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ABSORPTIVE CAPACITY AND TECHNOLOGY SPILLOVERS: A CASE FROM TURKEY

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ABSTRACT

Due to the increase of technological capacity by reverse engineering, learning by doing and imitation effects, the interaction of production units with each other will lead productivity increases through exchanging and utilizing new and more variety of intermediate and capital goods. Departing from the assumption that technology spillovers which emerge as externalities resulting from R&D investments that take place through the inputs of intermediate and capital goods, this study examines the domestic technology spillovers in Turkish manufacturing industry within the framework of absorptive capacity. Considering that the relation between technology spillovers and absorptive capacity may not be linear, threshold regression techniques are applied to manufacturing industry data over the period 1992-2001. The results of the analyses show the existence of domestic technology spillovers through imports in Turkish Manufacturing Industry. The main result of threshold regression analyses is that the efficiency of spillovers are differentiated with respect to the industry specific absorptive capacities.

1. INTRODUCTION

Technology is a type of product generated as a result of industrial R&D activities and embodied in capital goods, intermediate goods and thus in final goods. However, technology differs from other products because the marginal cost of using technology can be ignored by the other economic units which have not contributed to its production (Grossman ve Helpman, 1997). The non-rivalness and non-excludability characteristics of R&D capital enables the transfer of the benefits of technology to economic units with relatively low performance. Ideas are circulated from one firm to another and from one industry to another together with input-output relations. This concept which economists call as "technology/R&D spillover" constitutes the initial motivation of this study. Spillovers might be realized by reverse engineering of a product developed by one firm being used by other firms or by the use of a product or service being used by other firms in their production processes as an input as well as through direct patent and license procurement or mobility of human capital among firms.

Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991) approach R&D spillovers within international trade framework. Particularly, due to the increase of technological capacity by learning by doing and imitation effects, the interaction of developing countries with outside world will lead economic growth together with productivity increases through observing and utilizing new and more variety of intermediate and capital goods. Thus trade of intermediate and capital goods between domestic and foreign sectors play an essential role in transferring foreign technologies to domestic economy and spillover among the sectors in the domestic economy.

Instead of the spillovers realized through international linkages which has an extensive coverage in the literature, this study attempts to explain the existence and efficiency of technology spillovers realized as a result of the input-output relations emerging in Turkish manufacturing industry itself with a special focus on absorptive capacity. Particularly the study aims to answer the question “does the efficiency of domestic technology spillovers between industries differ according to their respective absorptive capacities?”. In this respect the existence of technology spillovers and their efficiency is investigated by taking a series of factors which are thought to affect the absorption of technology into consideration. These factors which are assumed to affect absorptive capacity consist of factors which reflect the human capital, the own R&D efforts and the final goods market structure of the industries.

Hansen's (1999) threshold regression techniques are applied to the panel of 22 manufacturing sectors at 2-digit level classified under ISIC Rev.3 over the period 1992-2001 in this study. Alternative threshold regression models are used to estimate the effects related to technological knowledge spillovers considered for different sectors with different absorptive capacities. The rest of the study is as follows: In the next section a brief summary of the theoretical and empirical literature on technology spillovers is presented. The third section introduces the data and the methodology applied in the empirical investigation. In the fourth section empirical results and implications are discussed. Section five concludes.

2.LITERATURE REVIEW

When Robert Solow (1957) first introduced technology as a major component of economic growth he assumed that technological development was equally accessible to all producers. In Solow’s model technology was designed as an exogenous variable out of the production function. Solow (1956) displayed the capital accumulation process financed by total savings as the source of a transitional growth process. During this process capital-labor ratio will increase and in time this increase will cause a decline in the marginal product of capital.

Modern growth theories which emerge as endogenous growth models leaves the neoclassical assumption that marginal product of capital converges to zero (Jones and Manuelli, 2005:19). The determining characteristic of endogenous growth theory is the fact that growth emerges as a result of the increase in technological information and human capital stock during the internal processes. R&D based endogenous growth models, in which firms do not have an active role in the production of technological knowledge and this knowledge emerges as a by-product of economic activity, clearly separate the physical capital stock and technological knowledge stock from each other (Romer,1990; Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991; Aghion and Howitt, 1992; Jones, 1995). In these models while capital stock increase with savings, technological knowledge stock grows as a result of R&D activities based on the optimization incentives of economic units. Expanding the boundaries of technological knowledge R&D is not a direct factor of production and it enables firms to produce different and better quality products by introducing new ideas and new designs.

R&D based endogenous growth models shows that knowledge stock increases as a result of new 'ideas' generated through technology oriented R&D investments. Excluding decreasing returns and exogenous technology assumptions these models put forward an endogenous mechanism that is utilized for long term productivity increases and by this way they outperform Neoclassical growth theory. While Romer (1990) was building the endogenous growth theory he was inspired by Schumpeter’s (1942) and Abramovitz’s (1956) studies which emphasized innovation and technological change as the driving force of economic growth. According to this theory which put the Schumpeterian concepts of innovation, creative destruction and entrepreneurship onto to the agenda once again, technological progress is realized together with some external impacts. These external impacts are spillover effects which also have a positive impact on the third economic units. Accordingly, the following assumptions have been made about technology as a starting point of R&D based endogenous growth models: (i) Technology is partly or sometimes completely a public good. In other words there is non-rivalness and non-excludability in the use of technology. (ii) As a result of technological improvements spillovers emerge as positive externalities and the degree of these spillovers is important. (iii) Technology spillovers create increasing returns to scale conditions (Kibritçioğlu, 1998:9).

The fact that absorption and internalization of knowledge available in frontier technologies is an important factor in dissemination of external technologies have an important place in the technology spillover literature. The full extent of these factors is usually referred to as the absorptive capacity. It is possible to define the absorptive capacity as the capacity determining a country's, industry's or firm's speed in the adaptation of new technological knowledge or their limits in which they can use this knowledge (Cohen and Levinthal, 1990; Evenson and Westphal, 1995; Keller, 2002).

There are two factors which are often associated with the idea of absorptive capacity defined as a type of capability that is required by a firm, industry or country in order to absorb an external technology successfully. One of them is human capital and the other one is internal R&D efforts. Theoretical and empirical literature which studies human capital as a determinant of absorptive capacity within the framework of technology spillovers, emphasizes that human capital develops the ability of learning, absorbing and using new technologies which emerge as a result of R&D activities and thus facilitates spillovers (Nelson and Phelps, 1966). According to Cohen and Levinthal (1986), the own R&D efforts of firms is very important for understanding both direct technological trends and innovations and the ones embodied in intermediate and capital goods. They claim that in order to adopt and use external technologies production units should also execute their own R&D investments. Here the concept of absorptive capacity is shaped by the idea that R&D efforts are reflected to learning, reproduction and usage of external technologies rather than making own innovations.

Market structure is another significant factor which is associated with the absorptive capacity of economic units in terms of diffusion of new technologies. Considering the fact that innovation based growth models include R&D spillovers; the fact that processes of creating and adopting technological innovations are two distinct stages of technological improvement indicates that the arguments on the relation of innovation and market structure can easily apply to the arguments on adoption and absorption of external technology. According to the Schumpeterian approach, technology spillover between firms operating in markets dominated by imperfect competition conditions will be easier. A counter opinion to this approach, with solid empirical and theoretical bases, states that the need for adoption of new technologies in competitive markets is much stronger than monopolistic markets and hence there is a positive correlation between level of competition and technology spillover (Dorfman, 1987; Rosenberg, 1972). For example, Parente and Prescott (1999) especially regard monopoly rights to be one of the major obstacles in the absorption of exogenous technologies. In another discussion about absorptive capacity related to market structure and technology spillovers, it has been argued that higher competitive pressure is associated with imperfect appropriability and in turn, with stronger spillovers. (Kamien and Schwartz, 1982).

The empirical testing of the theoretical framework of technology spillovers begins with Coe and Helpman (1995). The studies of Coe and Helpman (1995) to be followed by Keller (1998), Lichtenberg and van Pottelsberghe de la Potterie (1998) and Xu and Wang (1999) are the most cited in terms of those shaping the literature of technology spillovers. The studies related to the relevant studies have mostly been carried out on country level and are particularly based on Grossman and Helpman's (1991) and Rivera-Batiz and Romer's (1991) models which use the concepts of foreign trade, accumulation of technological knowledge and endogenous growth together. In these models technological knowledge is modeled within a Cobb-Douglas type production function or its extension as a separate variable from conventional factor inputs. In the empirical studies made in this framework, generally the relationship between accumulated domestic and/or foreign R&D expenditures and total factor productivity is investigated. The next step has been to understand the efficiency of technology spillovers by focusing particularly on the international linkages such as foreign direct investments and foreign trade and by investigating the magnitude of spillovers within the scope of absorptive capacity (Apergis, Economidou and Filippidis 2008; Crespo, Foster and Scharler, 2004; Henry, Kneller and Milner, 2009; Lopez Pueyo, Visus and Sanau 2008; Schiff, Wang and Olarreaga, 2002; Teixeria and Fortuna, 2010), While most of the empirical studies on technology/R&D spillovers specific to Turkey focus on technology spillovers resulting from foreign direct investments or foreign trade (Alıcı and Ucal, 2003; Aslanoğlu, 2000; Lenger and Taymaz, 2006; Yılmaz and Özler, 2004); to our knowledge, there is no study dealing with domestic spillovers within the context of absorptive capacity.

3. METHODOLOGY AND DATA

In this study, domestic technology spillovers among the Turkish manufacturing sectors are studied within the absorptive capacity framework on the basis of the assumption that technology/R&D spillovers emerging as externalities which originate from R&D investments take place by means of intermediate and capital goods used as input by manufacturing sectors. In this study, threshold regression techniques are applied to a structural model obtained from a Cobb Douglas type production function; thus the efficiency of technology spillovers is allowed to differ between regimes which are determined in accordance with absorptive capacity variables. This analysis methodology enable us to determine the critical values endogenously in the estimation process instead of imposing exogenous threshold values of the factors treated in relation with absorptive capacity,

Within this framework, a Hicks-neutral production function with constant returns to scale: process shall be considered:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \qquad (1)$$

Where Y_t is total production, whereas K_t denotes physical capital stock and $L_t$represents labor.

Similar to Coe and Helpman (1995), let technology level depend on domestic and foreign R&D variables:

$$logA_t = \gamma_0 + \gamma_1 logRD_t^d + \gamma_2 logRD_t^f \qquad (2)$$

RD_t^dandRD_t^f represent foreign and domestic R&D variables respectively. In tis case while y_t shows production to labor and, k_t shows capital to labor ratios, if equation (2) is substituted into equation (1) the structural model (3) is obtained:

$$logy_t = \gamma_0 + \alpha logk_t + \gamma_1 logRD_t^d + \gamma_2 logRD_t^f \qquad (3)$$

Again similar to Coe and Helpman (1995) and many other works in the literature, domestic and foreign R&D variables that will be used in the estimation of this equation comprise of weighted domestic and foreign R&D stocks, and they represent technology/R&D spillover variables[1]. Positive and statistically significant coefficients related to weighted R&D stocks will indicate the existence of technology spillovers. A point which makes the difference in this single stage estimation process is that the effect of R&D stocks will be defined non-linearly.

$$lny_{it} = \mu_i + \alpha lnk_{it} + \gamma_1(q_{it})lnRD_{it}^{d} + \gamma_2 lnRD_{it}^{f} + +e_{it}, e_{it} \sim iid(0,\sigma^2) \quad (4)$$

According to our structural model of estimation defined by equation (4), where $\{1 \leq i \leq n, 1 \leq t \leq T\}$; it is assumed that the parameter γ_2 which determines the international technology spillovers can vary depending on a series of variables (q_{it})specific to each sector. In order to better elaborate on the estimation methodology, the relation between domestic technology spillover and industrial output is defined with a double threshold regression model where several variables which are thought to be the determinants of absorptive capacities in sectors are used as threshold variables (q_{it}):

$$lny_{it}\mu_i + \alpha lnk_{it} + \beta_1 lnRD_{it}^{d} I(q_{it} \leq \lambda_1) + \beta_2 lnRD_{it}^{d} I(\lambda_1 < q_{it} \leq \lambda_2) \quad + \beta_3 lnRD_{it}^{d} I(\lambda_2 < q_{it}) + \gamma_2 lnRD_{it}^{f} + e_{it} (5)$$

Accordingly, the slope parameters $(\beta_1, \beta_2, \beta_3)$which determine technology spillover on domestic R&D stock, may vary between regimes determined in relation to threshold parameters of absorptive capacity. Parameters (α, γ_2), which belong to additional control variables in the model, are constant between these regimes and do not affect the distribution of thresholds (Hansen, 1999; p.357). While I(.) is the indicator function of threshold values, (λ_1, λ_2) are the threshold parameters to be estimated. Therefore, impact of R&D spillovers is determined by β_1 for the observations with $q_{it} \leq \lambda_1$, β_2 for the observations with $\lambda_1 < q_{it} \leq \lambda_2$ and, β_3 for observations with $\lambda_2 < q_{it}$. In other words, the spillover effect of imported technology might vary depending on threshold variables.

The threshold parameters (λ_1,λ_2), used in double threshold model specification are determined endogenously during the estimation process of the model and threshold variables (q_{it}) are selected

[1]In this respect, domestic (foreign) R&D spillover variable belonging to sector *i* at time *t*, reflecting intra-sector spillovers together with inter-sectoral ones which are based on input-output relations; comprise of weighted sum of own domestic (foreign) R&D stock of sector *i* together with domestic (foreign) R&D stock of other sectors: $RD_{it}^{d-f} = RD\_own_{it}^{d-f} + RD\_others_{it}^{d-f} = RD\_own_{it}^{d-f} + \sum_{j=1}^{I} w_{ij} RD\_own_{jt}^{d-f}$.

In this specification, foreign R&D variables are formed by foreign R&D stocks weighted by imports. In this regard, $RD_{it}^{f} = \sum_k (\frac{M_{jkt}}{Y_{jt}+\sum M_{jkt}-\sum X_{jkt}}) RD_{jkt} + \sum_j [w_{ij} \sum_k (\frac{M_{jkt}}{Y_{jt}+\sum M_{jkt}-\sum X_{jt}}) RD_{jkt}]$; while *k* shows Turkey's foreign trade partners and, *i* and *j* are sector indices. M_{jkt}, indicates goods imported from country *k* and classified in sector *j*; Y_{jt}, indicates the total domestic production in sector *j*; and X_{jkt} indicates the volume of exports from sector *j* to country *k*. While RD_{jkt}, represents R&D stock in country *k* in sector *j*; foreign R&D stocks entering domestic sector *i* from other sectors are corrected with input-output coefficients w_{ij}. Perpetual inventory methodology is utilized in calculating the domestic and foreign R&D stocks ($RD_own_{it}^{d}$and RD_{jkt}).

based on factors assumed in the related literature to have effect on the absorptive capacity of a sector. These factors reflect human capital specific to sectors together with each sector's own R&D efforts and structure of the market for final goods. Other control variables used in the structural estimation model are introduced in *Table 1* together with threshold variables used to represent the absorptive capacities specific to industries.

Table 1: Definitions of the Variables

Variable	Definition	Measurement
y_{it}	Output-Labor ratio	Value added / Total hours worked
k_{it}	Capital-labor ratio	Capital stock / Total hours worked
Rd_{it}^{d}	Domestic R&D stock	Weighted sum of cumulative domestic R&D expenditures
Rd_{it}^{f}	Foreign R&D stock	Weighted sum of cumulative foreign R&D expenditures.
TP_{it}	Threshold variable-Technical workers intensity	High technical workers+Administrative workers/ Total number of workers
RI_{it}	Threshold variable- R&D intensity	Total internal R&D expenditures /Sales from production
HH_{it}	Threshold variable- Herfindahl-Hirschman Index	Sum of squared market shares determined by sales revenue

For this study, data of 22 manufacturing sector in Turkey at 2-digit level classified under ISIC Rev.3 over the period 1992-2001 was collected from Turkish Statistics Institute (TurkStat). The data used for establishing production, labor, domestic R&D stocks and threshold variables are obtained from the *Annual Manufacturing Industry Surveys* which are made for the enterprises with 10 or more employees by TurkStat. . Input-Output tables that are used for computing the input-output coefficients was obtained from TurkStat. Capital stock data for sectors was obtained from Taymaz, Voyvoda and Yılmaz (2008). The data related to calculating the R&D stocks of foreign trade partners[2] are obtained from "*OECD ANBERD ed. 9 Rev. 3*" (OECD Industry and Service Statistics-Structural Analysis (STAN) Databases-R&D Expenditure in Industry) database and bileteral import and export volumes have also been obtained from TurkStat.

Estimations made by utilizing Hansen's (1996, 1999) threshold regression techniques are performed in three stages. First, a single threshold regression model is defined, in the second stage, the statistical significance of the obtained threshold parameter is tested. In order to determine the *p-value* of this test, bootstrapping techniques proposed by Hansen (1996, 1999) are performed. If the existence of a threshold effect is determined in the second stage of single threshold estimation,

[2]Australia, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Israel, Italy, Japan, South Korea, Holland, New Zealand, Norway, Russia, Singapore, Sweden, United Kingdom, United States of America.

the second threshold effect is also tested and if this effect is confirmed, the double threshold model is estimated. [3].

4. EMPIRICAL RESULTS

Prior to progressing with threshold regression analysis, a basic model is estimated under the assumption that threshold effects do not exist :

Basic Model:

$$lny_{it} = \mu_i + \alpha lnk_{it} + \gamma_1 lnRD_{it}^{d} + \gamma_2 lnRD_{it}^{f} + e_{it}\ ,\ e_{it} \sim iid(0, \sigma^2)$$

Table 2: Coefficient Estimations: Basic Model

Variable	Coefficient	OLS-SE	White SE
$\boldsymbol{k_{it}}$	0.3214***	0.0620	0.0855
$\boldsymbol{RD_{it}^{d}}$	0.0191**	0.0075	0.0089
$\boldsymbol{RD_{it}^{f}}$	0.0163	0.0086	0.0097

***,**,* represent statistical significance at 1%, %5, and 10% level respectively

The estimated coefficients of simple model coefficients are presented in *Table 2*. The signs of the coefficients are in accordance with our expectations. Coefficient of Capital-work force ratio is statistically highly significant. The coefficient of the domestic R&D variable which includes the impact of intra-sectoral spillovers together with the inter-sectoral spillovers is positive and statistically significant at 0.05 level. This indicates the existence of domestic technology spillover in the manufacturing industry. The coefficient related to foreign technology spillover has also a positive value in accordance with expectations, however, it is not statistically significant within the conventional statistical boundaries.

Model A: Human Capital-Technical Workers Intensity as the Threshold Variable

$$\mathrm{lny_{it}} = \mu_i + \alpha \mathrm{lnk_{it}} + \gamma_1 \mathrm{lnRD_{it}^{f}} + \beta_1 \mathrm{lnRD_{it}^{d}} I(\mathrm{TP_{it}} \le \lambda_1) + \beta_2 \mathrm{lnRD_{it}^{d}} I(\lambda_1 < \mathrm{TP_{it}}) + e_{it}$$

Model A established under the assumption that the relationship between the domestic R&D stock[4] and average labor productivity may not be linear is estimated in order to determine whether human capital changes the efficiency of domestic technology spillovers.

[3]The threshold model can easily be expanded according to more than two threshold parameters. However, as a result of the low number of observations this was not preferred.

[4] R&D stock variables are generated as to include the embodied technology in intermediate and investment goods including both intra- and inter-sectoral technology spillovers (see footnote 1)

Table 3: Tests for the threshold effects: Technical workers intensity

Single Threshold	
F_1	*32.92***
p-value	*0.02*
(%10, %5, %1 critical values)	*(22.91, 27.14, 42.50)*
Double Threshold	
F_2	*16.80*
p-value	*0.23*
(%10, %5, %1 critical values)	*(19.90, 23.45, 37.79)*

Note: *F-statistics and p-values are obtained by 300 times repetition of the bootstrapping procedure*. ***, ** and * represent statistical significancy at %1, %5 and %10 levels respectively.

*Table 3 s*hows the Likelihood-ratio (LR) test results carried out to test the statistical significance of the estimated threshold values. Accordingly, for the single threshold effect, *F*test statistics is significant at 5% with a *bootstrapping p-value* of 0.02. A second threshold effect is not detected in the model. The threshold level of 0.3315 estimated at 71. Quantile verifies that the regression relation is not linear. Moreover the confidence interval which is constituted by exploiting the likelihood ratio test statistics regarding the threshold parameter minimizes the uncertainity about location of it (*Table 5*). Regression slope coefficients together with OLS standard errors and White-corrected standard errors are presented in *Table 4*. The estimated threshold value divides the observations into two regimes and the efficiency of the domestic R&D spillover above the threshold level rise significantly. Accordingly, the industrial structure of human capital changes the efficiency of domestic technology spillovers and industries above a specific threshold are able to benefit from the externalities by domestic R&D investments more than those which remain below the threshold.

Table 4: Coefficient Estimations: Single Threshold Model – Technical Workers Intensity

Variable	Coefficient	OLS-SE	White-SE
$\boldsymbol{k_{it}}$	0.3599***	0.0724	0.0995
$\boldsymbol{RD_{it}^{f}}$	0.0166	0.0092	0.0108
$\boldsymbol{RD_{it}^{d} I(TP_{it} \leq 0.3315)}$	0.0169*	0.0082	0.0095
$\boldsymbol{RD_{it}^{d} I(\ 0.3315 <} TP_{it})$	0.0218**	0.0097	0.0109

***, ** and * represent statistical significance at %1, %5 and %10 levels respectively

Table 5: Threshold Estimations: Technical Workers Intensity

	Estimation	95% Confidence Interval
λ_1	0.3315**	[0.331586, 0.337375]

***, ** and * represent statistical significance at %1, %5 and %10 levels respectively

In conclusion, the estimation results for Model A in which technical workers intensity is used as a threshold variable show that human capital embodied in labor force enhance the absorptive capacities of manufacturing industries and this human capital component change the efficiency of domestic technology spillovers. These results pertaining to the human capital factor are consistent with other studies in the literature which emphasize the importance of human capital in the absorption of external technologies (Coe, Helpman, Hoffmaister, 1997; Wang, 2005; Schiff and Wang, 2010; Teixeria and Fortuna, 2010) .

Model B: Internal R&D Efforts-R&D Intensity as the Threshold Variable

$$\ln y_{it} = \mu_i + \alpha \ln k_{it} + \gamma_1 \ln RD^{f}_{it} + \beta_1 \ln RD^{d}_{it} I(RI_{it} \leq \lambda_1) + \beta_2 \ln RD^{d}_{it} I(\lambda_1 < RI_{it}) + e_{it} \quad e_{it} \sim iid(0, \sigma^2)$$

When R&D intensity variable is applied to the structural model as a threshold variable, which is defined as the R&D expenditures to sales ratio, a single statistically significant threshold can be estimated. *Table 6* shows the *Likelihood-ratio (LR)* test results for single and double threshold effects. The results show that while test statistics for single threshold with a *bootstrapping p-value* of 0.00 is significant at 1% level, the second threshold effect with a *p-value* of 0.20 is not statistically significant within conventional boundaries. According to this finding there is a breaking point in terms of the efficiency of domestic technology spillovers for Turkish manufacturing industry sectors, depending on their own R&D efforts. Since the scope of benefiting from exogenous technologies includes learning by doing as well, it is quite meaningful that a threshold value in terms of sectors' own R&D efforts i.e. investing in their human capital and absorptive capacities is found for the manufacturing industry of a developing country [5] In *Table 8* the asymptotic confidence interval of the threshold parameter regarding R&D intensity variable can be seen. There is no room for uncertainty regarding the location of the threshold value estimated in this confidence interval.

Table 6:Tests for the threshold effects: R&D intensity

Single Threshold		
F_1		*50.41***
p-value	*0.00*	
(%10, %5, %1 critical values)		*(17.19, 22.67, 36.10)*
Double Threshold		
F_2		*11.81*
p-value	*0.20*	
(%10, %5, %1 critical values)		*(15.85, 17.76, 23.96)*

Note: *F-statistics and p-values are obtained by 300 times repetition of the bootstrapping procedure*. ***, ** and * represent statistical significancy at %1, %5 and %10 levels respectively.

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Table 7: Coefficient Estimations: Single Threshold Model – R&D Intensity

Variable	Coefficient	OLS-SE	White SE
k_{it}	0.3364***	0.0696	0.0914
RD^{f}_{it}	0.0166	0.0093	0.0105
$RD^{d}_{it} I(RI_{it} \leq 0.0012)$	-0.0058	0.0124	0.0139
$RD^{d}_{it} I(0.0012 < RI_{it})$	0.0214**	0.0096	0.0108

***, ** and * represent statistical significance at %1, %5 and %10 levels respectively

[5] See. Griffith, Redding and Van Reenen (2000); Eicher and Kim (1999).

Table 8: Threshold Estimations: R&D Intensity

	Estimation	95% Confidence Interval
$\boldsymbol{\lambda_1}$	0.0012**	[0.0012, 0.0012]

***, ** and * represent statistical significance at %1, %5 and %10 levels respectively.

In Model B where capital-labor ratio and foreign R&D stock is used as control variables the regimes generated by the threshold parameter differentiate the slope parameters regarding domestic R&D stock (see *Table 7*). Accordingly, the negative and insignificant coefficient in the relavent regime below the threshold value for R&D intensity indicates that domestic technology spillover is non-existent. The relevant coefficient over the threshold turns to be positive and is found statistically significant. This strong threshold effect supports the view that for developing countries the usage of external technologies; in other words taking advantage of external R&D activities is dependent on the own R&D efforts of the firms and industries themselves (Cohen and Levinthal, 1989; Eicher and Kim, 1998; Kinoshita, 2000). Accordingly, industries which exceed a certain threshold in R&D intensity are able to take the advantage of external technologies.

Model C: Market Structure-Herfindahl Hirschman Index as the Threshold Variable

$$\ln y_{it} = \mu_i + \alpha \ln k_{it} + \gamma_1 \ln RD^f_{it} + \beta_1 \ln RD^d_{it} I(HH_{it} \leq \lambda_1) + \beta_2 \ln RD^d_{it} I(\lambda_1 < HH_{it}) + e_{it} \quad e_{it} \sim iid(0, \sigma^2)$$

Tablo 9: Tests for the threshold effects: Herfindahl-Hirschman Index

Single Threshold		
F_1		49.19***
p-value		0.04
(%10, %5, %1 critical values)		(28.13, 37.23, 45.91)
Double Threshold		
F_2		15.80
p-value	0.176	
(%10, %5, %1 critical values)		(18.76, 21.10, 27.88)

Note: *F-statistics and p-values are obtained by 300 times repetition of the bootstrapping procedure*. ***, ** and * represent statistical significancy at %1, %5 and %10 levels respectively.

Following Model A and *Model B, Model C* was estimated in order to determine whether the structure of the final goods market changes the efficiency of domestic technology spillovers within the assumption that the relation between domestic R&D stock and average labor productivity may not be linear. When Herfindahl-Hirschman index, which represents structure of final goods market in which manufacturing sectors operate, is used as the threshold variable in the structural model, a single statistically significant threshold parameter can be estimated. *Table 9* displays the Likelihood Ratio test results for single and double threshold effects. The results show that while test statistics for the single threshold with a *bootstrapping p-value* of 0.04 is statistically significant, the second threshold effect with a *bootstrapping p-value* of 0.17 is not statistically significant. Based on this finding of the existence of a single threshold, analyses are continued with the single threshold model specification. In this respect, there exists a breaking point for domestic technology spillovers for Turkish manufacturing industry sectors depending on concentration ratio of the markets they operate in. This threshold level of Herfindahl-Hircshman index which is estimated as 0.3286, divides the observations into two different regimes.

Table 10:Coefficient Estimations: Single Threshold Model – Herfindahl-Hircshman Index

Variable	Coefficient	OLS-SE	White-SE
k_{it}	0.3406***	0.0711	0.1082
RD^f_{it}	0.0179	0.0094	0.0116
$RD^d_{it}I(HH_{it} \leq 0.3286)$	0.0198**	0.0083	0.0097
$RD^d_{it}I(0.3286 < HH_{it})$	0.0161	0.0089	0.0108

***, ** and * represent statistical significance at 1%, %5, and 10% levels respectively.

Table 11: Coefficient Estimations: Herfindahl-Hircshman Index

	Estimation	95% Confidence Interval
λ_1	0.1286***	[0.308902, 0.349670]

***, ** and * represent statistical significance at 1%, %5, and 10% levels respectively.

While the coefficient of the domestic R&D variable found to be positive and statistically significant above the threshold regarding market concentration the relevant coefficient becomes smaller and loses its significance. Accordingly, the efficiency of domestic technology spillovers changes among industries depending upon the level of market concentration. In other words, the market structure affects the absorptive capacities of industries and changes the distribution of externalities incurred from domestic R&D activities. For this reason, in contrast with the Schumpeterian approach, and parallel with the view which argues that the absorption of exogenous technologies in markets with high concentration ratios is more difficult (Dorfman, 1987, Parente and Prescott, 1999; Roy and Sikdar, 2003; Mcgahan and Silverman, 2006), the efficiency of technology spillovers increase below a threshold level of Herfindahl-Hircshman index. Accordingly, it can be argued that there is an adverse relation between the relevant market structure indicator and absorptive capacity. In other words, more competitive industries can benefit more from technology spillovers.

5. CONCLUSION

In R&D based endogenous growth theory, R&D is not a direct production factor and expands the limits of technological knowledge. Technological knowledge accumulation is generated by all technical innovations emerged as a result of R&D activities. In the R&D type growth modeling pioneered by Romer (1990) learning by doing and replicating are also implicit assumptions in addition to innovation. When innovations which arise as a result of R&D activities enter production processes, technological knowledge will spill over between economic units by Arrow's learning by doing and replication impacts as a byproduct. These impacts which develop in accordance with the non-rivalness and non-excludability characteristics of technology are called spillover effects by Romer (1990) and are revealed in the form of positive externalities.

The capability of production units to apply existing technologies is also dependent on the success of their adaptability to technology development processes (Keller, 2002). This adaptation provides economic units the opportunity to study exogenous advanced technologies, define them, adapt them, use and diffuse them. These concepts which are defined as absorptive capacity entirely are essential in explaining the differences in countries' benefiting from technology spillovers.

In this study the literature on technology spillovers is utilized together with the discussions on absorptive capacity. In this work, based on the assumption that technology/R&D spillovers which emerge as externalities resulting from R&D investments take place through intermediate and capital goods which are used as inputs by manufacturing industry sectors; technology spillovers of 22 Turkish manufacturing sectors classified under ISIC Rev.3 were examined within the scope of absorptive capacity over the period 1992-2001.

In this scope, existence and efficiency of technology spillovers are studied considering several factors thought to have effect on absorption of technology. These factors assumed to affect absorptive capacity are human capital together with each sector's own R&D efforts and structure of the final goods market. Hansen's (1999) threshold regression techniques are applied on a structural model obtained from a Cobb-Douglas type production function by which way the efficiency of technology spillovers is allowed to vary between regimes determined in relation with the absorptive capacity variables.

Above all, the results of the analyses proves the presence of technological knowledge spillovers in the Turkish manufacturing industry. Results of the estimation of threshold regression models defined for different absorptive capacity indicators indicate that using linear models in analysing technology spillovers may produce biased results. For example, it is evident that the efficiency of technology spillover varies above and below a critical value for human capital. The results show that human capital factor increases the absorptive capacity of sectors. Results of estimations for the structural model where R&D intensities specific to sectors are defined as threshold variables show that technology spillovers are less efficient below a critical value about internal R&D efforts of sectors, and are much more efficient above this critical value. Therefore industries that can exceed a certain threshold level can benefit from external R&D activities. Similarly, estimation results indicate that, for sectors in the Turkish manufacturing industry, there is a certain breaking point for domestic technology spillovers depending on the product market concentration ratios. When the Herfindahl-Hirschman index which is an important indicator of the market structure is used as the threshold variable, the threshold effect varies the slope coefficient for domestic R&D variable. While the aforementioned coefficient is positive and statistically significant below the estimated threshold, it is insignificant above the threshold. For this reason more competitive industries can benefit more from technology spillovers.

In conclusion, in order for the Turkish manufacturing industry sectors to benefit from external R&D investments, in is essential that they invest in their own absorptive capacities. In this regard, increasing the share of R&D expenditures in industrial sectors is vastly important for Turkey, as a developing country behind the technological frontier, in order to take its place among countries with strong competitive power. Similarly it has been concluded that reducing the oligopolistic structure in the Turkish manufacturing industry and increasing the conditions of competition can increase the potential of industries taking advantage of theexternalities of R&D activities.

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