# THE RELATIONSHIP BETWEEN INNOVATION ACTIVITIES AND PROFITABILITY OF BIST MANUFACTURING COMPANIES [1] [2]

Kafkas University
Economics and Administrative Sciences Faculty
KAUJEASF
Vol. 15, Issue 29, 2024
ISSN: 1309 – 4289
E – ISSN: 2149-9136

*Article Submission Date: 25.11.2023* *Accepted Date: 02.05.2024*

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ABSTRACT | This study's purpose is to analyze the connection between innovation activities and profitability of companies trading in the manufacturing industry on the Istanbul Stock Exchange. For this purpose, data from independently audited financial and income statements of 45 manufacturing companies with R&D expenditures during 2008-2021 are analyzed using the panel data. According to the examination's findings, there is an important and advantageous connection between business innovation activities and firm profitability. To conclude, the results of research examining the connection between innovation activity and profitability have both micro and macro implications. On a micro level, the solution assists firms in gaining a competitive advantage by ensuring that existing production systems operate effectively and increasing their share. At the macro level, they improve the welfare of society and help promote long-term economic growth and the accumulation of knowledge, especially the effective and cost-effective utilization of national resources.

***Keywords:*** *Innovation activities, research and development, patent, utility model, intangible assets*
***JEL Code:*** *M1, F65, O14*

***Scope:*** *Economics*
***Type:*** *Research*

**DOI: 10.36543/kauiibfd.2024.008**

**Cite this article:** Zengin, B., & Kurt, G., (2024). The relationship between innovation activities and profitability of BIST manufacturing companies. *KAUJEASF, 15*(29), 188-213.

[1] This study is derived from the Ph.D. Thesis entitled "Borsa İstanbul'da İşlem Gören İmalat Sanayi Şirketlerinin İnovasyon Faaliyetleri Ve Kârlılık İlişkisinin İncelenmesi", which was prepared at Ankara Hacı Bayram Veli University Institute of Graduate Programs, department of Banking and accepted in 2023.
[2] Compliance with the ethical rules of the relevant study has been declared.

# BIST İMALAT ŞİRKETLERİNİN İNOVASYON FAALİYETLERİ VE KARLILIK İLİŞKİSİNİN ARAŞTIRILMASI

Kafkas Üniversitesi
İktisadi ve İdari Bilimler Fakültesi
KAÜİİBFD
Cilt, 15, Sayı 29, 2024
ISSN: 1309 – 4289
E – ISSN: 2149-9136

*Makale Gönderim Tarihi: 25.11.2023* *Yayına Kabul Tarihi: 02.05.2024*

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ÖZ | Bu çalışma, Borsa İstanbul'da faaliyet gösteren imalat sanayi şirketlerinin inovasyon faaliyetleri ile kârlılık ilişkisinin incelenmesini amaçlamaktadır. Bu noktada, 2008-2021 yılları arasında imalat sanayinde işlem gören ve AR-GE gideri olan 45 şirketin bağımsız denetimden geçmiş finansal durum ve kapsamlı gelir tablosundan alınan veriler panel veri yöntemi kullanılarak analiz gerçekleştirilmiştir. Çalışmadaki bulgulara göre, inovasyon faaliyetleri şirket kârlılığını pozitif ve istatiksel olarak anlamlı etkilediği tespit edilmiştir. Böyle bir ilişki, mikro açıdan değerlendirildiğinde şirketlerin rekabet avantajı elde etmesine, mevcut üretim sistemlerinin etkili bir şekilde çalışmasına ve şirketlerin pazar paylarını arttırmalarına katkıda bulunmaktadır. Makro açıdan etkisi incelendiğinde ise toplumun refah seviyesini artırarak başta ülke kaynaklarının etkin ve verimli kullanılması olmak üzere sürdürülebilir ekonomik büyüme ve bilgi birikimi gibi pek çok faktöre önemli katkıları olmaktadır.

***Anahtar Kelimeler:*** *İnovasyon faaliyetleri, araştırma ve geliştirme, patent, faydalı model, maddi olmayan duran varlıklar*
***JEL Kodları:*** *M1, F65, O14*

***Alan:*** *İktisat*
***Türü:*** *Araştırma*

## 1. INTRODUCTION

Investing in innovation is one strategy to tackle increasing competition and uncertainty (Paula & Silva, 2019). Therefore, in such a competitive environment, companies need to take into account the importance of research and development. As intangible assets, R&D is seen as an important determinant of profitability as well as firm value. Therefore, the intangible asset investment made by the companies can increase the market performance of the product and service by increasing the competitive chance of company (Chauvin & Hirschey, 1993). Moreover, R&D investment leads to the production of new products and processes, providing sustainable growth for companies and contributing to increased business efficiency (Jung & Kwak, 2018). On the other hand, patents are also an important output of innovation activities and provide important technical resources when developing new products and processes (Chen & Chang, 2010). The utilization of this know-how leads to the importance of patenting activities and patent strategies are thus of great interest to businesses (Yuan & Li, 2019).

Several studies analyzed the effects of innovation on firm performance using various proxies of innovation performance, such as investments in R&D (Geroski, Machin & Van Reenen, 1993; Andras & Srinivasan, 2003; Ayaydın & Karaaslan, 2014; Chen & Wu, 2020; Chen, Guo, Chen & Wei, 2019), intangible assets (Darabi & Vojohi, 2013; Gamayuni, 2015; Aytekin, Sönmez & Ekinci, 2017; Mohanlingam, Nguyen & Mom, 2021), number of patents (Sohn, Hur & Kim, 2010; Chang, Chen & Huang, 2012; Takım, 2013; Öztürk, 2019), etc. Considering the existing studies, there are studies on the relationship between innovation activities and profitability using many country samples. These include the United Kingdom (Geroski et al., 1993), China (Chen & Wu, 2020), G7 countries (Usman, Shaique, Khan, Shaikh & Baig, 2017), Latin America (Paula & Silva Rocha, 2021). In addition to countries, the sectors that are analyzed include manufacturing, technology and banking. While Akgün and Akgün (2016) examined the data of Aselsan company, Altınbay, Altunal and Karaş (2017), Luca, Maia, Cardoso, Vasconcelos and Cunha (2014) used companies in the sustainability and innovation indexes, respectively. Dikici and Gürdal (2021) used data from both manufacturing and technology companies. Including financial institutions in their studies, Abebe Zelalem and Ali Abebe (2022) and Yanık, Dilmaç and Sumer (2018) conducted an analysis using the banking sector. However, among these sectors, there are mostly studies on the manufacturing sector (Doğan & Yıldız, 2016; Dağlı & Ergün, 2017; Geroski et al., 1993; Andras & Srinivasan, 2003; Bae, Park & Wang, 2008; Chen & Wu, 2020). In our study, an analysis was conducted for companies with research and development expenses in the manufacturing industry of Borsa Istanbul.

Nowadays, relatively less is known about the impact of innovation activities such as R&D, intangible assets and patents on firm performance both in Turkey and in other developed and developing countries (Ameer & Othman, 2020; Hirschey, Skiba & Wintoki, 2012). Accordingly, the contribution of the study to the literature will be as follows. The analysis was carried out using the data of a certain number of manufacturing companies with R&D expenditures in Borsa Istanbul. In the literature, there are many studies that focus on R&D, especially for manufacturing companies (Ayaydın & Karaaslan, 2014; Doğan & Yıldız, 2016; Dağlı & Ergün, 2017; Demir & Güleç, 2019). There are also studies such as Tatar (2010), Aytekin et al. (2017) that examine the relationship between intangible assets and profitability using the manufacturing sector. On the other hand, Takım (2013) and Demir and Soydoğan (2017) used patent/utility models for the manufacturing sector. In this regard, the first contribution of the study is to add intangible assets and the number of patents/utility to the model established for manufacturing companies in addition to R&D expenditures and to investigate their impact on firm performance. Thus, the contribution to the literature is investigated by revealing to what extent the impact of innovation activities as a whole will affect firm performance in the current period. Also, the impact of the number of patents and utility models on company performance may vary depending on various factors. In general, patents and utility models can have a positive impact on innovation and competitive advantage, market positioning, cash flow, risk mitigation and market entry; negatively in terms of costs and resources, innovation output and flexibility. Patents and utility models are therefore important factors that may affect company performance. The second contribution of the study is the addition of firm-level export and import intensities to the model. While exporting contributes positively to a company's market share, production capacity, competitive advantage, reduction in market research costs and technological know-how, importing has benefits for a company in terms of introducing new products to the market, reducing costs, becoming a leader and providing quality products. Taking these situations into consideration, it is expected that the addition of import intensity and export intensity to the established model will significantly affect innovation activities and have an impact on profitability.

This study's objective is to look into the link between innovation activities and profitability in the manufacturing industry of the Istanbul Stock Exchange. This data was gathered from companies listed on the Borsa Istanbul's manufacturing sector. The research was conducted using the 'Driscoll-Kraay standard errors random effects' method within the framework of panel data. For this purpose, the analysis was conducted using data from independently audited financial statements and comprehensive income statements of manufacturing companies with R&D expenditures between 2008 and 2021. The literature, hypothesis, data, methodology and results are explained in the following sections.

## 2. THEORETICAL BACKGROUND AND HYPOTHESES

The economist and political scientist J. Schumpeter, who first discussed and analyzed the concept of innovation, defined innovation as the establishment of a new production process. This includes a new good as well as a new organization, such as a merger or the creation of new markets. Schumpeter also defined innovation in terms of the cost of money (Schumpeter, 1939, p. 84-85). After Schumpeter, the Austrian management scientist Peter F. Drucker is the other person who talks about innovation. Drucker defined innovation as a special function of entrepreneurship, whether in an existing company, a public institution or an individually initiated venture (Drucker, 2002). Innovation is a development that leads to changes in the quality of life of individuals through changes made by companies in their products or production processes. This development is the result of a cultural environment and is a continuous phenomenon that benefits economic and social life (Kahraman & Taşkın, 2018, p. 10). Innovation is fundamentally aimed at solving company problems, and it does so for the sake of sustainability, leadership and company profitability (Emiroğlu, 2018, p. 5). Innovation by companies affects the growth rate of the economy at the macro level and increases profits and market share at the micro level. It also facilitates the living conditions of individuals and positively affects the welfare of society. Therefore, innovation is important not only for companies but also for consumers, society and the economy (Dinler Sakaryalı, 2016, p. 4).

R&D is one of the leading factors leading to innovation. OECD, Statistical Office of the European Communities (2006) define research and experimental development as "the creative work carried out on a systematic basis to increase the body of knowledge of people, culture and society and to use this body of knowledge to design new applications". R&D constitutes a constant process for the future goals of technology-based companies. In order for new products to be successful in the market, it is important to increase their efficiency and technical features by taking into account customer expectations (Kahraman & Taşkın, 2018, p. 31). Another one is patents or utility models. Turkish Patent and Trademark Office (2022) defines a patent as "monopoly rights granted to the patent owner for a limited time and place in order to prevent the invention from being produced, sold, used or imported by third parties without permission". Patent right, which has an important place among industrial property rights, is a right related to intangible assets, especially since it is seen as a technology transfer tool. Intangible assets, which are not fully reflected in the company's accounting records, are the assets needed for the company's sustainability, the ability to organize its production and services according to market conditions, to compete in its market and to innovate accordingly (Özaydın, 2019, p. 92).

The theoretical background of this study consists of innovation policies in the literature. In the literature, J. Schumpeter and F. Drucker have been the main authors in the definition and classification of innovation. On the other hand, there is a philosophical dimension that explains the innovation models followed by companies. In Roy Rotwell's article published in 1992, which is the main source for the emergence of innovation models, innovation models are explained by dividing them into different groups. These are the first generation innovation model (1950-mid 1960s), the second generation innovation model (mid 1960s-early 1970s), the third generation innovation model (early 1970s-mid 1980s), the fourth generation innovation model (1980s-early 1990s), and the fifth generation innovation models. In addition, the sixth generation model (innovative environment) has been later added to this classification. Based on these models and considering the studies in the literature, the effects of R&D spending, patents/utility models and intangible assets on firm performance are analyzed.

In the following sections, both national and international studies on R&D, intangible assets and patents are reviewed. The hypotheses of the study are also included here.

**2.1. R&D and Profitability**

Considering national studies, Ayaydın and Karaaslan (2014), Doğan and Yıldız (2016), Dağlı and Ergün (2017), Kalaycı (2019), and Demir and Güleç (2019), who analyzed data from BIST manufacturing firms, found a strong link between R&D and profitability. Özer, Öztürk and Özer (2019) did not obtain any results in the connection between R&D and profitability and market capitalization in their static panel analysis, while they obtained a positive relationship with both profitability and market capitalization in the dynamic panel study. Similarly, Işık, Engeloğlu and Kılınç (2016), who investigated the relationship between R&D and company profitability and sales using manufacturing industry data, found that R&D expenses contribute positively to both profitability and sales, but R&D intensity and R&D ratio does not significantly affect profitability and sales. The studies that have examined BIST manufacturing firms have consistently found a strong relationship between spending on research and development (R&D) and profitability. Some studies initially found no relationship in static analyses. However, dynamic studies found a positive relationship. Moreover, R&D intensity and R&D ratio do not have a significant impact on these measures, while R&D expenditure has a positive impact on profitability and sales. These findings underscore the critical role of R&D investment in the improvement of financial performance within the manufacturing sector.

On the other hand, in international studies, Geroski et al. (1993), who conducted research with manufacturing industry data in the United Kingdom, as well as Andras and Srinivasan (2003) and Bae et al. (2008), who used manufacturing industry company data in the United States, discovered a favorable connection between R&D and profitability. Gui-Long, Yi, Kai-Hua and Jiang (2017) and Chen and Wu (2020) discovered that R&D expenses had a favorable impact on firm performance. Similarly, Chen et al. (2019), who investigated the connection between research and development expenses and financial success of the semiconductor industry in China, discovered that the current year's R&D negatively affects the current business performance. The rationale for this is that R&D spending are represented in the financial accounts as company expenses, and hence an increase in company expenses in a particular year may be correlated with lower company performance. Shin, Kraemer and Dedrick (2017) examine the relationship between financial performance and R&D using data from firms in the semiconductor industry. They discover an inverse link between R&D activity and ROA. Overall, while some studies indicate a positive association between R&D spending and profitability, others suggest a more complex connection, influenced by factors such as industry specifics and accounting practices.

Geroski et al. (1993), Sher and Yang (2005), Karacaer, Aygün and İç (2009), Wang (2011), Dağlı and Ergün (2017), Chen and Wu (2020) and Özkan (2022) found a positive relationship between R&D and firm performance. Accordingly, the first hypothesis investigating the relationship between R&D expenses and profitability of companies is established as follows:

***Hypothesis 1:*** *R&D expenses of BIST manufacturing industry companies have a significant effect on corporate profitability.*

### 2.2. Intangible Assets and Profitability

In an analysis of national studies on the relationship between intangible assets and profitability, Tatar (2010) looked at the impact of research and development as an innovation indicator on financial performance. For this purpose, the data of 43 manufacturing industries traded on the IMKB for the period 2003-2008 is used. The findings show that R&D increase the company's profitability, and the intangible assets/total assets ratio has no effect on the profitability of the company. In a similar sector, Aytekin et al. (2017) focused on a related industry and analyzed the connection between R&D and financial success of businesses listed in the the Istanbul Stock Exchange chemical sector between 2008 and 2014. The findings indicate a statistically important and favorable connection between ROA and intangible asset to total asset ratio. Akdemir (2019) has demonstrated the long-term relationship between intangible property and net sales, equity, and share prices of firms. Overall, these findings emphasize the significance of intangible assets, especially R&D, in improving profitability across different sectors.

On the other hand, in international studies, the question of whether intangible assets are affecting the financial performance of companies has been investigated by Kaymaz, Yılmaz and Kaymaz (2019). To that end, for the years 2013 to 2017, an analysis was carried out using the data of the nonfinancial public companies listed on the Muscat Securities Market. Intangible assets are shown to have a big and favorable effect on financial performance. Darabi and Vojohi (2013) evaluated the association between intangible assets and performance ratios in companies quoted on the Tehran Stock Exchange between 2005 and 2011. The outcomes indicate a favorable and substantial connection between intangible assets and management performance. Using data from 2001 to 2010 for 562 companies listed on the Frankfurt and London Stock Exchanges, Tiron Tudor, Dima and Valeria Ratiu (2014) investigated the impact of intangible asset to total asset ratio on profitability. The findings reveal a relatively stable relationship between intangible assets and profitability. Gamayuni (2015) evaluated the interaction of intangible assets, financial policy, and financial performance of Indonesian listed businesses from 2007 to 2009. The findings reveal that intangible property are beneficial impact on company performance. Bhatia and Aggarwal (2018) found that investment in intangible assets positively affects the company performance in India. On the other hand, Mohanlingam et al. (2021), who analyzed the data of 33 firms traded on the Thai Stock Exchange between 2015 and 2019, discovered that intangible assets had a positive association on ROA. These findings underscore the importance of considering intangible assets in assessing and managing a company's financial performance.

Darabi and Vojohi (2013), Gamayuni (2015), Aytekin et al. (2017), Zhang (2017), Lopes and Carvalho (2021), who examined the relationship between intangible assets and financial performance in the literature, obtained positive results between intangible assets and financial performance. Accordingly, the second hypothesis, which investigates the relationship between intangible assets and profitability of companies, is established as follows:

***Hypothesis 2:*** *The percentage of intangible fixed assets to total assets of companies in the BIST manufacturing industry has a significant impact on the companies' profitability.*

### 2.3. Patents and Profitability

Takım (2013) analyzes the significance of R&D expenditures and patent applications the company's performance when examining the studies investigating the relationship between patent-utility model and profitability. It uses data from 21 manufacturing companies on the Istanbul Stock Exchange from 2000-2011. The results reveal that innovation and technological activities affect firms' market performance. Demir and Soydoğan (2017), who investigated the relationship between patents and company performance between 2009 and 2013 by selecting the first 50 companies from the list named "Turkey's Top 500 Industrial Enterprises-2013" by Istanbul Chamber of Industry, found that the number of patents has no relationship with ROA and ROE. Özturk (2019) found that patent/personnel variable negatively but significantly affects ROA and ROE. Taken together, these studies contribute to our understanding of how innovation activities, as measured by R&D expenditures and patents filed, affect the financial performance of manufacturing firms in Turkey. While some findings suggest a positive impact of innovation on market performance, others suggest more nuanced relationships, such as the lack of a direct correlation between the number of patents and financial measures such as ROA and ROE.

On the other hand, in international studies, using data from 50 German manufacturing firms between 1984 and 1992, Ernst (2001) analyzed the relationship between patenting and firm performance. National patent applications result in revenue growth 2-3 years after filing, but European patent applications result in revenue growth 3 years after filing. Chang et al. (2012) investigated the relationship between financial performance indicators and patent performance. For this purpose, the data between 1996 and 2009 of the companies with the highest global prescription drug sales in the 2010 PharmExec 50 were analyzed. The results show that the Patent H index and the current impact index are related to market capitalization, revenue, and return on equity in a positive way. Sohn et al. (2010) investigated whether R&D and patents affect financial performance in a study conducted in Korea. The findings reveal that R&D and patenting have no meaningful impact on financial performance. In brief, there are mixed results from studies on patenting and firm performance. Some studies suggest that patents lead to sales growth, while others find no effect. This difference may depend on factors such as industry, patent quality, and market dynamics. Overall, the relationship between patenting and firm performance is complex.

Ernst (2001), Takım (2013), Zhang, Rong and Ji (2019), and Yuan, Hou and Cai (2021), who examined the relationship between patents and utility models and profitability, found a positive relationship between patents and financial performance. Accordingly, the third hypothesis, which investigates the relationship between patent/utility models and profitability of companies, is established as follows:

***Hypothesis 3:*** *The number of patents and utility models per employee of companies in the BIST manufacturing industry has a significant impact on the companies' profitability.*

## 3. DATA, VARIABLES AND METHODOLOGY

### 3.1. Dataset and Variables

The study is conducted using the panel data analysis method by obtaining data from companies listed in the manufacturing sector of Borsa Istanbul. For this purpose, the analysis was carried out using data from independently audited financial statements and income statements of 45 manufacturing companies with R&D expenditures between 2008 and 2021. The most important reason for choosing 2008 as the beginning of the study is that some manufacturing companies have started to invest in research and development since this year. In other words, when we go backwards from 2008, the number of companies investing in research and development decreases. STATA 16 package program was used to investigate the relationship between innovation activities and profitability.

Table 1 displays the types, abbreviations, and explanations of the variables used in the analysis to measure the connection between innovation and activity and profitability of manufacturing firms. The dependent variable is the ROA variable, which represents the company's profitability. The reason for using return on assets in this study is that this variable has been used in many studies both in the national and international literature. In fact, another reason is that it is appropriate to use the return on assets variable since it will be the main basis for linking the results to the literature. On the other hand, return on equity was also analyzed. However, since the findings obtained were not statistically significant, they were not shared in the study. In other words, in the analysis where return on equity is used, the coefficients as well as the model itself are not reported in the study since they are not significant and the explanatory coefficient is very low. As independent variables, the variables lnR&D, IA/TA, and PAT/EMP, which indicate innovation activities, are employed. IMP, EXP, and LEV are firm-specific variables. Data for every variable in the research were gathered from the

FINNET software and annual reports of corporations available on the Public Disclosure Platform's website.

**Table 1:** Variables and Explanation

| **Dependent Variable** | | **Explanation** | **In Literature** |
|---|---|---|---|
| Firm Profitability Variable | ROA | Return on Assets Ratio<br><br>(net profit/loss for the period/total assets) | Qian and Li (2003), Bae et al. (2008), Karacaer, et al. (2009) |
| **Independent Variables** | | **Explanation** | **In Literature** |
| Innovation Activities Variables | lnR&D | Logarithm of Research and Development Expenses | Akgün and Akgün (2016), Altınbay et al. (2017), Güzen and Başar (2019) |
| | IA/TA | Intangible Assets/Total Assets | Darabi and Vojohi (2013), Luca et al. (2014), Demirhan and Aracıoğlu (2017) |
| | PAT/EMP | Number of Patent-Utility Model Registrations/Number of Personnel | Almeida, Hsu, and Li (2013), Öztürk (2019) |
| **Control Variables** | | **Explanation** | **In Literature** |
| Firm-specific Variables | IMP | Import Intensity (Imports/Net Sales) | Geroski et al. (1993), Mahajan, Nauriyal, and Singh (2018) |
| | EXP | Export Intensity (Exports/Net Sales) | Gui-long et al. (2017), Aksoy and Göker (2020), Özkan (2022) |
| | LEV | Financial Leverage Ratio<br><br>(Total Debt/Total Assets) | Qian and Li (2003), Bae, Park, and Wang (2008), Wang (2011), Ayaydın and Karaaslan (2014) |

The list of manufacturing companies included in the analysis is shown in Table 2. This list includes company codes and the sector, in which they are located. Metal products, machinery, and electrical equipment have the most companies (13 in total). This is followed by the textile, clothing, and leather sector with eight companies. There are six companies in the chemical, pharmaceutical, petroleum, rubber, and plastics industries; six in the stone and earth industry; five in the food, beverage, and tobacco industry; three in the paper and paper products industry; three in the basic metals industry; and one in the forest products and furniture industry.

**Table 2:** List of Manufacturing Firms

| Firm Code | Sectors |
| --- | --- |
| CEMTS | METAL INDUSTRY |
| DMSAS | |
| EREGL | |
| KERVT | FOOD, BEVERAGES AND TOBACCO |
| PNSUT | |
| KRSTL | |
| PETUN | |
| ULKER | |
| ALKIM | PAPER AND PAPER PRODUCTS |
| BAKAB | |
| VKING | |
| AKSA | CHEMICAL, PHARMACEUTICAL, PETROLEUM, TIRE AND PLASTIC PRODUCTS |
| ALKA | |
| AYGAZ | |
| DYOBY | |
| PETKM | |
| TUPRS | |
| ALCAR | TRANSPORTATION VEHICLES AND MACHINERY ELECTRICAL EQUIPMENT |
| ASUZU | |
| ARCLK | |
| EGEEN | |
| FROTO | |
| DITAS | |
| IHEVA | |
| OTKAR | |
| PRKAB | |
| TOASO | |
| TTRAK | |
| VESTL | |
| VESBE | |
| GENTS | FOREST PRODUCTS AND FURNITURE |
| BUCIM | STONE AND SOIL |
| CIMSA | |
| EGSER | |
| NUHCM | |
| OYAKC | |
| USAK | |
| ATEKS | TEXTILES, CLOTHING AND LEATHER |
| BOSSA | |
| DESA | |
| YATAS | |
| KRTEK | |
| KORDS | |
| SKTAS | |
| YUNSA | |

**Source:** Public Disclosure Platform

### 3.2. Research Model

We develop an econometric model that investigates the association between firm profitability and innovation activity for manufacturing companies. The model's independent variable is return on assets. R&D expenses, intangible asset to total asset ratio, the number of patent and utility model registrations, import intensity, export intensity, and financial leverage ratio are used as independent variables. The econometric model established to investigate this relationship is presented as follows:

$$ROA_{it} = a_{it} + \beta_1 lnR\&D_{it} + \beta_2 IA/TA_{it} + \beta_3 PAT/EMP_{it} + \beta_4 IMP_{it} + \beta_5 EXP_{it} + \beta_6 LEV_{it} + u_{it}$$

where sub-index "i" (=1, 2, 3,...., N) represents companies and sub-index "t" (between 2008 and 2021) represents time. $ROA_{it}$, annual rate of return on assets; $a_{it}$, constant parameter; $lnR\&D_{it}$, logarithm of annual research and development expenditures; $IA/TA_{it}$, annual rate of intangible assets in total assets; $PAT/EMP_{it}$, annual ratio of number of patent and utility model applications to number of employees; $IMP_{it}$, annual import intensity; $EXP_{it}$, annual export intensity; $LEV_{it}$, annual financial leverage ratio, and $u_{it}$ denotes the error term.

In econometric analysis, there are three types of data: time series, cross-sectional data, and panel data (Tatoğlu, 2020, p. 1). The panel data analysis method was applied in this investigation. Panel data is a collection of horizontal cross-sectional observations of units such as persons, countries, firms, and households during a specific time period. Panel data is made up of N units and T observations for each unit. For example, the daily return rates of stocks traded on BIST-30 in 2019 or the number of workers employed in manufacturing industry companies in the period 2000-2021 (Tatoğlu, 2021, pp. 1-2). Panel data can be defined as a balanced panel or an unbalanced panel, according to the type of data. Balanced panels are those in which each unit is observed at each point in time, and unbalanced panels are those in which data are missing for any unit at any point in time (Sarıkovanlık, Koy, Akkaya, Yıldırım & Kantar, 2019, pp. 167-168).

Before estimating the model, there is a preference stage for the pooled model or the fixed model. At this stage, if the pooled model is rejected, the Hausman test is applied, and the efficient estimator type is determined. We also use tests for multicollinearity, autocorrelation, variance transformation, and cross-sectional dependence to assess whether the panel data assumptions have been met. Once all these steps are in place, the next step is the estimation of the model. The model is estimated using Driscoll-Kraay's (1998) standard errors. Driscoll-Kraay (1998) standard errors are used because they are robust to autocorrelation and heteroskedasticity and crosssectional dependence. Likewise, the Driscoll-Kraay's (1998) approach is more proper than the Beck-Katz (1995) approach when the quantity of cross segments (N>T) is huge (Knight, 2014, p. 38). Notwithstanding, it is vital to take note of that Driscoll and Kraay's technique is pertinent to both fixed and arbitrary impacts models, while Beck, Katz, and Newey-West (1987) just apply it to pooled models.

## 4. ANALYSIS AND FINDINGS

The model's analysis and findings are provided in this section. It comprises testing of fundamental assumptions, correlation coefficients, choice of estimator type, and model estimates in addition to variables' statistical description.

**Table 3:** Descriptive Statistics

| Variable | Number of Observations | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| ROA | 630 | .0595482 | .0853716 | -.2590242 | .4330926 |
| lnR&D | 630 | 13.80773 | 4.225659 | 0 | 20.33837 |
| IA/TA | 630 | .0225282 | .0360641 | 0 | .2360121 |
| PAT/EMP | 630 | .0013369 | .0042013 | 0 | .0603865 |
| IMP | 630 | .2680763 | .1904052 | 0 | .8384196 |
| EXP | 630 | .349101 | .8152096 | .0042706 | 19.8964 |
| LEV | 630 | .5187029 | .2242119 | .0638487 | 1.292403 |

The sample's descriptive statistics, which comprise 630 observations from the manufacturing sector of Borsa Istanbul, are shown in Table 3. The variables for ROA, lnR&D, IA/TA, PAT/EMP, IMP, EXP, and LEV are displayed in the table along with their mean, standard deviation, minimum, and maximum values. Accordingly, lnR&D has the highest mean value at 13.81. lnR&D has the highest standard deviation value at 4.23. A high standard deviation shows a lot of variation in the data around the mean of the relevant variable, indicating that the data is highly scattered. For example, since the PAT/EMP variable has the lowest standard deviation, the data for that variable clusters more tightly around the mean. When the minimum value is analyzed, the ROA variable contains the lowest value. When the maximum value is analyzed, the values in the data set of the lnR&D variable contain the highest value compared to the values in the other variable's dataset.

**Table 4:** Correlation Coefficients of Variables

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | VIF |
|---|---|---|---|---|---|---|---|---|
| ROA (1) | 1 | | | | | | | 1.22 |
| lnR&D (2) | 0.06 | 1 | | | | | | 1.15 |
| IA/TA (3) | 0.11 | 0.23 | 1 | | | | | 1.13 |
| PAT/EMP (4) | 0.17 | 0.19 | 0.33 | 1 | | | | 1.11 |
| IMP (5) | -0.02 | 0.11 | 0.06 | 0.08 | 1 | | | 1.03 |
| EXP (6) | -0.00 | -0.13 | 0.03 | 0.05 | 0.00 | 1 | | 1.03 |
| LEV (7) | -0.43 | 0.21 | 0.24 | 0.07 | 0.15 | -0.03 | 1 | 1.22 |
| Mean VIF | | | | | | | | 1.11 |

The Pearson correlation between the variables is displayed in Table 4. The table illustrates whether the variables have a positive or negative connection. However, there are no binary variables that are highly correlated with each other. In addition, the same table shows the results obtained using the Variance Inflation Factor test. According to this test, it can be said that there is no multicollinearity since the mean VIF value is less than 5, i.e., (1.11<5). But moreover, analyzing the results of the auxiliary regression using the variables lnR&D, IA/TA, PAT/EMP, IMP, EXP, and LEV, we can observe that each variable's VIF value was less than 5, indicating that there were no variables that would cause multicollinearity. This shows that there is no variable that would cause multicollinearity.

**Table 5:** Test Statistics for the Specification of the Model

| | Tests | Preference | Test Statistics | Estimator |
|---|---|---|---|---|
| Testing the Pooled Model | F-Test | Pooled / Fixed | 11.31 (0) | Fixed |
| | Breusch-Pagan Lagrange Multiplier Test (LM) | Pooled / Random | 418.88 (0,000) | Random |
| Fixed Effects vs. Random Effects? | Hausman Test | Fixed / Random | 4.85 (0,563) | Random |
| | Cluster-Robust Hausman Test | Fixed / Random | 1.92 (0,927) | Random |

**Note:** The p-value is denoted by (,).

Table 5 presents the F-statistic and probability value for the two-way model validity test. The F-statistic finding rejects the null hypothesis $H_0$ that the unit and time effects are equal to zero. Accordingly, it is clear that the pooled model does not hold and that there is at least one effect that does. One test used to evaluate the validity of the pooled model is the Breusch-Pagan (1980) Lagrange Multiplier Test (LM). The pooled model is inappropriate because the zero hypothesis, $H_0$, which asserts that unit effects variance is equal to zero, is rejected based on the findings of the LM test. Selecting between estimators is also done using the Hausman test, which was created to test for identification error. In Table 5, the Hausman specification test is utulized to compare the random effects with a one-way unit effect to the fixed effects. In accordance to the Hausman test statistic result, the zero hypothesis $H_0$ that "the random effects is efficient" cannot be rejected, and the random effects estimator is consistent. For the random effects model to be fully efficient under the null hypothesis, the model should be free of efficiency-distorting factors like heteroskedasticity and autocorrelation. Otherwise, the Hausman test is unreliable. Here, we obtain a version of the Hausman test that uses the robust variances obtained by boostrap. According to the cluster-robust Hausman test in the table, it is clear that the random effects estimator is efficient. If we compare this result with the Hausman test statistic, then both of the test statistics show that the random effects estimator is consistent.

**Table 6:** Efficiency-Distorting Assumptions Test Results

| **Tests** | | **Results** |
|---|---|---|
| Autocorrelation | modified Bhargava and co. DW | 1.094 |
| | BW LBI | 1.387 |
| Heteroscedasticity | Levene, Brown and Forsythe's Tests | 3.928 (0,000) |
| Cross-sectional Dep. | Pesaran's CD test of cross sectional independence | 20.105 (0,000) |

**Note:** (,) denotes p-value.

Table 6 displays the outcomes of the tests for autocorrelation, heteroskedasticity, and cross-sectional dependence, which are the main assumptions that are obstacles to efficiency. The table presents the DW test proposed by Bhargava, Franzini, and Narendranathan (1982) and the LBI test statistics proposed by Baltagi-Wu (1999) for autocorrelation. As shown, both test values are less than the critical value of 2 in the random effect, indicating the first-order autocorrelation' presence in the random effects model. autocorrelation in the random effects model. Levene, Brown and Forsythe's (1974) test statistics for heteroskedasticity are compared with Snedecor's F table, and the zero hypothesis $H_0$, which states that "the unit variances are equivalent" is rejected and the existence of heteroskedasticity is accepted. The table also includes Pesaran's (2004) cross-sectional dependence test as one of the inefficiency tests. When the relevant test statistic and probability values are analyzed to test the null hypothesis that no cross-sectional dependence is present, the $H_0$ hypothesis is rejected, and he conclusion is that cross-sectional dependence exists.

The model is subject to autocorrelation, heteroscedasticity, and cross-sectional dependence. In the case of estimation by neglecting autocorrelation, the parameters are consistent but not efficient. In such a situation, the standard errors will be biased. Therefore, if the model contains at least one of heteroskedasticity, autocorrelation, or cross-sectional dependence, standard errors can be corrected by leaving parameter estimates unchanged or estimating with appropriate methods. For this purpose, random effects regression with Driscoll-Kraay standard errors was applied in this study.

**Table 7:** Driscoll-Kraay Estimation with Standard Errors

| Dependent Variable: ROA | | | | |
|---|---|---|---|---|
| Independent Variables | Coef. | Drisc/Kraay Standard Error | t | P > \|t\| |
| lnR&D | .0015962 | .00062 | 2.57 | 0.023** |
| IA/TA | .2335358 | .1170728 | 1.99 | 0.067* |
| PAT/EMP | 2.30449 | .6891412 | 3.34 | 0.005*** |
| IMP | -.0124402 | .0231877 | -0.54 | 0.601 |
| EXP | -.0033612 | .0009999 | -3.36 | 0.005*** |
| LEV | -.1582313 | .032501 | -4.87 | 0.000*** |
| C | .1157502 | .0326782 | 3.54 | 0.004 |

| | |
|---|---|
| Number of Observation | 630 |
| Number of Group | 45 |
| $R^2$ | 0,2583 |
| F-Statistics | 46,82 (0,000) |

Notes: ROA, Return on Assets Ratio; lnR&D, Logarithm of Research and Development Expenses; IA/TA, Intangible Assets/Total Assets; PAT/EMP, Number of Patent-Utility Model Registrations/Number of Personnel ; IMP, Import Intensity (Imports/Net Sales) ; EXP, Export Intensity (Exports/Net Sales) ; LEV, LEV Financial Leverage Ratio (Total Debt/Total Assets). The symbols ***, **, and * represent significance criteria of 1%, 5%, and 10%, respectively. The p-value is denoted by (,).

The results of estimating using Driscoll-Kraay standard errors are shown in Table 7. The total number of observations utilized in the estimation is 630, and the number of firms (number of groups) is 45. According to the Driscoll-Kraay model estimation results, the F-Test reflecting the model's significance is significant, and the $R^2$ value for the entire model is 25%. The statistical significance of the individual parameters in the model indicates that, apart from the independent variables IMP (import intensity), all other factors, namely lnR&D (R&D expenses), IA/TA (intangible assets to total assets ratio), PAT/EMP (ratio of patents and utility models to employees), EXP (export intensity), and LEV (financial leverage ratio), have a significant effect on the dependent variable ROA.

R&D has a favorable and considerable influence on return on assets at the 5% level. Accordingly, research and development (R&D) as part of innovation activities positively impacts a company's performance. This result supports the hypothesis that R&D spending by BIST manufacturing firms has a significant impact on firm profitability. The intangible asset to total asset ratio is acceptable and statistically significant influence on return on assets at the 10% level. Therefore, intangible asset to total asset ratio contributes positively to corporate profitability. This finding supports the hypothesis that implies a significant effect of intangible asset to total asset ratio on the corporate profitability of BIST manufacturing industry companies. The effect of the ratio of the number of patent-utility model registrations to the number of employees on return on assets is both favorable and significant at the level of significance of 1%. According to the findings, the number of patents and utility models has a beneficial impact on corporate profitability. Such a result is consistent with the hypothesis that ratio of patents and utility models to employees in BIST manufacturing industry companies has a significant effect on corporate profitability.

Furthermore, there is a negative but statistically insignificant relationship between import intensity, which is used as a control variable, and return on assets. However, here is a disadvantage and statistically substantial connection between export intensity and return on assets at the 1% level. Although there's an unfavorable association between import intensity and return on assets, it is statistically negligible. The relationship between export intensity and return on assets is negative and statistically significant. In other words, exports have a detrimental impact on the return on assets. In addition, there is a disadvantage and statistically substantial connection between the financial leverage ratio, which is another control variable, and return on assets at the 1% level.

## 5. DISCUSSION AND CONCLUSION

In this study, using data from manufacturing companies listed on the Borsa Istanbul, the Driscoll-Kraay standard errors random effects method was used to find out the impact of innovation activity on firm profitability in the Turkish Capital Market. The examination is based on data from the independently audited financial statements and comprehensive income statements of 45 manufacturing companies with R&D spending between 2008 and 2021.

According to the study's findings, there is a favorable and strong relationship between innovation activities and corporate profitability. The impact of R&D, which is the first of the variables used in innovation activities, on return on assets is both positive and significant at the significant level of 5%. Based on this finding, the first hypothesis, which states that R&D expenditures of BIST manufacturing industry companies have a significant effect on corporate profitability, is accepted. This result is consistent with the studies conducted by Andras and Srinivasan (2003), Bae, Park and Wang (2008), Karacaer et al. (2009), Wang (2011), Kocamış and Güngör (2014), Dağlı and Ergün (2017), Demir and Güleç (2019) and Chen and Wu (2020).

The second variable considered in the context of innovation activities, the intangible asset to total asset ratio, has a favorable and statistically substantial effect on return on assets at the 10% level. As a result, the second hypothesis—which holds that corporate profitability is significantly impacted by intangible asset to total asset ratio of BIST manufacturing industry companies—is accepted.

Tiron Tudor et al. (2014), Andonova and Ruíz-Pava (2016), Zhang (2017), Lopes and Carvalho (2021), and Mohanlingam et al. (2021) have comparable results to this one.

The last variable used within innovation activities, the ratio of number of patent-utility model to number of employees, has a statistically significant beneficial impact on ROA at the 1% level. Therefore, the third hypothesis, that the number of patents and utility models per employee of BIST manufacturing industry companies has a significant effect on corporate profitability, is also accepted. This finding is compatible with the outcomes obtained from the studies carried out by Ernst (2001), Takım (2013), Abdol Ghapar, Brooks and Smyth (2014), Sezer, Çetin Gürkan and Aktaş (2017), Zhang, Rong and Ji (2019) and Yuan et al. (2021).

In addition to the variables of innovation activities, the variables of import intensity, export intensity, and debt-equity ratio are used as control variables in the study. Whereas the connection between import intensity and ROA is negative but not significant, the relationship between export intensity and ROA is substantial and adverse at the 1% level. Another control variable, the leverage ratio, has a negative association with ROA at the 1% level.

This study, which examines the relationship between innovation activities and profitability, has found that innovation activities of manufacturing companies with research and development expenses in Borsa Istanbul positively affect firm profitability. In other words, in addition to R&D expenditure as an innovation activity, it is revealed that intangible assets and the number of patents/utility models together have a positive effect on profitability. The inclusion of the number of patents/utility in the model has contributed to the literature, especially with the studies of Takım (2013) and Demir and Soydoğan (2017) in the literature. In addition, examining the effect of firm-level export and import on firm profitability together with innovation activities and obtaining different results has contributed to the literature. Considering the theoretical background on which the study is based, it can be stated that each innovation model rather than a single innovation model can help to achieve a positive relationship between innovation activities and profitability. It can be emphasized that this situation may change depending on the sector, innovation objectives and available resources of the firm. As a result, when an evaluation of the relationship between innovation activities and profitability is made on an in practice scale, it can be said that from a micro perspective, it contributes to companies to gain competitive advantage, to the effective operation of existing production systems and to increase the market share of companies, while from a macro perspective, it will contribute to many factors such as the effective and efficient use of national resources, sustainable economic growth and knowledge accumulation by increasing the welfare level of the society.

For future studies, some limitations of this study can be mentioned. It is recommended to conduct an analysis using patent data as well as the number of trademarks and designs in Borsa Istanbul, especially covering companies with R&D expenditures, in a longer time dimension. In addition, if a sectoral analysis is to be conducted, the effect on profitability can be examined by building a model that includes all firms with or without R&D expenditures.

## 6. CONFLICT OF INTEREST STATEMENT

There is no conflict of interest between the authors.

## 7. FINANCIAL SUPPORT

This study got no specific funding from any agency

## 8. AUTHOR CONTRIBUTIONS

The authors' contributions to the study are equal.

## 9. ETHICS COMMITTEE STATEMENT AND INTELLECTUAL PROPERTY COPYRIGHTS

The study does not require clearance from an ethics commission.

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