Technology Spillovers through Imports and Absorptive Capacity in Turkey

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Abstract

In R&D based endogenous growth framework, due to the increase of technological capacity by reverse engineering, 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. The aim of this study is to examine the technological knowledge spillovers through imports within the frame of absorptive capacity for Turkish Manufacturing Industry. Departing from the assumption that the relation between technology spillovers and absorptive capacity is non-linear, threshold regression techniques are employed. The results provide evidence on the existence of international technology spillovers in Turkish Manufacturing Industry. The main finding of threshold regression analyses is that the efficiency of spillovers is differentiated with respect to the industry specific absorptive capacities.

Keywords: Imports, Technology Spillover, Absorptive Capacity, Threshold Regression Analysis, Turkish Manufacturing Industry

JEL Classification: *O30, F43*

I. Introduction and Theoretical Framework

Although economic growth is considered within the efforts of maintaining stability in developed countries, the term comes up as a more important concept in the relatively poor regions of the world. Economic growth, which is an essential priority in social growth and development, is closely related to concepts of technology and innovation. In particular, the efforts in order to account for the differences in development between countries influenced growth theory.

While neoclassical growth theory conceives technological development as an exogenous process, R&D based endogenous growth models place the concept of innovation to the center of growth, abandoning diminishing returns and exogenous technology assumptions. In this respect, the productivity level and hence growth rate of an economy depends on cumulative R&D investments and technological knowledge stock (Aghion and Howitt, 1992; Grossman and Helpman, 1991; Romer, 1990). According to this theory, technological development occurs along with some external factors. When innovations which arise as a result of R&D activities, enter production processes, technological knowledge will spillover between economic units by Arrow's learning by doing effect and imitation as a byproduct. These exogenous factors are spillover effects which affect other economic units positively.

In R&D based growth models, technology development rate and hence the growth rate is in a direct relation with the amount of resources allocated for R&D. One classification of these models is made according to the scope of innovations which arise from R&D activities. In horizontal innovation models, an increase in the diversity of intermediate and capital goods which are used in production process triggers growth (Grossman and Helpman, 1991; Jones, 1995; Romer, 1990). The other areas which develop with respect to the scope of innovation are the vertical innovation models which are based on the increase in product quality (Aghion and Howitt, 1992).

In the endogenous growth models; the international factors such as trade, capital movements, mobility of the labor force inevitably cause important results in terms of economic growth. Rivera-Batiz and Romer (1991) studied the effect of intermediate goods trade and technological knowledge transfer between countries on growth by integrating Romer's (1990) horizontal innovation model and the internationalization process. According to this study, without the technology spillovers, trade of goods does not affect long term growth. However, technology spillovers arising as a result of international trade permanently increase the growth rate.

In the knowledge based R&D approach of Rivera-Batiz and Romer (1991), international trade between countries will stimulate the economy with the increase in diversity of intermediate goods used in the production of final goods and as a result of specialization due to the diversity of intermediate goods in the final goods sector, efficiency increases will occur. In addition to the goods trade, when technological knowledge transfer between countries starts, technological knowledge stock alongside with the amount of inputs in the innovative process will increase, and hence growth rate of the economy will permanently increase. Grossman and Helpman (1991) combined an R&D based endogenous growth model of horizontal innovation with international trade for a small developing country and investigated the effects of technological knowledge transfer between countries on economic growth. In this respect; technology spillovers and the resulting increase in the diversity of intermediate goods depend on the boundaries of foreign trade of the small developing country. In other words, technological knowledge stock increases in parallel to foreign trade volume.

In summary, since technology is the driving force in economic growth; how technology spillovers between economic units is very important. In an international economic system technology spillover occurs essentially by means of export and/or import of final or intermediate and capital goods or foreign direct investments. Naturally, international patenting and licensing activities also cause technology transfer. According to Grossman and Helpman (1991), and Rivera-Batiz and Romer (1991), growth is determined by both a country's own technology production and foreign technology production efforts; in other words by total domestic and foreign R&D stock. Trading intermediate and capital goods between domestic and foreign sectors play an essential role in transferring foreign technologies to domestic economy and spillover through the sectors in the domestic economy.

In the literature, the fact that for countries, effective absorption and internalization of knowledge from frontier technologies are essential factors for transferring the foreign technologies to the domestic economy holds vast importance. These factors as a whole are generally referred to as absorptive capacity. Dahlman and Nelson (1995) defines absorptive capacity as the ability to adapt and implement the advanced technologies and related applications of developed countries. It is possible to state that absorptive capacity essentially reflects the rate of adapting to the new technological knowledge by a country, a sector or a firm or the capacity that determines the extent of the utilization of this knowledge (Cohen and Levinthal, 1990; Evenson and Westphal, 1995; Keller, 2002).

Differences between the technology levels of economies have gradually attracted more researchers to the concept of absorptive capacity. A large number of studies mention that especially in developing countries, differences in productivity levels arising from technology depend on the absorptive capacity and related factors. For example, according to Parente and Prescott (2000) technological knowledge is global but differences in the levels of income per capita between countries result from the differences in usage of technological knowledge.

There are two factors in the literature that is frequently related to the idea of absorptive capacity, which is in the form of a sector or a country needing a special kind of ability in order to successfully adopt a foreign technology. These are human capital and internal R&D efforts. Theoretical and empirical literature which study human capital within technology spillover framework as an indicator of absorptive capacity, express that human capital develops the ability to learn, absorb and implement the new technologies which arise as a result of R&D activities and hence catalyzes the emergence of technology spillovers (Nelson and Phelps, 1996). According to Cohen and Levinthal (1986), firms' own R&D efforts are highly important in their understanding of new technological trends and innovations which are either included in intermediate and investment goods or directly obtained. On the subject of internal R&D efforts, it has been suggested that production units should make their own R&D investments in order to adopt and implement external technologies. In this scope, the concept of absorptive capacity is shaped with the idea that R&D activities are reflected towards adopting, imitating and implementing external technologies rather than creating innovations. Market structure is another important factor in relating the spillover of new technologies to the absorptive capacity of economic units.

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 one of the major obstacles in 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[1] and in turn, with stronger spillovers. (Kamien and Schwartz, 1982).

In conclusion, since developing countries do not engage in strong R&D activities in quality or quantity, their export of technology from technology leading countries is the key to increase productivity and growth in these countries. For Turkey, with the structure of production being dependent on imported intermediate and investment goods, determining the factors affecting technology spillovers through international trade and their respective benefits is thought to produce important results in terms of proposing policies regarding the technological development resulting in productivity increase and growth. In this study, departing from the assumption that technology/R&D spillovers which emerge as externalities resulting from R&D investments take place through the inputs of intermediate and capital goods, technology spillovers in Turkish manufacturing industry are studied within the framework of absorptive capacity. In this scope, the aim of this study is to analyze the effectiveness of technology spillovers emerging in Turkish manufacturing industry through imports by utilizing various factors considered to have effect on absorptive capacity.

In order to make our analyses Hansen's (1999) threshold regression techniques are applied to a dataset of 22 manufacturing sectors at 2-digit level classified under ISIC Rev.3 over the period 1992-2001. In this respect, in order to determine the effects of technological knowledge spillovers through imports on different sectors with different absorptive capacities, alternative threshold regression models are estimated. The remainder of this paper is organized into three sections. Section two provides a summary of empirical literature on technology spillovers. In section three we report our empirical results. Section four concludes.

II. Empirical Literature

Most of the studies analyzing R&D-productivity-growth relation empirically take developed OECD countries into account. In most studies, it has been put forward that foreign technology resources are important for increase in productivity and growth in developed countries (Coe and Helpman, 1995; Keller, 2002). However, studies on technology spillovers in developing countries constitute a small proportion in the literature.

Empirical testing of theoretical framework of technology spillovers begin with Coe and Helpman (1995). Studies of Coe and Helpman (1995), later Keller (1998), followed by Lichtenberg and van Pottelsberghe de la Potterie (1998), and Xu and Wang (1999) are the most cited works shaping the technology spillover literature. Considering the R&D activities as technological developments early works in the related literature are mostly carried out on national level based on Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991) models which use foreign trade, technological knowledge accumulation and endogenous growth concepts together. Technological knowledge is modeled within a Cobb-Douglas type production function as a separate variable from conventional factor inputs. In the empirical studies made in this frame, generally the relationship between domestic/foreign based R&D expenditures and total factor productivity is investigated. On the next step, efficiency of technology spillovers were tried to be understood by investigating the magnitude of this relation and performing analyses within the scope of absorptive capacity.

[1] This corresponds to the environmental factors that govern an innovator's ability to capture the profits generated by an innovation. According to the appropriability hypothesis, firms in oligopolistic or monopolistic environments face less market uncertainity, and can more easily appropriate the benefits of R&D which is in line with the idea that a higher market share increases the market valuation of innovation activity.

The most important contribution of Coe and Helpman's (1995) study which tests the scope of technology spillovers for the first time, is defining a foreign R&D stock variable weighted by imports share in order to assess the foreign R&D spillovers quantitatively. According to the results of their analysis, the more an economy is open to international trade, the greater the potential effect of foreign technologies on the total factor productivity of production processes of that economy.

Coe, Helpman and Hoiffmaister's (1997) contribution to the literature is taking the technology spillover variable as imports of capital and intermediate goods instead of total imports from industrialized countries. In their study, where the technology spillover effects of capital goods imports from technologically advanced countries to 77 developing countries including Turkey are analyzed, it has been concluded that the developing countries trading with technologically advanced economies will advance technologically and grow faster.

Another pioneering study belongs to Coe, Helpman and Hoffmaister (2008) testing Coe and Helpman's (1995) model empirically as well as examining the efficiency of technology spillovers by utilizing control variables representing the corporate structure in addition to domestic and foreign R&D stocks.

In a study conducted on national level for Portuguese economy, Teixeria and Fortuna (2010) tested whether human capital and domestic R&D factors of the country's absorptive capacity has any effect on the relationship between machinery imports/foreign direct investments and total factor productivity.

Henry, Kneller and Milner (2009) used stochastic frontier analysis method in order to determine the effects of technology transfer and absorptive capacity on output level in the 1970–1998 period for 57 developing countries. Their results suggest that the production limit for developing countries depends on the capital and labor inputs together with foreign R&D stock which is accessible by capital goods imports. Deviations from this limit which are defined as inefficiency vary with respect to openness to foreign trade and absorptive capacity.

Crespo, Foster and Scharler (2004, 2008), studied the efficiency of technology spillover within the absorptive capacity framework by utilizing threshold regression methods using data from 21 OECD countries over the period 1973-1997. Their results support the idea that human capital and especially domestic R&D efforts increase a country's absorptive capacity.

Schiff, Wang and Olarreaga's (2002) research on manufacturing industries in developing countries for the period 1976-1998 is one of the pioneering studies examining the effects of foreign trade on technology spillovers on an industrial basis. The results of their analysis show that North-South and South-South spillovers are positively correlated with total factor productivity and within the context of absorptive capacity North-South spillovers increase total factor productivity primarily in R&D intensive sectors.

Schiff and Wang (2010), examined the technology spillovers related to North-South trade for Latin America and Caribbean region regarding absorptive capacity using industrial level data and taking education and governance criteria in consideration. According to their analysis, education, governance and North R&D have meaningful effects on total factor productivity of R&D intensive sectors in Latin America and Caribbean countries. Moreover, spillovers from North increases with North's R&D activities and South's openness to trade and this R&D capital increases the productivity level of South even more when activated with South's education and governance variables.

Driffield and Henry (2008) studies the effects of foreign knowledge entry to economies in the context of different corporate factors and different levels of human capital. In this respect, when R&D stock weighted by foreign trade is considered as a technology spillover variable, meaningful thresholds could be found showing that foreign technology impact is not homogeneous among countries.

Although Turkey is included in some technology spillover studies of developing countries (Navaretti, Schiff and Soloaga, 2006; Savvides and Zachariadis, 2005; Ülkü, 2007) there is a limited number of studies analyzing Turkey particularly. Most of the empirical studies on technology/R&D spillovers specific to Turkey focus on technology spillovers in manufacturing industry through foreign direct investments and very few take spillovers resulting from foreign trade into consideration (Alıcı and Ucal, 2003; Aslanoğlu, 2000; Lenger and Taymaz, 2006; Yılmaz and Özler, 2004).

To our knowledge, the first study conducted on Turkey about technology spillovers resulting from imports belongs to Mıhçı and Wigley (2000). In this study, foreign R&D is represented by an import variable. Their results suggest that domestic R&D investment is the major important factor in increasing productivity and imports has positive effects on industrial productivity.

One of the rare studies for Turkey belongs to Yaşar and Paul (2007). In their plant level study on clothing, textile and motor vehicle sectors they investigated technology spillovers through foreign direct investments and imports as well as exports. The results of this study indicate that technology transfers by machinery, equipment and intermediate goods imports imply positive effects on productivity, however these effects at the imports side are weaker than those by direct foreign investments and exports.

In Yardımcı (2007) technology spillovers through trade and in particular the long term relationship between foreign trade and economic growth in Turkish economy over the period 1968-2002 is examined. In this study, where trade with countries of high R&D investments are taken into account, in order to represent the effects of technological knowledge spillovers the ratio of imports to gross domestic product was used as the spillover variable. The results of the analyses where national human capital is also included as an absorptive capacity indicator show that the spillovers resulting from imports have more significant effects on growth relative to exports. In another study specific to Turkey, Ay and Yardımcı (2007) investigated the relations between physical capital, human capital, and trade with R&D leading economies and gross domestic product for 1963-2002 period. The results of the study suggest that contribution of imports by means of technological knowledge spillovers to growth is small. In this respect, it has been expressed that in order to utilize technological knowledge spillovers technology development efforts at national level are strategically important.

III. Methodology, Data and Results

In this part of the study, with the motivation of clarifying the existence and efficiency level of technological spillovers in Turkish manufacturing industry, we basically try to answer the following questions: *(1) How important is foreign trade to technological knowledge spillovers in Turkish Manufacturing Industry? (2) Does the efficiency of foreign technology spillovers vary according to their absorptive capacity?*

This study is mainly based on Grossman and Helpman (1991) and Coe and Helpman (1995). Departing from the assumption that technology spillovers emerging as externalities from R&D investments take place by means of intermediate and capital goods used as inputs in manufacturing sectors, we investigate technology spillovers in Turkish manufacturing sectors within absorptive capacity framework. In this context, we study the existence and efficiency of technology spillovers by examining several factors which are thought to be effective in absorption of technology. These factors which are assumed to affect absorptive capacity are the ones which reflect human capital specific to sectors, sectors' own R&D efforts and structure of final goods market.

The existence and efficiency of technology spillovers will be tried to be determined by estimating a Cobb Douglas type production function using a single stage approach instead of the two stage approach common in the literature. Threshold regression techniques with Hansen's (1999) methodology will be applied to the structural model obtained from this production function. Hence efficiency of technology spillovers will be allowed to vary between regimes determined by absorptive capacity variables. Instead of externally imposing the threshold values of the factors treated in relation with absorptive capacity, this analysis methodology enable us to determine these values internally in the estimation process.

Within this scope we take a Hicks-neutral production function with constant returns to scale:

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

where Y_t, K_t and L_t represents total production, physical capital stock and, labor respectively.

Let the technology level depends on the domestic and foreign R&D variables as in Coe and Helpman (1995):

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

RD_t^d and RD_t^f represents domestic and foreign R&D variables respectively. 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 of (3) is obtained:

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

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 process comprise of weighted domestic and foreign R&D stocks, and they indeed proxy technology/R&D spillover variables[2]. Positive and statistically significant coefficients related to the 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.

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

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 this empirical configuration, foreign trade which is defined as a means of international technology spillover, is necessary for transfer of technological knowledge, however it does not guarantee the absorption of this knowledge. Therefore, efficiency of technology spillovers may vary according to the levels of several variables defined in relation to absorptive capacity.

In order to elaborate on the estimation methodology, we define the relationship between international technology spillover and industrial output, with a double threshold model where several variables which are thought to be the determinants of absorptive capacities in sectors are used as threshold variables (q_{it}):

$$lny_{it} = \mu_i + \alpha lnk_{it} + \gamma_1 lnRD_{it}^d + \beta_1 lnRD_{it}^f I(q_{it} \leq \lambda_1) + \beta_2 lnRD_{it}^f I(\lambda_1 < q_{it} \leq \lambda_2) +$$

$$\beta_3 lnRD_{it}^f I(\lambda_2 < q_{it}) + e_{it} \tag{5}$$

In this view, slope parameters $(\beta_1, \beta_2, \beta_3)$ which determine international technology spillover on foreign R&D stock, may vary between regimes determined by the threshold parameters of absorptive capacity. Parameters (α, γ_1), which belong to additional controls in the model, are constant between these regimes and do not affect the distribution regarding thresholds (Hansen, 1999; p.357). While I(.) is the indicator function of threshold variables, (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) in the double threshold model specification are determined endogenously within the estimation process and, threshold variables (q_{it}) are selected upon the factors that are assumed to affect the absorptive capacities of industries. These factors proxy human capital content specific to each industry together with each industry's internal R&D efforts and final goods market structure.

As one of the threshold variables technical workers intensity (TP_{it}), is constituted in order to reflect the labor force quality i.e. human capital included in labor. For each sector, it is calculated by dividing the sum of number of high level technical staff and number of administrative staff by total number of workers. R&D intensity (RI_{it}), which is another threshold variable, is generated in order to represent the internal R&D efforts of sectors. The Herfindahl-Hirschman concentration index (HH_{it}) is used in order to represent the final goods market structure.

In this study, the data for the period 1992-2001, belonging to 22 manufacturing sector in Turkey at 2-digit level which are classified under ISIC Rev.3 was collected from Turkish Statistics Institute (TurkStat).

[2] 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}).

The data used for generating production, labor force, domestic R&D stocks and threshold variables are gathered from Annual Manufacturing Industry Statistics of TurkStat which are made for the enterprises with 10 or more employees. Input-Output tables that are used for computing the input-output coefficients are obtained from TurkStat. Capital stock data for sectors is obtained from Taymaz, Voyvoda and Yılmaz (2008). The data regarding our measures of R&D stocks of foreign trade partners[3] are collected from "*OECD ANBERD ed. 9 Rev. 3*" (OECD Industry and Service Statistics-Structural Analysis (STAN) Databases-R&D Expenditure in Industry) database and bilateral trade values are obtained from TÜİK.

Our estimations made by utilizing Hansen's (1996, 1999) threshold regression techniques were performed in three stages. Firstly, 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. For each model specification, in the second stage of single threshold estimation, in the case of the existence of a threshold effect, the second threshold effect is also tested. Following that this second effect is confirmed, the double threshold model is estimated.

Prior to the threshold regressions, a basic model is estimated under the assumption that threshold effects do not exist:

Basic Model:

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

where y_t is value added per worker, k_t is capital per worker and RD_{it}^{d} and RD_{it}^{f} denotes domestic and foreign R&D spillover variables respectively.

Table 1: Coefficient Estimates: Basic Model

Değişken	Katsayı Tahmini	SEKK SH	White SH
k_{it}	0.3214***	0.0620	0.0855
RD_{it}^{d}	0.0191**	0.0075	0.0089
RD_{it}^{f}	0.0163	0.0086	0.0097

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

In *Table 1* estimated coefficients from the basic model are presented. The coefficient of the variable domestic R&D variable which includes the impact of intra-sectoral spillovers together with the inter-sectoral spillovers is positive and statistically significant at 5 percentage level. This implies the existence of domestic technology spillovers in Turkish manufacturing industry. The coefficient on the foreign technology spillover variable is positive which is compatible with our expectations however; it is not statistically significant in conventional boundaries. This insignificance might be attributed to the heterogeneity in the absorptive capacities and factors affecting this capacity in industries.

Model 1: Human Capital-Technical Workers Intensity as the Threshold Variable

$$lny_{it} = \mu_i + \alpha lnk_{it} + \gamma_1 lnRD_{it}^{d} + \beta_1 lnRD_{it}^{f} I(TP_{it} \leq \lambda_1) + \beta_2 lnRD_{it}^{f} I(\lambda_1 < TP_{it}) + e_{it} \ , e_{it} \sim iid(0, \sigma^2)$$

Table 2: Tests for the threshold effects: Technical workers intensity

Tek Eşik	
F_1	*35.39***
p-değeri	*0.043*
(%10, %5, %1 kritik değerler)	*(25.71, 34.54, 44.54)*
İki Eşik	
F_2	*19.11*
p-değeri	*0.17*
(%10, %5, %1 kritik değerler)	*(22.73, 27.70, 40.04)*

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

[3] 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.

In the next model, technical workers intensity is applied as the threshold variable to the structural model of estimation which is modeled in a way that includes the embodied technology in intermediate and investment goods including both intra- and inter-sectoral technology spillovers, a single statistically significant threshold is estimated. According to the statistical findings there is a breaking point for the efficiency of foreign technology spillovers based upon the quality of labor. Thus a linear modeling in order to confirm the spillover effect might give biased results. *Table 2* presents *Likelihood Ratio* test results for single and double threshold effects. While the *F-statistic* regarding the single threshold effect is substantially significant with the 0.043 *bootstrap p-value*, the second threshold effect is not significant in the traditional boundaries with the *p-value* of 0.17. Under these circumstances we have significant findings of a single threshold effect for the underlying regression relation. In another words the null hypothesis of that the structural model could be estimated linearly is rejected strongly. Thus we continue our analysis with a single threshold model. The threshold parameter which is estimated as 0.3315 breaks down our sample into two regimes.

Regression slope estimates together with OLS standard errors and White-corrected standard errors are displayed in *Table 3*. Estimation results indicate that the regimes which are constituted by the estimated threshold differs in the slope parameters used for measuring the foreign spillover effect. i.e. the technology spillovers emerging by intermediate and investment goods imports are more efficient over the threshold value of technical workers intensity with respect to below and is statistically significant above the threshold. This situation shows that human capital factor raises the absorptive capacity of the industries.

Domestic R&D stock has a positive and significant effect on labor productivity which is defined as value adder per worker. Since the estimation model is structured on the natural logarithms of the variables, the regarding coefficients represent the elasticities of average labor productivity according to the underlying covariates. Therefore a one percentage increase in the domestic R&D stock which is calculated as for involving inter- and intra-sectoral spillovers increases average labor productivity by .0201 percentage points.

Table 3: Coefficient estimates: Single Threshold Model-Technical workers intensity

Variable	Coefficient	OLS-SE	White-SE
$\boldsymbol{k_{it}}$	0.3672***	0.0722	0.0831
$\boldsymbol{RD^{d}_{it}}$	0.0201**	0.0089	0.0101
$\boldsymbol{RD^{f}_{it}I(TP_{it} \leq 0.3315)}$	0.0159	0.0099	0.0116
$\boldsymbol{RD^{f}_{it}I(0.3315 < TP_{it})}$	0.0187*	0.0102	0.0112

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

Model 2: Internal R&D Efforts-R&D Intensity as the Threshold Variable

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

Tablo 4: Tests for the Threshold Effect: R&D Intensity

Tek Eşik	
F_1	*88.72***
p-değeri	*0.013*
(%10, %5, %1 kritik değerler)	*(17.58, 24.21,91.35)*
İki Eşik	
F_2	*13.62*
p-değeri	*0.146*
(%10, %5, %1 kritik değerler)	*(15.46, 19.38, 34.28)*

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.

When R&D intensity is applied to the structural model as a threshold variable, a single statistically significant threshold can be estimated. *Table 4* shows the *Likelihood-ratio (LR)* test results for single and double threshold effects. The single threshold effect with a *bootstrapping p-value* of 0.013 is statistically significant and the second threshold effect is not statistically significant within conventional boundaries with a *p-value* of 0.14.

According to these findings, the efficiency of foreign technology spillovers in Turkish manufacturing industry show variations depending on sectors' own R&D efforts.

Table 5: Coefficient Estimates: Single Threshold Model – R&D Intensity

Variable	Coefficient	OLS-SE	White-SE
$\boldsymbol{k_{it}}$	0.3255***	0.0649	0.0982
$\boldsymbol{RD^{d}_{it}}$	0.0199**	0.0085	0.0098
$\boldsymbol{RD^{f}_{it}I(RI_{it} \leq 0.0012)}$	-0.0051	0.0112	0.0140
$\boldsymbol{RD^{f}_{it}I(0.0012 < RI_{it})}$	0.0179*	0.0096	0.0107

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

According to the estimation results of Model 2 as shown in *Table 5*, depending on a threshold value of R&D intensity, slope parameters for foreign R&D stock differ. Therefore, the negative and insignificant coefficient of foreign R&D stock below the threshold value for R&D intensity indicates that technology spillovers resulting from imports do not exist. Above the threshold, the coefficient becomes positive and found statistically significant. This strong threshold effect supports the idea that especially for developing countries, utilizing external technologies; in other words benefiting from external R&D activities is conditional on firms' and industries' internal R&D efforts. Thus, only the industries that exceed a certain threshold level can benefit from foreign R&D activities.

Model 3:Market Structure-Herfindahl Hirschman Index as the Threshold Variable

$$lny_{it} = \mu_i + \alpha lnk_{it} + \gamma_1 lnRD^{d}_{it} + \beta_1 lnRD^{f}_{it}I(HH_{it} \leq \lambda_1) + \beta_2 lnRD^{f}_{it}I(\lambda_1 < HH_{it}) + e_{it} \quad e_{it} \sim iid(0, \sigma^2)$$

Tablo 6: Tests for the threshold effects: Herfindahl-Hirschman index

Single threshold	
F_1	*50.96***
p-value	*0.033*
(%10, %5, %1 critical values)	*(32.56, 45.87, 64.08)*
Double threshold	
F_2	*11.14*
p-value	*0.476*
(%10, %5, %1 critical values)	*(21.05, 25.49, 31.17)*

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.

When Herfindahl-Hirschman index representing the structure of final goods market that manufacturing firms operate in, is used as threshold variable, a single statistically significant threshold parameter is estimated. As one can observe from *Table 6* while the single threshold effect with a *bootstrapping p-value* of 0.033 is statistically significant, the second threshold effect is not statistically significant within conventional boundaries. Accordingly, there exists a breaking point for foreign technology spillovers in Turkish manufacturing industry sectors, depending on a threshold level of concentration ratio. This threshold level estimated as 0.1286 divides our observations into two regimes.

Table 7: Coefficient estimates: Single Threshold Model – Herfindahl-Hircshman Index

Variable	Coefficient	OLS-SE	White-SE
$\boldsymbol{k_{it}}$	0.3391***	0.0695	0.0953
$\boldsymbol{RD^{d}_{it}}$	0.0195**	0.0085	0.0098
$\boldsymbol{RD^{f}_{it}I(HH_{it} \leq 0.1286)}$	0.0173*	0.0092	0.0101
$\boldsymbol{RD^{f}_{it}I(0.1286 < HH_{it})}$	0.0142	0.0103	0.0121

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

In *Table 7*, it can be observed that depending on a threshold level of the Herfindahl-Hircshman index estimated slope parameters for foreign R&D stock differ. Under the threshold, efficiency of foreign technology spillover increase. In other words, the more competitive are the sectors the more they can benefit from technology spillovers. Below the estimated threshold parameter, while an increase of one percentage in foreign R&D stock leads to an increase of 0.017 percentage points in average labor productivity above the threshold level coefficient for foreign R&D stock it is not statistically significant though it has a positive value.

IV. Conclusion

Economic growth holds an important place in arrangement of government policies in both developed and developing countries and both for centralized and free economic systems. Endogenous growth theory regards innovation efforts as a driving force for growth and correlates human capital and R&D investments with increases in productivity levels. In R&D based endogenous growth models, innovation emerge as a result of R&D activities of economic units and feeds the existing technological knowledge. In this kind of growth modeling where technological knowledge spillover matters, the impacts of international relations and activities cannot be disregarded. Grossman and Helpman (1991) and Rivera-Batiz and Romer (1991) integrates R&D based endogenous growth framework with foreign trade. They indicate that technology spillovers taking place in an economy depends on the boundaries of foreign trade of that economy. Imports of inputs especially from countries with intensive R&D activities, enables the transfer of R&D benefits to the importing countries (Grossman and Helpman, 1991).

Since developing countries do not engage in qualitatively and quantitatively strong R&D activities, importing technologies from leading countries is the key for growth in these countries with increasing productivity levels (Savvides and Zachariadis, 2005). For developing countries, the ability to implement existing technologies also depends on successfully adapting to technology development processes (Keller, 2002). This adaptation enables to research, define, adopt, utilize and spread of advanced foreign technologies. These concepts which are defined as absorptive capacity entirely are essential in explaining the differences in countries' benefitting from technology spillovers.

The theoretical and empirical framework of this study is essentially based on Grossman and Helpman (1991) and Coe and Helpman (1995) and it utilizes the literature regarding technology spillovers together with discussions on absorptive capacity. Departing from the assumption that technology/R&D spillovers which emerge as externalities from R&D investments take place through intermediate and capital goods that are used as inputs by manufacturing industry sectors; we examine technology spillovers of 22 Turkish manufacturing sectors classified under ISIC Rev.3 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 are human capital, internal R&D efforts and structure of the final goods market. Hansen's (1999) threshold regression techniques are applied to the structural model obtained from a Cobb-Douglas type production function. By this way efficiency of technology spillovers is allowed to vary between regimes determined in relation with the absorptive capacity variables.

Our analyses results, above all, approve the existence of technological knowledge spillovers in Turkish manufacturing industry by means of international trade. Estimation results of the threshold regression models defined for absorptive capacity variables indicate that using linear models for the analysis of technology spillovers in Turkish manufacturing industry can produce biased results. For example, it can be seen that technology spillovers varies above and below a critical value for human capital indicating that human capital factor increases the absorptive capacity of industries. Estimation results of a model where R&D intensity is defined as threshold variable show that technology spillovers are inefficient below a critical value for internal R&D efforts of sectors, and are much more efficient above this critical value. Therefore sectors that can exceed a certain threshold level can benefit from external R&D activities. Similarly, in Turkish manufacturing industry, there is a certain breaking point for foreign technology spillovers depending on the product market concentration which these sectors operate in. When Herfindahl-Hirschman index which is an important indicator of the market structure is used as threshold variable, the threshold effect changes the estimated slope coefficients for foreign R&D stocks. While the aforementioned coefficient is positive and statistically significant below the estimated threshold, it is insignificant above it.

As a result, in order for Turkish manufacturing industry sectors to benefit from external R&D investments, it is essential that they invest in their own absorptive capacities. In this regard, increasing the share of R&D expenditures and investing in human capital 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 competitive power. Therefore, science and technology policies should be approached systematically, and R&D investments should be increased in order for obtaining the globalized technology. Similarly it has been concluded that reducing the oligopolistic structure in Turkish manufacturing industry and increasing competition conditions can increase the potentials of sectors in benefiting from externalities of R&D activities and hence more sectors can take place below the threshold level of concentration.

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