, which loses 3779 observations. We also drop those observations with sales growth of more than 3 and less than -0, 9. This results in a loss of 188 observations. Although we follow the literature in selecting the cut off rates for various variables, we also scrutinize the data via scatterplots with respect to size. These scatterplots which are presented in Appendix H also corroborate our cutoff points for the cleaning of outliers. When we compute the physical capital stock variable, we lose some observations due to missing capital stock which amounts to 3245 observations and also there are 504 observations with negative value added entries. Since we take natural logarithm of the ratio of value added to labor as our dependent variable, we lose them which reduce the sample size by 504 observations. Furthermore, there are 652 observations with export to sales ratios greater than 1, these are replaced with the value 1 relying on the fact that any ratio should have a maximum of 1. Moreover, the foreign ownership variable which is a ratio of foreign capital share to total capital share has 4 observations that are larger than 1, they are also replaced with 1. At this point we have a total of 29519 observations left in the sample, out of which 2077 belong to R&D performing firms. The data cleaning process is summarized in Table 17.

Table 17: Data Cleaning Process II

Total number of observations at the beginning	92456	2499	*Total number of observations for R&D performers at the beginning*
Nonmanufacturing firms	43473		
Firms with number of employees<20	3565		
Firms with nonconsecutive observations	7733	143	
Sales growth rate <-0.9 or >3	188	5	Sales growth rate <-0.9 or >3
Value added growth rate <-0.9 or >3	3779	107	Value added growth rate <-0.9 or >3
Employee growth rate <-0.5 or >2	383	20	Employee growth rate <-0.5 or >2
R&D expenditures/Sales <-0.5 or >2	66	66	R&D expenditures/Sales <-0.5 or >2
Missing physical capital stock	3245	70	
Negative value added	504	11	
Missing provincial code	1		
	29519	**2077**	

To compute the labor productivity variable we use the natural logarithm of the ratio of value added to labor. Value added is defined as the difference between output, raw material costs and energy costs. It is deflated by the wholesale price index at the two digit NACE level. Hall et al. (2010) indicates that theoretically using sales as a proxy of output is better than using value added because firms can substitute between materials and inputs. Theoretically, gross output is to be preferred over value-added as a measure, because it allows for substitution between materials and the other two inputs. However, at the firm level, certain factors need to be considered when choosing between gross output and value added. For instance if the materials-output ratio varies a lot across firms because of different degrees of vertical integration, then value added would be a better measure. Secondly, if one needs to model the demand for inputs properly, then the stocking of materials would generate some adjustment costs that need to be considered. Following the suggestions of Hall et al. (2010) we prefer to use value added over gross output in the definition of labor productivity.

To determine the physical capital stock variable we use two different candidates: the investment flow and the annual depreciation. Both of these variables are first deflated by capital deflators at the two digit level. Next following Coelli et al. (2005) who claims we need to solve the problem of zero values for the inputs, we interpolate the depreciation variable. When doing this, we assume that any firm that has sales revenue in a year must have a positive depreciation value. However, we do not interpolate the investment variable as we cannot make the same assumption for investment flows, because a firm may not necessarily have positive investment flow every single year. Despite interpolation, there are still many missing values in the two variables so among the two we pick the depreciation variable to use in the calculation of our physical capital stock as it has less missing values. The annual average of both the investment-based capital stock intensity and the depreciation-based capital stock intensity variables are graphed below in Figure 9.

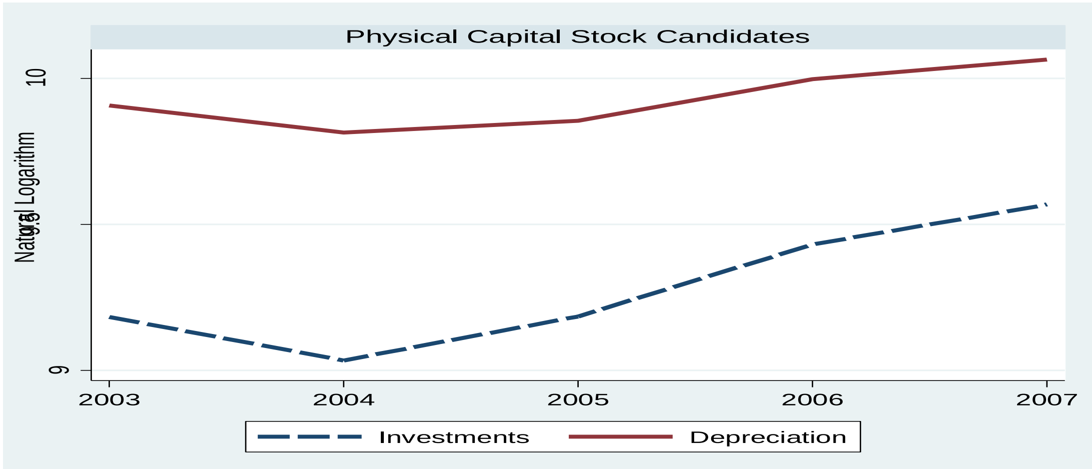

Figure 9: Physical Capital Stock Intensity Candidates: Investments versus Depreciation

In order to determine the depreciation rate to be used for the physical capital stock intensity, we study the literature. The depreciation rates used for physical capital stock vary from 5% (Parameswaran, 2009) to 6% (Hasan, 2002), or even 10% (Doralzesky, 2007). However, as Taymaz et al. (2008) use 6.7% in a study where they compute a physical capital stock for Turkey, we follow their route. In any case just to be on the safe side, we also employ 10% but the two capital stocks turn out parallel. Since we do not observe much of a difference between these two rates, we pick the 6.7% used by Taymaz et al. (2008) and continue with our work.

R&D expenditures and value added figures are deflated by the producers' price index. Using the perpetual inventory method again, we construct an R&D stock variable. In the computation of the R&D stock we use a depreciation rate of 20% because in a country where intellectual property regulations are not securely in place yet, the depreciation of new knowledge could be very high. Yet, just to see how the effect of a different depreciation rate would be on the knowledge capital, we also try a 25% depreciation rate but other than pushing the graph down, nothing else changes. Although other depreciation rates have been used in the literature such as 15% (Hasan, 2002), 10% (Higon, 2007) or even 30% (Hall and van Reenen, 2000), as indicated in the literature the value of this rate does not matter much as far as the computation of the R&D capital stock is concerned (Hall. et al., 2010). As we will use the Heckman two stage procedure to deal with the selection bias, we have two sets of variables, namely, the selection and the outcome variables. Table 18 lists the selection variable definitions, Table 19 presents summary statistics. Table 20 presents the outcome variables' definitions while Table 21 provides summary statistics for outcome stage variables. Table 22 exhibits the between and within standard deviations of each variable for outcome stage. As we look at Table 18, we see that the number of observations is increasing from 2003 to 2007. This situation is attributable to the deletion of the missing observations in the depreciation variable. For the year 2003, there are higher number of missing values for depreciation. As we delete these observations, we lose more data in 2003 than the other years. Moving on to Table 19, we see that among all manufacturing firms in the cleaned sample, about 6-7% of them conduct R&D. While size and skill seem to be increasing in time foreign ownership seems rather stable for the period under study. The decrease in absorptive capacity indicates a fall in the distance between the sector leaders and the followers in an industry. The increase in foreign knowledge spillover indicates the rise in the accumulated knowledge in the sector as a whole but the increase in geographic spillover is higher in magnitude than that of the foreign knowledge spillovers. While the sector's export ratio and the Herfindahl index remain rather stable throughout the five years, there seems to be an increase in the total subsidy at the sector level in 2007.

Looking at Table 20 where we present the descriptive statistics for R&D performers, we again observe that the number of observations in 2003 is lower than the other years which is attributed to the higher number of missing depreciation data in 2003 and our deletion of those data due to the detrimental effect it can cause in the generation of physical capital stock. Table 21 reveals an increase in labor productivity, physical and R&D capital stock intensity and in scale. Foreign ownership seems to be increasing towards in 2007 after varying between 10-11% in the remaining years. There is also some increase in the skill level for all R&D performers. We observe an increase in foreign knowledge spillovers available to R&D performers, but again the increase in the geographic spillovers is higher than that of the foreign knowledge spillovers at the sector level.

Table 18: Selection Variables' Definitions and Number of Observations for all Manufacturing Firms (2003-2007) II

Variable	Definition	2003	2004	2005	2006	2007	Total
RD dummy	1 for R&D performers, 0 for others	5151	5603	6067	6189	6509	29519
Size	Ln(employees)	5151	5603	6067	6189	6509	29519
Skill	Ln(wage per employee)	5151	5603	6067	6189	6509	29519
Foreign ownership	Share of foreign capital in total capital	5151	5603	6067	6189	6509	29519
Absorptive capacity	Ln(Max value added per worker in the sector/value added per worker of the firm i)	5151	5603	6067	6189	6509	29519
Location dummy	Dummy=1 for İstanbul, Ankara, İzmir, Bursa, Sakarya and Kocaeli 0 otherwise	5151	5603	6067	6189	6509	29519
Foreign knowledge spillover	[(sum of R&D expenditures of foreign firms in the sector-firm i's R&D expenditures)/sum of R&D exp. in the sector]	5151	5603	6067	6189	6509	29519
Geographic spillover	[(sum of foreign firms' RD expenditures in the same province as firm *i*- firm i's R&D expenditures)/sum of R&D exp. in the province]	5151	5603	6067	6189	6509	29519
Sector's export ratio	(Total exports in the sector calculated from micro data)/(Total sales of the sector)	5151	5603	6067	6189	6509	29519
Total subsidy of the sector	Ln(Total subsidies in the sector)	5151	5603	6067	6189	6509	29519
Herfindahl	Sum of the squared market shares of firms for the sector	5151	5603	6067	6189	6509	29519
Sector's R&D stock*market share	Sum of R&D capital stock in the sector*firm's market share	5151	5603	6067	6189	6509	29519
Sector's capital stock intensity	Ln(sum of capital stock at the sector level/ number of employee)	5151	5603	6067	6189	6509	29519

Table 19: Selection Stage Variables' Descriptive Statistics for R&D Performers (2003-2007) II

Variable		2003	2004	2005	2006	2007
RD dummy	Mean	.06	.07	.07	.07	.06
	Standard Deviation	.24	.26	.28	.25	.24
Size	Mean	4.29	4.35	4.36	4.39	4.42
	Standard Deviation	.99	.99	.98	.98	1.00
Skill	Mean	8.63	8.78	8.84	8.89	8.90
	Standard Deviation	.58	.53	.54	.55	.55
Foreign ownership	Mean	.04	.04	.04	.04	.04
	Standard Deviation	.18	.18	.18	.18	.18
Absorptive capacity	Mean	2.02	2.07	2.00	1.95	1.89
	Standard Deviation	1.09	1.06	1.05	1.00	.97
Location dummy	Mean	.75	.74	.74	.74	.73
	Standard Deviation	.44	.44	.44	.44	.44
Sector Level Variables						
Foreign knowledge spillover	Mean	.08	.12	.12	.11	.10
	Standard Deviation	.22	.25	.25	.23	.22
Geographic spillover	Mean	.19	.31	.33	.38	.34
	Standard Deviation	.18	.25	.27	.30	.27
Sector's export ratio	Mean	.28	.28	.28	.26	.27
	Standard Deviation	.18	.17	.17	.16	.16
Total subsidy of the sector	Mean	4.01	4.47	4.92	3.81	5.38
	Standard Deviation	5.63	5.71	5.91	5.67	5.96
Herfindahl	Mean	.01	.01	.01	.01	.01
	Standard Deviation	.05	.05	.04	.04	.04
Sector's R&D stock*market share	Mean	5.95	6.59	7.53	7.80	16.02
	Standard Deviation	3.53	3.63	3.32	3.46	1.51
Sector's capital stock intensity	Mean	14.0	14.96	15.48	15.85	8.06
	Standard Deviation	1.57	1.53	1.52	1.51	3.53

Table 20: Outcome Stage Variables' Definitions and Number of Observations for R&D Performers (2003-2007) II

Variable		2003	2004	2005	2006	2007	Total
Labor productivity	**Ln (value added per employee)**	**326**	**415**	**536**	**404**	**396**	**2077**
Physical capital stock intensity	**Ln (Capital stock per employee)**	**326**	**415**	**536**	**404**	**396**	**2077**
R&D capital stock intensity	**Ln(R&D stock per employee)**	**326**	**415**	**536**	**404**	**396**	**2077**
Scale	**Ln (Number of employees)**	**326**	**415**	**536**	**404**	**396**	**2077**
Foreign ownership	**Share of foreign capital in total capital**	**326**	**415**	**536**	**404**	**396**	**2077**
Skill	**Ln(average wage)**	**326**	**415**	**536**	**404**	**396**	**2077**
Sector level variables							
Foreign knowledge spillover	**[(sum of R&D expenditures of foreign firms in the sector-firm i's R&D expenditures)/sum of R&D exp. in the sector]**	**326**	**415**	**536**	**404**	**396**	**2077**
Sector level export ratio	**(Total exports in the sector)/(Total sales of the sector)**	**326**	**415**	**536**	**404**	**396**	**2077**
Instruments for physical capital stock intensity and R&D capital stock intensity							
Sector's R&D*firm's market share	**Sum of R&D capital stock in the sector*firm's market share**	**326**	**415**	**536**	**404**	**396**	**2077**
Sector's capital stock intesity	**Ln(sum of capital stock at the sector level/ number of employee)**	**326**	**415**	**536**	**404**	**396**	**2077**
Geographic spillover	**[(sum of foreign firms' RD expenditures in the same province as firm *i*- firm i's R&D expenditures)/sum of R&D exp. in the province]**	**326**	**415**	**536**	**404**	**396**	**2077**

Table 21: Outcome Stage Variables' Descriptive Statistics for R&D Performers (2003-2007) II

Variable		2003	2004	2005	2006	2007
Labor productivity	Mean	10.68	10.65	10.57	10.77	10.74
	Standard Deviation	.99	.93	.94	.91	.84
Phsyical capital stock intensity	Mean	9.52	10.41	10.77	11.25	11.51
	Standard Deviation	1.52	1.38	1.38	1.23	1.21
R&D capital stock intensity	Mean	7.92	8.80	8.73	9.42	9.79
	Standard Deviation	1.62	1.31	1.55	1.35	1.33
Scale	Mean	5.13	5.29	5.32	5.53	5.56
	Standard Deviation	1.19	1.30	1.29	1.33	1.33
Foreign ownership	Mean	.10	.11	.10	.11	.12
	Standard Deviation	.28	.27	.27	.28	.28
Skill	Mean	9.22	9.37	9.38	9.52	9.54
	Standard Deviation	.71	.69	.69	.69	.69
Export intensity	Mean	.24	.23	.22	.26	.26
	Standard Deviation	.25	.25	.24	.26	.27
Sector Level Variables						
Foreign knowledge spillover	Mean	.11	.16	.16	.18	.16
	Standard Deviation	.22	.25	.25	.26	.24
Instruments for physical capital stock intensity and R&D capital stock intensity						
Geographic spillover	Mean	.21	.31	.33	.40	.35
	Standard Deviation	.19	.24	.27	.31	.28
Sector's R&D stock*market share	Mean	9.43	10.41	10.66	11.48	11.76
	Standard Deviation	2.22	2.48	2.65	2.65	2.68
Sector's capital stock intensity	Mean	13.04	13.94	14.34	14.58	14.82
	Standard Deviation	1.56	1.54	1.53	1.59	1.53

Table 22: Outcome Stage Variables' Between and Within Standard Deviations for R&D performers (2003-2007) II

Variable		
Labor productivity	Between	.89
	Within	.37
Physical capital stock intensity	Between	1.39
	Within	.70
R&D capital stock intensity	Between	1.38
	Within	.91
Scale	Between	1.28
	Within	.17
Foreign ownership	Between	.25
	Within	.08
Skill	Between	.67
	Within	.20
Export intensity	Between	.24
	Within	.12
Sector Level Variables		
Foreign knowledge spillover	Between	.22
	Within	.11
Instruments		
Geographic spillover	Between	.25
	Within	.10
Sector's R&D stock*market share	Between	2.63
	Within	.77
Sector's capital stock intensity	Between	1.57
	Within	.60

3.4 Methodology

An important issue that has not been addressed until 1998 has been the issue of selection bias. While studying the impact of R&D on productivity, most researchers only used data belonging to R&D performers, i.e. (Dillig-Hansen et al 1999, Tsai and Wang, 2004, Yrkko and Maliranta 2006, Aldieri et al., 2008). In a seminal paper Crepon, et al. (1998), connected three different strands of R&D research in one study. Via three equations they addressed the selection bias issue and the simultaneity problem. To account for a firm's research behavior they first use a tobit model, then in the second equation they study the determinants of innovation, one of which is R&D investment. Finally, in the last equation they examine the impact of innovation on productivity. After their paper, researchers have started to use models such as Heckman two stage procedure or probit or tobit to deal with the selection bias (Loof and Heshmati 2002**,** Damijan et al. 2003, Damijan 2005, Aiello and Cardamone 2008, Loof 2009, Banri et.al. 2010 and Vakhitova and Pavlenko 2010).

In addition to the above stated problems Griliches (1979) points to two other econometric problems regarding the impact of R&D on productivity: multicollinearity and endogeneity. He claims multicollinearity arises because most of the variables used in the regressions turn out to be highly collinear with one another. However, he also points out that when data is at the firm level, this problem is not that much of an issue. On the other hand, he underlines the causality issue between productivity and R&D investment. As output depends on past R&D investment, past R&D investment itself may be dependent upon previous productivity. Furthermore current R&D depends on the expectation of productivity in the future.

Taking these two issues, namely the selection bias and the endogeneity problem into consideration we employ the Heckman two step procedure which is applied to the panel data with endogeneity issues by Semykina and Wooldridge (2010). At the first stage of the Heckman procedure the dependent variable is again a dummy variable taking the value 1 for those who conduct R&D and 0 otherwise. In the second step, labor productivity is the dependent variable and physical capital intensity, R&D capital stock intensity, scale, foreign ownership, foreign knowledge spillovers, export intensity and skill are independent variables. Two variables among these are most likely to be endogenous: the physical capital stock intensity and R&D capital stock intensity (Lichtenberg and Siegel, 1991; Loof & Heshmati, 2002; Parisi et. al 2006;

Doralzelsky & Jaumandreu, 2007; Arvanitis & Sturm 2008; Bednarek, 2010). Therefore, we pick some instruments to act on their behalf. For the physical capital stock intensity we use the sector's physical capital stock intensity which is taken at the two digit level. For the R&D capital stock intensity, we take two instruments which are the product of the sector's R&D stock and the firm's market share and a third variable which is the sum of the R&D expenditures at the province level (geographic spillovers). The reasoning behind these instruments is that we make the assumption that the higher the market share, the more a firm can have liaison with the rest of the sector and indirectly the more access it enjoys to the knowledge pool of the industry. If there are high geographic spillovers in a province, this may induce the firm to act on that knowledge and try to reach out to learn from others located in the vicinity. These instruments will be acting as exogenous variables in the labor productivity equation and according to the Semykina and Wooldridge (2010) procedure they need to be included in the first stage regression as well[14].

Initially fixed effects estimation is performed. Fixed effects deals with firm heterogeneity by transforming the data in a way that eliminate all the unobserved characteristics such as management abilities. The downside of fixed effects is the fact that it takes only the variation in the time dimension and disregards the one in the cross section. As our time dimension spans only 5 years, and as R&D investment is not an easily changing investment in time (Cincera and Ravet, 2010), fixed effects may have a hard time trying to analyze the variation of R&D stock. Poor results coming out of fixed effects estimation is not an uncommon finding as reported in the literature. Low fixed effects coefficient estimates or even insignificant estimates are reported by numerous studies (Griliches and Mairesse, 1984; Los and Verspagen, 2005 ; Hall et al. 2010). On the other hand random effects seem more likely to capture the cross sectional variation across the firms, but then again with random effects there is the assumption of no correlation of the error term with the explanatory variables or no omitted variable bias which may not hold either. In our case, random effects does not suit the nature of the R&D process as the unobserved variables could be correlated with the explanatory variables because their production process entails uncertainty which is not present in non-R&D manufacturing firms. That is the reason for us not using random effects in our regressions.

[14] The results of the first stage Heckman procedure which are presented annually are reported in the Appendix I.

Furthermore, as past productivity could affect current productivity, we need to consider another estimation procedure to take care of the lagged dependent variable issue (Loof and Heshmati, 2002; Damijan, 2003; Damijan, 2005; Loof and Heshmati, 2006; Sun and Du, 2010). The preferred method in the literature in such cases is system GMM (Mairesse and Hall, 1996; Griffith et al. 2006; Banri and Naomitsu, 2010). Mairesse and Hall (1996) report that with system GMM the standard errors are much smaller as opposed to the ones obtained with IV estimation because system GMM uses more regressors than instrumental variables technique does. An important issue with system GMM is the determination of the endogenous, predetermined and exogenous variables. A review of the literature reveals that some researchers take physical capital, knowledge capital and labor as endogenous (Okada, 2005; Aldieri et. al, 2008), while others take all firm level variables as endogenous (Griffith et al., 2006). In the literature we found some studies taking foreign ownership as endogenous claiming foreign firms would acquire highly productive firms in the first place (Dillig-Hansen et. al 1999; Kemme et. al 2009). On the other hand, there were others who claimed, foreign firms would mostly buy below average productivity (lemons) and some with higher productivity than average (cherries) (Mattes, 2010). Therefore, we considered foreign ownership both as endogenous and predetermined but as the overidentification test failed when foreign ownership was endogenous, we proceeded with this variable as predetermined. On the other hand, the foreign knowledge spillovers and the export intensity variables are regarded as strictly exogenous. As the foreign knowledge spillover variable is generated at the industry level, we presume it can be taken as exogenous. Here we follow the assumption that no single firm can affect the industry on its own (Aiello and Cardamone, 2008). On the other hand, the export intensity variable has been tested for endogeneity and it is found exogenous. As instruments in the system GMM, we use the second and further lags of the endogenous variables for the first-differenced equation and the first-differenced lags for the level equation. We employ two-step GMM estimation with robust standard errors using year dummies as strictly exogenous.

3.5 Estimation Results

Initially we perform fixed effects estimation on R&D performers only. The results from this estimation are presented in Table 23. The first column lists the estimation results for all R&D performers, the second column only for the high-med tech ones and the third one for the low tech firms. The fixed effects results reveal that physical capital stock intensity has a positive and significant effect on labor productivity for all R&D performers and for high-mid-tech R&D performers. On the other hand R&D capital stock intensity has a statistically significant negative effect on labor productivity. Moreover, there seems to be decreasing returns to scale for all R&D performers and high-mid-tech R&D performers as indicated by the scale variable's coefficients. While skill seems to have a positive and statistically significant impact on labor productivity for all R&D performers, high-mid tech and even the low-tech R&D performers, these results are not reliable because they suffer from the selection bias problem. Therefore, next we implement the two stage Heckman procedure with instrumental variables via the Semykina and Wooldridge (2010) procedure, the results of which are presented in Table 24.

Table 23: Fixed Effects Results

	All R&D performers	**High-Med Tech R&D performers**	**Low Tech R&D performers**
Physical capital stock intensity	0.0823**	0.0861**	0.0316
	(0.0325)	(0.0356)	(0.0778)
R&D capital stock intensity	-0.0425**	-0.0594**	-0.00439
	(0.0198)	(0.0236)	(0.0378)
Foreign ownership	-0.110	-0.274	0.268
	(0.151)	(0.174)	(0.185)
Scale	-0.418***	-0.391***	-0.508***
	(0.0980)	(0.119)	(0.168)
Foreign knowledge spillover	-0.0979	-0.0443	-0.316
	(0.120)	(0.136)	(0.193)
Export intensity	-0.335	-0.404	0.209
	(0.248)	(0.273)	(0.592)
Skill	0.356***	0.368***	0.359***
	(0.0639)	(0.0778)	(0.0995)
Constant	9.236***	9.060***	9.925***
	(0.960)	(1.105)	(1.880)
Observations	2,077	1,574	498
R-squared	0.101	0.088	0.212
Number of firms	672	489	182

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1.Time dummies included.

In the two stage Heckman procedure with instrumental variables, the R&D capital stock and the physical capital stock variables are taken as endogenous. Three instruments are used with the aim to render them uncorrelated with the error term and correlated with the dependent variable. To see if they perform well as instruments, the relevant tests of underidentification, weak identification and overidentification are performed. The p value of the Kleibergen-Paap rk LM statistics which are listed under the table indicate that the null hypothesis of underidentification is rejected for all R&D performers, for high-mid tech and for low-tech R&D performers. Thus our instruments seem to be good candidates for the endogenous variables. The Kleibergen-Paap rk Wald F statistics values are compared to the critical value from Stock and Yogo (2005) computed for the case of two endogenous variables and three instruments. As the Kleibergen-Paap rk Wald F statistics are higher than the Stock and Yogo (2005) critical value, we can reject the presence of weak identification problem. Finally, the p-value of the Hansen test statistics signal that our instruments are valid and, therefore, we can use these instruments safely in our instrumental variables estimation.

As observed from Table 24, for the case of all R&D performers, all five lambdas turn out significant validating the employment of the Heckman selection procedure. The same results hold for high-mid-tech R&D performers as well. However for low tech R&D performers the Heckman selection procedure seems unnecessary as none of the lambdas turn out statistically significantly. This finding may be attributable to the low number of low-tech observations represented in our sample (498). The physical capital stock intensity has a positive and statistically significant coefficient at 1 % level for both all R&D performers and high-mid tech R&D performers. However no such finding is observed for low-tech R&D performers. Thus for R&D performers and high-mid-tech R&D performers the higher the physical capital stock intensity the higher is the labor productivity, which is a rather expected result. R&D capital stock intensity comes out statistically significant at the 1% level with a positive coefficient of 0.21 for all R&D performers. This is a result that is expected and also found in the literature (Kathuria, 2010; Yang et. al 2010; Chandan 2011; Zhang et al 2011). This outcome signals that R&D capital stock per capita has a positive association with labor productivity. The size of the R&D elasticity falls within the range of 0.01 to 0.25 cited by Hall et al. (2010) in their literature review article. On the other hand, the size of the R&D elasticity for high-mid tech R&D performers is found to be higher at 0.23 which indicates that a 1% increase in R&D capital stock intensity gives rise to a 0.23% increase in labor productivity. Thus, we can state that R&D activities matter more for high-mid-tech R&D performers than for all R&D performers. On the other hand, for low-tech R&D performers R&D capital does not have any significant effect on labor productivity. As a matter of fact, the other statistically significant variable happens to be skill for all R&D performers and for high-mid tech firms. Thus, the higher the skill level of an R&D performer, the higher is the labor productivity but again we need to discount the low-tech-R&D performers from this statement as skill does not turn out as a significant factor affecting labor productivity in their case.

Foreign knowledge spillovers variable is not significant at 10% level. Kinoshita (2000) reports that there are no knowledge spillovers in the low tech industries. Kemme et al (2009) comparing two sectors from the foreign knowledge spillovers' effect on productivity point of view find a positive significant effect for the IT sector and no significant effect for the textile sector.

None of the other variables turn out to be significant for all R&D performers. The finding of insignificant results with the fixed effects model is rather frequently observed in the literature. Griliches and Mairesse (1984) and Mairrese and Sassenou (1991) report that time series results are much smaller or even insignificant than the results of the cross section regressions and they attribute this to the low within variance in all regressors. In our case this situation seems to be the case as well as can be observed from the low within variation as opposed to high between variations in Table 22. The estimations so far have been conducted for all R&D performers, however, to study the effect of R&D and knowledge spillovers on labor productivity in the case of local firms, we need to isolate them. Therefore we perform the two stage Heckman procedure for panel data for domestic R&D performers. The results are presented in Table 25.

In the case of the domestic R&D performers, the effect of physical capital stock intensity on labor productivity is statistically significant at the 1% level and positive with an elasticity of 0.33. As for the R&D capital stock intensity's effect on labor productivity, we find a similar result with all R&D performers, but the coefficient is higher at 0.22. Thus R&D capital stock has more impact on labor productivity for domestic R&D performers than all R&D performers. Skill also turns out to be highly significant at 1 % with a positive coefficient while none of the other variables have statistically significant results.

Table 24: Panel Heckman Two-stage Estimation Results with IV

	All R&D performers	High-Med Tech R&D performers	Low Tech R&D performers
Physical capital stock intensity	0.285***	0.222***	0.959
	(0.0772)	(0.0785)	(0.788)
R&D capital stock intensity	0.208***	0.231***	0.126
	(0.0635)	(0.0864)	(0.251)
Foreign ownership	-0.0897	-0.233	0.553
	(0.145)	(0.163)	(0.420)
Scale	-0.0353	-0.0189	0.279
	(0.122)	(0.162)	(0.474)
Foreign knowledge spillover	0.0842	0.124	-0.242
	(0.134)	(0.151)	(0.352)
Export intensity	0.0364	-0.0176	-0.0144
	(0.0791)	(0.0903)	(0.351)
Skill	0.254***	0.250***	0.249
	(0.0737)	(0.0876)	(0.200)
Lambda	-0.543***	-0.715***	0.660
	(0.157)	(0.192)	(0.834)
lam2	0.161*	0.299**	-0.240
	(0.0867)	(0.118)	(0.245)
lam3	0.356***	0.501***	-0.109
	(0.120)	(0.167)	(0.377)
lam4	0.375***	0.505***	-0.117
	(0.126)	(0.173)	(0.433)
lam5	0.444***	0.605***	-0.135
	(0.121)	(0.165)	(0.413)
Cons	2.905***	2.759***	1.853
	(0.703)	(0.907)	(2.305)
Observations	2077	1574	498
Kleibergen-Paap rk LM statistic:	62.18	41.80	18.00
(P value):	0.000	0.000	0.000
Kleibergen -Paap rk Wald F statistic:	89.09	26.59	26.36
(Stock and Yogo critical value):	13.43	13.43	13.43
P value of Hansen statistic:	0.48	0.67	0.54

Dependent Variable is labor productivity (natural logarithm)
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1.Time dummies included.

Table 25: Panel Heckman Two-stage Estimation Results with IV for Domestic R&D Performers

Physical capital stock intensity	0.332**
	(0.160)
R&D capital stock intensity	0.223***
	(0.0806)
Scale	0.0167
	(0.384)
Foreign knowledge spillover	0.0669
	(0.177)
Export intensity	0.0612
	(0.104)
Skill	0.241***
	(0.0903)
lambda	-0.504**
	(0.232)
lam2	0.163
	(0.102)
lam3	0.367***
	(0.136)
lam4	0.378***
	(0.144)
lam5	0.426***
	(0.137)
Cons	2.448***
	(0.813)
Observations	1636
K-P rk LM:	50.51
(P value):	0.000
K-P rk Wald F:	29.71
(S-Y critical value):	13.43
P value of Hansen stat:	0.50

Dependent Variable is labor productivity (natural logarithm)
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1. Time dummies included.

So far we make the assumption that the current labor productivity is not dependent upon the past labor productivity. However, as the literature suggests this may very well be the case (Damijan, 2003; Damijan, 2005; Loof and Heshmati, 2006; Sun and Du, 2010). When we need to use a lagged dependent variable in the presence of fixed effects, system GMM is the recommended technique (Hall et al., 2010). Therefore next, we perform system GMM, the results of which are presented in the Appendix J. Except for the high-mid-tech R&D performers, all the GMM estimations pass the second degree autocorrelation test. The Hansen overidentification test for all R&D performers, high-mid-tech, low-tech and domestic ones indicate that the instruments are valid. The results in the system GMM render the R&D capital stock intensity an insignificant factor for labor productivity. Yet, the significance of a positive skill variable persists in the GMM estimations for all R&D performers and for domestic R&D performers. On the other hand, no other variable turns out significantly. The system GMM is a highly preferred estimation technique in the literature when lagged dependent variable needs to be used in the presence of fixed effects but it is also a rather troublesome one to employ because as Roodman (2008) points out GMM can easily produce results that are in fact not free of endogeneity. Furthermore, depending on the use of lags and differences as instruments, the results may vary a lot, particularly when the estimation period is short as ours. Therefore, we prefer to rely on the Semykina and Wooldridge (2010) procedure to base our results on.

Furthermore, assuming it make take some time for knowledge spillovers to take place and R&D capital stock's effect to persist, we have also performed another Heckman two stage procedure with instrumental variables where we used one year lagged values for both foreign knowledge spillovers and R&D capital stock intensity. However, as the weak identification tests failed, our instruments did not fare very well in this case. Therefore, we chose to place the results in the Appendix K although the persistence of R&D capital stock intensity and skill was observed in these results as well.

3.6 Discussion of estimation results

In this chapter we studied the impact of R&D on labor productivity in Turkey. To that end, we make use of a framework most of the firm level literature prefers, i.e. an extended Cobb Douglas production function. The data comes from the Structural Business Survey and R&D survey, both conducted by Turkstat. It is enterprise level data which spans a five year period from 2003 to 2007.

We find that both the physical capital stock and R&D capital stock intensity have a positive and significant effect on labor productivity for all R&D performers and for high-mid tech sectors. This result holds for domestic R&D performers as well. However we cannot find any significant effect for low tech sectors. The elasticity of labor productivity with respect to R&D capital stock intensity turns out to be 0.21 for all R&D performers and 0.23 for high-mid tech sectors and 0.22 for domestic R&D performers. This means that when other factors are given, a 1% rise in

R&D capital stock intensity causes a 0.21% rise in labor productivity for all R&D performers and 0.23% for high-mid-tech firms and 0.22% for domestic R&D firms. In other words, we find evidence that investing in R&D has a payoff in increased labor productivity. However, we cannot make this statement for low-tech R&D performers.

Skill is another factor that affects labor productivity positively. A 1 % rise in the skill level of the staff holding everything else constant is associated with a 0.25 % rise in labor productivity for all R&D performers and 0.24 % for domestic R&D performers which indicates the cruciality of skilled staff for R&D performing firms. This is a result for which we find support in our interviews as well. An interviewee who is the head of the engineering department of an electronics and telecommunications equipment manufacturer in Ankara points out that their R&D staff is very important to them and they try their best to sustain a good work environment for them by attending to their needs, checking the physical quality of the work environment, conducting frequent meetings with the new recruits to see it they have any problems and also making sure they receive good salaries which are not below the industry average. Yet he also mentions that most of their staff are not formally educated. Another interviewee, one of the partners of a firm in the chemicals manufacturing industry indicates that they recruit master's students of engineering departments from domestic universities and train them for R&D on the job. They have employed three R&D employees this way and they are rather content with their performance. On the other hand another interviewee from a firm operating in metal manufacturing indicates they resort to professors at domestic universities to benefit from their knowledge because as an interviewee from an electronics manufacturer emphasized skilled people particularly in software engineering is very hard to find for two reasons: firstly they are rather expensive and secondly, they can quit the job for a higher paying one. As a result, companies often use help from university professors to deal with the scarce skilled staff problem. She states that the existence of a separate Human Resources department is vital for R&D performers because then they can trace the needs of their staff and try to accommodate such needs which will result in better performance measures[15].

We find no evidence of foreign knowledge spillovers on labor productivity. When we consider the significantly positive effect of the R&D capital stock intensity and the insignificance of the

[15] At the time of the interview this firm was restructuring to create a separate Human Resources department.

foreign knowledge spillovers, we can deduce that Turkish R&D performers in the manufacturing sector may be relying on their own efforts to increase the labor productivity. On the other hand, it may be the case that the positive knowledge spillovers we expect to see may be absent because of the competition effect that is created by the foreign R&D performers in the market. Therefore, in the future if data with a longer time series dimension can be employed the second and third lags of foreign knowledge spillovers can be introduced to the model.

CHAPTER IV

THE IMPACT OF R&D ON EFFICIENCY

In the previous chapter, it has been found that R&D capital stock intensity has a positive and statistically significant role on the labor productivity of high-mid tech R&D performers in the manufacturing sector in Turkey for the period 2003- 2007. However, for the low tech R&D performers no significant effect of R&D capital intensity has been observed. This finding presents a counter example to the argument that low tech sectors benefit from the 'late-comer advantage' by investing less in R&D but benefiting more from it when compared with the high-tech R&D performers (von Tunzelman and Acha, (2005). However, it may be the case that the firms in the low tech sectors might be using their R&D investments in order to reach the leading firms' productivity level rather than exceeding it (Fu and Gong, 2011). In order to be able to test this hypothesis we need to examine the effect of R&D intensity on technical efficiency of R&D conductors in high-med tech versus low-tech sectors in Turkey. As Turkish manufacturing sector is heavily composed of low tech firms (Table 26) it is crucial to determine whether the scarce resources of these firms are put to good use in terms of R&D investment.

Table 26: The Number of Firms (with more than 20 employees) in the Manufacturing Sector in Turkey

	2003	2004	2005	2006	2007	Total	%
High tech	1819	1638	1633	1605	1515	8210	**21**
Med tech	2187	1833	1913	1941	1894	9768	**25**
Lowtech	5200	4335	4223	4070	3923	21751	**55**
Total	9206	7806	7769	7619	7332	39729	

Source: Turkstat, Structural Business Surveys

Since R&D expenditures of the business enterprises have been rising in the 2003-2007 period, analyzing the question "Does R&D investment in high-med tech and low-tech sectors contribute to their catch up with the technology leaders?" seems rather suitable for the case of Turkey. The reasoning follows from the finding of the previous chapter. Since no evidence has been found for an increase in R&D investment in low tech sectors to lead to a labor productivity increase, could there be some other way these investments may be contributing to the performance of these firms? This question is the motivator for this chapter.

To the best of our knowledge, the effect of R&D intensity on the catching up of R&D performers has not been studied for the Turkish manufacturing sector before. Therefore this chapter will contribute to the literature by providing the first empirical evidence for the case of R&D performing manufacturers in Turkey for the period 2003-2007.

The first section will introduce the distinction between productivity and efficiency. The second and third will present a literature review of R&D and efficiency studies, the fourth and fifth sections will lay out the methodology and the model respectively. The sixth, seventh and eighth sections will provide explanation on data cleaning, variable construction for the production function and efficiency effects. The ninth section will present the various hypothesis tested regarding the employed model. Finally, the last section will exhibit the econometric estimation results.

4.1 Some Notes on the Distinction Between Productivity and Efficiency

Efficiency is a concept closely related to productivity but different from it; therefore we need to make a distinction between them. To illustrate the difference, we make use of a figure from Coelli et. al (2005, p4.) (see Figure 10)

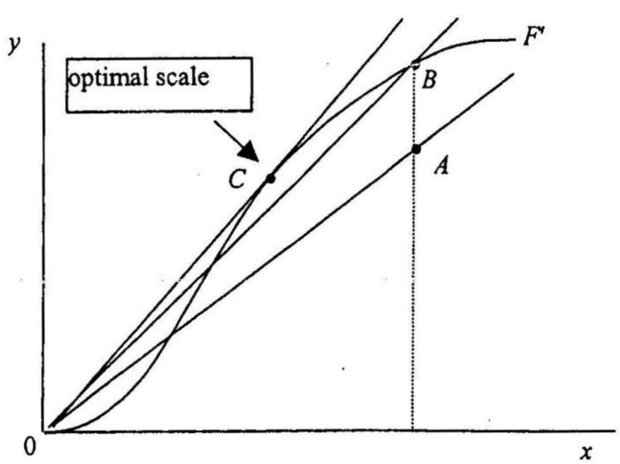

Figure 10: Productivity

Source: Coelli et al. (2005,p.5.)

In Figure 10 the slope of a ray from the origin indicates productivity: y/x. The points on the curve F indicate the maximum achievable output (y) given the input (x). If a firm operates at point A, then by moving to point B, the firm can increase its productivity, the slope of the line at point A is less than the slope at B. This move from A to B also indicates the improvement in technical efficiency because with the same amount of input, a higher amount of output is made possible. This may have happened with an organizational change, by better management of resources or other means. However at point B, the firm can still improve its productivity by moving to point C. This move indicates a change in scale. In this case, at point B, the firm is too large and by reducing its scale of operations while keeping the same input, it can increase its productivity because point C represents the most technically optimal scale. By benefiting from scale economies, the firm can increase its productivity, but not its technical efficiency because once a firm reaches the production frontier; it has fulfilled its capacity of technical efficiency.

Another concept related with efficiency is allocative efficiency. Allocative efficiency has to do with prices of factors in the market and selection of an input mix in order to produce a given quantity of output at a minimum cost. When allocative and technical efficiencies are considered together, economic efficiency measure is reached (Coelli et.al. ,2005).

In this discussion there is no time dimension but when time is allowed, then we need to take account of technological progress and its effects on the production frontier. Technical change creates new ways of production which shifts the production frontier outwards. On the other hand, efficiency gains are enjoyed as the distance to the frontier falls. However, efficiency gains cannot be sustained without technological progress once the frontier is attained. At that point technological development is the only force to create further increases in productivity and also technical efficiency. The main driving force of technological development is R&D and innovation which is shown by Figure 11 where an upward shift in the production frontier is observed from F_0' to F_1' as a result of advances in technology. A good example to this is the increase in productivity when one installs a new computer software on a computer. The same computer (capital) , and the same user (labor) achieves a higher level of productivity, when a new program, (technological advancement) is introduced in to the production process (Weil, 2005,p.206).

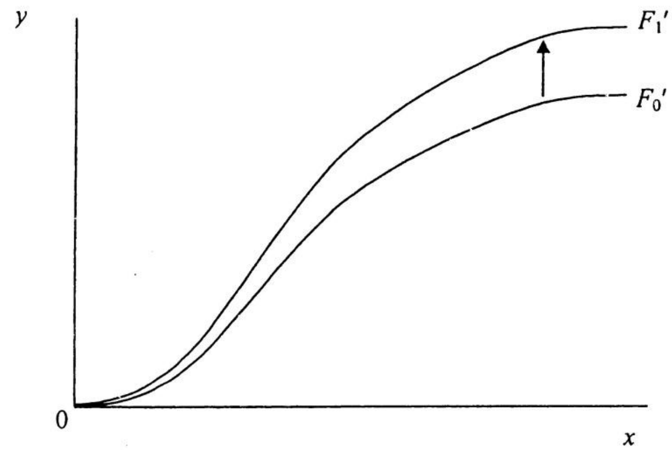

Figure 11: Technical Change

Source: Coelli et al. (2005,p.6.)

In sum, productivity growth can be attained by the cumulative effects of technical progress, technical efficiency change and scale economies.

4.2 Review of Studies Investigating the Impact of R&D on Efficiency

In the literature there are two methods mostly employed in the analysis of efficiency. The first one is the stochastic frontier analysis and the other one is the data envelopment analysis. Both make use of the computation of a production frontier by the most technologically advanced firms and then computes technical inefficiency for each firm as the distance towards that frontier. There is a large literature on empirical analyses of firm efficiency. Examining Hungarian firms' efficiency from 1985 to 1991 when Hungary was in an economic transition Piesse and Thirtle (2000) find that there is a technological regress, at the rate of 4.8% in agriculture and 8.1% in manufacturing. As determinants of inefficiency they use state subsidies, the value of exports, capital-labor ratio and time for the agricultural sector and for the manufacturing sector they use the same variables and the manager to labor ratio. They find that in the agricultural sector overcapitalization and excess use of subsidies are factors contributing to inefficiency and the increases in the numbers of managers and their salaries are blamed for the inefficiency in the manufacturing sector.

Studying the impact of FDI spillovers and R&D on productivity growth at the pharmaceutical industry in India with a panel data for the period from 1989 to 2001, Pradhan (2002) finds that neither the firm's own R&D activities nor the spillover effects from the foreign firms are significant in increasing efficiency in the host country. What matters for efficiency is the know-how, design and specification agreements made with firms from abroad and the size of the firm. The ones that have high expenditures on disembodied knowledge and are large in size seem to benefit positively and significantly from the spillover effects from the foreign firms.

Examining R&D conducting Danish firms from an efficiency point of view Dillig-Hansen et.al. (2003) find that R&D has a positive and significant effect on efficiency. With a sample of 2370 firms they study the legal form of the firm as a determinant of efficiency, and reach the conclusion that limited liability firms have higher efficiency levels as opposed to single owner ones. An interesting result of their study suggests that companies that rely on R&D for competitive advantage enjoy increased efficiency unless the research is on product development or basic research. In the latter case, they find that the outcome on efficiency can be realized in the long run.

Sangho (2003) studies the factors that are associated with the inefficiency of the Korean firms after the financial crisis of 1997. Focusing on firm size, dependency on external funds, investment in R&D and exports as the main determinants of efficiency and employing a stochastic frontier analysis approach at the industry level, he finds that R&D investment is significantly associated with efficiency in the textile, chemical and electronics and computers manufacturing industries but not in the paper, food and basic metal industries. The author finds that R&D in the high-tech sectors such as electronics or computers manufacturing contributes to the expansion of the frontier and those firms that fall behind remain inefficient. In the case of the textile and chemical sectors, he attributes the positive relation between R&D and efficiency to the fact that R&D helps firms catch up with the front liners. Therefore R&D in textile and chemical industries do not push the frontier forward but act as a boosting force for the laggards to move towards the frontier. Increased exports are found to be positively related with efficiency in the food and paper industries and not so in the other industries. As for the size effects, in all industries size is found to be positively related with efficiency.

Using a large data set consisting of 35000 firms for the years from 1992 to 2002, Badunenko et al. (2008) study the determinants of technical efficiency in the German manufacturing sector.

Size, outsourcing, R&D and industry effects are the factors that are included in their analysis of efficiency. They find that there is a lag between the R&D investment and its result on productivity and particularly so if the R&D performer is a young firm. They find that size and outsourcing have positive and significant effect on efficiency while R&D has a negative and significant effect. They argue that as the R&D investment pushes the technological frontier outward, the laggard's distance to the frontier increases, which could be the reason for the negative relation between R&D and efficiency.

Kumbhakar et al. (2010) examine the largest R&D investors in Europe from a technical efficiency point of view. Covering the period 2000-2005 for 532 firms, they test the hypothesis that firms in low-tech sectors benefit from R&D more than the ones in the high-tech industries. They explain this claim by stating that the low-tech ones do not have to incur all the large investment the high-tech ones conduct. Performing stochastic frontier analysis technique, they find that capital intensity has no effect on efficiency but R&D is a significant determinant of labor productivity for all high, medium and low tech sectors. They also find that for low-tech firms R&D intensity has a significantly positive relation with efficiency and this they claim is important in keeping these firms competitive vis-a-vis their rivals.

Using data envelopment analysis on 204 randomly selected observations from Iceland for the years 2004 to 2006 Oh et. al (2009) study the effect of R&D on technical efficiency and try to determine if Iceland was a victim of a financial crisis or merely inefficient. They find that nine out of ten Icelandic firms are inefficient in turning R&D, labor and capital into productive outputs. They argue that by changing production methods Icelandic firms can benefit more by increasing output without increasing the inputs. They also indicate that most of the manufacturing firms are too small and they need to grow in size to be able to benefit from economies of scale and increased productivity.

Hamit-Haggar (2009) examines the manufacturing sector of Canada from 1990 to 2005 with a panel data set of eighteen industries at the three digit level. Employing stochastic frontier analysis he finds that out of the eighteen industries only six had a positive growth rate of technical efficiency and those were the primary metal, paper, computer and electronics, transportation equipment, chemical and furniture related. The rest went through a period of technical efficiency deterioration which indicates poor input use in these industries. He finds R&D intensity, ICT intensity and openness to be significantly and positively associated with technical efficiency. An interesting finding he notes is that the increase in the number of hours worked by university graduates does not have a positive effect on technical efficiency.

Using both stochastic frontier analysis and data envelopment analysis, Amornkitvikai and Harvie (2011) study the technical inefficiency effects for the listed firms in the manufacturing industry of Thailand. Conducting their work on 178 enterprises from 2000 to 2008, they find that although R&D does not contribute positively to technical efficiency for the manufacturing sector as a whole, for the publishing, construction materials, and computer components sectors R&D has a significantly positive impact on technical efficiency. On the other hand, for the consumer products sector R&D has a significantly negative effect on technical efficiency. They also note that liquidity and external financing have positive effects on technical efficiency while financial constraints, executive renumeration, exports, managerial ownership and foreign ownership are negatively associated with technical efficiency for the manufacturing sector in general.

Assuming R&D can lead to innovation, innovation generates profits and profits in return fund more R&D, Bogliacino and Pianta (2010a) undertake a simultaneous three-equation model. They test the model for 38 manufacturing and service sectors in eight European countries over two time periods from 1994 to 2006. The hypothesis they test is one of catching up. They hypothesize that the longer the distance to the frontier, the farther away the industry will be from the cutting edge technology and R&D will not have much of an effect on firm performance. In line with their expectations they find that the closer an industry is to the technological frontier, the higher is the pressure for that industry to undertake R&D. This finding holds true for both manufacturing and services sectors.

Studying the relationship between efficiency, innovation and competition, Berghall (2010) asks if competition has reduced innovation and increased efficiency in the ICT industry in Finland. With an unbalanced panel data for the period from 1990 to 2003, Berghall (2010) finds support to the inverted U shaped relationship between competition and innovation with respect to efficiency. In other words, she finds that beyond some point additional competition increases innovation and raises inefficiency. This happens as higher competition motivates the frontier firms to innovate and when they innovate, the frontier moves further but some firms still lag behind which causes inefficiency to increase within a sector.

Radam et al. (2010) study the wood furniture industry in Malaysia from a technical efficiency point of view using stochastic frontier analysis. They state that the wood furniture industry is a significant industry for small and medium sized firms in Malaysia and it is also heavily export oriented. Conducting the analysis for 511 firms in 2005, they find that an average rate of inefficiency of 54.47 % in the sample and also indicate that there is a widespread distribution off inefficiency ranging from 1.63% to 94.69% within the sector . They attribute this finding to the market structure of the industry which is dominated by a few large firms versus a high number of small and medium sized firms which are highly inefficient. As a remedy to the inefficiency they propose investment in human resources and use of better technology.

Assuming that middle income countries are not only users of technology but are creators of it, Fu and Gong (2011) study the effects of local versus foreign innovation efforts on technological upgrading in China. They use data on 56125 firms from 2001 to 2005 and employing the data envelopment technique. They find that the technological progress rate is largest in the medium high-technology industries and it is driven by both indigenous and foreign firms' R&D efforts. In the low-technology industries, it is the indigenous firms that drive technical change. Fu and Gong (2011) choose age, firm size, market concentration, intangible assets, exports, foreign capital share, and training expenditures as control variables in the estimation of technical efficiency. They report that that while foreign firms do not have a role in extending the technological frontier, the spillover arising from them does help local firms in some industries, particularly low-tech ones to catch-up with the frontier. Also, they claim R&D intensity is a significant determinant of technical efficiency but not a significant determinant of technical progress for low tech sectors. They conclude that in order to benefit from foreign technology indigenous firms need to develop R&D capability.

4.3 Review of Literature in the Turkish Economy

Gokcekus (1995) analyzes the effects of trade liberalization in the 1980s on efficiency level of Turkish firms in the rubber industry. Using plant level data from the Structural Business Survey of Turkstat for two years namely 1980 and 1985, the author employs a stochastic frontier model where firms are classified into three groups: the incumbents, those with port-city plants and incumbents with port-city plants. He also looks at the effect of the ratio of external financing to internal financing. He finds neither location nor financing has an effect on technical efficiency while being closer to international markets considerably exhibits a significantly positive effect on technical efficiency.

Taymaz and Saatci (1997) study the technological progress and technical efficiency effects in the textile, cement and motor vehicles industries from 1987 to 1992 when export growth was declining after a fast paced period in the 1980s. The authors find that there is technological progress at the average rate of 6% and 4 % in the textile and motor vehicles industries but an insignificant technological regress in the cement industry. As far as efficiency effects are concerned, the use of subcontracted input turns out to be a significant contributor to efficiency in all sectors, but being a subcontractor firm does not have the same effect. Working overtime has a positive and significant effect on technical efficiency in textile and cement sectors and a negative effect in motor vehicles sector. Being a joint stock company improves efficiency in the cement industry but reduces efficiency in the motor vehicles industry. While advertisement and telecommunication intensity variables have a negative effect on efficiency in motor vehicles industry, technology transfer variable seems to exert a positive effect. Finally size has a positive impact on efficiency in cement and motor vehicles industry. They conclude that there are significant differences between sectors in the rates of technical change and factors affecting technical efficiency.

There are also some studies on the effect of privatization on technical efficiency in Turkey. Comparing the efficiency of public and private plants in the cement industry in 1985 Çakmak and Zaim (1993) employ a stochastic frontier analysis. The authors reach the conclusion that ownership does not matter in the cement industry as far as technical efficiency is concerned.

Saygılı and Taymaz (2001) study the effects of privatization and ownership on technical efficiency in Turkish cement industry. Using control variables such as firm age, exports/sales ratio, share in regional sales, location, size, time, share of technical personnel, share of subcontract employees, technology age and type, Saygılı and Taymaz (2001) conclude that privatization and ownership do not significantly affect the technical efficiencies of establishments.

Finally, Önder et al. (2003) measure the rate of technical change and technical efficiency in the selected provinces of the Turkish manufacturing industry for the 1990-1998 period. Employing a stochastic frontier analysis on province level data, the authors take average firm size, region, population density, the number of establishment variables to capture the regional agglomeration and urbanization externalities' effects. To control for the specialization in a region, they use an index they develop and a dummy variable for public ownership in the manufacturing industry. While they find no significant relation between the region variable and technical efficiency, the coefficients of population density and the number of establishments turn out significantly negative indicating that there are positive externalities for industries located in highly dense regions. İstanbul, Ankara and İzmir turn out to have the highest technical efficiencies.

4.4 Methodology

In the literature there are two main approaches to deal with the measurement of technical efficiency: data envelopment analysis and stochastic frontier analysis. Both of them necessitate the computation of a production possibilities frontier of the most efficient type. If we assume a production function

$$q_i = x_i^{'}\beta - u_i \qquad (3.1)$$

where q stands for (the logarithm) of output, x for a kx1 vector of (the transformation of) k inputs and u represents the non-negative inefficiency effects, the production frontier happens to be represented by the $x_i^{'}\beta$ portion of the function. The significant point here is that this function is bounded from above because all the inefficiency terms are subtracted from $x_i^{'}\beta$ portion of the function. Here all the errors turn out to be attributed to inefficiency and no measurement error term is allowed for. This is what happens with the data envelopment analysis because it does not have a random component in the production function. In other words the data envelopment analysis has a non-stochastic frontier. Using a linear programming technique, the data envelopment analysis is prone to the outlier observations' effect. Since outliers are treated like the other observations, the frontier is very much dependent on their impact. Any deviation from the frontier is attributed to inefficiency due to the absence of a random error term. In other words, as Cincera et al. (2007) point out "efficiency scores are attributed to inputs while other factors may also contribute". Thus, the accuracy of the data in data envelopment analysis plays a pivotal role in sound estimation of the efficiency scores. On the other hand, data envelopment analysis has more than one output whereas stochastic frontier analysis has one output or a weighted average of multiple outputs. However, as Coelli et al. (2005,199) point out data envelopment analysis can perform poorly if weights assigned to the inputs/outputs do not exhibit realistic properties. These are the main drawbacks of the data envelopment analysis.

On the other hand, the stochastic frontier analysis which was introduced by Aigner et al. (1977) and Meeusen and van den Broek (1977) allows for the inclusion of a random error term. Then the production function becomes

$$q_i = x_i^{'}\beta + v_i - u_i \tag{3.2}$$

where v_i is a symmetric error term; it can take on both negative and positive values. This term stands for all the omitted variables, measurement errors, the effect of luck, weather conditions, job specific factors or other such effects. When this stochastic error term v_i is included in the production function, the frontier becomes bounded from above by the random variable (v_i - u_i). This random variable can be either positive or negative. The u_i term represents the inefficiency of a single firm and through the use of this term technical efficiency can be computed as

$$TE_i = \frac{q_i}{\exp(x_i'\beta + v_i)} = \frac{\exp(x_i'\beta + v_i - u_i)}{\exp(x_i'\beta + v_i)} = \exp(-u_i) \tag{3.3}$$

Technical efficiency states how efficient this firm is with respect to the most efficient firm on the frontier and takes a value between zero and one. In order to compute the technical efficiency, one first needs to estimate the parameters of the production function:

$$q_i = x_i^{'}\beta + v_i - u_i \tag{3.4}$$

where as defined before q_i is the log of output and x_i stands for the transformation of input j and other factors that may affect the output. Making the following assumptions

$$E(v_i) = 0 \tag{3.5}$$

$$E(v_i^2) = \sigma_v^2 \tag{3.6}$$

$$E(v_i v_j) = 0 \text{ for all i} \neq j \quad (3.7)$$

$$E(u_i^2) = \text{constant} \quad (3.8)$$

$$E(u_i u_j) = 0 \text{ for all i} \neq j \quad (3.9)$$

we can apply OLS to estimate the production function. The estimated residuals will be either above or below the regression line. However, if some companies are not technically efficient and produce outputs below the production frontier line, the OLS will come up with a downward biased intercept coefficient because the OLS assumes all firms to be technically efficient (Coelli et.al 2005, 245). In other words, the error component of OLS is assumed to have a zero mean, however with the frontier function the inefficiency error term u_i is assumed to have a non-zero mean. That is due to the requirement that the maximum production at the frontier must be greater than or equal to any firm's production in the sample. Therefore, we cannot use the OLS and we need to use the stochastic frontier model. The stochastic frontier analysis uses maximum likelihood and assumes that $v_{i\sim} iidN(0, \sigma_v^2)$ and $u_{i\sim} iidN^+(0, \sigma_u^2)$ which means that the v_is are independently and identically distributed with zero mean and constant variance σ_v^2 and the u_is are independently and identically distributed half normal random variable. This means the error term u_i can only take on positive values which is a necessary condition for the frontier to be bounded above.

There have been different distributional assumptions regarding the u_i such as the exponential, (Meeusen and van den Broek, 1977) , gamma (Greene, 1980) and truncated normal distribution (Stevenson, 1980). However Kumbhakar and Lovell (2000) suggest that the different distributional assumptions do not make much of a difference as far as the efficiency rankings of firms are concerned and they recommend using the more simple distribution such as half normal and exponential over the truncated normal and gamma.

4. 5 The Model

We choose to use the Battese and Coelli (1995) model which is the panel data version of the stochastic frontier model presented earlier. This model allows for technical efficiency effects to change in time. The production function and the inefficiency effects are simultaneously estimated in this model. We estimate a translog model as the stochastic production function which is defined as

$$\ln q_{it} = \alpha_0 + \alpha_k \ln k_{it} + \alpha_l \ln l_{it} + \alpha_{tl} t + \frac{1}{2}\left[\alpha_{kk}(\ln k_{it})^2 + \alpha_{ll}(\ln l_{it})^2 + \alpha_{tt}(t)^2\right] + \alpha_{kl} \ln k_{it} \ln l_{it} +$$
$$\alpha_{kt} t \ln k_{it} + \alpha_{lt} t \ln l_{it} + \alpha_s \ln s_{it} + \sum_j \beta_j B_{it} + v_{it} - u_{it}$$

(3.10)

where the subscripts i and t stand for the firm and time. The variables k, l and s stand for capital, labor, and skill. The vector B represents a set of two digit sector dummies to control for unobservable differences in frontier between sectors. We do not introduce the R&D capital stock intensity here because we want to isolate its effect on efficiency by including it only in the efficiency effects. If we do include it in the production function, then we may have a hard time distinguishing its effect on the frontier from its effect on efficiency. We add the skill variable to account for the heterogeneity of labor in R&D performing firms. The dependent variable q_{it} is the natural logarithm of the value added per employee. k, l and s are measured as the physical capital stock intensity, number of employees and average wage. The v_{it} are assumed to be identically and independently distributed random errors with a N(0,σ_v^2) distribution. u_{it} is assumed to be a non negative, independently distributed and truncated normal random variable, with a mean $\mu_{it}\alpha$ and it captures the inefficiency effects as indicated in the following

$$u_{it} = \delta_0 + \delta_1 S\_input + \delta_2 S\_output + \delta_3 mshare + \delta_4 RD\text{int} +$$
$$\delta_5 Sec\_spill + \delta_6 Sub\_dum + \delta_7 \exp\_\text{int} + \delta_8 geo\_spill$$
$$+ \delta_9 js\_dum + \delta_{10} t04 + \delta_{11} t05 + \delta_{12} t06 + \delta_{13} t07 + w_{it}$$

(3.11)

where s_input represents the share of subcontracted input to total cost, s_output is the share of subcontracted output in total output, mshare is firm's market share, RDint is the natural logarithm of the ratio of R&D expenditures to sales, sec_spill is the knowledge spillovers in the sector, sub_dum is a dummy which gets a value 1 for RD subsidy receivers and is zero otherwise, exp_int is the export intensity, geo_spill is the geographic spillover at the province, js_dum is a dummy that gets a value of 1 if the firm has a joint stock ownership and 0 otherwise.

Technological change effect is given by the derivative of ln q with respect to t in equation 3.10 (Coelli et al, 2005, 213).

$$\partial lnq/\partial t = \alpha_t + \alpha_{tt} t + \alpha_{kt} lnk_{it} + \alpha_{lt} lnl_{it} \quad (3.12)$$

The inclusion of the time variable in the stochastic frontier model allows for non-neutral technical change. If the α_{kt} is positive then technical change is capital using, and if it is negative, then the technical change is capital saving. In the case that α_{kt} and α_{lt} are zero, then technical change is neutral. (Coelli et al, 2005).

The variance parameters of the frontier regression's error term are expressed in terms of $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$ where γ takes a value between zero and one. σ^2 and γ are computed from maximum likelihood estimates. As σ_u^2 represents the variance of the error term of the inefficiency effects, its magnitude with respect to the variance of the frontier function's error yields the size of the inefficiency as opposed to statistical noise. If γ turns out to be high and significant, then, this implies that a substantial part of the error term's variance is attributable to technical inefficiency of production or the stochastic frontier model is the appropriate approach. If the stochastic model is significant, the next step is to estimate the determinants of the inefficiencies.

4.6 Data cleaning and variable construction:

We continue to use two surveys from Turkstat, namely the R&D survey and the Structural Business Survey (SBS) for the years 2003-2007. We apply the same cleaning procedure as in the previous chapter (Table 17). All of this procedure leaves us with 29519 observations out of which 2077 belong to the R&D performers. In addition to some of the variables used in the prior chapters, we introduce 3 new variables to be used as regressors in the efficiency section: the S_input, S_output and Joint_stock variables. The S_input and S_output variables stand for the subcontracted work to third parties and income earned from undertaking subcontract work respectively. They are used as ratios: S_input is defined as the ratio of inputs subcontracted to suppliers total costs and S_output is the ratio of output subcontracted from other enterprises. There are some figures that are larger than 1 in the S_output variable, so we replace those with 1, not to lose valuable data. The Joint_stock variable is a dummy that takes the value of 1 for joint the stock ownership and 0 otherwise. The definitions and the number of observations of the variables used in the estimation are listed in Table 27. The summary statistics of these observations are presented in Table 28.

Table 27: Definitions of the Variables Used in the Stochastic Frontier Estimation

Variable	Definition	2003	2004	2005	2006	2007	Total
Skill	Ln(average wage)	326	415	536	404	396	2077
S_input	Share of subcontracted input in total cost	326	415	536	404	396	2077
S_output	Share of subcontracted output in total output	326	415	536	404	396	2077
Market share	Share of firm sales in industry sales	326	415	536	404	396	2077
R&D intensity	Ln(R&D expenditures/sales)	326	415	536	404	396	2077
Joint_stock	1 for joint stock firms, 0 for others	326	415	536	404	396	2077
Subsidy dummy	1 for subsidy receivers, 0 for others	326	415	536	404	396	2077
Export intensity	Exports / sales	326	415	536	404	396	2077
Sector level Variables							
Geographic spillover	Ln (Sum of R&D expenditures at the province level-firm's R&D exp- firm I's R&D exp..)]	326	415	536	404	396	2077
Knowledge Spillovers	Ln (Sum of all firms' R&D expenditures at the Sector-firm i's R&D expenditures)	326	415	536	404	396	2077

Table 28: Summary Statistics of the Explanatory Variables Used in the Stochastic Frontier Estimation

Variable		2003	2004	2005	2006	2007
Skill	Mean	8.89	9.05	9.07	9.16	9.19
	Standard Deviation	.33	.34	.36	.37	.38
S_input	Mean	.02	.02	.02	.02	.02
	Standard Deviation	.06	.05	.06	.04	.05
S_output	Mean	.01	.01	.02	.01	.01
	Standard Deviation	.06	.08	.11	.07	.09
Market share	Mean	.11	.11	.10	.12	.11
	Standard Deviation	.18	.18	.17	.19	.18
R&D intensity	Mean	6.72	6.76	6.68	6.87	7.06
	Standard Deviation	1.62	1.39	1.44	1.47	1.41
Joint stock dummy	Mean	.83	.82	.80	.84	.85
	Standard Deviation	.38	.38	.39	.37	.35
Subsidy dummy	Mean	.16	.14	.19	.21	.29
	Standard Deviation	.36	.35	.40	.41	.46
Export intensity	Mean	.24	.23	.22	.26	.26
	Standard Deviation	.25	.25	.24	.26	.27
Sector Level Variables						
Foreign knowledge spillover	Mean	16.08	16.69	16.91	17.12	17.30
	Standard Deviation	1.56	1.68	1.99	1.69	1.67
Geographic spillover	Mean	16.40	17.09	17.44	17.48	17.65
	Standard Deviation	2.65	3.49	3.58	3.72	3.44

4.7 Production Function Variables

The dependent variable is labor productivity which is measured as the natural logarithm of the value added per employee. In order to find value added we add sales to increases in inventory and subtract energy and materials cost from that total to reach value added. Using the producers price index at the four digit level, we deflate the value added to the price level of

2003. Capital stock per employee is the first explanatory variable in the translog equation. In order to compute capital stock we make use of the perpetual inventory method [16]

$$C_t = I_t + (1-\delta)C_{t-1} \tag{3.12}$$

where C represents the capital stock, d stands for the depreciation rate and I_t represents the annual investment. Here capital stock is used to indicate the total service flows from capital assets of the firm because unlike labor or other inputs which are purchased and consumed in the period when production is undertaken, capital assets are acquired once and are used in the production throughout the lifetime of the asset. The initial capital stock is calculated assuming there is permanent growth at the sum of the sectoral rate of growth and the rate of depreciation.

In fact, we have two candidates to compute capital stock from: the physical investments and the depreciation expense. There are less missing observations in the depreciation variable than in the investments (3603 versus 3802) therefore, after computing two different capital stock variables, we choose to use the one generated from the depreciation expense. Before using the depreciation expense in the calculation of capital stock, it is deflated by capital stock deflator[17] to obtain the real values of depreciation expense.

As the second variable of the production function we have scale that is measured in terms of the natural logarithm of the number of employees. A positive coefficient indicates increasing returns to scale and a negative one represents decreasing returns to scale. Next we have time to account for technological change (Battese and Coelli 1995, p329). Furthermore, there are interaction variables of time and the inputs which capture the factor-saving or factor-using effects in the production function. If the coefficients of these variables are positive then technical change is input using and negative if technical change is input saving. Since we use the translog form, we have interaction terms between the factors of production and time. When using interaction terms, mean centering is advised because it makes the computation of the marginal effects rather practical (Brambor et al., 2006). Mean centering can be described as subtracting the mean from a variable. When the mean of the transformed variable is taken, it

[16] The detailed account of the computation of the capital stock is provided in section 3.3.

[17] Capital deflator is obtained from the State Planning Organization, and it is an aggregate measure for the whole manufacturing sector.

turns out as zero. As we evaluate the partial derivative of the production function for instance with respect to time (see equation 3.12), all the interaction variables in the translog function of equation 3.10 which are valued at their means get the value zero, so the only coefficient left is time's coefficient.

$$\frac{\partial q}{\partial t} = \alpha_t + \alpha_{tt}t + \alpha_{kt}lnk_{it} + \alpha_{lt}lnl_{it} \qquad (3.13)$$

Therefore we use mean correction for the capital and labor in the interaction terms. Since labor is not homogenous in R&D performing firms, we include natural logarithm of average wage rate in the production function to proxy for skilled labor. The expectation is that ceteris paribus, the higher the skill level, the lower the inefficiency, thus a negative coefficient is expected.

4.8 Efficiency Effect Variables

In order to examine the effect of R&D activities on technical efficiency, we use R&D intensity defined as the natural logarithm of the ratio of real R&D expenditures over the number of employees. Perelman (1995) claims that efficiency increases with R&D investment. However if some firms cannot apply the new technology as effectively as the previous ones as the production frontier shifts outward, then their inefficiency increases as the distance to the frontier grows. This mechanism may hold for large scale R&D investment but not for small scale or adaptive R&D investment which may not shift the frontier. Since only a small percentage of industrial R&D projects end up with a radically innovative result, small scale R&D may help the firm to catch up with the frontier rather than to extend it further.

Perelman (1995) found a negative relationship between R&D expenditure and technical efficiency while Sangho (2003) found a positive relationship between R&D and efficiency in textile and chemical industries and a negative relationship for high-tech industries such as electronics and computers manufacturing. Fu and Gong (2011) report that indigenous firm R&D intensity has a positive significant effect which holds true for high-tech, med-tech, med-low and low-tech industries. Examining the determinants of technical efficiency of German manufacturing enterprises from 1992 to 2002, Badunenko et al.(2008) find R&D does not have any positive effect on technical efficiency. Thus, the evidence in the literature is mixed as far as the impact of R&D on efficiency is concerned.

The effect of firm's market share on efficiency is also debated in the literature. While there are studies concluding that increased market share has a positive effect on efficiency (Hay and Liu, 1997; Diaz and Sanchez, 2008), others claim increased competition is negatively related to efficiency (Nickell et al. 1997) We define market share as the ratio of firm's sales to total sales aggregated at the 4 digit.

Studying the effect of knowledge spillovers on technical efficiency and technological change, Fu and Gong (2011) find that while foreign knowledge spillovers has no effect on the extension of the production frontier, they do have a positive effect on technical efficiency. On the other hand, Pradhan (2002) in his study on the Indian pharmaceutical industry concludes that the knowledge spillovers arising from R&D conductors has no effect on the technical efficiency. Therefore, there is inconclusive evidence as to the knowledge spillover effects within the sector. This variable is constructed as the natural logarithm of the sum of all R&D expenditures in the industry minus the firm's R&D expenditures in order to prevent double counting.

Karadağ (2010) indicates that there is a large discrepancy between different regions in Turkey in terms of concentration of manufacturing activities and the creation of value added. Thus, being located in certain provinces such as İstanbul, Kocaeli or Bursa with high levels of value added and knowledge accumulation may have a positive effect on technical efficiency. To take that factor into account we take the natural logarithm of the sum of all R&D expenditures conducted by the R&D performing firms in the province minus the firm's own R&D expenditures and name it the geographic knowledge spillover at the province level.

Although firms value development of new products via R&D, the outcome of such investment is never certain for a number of reasons. Therefore, some firms may refrain from investing in R&D projects characterized by commercial, technical risks. Government subsidies provide one way to alleviate this problem however the evidence in the literature is far from conclusive as to the validity of such policy. Examining 5349 observations for nine years from 1993 to 2002, Jorge and Suarez (2011) find that those firms that use subsidies are less efficient and less efficient ones are those that lack the resources for funding R&D and apply for subsidies. Piesse and Thirtle (2000) also find that excess use of subsidies is associated with lower efficiency in the manufacturing sector of Hungary. Badunenko et al. (2008) also find that firms that receive high amounts of subsidies are less technically efficient. We use a dummy variable taking the value of 1 for those firms that receive R&D subsidy and 0 otherwise.

Exports are claimed to expose firms to increased competition and increase efficiency because firms are expected to better utilize resources and benefit from economies of scale when they compete in foreign markets (Pradhan, 2002). Sangho (2003) finds that export intensity is positively associated with efficiency for food and paper industries and a negative one for textile, chemical and high tech industries such as electronics and computers manufacturing. Piesse and Thirtle (2000) also find those firms that have an established export market are more efficient in Hungary. Saygılı and Taymaz (2001) find a positive association between the export ratio in the cement industry and technical efficiency in Turkey. On the other hand, Dillig-Hansen et al. (2003) state there is weak support to the expected relationship between export and efficiency for Danish firms. This variable is defined as the sector's ratio of exports to sector's output.

S_input is the ratio of subcontracted work to total cost while S-output is the ratio of the income from subcontracted work to total output. In other words, if S-input is equal to 1, this indicates that the firm subcontracts all its work to others. If S-output is equal to 1, this firm performs work for other companies and receives all its income from such lines. Working closely with other firms in a network facilitates specialization of firms in certain areas. Taymaz and Saatçi (1997) use these variables for their study on the determinants of technical efficiency in three sectors in Turkey. They find using subcontracting input has a significantly positive effect on technical efficiency for all three industries but this is not true for subcontractor companies. To see if these effects still prevail for the period of this study (2003- 2007) these two variables are included as well.

As opposed to other forms of legal status (limited liability companies, ordinary partnerships, etc.) joint stock companies have board of directors where groups of professional managers undertake the management. Taymaz and Saatçi (1997) find that being a joint stock firm improves efficiency in the cement industry but reduces it in the motor vehicle industry in Turkey in the period from 1987 to 1992. On the other hand, Diaz and Sanchez (2008) find that having a legal status of public limited company is positively related with technical efficiency. Dillig-Hansen et al. (2003) report a finding that limited liability firms are more efficient than individually owned firms. To control for the effect of joint stock ownership we include a dummy variable that takes the value of 1 for joint stock firms and zero for all others.

Four year dummies are introduced for the years 2004 to 2007 to accommodate the macroeconomic factors common to all firms and sector dummies (at the two digit level) are used to control for the differences between sectors within the manufacturing sector.

4.9 Hypothesis Testing

We have five different hypothesis tests to determine if our model is robust. The first hypothesis states the null that Cobb Douglas production function should be used, whereas the alternative is the translog production function. The second null hypothesis assumes no technical inefficiency effects and the alternative states inefficiency effects exist. The third hypothesis has the null stating that the inefficiency effects are nonstochastic (Υ=0), meaning the ordinary least squares would be suitable; whereas the alternative assumes stochastic frontier analysis is appropriate. The fourth hypothesis asserts that the inefficiency effects are not a linear function of the inefficiency regressors. Last, but not the least, the null hypothesis states that the inefficiency effects are time invariant.

To test these hypotheses we use a likelihood-ratio test (LR test). The likelihood ratio test essentially compares the likelihood of the data under the alternative hypothesis against the likelihood of the data under the more restricted null hypothesis. The aim is to see whether the alternative has support over the null. In other words, the researcher tries to answer the question "Is the chance of data arising as it does, significantly less if the null hypothesis is true than if the alternate hypothesis is true? The test is conducted by the computation of two likelihoods values, $\log[\mathrm{L}(\mathrm{H}_0)]$ and $\log[\mathrm{L}(\mathrm{H}_\mathrm{a})]$ calculated as maximum values of the log likelihood function under the two hypotheses of the null (H_0) and the alternative (H_a), respectively.The difference between these log likelihoods can be conducted as follows:

$$\lambda = -2\{\log[\mathrm{L}(\mathrm{H}_0)] - \log[\mathrm{L}(\mathrm{H}_\mathrm{a})]\} \quad (3.14)$$

The difference between the likelihoods is multiplied by -2 in order to make its distribution similar to that of the Chi-square distribution. The arising test statistic is then compared to the Chi-square's critical values. The degrees of freedom equal the difference in the number of parameters that are estimated in the null and alternative hypothesis.

We proceed with testing the first hypothesis whose null states Cobb Douglas production model is appropriate for the data versus the alternative of the translog. The value of log-likelihood functions obtained from the estimation of the Cobb Douglas and translog representations are -771.31 and -755.49, respectively (see Table 29). Applying a likelihood ratio test, we find a value of the test statistic as 31.65, which is significantly greater than the critical Chi square table value of 12.59 with 6 degrees of freedom at the 5% significance level. Relying on this statistic, we reject the null hypothesis, and favor the translog specification over the Cobb Douglas representation. Secondly, we test the null hypothesis of no technical inefficiency against the alternative that inefficiency effects exist. Then the null hypothesis of no technical efficiency states that the technical efficiency model's coefficients are all zero. When we impose this restriction, we get likelihood value of -831.13. Performing the likelihood ratio test again, we get a test statistic of 151,30 which is greater than the critical value of the mixed Chi square test statistic of 26.98, which is a value taken from Kodde and Palm (1986, Table 1) who provide the critical values of the likelihood ratio test when distributions are mixed. [18] Hence, we find that the technical inefficiency effects prevail as our model suggests. Thirdly we test the null hypothesis that the inefficiency effects are non stochastic. The likelihood ratio statistic we get given this null hypothesis versus the stochastic form is 87.79 with a degrees of freedom of 4. If $\Upsilon=0$ or in other words, if the inefficiency effects are non stochastic, the model becomes an ordinary least squares (Coelli and Battese, 1996) . Then the model does not have the four parameters which are included in the alternative model: Υ, δ_0, and the coefficients of two time dummies. If $\Upsilon=0$, the constant in the efficiency effects which is δ_0 cannot be identified separately because the constant in the production function captures the intercept. The two time dummies also cannot be estimated because the t and t^2 variables are present in the production function. As a result of these restrictions the degrees of freedom becomes 4. The critical value of the test statistic which again comes from a mixed distribution is 8.76 (Kodde and Palm, 1986). Therefore, at the 5% significance level, we reject the null and continue with our stochastic frontier analysis. Next, we test the null hypothesis that our inefficiency effects are not a linear function of all the explanatory variables. In other words, this hypothesis means that other than the constant all inefficiency effects coefficients are zero. With a likelihood ratio test statistic of 38.26 which is higher than the critical test statistic of 24.99 with 17 degrees of

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[18] The distribution is mixed because the alternative hypothesis has an inequality constraint where $\Upsilon\geq0$. Kodde and Palm (1986) provide the upper and lower bounds for the critical value when equality and inequality restrictions are tested together. According to Kodde and Palm (1986) the degrees of freedom of the lower and upper bounds of the critical value are q+1 and p. Here q stands for the number of equality constraints and p represents the total number of constraints. In the case where the test statistic is higher than the upper bound, the null hypothesis is rejected. Since we have one inequality constraint , p equals to q+1 and the lower and upper bound values are the same.

freedom at the 5% significance level, we claim that our inefficiency factors coefficients are different than zero.

Finally, we test the null hypothesis that the inefficiency effects are time invariant, i.e. the time dummy variables in the inefficiency equation have zero coefficients and inefficiency does not change in time. The likelihood ratio statistic is -11.65 and the Chi-square test statistic with 4 degrees of freedom is 9.49. As the value of the test statistic does not exceed that of the critical value, we fail to reject the null hypothesis that inefficiency effects are time invariant (Table 29). As a matter of fact, this model suits our case better than the translog model where time dummies are included in the inefficiency effects but none are significant. Thus, we choose the time invariant inefficiency effects model to proceed with the high-mid-tech and low-tech R&D performers' stochastic frontier analysis.

Table 29: List of Hypothesis Tested

Log likelihood	Test Stat	Critical Value$_a$	Decision
CD H_0:All βs are equal to zero.			
-771,309	31,65	12,59	Reject H_o
No inefficiency, $H_0:\gamma=\delta_0=\delta_1=...=\delta_n=0$.			
-831,13	151,30	26,98$_b$	Reject H_o
Non-stochastic inefficiency $H_0:\gamma=0$			
-799,38	87,79	8,76$_b$	Reject H_o
No inefficiency effects $H_0:\delta_1=...=\delta_n=0$.			
-774,62	38,26	24,99	Reject H_o
Time invariant inefficiency $H_0:\delta_8=\delta_9=\delta_{10}=\delta_{11}=0$.			
-749,11	-11,65	9,49	Fail to Reject H_o

a: critical value of the test statistic at the 5 %level of significance.

b: The critical values are taken from Kodde and Palm, 1986, Table 1.

Table 30: Results of the Stochastic Frontier Estimation

	All R&D performers		High-mid-tech R&D performers		Low-tech R&D performers	
Production function	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Constant	-0,01	-0,01	0,76	0,78	0,42	0,42
C	0,01	1,39	0,01	1,46	0,00	-0,27
L	-0,03***	-3,52	-0,02***	-2,57	-0,02*	-1,70
T	0,00	0,44	0,00	0,36	0,03**	1,97
Tt	0,05***	4,21	0,05***	3,46	0,05**	2,39
Lt	0,00	0,29	0,00	0,43	-0,01	-1,14
LL	0,01	0,66	0,01	1,13	-0,01	-0,70
CC	0,01***	2,78	0,01***	2,30	0,01	1,26
Ct	-0,03***	-5,45	-0,03***	-4,71	-0,02**	-2,26
LC	-0,01**	-2,20	-0,01	-1,59	-0,01	-1,08
Skill	0,02	0,18	-0,05	-0,47	-0,02	-0,22
Efficiency effects						
Constant	-0,82	-1,22	0,36	0,64	-0,14	-0,19
S input	-6,60***	-7,04	-6,08***	-3,21	-5,48**	-2,27
S output	2,07***	3,52	1,27***	3,42	0,84***	2,86
Market share	-3,06***	-3,17	-0,84**	-2,07	-0,68**	-2,03
R&D Intensity	0,12**	2,50	0,05	1,51	0,04	0,99
Sectoral spillover	-0,19***	-4,02	-0,07**	-2,20	-0,04	-1,33
Subsidy dummy	-0,09	-1,07	0,02	0,18	-0,16	-0,92
Export Intensity	0,25	1,41	0,10	0,54	0,34	1,46
Geographic spillover	-0,01	-0,94	0,00	-0,39	-0,01	-0,52
Joint Stock dummy	-0,29***	-2,89	-0,11	-1,17	0,08	0,44
Variance parameters						
sigma-squared	0,78***	4,38	0,38***	9,74	0,31***	6,30
gamma	0,90***	35,66	0,79***	27,55	0,82***	26,55
Mean efficiency	0,82		0,80		0,81	
# obs.	2077		1573		504	
Log Likelihood	-749,65		-620,83		-121,82	

*** p<0.01, ** p<0.05, * p<0.1

4.10 Discussion of Estimation Results

The production function estimates in Table 30 for all R&D performers, high-med tech R&D performers and low tech R&D performers indicate that an increase in physical capital intensity has a positive effect on labor productivity however it is insignificant at the 10% level . On the other hand, the coefficient of labor which informs us about the returns to scale is negative and significant for all R&D performers and for high-med tech R&D performers at 1% significance level (Table 30) and 10 % level for low-tech R&D performers. These findings indicate that a 1% increase in all inputs have less than 1% increase in output. In other words, the assumption of decreasing returns to scale is valid for all R&D performers, high-med tech and low-tech R&D performers. There are other studies reporting the same finding regarding returns to scale. (Kox et al, 2010; Amornkitvitaki and Harvie, 2010 and Kumbhakar et al., 2009). Decreasing returns to scale could prevail if a firm grows too much. For instance a firm could start hiring new labor to have specialization of labor but after a point becomes too large to manage the production process effectively. Then decreasing returns to scale could set in. Coelli et al. (2005) attribute decreasing returns to scale to a firm's being too large.

Time represents technical change and its coefficient is defined as the derivative of the production function with respect to time (Coelli et al., 2005). For all R&D performers and for high-mid-tech R&D performers the coefficient of time is zero and insignificant, but for low-tech R&D performers there is positive technical change statistically significant at 5% level.
In order to observe whether technical change has been capital saving and/or labor saving, we need to look at the coefficients of capital and labor variables interacted with time. In Table 30, the coefficient of capital intensity interacted with time is negative and statistically significant at 1% level for all R&D performers and high-mid tech R&D performers and 5% for low-tech R&D performers indicating that there has been technical change has been capital using.

As for the efficiency effects, first we examine if gamma turns out to be significant or not because a significant gamma indicates that a substantial proportion of the error variance is attributable to the inefficiency effects. As can be observed from Table 30, gammas are significant for all sub-groups of R&D performers and for the whole group, so we can claim the stochastic frontier model is appropriate. R&D intensity which is our variable of concern has a positive and statistically significant coefficient at 5% level for all R&D performers. This finding indicates that as R&D intensity increases efficiency will be affected negatively for all R&D performers. For high-med tech firms and low tech firms the effect of R&D intensity is not statistically significant. This negative effect of R&D intensity on technical efficiency is found in the literature as well (Perelman,1995; Sangho, 2003). R&D is an activity that has potential to extend the technical frontier further. If R&D activities of the sector leaders could extend the frontier, then the distance to the frontier for the follower R&D performers increases. As a result, their R&D activities cannot help them to approach the frontier. Since the sector leaders will be working on leading technologies concurrently, the R&D activities of the followers may not compensate the distance between them and the leaders. Our interviews also provide corroborating evidence for this argument. For instance, one interviewee in the machinery and equipment sector claims that when they attend trade fairs and see competitors' advanced technologies, they realize they need to upgrade their technology. That is when they conduct R&D. This is an important finding because it shows that R&D is performed only after the leaders' advanced technology in market is observed by the other R&D performers.

However, another variable of our concern, the R&D spillover variable has a significantly positive effect on technical inefficiency at 1% level for all R&D performers and for high-mid-tech R&D performers but not for low-tech R&D firms. This finding highlights the significance of knowledge spillovers occurring at the sector level for R&D performers in their catching up efforts with the technological frontier and also indicates the low tech R&D performers do not or cannot make use of such spillovers. One factor we need to take into account in studying the effect of spillovers and R&D intensity on technical efficiency is the time it takes for knowledge to travel in the industry and the time it takes for the R&D activities to impact on technical efficiency. When we introduce one year lag to both the spillover variables and the R&D intensity, the significance of the knowledge spillover disappears but R&D intensity continues to exert a negative effect on efficiency. This result could be due to the explanation provided above or there may be a longer time than one year, for the results of R&D activities to show their effects on efficiency. The results from the lagged R&D intensity and spillovers are provided in Appendix L.

Among the control variables, the effect of subcontracting is highly significant and positive for all sub-groups of R&D performers as well as for all R&D performers at the 1% level. This is a result that finds support in the literature (Taymaz and Saatçi, 1997). We can deduce from this finding that those companies that subcontract work to others improve their efficiency. On the other hand the opposite effect is observed for the ones that undertake subcontracted work because the coefficients of the S_output variable are significantly negative at 1% level for all R&D performers and high-mid-tech and low-tech firms. We can deduce from this result that as firms subcontract part of their work to others, they focus on their own specialization which pays off in terms of higher efficiency. Our deductions from the interviews conducted with R&D performers support this finding to some extent. Some interviewees claim their subcontractors enable them to benefit from expert knowledge, thus, they claim subcontractors are indispensable as far as their R&D activities are concerned. On the other hand, there are other interviewees who state subcontractors are unreliable and therefore they try not to use subcontractors for R&D or manufacturing purposes. Therefore, we cannot directly make a link with the results of the econometric findings and those of the interviews in the case of the subcontracting's effect on efficiency.

Firm's market share's positive and statistically significant effect on efficiency is consistently observed for all firms and for the two sub-groups considered here. This finding signals the significance of market share for a firm to catch up with the frontier. As Marksun and Venables (1997) indicate if the rise in the market share happens at the cost of other inefficient firms, the competitive pressure from the survivors may be tougher. This pressure could induce the firm to reorganize itself as far as its management and resource control is concerned. As a result its efficiency may increase. Hay and Liu (1997), Diaz and Sanchez (2008) and Mazumder and Adhikary (2010) also find market share to be an important variable in improving efficiency.

On the other hand, the geographic knowledge spillovers at the province level has a positive effect on efficiency for high and med tech R&D performers and for all R&D performers but the coefficients are not statistically significant at 10% level. This result could be attributable to the use of administrative provinces. Perhaps with a definition based on manufacturing clusters' locations, more statistically significant results could be achieved.

Being a joint stock firm has a positive effect on technical efficiency for the whole group of R&D performers but not for the sub-groups of high-mid tech and low-tech R&D performers. This is quite a significant result at 1% level for all groups of firms. Finding a similar result for public limited companies in a study on Spanish manufacturing firms, Diaz and Sanchez (2008) claim in this form of ownership, risk remains with share capital and managers are able to take on risky projects with high returns. The same argument may hold for joint stock firms here as well. With a separate board of directors, and a will to undertake R&D which is a highly uncertain investment, these firms may be less risk averse than companies with other types of legal status. Our results are also in line with the findings of Taymaz and Saatçi (1997) who examine technical change and efficiency in textile, cement and motor vehicles sectors. In the cement industry they report that joint stock ownership has a positive significant effect on efficiency.

CHAPTER V

POLICY RECOMMENDATIONS

Based on the results from our findings we have some policy recommendations which will be presented at three levels: macro, meso and micro. These levels cover policies at the national, industrial and firm level respectively. For each policy aim a policy tool is also presented.

The first policy aim has to do with increasing subsidies to promote R&D intensity. This is a macro aim as it can be carried out at the national level. Our results in the first chapter indicate that extending subsidies increases R&D intensity. However, one point needs to be underlined. As the results of our interviews also emphasized, once a firm gets an R&D subsidy and comes up with a prototype at the end of the subsidy period, it needs help in commercializing the product. Particularly with new entrepreneurs or startups, this is a very difficult stage to survive. Therefore, extending subsidies in a step-wise manner could mitigate the problem of survival and ensure the effectiveness of the subsidies. After the financial subsidy stage, a commercialization training or a mentoring program could be started. Although TUBITAK has started this type of a structure in 2012 as a program which is tailored for young entrepreneurs, it should have been initiated earlier.

Another macro aim is to ensure that subsidies are serving their purpose in generating commercial outcomes and building knowledge accumulation. As Tandoğan (2011) suggests an instrument to be used could be an impact assessment study for the beneficiaries. If these impact assessment studies are not conducted, then we can never know if the intended effects are realized. Both qualitative and quantitative methods should be employed and perhaps an auditing system could be brought into the national innovation system in order to carry out these impact assessment studies.

In order to complement the state subsidies in promoting an increase in R&D intensity, private sector's R&D financing schemes should also be enabled. This is also a macro aim as it has to do with the provision of relevant legislature and rules and regulations. The tool is to open the way to the foundation of venture capital firms and angel investors. Although actions towards the employment of these tools are taken, solid and sustained results in the form of increased private capital funding to R&D performers will be observed in time.

In our interviews with R&D performers, we have come across firms that were aware of R&D subsidies but did not qualify for application for various reasons. This is a problem that needs to be attended at the meso level as each sector has its-own sector specific issues. However the aim is to learn the reasons for not applying to R&D subsidies. Via tools like focus groups or face-to-face interviews with managers, these reasons could be identified and each could be analyzed as to how it can be overcome. Moreover, publishing R&D success stories at the sector level could also work as an incentive to attract more firms to carry out increasing amounts of R&D expenditures. Giving awards to R&D performers at the sector level could be another tool to raise awareness in this issue.

The results of the first two chapters indicate skill is a major determinant of R&D intensity and has a significant effect on productivity. Therefore our first macro aim is to increase R&D staff in number and in quality. In the short-term bringing back experienced Turkish researchers from abroad can be the first tool. As these people are already working in R&D related fields and can help in building essential bridges between the Western Research Institutes and Turkey, they constitute a natural target to start from. With exactly the same tool in mind, TUBITAK has held a conference in Istanbul on July 12-13, 2012 for Turkish scientists abroad (Ocak, 2012). Although this is a move in the right direction, an easier and a cheaper way to learn about the difficulties one faces coming back to Turkey could be to survey the recently returned scientists. As Akçomak (2012) argues in an Internet blog article, in the one and a half years he has returned from Holland with a PhD degree to a Turkish university, he had to gather 68 different documents to be able to adapt to Turkey. Even this single number gives considerable amount of information as the amount of red tape the government needs to eliminate to bring back more researchers. Following Akçomak's suggestion, we propose that recent returnees should be contacted and an inventory of the problems they had to go through should be made. Later each one should be addressed and relevant rules and regulations should be changed.

Since researchers with PhD degrees is a rather scarce resource, in order to increase their numbers post-doc positions can be generated at universities. This can enable them to carry out further research once they get their degrees. Another much needed program for PhDs is sabbatical. Sabbatical programs allow researchers to spend some time abroad doing research with the guarantee of keeping their jobs in Turkey. This program allows researchers to work in close collaboration with foreign researchers which is a vital part of keeping up with recent developments and taking part in them.

At the master's level and undergraduate level, students can be employed in R&D projects of the faculty members. This can enable the students to have a sense of a research environment before graduation and think about pursuing a career in R&D in addition to other career options. Another option could be launching summer courses generated by collaborative work of R&D performing firms and faculty members. Firms can assign summer projects where students can exhibit their team-work characteristics, discipline and analytical skills. Projects can be carried out under the guidance of a faculty member. At the end of the term, students can present their work to representatives of the firm. This could help the firms and faculty members identify those students equipped with the skills R&D work requires. Later on, those students can be offered jobs in R&D or graduate study scholarships. Moreover, career placement centers should introduce students to R&D firms because most of the time it is difficult for students to find out about them on their own when they are looking for a job. At the vocational school level, curriculums should be examined to make them more accommodative towards technician development who can work in R&D projects.

At the high-school and elementary school levels, interest in science should be promoted. Lately, summer schools targeting high-school and elementary school students have been started with the theme 'science-is-fun' [19]. These type of activities should be undertaken as social-service activities by universities and private firms. If private R&D performing firms can sponsor the funding of these activities, students can be trained for science in a play-like environment. However, one of the key needs at elementary and high-school education is teaching English effectively because without being able to fluently communicate in English, it is

[19] For instance Atılım University Summer Science Camp (Atılım University, 2012) or TUBITAK summer camp 2011 (TUBITAK, 2011).

extremely difficult to benefit from international networking and following up developments in the R&D world as an adult.

Looking at the skill scarcity problem from the demand side, we believe there are certain policy options R&D performing firms can take at the micro level. In order to effectively locate skilled staff, faculty members should develop elective courses for the summer term in collaboration with R&D performing firms to let students undertake project work where they can exhibit their skills such as team-work abilities, patience, attention to details, abiding budgets, etc. Then firms could offer internships to the selected few. Such a proactive approach by the firms could increase the chances of recruiting correct people and lower the costs of hiring as well. Furthermore, another micro aim of the R&D performing firms is to prevent poaching and to hold on to their skilled R&D staff for longer periods. A viable tool that was used by one firm in interviews was starting Human Resources Management practices. First of all, setting up a Human Resources Department or making a manager in charge of Human Resources issues in the firm is a good starting point. The top management's involvement in this practice is vital. If the R&D employees realize they are being cared for, their loyalty to the firm can increase. Furthermore, making long-term career plans in the firm for the R&D staff also could make them feel cared for and respected. If the staff knows they have a planned future in the firm, they can work towards achieving that goal and feel more attached to the firm. Instilling such a feeling among R&D staff should be a key goal of an R&D firm because R&D is a long-term process which requires sustained staff. In addition to these, one more tool firms can use to retain their R&D personnel could be issuing stock options but as stocks can only be possible with joint-stock companies, this is more of an alternative for large firms.

A disadvantage of being small is being deprived of the large pockets advantage of larger firms. Thus, for small firms finding and keeping skilled staff could be a challenge while performing R&D. Therefore at the meso level, organizations such as chambers of commerce can hold training sessions on human resources practices for small firms. This could enable them to learn about the correct way to serve the needs of R&D personnel.

The macro aim regarding foreign knowledge spillovers is to allow time for foreign firms to blend in with the domestic firms. As our results indicate, it takes time for foreign knowledge spillovers to arise, however in order for the domestic firms' R&D activities not to be hurt by the competitive pressure from foreign enterprises in the market, they need to invest in their own R&D capacities as well. Yet, building R&D capacity also takes time. Therefore, the state could initiate a leading role in welcoming foreign enterprises into the country and working towards embedding them among the domestic firms environment. Furthermore, if joint R&D projects by foreign sector leaders and domestic small R&D firms can be promoted, the embedding of the foreign firms into the national innovation system can be expedited and spillovers can flourish more easily.

Using subcontracting as a means to focus on one's own line of business emerges as an outcome of both of our the qualitative and quantitative study. At the meso-level, awareness on use of subcontracting can be raised. As a tool, success stories of R&D performers who have used subcontracting successfully could be published. The idea that successful subcontracting relations take time to nurture should be introduced to R&D performers so that they should understand that they need to work on subcontracting relationship rather than readily disposing them due to their preconceptions.

CHAPTER VI

CONCLUSION

Although the effect of R&D on productivity has been well established in the case of developed countries, its effect in the case of developing countries is found to depend on the presence of such factors as economic stability, well established institutions such as intellectual property rights and a properly working national innovation system (Song, 2005; Kothari, 2009). Given the low levels of knowledge accumulation in developing countries when compared to those in the developed countries, foreign direct investment is seen as one of the mechanisms through which they can draw from the global knowledge pool. As Turkey has been a country whose R&D expenditures have been rising in the period 2003-2007, with accompanied rise in foreign direct investment, Turkey seemed to be a good candidate to study the determining factors of the increase in R&D expenditures and how the higher R&D expenditures affected the productivity and the technical efficiency of firms in the manufacturing sector.

The research question we pursued in the first chapter was 'How does foreign ownership and related foreign knowledge spillovers affect R&D activities in Turkey?". As there were many firms with zero R&D investments in our sample, we faced a selection bias problem. To overcome this obstacle, we had to use Heckman two-stage procedure. However when endogenous variables are present in the model, as was the case in this instance, one had to use instrumental variables together with the Heckman selection procedure. Performing both of these procedures in the panel data context added to the challenge from a methodological point of view. Employing a recently proposed procedure by Semykina and Wooldridge (2010) which comprised Heckman two-stage procedure with instrumental variables in panel data context, we overcame the estimation challenge. Thus, our first contribution has been the employment of this new methodology. Secondly, we proposed two instruments, sum of subsidies at the sector level and licensing expenditures at the firm level for the endogenous variable, the R&D subsidy received by the R&D performer. These instruments worked for us in the first chapter and constituted our second contribution since they passed all the identification tests. Thirdly, we used 2003-2007 firm level data from Turkstat generated by the matching of two surveys which have recently become available.

Our findings reveal that foreign ownership does not have a statistically significant effect on R&D expenditures of (foreign) R&D performers in the manufacturing sector. However, we find that foreign knowledge spillovers exert a negative pressure on R&D activities. Although this result could be attributable to an “asset-exploiting” motive on the part of the foreign enterprises, when we allow a one year lag into the foreign knowledge spillovers, we observe that the negative effect ceases to exist. On the contrary, positive and statistically significant foreign knowledge spillovers at the sector level are observed for low-tech R&D performers. This result indicates that it takes time for foreign firms to adapt their intangible proprietary assets to the environment and once they are embedded in the host country, knowledge starts to stem from their R&D activities and propagate to the rest of the sector. Thus, if we go back to our research question, we can say that foreign knowledge spillovers do have a positive effect on R&D activities but one needs to be patient for this effect to emerge. Particularly with high-mid tech sectors, although we cannot claim to find such an effect, this can be attributable to the one year lag we employed. As we had a short time frame which was five years, we could not take additional lags and that may be the reason for the insignificance of the positive foreign knowledge spillovers at the sector level for high-mid-tech R&D performers. Yet, the conversion of the negative statistically significant sign into a positive one for high-med tech sectors, hints that with a longer time dimension one might find a statistically positive foreign knowledge spillovers effect on R&D. Thus a future research agenda is to use longer time dimension and test second and third lags of foreign knowledge spillovers to see the effect of foreign knowledge spillovers on R&D intensity.

Another factor that emerges as another significant determinant of R&D intensity among Turkish manufacturing firms is skill. The higher the skill level in an R&D performing firm, the higher is the R&D intensity. This finding is also underscored in our qualitative research. Interviewees stated that they needed skilled staff and had a hard time finding skilled personnel. Feeling desperate for this scarce resource, R&D performers resorted to consulting with university professors in and out of Turkey. They also hired master’s students to compensate for the lack of skilled staff. Establishing links with experts on a project basis was another solution firms employed to make up for this deficiency. Thus, a vital ingredient in R&D activities is addressed as skilled staff, yet acknowledgement of this fact is not enough for R&D performers to secure this resource.

As we find subsidies to be strongly associated with R&D intensity, another area of concern with raising R&D expenditures is R&D subsidies. This is also related to the finding with firm size. Our findings suggest that R&D intensity increases as size decreases other factors remaining the same. Thus, one deduction has to do with the limited resources of smaller firms, both financially and otherwise. Yet, as their efforts are rather high given their limited conditions, they need to be subsidized. Of course, issues pertaining to additionality have to be taken into account for an effective innovation policy (Pamukçu and Tandoğan, 2011).

Another positive determinant of R&D intensity emerges as the export intensity of the sector. We attribute this outcome to the information advantage a firm has over those who are located in a sector that does not export. Exporting firms could accumulate information about the developments in the rest of the world and R&D performing firms could use this information spilling into the sector and steer their R&D activities towards where the world is going . Thus exporting activities in a sector might create a boosting effect on the R&D intensities of firms.

Last but not the least, past R&D activity seems to be a positive determinant of current R&D intensity. Our interviews also emphasize the value of R&D experience in current R&D projects and the finding that none of the interviewees acknowledge any failed R&D projects suggest that they expect a positive outcome, financial or learning wise, from any R&D activity they undertake. There seems to be an acceptance by the firms that R&D is a long-term process, and any investment may generate some form of utility in the future, so there is no sunk-cost perception for the R&D investments among the interviewees performing R&D.

The research question in the second chapter was “How does the increase in R&D capital stock and how do foreign knowledge spillovers affect labor productivity?” Since our sample was composed of R&D performers only, we employed the Heckman two stage procedure with the instrumental variables technique for panel data (Semykina and Wooldridge, 2010) in this chapter as well. Our contribution here is our three instruments for two endogenous variables:

the interaction of sector level R&D expenditures and market share as the first instruments and the sum of R&D expenditures at the province level as the second instrument for the endogenous variable of R&D capital stock intensity. Furthermore, for the other endogenous variable which is physical capital stock intensity, we used the sector's physical capital stock intensity. Our findings signal that it is the indigenous efforts of R&D performers and their physical capital stock intensity that have a positive effect on labor productivity. However, neither foreign ownership nor foreign knowledge spillovers are found to affect R&D performers' labor productivity positively. On the other hand, skill exerts a rather strong positive impact on productivity once again emphasizing the role of employing educated personnel in R&D performing firms. Thus, we can conclude that Turkish R&D performers are dependent on their accumulated physical capital stock intensity and their own R&D efforts when it comes to increasing labor productivity. Again, the short time dimension of our panel data hindered the lags we tried to introduce into the system. Therefore a longer time dimension could be more favorable towards analyzing the effects of foreign knowledge spillovers and foreign ownership on labor productivity in the future.

In the third chapter where we analyzed if R&D activities could help firms catch up with the sector leaders, we employed a stochastic frontier analysis estimation procedure. We hypothesized that for low-tech R&D performers R&D activities could be facilitating their catch up process with the sector leaders. However our findings revealed that for R&D performers as a whole R&D activity exerts a negative effect on technical efficiency. We attributed such a result to the sector leaders' activities to extend the frontier which can raise the distance between the followers and the leaders in terms of productivity. The results of our interviews also underlined the factor that R&D performers are following the sector leaders' and foreign firms and only upon demand from their clients or customers, do they undertake R&D activities. Realizing the developments in the market (both domestic and abroad) they invest in their R&D efforts but this happens in order to meet customer orders. Such a reactive manner could not be a wise strategy in catching up with the frontier, therefore, more pro-active R&D efforts could change this situation.

On the other hand, the R&D spillovers variable has a significant and positive effect on technical efficiency. Therefore, we observe the positive effect of knowledge spillovers at the sector level

to help an R&D performer reduce the gap between itself and the sector leader. However, the absence of the significant effect of lagged R&D spillovers on technical efficiency could be attributable to the longer time it takes for knowledge to travel than just one year. Among the control variables, subcontracting is observed to have a robustly positive effect on technical efficiency. This is corroborated by the outcomes from the interviews with R&D performing firms. Subcontracting seems to allow the firms to focus on their own line of work and excel on their core competence. Furthermore, subcontracting allows these firms to benefit from expert knowledge which in some cases could be indispensable as some of our interviewees stated. However, not all R&D firms may be aware of the positive effects subcontracting may have on their technical efficiency, as some believe subcontractors are unreliable.
Finally being a joint stock firm also facilitates the catch up process which could be due to the employment of professional managers and management techniques when a firm is a joint stock company ruled by a board of directors. With the separation of management and ownership, management may be more inclined to take more risky projects which can yield high returns and carry the firm towards the production frontier.

As far as future research needs are concerned, longer time series data emerges as one that arises in all three chapters. With a longer dimension in time, taking second and further lags of certain variables such as knowledge spillovers can reveal some effects that emerge in time.

Another future research need has to do with the sample of interviews with R&D performers. Although we have conducted some face-to-face interviews in this dissertation, due to time and financing limitations, the sample was a convenience-based one. For the sake of getting a more precise picture of R&D performers' problems and their approaches to overcome those, a larger qualitative study needs to be performed. Focus-groups, in depth interviews, or semi-structured face-to-face interviews can be conducted with R&D performers. As we found out during the course of our search for R&D performers, there are firms who perform R&D without receiving any subsidies. Finding such firms and learning about their stories is another essential research agenda. Since these R&D performers do not receive any subsidy, they are not registered in the lists of subsidy or incentive providers. However, their efforts are extremely valuable to shed some light on how a firm struggles in performing R&D on its own. This is a group that needs to be paid special attention otherwise it is very likely that they will be underrepresented in the sample which can lead to biased results. Furthermore, learning the reasons for not taking subsidies would generate valuable information. Moreover, particularly qualitative information from small R&D performers would be rather informative as our results indicate small firms have a strong tendency for R&D activities.

Another future research agenda has to do with Turkstat's discretion on permitting the use of R&D data available in the Structural Business Survey. Although such data is present, Turkstat currently does not permit its use claiming the R&D survey provides appropriate. However, the size of the data in the R&D survey is very limited in comparison to the size of the Structural Business Survey and valuable information can be reached should Turkstat decide to open it for use.

REFERENCES

Abdelmoula, M. and Etienne, J.M. (2010). Determination of R&D investment in French firms: A two-part hierarchical model with correlated random effects. *Economics of Innovation and New Technology*, 19 (1/2),53-70.

Aiello, F. & Cardamone, P. (2005). R&D spillovers and productivity growth: Evidence from Italian manufacturing micro data. *Applied Economics Letters*, 12 (10), 625-631.

Aiello, F. & Cardamone, P. (2008). R&D spillovers and firms' performance in Italy. *Empirical Economics*, 34 (1), 143-166.

Aiello, F., & P. Cardamone (2010). Regional economic divide and the role of technological spillovers in Italy. Evidence from micro data, Retrieved from: http://mpra.ub.uni-muenchen.de/22572/1/MPRA_paper_22572.pdf, last accessed at August 2012.

Aigner, D., Lovell, C.A.K., & P. Schmidt (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics,* 6, 21-37.

Aitken, B. J., & Harrison, A. E. (1999). Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. *The American Economic Review,* 89 (3), 605–618.

Akçomak, S. (2012) Beynim göçtü. Personal blog on reverse brain drain policies in Turkey. Retrieved from: http://www.bilgicagi.com/Blog/528-beynim_goctu.aspx, Last accessed at August 2012.

Aldieri L. ,Cincera, M., Garofalo, A. ,& Vinci C.P. (2008). Micro evidence of the effects of R&D on labor productivity for large international R&D firms. *International Journal of Manpower*, 29 (3), 198-215.

Aldieri, L. & Cincera, M. (2009). Geographic and technological R&D spillovers within the triad: Micro evidence from US patents. *The Journal of Technology Transfer*, 34(2), 196-211.

Amornkitvikai, Y.& Harvie, C. (2011). Finance, ownership, executive remuneration and technical efficiency: a stochastic frontier analysis of Thai listed manufacturing enterprises. *Australasian Accounting Business and Finance Journal*, 5(1), 35-55.

Amsden, A.H. (1989). Asia's next giant South-Korea and late industrialization, Oxford, Oxford University Press.

Amsden, A.H. (1991). Diffusion of development: The late_industrializing model and greater East Asia. *The American Economic Review*, 81(2), 282-286.

Amsden, A. H. (2001). The Rise of the Rest, Oxford, Oxford University Press.

Ansal, H. and A. Soyak (1999). Privatization on R&D activities: The case of Turkish telecommunications industry., Civilization, Modern technology and Sustainable Development: Conference Proceedings, Part I, pp. 39-49, 8th International Conference on Management of Technology, IAMOT 1999, 15-17 Mart 1999, Cairo, Egypt .

Artes, J. (2008). A Selection model of RD intensity and market structure in Spanish firms, Retrieved from: http://www.ief.es/documentos/recursos/publicaciones/ papeles_trabajo /2008_09.pdf , last accessed at August 2012.

Arvanitis S. & Sturm J.E. (2008). Innovation and labor productivity growth in Switzerland: An analysis based on firm level data. In S. Arvanitis & J.-E. Sturm(Eds.) Productivity Measurement and Analysis: Proceedings from OECD Workshops, FSO. ISBN 978-3-303-04079-9.

Atılım University (2012), Eğlenceli Bilim Merkezi, İncek, Ankara. http://eglencelibilim.atilim.edu.tr/faaliyet-alanlarmz, last accessed at August 2012.

Aw, B-Y. (2001). Accumulating technology and location spillovers among firms in Taiwan's electronics industry. *Journal of Development Studies*, 39(1),94-118.

Aw, B.Y., Roberts, M. and Xu, D.Y. (2011). R&D investment, exporting and productivity Dynamics. *The American Economic Review*, 101(4), 1312–44.

Ayhan, A. (2002). Dünden bugüne Türkiye'de bilim teknoloji ve geleceğin teknolojileri, Beta Basım Yayım ve Dağıtım A.Ş., İstanbul.

Badunenko, O., Fritsch , M. & Andreas S. (2008). What drives the productive efficiency of a firm? The importance of industry, location , R&D and size. Deutsches Institut for Wirtschaftsforschung, Berlin. Discussion Papers 775. Retrieved from: http://www.diw.de/documents/publikationen/73/diw_01.c.81440.de/dp775.pdf, last accessed at August 2012.

Banri, I., Yashiro, N., Xu, Z. Chen, X.,& Wakasugi, R. (2010). How do Chinese industries benefit from FDI spillovers? Retrieved from: http://www.rieti.go.jp/jp/publications/dp/10e026.pdf , last accessed at August 2012.

Barbosa, N., & Faria, A.P. (2008). Technology adoption: does labor skill matter? Evidence from

Portuguese firm-level data. *Empirica*, 35, 179-194.

Baum, C.F. , Schaffer, M.E, & Stillman, S.(2003). Instrumental variables and GMM: Estimation and testing, Boston College Working paper No.545.

Baum, C.F. , Schaffer, M.E, & Stillman, S.(2007). ivreg2: stata module for extended instrumental variables/2SLS, GMM and AC/HAC, LIML and k-class regression. Boston College Department of Economics, Statistical Software Components s425401. Retrieved from: http://ideas.repec.org/c/boc/bocode/s425401.html, last accessed at August 2012.

Baum, C.F. (2009). Instrumental variable and panel data methods in economics and finance. Presentation Notes. Retrieved from: http://fmwww.bc.edu/Gstat/docs/StataIV.pdf, last accessed at August 2012.

Barrios, S., Görg, H. and Strobl, E. (2005). Foreign Direct Investment, Competition and Industrial Development in the Host Country, *European Economic Review*, 49, (7),1761-84.

Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, (20), 325–332.

Becker, B. and Pain, N. (2008) What determines industrial R&D Expenditures in U.K.? *The Manchester School*, 76(1), 66-87.

Bednarek, Z. (2010). Does R&D investment depend on ex-ante productivity? Retrieved from: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1695270, last accessed at August 2012.

Benavente, J.M. (2006). The role of research and innovation in promoting productivity in Chile. *Economics of Innovation and New Technology*, 15 (4/5), 301-315.

Berghall, E. (2010). Innovation, competition and technical efficiency, paper presented at the Summer Conference 2010, "Opening Up Innovation: Strategy, Organization and Technology" at Imperial College London Business School, June 16 – 18.Government Institute for Economic Research.

Bernstein, J.I. & Nadiri, M.I. (1988). Interindustry R&D spillovers, rates of return, and production in high-tech industries. *The American Economic Review*, 78, (2), 429-434.

Bernstein, J.I. & Mamuneas, T.P. (2006). R&D depreciation, stocks, user costs and productivity growth for US R&D intensive industries. *Structural Change and Economic Dynamics,* 17, 70–98.

Blundell, R.W. & S.R. Bond (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87, 115-143.

Bogliacino, F. & Pianta, M. (2010a). Profits, R&D and innovation: a model and a test, IPTS Working Paper On Corporate R&D And Innovation - No. 05/2010.

Bogliacino, F. & Pianta, M. (2010b). The impact of innovation on labor productivity growth in European industries: Does it depend on firms' competitiveness strategies?, IPTS Working Paper On Corporate R&D And Innovation No.13/2009. Retrieved from: http://iri.jrc.ec.europa.eu/papers/13_IPTS_WP_JRC53698.pdf ,last accessed at August 2012.

Brambor, T, Clark, W.R. & Golder, M. (2006). Understanding interaction models: Improving empirical analysis. *Political Analysis*, 14,63–82. doi:10.1093/pan/mpi014

Cameron, A.C. & Trivedi, P.K. (2005). Microeconometrics: methods and applications, New York:Cambridge University Press.

Capron, H. (1992). Economic quantitative methods for the evaluation of the impact of R&D programmes, Brussels: EU.

Capron, H. and Cincera, M. (1998). Technological competition, economics performance and strategic behavior of international firms, Dulbea-Cert.

Castellani, D., Zanfei, A. (2006). Multinational firms, innovation and productivity, Cheltenham,UK Edward Elgar Publishing Limited.

Cefis, E. (2010). The Impact of M&A on technology sourcing strategies, *Economics of Innovation and New Technology*, 19 (1/2),27-52.

Chandan, S. (2011). R&D and productivity in the Indian pharmaceutical firms, Munich Personal RePec Archive No. 31681.Retrieved from: http://mpra.ub.uni-muenchen.de/31681/ , last accessed at August 2012.

Chudnovsky, D., L´opez,A., & Pupato, G. (2006). Innovation and productivity in developing countries: A study of Argentine manufacturing firms' behavior (1992–2001), *Research Policy* 35, 266–288.

Cincera, M. (2005). Firms' productivity growth and R&D spillovers: An analysis of alternative technological proximity measures. *Economics of Innovation and New Technology*, 14(8), 657–682

Cincera, M., Czarnitzki, D. & Thorwarth, S. (2007). Efficiency of public spending in support of R&D activities. Technology and Economic Development 2nd International Conference on the Dynamics of Science and Technology Policies, İzmir.

Cincera, M. & Ravet, J. (2010). Financing constraints and R&D investments of large corporations in Europe and the US. *Science and Public Policy*, 37(6), 455-466.

Coelli, T. (1996). 'A guide to FRONTIER version 4.1: A computer program for stochastic frontier production and cost function estimation', CEPA Working Paper 96/08, University of New England.

Coelli, T. and G.E. Battese (1996). Identification of factors which influence the technical efficiency of Indian farmers, *Australian Journal of Agricultural Economics*, 40, 103-128.

Coelli, T.J., Rao, D.S.P, O'Donnell, C.J. and Battese, G.E. (2005*).* An introduction to efficiency and productivity analysis, Springer Science and Business Media, New York, USA.

Cohen, W. & Levinthal, D.A. (1989). Innovation and learning: Two faces of R&D. *Economic Journal* (99),569-596.

Cohen, W. & Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35 (1), 128-52.

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 (2), 115 - 158.

Criscuolo, C., Squicciarini, M.,Lehtoranta, O. (2010). R&D, innovation and productivity, and the CIS: sampling, specification and comparability issues, paper presented at the Corporate R&D: An Engine for Growth, A Challenge for European Policy Conference, March 3-4, Sevilla.

Cuneo and Mairesse (1983). Productivity and R&D at the firm level in French manufacturing' NBER Working Paper No.1068, National Bureau for Economic Research, Cambridge, MA.

Czarnitzki, D. and O'Byrnes, N.(1999). The impact of R & D on productivity, *Quarterly Journal of Economics*, Vol.91No 2, pp. 315-329.

Czarnitzki, D. and Toole, A.A. (2007). Business R&D and the interplay of R&D subsidies and product market uncertainty, *Review of Industrial Organization*, 31, pp.169-181.

Çakmak, E. H. and Zaim O. (1992). Privatization and comparative efficiency of public and private enterprise in Turkey: the cement industry, *The Annals of Public and Cooperative Economics*, 63:271-284.

Çelikel Tuncay, A. (2009). Factors affecting research and development collaboration of MNEs and their local partner firms: A case study of Turkish automotive industry, unpublished PhD thesis, Isik University.

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

Damijan, J.P., Knell,M. Majcen, B. & Rojec M. (2003). The role of FDI, R&D accumulation and trade in transferring technology to transition countries: evidence from firm panel data for eight transition countries, *Economic Systems* 27, 189–204.

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/doc7en.pdf, last accessed at August 2012.

Deng, P.D. (2009). Three essays on China's productivity growth and technology development in international perspective, PhD dissertation, Brandeis University.

Diaz, M.A. and Sachez, R. (2008). Firm size and productivity in Spain: A stochastic frontier analysis, *Small Business Economics,* vol. 30,pp.315–323
DOI 10.1007/s11187-007-9058-x.

Dilling-Hansen, M., Eriksson, T., Madsen, E.S. and Smith,V. (1999). The impact of R&D on productivity: Evidence from Danish manufacturing firms. Retrieved from: http://www.afsk.au.dk/ftp/workingpapers/wp99-1.pdf ,last accessed at August 2012.

Dillig-Hansen, M., Madsen, E.S. and Smith, V. (2003). Efficiency, R&D and ownership – some empirical evidence, *International Journal of Production Economics* 83: 85–94.

Doralzelsky, U. and Jaumandreu, J. (2007). R&D and productivity: Estimating production functions when productivity is endogenous.
Retrieved from: http://mpra.ub.uni-muenchen.de/1246/1/MPRA_paper_1246.pdf , last accessed at August 2012.

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, pp.171–191.

Erdilek, A.(2005). Historical background of foreign direct investment in Turkey,Yased conference: The New Favorite Destination for foreign Direct Investments: Turkey Where the Opportunities Abound, November 8-9. İstanbul.

Fagerberg, J. Srholec, M and Verspagen, B. (2009). Innovation and economic development, UNU-MERIT Working Paper no 2009-032.

Fang, C. and Mohnen, P. (2009). FDI, R&D and innovation output in the Chinese automobile industry, UNU-MERIT Working Paper #2009-044, Retrieved from: http://www.merit.unu.edu/publications/wppdf/2009/wp2009-044.pdf, last accessed at August 2012.

Findlay, R. (1978). Some aspects of technology transfer and direct foreign investment. *The American Economic Review*, 68(2), 275-279.

Forbes, N and Wield, D. (2000). Managing R&D in technology-followers, *Research Policy* 29, 1095–1109.

Fu, X. (2008). Foreign direct investment, absorptive capacity and regional innovation capabilities: Evidence from China. *Oxford Development Studies*, 36(1), 89–110.

Fu, X. and Gong, Y. (2011). Indigenous and foreign innovation efforts and drivers of technological upgrading: Evidence from China, *World Development*, 39(7), 1213-1225.

Fu, X., Piotrebelle, C. and Soete, L. (2010). The role of Foreign Technology and Indigenous Innovation in Emerging Economies: Technological Change and Catching Up, Inter-American Development Bank Technical Notes, No: IDB-TN_166.

Geroski, P.A. (1989). Entry, Innovation and productivity growth. *Review of Economics and Statistics*, 71(4), 572-578.

Gerschenkron, A. (1962). Economic Backwardness in Historical Perspective: A Book of Essays. *Cambridge*, Mass: Harvard University Press.

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, last accessed at August 2012.

Griffith,R. Harrison, R. and Van Reenen, J. (2006). How special is the special relationship ? Using the impact of U.S. R&D spillovers on U.K. firms as a test of technology sourcing. *The American Economic Review*, vol. 96, No 5. pp. 1858-1875.

Griliches, Z.(1979). Issues in Assessing the Contribution of Research and Development to Productivity Growth, *Bell Journal of Economics*, 10,92-116.

Griliches, Z., and J. Mairesse (1982). Comparing Productivity Growth: An Exploration of French and US Industrial and Firm Data' NBER Working Paper No961, National Bureau of Economic Research, Cambridge, MA.

Griliches, Z., and J. Mairesse (1984). Productivity and R&D at the firm Level, in *R&D, Patents, and Productivity*, ed. by Z. Griliches. Chicago, Ill.: Chicago University Press, 339-374.

Griliches, Z., and J. Mairesse (1990). R&D and productivity growth: Comparing Japanese and U. S. manufacturing firms, in Productivity Growth in Japan and the United States, ed. by C. R. Hulten. Chicago: Chicago University Press, 317-340.

Gökçekuş, Ö. (1995). The effects of trade exposure on technical efficiency: New evidence from the Turkish rubber industry, *The Journal of Productivity Analysis*, 6: 77-85.

Greene, W.H. (1980). Maximum likelihood estimation of econometric frontier functions, *Journal of Econometrics*, 13(1) : 27-56.

Griliches, Z., (1998). R&D and productivity: The econometric evidence, Chicago University Press.

Gustavssohn, P. and Poldahl, A. (2003). Determinants of firm R&D: Evidence from Swedish firm level data, FIEF Working Paper Series, Retrieved from: http://swopec.hhs.se/fiefwp/papers/WP190.pdf , last accessed at August 2012.

Hall, B.H., and Mairesse, J., (1995). Exploring the relationship between R&D and productivity in French manufacturing firms. *Journal of Econometrics*. 65, 265-293.

Hall, B.H. , Mairesse, J. and Mohnen, P. (2010). Measuring the returns to R&D. Retrieved from: http://www.nber.org/papers/w15622.pdf , last accessed at August 2012.

Hall, B.H., v.Reenen, J. (2000). How effective are fiscal incentives for R&D? A review of the Evidence, *Research Policy*, 29, 449-469.

Hamit-Haggar, Mahamat (2009). Total factor productivity growth, technological progress, and efficiency changes: Empirical evidence from Canadian manufacturing industries, University of Ottowa, Faculty of Social Sciences, Department of Economics, Working paper #0905E.

Harhoff,D. (1994). R&D and productivity in German manufacturing firms, ZEW Discussion Paper No.94-01. Zentrum für Europaische Wirtsschaftsforschung, Mannheim.

Harhoff,D. (1998). R&D and productivity in German manufacturing firms, *Economics of Innovation and New Technology*, 6,29-49.

Harris, R., & Trainor, M. (2009) Why do some firms undertake R&D whereas others do not? Spatial Economics Research Center Discussion Paper 20, Retrieved from: http://www.spatialeconomics.ac.uk/textonly/serc/publications/download/sercdp0020.pdf , last accessed at August 2012.

Hasan, R.(2000). The impact of imported and domestic technologies on productivity: Evidence from Indian manufacturing firms, East-West Center Working Papers, No6.

Hay, D., & Liu, G. (1997). The efficiency of firms: What difference does competition make? *Economic journal*, 107:597–617.

Heckman, J.J. (1979). Sample selection bias as a specification error. *Econometrica*, 47, 153-161.

Higon, D.A. (2007). The Impact of R&D spillovers on UK manufacturing TFP: A dynamic panel data approach, *Research Policy*, 36, 964-979.

Jaffe, A. B. (1986). Technological opportunity and spillovers of R&D: evidence form firms' patent, profits, and market value, *American Economic Review*, 76, 984–1001.

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.

Javorcik, B.S. (2006). Technological leadership and the choice of entry mode by foreign investors, in B. Hoekman, and B.S. Javorcik (eds) Global Integration and Technology Transfer,(Hampshire, England: Palgrave and Macmillan.pp.179-206.

Jorge, J. & Suarez, C. (2011). Influence of R&D subsidies on efficiency: The case of Spanish manufacturing firms, *Cuadernos de Economia y Direccion de la Empresa*, 19:1-9. Doi:10.1016/j.cede.2010.11.001

İzmen, Ü. and Yılmaz, K., (2009). Turkey's recent trade and foreign direct investment performance", *TÜSİAD-Koç University Economic Research Forum Working Paper Series*, Working Paper 0902. Retrieved from: https://www.econstor.eu/dspace/bitstream/10419/45435/1/599164409.pdf , last accessed at August 2012.

Karadağ, M.(2010). The Impact of public capital on the efficiency of private manufacturing industry at the regional level, *Ege Academic Review*, 10 (4):1167-1174.

Karray, Z. and Kriaa, M. (2009). Innovation and RD investment of Tunisian firms: A two regime model with selectivity correction, Economic Research Forum Working Paper # 484.

Kathuria, V. (2010).Does the technology gap influence spillovers? A post-liberalization analysis of Indian manufacturing industries', *Oxford Development Studies*, 38: 2, 145 — 170.

Kleibergen, F. and R. Paap (2006). Generalized Reduced Rank Tests Using the Singular Value Decomposition, *Journal of Econometrics*, 133:97-126.

Kemme, D.M., Lugovskyy, V., Mukherjee, D. (2009). Labor mobility, knowledge transfer and productivity spillover: Evidence from Indian firms, Retrieved from: http://www.stat.unipg.it/aissec2009/Documents/papers/CI2_Kemme_Lugovskyy_Mukherjee.pdf , last accessed at August 2012.

Kinoshita, Y. (2000). R&D and technology spillovers via FDI in the Czech manufacturing firms Retrieved from: http://www.cepr.org/meets/wkcn/7/745/papers/Kinoshita.pdf , last accessed at August 2012.

Kodde, D. A. and F. C. Palm. (1986). Wald criteria for jointly testing equality and inequality restrictions. *Econometrica* (54), 1243–1248.

Konings, J., (2000).The effects of foreign direct investment on domestic firms: Evidence from firm level panel data in emerging economies. CEPR Discussion Paper No. 2586. Retrieved from: http://www.wdi.umich.edu/files/Publications/WorkingPapers/wp344.pdf, last accessed at August 2012.

Kothari, T.V. (2009). The ball is in their court: Changing role of multinational companies from emerging nations. Unpublished PhD dissertation. Temple University. USA.

Kumar, N. & 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.

Kumbhakar, S. C. & C. A. K. Lovell (2000). Stochastic frontier analysis, Cambridge University Press, Cambridge, U.K.

Kumbhakar, S.C., Ortega-Argiles, R., Potters, L., Vivarelli, M. and Vogit, P. (2010). Corporate R&D and firm efficiency: Evidence from Europe's top R&D investors, IPTS Working paper on Corporate R&D and Innovation - No. 11.

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(4), 258-265.

Lenger, A. And Taymaz, E. (2005). To innovate or to transfer? *Journal of Evolutionary Economics*, 16, 137–153 .

Lichtenberg, F.R., Siegel, D., (1991). The impact of R&D investment on productivity: New evidence using linked R&D-LRD data. *Economic Enquiry* 29, 203–228.

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.

Los, B. an Verspagen, B. (2005). R&D spillovers and productivity: Evidence from US manufacturing microdata. *Empirical Economics*, 25,125-148.

Lööf, H. and A. Heshmati (2002). Knowledge capital and performance heterogeneity: A firm-level innovation study, *International Journal of Production Economics*, 76(1), 61-85.

Lööf, H. and A. Heshmati (2006). On the Relation between Innovation and Performance: A Sensitivity analysis, *Economics of Innovation and New Technology*, 15317-344.

Lööf, H. (2009). Multinational enterprises and innovation: firm level evidence on spillover via R&D collaboration, *Journal of Evolutionary Economics* (19), 41–71. DOI 10.1007/s00191-008-0103-y.

Lundin, N., F. Sjoholm, P. and He, J. Qian, (2007). FDI, market structure and R&D investments in China, IFN Working Paper No. 708, Retrieved from: http://www.ifn.se/BinaryLoader.axd?OwnerID=b41a13e3-e243-48f0-924a-37464e3b46df&OwnerType=0&PropertyName=File1&FileName=Wp708.pdf, last accessed at August 2012.

Luintel,K.B., Khan, M. and Theodoridis, K. (2010. How robust is the R&D–productivity relationship? *Evidence from OECD Countries,* Cardiff Economics Working Papers E2010/7. Retrieved from: http://www.cardiff.ac.uk/carbs/econ/workingpapers/papers/E2010_7.pdf, last accessed at August 2012.

Machlich, J.C. and Roedier-Schluga, T. (2001). The changing nature of pharmaceutical R&D-opportunities for Asia? MERIT Infonomics Research Memorandum Series 001.

Mairesse, J. &Hall, B. H. (1996). Estimating the productivity of research and development : An exploration of GMM methods using data on French and United States manufacturing firms. NBER Working paper 5501.

Mairesse, J and Mohnen, P. (2003). R&D and Productivity: A reexamination in light of the innovation surveys. Retrieved from: http://www.druid.dk/conferences/summer2003/papers/MAIRESSE_MOHNEN.pdf , last accessed at August 2012.

Mairesse, J. and Mohnen, P. (2005). The Importance of R&D for Innovation: A Reassessment Using French Survey Data. *Journal of Technology Transfer*, 30, 183-197.

Mairesse, J. & Sassenou, M. (1991).R&D and productivity: A survey of econometric studies at firm level. NBER Working Paper 3666. Cambridge, Massachusetts: National Bureau of Economic Research (NBER).

Marin, A. and M. Bell, (2006). Technology spillovers from foreign direct investment (FDI): the active role of MNC subsidiaries in Argentina in the 1990s, *Journal of Development Studies*, 42 (4), pp.678-697.

Marin, A., Sasidharan, S., (2010). Heterogeneous MNC subsidiaries and technological spillovers: Explaining positive and negative effects in India. *Research Policy*, doi:10.1016/j.respol.2010.06.001 in press.

Marksun, J. R., and A. J. Venables (1997). Foreign Direct Investment as a Catalyst For Industrial Development. NBER Working Paper 624. Cambridge, Massachusetts: National Bureau of Economic Research (NBER).

Markusen, J.R. and Trofimenko, N. (2009). Teaching locals new tricks: Foreign experts as a channel of knowledge transfers, *Journal of Development Economics* (88), 120–131.

Marshall, M.N. (1996). Sampling for qualitative research, *Family Practice* (13), 522-525.

Mattes, A. (2010). International M&A: evidence on effects of foreign takeovers. IAW Discussion Papers 60. Institute für Angewandte Wirtschaftsforschung, Tübingen.

Mazumder, R. & Adhikary, M. (2010). Measuring technical efficiency in the Indian automobile industry, *South Asia Economic Journal*, 11, 53-67.

Meeusen, W. And J. Van den Broeck, Efficiency (1977). Estimation from Cobb Douglas production functions with composed error, *International Economic Review*, 18:435-444.

Mileva, E. (2007). Using Arellano – Bond Dynamic Panel GMM Estimators in Stata. Retrieved from:http://www.fordham.edu/economics/mcleod/Elitz- usingArellano%E2%80%93 BondGMMEstimators.pdf , last accessed at August 2012.

Mishra, V. (2007). The determinants of R&D expenditure of firms: Evidence from a cross-section of Indian firms", *Economic Papers*, 26, 237-248.

Mohnen P., (1996). R&D externalities and productivity growth, *STI Review*, 18, 39-66, OECD Paris.

Müftüoğlu, T. & Haliloğlu, N. (2011). Nasıl girişimci olunur? Ankara, Turhan Kitabevi.

Narula R, & Zanfei A (2005). Globalization and innovation: the role of multinational enterprises. In: Fagerberg J, Mowery DC, Nelson RR (eds) *The Oxford Handbook of Innovation* Oxford: Oxford University Press,.

Narula, R. (2005). Knowledge creation and why it matters for development: The role of TNCs, globalization of R&D and developing countries. Proceedings of the Expert Meeting, Geneva, Jan-24-26.

Narula, R. & Guimon, J. (2010). The R&D activity of multinational enterprises in peripheral economies: Evidence from the EU new member states, United Nations University, Working Paper Series, #2010-48.

Nickell, S., Nicolitsas, D., & Dryden, N. (1997). What makes firms perform well? *European Economic Review*, 41: 783–796.

Nielsen, H. B. (2005). Generalized method of moments estimation. Retrieved from: http://www.econ.ku.dk/metrics/Econometrics2_07_I/Slides/12_gmm.pdf , last accessed at August 2012.

Nieto, M. and Quevedo, P. (2005). Absorptive capacity, technological opportunity, knowledge spillovers and innovative effort, *Technovation*, 25:1141-1157.

Ninth Development Plan 2007-2013 T.R. Prime Ministry State Planning Organization. Retrieved from: http://ekutup.dpt.gov.tr/plan/ix/9developmentplan.pdf , last accessed at August 2012.

Ocak, S. (2012). Bilim politikası var mi ki geri dönelim, Radikal July 17. Retrieved from: http://www.radikal.com.tr/Radikal.aspx?aType=RadikalDetayV3&ArticleID=1094375&CategoryID=77&Rdkref=6 , last accessed at August 2012.

OECD (1993). Frascati Manual, Paris, OECD.

OECD (1995). Reviews of National Science and Technology Policy Turkey, France.

OECD (2002). Science and Technology Industry Outlook, Paris, OECD.

OECD (2003). Classification of Manufacturing Industries Based on Technology,OECD Science Technology Scoreboard 2003- Towards a Knowledge Based Economy, Paris.

Ogawa,K. (2007). Debt, R&D investment and technological progress: A panel study of Japanese manufacturing firm's behavior during the 1990s. *Journal of Japanese International Economies*, 21,403-423.

Oh, Dong hyun, H. Lööf and Almas Heshmati (2009). The Icelandic economy: a victim of the financial crisis or simply inefficient?, The Royal Institute of Technology, Center of Excellence for Science and Innovation Studies Electronic Working paper series 199.

Okada, Y. (2005). Competition and productivity in Japanese manufacturing industries. *Journal of Japanese and International Economies*, 19, 586-616.

Önder, A.Ö., Deliktaş, E. & Lenger, A. (2003). Efficiency in the manufacturing industry of selected provinces in Turkey: A stochastic frontier analysis. *Emerging Markets Finance and Trade*, 39(2), 98-112.

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.

Özçelik, E. and Taymaz, E. (2008). R&D support programs in developing countries: The Turkish experience, *Research Policy* 37, 258–275.

Pack, H.(2000). Research and development in the industrial development process in: *Linsu, K. ad Nelson, R. (ed.) Technology, Learning and Innovation Experienced of Newly Industrializing Economies*, Cambridge: Cambridge University Press: 69-94.

Pakes,A. & Schankerman, M. (1984). The Rate of obsolescence of patents, research gestation lags, and the private rate of return to research resources", with Ariel Pakes, in Zvi Griliches,ed., *R&D, Patents and Productivity* ,Chicago: University of Chicago Press: 98-112.

Pamukçu, T. (2003). Trade liberalization and innovation decisions of firms: Lessons from post-1980 Turkey, *World Development*, 31(8),1443-1458.

Pamukçu, M.T. and Erdil, E. (2011). R&D activities of multinational companies in emerging economies: Analyzing the Turkish case, Paper presented at the ECON ANADOLU conference held in Eskişehir, June 15-17.

Pamukçu, M.T. and Tandoğan, V.S. (2011). Evaluating Effectiveness of Public Support to Business R&D in Turkey through concepts of input and output additionality, ERF Working Paper, No.593,36 pages.

Parameswaran, M. (2009). International trade, R&D spillovers and productivity: Evidence from Indian manufacturing industry. *Journal of Development Studies*, 45(8),1249-1266.

Parisi, M. L., Schiantarelli, F., & Sembenelli, A. (2006). Productivity, innovation and R&D: Micro evidence for Italy, *European Economic Review*, 50, 2037-2061.

Pavitt, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory, *Research Policy*, 13(6), 343-373.

Perelman, D. (1995). R&D, technological progress and efficiency change in industrial activities , *Review of Income and Wealth*, 41, 349-66.

Piga, C. and Vivarelli M. (2003). Sample Selection in estimating the determinants of cooperative R&D, *Applied Economics Letters*, 10, 243-246.

Piesse, J. & Thirtle, C. (2000). A stochastic frontier approach to firm level efficiency, technological change and productivity during the early transition in Hungary. *Journal of Comparative Economics*,28 (3), 473-501.

Pradhan, J. P. (2002). FDI spillovers and local productivity growth: Evidence from Indian pharmaceutical industry. *Artha Vijnana*, 44(3-4) 317-332.

Radam, A., Jacob, M.R. and Muslim H. F.M., (2010). Technical efficiency of the wooden furniture industry: A Stochastic frontier production approach, *International Business Research*, 3 (3), 10-15.

Ravenscraft, D. J., & F. M. Scherer (1982). The lag structure of returns to research and development. *Applied Economics* 14, 603-620.

Rogers, M.(2006). R&D and productivity in the UK: Evidence from Firm-Level Data in the 1990s, Economics Series Working Papers No.255, University of Oxford.

Romer, P. M, (1990). Endogenous technological change. *Journal of Political Economy*, University of Chicago Press, 98(5), S71-102.

Roodman, D. (2008). A note on the theme of too many instruments, Center for Global Development Working Paper Number 125.

Saggi, K. (2006) FDI, spillovers and linkages, in B. Hoekman, and B.S. Javorcik (eds) *Global Integration and Technology Transfer,*Hampshire, England: Palgrave and Macmillan, 51-65.

Sangho, K.(2003). Identifying and estimating sources of technical inefficiency in Korean manufacturing industry, *Contemporary Economic Policy*, 21 (1) 132-144.

Sasidharan and Kathuria, (2011). Foreign direct investment and R&D: Substitutes or complements—A case of Indian manufacturing after 1991 reforms, *World Development* (39) 7, 1226–1239.

Saxena, S. (2009). Technology and spillovers: Evidence from Indian manufacturing microdata, *Applied Economics*,1-17, iFirst.

Saygılı, Ş. And Taymaz, E. (2001). Privatization, ownership and technical efficiency: A study of the Turkish cement industry, *Annals of Public and Cooperative Economics*, 72(4), 581-

605.

Scherer, F. (1980) Industrial market structure and economic performance, Rand McNally, Chicago, 2nd ed.

Schumpeter, J. (1942). Capitalism, socialism and democracy, New York: Harper.

Semykina, A. and Wooldridge, J. M. (2010). Estimating panel data models in the presence of endogeneity and selection. *Journal of Econometrics* 157, 375-380.

Sharma, C. (2011). R&D and productivity in the Indian pharmaceutical firms. Munich Personal Repec Archive paper no. 31681. Retrieved from: http://mpra.ub.uni-muenchen.de/31681/ , last accessed at August 2012.

Sjoholm, F., (1999). Technology gap, competition and spillovers from direct foreign investment: Evidence from establishment data, *Journal of Development Studies*; 36 (1), 53-74.

Smeets, R. (2008). Collecting the pieces of the FDI knowledge spillovers puzzle. *The World Bank Research Observer*, 23 (2), 107-138.

Song, B. (2005). Panel data analysis of sources of productivity growth in Korean manufacturing plants. Unpublished PhD dissertation. The Pennsylvania State University The Graduate School College of Liberal Arts.

Stevenson, R.E. (1980). Likelihood functions for generalized stochastic frontier estimation, *Journal of Econometrics*, 13 (1), 57-66.

Stock & Yogo (2005). Testing for weak instruments in linear IV regression in D. W.K. Andrews and J.H. Stock (eds) Identification and inference for econometric Models: Essays in Honor of Thomas Rothenberg, 80-108.

Stock, J.H. and Watson, M.W. (2007). *Introduction to econometrics*, Boston: Pearson Education.

Sun, S. (2010). Foreign Entry and Firm R&D: The Chinese Evidence, paper presented at the 39th Australian Conference for Economists. Retrieved from: https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=ACE10&paper_id=74 , last accessed at August 2012.

Sun, Y. and Du, D. (2010) Determinants of industrial innovation in China: Evidence from its recent economic census, *Technovation,* 30 :540–550.

Şahin, Ş. (1997). Türkiye'de bilim ve teknoloji politikası: 1963-1997 kurumlar- belgeler, Göçebe Yayınları, İstanbul.

Stolzenberg, R.M. and Relles, D.A. (1997). Tools for intuition about sample selection bias and its correction, *American Sociological Review*, 62: 494-507.

Tandoğan, V.S. (2011). Impact analysis of industrial research and development subsidy programs in Turkey: An appraisal of quantitative approaches, Unpublished PhD dissertation, Middle East Technical University.

Tang, J. and Rao, S. (2001). R&D Propensity and productivity performance of foreign controlled firms in Canada, WP No 33, Industry Canada Research Publications Program.

Tarakçıoğlu, I. (2006). Milliyet Gazetesi, August 6th in Müftüoğlu, M. T. and Haliloğlu, N. (2011) Nasıl Girişimci Olunur?, Turhan Kitabevi, Ankara.

Taymaz, E. and Üçdoğruk, Y. (2009). Overcoming the double hurdles to investing in technology, R&D activities of small firms in developing countries, *Small Business Economics*, 33, 109-128.

Taymaz, E. and Saatçi, G. (1997). Technical change and efficiency in Turkish manufacturing industries, *Journal of Productivity Analysis*.8,461-475.

Taymaz, E. , Voyvoda, E. and Yılmaz, K. (2008). Türkiye imalat sanayiinde yapısal dönüşüm, Üretkenlik ve Teknolojik Değişme Dinamikleri, ERC Working Papers in Economics 08/04.

Taymaz, E. (2009). Does innovation and technology policy pay-off? Knowledge Economy Forum VIII, INSEAD, Fontainebleau, France.

Teece, D. (1981). The market for know-how in technology transfer: New issues , new analysis, special issue of The Annals of the American Academy of Political and Social Science, 81-96.

Tingvall, P.G. & Poldhal, A. (2011). Determinants of firm R&D: The role of relationship-specific interactions for R&D spillovers, Center of Excellence for Science and Innovation Studies Electronic Working Paper Series.

Thomas, R. L. (1997). *Modern econometrics an introduction*, Harlow, Pearson Education Limited.

Todo, Y. (2006). Knowledge spillovers from foreign direct investment in R&D: Evidence from Japanese firm-level data, *Journal of Asian Economics*, 17(6), pp. 996-1013.

Tsai, K.H. and Wang, J.C. (2004). R&D, productivity and the spillover effects of high-tech industry on the traditional manufacturing sector: the case of Taiwan. Blackwell Publishing, 1555-1570.Oxford, UK.

TUBITAK, (2010). National Science, technology and innovation strategy 2011-2016. Retrieved from:http://www.tubitak.gov.tr/tubitak_content_files//BTYPD/btyk/22/BTYK22_Ek4_UBTYS_2011-2016.pdf , last accessed at August 2012.

TUBITAK, (2011) Yaz bilim kampı. Retrieved from: www.yazbilimkampi.comu.edu.tr, last accessed at August 2012.

Türkcan, E. (2009). Dünya'da ve Türkiye'de ve bilim, teknoloji ve politika. İstanbul Bilgi Üniversitesi Yayınları, İstanbul.

Republic of Turkey Ministry of Industry and Trade (2010). Turkish industrial strategy document 2011-2014 .

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) (2005), World Investment Report (WIR) 2005: Transnational Corporations (TNCs) and the Internationalization of R&D,UNCTAD, Geneva.

Üçdoğruk, Y. (2009). R&D Investment decision and internationalization: Evidence form ISE listed firms, Paper presented at EconAnadolu 2009: Anadolu International Conference on Economics, June 17-19, 2009, Eskişehir.

Ülkü, H. (2007). R&D, innovation and output: evidence from OECD and nonOECD countries, *Applied Economics*, 39: 291–307.

Vahter, P. (2010) Does FDI spur innovation, productivity and knowledge sourcing by incumbent firms? Evidence from manufacturing industry in Estonia. Retrieved from: http://infutik.mtk.ut.ee/www/kodu/RePEc/mtk/febpdf/febawb69.pdf , last accessed at August 2012.

Vakhitova, G. and Pavlenko, T. (2010) Innovation and productivity: a firm level study of Ukrainian manufacturing sector, Kyiv School of Economics Discussion Papers.DP#27. Retrieved from: http://repec.kse.org.ua/pdf/KSE_dp27.pdf , last accessed at August 2012.

Van Dijk, B., Hertog, R.D., Menkveld, B. & Thurik, R. (1997). Some new evidence on the determinants of large and small firm innovation. *Small Business Economics*, 9, 335-343.

Vella, F. (1998). Estimating models with sample selection bias. *Journal of Human Resources*, 33(1), 127- 169.

Verbeek, M.(2000). *A Guide to Modern Econometrics*, Chichester, John Wiley and Sons. Ltd.

Verspagen (1995). R&D and Productivity: A broad cross section cross country look, *Journal of Productivity Analysis*, 6, 117-135.

Von Tunzelmann, N. and Acha, V. (2005). Innovation in low-tech industries in Fagerberg, J. Mowery, D.C. and Nelson, R.R. (eds) *The Oxford Handbook of Innovation*, 407-432, Oxford University Press, New York.

Wakelin, K.(2001). Productivity growth and R&D expenditure in UK manufacturing firms, *Research Policy* 30, 1079–1090.

Wiel, van der H.P. (2010). Competition and innovation: Together a tricky rollercoaster for productivity. Unpublished Phd dissertation. University of Tilburg.

Wieser, R. (2005). Research and development productivity and spillovers: empirical evidence at the firm level. *Journal of Economic Surveys*, 19(4),587-622.

Wooldridge, J.M. (1995). Selection corrections for panel data models under conditional mean independence assumptions, *Journal of Econometrics*, 68, 115-132.

Worter, M., Rammer, C., Arvanitis, S. (2010). Innovation, competition and incentives for R&D, KOF Working Papers, No 259. Retrieved from: http://econstor.eu/bitstream/10419/36382/1/630427380.pdf , last accessed at August 2012.

Worldbank (2009). Turkey national innovation and technology system, recent progress and ongoing challenges. Europe and Central Asia Region: Worldbank, 48755-TR.

Yalçın, C., & Yalova, Y. (2005). Bilim ve teknoloji politikaları ışığında Türkiye, Nobel Yayın Dağıtım Şirketi, Ankara.

Yang, C-H., Lin, C-H, & Ma, D. (2010). R&D, human capital investment and productivity: Firm Level evidence from China's electronics industry, *China & World Economy*, 18, (5),72-89.

Yrkkö, J.A. & Maliranta, M. (2006). Impact of R&D on productivity-firm level evidence from Findland, Keskusteluaiheita – Discussion papers, No. 1031. Retrieved from: http://www.etla.fi/files/1557_Dp1031.pdf, last accessed at August 2012.

Zhang, R., Sun K., Delgado, M, & Kumbhahar, S. (2011). Productivity in China's high technology industry: Regional heterogeneity and R&D, MPRA Paper No. 32507. Downloaded from: http://mpra.ub.uni-muenchen.de/32507/ , last accessed at August 2012.

Zhao, Z. & Zhang, K.H. (2010). FDI and industrial productivity in China: Evidence from panel data 2001-2006. *Review of Development Economics*, 14(3), 656-665.

Appendix A: A Sample of Studies on Determinants of R&D Intensity

Authors	Tang and Rao (2001)	Kumar and Aggarwal (2005)	Un and Cazurra (2008)	Gustavsson and Poldahl (2003)	Kumar (1987)	Parameswaran (2009)	Ogawa (2007)	Erdilek (2005)	Becker and Pain (2008)	Fang and Mohnen (2009)
Dependent Variable	R&D/sales	R&D/sales	R&D investment	R&D exp	R&D/industrysales	R&D/sales	Real RD/ output$_{t-1}$	R&D expenditure	Change in Ln R&D	R&D/sales
Ownership	foreign dummy**,-	foreign dummy	foreign dummy$_{t-1}$***,-	foreign dummy, public dummy	foreign share***,-	foreign dummy**,+(in science based, scale intensive, specialised suppliers)	ratio of shares owned by top 10 shareholders	private ownership dummy**,- foreign ownership dummies**,-	foreignRD/total RD***,+	foreign share***,-
Size	large sales dummy**,- mid sales summy,-	sales***,- sales2***,+ sales3***,-	sales$_{t-1}$	small sales***,+, large sales***,+		sales**,+	real output***,-	total output***,+	value added of industry***,+ lagged value added**,+	# of employees
Profit		profit|/sales$_{t-1}$ ***, -	profit/sales$_{t-1}$	profit/sales***, +	profit/sales	profit tax/sales**,+ in scale intensive &science based				
Market structure			Cr4$_{t-1}$	Herfindahl		Herfindahl **,- (in supplier dominated &science based)		Herfindahl		
			intensity of competition$_{t-1}$**,+	Cr3***,-	Cr4*,-					
Exports	export dummy**,+	exports**,+	export dummy$_{t-1}$***,+	export***,+		export/ sales*,+				
Skill			skill$_{t-1}$***,+	skill***,+	Skill					
Technological Opportunities	High tech**,+	Engineer dummy***,+	industry dummies$_{t-1}$	industry dummies	Engineer dummy	Science-based			sub industry dummies	
		Chemical dummy***,+		time dummies*	Chemical dummy*,+	Specialized industry				time dummies
					Consumer goods dummy**,-	Scale intensive				

					Convenience goods dummy	Supplier Dominated				
Advertisement			ad/sales$_{t-1}$		ad/sales***,+	ad/sales***,+				
Age			age			age**,+				
Capital intensity				capital intensity***,+	capital intensity***,-					
Technology Imports		disembodied tech. imports$_{t-1}$			licencing***,+	tech.import/sales**, + (in supplier dominated, scale intensive)				
Funds, Subsidies			long term leverage$_{t-1}$***,+	gov. dummy			cashflow***,+		lagged gov. funding***,+	
			value added$_t$**,+				debt/ asset***,-			
Other factors	Time*,+	Outward investment***,+	patented innovation dummy$_{t-1}$***,+	spillover***,+		Cap. Good import/sales**, + (supplier dominated)	affiliated banks' bad loans	sector FDI share***,+	Lagged RD***,_	market share***,+
	Ownership* time	Embodied tech. import***,+	tech. sophs.dummy$_{t-1}$***,+			Value add/sales**, +(in supplier dominated & science based)	banks willingness to lend*,+	vertical integration**,+	import penetration	regional dummies
			foreign suppliers$_{t-1}$***,+			Import competition**, - (in supplier dominated & science based)	ratio of bankloans to total debt**,+	exports/(exp+imp)sectoral level	real interest rate***,-	
			concentration of suppliers$_{t-1}$***,-			Import comp.*market conc.**, + (in high concentration)	Average growth of real output***,+	year and region dummies	real exchange rate***,-	
			concentration of clients$_{t-1}$***,+					comparative advantage*,-	industry profit*,+	

Note: * indicates significance at 0.01 level. ** 0.05 level * 0.1 level. No asterix indicates the result is insignificant.**

Appendix B: Classification of Manufacturing Industries Based on Technology

<u>High-technology industries</u>	**ISIC Rev. 3.**
Aircraft and spacecraft	353
Pharmaceuticals	2423
Office, accounting and computing machinery	30
Radio, TV and communications equipment	32
Medical, precision and optical instruments	33
<u>Medium-high technology industries</u>	
Electrical machinery and apparatus, n.e.c.	31
Motor vehicles, trailers and semi-trailers	34
Chemicals excluding pharmaceuticals	24 excl. 2423
Railroad equipment and transport equipment, n.e.c	352,359
Machinery and equipment, n.e.c.	29
<u>Medium-low technology industries</u>	
Building and repairing of ships and boats	351
Rubber and plastics products	25
Coke, refined petroleum products and nuclear fuel	23
Other non-metallic mineral products	26
Basic metals and fabricated metal products	27-28
<u>Low technology industries</u>	
Manufacturing, n.e.c., Recycling	36-37
Wood, pulp,paper products, printing and publishing	20-22
Food products, beverages and tobacco	15-16
Textiles, textile products, leather and footwear	17-19

Source: OECD (2003)

Appendix C: Various Econometric Methods Employed Throughout the Study

Fixed effects regression is devised with the purpose of dealing with the omitted variables in panel data. The omitted variables are time invariant but vary among entities(firms). The fixed effects regression model has n different intercepts. Each of these intercepts belong to one entity. Assume we have the following model:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Z_i + u_{it} \quad \text{(A3.1)}$$

Where $Z_i$represent the unobserved effects that vary from one firm to the next but remain time invariant.Some examples of such effects could be the management styles of the managers, or the organizational culture within the firms or the networking relationships a firm feeds on. Our goal is to estimate β_1 while holding the unobserved effects constant. As the firm specific effects do not vary from one firm to the next we can include n different intercepts by letting $\alpha_i = \beta_0 + \beta_2 Z_i$. (A3.2)

$$Y_{it} = \beta_1 X_{it} + \alpha_i + u_{it} \quad \text{(A3.3)}$$

The $\alpha_1, \alpha_2, \ldots . \alpha_n$are the unknown intercepts that we need to estimate for each firm. While the slope coefficient β_1 is common to all firms in the sample, each firms has its own intercept. The omitted and unobserved effects are the reason for the variation in the intercepts. In order to compute the fixed effects regression, one first needs to eliminate the unobserved effects because they cannot be controlled for. This is performed by subtracting the firm-specific average from each variable. This step is also called demeaning. For instance $\bar{Y_i} = \beta_1 \bar{X_\iota} + \alpha_1 + \bar{u_\iota}$.

$$\bar{Y_i} = \frac{1}{T}\sum_{t=1}^{T} Y_{it} \, , \bar{X}_i = \frac{1}{T}\sum_{t=1}^{T} X_{it}, \bar{u}_i = \frac{1}{T}\sum_{t=1}^{T} u_{it}. \quad \text{(A3.4)}$$

Subtracting the averages from the initial model we get the following:

$Y_{it} - \bar{Y_i} = \beta_1 (X_{it} - \bar{X}_i) + (u_{it} - \bar{u}_i)$ because as α_i is constant, $\alpha_i - \bar{\alpha} = 0$. Therefore the unobserved effects are eliminated. From now on β_1 can be estimated with OLS. An advantage of fixed effects regression is that it allows the unobserved fixed effects to be correlated with the independent variables which is not the case with random effects. With random effects the unobserved effect is supposed to be independent from all independent variables (Stock and Watson, 2007).

In the case of endogenous variables fixed effects is not enough because with fixed effects strict exogeneity is required. However, when endogeneity is an issue, instrumental variables or generalized method of moments estimators can be used. To start out with these two estimators, one needs to first understand moments. A moment condition involves a relationship of data and parameters such as the following:

$$g(\theta_0) = E[(f(w_t, z_t, \theta_0)] = 0 \qquad \text{(A3.5)}$$

where θ is a Kx1 vector of parameters; f(.) is a vector of functions with R dimensions; w_t comprises the variables and z_t stands for instruments.

When the moment condition has the following form:

$$f(w_t, z_t, \theta) = u(w_t, \theta). z_t \qquad \text{(A3.6)}$$

where $u(w_t, \theta)$ is of the dimension 1x1 and z_t by Rx1 the instruments inz_t are multiplied by the disturbance term $u(w_t, \theta)$. Here $u(w_t, \theta)$ can be taken as the error term. Then the moment condition is $g(\theta_0) = E[u(w_t, \theta). z_t] = 0$ indicating that the instruments are uncorrelated with the error term. This estimator is known as the Instrumental variables estimator.

On the other hand, if we have a sample of data, w_t and z_t (t=1,2,3,...T), we cannot directly calculate the expectation. Therefore we need to use sample averages to get the sample moments as in the following

$$g_T(\theta) = 1/T \sum_{t=1}^{T} f(w_t, z_t, \theta_0) \qquad \text{(A3.7)}$$

An estimator $\hat{\theta}_{MM}$ can be derived by equating $g_T(\hat{\theta}_{MM})$ to zero. To be able to find an estimator we need at least a number of equations that are equal to the number of parameters. In other words, there are more sample moment conditions than there are parameters. In such a case, the system of equations is called overidentified and the estimator is called the GMM estimator, $\hat{\theta}_{GMM}$.(Nielsen, 2005)

As an example, consider the following production function:

$$y_{it} = \beta_n n_{it} + \beta_k k_{it} + \gamma_t + (n_i + v_{it} + m_{it}) \qquad \text{(A3.8)}$$

$v_{it} = \rho v_{i,t-1} + e_{it} \quad |\rho| < 1$ (A3.9)

$e_{it}, m_{it} \sim MA(0)$ (A3.10)

n_i is an unobserved firm-specific effect, v_{it} is autoregressive error term, m_{it} is the measurement error term. We need to estimate (β_n, β_k, ρ). The number of firms N is larger than the number of years T. n_{it} and k_{it} can be correlated with the n_i the unobserved firm specific effect and with m_{it} and e_{it}. In the dynamic representation the following form arises

$$y_{it} = \beta_n n_{it} - \rho\beta_n n_{i,t-1} + \beta_k k_{it} - \rho\beta_k k_{i,t-1} + \rho y_{i,t-1} + \gamma_t - \rho\,\gamma_{t-1} + \big(n_i(1-\rho) + e_{it} + m_{it} - \rho m_{i,t-1}\big) \quad \text{(A3.11)}$$

Here there are two restrictions. The coefficient of $n_{i,t-1}$ is equal to the product of the coefficients of n_{it} and γ_{t-1}.The coefficient of $k_{i,t-1}$ is equal to the product of the coefficients of k_{it} and γ_{t-1}.

Given the following assumptions on the initial conditions $E[x_{i1}e_{it}] = E[x_{i1}m_{it}] = 0$ for t=2,....,T) gives the following moment conditions:

$$E\big[x_{i,t-s}\Delta(e_{it} + m_{it} - \rho m_{i,t-1})\big] = 0 \quad \text{(A3.12)}$$

Where $x_{it} = (n_{it}, k_{it}, y_{it})$ for s≥2 when $(e_{it} + m_{it} - \rho m_{i,t-1})$~MA(0), and for s≥3 when $(e_{it} + m_{it} - \rho m_{i,t-1})$~MA(1). This way lagged levels of the variables can be used as instruments once the equation's first difference is taken to get rid of the firms-specific effects. This is the first differenced GMM estimator but it does not perform well if the lagged levels of the variables are weakly correlated with first differences. In such a case if the following assumptions are made

$E[\Delta n_{it} n_i(1-\rho)] = E[\Delta k_{it} n_i(1-\rho)]$=0 and $E[\Delta y_{i2} n_i(1-\rho)] = 0$ we get the following moment condition $E\big[\Delta x_{i,t-s}\big((n_i(1-\rho)\big) + (e_{it} + m_{it} - \big(\rho m_{i,t-1}\big))\big]$ =0 for s=1 when for s=1$e_{it} + m_{it} - \big(\rho m_{i,t-1}\big) \sim$MA(0) adn for s=2 $e_{it} + m_{it} - \big(\rho m_{i,t-1}\big) \sim$MA(1). Thus lagged first differences of the variables can be used as instruments for the levels equations.The system GMM employs both first-differenced and levels equations.(Blundell and Bond, 1998)

Appendix D: First Stage Heckman Outputs for the Determinants of R&D :

Probit regression		Observations		9208
for 2003		LR chi2(24)		847.56
		Prob >		0
Log likelihood	-1237.38	Pseudo R2		0.2551
	Coef.	Std. Err.	z	P>|z|
Sector's subsidy	0.02	0.01	2.56	0.01
Technology Transfer	0.02	0.01	1.86	0.06
Absorptive Capacity	-0.03	0.03	-1.07	0.28
Foreign Knowledge Spillover	-0.25	0.16	-1.56	0.12
Capital Intensity	0.00	0.01	0.30	0.77
Size	0.09	0.11	0.83	0.41
Skill	0.29	0.11	2.77	0.01
Foreign ownership	0.12	0.44	0.28	0.78
Sector's Export Ratio	-2.18	0.58	-3.76	0.00
Herfindahl	-3.20	2.64	-1.21	0.23
Provincial Spill.	0.14	0.26	0.54	0.59
Location dummy	-0.31	0.33	-0.95	0.34
Constant	-6.57	0.54	-12.17	0.00

Probit regression		Observations		7808
for 2004		LR chi2(24)		991.34
		Prob	>	0
Log likelihood	-1264.14	Pseudo R2		0.2817
	Coef.	Std. Err.	z	P>|z|
Sector's subsidy	-0.01	0.01	-1.00	0.32
Technology Transfer	-0.01	0.01	-0.76	0.45
Absorptive Capacity	0.09	0.06	1.67	0.10
Foreign Knowledge Spillover	-0.35	0.23	-1.49	0.14
Capital Intensity	-0.01	0.02	-0.51	0.61
Size	0.02	0.17	0.12	0.90
Skill	0.01	0.15	0.05	0.96
Foreign ownership	-0.14	0.47	-0.30	0.76
Sector's Export Ratio	1.47	0.72	2.06	0.04
Herfindahl	3.19	3.12	1.02	0.31
Provincial Spill.	-0.73	0.34	-2.13	0.03
Location dummy	0.57	0.46	1.23	0.22
Constant	-6.58	0.55	-12.03	0.00

Probit regression		Observations		7772
for 2005		LR chi2(24)		1092.81
		Prob >		0
Log likelihood	-1504.03	Pseudo R2		0.2655
	Coef.	Std. Err.	z	P>|z|
Sector's subsidy	0.00	0.01	-0.45	0.65
Technology Transfer	0.02	0.01	1.66	0.10
Absorptive Capacity	-0.01	0.04	-0.25	0.81
Foreign Knowledge Spillover	-0.29	0.21	-1.39	0.17
Capital Intensity	-0.01	0.02	-0.51	0.61
Size	-0.06	0.19	-0.30	0.76
Skill	-0.02	0.15	-0.17	0.87
Foreign ownership	-0.20	0.41	-0.48	0.63
Sector's Export Ratio	-0.02	0.64	-0.04	0.97
Herfindahl	-3.87	4.20	-0.92	0.36
Provincial Spill.	-0.35	0.26	-1.33	0.19
Location dummy	-0.24	0.45	-0.53	0.60
Constant	-6.47	0.51	-12.79	0.00

Probit regression		Observations		7618
for 2006		LR chi2(24)		1068.69
		Prob >		0
Log likelihood	-1102.37	Pseudo R2		0.3265
	Coef.	Std. Err.	z	P>|z|
Sector's subsidy	0.01	0.01	1.49	0.14
Technology Transfer	0.00	0.01	-0.55	0.58
Absorptive Capacity	-0.18	0.05	-3.46	0.00
Foreign Knowledge Spillover	-0.16	0.30	-0.53	0.59
Capital Intensity	-0.03	0.02	-1.36	0.17
Size	0.31	0.17	1.81	0.07
Skill	-0.13	0.16	-0.80	0.42
Foreign ownership	0.32	0.49	0.66	0.51
Sector's Export Ratio	1.40	0.74	1.89	0.06
Herfindahl	-1.63	3.44	-0.47	0.64
Provincial Spill.	0.16	0.37	0.42	0.67
Location dummy	-0.25	0.45	-0.55	0.59
Constant	-6.82	0.58	-11.74	0.00

Probit regression		Observations		7334
for 2007		LR chi2(24)		960.33
		Prob >		0
Log likelihood	-1100.65	Pseudo R2		0.3037
	Coef.	Std. Err.	z	P>|z|
Sector's subsidy	0.01	0.01	0.87	0.39
Technology Transfer	0.00	0.01	-0.26	0.80
Absorptive Capacity	-0.02	0.05	-0.42	0.68
Foreign Knowledge Spillover	0.58	0.31	1.87	0.06
Capital Intensity	-0.02	0.02	-1.13	0.26
Size	0.09	0.12	0.71	0.48
Skill	0.01	0.14	0.09	0.93
Foreign ownership	-0.20	0.37	-0.55	0.58
Sector's Export Ratio	-0.14	0.67	-0.20	0.84
Herfindahl	1.64	2.73	0.60	0.55
Provincial Spill.	0.21	0.41	0.52	0.60
Location dummy	0.46	0.47	0.97	0.33
Constant	-6.84	0.58	-11.73	0.00

Appendix E: The Effect of Capital Stock Intensity on R&D Intensity and the Effect of Size dummies on R&D Intensity

	All R&D performers	All R&D performers
Subsidy	0.0697***	0.0589***
	(0.0151)	(0.0171)
Absorptive Capacity	-0.0664*	-0.0488
	(0.0393)	(0.0417)
Foreign Knowledge Spillover	-0.857***	-0.978***
	(0.223)	(0.231)
Capital Intensity	-0.0101	
	(0.0184)	
Capital Stock Intensity		0.00836
		(0.0572)
Size		-0.923***
		(0.151)
s2	-0.316**	
	(0.158)	
s3	-0.683***	
	(0.186)	
s4	-0.773***	
	(0.238)	
s5	-0.993***	
	(0.294)	
Skill	0.469***	0.320**
	(0.120)	(0.125)
Foreign Ownership	-0.176	-0.284
	(0.242)	(0.249)
Sector’s export ratio	-0.422	-0.621
	(0.467)	(0.482)
Herfindahl	2.980	-6.727
	(4.467)	(7.454)
Geographic Spillover	-0.0541	-0.0347
	(0.240)	(0.254)
Constant	-3.956***	-5.171***
	(1.410)	(1.728)
Observations	2278	2139

Standard errors in parentheses, Time dummies included. Lambdas included and all are significant.
S1 is the excluded dummy standing for firms with employees 20-49.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix F: Panel Heckman Two Stage Estimation with IV for Domestic R&D performers and Interaction of absorptive Capacity and Spillovers

Subsidy	0.0778***
	(0.0161)
Absorptive Capacity	-0.0608
	(0.0482)
Foreign Knowledge Spillover	-0.879**
	(0.370)
Absorptive Capacity*Foreign Knowledge Spillover	0.0288
	(0.216)
Capital Intensity	-0.00905
	(0.0199)
Size	-0.946***
	(0.150)
Skill	0.470***
	(0.133)
Sector's export ratio	-0.688
	(0.526)
Sector's export ratio(lagged)	
Herfindahl	1.961
	(5.090)
Geographic Spillover	-0.0884
	(0.253)
Geographic Spillover(lagged)	
Lambda	1.839***
	(0.280)
lam2	-1.058***
	(0.153)
lam3	-1.171***
	(0.157)
lam4	-1.332***
	(0.164)
lam5	-1.104***
	(0.162)
Cons	-3.589**
	(1.591)
Observations	1939

When we interact the absorptive capacity with foreign knowledge spillover at the sector level to verify whether firms that have higher absorptive capacity (those that are closer to the leader) can benefit more easily from foreign knowledge spillover, the sign of the interaction variable comes out as positive. However we cannot readily interpret the coefficient of the interaction term because as Brambor et al. (2006) indicates when an interaction variable is used, the significance of the marginal effect of the interacted variables needs to be calculated in a second step. Here our aim is to calculate the effect of the foreign knowledge spillover at different values of the absorptive capacity; therefore we need to compute the marginal effect of foreign knowledge spillover at different values of absorptive capacity. In Brambor et al.'s (2006) terminology foreign knowledge spillover is the independent variable and the absorptive capacity is the modifying variable as explained below. Following Brambor et al. (2006) we compute the marginal effect of a change in foreign knowledge spillover when absorptive capacity takes certain values. For instance let

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 (X_{1i} * X_{2i}) + u_i \qquad \text{(A6.1)}$$

where the effect on Y of a unit change in X_1 holding X_2 constant is going to be

$$\frac{dY}{dX1} = \beta_1 + \beta_3 X_2. \qquad \text{(A6.2)}$$

Here we let X_2 be the absorptive capacity and X_1 be the foreign knowledge spillover. We give different values to absorptive capacity and look at the effect on R&D intensity of a change in foreign knowledge spillover. When absorptive capacity is given the value 0,4 (which equals to the natural logarithm of 1,5 and represents the case of a firm whose value added per employee is about two thirds of that of the leader), then the marginal effect is -0,87=(-0,88+0,03*(0,41)). In other words when a firm's absorptive capacity equals to two thirds of that of the sector leader, a 1% change in foreign knowledge spillover is associated with a 0,87% decrease in R&D intensity, assuming everything else remains the same. Thus even firms with high absorptive capacity cannot escape from the strong negative foreign knowledge spillover effect as far as R&D intensity is concerned. As we apply different values of the absorptive capacity to see the marginal effect of foreign knowledge spillover for firms at different levels of value added per employee, we find that for firms that have a value added per employee of 6% of the leading firm or more are statistically significantly prone to the marginal effect of the interaction variable at 10% level. However, beyond this range, the marginal effect is not found to be significant. In other words, if the value added per employee of the leader is less than or equal to 15 times that of a firm, then that firm is subject to the from the foreign knowledge spillovers' effect on R&D intensity negatively and statistically significantly at 10% level. However, no significant effect is observed for others whose value added per employee falls beyond the above mentioned range. The standard errors used in the calculation of the Z statistics that indicate the significance level of these variables are computed using the following formula

$$se = \sqrt{(var_{b1}) + var_{b3}(MV^2) + 2covb_1b_3MV}$$

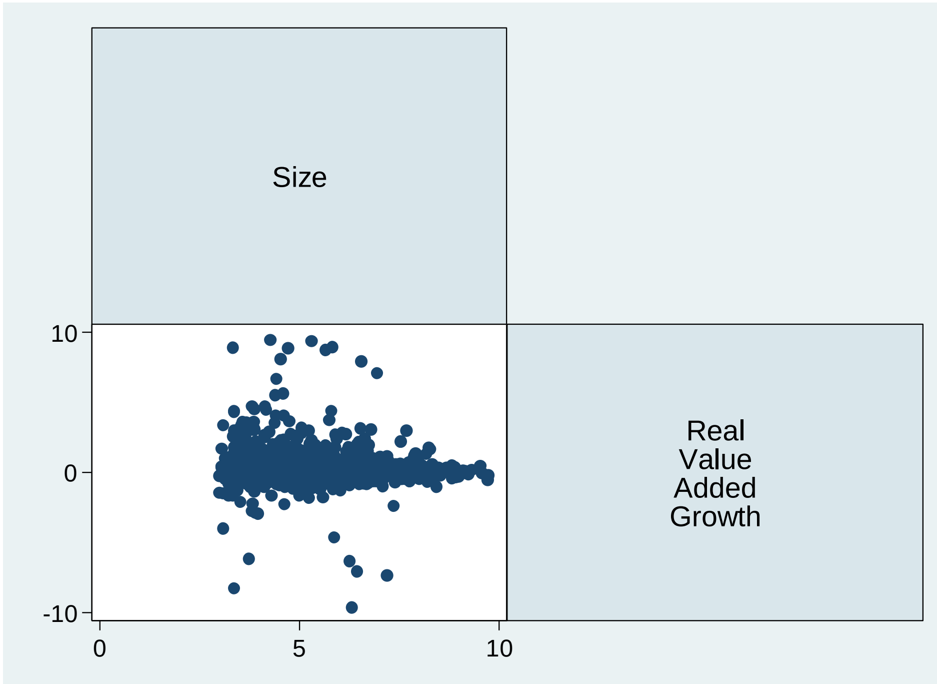
where var_{b1} is the variance of estimated coefficient of the foreign knowledge spillovers and var_{b3} is the variance of estimated coefficient of the interaction variable and $covb_1b_3$ is the covariance between the estimated coefficients of the two variables and MV stands for the value of the absorptive capacity (Brambor et al., 2006). We use the variance and covariance values of the foreign knowledge spillovers and interaction variables from the S&W (2010) procedure outputs.

Appendix G: System GMM Results for the Determinants of R&D Intensity

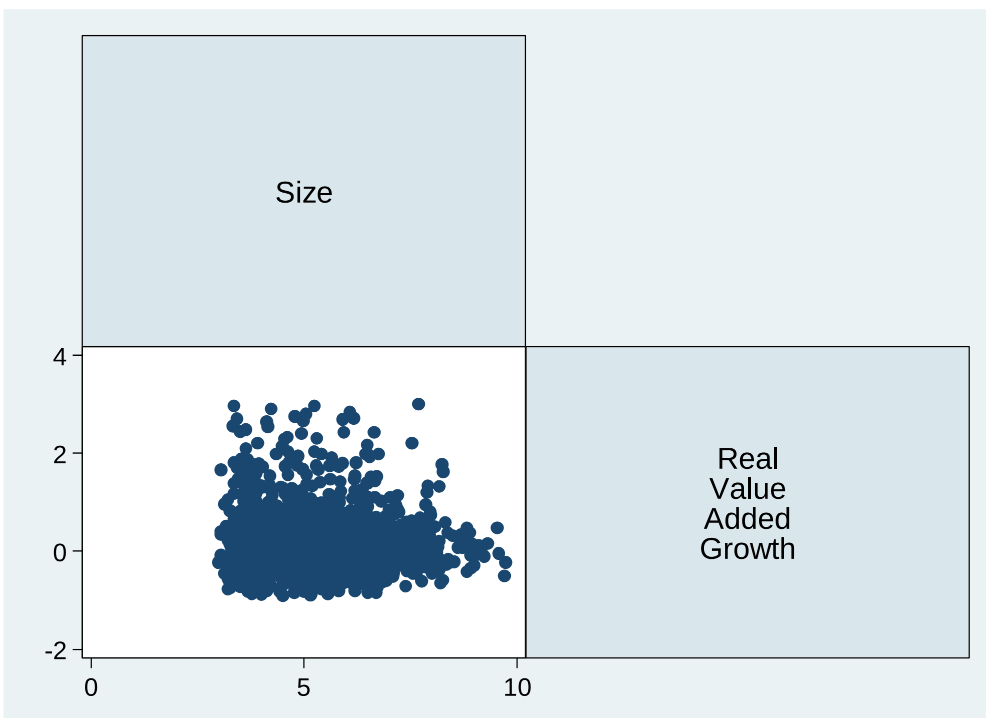
	All R&D Performers	High-Med Tech R&D Performers	Low Tech R&D Performers	Domestic R&D Performers
Lagged R&D Intensity	0.180**	0.192***	0.207	0.169*
	(0.0725)	(0.0656)	(0.194)	(0.0863)
Foreign Ownership	1.616	0.427	-2.301	
	(1.717)	(1.352)	(3.740)	
Subsidy	-0.0245	0.0198	0.0645	-0.00908
	(0.0477)	(0.0396)	(0.125)	(0.0564)
Foreign Knowledge Spillover	-0.621	-0.676	0.493	-0.620
	(0.509)	(0.507)	(1.303)	(0.467)
Capital Intensity	0.233	0.209	-0.0748	0.273
	(0.211)	(0.163)	(0.581)	(0.283)
Size	0.0967	0.335	0.513	-0.0488
	(0.443)	(0.440)	(0.919)	(0.463)
Absorptive Capacity	0.357	0.539	-1.392	0.346
	(0.607)	(0.548)	(0.939)	(0.546)
Skill	1.243**	0.995*	0.155	1.523***
	(0.533)	(0.542)	(1.179)	(0.539)
Sector’s Export Ratio	-0.0592	-1.076	4.043	0.113
	(1.122)	(1.241)	(3.705)	(1.074)
Herfindahl	6.988	8.001	-27.56	9.305
	(9.937)	(7.750)	(102.7)	(8.747)
Geographic Spillover	-4.879	-0.412	-6.162	-4.644
	(3.301)	(2.451)	(8.492)	(4.249)
High tech dummy	1.185*	0.958***		0.978
	(0.646)	(0.351)		(0.618)
Med tech dummy	0.318			0.0564
	(0.578)			(0.546)
Constant	-8.075*	-8.093*	3.924	-9.878**
	(4.381)	(4.506)	(8.610)	(4.539)
Observations	1,459	1,132	323	1,226
Number firms	567	431	135	500
P value of AB test for AR(2)	0.64	0.32	0.49	0.51
P value of Hansen stat.	0.77	0.67	0.98	0.64

Appendix H: Scatterplot Diagrams of Variables Used in Data Cleaning

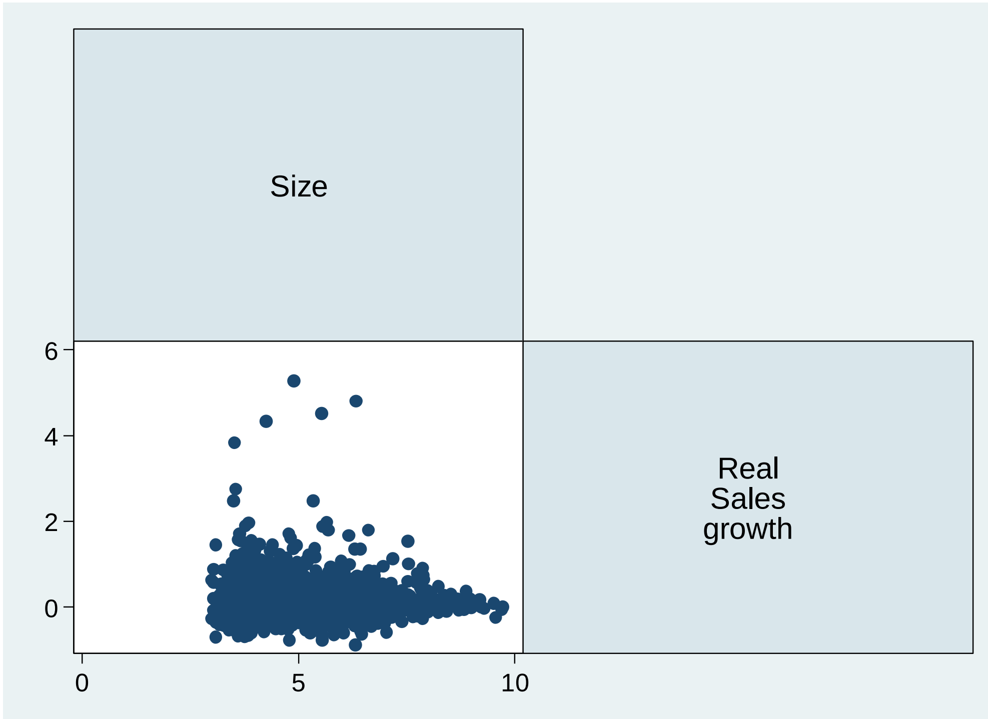
Scatter Plot of Real Value Added Growth versus Size Before Data Cleaning



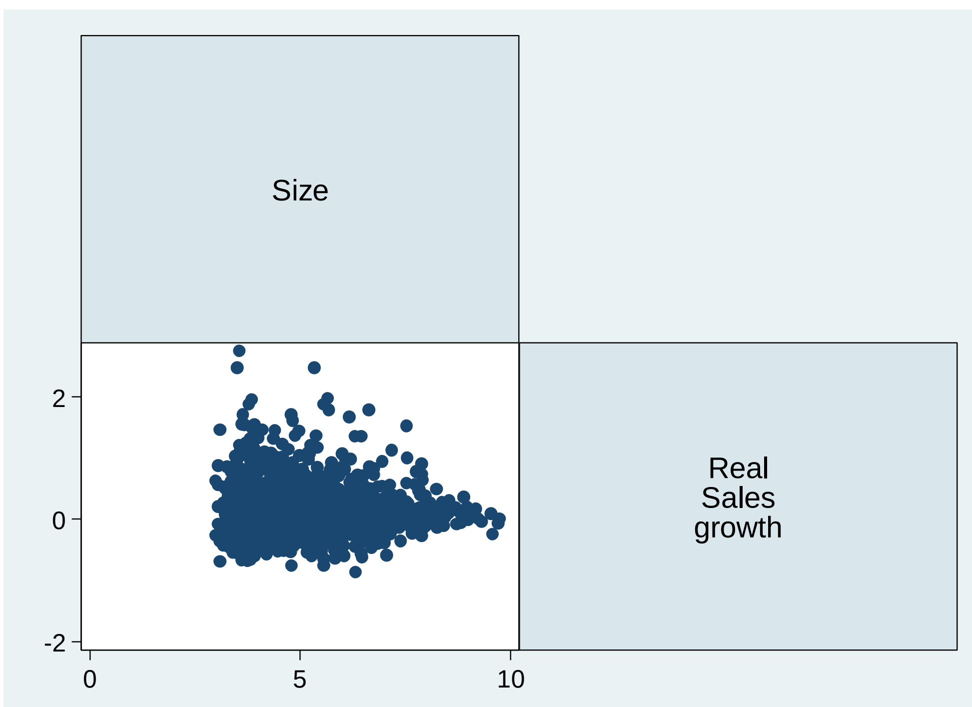
Scatterplot of Real Value Added Growth versus Size After Data Cleaning



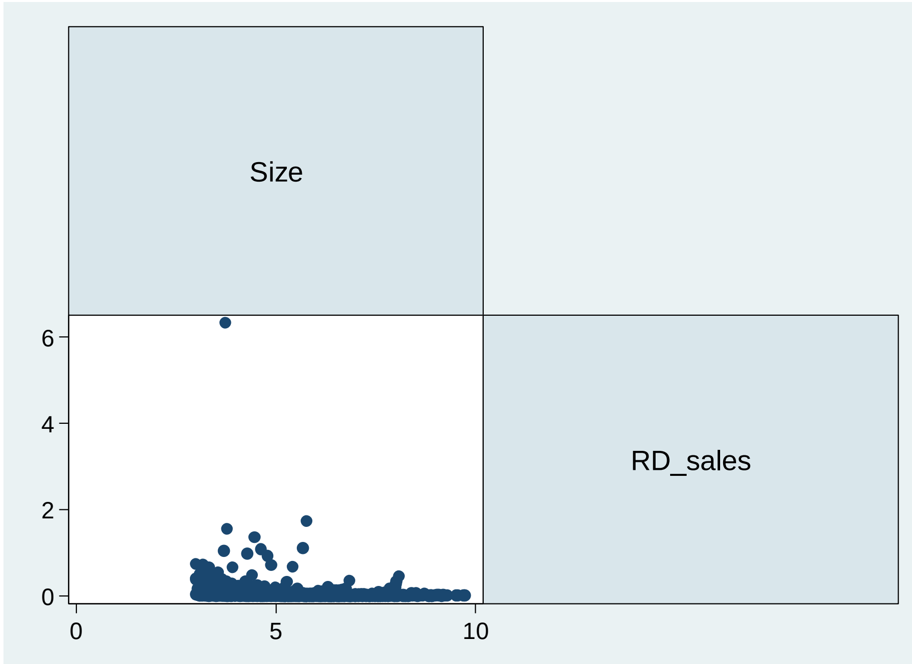
Scatterplot of Real Sales Growth versus Size Before Data Cleaning



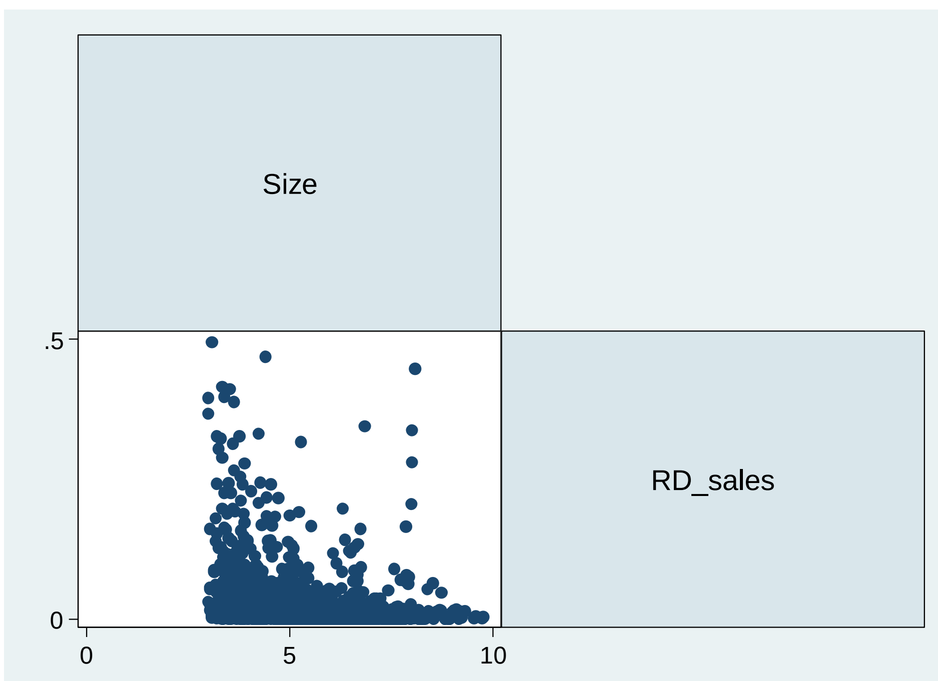
Scatterplot of Real Sales Growth versus Size After Data Cleaning



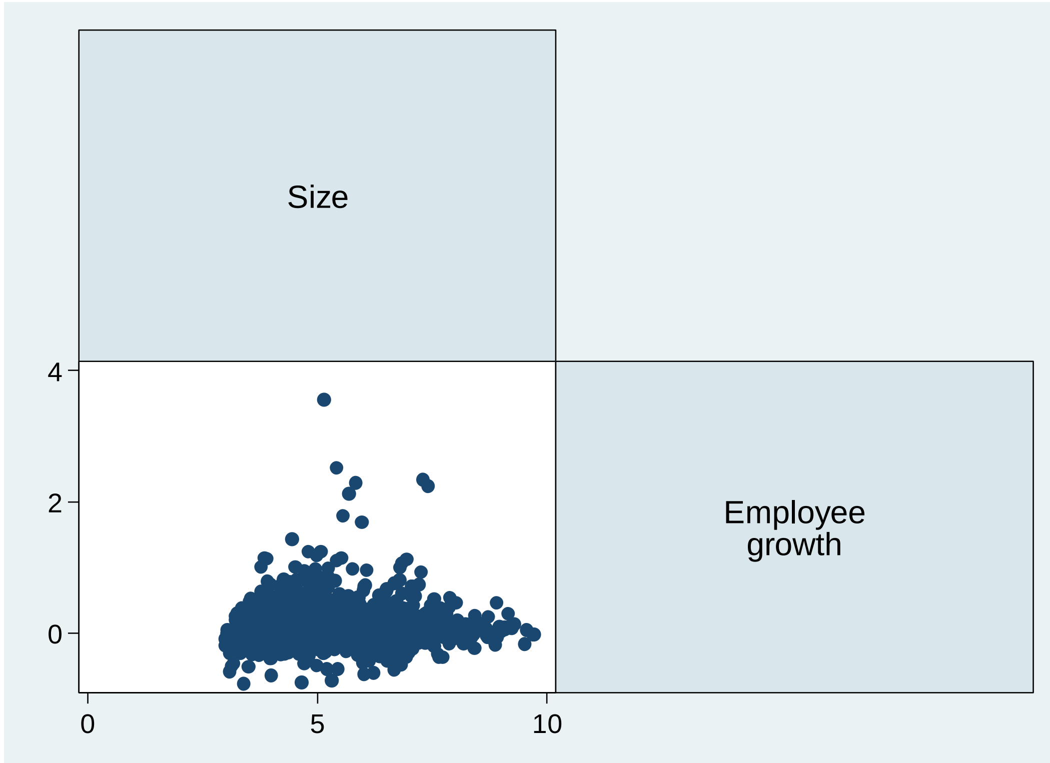
Scatterplot of R&D expenditures/Sales versus Size Before Data Cleaning



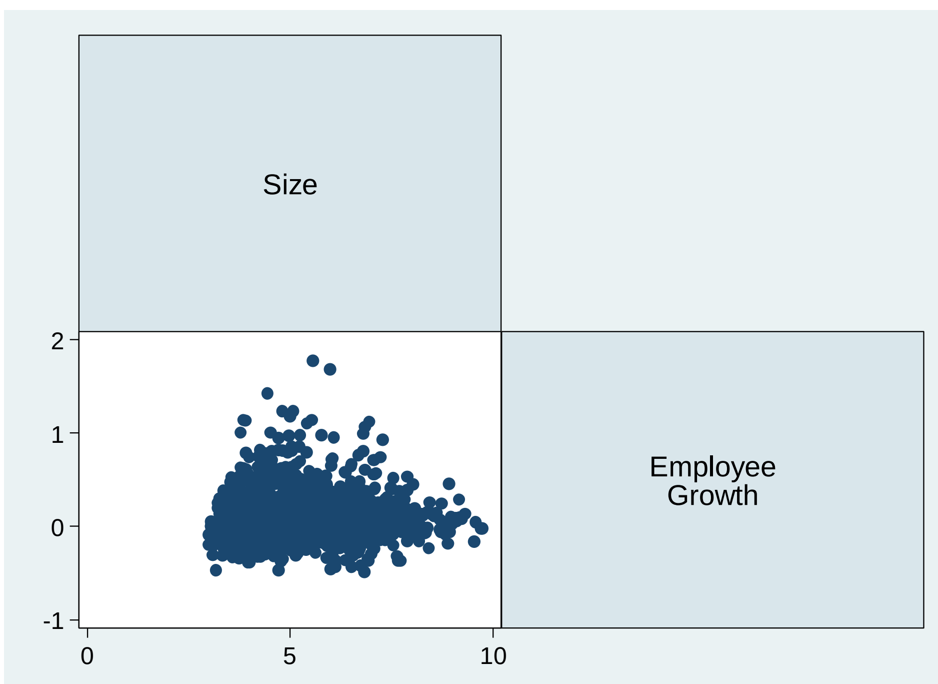
Scatterplot of R&D expenditures over Sales versus Size Before Data Cleaning



Scatterplot of Employee Growth versus Size Before Data Cleaning



Scatterplot of Employee Growth versus Size After Data Cleaning



Appendix I: First Stage Heckman Outputs for R&D's Effect on Productivity for all R&D Performers

Probit regression		Observations		5151
for 2003		LR chi2(26)		745.34
		Prob >	chi2	0
Log likelihood	-842.56	Pseudo	R2	0.307
	Coef.	Std. Err.	z	P>|z|
Sector's Capital Stock	0.26	0.12	2.13	0.03
Sector's RD stock*marketshare	0.08	0.03	2.35	0.02
Geographic Spillovers	-0.04	0.32	-0.11	0.91
Foreign Ownership	-0.03	0.54	-0.05	0.96
Size	0.29	0.17	1.69	0.09
Foreign Knowledge Spillovers	-0.72	0.19	-3.68	0.00
Sector's Export Ratio	-0.91	0.73	-1.25	0.21
Skill	0.22	0.13	1.73	0.08
Herfindahl	-10.23	5.72	-1.79	0.07
Absorptive Capacity	-0.03	0.06	-0.51	0.61
Sector's Subsidy	0.01	0.01	1.71	0.09
Location Dummy	-0.30	0.39	-0.78	0.44
Constant	-4.08	0.83	-4.93	0.00

Probit regression		Observations		5603
for 2004		LR chi2(26)		967.9
		Prob >		0
Log likelihood	-995.44	Pseudo	R2	0.327
	Coef.	Std. Err.	z	P>|z|
Sector's Capital Stock	-0.32	0.16	-2.07	0.04
Sector's RD stock*marketshare	0.19	0.05	3.43	0.00
Geographic Spillovers	-0.43	0.39	-1.08	0.28
Foreign Ownership	-0.37	0.50	-0.73	0.47
Size	-0.18	0.24	-0.74	0.46
Foreign Knowledge Spillovers	-0.23	0.28	-0.81	0.42
Sector's Export Ratio	0.27	0.89	0.30	0.76
Skill	0.02	0.17	0.10	0.92
Herfindahl	16.66	10.87	1.53	0.13
Absorptive Capacity	0.11	0.07	1.54	0.12
Sector's Subsidy	-0.01	0.01	-1.79	0.07
Location Dummy	0.16	0.50	0.32	0.75
Constant	-4.29	0.76	-5.68	0.00

Probit regression		Observations		6067
for 2005		LR chi2(26)		1097.31
		Prob >		0
Log likelihood	-1265.8	Pseudo	R2	0.3024
	Coef.	Std. Err.	z	P>|z|
Sector's Capital Stock	-0.24	0.14	-1.79	0.07
Sector's RD stock*marketshare	0.16	0.05	3.33	0.00
Geographic Spillovers	-0.23	0.31	-0.73	0.46
Foreign Ownership	-0.30	0.45	-0.66	0.51
Size	-0.26	0.24	-1.11	0.27
Foreign Knowledge Spillovers	-0.03	0.25	-0.12	0.91
Sector's Export Ratio	1.14	0.84	1.35	0.18
Skill	0.07	0.16	0.44	0.66
Herfindahl	-13.15	14.49	-0.91	0.36
Absorptive Capacity	0.07	0.06	1.05	0.30
Sector's Subsidy	-0.01	0.01	-1.06	0.29
Location Dummy	-0.62	0.49	-1.26	0.21
Constant	-2.43	0.66	-3.67	0.00

Probit regression		Observations		6189
for 2006		LR chi2(26)		1047.84
		Prob >		0
Log likelihood	-969.69	Pseudo	R2	0.3509
	Coef.	Std. Err.	z	P>|z|
Sector's Capital Stock	-0.28	0.15	-1.84	0.07
Sector's RD stock*marketshare	0.13	0.05	2.48	0.01
Geographic Spillovers	0.34	0.43	0.80	0.42
Foreign Ownership	0.55	0.51	1.07	0.28
Size	0.00	0.24	0.01	0.99
Foreign Knowledge Spillovers	0.40	0.32	1.25	0.21
Sector's Export Ratio	1.20	0.91	1.32	0.19
Skill	0.14	0.17	0.80	0.42
Herfindahl	12.28	13.32	0.92	0.36
Absorptive Capacity	-0.01	0.07	-0.09	0.93
Sector's Subsidy	0.01	0.01	1.55	0.12
Location Dummy	0.24	0.53	0.46	0.65
Constant	-2.95	0.77	-3.86	0.00

Probit regression		Observations		6509
For 2007		LR chi2(26)		1032.87
		Prob >		0
Log likelihood	-975.88	Pseudo	R2	0.3461
	Coef.	Std. Err.	z	P>|z|
Sector's Capital Stock	-0.10	0.14	-0.71	0.48
Sector's RD stock*marketshare	0.17	0.04	3.85	0.00
Geographic Spillovers	-0.13	0.50	-0.26	0.79
Foreign Ownership	-0.20	0.42	-0.48	0.63
Size	-0.13	0.19	-0.69	0.49
Foreign Knowledge Spillovers	0.70	0.33	2.15	0.03
Sector's Export Ratio	-1.21	0.81	-1.48	0.14
Skill	0.04	0.15	0.25	0.80
Herfindahl	3.42	10.96	0.31	0.76
Absorptive Capacity	-0.01	0.07	-0.19	0.85
Sector's Subsidy	0.01	0.01	1.34	0.18
Location Dummy	0.80	0.53	1.52	0.13
Constant	-2.14	0.78	-2.75	0.01

Appendix J: System GMM Results (Dependent Variable: Labor Productivity)

	All R&D performers	High-Med Tech R&D performers	Low Tech R&D performers	Domestic R&D performers
Lagged labor productivity	0.248*	0.409***	0.448**	0.192
	(0.136)	(0.0923)	(0.204)	(0.129)
Physical capital stock intensity	0.150	0.0542	0.155	0.153
	(0.161)	(0.0910)	(0.342)	(0.101)
R&D capital stock intensity	-0.198	-0.0363	-0.190	-0.0884
	(0.132)	(0.0612)	(0.131)	(0.0991)
Foreign ownership	-0.962	-0.0433	-1.294	
	(2.414)	(0.531)	(1.668)	
Scale	-0.182	0.0427	-0.156	0.00514
	(0.249)	(0.126)	(0.162)	(0.203)
Foreign knowledge spillovers	-0.0975	0.136	-0.278	-0.0132
	(0.158)	(0.0866)	(0.244)	(0.119)
Export intensity	3.234	-0.0123	0.826	1.157
	(2.143)	(0.538)	(1.314)	(1.426)
Skill	0.888*	0.313	0.749	0.638**
	(0.475)	(0.262)	(0.492)	(0.319)
HITEK	-0.0259	-0.0119		0.0406
	(0.255)	(0.108)		(0.227)
MEDTEK	-0.179			0.0138
	(0.231)			(0.152)
Constant	0.325	2.913	-0.248	1.561
	(3.414)	(1.775)	(2.407)	(1.986)
Observations	1,343	1,043	296	1,124
Number of firms	523	396	126	459
P value of AR(2)	0.58	0.004	0.58	0.27
P value of Hansen statistic	0.61	0.18	0.20	0.49

Appendix K: Panel Heckman Two-stage Procedure Results with IV with lagged R&D Capital Stock Intensity and Foreign Knowledge Spillovers

	All R&D performers	High-Med Tech R&D performers	Low Tech R&D performers
Physical capital stock intensity	0.568	0.337	-1.194
	(0.465)	(0.363)	(2.642)
R&D capital stock intensity (lagged)	0.312*	0.318	0.751
	(0.183)	(0.197)	(1.150)
Foreign ownership	0.941	0.563	-9.224
	(3.878)	(2.793)	(13.53)
Scale	1.428	1.092	-0.423
	(0.981)	(0.744)	(1.658)
Foreign knowledge spillover (lagged)	0.0893	0.118	0.407
	(0.195)	(0.163)	(1.038)
Export intensity	-0.155	-0.151	0.815
	(0.241)	(0.225)	(1.139)
Skill	0.455***	0.459***	1.174
	(0.142)	(0.134)	(1.640)
Lambda	-0.346	-0.671	-2.837
	(0.555)	(0.415)	(3.584)
lam2	0.237	0.311	0.913
	(0.188)	(0.206)	(1.304)
lam3	0.531*	0.577*	1.431
	(0.320)	(0.349)	(2.026)
lam4	0.580*	0.643*	1.483
	(0.332)	(0.350)	(2.000)
Cons	1.411	1.895	2.835
	(1.714)	(1.657)	(5.524)
Observations	1472	1133	335
Kleibergen-Paap rk LM statistic:	8.22	22.68	1.99
(P value):	0.04	0.000	0.37
Kleibergen -Paap rk Wald F stat:	2.38	8.33	1.42
(Stock and Yogo critical value):	4.73	7.56	5.45
P value of Hansen statistic:	0.15	0.58	0.86

Dependent Variable is labor productivity (natural logarithm)
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1.Time dummies included.

Appendix L:
Results of the SF estimation when R&D intensity and Spillovers are Lagged

Production function	**Coeff.**	**t-ratio**
Constant	-1.55	-1.60
C	0.00	0.64
L	-0.02***	-2.66
t	0.00	0.05
tt	0.03*	1.83
Lt	0.00	-0.47
LL	0.00	0.59
CC	0.00	1.14
Ct	-0.02**	-2.50
LC	0.00	-0.12
Skill	0.19*	1.75
Efficiency effects		
Constant	-1.36	-1.63
S input	-5.60***	-3.71
S output	0.59**	2.08
Market share	-1.40***	-3.53
R&D Intensity	0.06**	2.37
Sectoral spillover	-0.02	-0.44
Subsidy dummy	0.11	1.46
Export Intensity	-0.10	-0.77
Geographic spillover	0.01	1.59
Joint Stock dummy	-0.23***	-2.83
Variance parameters		
sigma-squared	0.36	6.75
gamma	0.85	34.45
Mean efficiency	0.85	
# obs.	1706	
Log Likelihood	-274.69	

*** p<0.01, ** p<0.05, * p<0.1

Appendix M: Questions Asked In the Interviews and A Brief Summary of the Answers
Questions Asked to the R&D Performing Firms

All questions have been asked for the 2003-2007 period.

1. How many employees work in the firm? Is there foreign partner in the firm?
2. Why do you conduct R&D? Is there process R&D?
3. How do you finance R&D? With R&D supports or own resources? What do you think about the current R&D supports and the ones before 2008 ?
4. Can you easily find R&D employees? Can you find skilled employees from the universities? How else do you find skilled employees? Do you lose skilled people to other firms?
5. Do foreign firms conducting R&D affect your R&D activities? Do you do anything to benefit from the knowledge of the foreign firms? If yes, how do you do this, via reverse engineering or employing people from foreign firms.. etc?
6. How do you measure the impact of R&D on productivity? Have you ever had projects that were not fruitful? How long does it take for an R&D project to start and to end as a product in the market?
7. Do you use licensing? Is there a fall or a rise in your R&D expenses because of your license use?
8. Do you use subcontracting? Does subcontracting allow you to focus on your own core competence and let you increase your productivity?
9. Does conducting R&D make you closer to the market leader in terms of productivity?
10. How do previous R&D activities affect new R&D expenditures?
11. Do you have exports? Does exporting positively affect your R&D activities? Do R&D activities have an effect on exporting? If yes, how?

Questions Asked to the Organizations

1. Do members of your organization perform R&D?
2. Why do you thing they perform R&D?
3. How do they finance their R&D activities?
4. What are the motives for applying for R&D subsidies, if they do so?
5. Do foreign firms' R&D practices affect the R&D activities of the members of your organization? How?
6. Do they use licensing? How much do you think their licensing expenditures affect R&D activities?
7. Do they use subcontracting? Does subcontracting enable them to focus on their core competence?
8. Do R&D activities make your firms catch up with the sector leader?
9. How do previous R&D activities affect new R&D expenditures in the members of your organization?
10. How does exporting affect R&D and vice versa?

The list of firms included in the interviews is presented in the following two tables:

Title of the firm	Interviewee	foundation date	Legal status	Industry
Matay Otomotiv Yan Sanayi ve Ticaret A.Ş.	Bekir Girgin	1987	Holding company	Automotive supplier
BAMA Teknoloji Ltd. Sti	Ömür Deler	2010	Partnership	Robotic medical devices
Meteksan Savunma Sanayi A.Ş.	Cihangir Duran	2006	Holding company	Defense
İksa İnşaat Katkıları San. Ve Tic. Ltd. Şti.	K. Yaşar Levent	1979	3 partners	Construction
Teknoset Ltd. Sti.	Cengiz Bayazıt	2003	2 partners	Wireless automation
Karel Elektronik Sanayi ve Ticaret A.Ş.	İsmet Arsan	1986	3 partners	Communication electronics
Unimetal Hassas Döküm Makina ve Yedek Parça San. ve Tic. A.Ş.	Hakan Batılı	2000	4 partners	Precision Casting
Gate Elektronik Sanayi ve Tic. A.Ş.	Ayşegül Savgı	1989	2 partners	Defense
Melekler Biyoloji	Şükrü Atakan	2011	1 person	Medical imaging
Protaş A.Ş.	Filiz Öngay	1989	3 partners	Machinery
Aspar Asansör Aksamları A.Ş.	Hasan Aksöz	1976	Family firm	Machinery
KOSGEB	Metin Şatır		State organization	Supporting SMEs
Tekno Girişim Derneği	Emin Okutan	2010	NGO	Supporting R&D firms
OSIAD	Gülay Özdemir			Supporting OSTIM firms

	Product	Employees	Foreign partner	Export	R&D dep	Date and time of interview	Place
Matay	Exhaust systems	400	yes	limited	yes	Dec 20, 2011 10:00	Telephone
BAMA	Robot driven rehabilitation system	2	no	no	yes	--	E-mail
Meteksan	Radar, software	150	no	no	yes	---	E-mail
İksa	Concrete admixtures	20	no	yes	yes	Nov 21, 2011 13:00	Tandoğan
Teknoset	Smart irrigation system	4	no	yes	yes	Nov 14, 2011 13:30	Telephone
Karel	Switchboard	110	no	yes	yes	Oct 25, 2011 9:30	Bilkent
Unimetal	Material alloys	150	no	yes	yes	Nov 1, 2011 14:30	Telephone
Gate	AUV, mouth imaging device	220	no	yes	yes	Nov 28, 2011 14:00	Telephone
Melekler	Laboratory device	2	no	no	no	Nov 23, 2011 14:00	Bilkent
Protaş	Elevator motors and exproof equipments	50	no	yes	yes	Nov 2, 2011 9:00	Telephone
Aspar	Elevator	170	no	yes	no	Nov 16, 2011 12:00	OSTİM
OSIAD	N/A	N/A	N/A	N/A	N/A	N/A	OSTİM
Teknogirişim Derneği	N/A	N/A	N/A	N/A	N/A	N/A	Çayyolu
KOSGEB	N/A	N/A	N/A	N/A	N/A	N/A	Mamak

Firms that claim to perform R&D can be divided into two as far as the reason for starting R&D efforts. Those that start out by a market pull and those that start out with a technology push. Usually the first group's goal is to protect their market share whereas the second group tries to create a market of its own. However a common goal in both groups is to reduce the foreign exchange flowing to imported material by producing domestic substitutes. Most of the firms claim that they have both product and process R&D but their product R&D efforts seem to be more than the process R&D. Being a supplier to the defense industry is a major reason for performing R&D. Also competition with foreign firms in the domestic and in the export markets is a significant reason for small firms in the manufacturing industry. Participation in international fairs allows firms to be able to benchmark their products with others in the world.

Almost all the interviewees said they used R&D supports, there was only one firm, PROTAŞ that did not use any support but their own financial resources. PROTAŞ said it knew about the supports but was not able to study its details and the procedures of applications. It felt it should not pay a significant amount to the consultants who fill out those applications. Therefore so far it preferred to use its own resources but after the foundation of the 'Development Agencies' it also is planning to apply in the coming years. Most firms thought the current R&D supports are enough and they are able to get financing when they apply. However, one said it had a hard time receiving R&D support as opposed to the period before 2008. The common belief is that the percentage of R&D support receivers dropped after 2008 but the quality of the projects applying for support has increased.

Some firms claim they cannot conduct R&D without support, however there are others who claim they can continue with their R&D efforts with their own resources but it will take longer to finalize the projects. Some of the firms state that they have a hard time finding R&D employees. The reason is that the needed area of expertise is simply not there. There are not enough people with PhD degrees studying in that area. They try to find those highly skilled people from universities on a project basis. Another solution is they find master's students and hire them and benefit from their knowledge as they learn themselves. Some firms who have a PhD among their partners have less of a problem in finding R&D employees because they claim they follow the literature themselves and learn on their own if worst comes to worst. Some of the firms raise their own human capital and take the risk of losing these people to competitors, but they also view this is as a civil duty to the country.

Other than the firms in the defense industry, all the others claim that foreign competition drives them to conduct R&D to improve their products. One of the firms state it this way "We do benchmarking with the products of our foreign competitors." They do not try to replicate their foreign competitors' products, but they aim to surpass those products. In order to benefit from the foreign firms' knowledge pool, they read the testing requirements and reports of those firms. They study the foreign competitor's product, read the brochures or ask the users about the products. However they claim that their main source of knowledge is university professors who are more than willing to help with any problem they may have. One of the firms, Unimetal, even has a Chinese professor whom they met though a TUBITAK project at Istanbul Technical University and they have been enjoying consulting services from him ever since. However, most of the others state that they never needed to search for help from foreign universities because they think knowledge level in Turkish universities is enough to satisfy their needs.

KOSGEB makes the observation that imitation from foreign firms is a starting point for R&D for the small firms. OSIAD states that being a supplier of a foreign firm raises quality awareness in the small firms in OSTİM.

Apart from two firms all firms claimed that they measured the impact of R&D on productivity by looking at the sales revenue. One firm, KAREL mentioned a system called CMMI3 and another, MATAY mentioned another by the name OEE. A few of them (GATE Elektronik, Teknoset and stated that they did have projects that did not bear fruit, but then they also stated that those projects did trigger other projects that turned out to be successful. Therefore they believe in some kind of a payoff in R&D somehow. For instance KAREL gave the example of a large project in India that could not pass the late testing at a rather late stage in the project and was terminated however because of that project they were able to get into another tender in India. They claim that R&D projects take between 2 to 3 years. Sometimes they have projects that take longer or are suspended because of management reasons or problems in the client than this period takes longer.

Among all the firms, there was only one, MATAY who used licensing and that firm stated that being tied to a license agreement seriously hindered their R&D efforts. In the words of the company officer " License agreement creates addiction and does not bring along R&D opportunities". This is an automotive part supplier company and it manufactures according to the design dictated by the clients who are foreign auto manufacturers in Turkey. The designs of these firms are done in France and Italy and therefore as a local supplier here they have to comply with the wishes of the clients and those are only related to cost cutting. However, the firm feels it needs to be able to compete with the designers in Europe so it has decided to set up its own R&D center in 2012 and directly approach European car manufacturers with the offer of conducting their design and R&D needs in Turkey at a much lower cost than their European counterparts.

There was one firm PROTAŞ that used knowhow at the start-up stage back when the firm was opened. Later on they have built on that knowledge by conducting their own R&D therefore they believe in the use of purchasing knowhow only when necessary.

As far as subcontracting goes, there is a variety of attitudes. Some believe subcontracting is unreliable because they have had some bad experiences with subcontractors before. Others think subcontracting can only be used in manufacturing but not in R&D. However there is one Gate Elektronik that uses subcontracting for R&D purposes because this allows them to alleviate the problem of not being able to find skilled people. One thing that sets this firm apart from the others is the subcontractor management they perform. They choose their subcontractors carefully and this gains them access to expertise which they need for certain projects. Another firm, and Meteksan Savunma picks his subcontractors from certified ones and that's how they make sure they will be reliable business partners.

Firms believed conducting R&D surely gets them closer to the market leader. Only one claimed it is the market leader because of its R&D activities.

Only two of the interviewed firms Melekler Biyoloji and BAMA did not perform exports because they were too young. Among the others one said exporting increased their R&D activities. Another, İKSA Ltd. said their exporting did not affect their R&D efforts. However this company's exports were realized to Azarbaycan, Turkic countries in Asia. KOSGEB vice president made the observation that those that conduct R&D and can compete with foreign firms gain a self-confidence and want to start exporting. Sure enough one of the firms, PROTAŞ claimed once their new product is launched after R&D, they expected to increase their exports.

Appendix N: A Brief Review of Science and Technology Policies in Turkey

Science and Technology policies in Turkey date back to the establishment of the State Planning Organization (Devlet Planlama Teşkilatı, DPT) in 1960. The aim of DPT was to prepare plans that would help prosper the economy while benefiting from the opportunities generated by the liberal economy. In the first Five Year Development Plan which was prepared by DPT it was planned for 3000 students to be sent overseas to get PhD education. The number of researchers in public services was to be increased by three fold. Another goal was to allocate 0.6% of GDP on research expenditures and to establish a scientific and technical research council (Şahin, 1997). Among all of these goals only the last one has been accomplished. In 1963 , the Scientific and Technological Research Council of Turkey (Türkiye Bilimsel ve Teknolojik Araştırma Kurumu, TÜBİTAK) was established as an autonomous institution with the goal of coordinating, organizing, and providing initiatives to the research and development activities in Turkey.

In the second five year plan which covers the period from 1968 to 1972, the two goals of sending 3000 PhD students abroad and increasing the research expenditures to 0.6% of GDP have been renewed as only 500 students had been sent to get PhD education in the previous five years.(Şahin, 1997). The two specific achievements of this period are the establishment of Marmara Research Center (MAM) and Construction Research Center and Documentation Center (Şahin, 1997).

In the third five year plan covering 1973 to 1977, there has been an awareness of the importance of applied sciences and technology transfer and intellectual property rights topics. The necessity of advanced technologies for industrialization is acknowledged and the need for institutions that can make decisions on technology transfer and the linking of technological innovations with the industry is underlined (Ayhan, 2002).The goal of sending PhD students abroad is once again rescheduled as only 1181 students had been sent in the past 10 years (Şahin, 1997).Some of these researchers with PhD have not returned to Turkey or the ones who have returned could not be used in R&D so their contribution to economic development has not been much(Ayhan, 2002). TÜBİTAK is assigned the responsibility of the development of scientific researchers both within the country and abroad. Although the third five year plan states the significance of technology transfer and technology import along with foreign capital and the attraction of high skilled human capital into the country, these goals have not been achieved at the end of the term (Ayhan, 2002).

The fourth five year plan (1979 to 1983) acknowledges the insufficiency of the science and technology policies that have been planned until then. However one accomplishment that takes place in this period is the publishing of the document titled “1983-2003 Turkish Science Policy” where technology is taken as a main heading and different technological areas have been identified as areas of priority (Yalçın and Yalova, 2005). Although this policy document has never been put into action it signifies the establishment of the Supreme Council for Science and Technology (BTYK) . A milestone in the Turkish economy takes place in 1980 and export oriented industrialization policies are put into action.

The main goal of the fifth development plan spanning the years from 1985 to 1989 is the preparation of a Science and Technology master plan in the light of the 1983-2003 Turkish Science Policy (Şahin, 1997).Some of the goals of this plan is to establish centers of excellence in basic and applied science areas which will act to kindle relations between university and industry. Furthermore the founding of a national total quality control is system is also planned. Tax breaks and tax postponements are some of the research and development incentives that have been devised in this period. The BTYK conducts its first meeting in 1989 and decides on raising the number of R&D personnel to 30 per 10000 labor force, to increase GERD to 2% of GDP, to establish a national metrology institution, to renew legislation on industrial rights (OECD, 1995).

In the sixth five year plan covering the years 1990 to 1994 sets up R&D priority areas which are information technologies, microelectronics, telecommunications, satellite technologies, nuclear technologies, advanced materials, etc. (OECD, 1995) GERD as a percentage of GDP is targeted to be 1%. (Şahin, 1997) The need for technoparks is first realized in this plan and the number of researchers per 10000 labor force is also targeted to be 15 (Şahin, 1997). The distinguishing achievement of this period is the meeting of the first Science and Technology Assembly. The Assembly’s objectives were to develop the criteria to evaluate R&D activities both at the institutional scale and also on a project basis and to coordinate R&D activities between institutions.(OECD, 1995)The law to establish TUBA is enforced in this period and the science and technology policy making power is taken from DPT and granted to BTYK. Although its meetings are scheduled to be two times a year, BTYK does not make its second meeting not until 1993. In that meeting BTYK prepares the “Turkish Science Policy: 1993-2003” document which proposes new policies such as R&D support programs. Yalcın and Yalova (2005) claim that this document sets a milestone in the Turkish science and technology policies by underlining the necessity for the country to generate innovation-based national policies. However, the economic crisis that happens in 1994 calls forth the stabilization package on April 5th, 1994. Therefore most of these Science and Technology policies are postponed.

In the seventh five year plan from 1996 to 2000 more focused targets are decided upon. Among them are the establishment of technoparks, development of technologies that will help the defense industry, the generation of pre-competition research collaborations, and the promotion of research partnerships by the public sector , universities and the private sector. Certain sectors such as communication, new materials, space and military technologies, healthcare, environment and biotechnology are targeted as areas where product design and development should take place (Şahin, 1997). For the year 2000, the number of university instructors is planned to be 75,000. However not enough resource has been devoted to R&D and the number of researchers per 10000 labor force has not been 15. No significant development has been achieved in terms of university-industry relations and not enough progress has been recorded in the technologically high priority designated areas such as space and defense, healthcare, robotics, biotechnology etc. Venture capital has not been established.

In the eighth five year plan from 2001 to 2005 some concepts are mentioned for the first time. Among them is the establishment of a national innovation system, a national R&D budget, support to commercialization of R&D projects. Local and regional extensions based on the national innovation system are also declared as other goals of this plan. The failure in the promotion of venture capital partnerships is once again acknowledged and venture capital is stated yet as another goal in this period. The GERD as a % of GDP is targeted to be 1,5% (Ayhan, 2002).

The ninth development plan spans the years from 2007 to 2013 and addresses that the aim of the science and technology policy is to equip the private sector with innovation capability. According to this plan the share of R&D expenditures in GDP is targeted to be 2% and the share of the private sector in all R&D expenditures by the end of 2012 is planned as 60%. The plan states that the R&D incentives and the support system will be restructured, and entrepreneurship will be supported through the development of venture capitalists. Nanotechnology, biotechnology, new generation nuclear technologies, space and defense technologies are listed as areas that will be given priority in R&D activities. Strengthening of university private sector relations and improvement of human capital are also mentioned as other areas underlined in the plan (SPO). These same targets have been set in the 22nd meeting of the BTYK under the document titled ‘National Science, Technology and Innovation Strategy 2011-2016’ where the role of small and medium businesses in generating innovation is highlighted and the significance of commercialization of R&D outputs is underlined as two of the strategic goals(TUBITAK, 2010).

Appendix O: Turkish Summary

18. yüzyılın sonralarındaki birinci sanayi devriminden ve bir yüzyıl sonra da Almanya ve Amerika Birleşik Devletleri'nde yaşanan ikinci sanayi devriminden bu yana teknoloji ve inovasyon ekonomik büyümede rol oynayan önemli faktörler olmuştur (Amsden, 1989). Gerschenkron (1962) İngiltere'deki sanayileşmenin buluşlara, Almanya ve Amerika'dakinin ise inovasyona dayalı olduğunu iddia eder. Oysa ki , Bulgaristan, İtalya ve Rusya'dakilerin ise daha önce sanayileşmiş ülkelerden yapılan teknoloji transferi ile gerçekleştiğini belirtir (Gerscheknron, 1962). Güney Kore, Japonya, Tayvan ve Tayland'ı geç sanayileşen ülkeler olarak çalışan Amsden (2001) bu ülkelerin ekonomik gelişmesinde 'ödünç alınan teknolojilerin' rollerinin altını çizmektedir. Teorik bir bakış açısından ise Romer (1990) endojen büyüme teorisinde ekonomik büyümeyi inovasyon ve beşeri sermayeye yapılan yatırımlara bağlamaktadır. Bilgi biriktikçe ve bilgi taşmalarından ekonomideki diğer firmalar yararlandıkça ekonomik büyüme süreklilik kazanmaktadır. Araştırma ve geliştirmenin (AR-GE) verimliliğe etkisi üzerine olan literatür de günümüze kadar epey gelişmiştir. (Griliches and Mairesse, 1990; Hall and Mairesse, 1995; Czarnitzki and O'Byrnes, 1999; Fagerberg et al., 2009; Criscuolo et al, 2010). Öte yandan AR-GEnin ekonomik büyümeye olan katkısının etkin çalışan milli inovasyon sistemi ve fikri mülkiyet hakları gibi kurumların varlığına bağlı olduğu öne sürülmüştür (Song, 2005; Kothari, 2009). Geç sanayileşen ülkelerde Amsden (2001) devletin teknolojik kapasitelerini geliştirmek üzere firmalara vereceği sübvansiyonlar için kararlı ve disiplinli bir yol izlemesi gerektiği konusunun altını çizmektedir. İyi eğitimli bir iş gücünün varlığı ve yabancı ülkelerdeki bilginin de yakın takip edilmesi gerekliliği 'öğrenme' tabanlı ekonomik büyümenin temellerinden birini oluşturmaktadır (Amsden, 2001). Tüm bu nedenlerden dolayı 'ödünç alınan teknoloji'nin bile bazı koşullar sağlandığı taktirde büyümeye pozitif etkisinin olacağı görülmektedir. Amsden (2001) kendisinin makro koşulları çalıştığını ve firmaların öğrenme süreçlerini etkileyecek mikro faktörlerin de çalışılması gerektiğini belirtmektedir. ARGE ve verimlilik üzerine çalışan başka araştırmacılar da gelişmekte olan ülkelerde artan ARGE harcamalarının ekonomik etkileri üzerine çalışılması gerektiğini öne sürmektedirler (Hall et al., 2010).

Türkiye 2003-2007 yılları arasında ARGE harcamaları artan bir gelişmekte olan ülke olarak ARGE harcamalarının verimliliğe etkisi açısından çalışılabilecek iyi bir örneği oluşturmaktadır. 1990ların sonlarında Türkiye'deki brüt yurtiçi ARGE yatırımı Gayrı Safi Yurtiçi Hasılanın % 0.47'si kadar gerçekleşmiştir. 2009'da ise bu oran % 0.85 olarak gözlemlenmiştir. Bu süre zarfında değişen bir başka faktör de devletin ARGE harcamalarındaki payının düşmesi ve özel sektörün payını artmasıdır. Bu tezi tetikleyen unsurlar bu değişiklikler olmuştur.

O1. Yabancı Sahipliği ve Yabancı Bilgi Taşmalarının Türkiye'deki AR-GE Harcamalarına Etkisi Nasıldır?

Bilgiye ulaşma yolları gelişmiş ülkelerde ve gelişmekte olan ülkelerde farklı mekanizmalarla gerçekleşmektedir. Gelişmiş ülkeler son teknolojiyi geliştirerek teknolojik araştırma yaparlarken gelişmekte olanlar onları takip etmektedir (Forbes ve Wield, 2000). Fakat teknoloji transferinin önünde bazı engeller vardır. Teece (1981) bilgiyi kodifiye edilebilir ve edilemez olarak ikiye ayırmaktadır ve kodifiye edilemeyen tarafından dolayı da transferinin zorluğundan bahsetmektedir. Cohen ve Levinthal (1990) bilgiyi alacak taraftaki absorbe etme kapasitesinin bilgi edinmede sınır oluşturacağını öne sürmektedir. Güvenin oluşmaması ve şeffaflığın bulunmaması da bilgiye ulaşmaya çalışanlar için aşılacak diğer sorunlar olarak literatürde kaydedilmiştir (Narula, 2005; Kothari, 2009). Doğrudan yabancı yatırım gelişmekte olan ülkeler ile gelişmiş ülkeleri birbirine bağlayan bir köprü olarak karşımıza çıkmaktadır. Firmaların yaptığı stratejik birliktelikler, müşteri ve tedarikçi ilişkileri ve ortak yatırımlar doğrudan yabancı yatırım vasıtasıyla bilgi transferine yol açabilir. Öte yandan yabancı firmaların sahip olduğu üstün teknoloji yerli firmalar üzerinde bir rekabetçi etki de oluşturarak onları pazarın dışına atabilir (Aitken ve Harrison, 1999). Bu tür bir tehdit karşısında yerli firmalar kendilerini koruma amaçlı olarak kendi AR-GE yatırımlarını yaparak yabancı firmalarla rekabet edebilecek hale gelebilirler (Fagerberg et al., 2009). Dolayısıyla doğrudan yabancı yatırımın gelişmekte olan ülkelerdeki AR-GE harcamalarına olan etkiyi araştırmak gerekmektedir.

Türkiye'de doğrudan yabancı yatırım 1950'lerdeki 5583 sayılı kanunla başlamıştır. Bu kanuna göre yabancı firmalar sınırlı koşullara uyarak kendi ülkelerine kar transferi yapabileceklerdir (Erdilek, 2005). 1950'den 1980'e kadar ülkeye yabancı sermaye girişi 229 milyon dolar olarak gerçekleşmiştir (Öniş, 1994). 1990'lardaki iki ekonomik kriz de bu yıllardaki doğrudan yabancı sermaye girişini olumsuz etkilemiştir. 2000'lere baktığımızda ise Haziran 2003'te yürürlüğe giren 4875 sayılı kanun ile minimum sermaye miktarı ve izin gerekliliğinin kaldırıldığını, herhangi bir sınırlama olmadan mülk sahibi olmanın getirildiğini, yabancı uyruklu eleman çalıştırmanın mümkün olduğunu görmekteyiz. Tüm bu farklılıkların sonucu olarak da doğrudan yabancı sermaye yatırımı 2003 yılında Gayrı Safi Yurtiçi Hasılanın %0.56'sından 2006 yılında %3.58'e çıkmış bulunmaktadır. 2003- 2009 yılları arasında Türk AR-GE yoğunluğunun (Gayrı Safi Yurtiçi AR-GE harcamasının Gayrı Safi Yurtiçi Hasılaya oranı) artarak 2009 itibarıyle EU27 ülkeleri için aynı oranının %42'sine ulaştığını gözlemlemekteyiz.[20] 2004'ten itibaren de özel sektörün AR-GE harcamalarındaki payının arttığını ve ilk defa 2008'de yüksek öğretim sektörünün payının üzerinde gerçekleştiğini gözlemlemekteyiz.[21] Hem doğrudan yabancı yatırımın hem de AR-GE harcamalarının arttığı bir dönem olan 2003-2007 yılları arasında akla gelen soru 'Türkiye'de Yabancı sahipliğinin AR-GE harcamalarına etkisi ne olmuştur?' olmaktadır. Bu soru birinci bölümün araştırma sorusunu oluşturmaktadır.

Smeets (2008)'e gore doğrudan yabancı yatırımın bir ülkenin bilgi birikimini etkilemesi dört farklı yolla olmaktadır: yabancı sahipliği, rekabet, teknoloji transferi ve bilgi taşmaları yoluyla. Yabancı sahipliği etkisi yabancı firmaların bulundukları ülkede teknoloji arama amaçlı yaptıkları çalışmalardan kaynaklanmaktadır. Gelişmekte olan ülkelerde yabancı firmalar kendi ürünlerini yerli pazara adapte etmek üzere AR-GE yapabilirler. Sasidharan ve Kathuria (2011) yabancı sermayenin yeni kurulmuş yerli firmaların AR_GE harcamalarını destekleyici etkide bulunduğunu, diğerlerine ise olumsuz etkide bulunduğunu göstermektedirler. Schumpeter (1942) artan rekabetin daha az AR-GE harcamasına sebep olacağını iddia etmektedir zira elde edilecek tekelci kar azalacaktır. Öte yandan Scherer (1980) artan rekabetin AR-GE harcamalarını artıracağını savunmaktadır. Bu argüman firmalar inovasyonda bulunmazlarsa pazarı terk etmek zorunda kalacaklardır varsayımına dayanmaktadır. Yabancı firmalar yerli tedarikçilerle dikey entegresyona girdiklerinde de bir bilgi transferi gerçekleşmektedir. Smeets (2008) bunu bilinçli yapılan bir seçim olmasından dolayı bilgi transferi olarak adlandırmakta ve bilgi taşmalarından ayrı şekilde değerlendirmektedir. Bilgi taşmaları ise istemsiz olarak ortaya çıkan dışsallık olarak ortaya konmaktadır. Çalışanların firmalar arası iş değiştirmeleri bilgi taşmalarının oluşmasında önemli bir etken olarak öne sürülmektedir (Smeets, 2008). Tersine mühendislik ve ürün taklitçiliği de yabancı firmalardan bilgi taşmasını sağlayan yollar olarak görülmektedir (Saggi, 2006). Bu yollara ek olarak, absorbe etme kapasitesi ve yerel yakınlık bilgi taşmalarının gerçekleşmesi için gerekli iki ayrı faktör olarak belirtilmektedir (Smeets, 2008). Findlay (1978)'e

[20] Figür 4'te Gayrı Safi Yurtiçi AR-GE harcamalarının Gayrı Safi Yurtiçi Harcamasına oranı ve aynı istatistiğin EU27 ile karşılaştırması grafiği bulunmaktadır.

[21] Figür 5'te AR-GE Harcamalarının Sektörler İtibarıyle Performansı sergilenmektedir.

göre yerli firmalarla yabancı firmalar arasındaki teknolojik mesafe ne kadar fazla ise bilgi taşması o kadar cok olacaktır zira katedilecek yok uzundur. Cohen ve Levinthal (1990)'a göre ise firmalar teknoloji liderlerine ne kadar yakınsa bilgi taşmasından o kadar cok etkileneceklerdir zira onlara bilgi ve beceri açısından daha benzer olacaklardır. Bu görüşü destekleyen ampirik çalışmalar vardır (Marin ve Bell, 2006; Fu, 2008; Karray and Kriaa, 2009; Deng, 2009).

Türk firmalarının AR-GE harcamalarının belirleyicileri üzerine literatürde az sayıda çalışma bulunmaktadır. Üçdoğruk (2009) 1998'den 2007'e kadar panel veri üzerinde yaptığı çalışmada küçük firmaların daha fazla ARGE harcaması yaptığını rapor etmektedir. Yabancı sahipliğinin ise istatistiki olarak anlamlı bir etkisinin bulunmadığını belirtmektedir. Taymaz ve Üçdoğruk (2009) 1993-2001 aralığını kapsayan çalışmalarında yabancı sahipliğinin ARGE yoğunluğuna bir etkisinin olmadığını bulmuşlardır. Özçelik ve Taymaz (2008) ise kamunun AR_GE desteklerinin özel AR-GE yatırımını pozitif ve istatistiki olarak anlamlı etkilediğini raporlamaktadır. Küçük firmaların AR-GE desteklerinden daha fazla yararlandığını ve daha fazla AR-GE harcaması yaptığını savunmaktadır. Tandoğan (2011) yabancı sahipliğinin ARGE yoğunluğuna olumsuz ve istatistiki olarak anlamlı bir etkisinin olduğunu raporlamaktadır. Kalitatif araştırma teknikleri kullandıkları çalışmalarında Pamukçu ve Erdil (2011) Türkiye'deki yabancı firmaların çevreleri ile yeterince entegre olmadıklarını ve eğitimli eleman bulmada sıkıntı çektiklerini bildirmektedir, ayrıca yabancı sermayeye yönelik politikalarla AR-GE politikalarının uyumlu olmadığını öne sürmektedirler.

Bu çalışma Türkiye İstatistik Kurumu (TÜİK) tarafından yapılan iki farklı anketin firma bazında eşleştirilmesi ile oluşturulan ve 2003-2007 yıllarını kapsayan panel veri ile gerçekleştirilmiştir. Anketlerden birincisi AR-GE anketidir ki burada AR-GE Frascati Kılavuzuna gore tanımlanmıştır (OECD, 1993). İkinci anket ise Yapısal İş İstatistikleri anketidir. AR-GE anketi firmalar bazında 2003 yılından 2007 yılına kadar birbiri ardına eklenirken TÜİK tarafından verilen anahtarda sorun yaşandığı için verinin içinde bulunan bilgilere dayanarak yeni bir anahtar oluşturulmak zorunda kalınmıştır. Daha sonra Yapısal İş İstatistiğindeki ve AR-GE anketindeki firmalar 2003-2007 yılları itibarıyle eşleştirilmiş ve sadece imalat sanayindeki firmalar çalışmaya dahil edilmiştir. TÜİK 20'den fazla çalışanı olan firmaları her yıl takip ettiği için çalışan sayısı 20'den az olan firmalar örnekleme alınmamıştır. Veri temizliği aşamasında gelindiğinde literatürde bu konuda yapılmış çalışmalardaki metodoloji dikkate alınmıştır. Örneğin Hall ve Mairesse (1995) satış ve katma değer büyüklüğü 3'ten fazla ve -0.9'dan az olan firmaları, çalışan artış oranı 2'den fazla ve -0.5'ten az olanları çalışmalarına dahil etmemişlerdir.Bunun sebebi bu tür firmaların organik yollardan büyüme ihtimallerinin az olması ve bu yüzden de yanıltıcı sonuçlar yaratabilecek olmalarıdır. Aldieri ve Cincera (2009) AR-GE harcamalarının satışa oranlandığında 0.5'ten fazla ve 0.0002'den düşük gözlemlerin çalışma dışında tutulması gerektiğini öne sürmüşlerdir. Bu tür kesim noktaları her ne kadar tartışılabilir olsa da her yıl bir firmanın istikrarlı olarak satışlarının yarısı kadar AR-GE harcamasında bulunması biraz zor olacağı için tarafımızca bu rakamlar doğru olarak düşünülmüş, ve veri temizliğinde kullanılmıştır. Veri temizliğinden önce ve sonra verinin dağılımlarını gösteren grafikler Ek H'de bulunmaktadır.

Temizlenmiş veri incelendiğinde ilk dikkati çeken nokta bağımlı değişken olan AR-GE yoğunluğunun içinde çok miktarda sıfır olmasıdır. Bunun nedeni imalat sanayi firmalarının arasında az sayıda AR-GE yapanların olmasıdır. Bu durum seçim yanlılığı (selection bias) denilen bir sorun doğurmaktadır. Öncelikle bir firma AR-GE yapıp yapmayacağına karar vermek durumundadır. Sonrasında da AR-GE harcamalarının miktarına karar vermektedir. Seçim yanlılığı sorunu AR-GE kararını etkileyen bir faktörün AR-GE harcamasını da etkilemesinden ortaya çıkmaktadır. Bu durumu düzeltmek için Heckman seçim uygulaması (Cameron ve Trivedi, 2009) denilen bir uygulamayı kullanmak gerekmektedir. İlk aşamada bir probit regresyonu yapılmaktadır. Bağımlı değişken AR-GE yapanlar için bir, yapmayanlar için sıfır olmaktadır. Bağımsız değişkenler de AR-GE yapma kararını etkileyen faktörlerden oluşmaktadır. İkinci aşamada tüm ARGE yapan firmalar için bir regresyon yapılarak bağımlı değişken olarak AR-GE harcamasının çalışan sayısına oranı alınmaktadır. Bağımsız değişkenler AR-GE yoğunluğunu etkileyen faktörler arasından seçilmektedir ve bir de Ters Mills Oranı şeklinde adlandırılan ve birinci basamakta ortaya çıkan bir değişken bu aşamada bir bağımsız değişken olarak kullanılmaktadır.

Heckman iki-basamaklı prosedürü panel veri ile kullanıldığında, AR-GE yapmayı etkileyen ve gözlemlenemeyen firma bazlı özellikler olduğundan (örneğin, yönetimin becerileri, lokasyondan kaynaklık avantajlar vb.) sabit etkiler modelini uygulamak gerekmektedir. Bunlardan başka, bir de endojenlik sorununu dikkate almak gerekmektedir. Bağımsız değişkenlerimiz arasında AR-GE destekleri bulunmaktadır. Literatürde kamu görevlilerinin AR-GE desteklerini daha once AR-GE yapmış olanlara öncelik tanıyarak verme eğiliminde olmaları belirtilmektedir (Özçelik ve Taymaz, 2008; Pamukçu ve Tandoğan, 2011). Bu nedenden dolayı, daha önce AR-GE desteği alanların AR-GE harcamalarının fazla olması ihtimali doğmaktadır ve endojenlik sorununu ortaya çıkarmaktadır. Bu sorunu çözmek için ise enstrumantal değişkenler yönteminin kullanılması gerekmektedir. Oysaki hem Heckman iki –basamaklı prosedürünün panel veri ortamında uygulanması hem de enstrumental değişkenlerin eş zamanlı kullanımı teknik olarak henüz kullanılmamış ve zor bir yöntem olarak karşımıza çıkmaktadır. Bu nedenle tam bu sorun için geliştirilmiş Semykina ve Wooldridge (2010) prosedürünü kullanmak gerekmektedir. AR-GE sübvansiyonları değişkeni için iki enstruman kullanmaktayız. Birincisi sektördeki tüm firmaların AR-GE sübvansiyon miktarlarının toplamı, ikincisi de her firmanın lisans harcamalarının miktarı. Bu enstrumanların geçerliliğini test etmek için gerekli testler yapıldıktan ve geçerlilikleri kanıtlandıktan sonra, Semykina ve Wooldridge (2010) yöntemi uygulanmıştır. Bölüm 2.7, Tablo 14'te sergilendiği üzere sübvansiyonların AR-GE yoğunluğu üzerine etkisi olumlu ve istatistiki olarak %1 seviyesinde anlamlıdır. Yabancı sahipliğinin AR-GE yoğunluğu üzerinde herhangi bir etkisi bulunmamakla birlikte yabancı bilgi taşmasıın etkisinin olumsuz olduğu gözlemlenmektedir. Eğitimli elemanın etkisinin ise %1 seviyesinde istatistiki anlamlı ve pozitif olduğu görülmektedir. Firmaların katma değerinin sektör liderlerinin katma değer miktarına yakınlıkları arttıkça AR-GE yoğunluğunun arttığını gözlemlemekteyiz. Ayrıca Heckman prosedürünün doğru bir uygulama olduğunu da lambda değişkeninin istatistiki olarak anlamlı çıkmasından anlamaktayız.

Bilgi taşmasının negatif ve istatistiki olarak anlamlı bir işaretinin olması yabancı firmalardan kaynaklanan rekabet baskısından kaynaklandığı düşünülse de bilgi taşmasının olabilmesi için belli bir zaman geçmesinin gerekmesi söz konusudur. Dolayısıyle yabancı bilgi taşması değişkenini bir yıllık bir gecikme ile regresyona dahil ettiğimizde Tablo 15'te görüldüğü gibi işaretin pozitife döndüğüne ve düşük–teknolojili sektörler için de istatistiki olarak anlamlı olduğuna şahit olmaktayız. Bu sonuç aslında yabancı sahipliğinden ARGE yapan firmalara bir bilgi taşması olduğunu fakat bunun zaman aldığınu göstermektedir. Sadece yerli firmalar örneklemi alındığında ise Tablo 16'da görüldüğü üzere aynı sonucun tekrarlandığı gözlemlenmektedir. AR-GE yoğunluğunun bir sonraki yılın AR-GE yoğunluğunu etkilemesi (Griffiths ve Webster, 2004; Vakhitova ve Pavlenko, 2010; Fu ve Gong,2011) dikkate alındığında sistem-GMM adı verilen bir yöntem kullanmak gerekmektedir. Burada bağımsız değişkenlerden biri geçmiş yılın AR-GE yoğunluğu olmaktadır. Ek G'de sunulan sonuçlarda per fazla istatistiki anlamlı sonuç bulunmamaktadır.Öte yandan AR-GE yoğunluğunun bir sonraki senenin AR-GE yoğunluğunu pozitif ve istatistiki olaran anlamlı bir şekilde etkilediği gözlemlenmektedir.

Birinci bölümün sonuçları değerlendirildiğinde yabancı sahipliğinin AR-GE yapan firmalarda herhangi bir etkisinin olmadığı ama yabancı firmalardan kaynaklı bilgi taşmasının bir yıl gibi bir zamandan sonra AR_GE yoğunluğuna olumlu bir etki yarattığı bulunmuştur. Coğrafi bilgi taşmaları açısından ise gecikmeli bir şekilde pozitif bir etkinin görüldüğü ama bu etkinin istatistiki anlamlılık açısından önem taşımadığı gözlemlenmiştir. Eğitimli elemanın AR-GE için gerekli olduğu bulunmuştur. Öte yandan AR-GE yapan firmalarla yaptığımız mülakatlarda firmaların eğitimli eleman bulmada sıkıntı çektikleri belirtilmiştir. Firmaların küçüldükçe AR_GE yoğunluklarının , diğer bütün faktörler sabit tutulduğunda arttığı gözlemlenmiştir. Literatürde benzer sonuçlar da bulunmuştur (Ogawa, 2007; Taymaz ve Üçdoğruk, 2009; Lundin et al. 2007). Mülakatlardan elde ettiğimiz sonuçlar büyük firmaların alt-yükleniciler kullanarak küçük firmalardan AR-GE konularında uzmanlık desteği aldığını ortaya çıkarmıştır. Sübvansiyonların AR-GE yoğunluğuna pozitif etkisinin olması (Czarnitzki ve Toole, 2007) küçük firmaların finansal kaynaklarının büyüklere nazaran zayıf olmasından kaynaklanmaktadır. Yaptığımız mülakatlarda da AR-GE yapan firmalar aldıkları desteklerin yaptıkları projelere büyük katkısı olduğunu belirtmektedirler. Son olarak, AR-GE konusunda tecrübenin ilerideki AR-GE harcamalarına olumlu etkisinin olması firmaların yaptıkları AR-GE yatırımlarını uzun dönemli yatırımlar olarak görmelerinden, ileride bu yatırımlardan pozitif getiri beklemelerinden ve bu projeler sırasında yeni AR-GE projeleri fikirleri doğmasından kaynaklanmaktadır.

O2. AR-GE’nin Verimliliğe Etkisi

AR-GE faaliyetlerinin firma verimliliğine etkisi AR-GE literatüründe genel kabul görmüş bir bulgudur (Griliches, 1979; Lööf ve Heshmat,, 2006; Rogers, 2006; Luintel at al.2010). Öte yandan gelişmekte olan ülkelerde yeterli bilgi birikimi olmadığı için firma verimliliklerini artırabilmek üzere, ya doğrudan yabancı yatırım gibi mekanizmalar sayesinde dünyadaki bilgi havuzunu kullanmalıdırlar ya da kendi AR-GE kapasitelerini geliştirmelidirler. Literatürde bazı araştırmacılar gelişmekte olan ülkelerin AR-GE faaliyetlerinin verimliliğe hiç etkisini olmadığını (Hasan, 2000; Benavente, 2006) bazıları da istatistiki olarak anlamlı olumlu etkisi olduğunu (Saxena, 2009; Kemme et al., 2009; Vakhitova ve Pavlenko, 2010; Zhao ve Zhang, 2010;Sharma, 2011) bulmuşlardır. Türkiye 2003-2007 yılları arasında e AR-GE harcamaları artan bir gelişmekte olan ülke olduğu için tezin ikinci araştırma sorusu ‘Artan AR-GE yatırımları sonucu Türk imalat sanayinde firma verimliliği nasıl etkilenmiştir?’ olmuştur.

Verimlilik çalışmalarının çoğunda Cobb-Douglas tarzı bir üretim fonksiyonu kullanılmaktadır[22]. Literatürde üretim fonksiyonu kullanımından dolayı ortaya çıkan bazı sorunlar belirtilmiştir. Griliches (1979) AR-GEnin kullanıldığı pek çok sektörde ürünün değerinin düzgün bir şekilde ölçülemediğini öne sürmektedir. Kalite geliştirmenin de üründe gözlemlenemediğini belirtmiştir. Örneğin uzay endüstrisinde AR-GE çıktısı adam saat olarak ölçülmektedir ve çıktının kalitesi uzaya gidişin başarısına bağlı olmamaktadır. Savunma sanayinde ürünler devlete satılmaktadır ve bu ürünlerdeki gelişmelerin dikkate alındığı fiyat endeksleri bulunmamaktadır. Firmalar tüketici ürünlerinde inovasyondan dolayı ürünün fiyatını rakiplerine nazaran biraz yüksek tutmaktadır, fakat tekel olmadıkları için ürünlerindeki sosyal getirileri fiyatlarına yansıtamadıklarından AR-GE yatırımının gerçek getirisinin ancak bir kısmı elde edebilmektedirler. Griliches (1979) ölçmedeki bu aksaklık probleminin kabul edilmesi gerektiğini belirtirken, Hall et al (2010) panel veri, sektörler için kukla değişkenler ve zaman kukla değişkenleri kullanıldığında bu sorunun büyük ölçüde azaldığını belirtmektedir. AR-GE harcamaları sermaye, emek ve malzeme faktörlerini içerdiğinden, AR-GE yatırımı üretim fonksiyonunda kullanıldığında 'iki kere sayma' problem ortaya çıkmaktadır.Üretim faktörleri AR-GE yatırımından ayrıştırılmadan kullanıldığında doğru olmayan girdi ölçüleri ortaya çıkmaktadır (Wakelin, 2001). Buradan kaynaklanan yanlılık pozitif veya negatif olabilmektedir (Hall ve Mairesse, 1995; Harhoff, 1994).

Girdilerle ilgili bir başka sorun ise eğitimli ve eğitimsiz iş gücüdür. Hall et al. (2010)'ın referans verdiği üç adet Fransızca çalışmada üretim fonksiyonlarında farklı eğitim seviyesinde emek değişkenleri kullanıldığında gitgide düşen seviyede AR-GE katsayıları elde edildiği belirtilmektedir. Bu bulgunun sebebi AR-GE harcamaları ile eğitimli işgücünün arasında yüksek korelasyon bulunmasıdır.

Üretim fonksiyonunda kullanılan bilgi sermaye stoğu Griliches (1979) tarafından sürekli envanter yöntemi yolu ile hesaplanmıştır. Bu yönteme göre cari bilgi sermaye stoğu geçmişteki AR-GE harcamalarının amortismana tabi tutularak toplanmasından oluşmaktadır. Önce ilk bilgi sermaye stoğu hesaplanmaktadır. Sonra bunun üzerine AR-GE harcamaları amortisman oranında azalarak eklenmekte ve AR-GE harcamalarının da sabit bir hızda büyüdüğü varsayılmaktadır. Bu prosedürde hangi amortisman oranının kullanılması gerektiği sorunu ortaya çıkmaktadır. Bir amortisman oranı varsayılmaktadır fakat gerçekte iki amortisman oranı vardır: biri özel diğeri sosyal amortisman oranıdır (Griliches, 1979). Ayrıca amortisman oranının

[22] Bölüm 3.1'deki 2.2 nolu denklem.

sabit olduğu varsayılmaktadır. Oysa ki, Wieser (2005)'e göre "Bir çok ekonomist bilginin mekanik bir şekilde amortismana tabi olmayacağı konusunda hemfikirdir"(s.592). Öte yandan amortismanın firmadan firmaya değişebileceği de literatürde öne sürülmüştür (Griliches, 1979; Bernstein ve Nadiri, 1988; Capron ve Cincera, 1988; Hall et al., 2010). Zira amortisman hem firmanın kendi yönetilme biçimine, hem rakiplerinin davranışlarına hem de bilim ve teknolojideki gelişmelere bağlı olarak değişebilir. Bilgi sermaye stoğu hesaplanırken bir gecikme zamanı da varsayılmaktadır. Şimdiki AR-GE harcamalarının verimliliği hemen etkilemesi mümkün olmayacağı için bu gecikmeyi uygulamak gerekmektedir. Ravesncraft ve Scherer (1982) bu gecikmenin 4 ila 6 yıl, Pakes ve Schankerman (1984) 1 ila 2 yıl olacağını savunmuşlardır. Geroski (1989) ise inovasyonun verimlilik artışına etkisinin üç yıla kadar etki edeceğini öne sürmüştür. Tüm bu belirtilen sorunlara rağmen araştırmacılar bilgi stoğu değişkenini farklı amortisman oranları kullanarak oluşturmuşlardır. Griliches ve Mairesse (1984), Griliches ve Mairesse(1990), Hall ve Mairesse (1995) Harhoff (1994) ve Bernstein ve Mamuneas (2006) %8 ile %26 arasında amortisman oranları kullanmışlardır.

Fikri mülkiyet haklarının zayıf olduğu veya başka zorluklardan da dolayı inovasyonun gizli kalamamasından ötürü AR-GE'den sağlanan getiriler inovasyonu yapan firmaya tam olarak kalamamaktadır. Bilgi ne kadar kodifiye edilebilirse, diğer firmaların ondan yararlanması o derece kolaylaşmaktadır. Sonuç olarak endüstride bilgi taşmaları oluşturmaktadır. Griliches (1979)'a göre iki türlü bilgi taşmaları vardır: rant bilgi taşmaları ve gerçek bilgi taşmaları.Rant bilgi taşmaları bir firma başka sektördeki bir firmadan ürün veya hizmet satın aldığı aşamada veya başka bir firmadan eleman aldığı aşamada oluşmaktadır (Hall et. al, 2010). Bu tür bilgi taşmaları tedarik zinciri içinde yer alan firmalarda sık görülmektedir (Javorcik, 2004). Öte yandan, gerçek bilgi taşmaları 'bir sektördeki araştırmacıların fikirlerinin başka bir sektördekiler tarafından ödünç alındığı zaman gerçekleşmektedir' (Griliches, 1979; s104). Capron (1992) gerçek bilgi taşmalarının oluşmasını bir sektördeki keşiflerin ve inovasyonların başka sektörlerde teknolojik ürün veya hizmet olarak kullanılmı şeklinde görmektedir. Gerçek bilgi taşmalarını fark etmek veya önceden bilebilmek rant bilgi taşmalarına göre daha zor olmaktadır (Mohnen, 1996). Fakat Capron (1992) bir firmanın en çok kendi sektöründeki bilgi taşmalarından yararlanacağını iddia etmektedir.

AR-GEnin verimliliğe etkisini üzerine literatürü incelediğimizde (Griliches, 1979; Lööf ve Heshmati, 2006; Rogers, 2006, Luintel et. al, 2010) bu çalışmaların çoğunun kesit ülke analizleri veya tek sektör analizi olduğunu görmekteyiz. Sektörel karşılaştırma veya firma bazında çalışmalar sayıca daha az bulunmaktadır. Firma seviyesinde veri kullanarak Griliches ve Mairesse (1992) ve Cuneo ve Mairesse (1983) sektör karşılaştırması yapan iki çalışma gerçekleştirmişlerdir. Bilim temelli sektörleri diğerlerinden ayırarak bilim temelli firmaların AR-GE esnekliğinin diğer firmaların AR-GE esnekliğine göre daha yüksek olduğunu bulmuşlardır.OECD sektör seviyesinde veri kullanan Verspagen (1995) yüksek-teknolojili sektörlerde AR-GEnin verimliliğe etkisinin pozitif olduğunu, düşük teknolojili sektörlerde ise olmadığını bulmuştur. Almanya'daki 442 adet imalat sanayi firması üzerine yaptığı araştırmada Harhoff (1998) AR-GE'nin yüksek teknolojili sektörlerde verimliliğe etkisinin pozitif ve istatistiki olarak anlamlı, düşük teknolojili sektörlerde ise istatistiki olarak anlamsız olarak bulmuştur. 170 İngiliz firmasını 1988-1992 dönemi için çalışmasına dahil eden Wakelin (2001) net inovasyon kullanıcılarının AR-GE getirilerinin diğerlerine oranla daha yüksek olduğunu raporlamaktadır. Tayvan Borsası'na endeksli 156 büyük firmayı örneklemlarine dahil eden Tsai ve Wang (2004) AR-GE yatırımlarının yüksek ve düşük teknolojili firmaların verimliliklerine etkilerinin sırasıyla 0.3 ve 0.7 olarak bulmuşlardır. 1977'den 1987'e olan 10 yıllık sure zarfında Hintli imalat sanayi firmalarını panel veri şeklinde çalışan Hasan (2000) ithal teknolojilerin firma verimliliğine pozitif etkisinin olduğunu fakat firmaların kendi AR-GE çalışmalarının verimliliklerine etkilerinin olmadığını gözlemlemektedir. Benavente (2006) ise 1988-1998 yılları arasında panel veri ile çalıştığı ve Şili için yaptığı araştırmada AR-GE'nin verimliliğe etkisinin istatistiki olarak anlamlı olmadığını bulmuştur. Yabancı sahipliğinin verimliliğe etkisini araştırdığı Hindistan'daki bilişim ve tekstil sektörlerinde Kemme et al. 2000-2006 yılları arası firma seviyesinde veri kullanmaktadır. Her iki sektörde de yabancı sahipliği kukla değişken yerine oran olarak alındığında AR-GE'nin verimlilik artışına etkisinin pozitif olduğunu bulmaktadırlar. Doğrudan yabancı yatırımın Çin'in sanayi verimliliğine etkisini 2001-2006 dönemi için araştırdıkları çalışmalarında Zhao ve Zhang (2010) AR-GE'nin hem verimliliğe hem verimlilik artışına sermaye yoğun ve emek yoğun sektörlerde pozitif ve istatistiki olarak anlamlı olarak raporlamaktadırlar. Fakat, sermaye yoğun sektörlerde yabancı bilgi taşmalarının emek yoğun sektörlere göre daha fazla olarak bulunduğunun da altının çizmektedirler.

Bu literatür taramasından da anlaşılacağı üzere gelişmekte olan ülkelerde AR-GEnin verimliliğe etkisi konusunda bir fikir birliğine varılamamıştır. Bazıları AR-GEnin verimliliğe etkisi bulunmamaktadır şeklinde sonuca ulaşırken (Hasan, 2000; Benavente, 2006), diğerleri düşük teknolojili veya sermaye yoğun sektörlerde AR-GEnin verimliliğe etkisi pozitifdir (Kemme et al., 2009; Zhao ve Zhang, 2010) biçiminde sonuçlar raporlamaktadırlar. Bu nedenle gelişmekte olan ülkeler bakımından AR-GEnin verimliliğe etkisi konusu henüz konsensusa ulaşmamıştır.

Veri seti olarak bu bölümde de TÜİK'in Yapısal İş İstatistikleri anket verisi ve AR-GE anketi verisi firma bazından eşleştirilerek kullanılmıştır. Bölüm 3.3'te veri temizliğinin nasıl yapıldığı detaylı bir şekilde açıklanmaktadır. Tablo 17'de görüldüğü üzere imalat sanayindeki 29519 firma örnekleme dahil edilmiş ve bunlardan sadece 2077'si AR-GE yapanları oluşturmuştur.Bu nedenle metodoloji olarak tekrar bir önceki bölümde başvurulmuş olan Heckman iki basamaklı prosedür, panel veri ve endojenlik dikkate alınarak kullanılmıştır. Emek verimliliği değişkeni oluşturulurken katma değer çalışan sayısına bölünmüş ve doğal logaritması alınmıştır. İki basamaklı NACE seviyesinde toptan fiyat endeksi ile deflate edilmiştir. Fiziksel sermaye stoğu değişkeni için iki aday düşünülmüştür: yatırımlar ve yıllık amortisman miktarları.Her iki veri de sermaye deflatörleri ile deflate edilmiştir. Daha sonra amortisman verisindeki çok sayıdaki sıfır değerlerinden kurtulmak için enterpolasyon tekniği uygulanmıştır. Burada satış hasılatı olan her imalat sanayi firmasının o yıl bir de pozitif amortisman değeri olması gerektiği varsayımı yapılmıştır. Fakat aynı varsayım ve enterpolasyon yatırım için kullanılmamıştır zira firmalar her sene semaye yatırımı yapmak zorunda değillerdir. Enterpolasyon işleminden sonra dahi her iki değişkende de çok sayıda sıfır değeri olduğu için ikisinin arasında daha az sıfır değeri olan amortisman serisi seçilmiştir.[23] Fiziksel sermaye stoğu için hangi amortisman oranını kullanmamız gerektiği konusunda literatüre başvurulmuştur. Taymaz et al. (2008)'ın Türkiye için yaptıkları bir sermaye stoğu hesaplama çalışmasında %6.7 oranını kullandıkları görüldüğü için biz de bu sayıyı kullanmaya karar verdik.

AR-GE harcamaları toptan fiyat endeksi ile deflate edilerek ve sürekli envanter metodu yöntemi kullanılarak AR-GE sermaye stoğu değişkeni oluşturulmuştur. AR-GE için amortisman oranı ise %20 şeklinde alınmıştır. Bunun sebebi fikri mülkiyet haklarının henüz tam oturmadığı bir ülkede bilginin amortismanının hızlı olacağı varsayımıdır.Fakat başka bir oranın AR-GE stoğu hesabını nasıl etkileyeceğini görmek adına %25'lik bir amortisman oranı da kullanılmıştır. Daha yüksek olan bu oran grafiği aşağıya itmekten başka bir değişiklik yaratmamıştır. Hall et al. (2010) farklı amortisman oranlarının bilgi sermaye stoğu değişkeninde çok fazla bir farklılık yaratmayacağını belirtmektedir. Tablo 18'de Heckman prosedürünün ilk basamağındaki değişken tanımları yer

[23] Figür 9 yatırımlar ve amortismonlar serilerinin birbirlerine oldukça benzer sonuçlar verdiğini göstermektedir.

almaktadır. Tablo 20'de de ikinci basamağındaki değişkenlerin tanımları bulunmaktadır. Tablo 19 ve 21 ise özet istatistiki bilgileri sunmaktadır.

Heckman iki basamaklı prosedürün ilk basamağında bağımlı değişken AR-GE harcaması yapmak veya yapmamak şeklinde iki durumu gösteren bir kukla değişken olmaktadır. İkinci basamakta da emek verimliliği bağımlı değişkeni oluşturmaktadır.İkinci basamaktaki bağımsız değişkenler arasında fiziksel sermaye stoğu yoğunluğu, AR-GE sermaye stoğu yoğunluğu, ölçek değişkeni, yabancı sahipliği, yabancı bilgi taşmaları, ihracat yoğunluğu ve eğitimli iş günü bulunmaktadır. Bunların arasından fiziksel sermaye stoğu ve AR-GE sermaye stoğu yoğunluğunun endojen olma ihtimalleri yüksektir (Lichtenberg ve Siegel, 1991; Lööf ve Heshmati, 2002; Parisi et al., 2006; Doralzelsky ve Jaumandreu, 2007; Arvanitis ve Sturm, 2008; Bednarek, 2010) Bu nedenle bu iki değişken için entstruman değişkenler kullanmak gereklidir. Fiziksel sermaye stoğu yoğunluğu için sektörün fiziksel sermaye stoğu yoğunluğu alınmıştır. AR-GE sermaye stoğu yoğunluğu için ise iki enstruman kullanılmıştır. Birincisi sektördeki AR-GE stoğunun firma pazar payı ile çarpımı ikincisi de AR-GE harcamalarının il bazında toplamıdır. Burada bir firmanın pazar payı ne kadar yüksekse sektördeki diğer firmalarla o kadar fazla ilişkisinin olduğu varsayılmıştır Ayrıca bir ildeki coğrafi bilgi taşmasının yüksek olmasının o ildeki firmaların bu bilgiden yararlanabilmek üzere bilgiye erişme çabalarının daha fazla olacağı şeklinde bir varsayım kullanılmıştır. Önce sadece AR-GE yapan firmalar için bir sabit etkiler regresyonu tahmin edilmiştir. Tablo 23'te bu regresyonun sonuçları sunulmaktadır. Fakat bu regresyonda seçim yanlılığı sorunu var olduğundan Heckman iki basamaklı prosedürü endojen değişkenler için bulunan enstrumanlar ile tahmin edilmiştir. Tablo 24'te bu regresyonun sonuçlarından görüldüğü gibi bu yöntem uygundur zira lambda katsayılarının hepsi de istatistiki olarak anlamlı bulunmuştur. Sadece düşük-teknolojili sektörler için bu katsayılar istatistiki olarak anlamlı değildir; bunun sebebi bu kategorideki az sayıdaki gözlem olabilir. Fiziksel sermaye stoğu yoğunluğu ve AR-GE sermaye stoğu yoğunluğunun emek verimliliğine etkisi AR-GE yapan firmalar için pozitif ve istatistiki olarak anlamlı bulunmuştur. Eğitimli eleman için de aynı bulgu geçerlidir. Bu sonuç beklenen bir sonuçtur (Kathuria, 2010; Yang et al. 2010;Chandan, 2011; Zhang et al.,2011). AR-GEnin esnekliği Hall et al. (2010)'un literatür taraması makalesinde verdikleri aralık olan 0.01 ila 0.25 arasına düşmektedir. Öte yandan yüksek ve orta teknolojili sektörlerde bu esneklik 0.23 olarak bulunmuştur ki gene aynı aralık içinde yer almaktadır. Yabancı bilgi taşmalarının katsayısı %10 seviyesinde istatistiki olarak anlamlı değildir.Diğer değişkenlerin katsayıları da istatistiki olarak anlamlı çıkmamışlardır. Literatürde sabit etkiler yöntemi kullanıldığında ve zaman içindeki varyansın çok fazla olmadığı durumlarda bu tür sonuçların sık görüldüğü belirtilmiştir (Griliches ve Mairesse, 1984; Mairesse ve Sassenou, 1991). Bizim sonuçlarımızın da bu tür bir sorundan etkilendiğini düşünmekteyiz zira Tablo 22'de de görüldüğü üzere değişkenlerin zaman içindeki varyansları kesit varyanslarından daha düşük seviyededir. Sadece yerli firmaları alarak yaptığımız regresyonlarda ise (Tablo 25) sonuçların aynen tekrarlandığımı görmekteyiz. Bugünün emek verimliliğinin geçmişteki emek verimliliğinden etkilenip etkilenmediği ise sistem-GMM yöntemi kullanılarak çalışılmıştır. Ek J'de bu çalışmanın sonuçları sunulmaktadır.Bu sonuçlara göre eğitimli eleman emek verimliliği üzerinde istatistiki anlamlı ve pozitif etki yaratmaktadır. AR-GE yapan firmalarla gerçekleştirdiğimiz mülakatlarda da eğitimli elemanın öneminin altı çizilmiştir. Firmalar eğitimli eleman bulmakta güçlük çektiklerini fakat elemanlarının çalışma ortamlarını iyileştirmek için ellerinden geleni yaptıklarını, onların her türlü ihtiyaçlarına şikayetlerini dinleyerek cevap vermeye çalıştıklarını belirtmişlerdir. Eleman bulamama sıkıntılarını kısmen yüksek lisans öğrencilerini henüz okulları bitmeden işe aldıklarını ve onları AR-GE departmanlarında çalıştırarak çözdüklerini belirten firmalar oldu. Öte yandan üniversite profesörlerini danışman olarak kullanarak uzmanlık bilgisinden faydalandıklarını bildiren firmalar da oldu. Yabancı bilgi taşmalarının AR-GE yapan firmalar üzerinde istatistiki bir etkisini bulamamayı iki noktaya bağlıyabiliriz. Birincisi, Türk firmaları kendi AR-GE çabalarına dayanarak emek verimliliğini artırıyorlar, veya aslında yabancı bilgi taşmaları var fakat yabancı firmaların varlığından kaynaklı bir rekabet etkisinin varlığından bu pozitif etki ortaya çıkamıyor. İleride daha uzun dönemli veri setleri kullanılarak ve gecikmeli yabancı bilgi taşmaları değişkeni kullanılarak bu alan biraz daha araştırılabilir.

O3. AR-GEnin Teknik Etkinliğe Etkisi

Bir önceki bölümde AR-GEnin verimliliğe etkisi olduğunu bulmuş fakat düşük teknolojili sektörlerde bu etkinin istatistitiki olarak anlamlı olmadığı görülmüştü. Bu nedenle bu bölüme 'Düşük teknolojili sektörlerde AR-GE yapmanın teknik etkinliğe bir etkisi olabilir' şeklinde bir hipotezle başladık. Von tunzelman ve Acha (2005)'e göre düşük teknolojili sektörler AR-GEye yüksek teknolojili sektörlere nispeten daha az yatırım yaparak daha çok kazanmaktadır. Öte yandan Fu ve Gong (2011) ise düşük teknolojili sektörlerin AR-GE yatırımlarını lider firmaların verimliliğine ulaşmak için kullandıklarını iddia etmektedir. Bölüm dört, Tablo 26'da görüldüğü üzere Türkiye imalat sanayinde çok sayıda düşük teknolojili sektör firmaları bulunmaktadır. Bu nedenle bu firmaların kıt kaynaklarını AR-GE yatırımına yönlendirmelerinin verimlilikleri açısından olmasa bile teknik etkinlik açısından bir etkisinin olup olmadığına bakmak yerinde bir araştırma sorusu olacaktır. Öncelikle verimlilik ile etkinlik arasındaki farkı belirtmek gereklidir. Bölüm dört, Figür 10'da gösterildiği üzere A noktasından B noktasına olan bir hareket teknik etkinliğin gelişmesini göstermektedir, zira aynı miktardaki bir girdi ile daha fazla miktarda bir çıktı elde edilmiş olunmaktadır. Bu sonuç organizasyonel bir değişimle veya kaynakların daha iyi yönetimi ile veya başka yollarla gerçekleşebilir. B noktasından C noktasına ise verimlilik tekrar artırılabilir, fakat bu artış ölçekten dolayı olmuştur. Bu tartışmaya zaman boyutunu kattığımızda teknolojik gelişmenin üretim sınırını daha da ileri taşıdığını görmekteyiz. Teknik gelişme yeni üretim biçimleri doğurarak üretim sınırının ilerlemesini sağlar. Öte yandan etkinlikten kaynaklı kazançlar ise sınıra olan mesafe azaldıkça ortaya çıkar. Üretim sınırına ulaşıldığında teknik etkinlikten kaynaklı kazanç artık oluşamaz. O noktada kazancı sağlayacak tek etken teknolojik gelişmedir. Teknolojik gelişmeyi mümkün kılacak ana faktör de AR-GEdir. Bu olaya güzel bir örnek, bir bilgisayara yeni bir program yüklediğimizde yaşadığımız sonuç olacaktır. Yeni programın (teknolojik gelişme) yüklenmesiyle üretimde aynı sermaye(bilgisayar) ve aynı emek (kullanıcı) ile daha fazla miktarda verim elde edilmektedir (Weil, 2005:s206). Özet olarak verimlilik artışı, teknolojik gelişme, teknik etkinlik ve ölçek ekonomilerinin toplamından ortaya çıkmaktadır.

Literatüre baktığımızda etkinlik analizi için kullanılan iki ana yöntem görmekteyiz. Birincisi stokastik sınır yaklaşımı (stochastic frontier analysis) bir diğeri de veri zarflama analizi (data envelopment analysis). Her ikisi de üretim sınırını teknolojik olarak en ileri firmalarla ortaya koymakta ve teknik etkinliği de o sınıra olan mesafeyi ölçerek belirlemektedir. Firma etkinliğinin ampirik analizi üzerine geniş bir literatür bulunmaktadır. 1985 ile 1991 yılları arasında Macaristan'daki firmaların teknik etkinliğini analiz eden Piesse ve Thirtle (2000) teknolojik gerileme bularak tarımda teknolojik gerilemenin % 4.8, imalatta ise % 8.1 olduğundan bahsetmektedirler. Etkinsizliğin belirleyicileri olarak devlet sübvansiyonlarını, ihracat miktarını, sermaye emek oranını, tarım sektörü için teknolojik gelişmeyi göstermesi açısından zamanı, imalat sanayi için de yöneticilerin işçilere oranını kullanmaktadırlar. Tarımda aşırı sermaye ve sübvansiyon kullanımının, imalatta da yönetici sayılarında ve ücretlerindeki artışın etkinsizliğe yol açtığını belirtmektedirler.

Hindistan'daki ilaç sanayindeki AR-GEnin ve doğrudan yabancı yatırımın verimlilik artışına etkisini 1989-2001 yılları arası için panel veri ile çalışan Pradhan (2002) ne firmanın AR-GE yatırımının ne de yabancılarından kaynaklı taşma etkisinin teknik etkinliğe bir etkisinin olmadığını bulmuştur. Etkinlik için tasarımın, işi yapabilme bilgisinin (know-how) ve yabancı firmalarla yapılan spesifikasyon anlaşmalarının ve firma büyüklüğünün önemli olduğunu raporlamaktadır.

AR-GE yapan 2370 Danimarka firmasını teknik etkinlik açısından inceleyen Dillig-Hansen et al. (2003) AR-GE'nin teknik etkinliğe pozitif ve istatistiki olarak anlamlı bir etkisinin olduğunu gözlemlemiştir. AR-GEnin ürün geliştirme veya temel araştırma odaklı olmadığı taktirde teknik etkinliğe olumlu şekilde etkisinin olduğunu bulunmuştur. Ürün geliştirme veya temel araştırma durumunda için ise daha uzun dönemli çalışmalar yapmak gerektiği belirtilmiştir.

Sangho (2003) 1997'deki finansal krizden sonra Kore firmalarının teknik etkinliğini çalışmıştır. Firma büyüklüğü, dış fonlara bağımlılık, AR-GE yatırımı ve ihracatı teknik etkinliği belirleyici ana faktörler olarak kullanmıştır. AR-GEnin yüksek teknolojili sektörlerde (elektronik, veya bilgisayar imalatı) cephenin ilerlemesine katkısı olduğunu ve arkada kalan firmaların etkinliklerinin azaldığını öne sürmektedir. Tekstil ve kimya gibi sektörlerde de AR-GE ve teknik etkinlik arasında pozitif bir ilişki bulmaktadır. Sangho (2003) firmaların bu sektörlerde AR-GEyi sektör liderlerinin verimliliklerine ulaşmak için kullandıklarını öne sürmektedir.

Kumbhakar et. al (2010) Avrupa'daki en büyük AR-GE yatırımcılarını teknik etkinlik açısından analiz ettikleri çalışmalarında 2000-2005 yılları arasında 532 firmayı örneklemlerine dahil etmektedirler. Düşük-teknolojili sektörlerin yüksek teknolojili sektörlere nazaran AR-GE'den daha fazla fayda elde edip etmediklerini araştırmaktadırlar. AR-GE'nin hem yüksek, hem orta hem de düşük teknolojili tüm sektörlerin teknik etkinliğini belirlemede önemli bir faktör olduğu sonucuna varmaktadırlar.

Hem stokastik sınır yaklaşımı hem de veri zarflama teknikleri kullanarak yaptıkları teknik etkinlik analizi çalışmasında Amonkitvitai ve Harvie (2011) Tayland'da borsaya endeksli imalat sanayi firmalarını örneklemlerine dahil etmektedirler. AR-GEnin imalat sanayinin tümü ele alındığında teknik etkinliğe katkısının olumlu olmadığını fakat inşaat malzemeleri, bilgisayar parçaları imalatı ve yayıncılık sektörlerinde pozitif bir katkı sağladığını bulmuşlardır.

Veri seti olarak daha önceki bölümlerde bahsedilen TÜİK veri setleri kullanılmıştır. Yalnız bu bölümde taşeronluk ilişkilerini ve firmanın anonim şirket olmasının etkilerini de görmek adına üç yeni değişken kullanılmıştır. Bölüm 4.9'da beş farklı hipotez testi ile modelin doğruluğu test edilmiş ve zamandan bağımsız teknik etkinlik kullanılması gerektiği sonucuna ulaşılmıştır.Tablo 30'da raporlanan sonuçlara göre AR-GE teknik etkinliği olumsuz olarak etkilemektedir. Bu sonuç literatürde de bahsedilmektedir (Perelman, 1995; Sangho, 2003). AR-GE üretim sınırını ileri itebilecek türde bir girdidir ve eğer sektör liderleri AR-GE çalışmaları ile üretim sınırını ilerletiyorlarsa diğer firmalar AR-GE çalışmaları yapsalar dahi sınıra yaklaşamayabilirler. Bu durumda AR-GE sanki etkinliği olumsuz etkiliyorlarmış şeklinde görünebilir. Öte yandan AR-GE kaynaklı taşma etkisinin ise %1 seviyesinde istatistiki anlamlı biçimde AR-GE yapan şirketlerin ve yüksek teknolojili AR-Ge yapan şirketlerin teknik etkinliğini olumlu etkilediğini görmekteyiz. Bu sonuç AR-GE yapanların sektörlerinde diğerlerine üretim sınırına yaklaşmalarında yarattıkları ek bir kaynağın varlığına işaret etmektedir.AR-GE ve AR-GE kaynaklı bilgi taşmaları değişkenlerini bir yıl geçikmeli olarak modele dahil ettiğimizde AR-GEnin etkisinin devamen olumsuz olduğunu gözlemlemekteyiz. Zaman boyutu daha fazla olan veri ile bu çalışmanın tekrarlanması bu sonucun açıklık kazanmasını sağlayacaktır. Kontrol değişlenleri arasında taşeron kullanımının ve pazar payının ve anonim şirket olmanın etkinliği olumlu etkilediğini bulmuş bulunmaktayız.

O4. Politika Önerileri

İlk öneri devlet tarafından AR-GE yapan firmalara verilen AR-GE desteklerinin artırılması, güdümlü şekilde ve sıkı bir takip disiplini ile sunulmasıdır. Desteklerin etki analizlerinin yapılması Tandoğan (2011)'in de önerdiği üzere elzemdir. Özel sektörün de AR-GE desteği sağlayacak finansman kaynakları yaratmasına yönelik çalışmalar hızlandırılmalıdır. Sektörler bazında AR-GE desteklerine ulaşamayan firmalara bunun sebepleri sorulmalı ve bu sorunların çözülmesi için çalışmalar yapılmalıdır. Eğitimli eleman sayısının artırılması için yurtdışından dönmüş araştırmacılara bu süreç zarfında yaşadıkları engeller sorulmalı, doktora sonrası yurtdışı çalışması yapmak isteyen akademisyenler için sabatik adı verilen ücretli izin programlarının alt yapısı hazırlanmalı, yüksek lisans ve lisans seviyesindeki öğrencilerin AR-GE projelerinde çalışmalarını sağlayacak programlar üniversitelerde uygulanmalı, lise ve ilköğretimde bilime olan ilginin artırılması için üniversite ve özel sektörce beraberce yüklenilebilecek projeler geliştirilmeli, ve özellikle bu seviyede İngilizce eğitiminin sağlam verilmesine dikkat edilmeli. Eğitimli eleman eksikliğine talep tarafından baktığımızda da firmaların ellerindeki eğitimli elemanların memnuniyetini ve geleceğe yönelik planlarına önem vermeleri açısından insan kaynakları yönetimi uygulamaları gerçekleştirmeleri, eğer bu tip bir departman kuramayacak kadar küçüklerse en azından bu farkındalığı sağlamaları gerektiği anlaşılmaktadır. Burada sektör bazında ticaret odalarına, derneklere insan kaynakları yönetimi konulu eğitimler verme şeklinde iş düşmektedir. AR-GE yapan firmaların yabancı firmalardan kaynaklı bilgi taşmalarından daha fazla faydalanabilmeleri için yabancı firmaların ülkeye getirilmesi için hazırlanan politikalarla AR-GE politikalarının uyumlulaştırılması ve yabancı sektör liderleri ile yerlilerin ortak AR-GE projesi yapmaları özendirilmelidir. Alt yüklenici ilişkileri takibi AR-GE için önemli bir gerekliliktir. Ayrıca başarılı AR-GE projeleri yapmış firmaların başarı hikayelerinin araştırılıp yayımlanması AR-GE yatırımı yapmayanlar veya nereden başlayacağını bilmeyenler için özendirici olacaktır.

Geleceğe dönük yapılabilecek araştırmalar açısından daha uzun zaman serileri ile panel veri ortamında AR-GEnin verimliliğe ve etkinliğe etkisi çalışılmalıdır. AR-GE çalışması yapan firmalarla kalitatif yöntemlerle görüşmeler yapılarak bu firmaların AR-GE yaparken yaşadıkları sorunlar ve bulabildikleri çözüm önerileri sektör bazında araştırılmalıdır. Özellikle devlet desteğini kullanmadan kendi çabaları ile AR-GE yapan firmalar bulunmaya çalışılmalı ve onların nasıl desteklerden yararlanabilecekleri araştırılmalıdır. Son olarak, TÜİK'in Yapısal İş İstatistikleri anketinde yer alan fakat kullanıma kapalı olan AR-GE verileri kullanıma açılmalıdır. AR-GE anketindeki veri Yapısal İş İstatistikleri'ndeki veriye nazaran çok küçüktür, ve halihazırda elde bulunan bu değerli bilgi kullanıma açılırsa araştırmacılar için büyük destek sağlanmış olacaktır.

Appendix P: CURRICULUM VITAE

Name : Elif Kalaycı

Email Address : elifkalayci11@yahoo.com

Education

2006-2012 : Ph.D. in Science and Technology Policy Studies at Middle East Technical University, Ankara.

1994-1996 : M.B.A. at Texas A&M University, College Station, U.S.A.

1989-1992 : B.A. in Economics at Boğaziçi University, İstanbul.

Career path

2004-present : Atılım University, ınstructor at the Department of management

2001-2004 : Full time mother to Ali Dayar

1999-2001 : Graduate assistant at Bilkent University Management Department

1997-1999 : Senior graduate assistant at Istanbul Bilgi University
Assisted Quantitative Methods, Business Finance, Financial Institutions, Markets and Instruments, and Business Research Methods courses

1995-1996 : Graduate assistant at Texas A&M University
Assisted the Quantitative Analysis Course

1992-1993 : Audit team member with Coopers & Lybrand, Istanbul
Participated in a year-long consulting project carried out by a British-Turkish team; took part in the audit of several domestic and international companies

Languages : English (fluent), German (intermediate)

Award : Beta, Gamma, Sigma membership; awarded to business administration students upon performance of high academic achievement

Research Grants : 2000 TL from Atilim University Research Fund to finance the research that produced the paper **"**How Does Foreign Ownership Affect Turkish R&D?" in 2009 BAP-HPD-09-01

11500 TL from Atilim University Research Fund to finance research on panel data version of "Türk İmalat Sanayindeki Firmaların ARGE Faaliyetlerinin Verimliliklerine Etkisi ?" in 2010 ATÜ BAP 2010-01

Lectured courses : Introduction to Business, Human Resources Management, Management Science, Introduction to Macroeconomics, Introduction to Microeconomics, Financial Mathematics, Seminar in Management, Project Management, Corporate Governance, Entrepreneurship, International Business.

Voluntary Work : ETPO, Eğlenceli Bilim Dergisi, Entrepreneurship studies

Publications :Kalaycı, E. (2011), "An Empirical Investigation of Agricultural Product Clusters in Turkey" *Atılım Social Sciences Journal*, vol:1, No:1, pp117-132.

Kalaycı, E. (2012), "A Look at the Turkish Higher Education System from the Institutional Economics Point of View", *International Journal of Business and Social Science*, vol.3, No2, pp.202-209. http://www.ijbssnet.com/journals/Vol_3_No_2_Special_Issue_January_2012/22.pdf

Conferences :Dayar, E. (2008), "Excerpts from Digitally Divided Lives in Turkey", Global Business and Technology Association 10th Annual Conference : Evolution and Revolution in the Global Knowledge Economy, Enhancing Innovation and Competitiveness Worldwide, Madrid.

Dayar, E. (2009), "An Empirical Investigation of Agricultural Product Clusters in Turkey", Global Business and Technology Association 11th Annual Conference: Business Strategies and Technological Innovations for Sustainable Development: Creating Global Prosperity for Humanity, July 7-11, 2009 – Prague.

Beyhan, B., Dayar, E., Fındık, D. and Tandoğan, S. (2009), "Comments and critics on the discrepancies between the Oslo Manual and the community innovation surveys in developed and developing countries", *Technology and Economic Development (TED), 3rd International Conference on Innovation, Technology and Knowledge Economics*, Ankara, Turkey, June 24-26.

Dayar, E. and Pamukçu, T. (2010), "Foreign Ownership, R&D and Spillovers in Developing Countries: Evidence from Turkey" *, CIBSEM Conference on Internationalisation of Innovation into Emerging Markets*, Brunel Business School, Brunel University, London, UK, July 14-15.

Dayar, E. and Pamukçu, T. (2010), How Does Foreign Ownership Affect Turkish R&D?" Competition and Innovation summer School, organized jointly by Katholieke Univesiteit Leuven, Europen Cooperation in Science and Technology (COST), Science and Technology Research in a Knowledge-based Economy (STRIKE), Center for European Economic Research (ZEW), Turunç/Marmaris (Turkey), May 17 - May 21, 2010.

Dayar, E. and Pamukçu, T. (2010), "How do Multinational Corporations affect R&D activities of Turkish manufacturing firms?", *Workshop on Internationalisation of R&D, organized jointly by JRC-IPTS* (Institute for Prospective Technological Studies), *METU-TEKPOL* (Science and Technology Policies Research Center) and *TUBITAK (*The Scientific and Technological Research Council of Turkey), Middle East Technical University, Ankara, May 25-26.

Dayar, E. and Pamukçu, T. (2010), "How Does Foreign Ownership Affect Turkish R&D?", *Second European Conference on Corporate R&D (CONCORD 2010). An Engine for Growth, a Challenge for European Policy*, Sevilla. Spain, March 3-4.

Dayar, E. and Pamukçu, T. (2011), "Analysis of Foreign Ownership, R&D and Spillovers in Developing Countries: Evidence from Turkey", *ERF 17th International Annual Conference*, Antalya, Turkey, March 20-22.

Dayar, E. (2011), "R&D expenditures and productivity at the firm-level. Evidence from the Turkish manufacturing sector" Anadolu International Conference in Economics II (EconAnadolu 2011) ,Eskişehir, 15-17 June 2011.

Can,S. Aydın,A., Kalaycı, E. and Özyurt,.E. (2012) "A Study on Antennas and Propagation Course's Project Collaboration with Department of Management" accepted to the *Second International MUEK conference*, Antalya, November.

Working Papers: Kalaycı, E. and Pamukçu, T. (2011), "Analysis of Foreign Ownership, R&D and Spillovers in Developing Countries: Evidence from Turkey", *ERF 17th International Annual Conference*, Antalya, Turkey, March 20-22. http://www.erf.org.eg/cms.php?id=conferences_details&conference_id=38

Beyhan, B., Dayar, E., Fındık, D. and Tandoğan, S. (2009), *Comments and critics on the discrepancies between the Oslo Manual and the community innovation surveys in developed and developing countries*, METU-STPS Working Paper Series, WP No:0903, Middle East Technical University, Ankara. http://www.stps.metu.edu.tr/stpswp/series09/0902.pdf

Appendix R. Tez Fotokopi İzin Formu

TEZ FOTOKOPİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Kalaycı

Adı : Elif

Bölümü : Bilim ve Teknoloji Politikası Çalışmaları

TEZİN ADI (İngilizce) : Analyzing the Determinants of R&D, Its Impact on Productivity and Efficiency of Firms in the Turkish Manufacturing Industry

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐

2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullancılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐

3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐

Yazarın imzası .... Tarih ....