The Effects of Firms' R & D Expenditures on Profitability: An Analysis with Panel Error Correction Model for Turkey

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Abstract

The purpose of this paper is to determine the impact of research and development expenditures on a firm's short- and long-term profitability. A dynamic panel data analysis was carried out on data collected between 1998 and 2012 from a sample of 46 publicly traded manufacturing firms on the Borsa Istanbul. The findings revealed that although research and development expenditures do not have a statistically significant effect on the short-term profitability of a firm, they do have a significantly positive and strong effect on long-term profitability. It show that for a one-unit increase in research and development expenditure, the gross profit increases by 10.19 units, the net operating income increases by 2.37 units, and the net income increases by 1.39 units.

Keywords: Research and Development Expenditures, Istanbul Stock Exchange, Gross Profit, Operating Income, Net Income, Panel Error Correction Models

JEL Codes: M41, O32

1. Introduction

In today's competitive landscape, firms' investments in innovative activities have become one of the most important factors that allow for their sustainability. In the information age of the 21st century, timely and adequate investment in knowledge and innovation will provide firms with a competitive advantage. Since the 1980s, when the globalization process gained momentum, the companies that have played a leading role in bringing innovation to their industries have increased their market share and provided added value to their economies. A number of published studies show that such firms are able to provide benefit both to themselves and to their economic systems with these innovative investments (Aghion and Howitt, 1992; Cameron, 1996; Grossman and Helpman, 1990; Schumpeter, 2003; Pessoa, 2010; Chen et all, 2015; Cucculelli and Bettinelli, 2015; Zhou and Song, 2016; Guan et all, 2016).

Although the effect of research and development (R & D) expenditures on profitability and stock returns has been investigated in studies such as those mentioned above, we have not encountered the usage of co-integration tests and error correction models to examine the relationship between the variables in both the short- and long-term, and we have not found a study using data that cover such a wide interval of time for Turkey.

Therefore, to contribute to the literature in this study, we plan to answer the question "how much do R&D expenditures affect firms' short- and long-term profitability?"

2. Literature Review

The relation between firms' R&D expenditures and profitability has been subjected to several studies since the 1970s. Researchers have used different profitability indicators of firm's indifferent sectors to measure the effects of R&D activities on business performance and have attempted to determine the factors that directly or indirectly affect this relation. A reason why there are so many such studies the diversity of available statistical and econometric models. Each study is distinctive and different. Thus, because these models have individual hypotheses, they require different variables and shed light on different aspects of the relation (e.g., the long or short term, continuity of the relation, interactive latency).

When examining the literature, studies indicating that there is a positive relation between R&D and profitability are relatively dominant. However, some studies indicate that R&D expenditures have no effect on the profitability of firms, such as those of Lee et al. (1994) and Yucel and Kurt (2003). As one of the first researchers on this subject, Branch (1974) suggested that R&D expenditures affect the future profitability and are affected by the former profitability. Later, Ben-Zion (1978) developed a model on the effect that the deferred amount has on the advertisement and R&D expenditures and determined there to be a positive relation between profitability, and R&D expenditures. Morbey (1988) confirmed that an R&D expenditure that is above a certain threshold value will reveal a strong relation between firms' R&D expenditures and the growth rate of the sale in the following years and determined a slight correlation between R&D density and an increase in profitability.

A positive and significant relation between the costs, which indicate firm's R&D expenditures or R&D density, and the profitability indicators was found in studies by Capon et al. (1990), Hajiheydari et al. (2011), Ayaydın and Karaaslan (2014), Kocamis and Gungor (2014); between the R&D expenditures and price-cost range in workby Yoon (2004); and among R&D expenses, share earnings and asset profitability in work by Karacaer et al. (2009).

In addition to the studies mentioned above, which indicate the existence of the relationship between R&D and profitability, other studies consider why, for how long and under which conditions the relation between R&D expenditures and profitability is positive. For example, Eberhart et al. (2004) stated that a sudden increase in firms' R&D expenditures returned more than the usual during 5-year periods due to the weak reaction of the market and mispricing. Moreover, Yeh et al. (2010) confirmed that the positive effect of R&D expenditures on firm performance continues, to a certain extent. Above a certain rate, R&D expenditures have a negative effect on profitability. Thus, Wang (2009) explained the relation between R&D expenditures and firm performance as a reversed s-curve. Yang et al. (2014) determined that there is an s-curve relation between R&D expenditures and performance as a result of their research on firms in Taiwan. Ciftci and Cready (2011) suggested that when a firm grows, the positive relation between R&D density and future income also increases; however the fluctuation decreases. Peters and Schmlele (2011) confirmed that firms that engaged in R&D activity made more profits than those that did not.

In addition, the writers stated that if firms are involved in R&D activity in other countries, rather than only in their own country, the effect of R&D on profitability is doubled (Peters and Schmlele, 2011). Moreover, Sahar and Yalali (2014) determined that the positive effect of R&D expenditures on profitability reached its maximum level in the 4th year of expenditures. Apergis and Sorros (2014) stated that the effect of R & D expenditures on profitability is greater in the energy sector, especially renewable energy firms. Identifying the relationship between R & D expenditures and profitability in literature affects the recognition of R&D expenditures. Chauvin and Hirshcey (1993) stated that R&D and advertisement expenses have major and consistent effects on the cash flows of firms and those very large firms should approach these expenses as ways of providing cash flow rather than costs. Nissim and Thomas (2000) expressed that capitalizing and amortizing R&D expenditures rather than expensing them make it easier to match the expenses with their advantages. Shin and Kim (2011) stated that R & D activities of small and midsize firms increase the firm value and that capitalized R&D expenditures have a greater effect on the firm value than do those expensed.

In some of the studies summarized above, the effect of R & D expenditures on firm profitability and share earnings has been studied, but no study using a co-integration test and error correction model to analyze the existence of a relation between these variables on both a short- and long-term basis has been found.

Moreover, it is confirmed that this subject has not been studied with data from a long time period in Turkey. Thus, in this study, we plan to search for an answer to 'how do R&D expenditures affect the long- and short-term profitability of a firm?' in an attempt to contribute to the literature.

3. Data and Methodology

The population of this study consists of firms in the manufacturing sector whose shares were registered to the Istanbul Stock Exchange (BIST) in 1998-2012. The scope of the study is limited to these firms because accurate data can be acquired from firms registered in BIST in specific years, because manufacturing sector firms are more numerous than many other sectors' firms, and because this sector places more importance on R&D expenditures due to its structure. The data used in this study are acquired from firms' annual financial statements. In the model, the short term means a 12-monthterm, and the long term means a term longer than12 months. In 2012, there were 178 firms registered to the BIST manufacturing sector. However, only 46 of these spent R & D expenditures regularly between 1998 and 2012. The data on these firms were compiled using the Finnet Financial Analysis Program. The information about R & D expenditures was acquired from R & D costs, which is a part of the operating expenses listed on income statements. The net profit for the period, operating profit (ordinary profit), and gross real operating profit were used to refer to profitability in this study. *Gross real operating profit* was used to examine the effect of R & D expenses on firms' sales; *operating profit* was used to determine the contribution of R & D expenditures to firms' main and subsidiary activities; and *net profit for the period* was used to observe the effect of R & D expenditures on the final profitability of firms. Descriptions of variables are included in Table 1.

Table 1: Summary of Variables

Type of Variables	*Code*	*Definition*
Independent Variable	**R & D**	**R & D expenditures**
Dependent Variables	**NPp**	**Net profit for the period**
	OP	**Operating profit**
	GROP	**Gross real operating profit**

Error correction models were utilized to determine the effects of firms' R & D expenditures on their profit in both the short and long term. First, the stability of the data sets was investigated with "Levin, Lin, Chu (LLC)", "Im, Pesaran, Shin (IPS)", and "Breitung" tests, which are commonly used in the literature. Once the stationary order was defined, we followed the methodology of the Pedronico-integration test, which was shaped following the theoretical framework of Engle-Granger and Johansen tests, to investigate the long-run co-integrated relationship between each pair of variables. The basic equation for the Pedroni test is as follows:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + ... + \beta_{mi} x_{mi,t} + e_{it} \quad (1)$$

fori = 1,…..,.N; t = 1,…..,T; where N refers to the number of individual members or firms in the panel and T refers to the number of observations over time. α refers to entity effect, and δ refers to time effect. If y and x are I(1) and integrated, the structure of estimated residuals is as follows;

$$e_{it} = p_i e_{it-1} + u_{it} \quad (2)$$

The Pedroni test consists of seven different sub-statistics to test panel data co-integration. Four of them are based on the "within" dimension, and three of them are based on the "between" dimension. Each subtest has same null hypothesis that "there is no co-integration between the variables". However, the specification of the alternative hypothesis is different for the "within" and "between" dimensions. Whereas the alternative hypothesis is pi = p < 1 for all i on the within sub-tests, it is pi < 1 for all i on the between dimension (Pedroni, 1999).

The relationship between two co-integrated variables in both the short and long term can be identified usingpanel error correction models (PECM). The Mean Group Estimator (MGE), developed by Pesaran and Smith (1995), provides unit estimates in both the short and long run because it assumes that parameters are always heterogeneous. However, the Pooled Mean Group Estimator (PMGE), developed by Pesaran, Shin and Smith (1999) assumes that parameters are homogeneous in the long run. Therefore, this test provides estimates according to all units only in the short run. We also use the Hausman specification test to choose between the MGE and the PMGE estimators.

The null hypothesis of the Hausman test is that there is no systematic difference between the long-run coefficients of two estimators. If the null hypothesis cannot be rejected, the PMGE will be preferred. However, if it is rejected, the results show that panel units are heterogeneous in both the short and long run (Tatoglu, 2012).

4. Empirical Evidence

During the analysis, the relations between R & D expenditures and profitability were studied within the context of both the short and long term to examine how and in which direction R & D expenditures affect the profitability of firms. In this way, ourmain hypothesis, "There is a significant relation between the R & D expenditures of firms and their profitability level," was developed. Here, R & D expenditures reflect the current expenses for R & D activities of each firm between 1998 and 2012. In contrast, Net Profit for the Period, Operating Profit and Gross Real Operating Profit were addressed to measure the profitability level of firms. Thus, three sub-hypothesis reflecting the main hypothesis have been formed:

H_1: "There is a significant relation between the R & D expenditures of firms and Net Profit for the Period."
H_2: "There is a significant relation between the R & D expenditures of firms and Operating Profit."
H_3: "There is a significant relation between the R & D expenditures of firms and Gross Real Operating Profit."
These hypotheses were formulated using the functional relations below:

Net Profit for the Period= f (R & D expenditures, Other Factors) (a)
Operating Profit= f (R & D expenditures, Other Factors) (b)
Gross Real Operating Profit= f (R & D expenditures, Other Factors) (c)

To examine these functional relations, three different econometric models with different dependent variables were formed:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + u_{it} \quad (3)$$

i = 1,…..,46 (46 Firms), t = 1,….,15 (1998-2012)

In equation number (3), X stands for R & D expenditures of firms, Y stands for net profit for the period for Model 1; operating profit for Model 2; and gross real operating profit for Model 3. "i" stands for each of the 46 firms, and "t" stands for each year from1998-2012.

The analysis primarily examined whether the variables that are addressed contain unit roots. The results of the Levin, Lin and Chu (LLC), Breitung and Im, Pesaran and Shin (IPS) stability tests performed on the "R & D" independent variable and "NPp, OP and GROP" dependent variables, are presented in Table 2. As shown in Table 2, neither the R & D expenditures variable nor other variables are unstable on the level [I(0)]. Thus, the null hypothesis built as "serials have unit roots" could not be rejected on all tests. To make these variables stable, first differences were taken. The test results show that the variables do not contain unit roots on their first differences [I(1)]. In other words, they have become stable ($p<0.01$).

Table 2: Results of Unit Root Tests

	Levin, Lin &Chu		**Breitung**		**Im, Pesaran&Shin**	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
R & D	-1.2536	-15.3178[a]	3.7862	-3.5513[a]	-0.1802	-10.2325[a]
NPp	-1.9710	-23.2653[a]	0.0491	-9.1001[a]	-1.0022	-18.0216[a]
OP	-1.6937	-21.0153[a]	0.2061	-7.0847[a]	-1.5774	-16.8662[a]
GROP	0.5722	-11.1176[a]	1.2572	-2.8206[a]	-0.6076	-7.76042[a]

***a, b, and c indicate levels of significance at 1 percent, 5 percent and 10 percent, respectively.**

Source: Authors' estimations.

The second phase of the study examined whether there is a co integrated relation between R & D expenditures that become stable on the same level and NPp, OP and GROP, based on the Pedroni Co integration Test.

Table 3: Results of Panel Cointegration Tests

	Within				Between		
	Panel v	Panel rho	Panel PP	Panel ADF	Grouprho	Group PP	Group ADF
R & D – NPp	1.7022[b]	-4.8183[a]	-11.7035[a]	-11.7758[a]	4.0922	-1.5663[c]	-6.7098[a]
R & D – OP	1.5216[b]	-2.6142[a]	-8.6622[a]	-11.3792[a]	4.2684	-1.3864[c]	-6.5512[a]
R & D – GROP	-1.8510[b]	-3.2606[a]	-4.8471[a]	-1.2231[a]	-0.3128	-6.4874[a]	-3.5652[a]

***a, b, and c indicate levels of significance at 1 percent, 5 percent and 10 percent, respectively.**

Source: Authors' estimations.

Table 3 shows that according to the test results, except for "Group rho", the H_0 hypothesis, which proposes that there is no co integrated relation among all of the variables addressed, is rejected ($p<0.01$; $p<0.05$; $p<0.10$). Accordingly, it can be said that there is a co integrated relation between R & D expenditures and the main variables, with business profits shown in the long term. Therefore, it can be assumed that R & D and other variables in different models are I(1) and co integrated. The error terms should be I(0) for all firms, and the terms are independently distributed across all times. In the case where the maximum length of latency is one unit for all variables, as occurs in model (3) and as Pesaran et al. (1999) state in ARDL (1,1), the latency can be formulated as

$$Y_{it} = \gamma_i + \lambda_i Y_{i,t-1} + \delta_{0i} X_{it} + \delta_{1i} X_{i,t-1} + \varepsilon_{it} \quad (4)$$

The error correction model is

$$\Delta Y_{it} = \Phi_i (Y_{i,t-1} - \hat{\theta}_{0i} - \hat{\theta}_{1i} X_{i,t-1}) + \delta_{1i} X_{i,t} + \varepsilon_{it} \quad (5)$$

Here, $\phi_i = -(1-\lambda_i)$, $\hat{\theta}_{0i} = \frac{\gamma_i}{1-\lambda_i}$,$\hat{\theta}_{1i} = \frac{\delta_{0i}+\delta_{1i}}{1-\lambda_i}$ (Y variable symbolized in Model 1: Net profit for the period, in Model 2: Operating Profit, in Model 3: Gross Real Operating Profit, X variable symbolizes R & D expenditures in each model).

The MGE and the PMGE from the panel error correction models were used to determine the short- and long-term directions of the relation between R & D expenditures and indicators of different firms' profitabilities. Table 4 shows the results of the MGE and the PMGE when examining the short- and long-term relations between R & D and NPp, OP and GROP. As mentioned above, the main difference between these estimators is based on whether the long-term parameters are different according to the units in the data set. Thus, whereasthe MGE estimates different long-term parameters for each firm, the PMGE estimates a joint long-term parameter for all of the firms in the sample. For each data set that is analyzed, the Hausman test was performed to determine which estimator provides the most valid and efficient results. As observed from the Hausman test results presented in Table 4, the null hypothesis built as "There is nosystematic difference between the long-term coefficients acquired from two estimators" cannot be rejected. Thus, the results of the PMGE creating a joint long term-parameter for firms in the data set are valid and consistent.

Table 4: Results of Panel Error Correction Models

	Model 1	Model 2	Model 3
	Y = NPp	Y = OP	Y = GROP
Results of MeanGroupEstimator			
R & D (Long Term)	9.161686	20.90355[b]	107.6434[c]
Errorcorrectionterm (ϕ)	-.8623833[a]	-.7806627[a]	-.525085[a]
R & D_{-1}(Short Term)	-11.01113	-12.8389	-18.84165
Constant	3383157	11200000	26500000
LogLikelihood	-	-	-
Results of PooledMeanGroupEstimator			
R & D (Long Term)	1.393082[a]	2.37518[a]	10.19964[a]
Errorcorrectionterm (ϕ)	-.6778585[a]	-.6146548[a]	-.3310764[a]
R & D_{-1}(Short Term)	-5.110817	-.171509	-.108716
Constant	13700000	13700000	32700000
LogLikelihood	687,038	-11424.87	-11542.38
Number of Observation	644	644	644
Number of Group	46	46	46
Results of Hausman Test			
chi2	0.94	3.99	2.44
p>chi2	0.3326	0.0458	0.1180

***a, b, and c indicate levels of significance at 1 percent, 5 percent and 10 percent, respectively.**

Source: Authors' estimations.

According to the PMGE results, there is a long-run relationship between R & D expenditure and dependent variables that are changed by models. These results show that for a one-unit increase in R & D expenditures, the gross profit will increase by 10.19 units, the net operating income will increase by 2.37 units and the net income will increase by 1.39 units. Therefore, firms' R & D activities have a significant and positive effect on their profitability.

5. Conclusion

In today's market conditions, firms are paying more attention to R & D expenditures every day to gain a competitive advantage. Although it is not possible to observe the direct effects of R & D expenditures (unlike the purchase of a fixed asset), statistical methods can help us measure their impact, especially on income statement items.

This study assumed that profit is one of the most important financial performance indicators, and it was designed to show the short- and long-term effects of R & D expenditures on firms' three most important profit indexes. This research has resulted in two major findings. First, R & D expenditures have no statistically significant effect on firms' gross profit, net operating income, or net income in the short term. Second, we conclude that R & D expenditures have a statistically significant, positive and strong effect on these profits in the long term. In other words, for firms that are listed in the BIST manufacturing sector between 1998 and 2012, continuous investment in R & D was found to have a positive impact on gross profit, net operating income and net income. These results support theories claiming that R & D expenditure effects would occur in the long term.

According to our research, for each one-unit increase in R & D expenditures, the gross profit will increase by 10.19 units. This effect maybe the result of a sales increase due to customers seeing a new product, lower manufacturing costs due to a new technology, or the combined effects of both. As noted above, R & D expenditures also have a positive effect on firms' operating income in the long term. For each one-unit increase in R & D expenditures, the operating income will increase by 2.37 units. The reasons for the decrease in the effect of R & D on profits from 10.19 to 2.37 may include the following: because firms deduct R & D expenditures from gross profit when calculating net operating income, an increase in R & D expenditures will increase the expenses and cause operating income to be reduced. In addition, due to the increase in firms' sales, "general management and marketing, selling and distribution expenses" will also increase, thus weakening the effect of the R & D expenditures' contribution.

Similarly, we determined the long-term positive effect of R & D expenditures on the total net income. A one-unit increase in R & D expenditures results in a 1.39 unit increase in total net income. By examining these values, we conclude that the inclusion of non-operating gains and losses in operating income causes a decrease in the effect of R & D expenditures on profitability.

BIST manufacturing sector firms that prioritize R & D expenditures and are continuously investing in R & D can see results in the long term. Thus, when evaluating future profit levels, financial analysts can expect increased profits for firms that value R & D investments. Although this study's results support the literature on R & D profit relationships, this subject can still be examined in other studies. Different samples and econometric models could be used, and researchers could study related questions such as "How long are the effects of R & D expenditures likely to continue?" or "Do R & D expenditures have a greater effect on increasing income or reducing costs?.

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