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The effect of gender diversity on eco-innovation

By ECATERINA PATRAS (s1061187)

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Program: Master's Program in Economics
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Supervisor: Dr Katarzyna Burzynska

Radboud Universiteit

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Introduction

Europe faces environmental challenges of unprecedented scale and urgency, as put forward in the 6th State of the Environment report presented by the European Environment Agency in 2020[1]. Biodiversity loss, resource use, and climate change are among the main risks that harm our environment, our health, and our well-being. The report also emphasizes that EU environmental and climate policies will not be able to deliver the Green Deal objectives in time if Europe does not act fast and firm in implementing its environmentally-safe strategies. Therefore, working together towards building a sustainable economy that does not harm the environment is of utmost importance.

According to the Organization for Economic Cooperation and Development (OECD), companies play an important role in the transition toward a greener economy. Accordingly, firms have to change their management strategies and create new business values to successfully achieve targeted environment-friendly economic outcomes. Scholars believe that firms that implement environmentally sustainable economic behaviour can benefit twofold: by advancing with a competitive advantage in the market (Cai & Li, 2018; Guerlek & Tuna, 2018; Hojnik & Ruzzier, 2016) and by creating a harmonious relationship between business activities and the environment. Green innovations, also known as eco-innovations are the mechanism through which companies can successfully achieve these aspirations. They describe the willingness of the companies to use technology that brings environmental benefits rather than alternatives (Kemp & Pearson, 2007).

Behind the curtain of eco-friendly guidelines are the top managers. They are involved in the decision-making processes within the company (Boeker, 1997). One dominant theory explains the corporate governance importance and the effect of board composition. The resource dependence theory delineates the main function of a corporate board, which is the provision of the fundamental resources to the company (Hillman & Dalziel, 2003). Moreover, it emphasize that board structure, such as gender diversity is of great significance as it is tightly related to each member's ability to bring resources and provide unique expertise.

[1] Source: https://www.eea.europa.eu/soer/2020

According to the prior literature, diversification within the leading team plays an important role to the strategic change of the company (Boeker, 1997; Wiersema & Bantel, 1992). Diversification relates to different demographic features and characteristics in the boardroom. It covers the advantage of promoting people with new, unique perspectives that influence the business models and decision-making within the company. It fosters creativity, and new ideas, and brings people with different interests and orientations to the discussion table (Aida, 2009).

Empirical evidence suggests that diversification based on gender has a positive effect on companies' performance (Joecks et al., 2013), innovation (Bantel & Jackson, 1989; Østergaard et al., 2011), and environmental-friendly innovation (Galia et al., 2015; He & Jiang, 2019; Orazalin & Mahmood, 2021). The reasoning behind this effect can be explained by gender socialization theory and social role theory of leadership. The former describes women as being altruistic and egalitarians (Ahern & Dittmar, 2012; Andreoni & Vesterlund, 2001). The latter suggests that women have a less hierarchical and more democratic style of management that encourage group participation (Rosener, 2011). These gender-based characteristics can be decisive in turning points of strategic management.

Drawing on gender socialization theory, social role theory of leadership, and, based on the prior literature on female board representation (He & Jiang, 2019; Konadu et al., 2022), the first hypothesis predicts that firms with greater female board representation are more successful in developing eco-innovations. The second hypothesis examines the robustness of critical mass theory, which states that only a threshold of minimum of three women can influence the environmental behaviour of a company (Konadu et al., 2022).

In conformity with He and Jiang (2019), to test these hypotheses, I include “green patents” as dependent variables which can measure eco-innovations. They describe patented innovations that are related to alternative energy production systems.

In the literature, much of the research is focused on the contribution of gender diversification to innovation (Miller and Triana, 2009; Østergaard et al., 2011; Torchia et al., 2011). This allows for robust estimations and increased credibility in the results. Very less research has been done with the focus on sustainable innovation (Díaz-García et al., 2013; Ruiz-Jiménez et al., 2016; Galia, Zenou and Ingham, 2015). This research adds value to the previous studies threefold. Firstly, to my knowledge, the implied method of using green patents by filtering out alternative energy production is not used before. Secondly, He and Jiang (2019) includes green patents as independent variables on Chinese companies, however, this study is focused on European firms. And finally, the study brings new significant findings that can contribute to the corporate governance literature.

The results of the paper show that increased female representation in the board of directors lead to a higher level of environmental innovations. The results are robust when using another model specification.

Unfortunately, because of the persistent gender biases, (Bigelow et al., 2014; Knippen et al., 2019; McDonald & Westphal, 2013), some companies or even some governments can be reluctant, or try to postpone the implementation of gender diversification regulations. In light of gender equality gaps and increasing concerns about environmental issues, this study's investigation of the effect of gender diversity on eco-innovations is significant and appropriate.

The research paper proceeds as follows. Chapter II describes the prior literature on the effect of gender diversification on innovation, and sustainable innovation. As well, it includes the application of the prior theoretical framework to construct the research question and hypothesis. Chapter III describes the data and methodological approach. Chapter IV presents the findings of the paper. Finally, chapter V includes concluding remarks, limitations and recommendations for future research.

1 Literature review and hypothesis development

This chapter focuses on the analysis of the previous literature on the role of the board of directors in the company as well as how the board gender diversity can change the dynamics of corporate management. As this research concentrates on eco-innovation, the next sections will analyze the prior literature on the effects of board gender diversity on innovations and eco-innovations. The final part of the chapter will include the gender-based characteristics that drive the effect as well as the formulation of the hypothesis.

1.1 Board gender diversity and decision making

Resource dependence theory describes one of the most important functions of a board, namely the ability of the board to provide essential resources to the organization (Hillman & Dalziel, 2003). According to Hillman and Dalziel (2003) from resource dependence theory, the activity of administering resources includes providing counselling, linking the firm to important stakeholders, getting access to capital, developing external connections, and giving expertise. Moreover, critical resources also contain knowledge, skills, and experience, as well as suppliers, buyers, customers, and social groups (Hillman et al., 2000). It can be assumed that these critical contributions of the board can support the firm's performance in the environmental area, promoting ecological innovative ideas.

In the earlier stages of research on corporate governance, scholars found that board composition (e.g., board size, percentage of outside directors) affects firm performance (Boyd, 1990). Hillman et al. (2000) further develop the resource dependence theoretical perspective suggesting that a more diverse board can have a positive impact on economic performance. Given the unique attributes of each member, the diversity of the board is related to the heterogeneity of the resources and skills they can bring to the organization (Hillman et al., 2000). Based on the availability of the variety of resources, board diversity (incl. gender, ethnicity and, age) affects the firm's long-term financial performance and competitive strategy (Robinson & Dechant, 1997). Moreover, a gender-balanced board holds a mix of resources which leads to improved economic performances (Ali et al., 2014; García-Meca et al., 2015; Low et al., 2015; Reguera-Alvarado et al., 2017), firm value (Carter et al., 2003), and stronger compliance with social ethical principles (Isidro & Sobral, 2015).

This research investigates one component of board composition which is gender diversity, where an increased number of female representation is expected to affect the pro-environmental innovative behaviour of the organization. A company's green aspirations require powerful resources for ecological innovations. Based on the resource dependence theory, we can predict that gender diversity can improve the ability to gain these extensive resources.

1.2 Gender diversity and innovation

The term “eco-innovation” can be divided into two segments. First one is “innovation”, which is defined as “the adoption of a change which is new to an organization and to the relevant environment” (Knight, 1967). Consequently, being closely connected to change, innovation demands certain business models, that require genuine abilities of the executives and the workforce. For Ruiz-Jiménez et al. (2016) innovation summarizes “the organization's ability to adopt and implement new ideas, processes, or products successful”. Furthermore prior studies describe innovation as a social process where individuals interact with each other (Østergaard et al., 2011). Each member’s unique attributes bring new perspectives and different viewpoints (Adams & Funk, 2012; Díaz-García et al., 2013), which, in conclusion, facilitates knowledge combination (Ruiz-Jiménez et al., 2016). Different ideas between managers are the key ingredient towards innovative thinking, which enables the improvement of management strategies. Heterogeneity plays a central role in the strategic decisions firms choose to undertake (Talke et al., 2010), as different views increase the likelihood of introducing an innovation (Østergaard et al., 2011).

Diversity is defined as “a characteristic of a group (of two or more people) which refers to demographic differences among group members in race, ethnicity, gender, social class, religion, nationality, sexual identity or other dimensions of social identity that are marked by a history of intergroup prejudice, stigma, discrimination or oppression” (Ramarajan & Thomas, 2010, p. 4). Diversity in the human and social capital has an impact on the innovation strategies (Bantel & Jackson, 1989) and contributes to a better economic performances of a firm (Singh et al., 2008). In this study the focus is on gender diversity, i.e., the percentage of individuals within a group that are represented by men or women, and its contribution to innovation levels, including the environmentally-friendly objectives.

Campbell and Mínguez-Vera (2008) find that there is a positive relations between women’s board representation and the firm value. They also suggest that the effect is one way, the board female representation affects performance and not the other way around. A study on German market, indicates that gender diversity negatively affects firm performance initially and only after a minimum of 30% of women is reached, the effect leads to a higher firm performance (Joecks et al., 2013). In contrast, Rose (2007) shows different results which suggest that woman board representation has no significant effect on firm's performance: "board members with an unconventional background are socialised unconsciously adopting the ideas of the majority of conventional board members, which entails that a potential performance effect does not materialise".

In support of the link between female representation and innovation comes the study of Díaz-García et al. (2013) which shows that " gender diversity within R&D researchers generates certain dynamics that foster novel solutions leading radical innovations[2]". These innovations require interpersonal skills and high work dynamics within the group. Gender diversity improves such developments favouring radical innovations. Ruiz-Jiménez et al. (2016) focused on the effect of the gender diversity within the top management teams. Their results suggest that gender heterogeneity coordinates the relationship between knowledge combination and innovation performance. Further analyses suggest that board gender diversity facilitate a more failure-tolerant and long-term thinking environment and promotes corporate cultures based on innovative thinking and heterogeneity in inventors (Griffin et al., 2021). These properties play an important role in increasing the innovative performances of the company. In contrast to earlier findings, however, there are studies showing negative relation between female board representation and firm's value (Ahern & Dittmar, 2012; Chen et al., 2016). An explanation of the results empathizes the ambiguity of "intra-board social psychological dynamics" that would result in "more exhaustive evaluations" (Ahern & Dittmar, 2012).

1.3 Gender diversity and eco-innovation

"Eco-" or "ecological" is the second segment of the "eco-innovation" term. It refers to the relationship between the living things and the environment. When thinking about the accomplices of the negative environmental impacts, firms and industries can be found at the top of the ladder. In accordance with the EU's objectives of achieving a greener economy, corporates

[2] According to Cristina Díaz-García et al. (2000) radical innovations are those that involve drastic changes and are related to high technological and market uncertainty. These radical innovations are important because they increase competitive advantages and create opportunities in opening new markets.

should make significant improvements in their business practices and act in harmony with nature. They are encouraged to develop eco-innovations, which allow the development of products and services that benefit the environment.

Environmental focused strategies include the development and implementation of eco-innovations. They are defined as “the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives” (Kemp & Pearson, 2007). The implementation of eco-innovation is a complex phenomenon that faces many challenges (He & Jiang, 2019). Environmental innovations demand knowledge intensive competences, which includes corporate’s sensitivity and dependence to external information and knowledges (De Marchi, 2012; Horbach et al., 2013). Therefore, top managers are expected to have strong motivation for a sustainable way of thinking, they have to be opened about structural changes, market uncertainties and expect challenges.

The empirical evidence provided by He and Jiang (2019) suggest that women at the top management play a positive role in developing firm's active environmental strategies, improving corporate governance along the environmental dimension. Women have a stronger commitment to green entrepreneurship (Braun, 2010) and increase corporate environmental performance (Elmagrhi et al., 2019). Other results show that greater board gender diversity is linked to less corporate environmental violations (Liu, 2018) and increases the board effectiveness on corporate social responsibility (Wang et al., 2021). Drawing from the eco-feminist theory and natural resource based theory, Pan et al. (2020) researched the question “how” female representation in the board influences the environmentally friendly behaviours. They found that women minimize unethical environmental behaviours within the company and are adepts of implementing environmental strategies.

Emphasizing on the eco-innovations, many researchers find significant evidence of positive relationship between gender diversity and innovation activities in the environmental sector. Based on the data of community surveys of French firms (Galia et al., 2015), survey of German firms (Horbach & Jacob, 2018), as well as results of firms from USA (Nadeem et al., 2020), the authors find a positive effect of mixed-gender management board and probability for firms to invest in eco-innovations. Other findings report that gender diversity reduces carbon emissions and the environmental innovations amplifies this relation (Konadu et al., 2022).

From all of the above we can distinguish the fact that the presence of women in the board of directors enhances the company's concern with environmental issues. Firms with higher gender diversity exhibit a more ethical behaviour implementing eco-friendly strategical management. In the following sections the characteristics that drive women towards adopting environmental-friendly behaviours will be discussed.

1.4 The drivers of the effect

1.4.1 Gender socialization theory

To be able to identify the reason behind the positive relations between gender diversity and eco-innovations, we should look at the environmental values and ethics. Stern and Dietz (1994) classify these values threefold. First are egoistic values which describe the environmental threat as a concern for themselves. Second are the altruistic values which describe the concern for others. Third are the biosphere values expressing concern for the environment. In consequence the specific characteristics that should be brought to attention are altruism and ecological apprehensiveness.

Previous studies reveal that women manifest stronger environmental concern than men (Lee et al., 2013; McCright, 2010; McCright & Xiao, 2014; L. C. Zelezny et al., 2000; Lynnette C Zelezny et al., 2000). Additionally, the theoretical explanation of stronger environmental driven behaviours of women can be found in the gender socialization theory (L. C. Zelezny et al., 2000). The gender socialization theory is based on analysing childhood socialization processes and life experiences which lead to a different development of characteristics of men and women (Stockard, 2006). These dissimilar characteristics like ethic of care, concern about safety and risk preferences are strongly associated with the gender's attitudes towards the environment (Davidson & Freudenburg, 1996).

To be in alignment with pro-environmental behaviours, one must follow the ecological value orientation. At the same time, in the previous literature on gender and environment, altruism has been recognized as the value which is closest related to pro-environmental attitudes (Dietz et al., 2002). People with altruism are characterized by selflessness and express concern for the welfare of others. Meanwhile, the prior research has found that, women are altruistic, express a stronger ethic of care and are equalitarians who prefer to share evenly (Ahern & Dittmar, 2012; Andreoni & Vesterlund, 2001), while men tend to be more competitive for resources (Arnocky & Stroink, 2010) and express a greater care for economic growth regardless of the economic spillovers (Blocker & Eckberg, 1997). In line with gender socialization theory, the relationship between female board representation (gender diversity) and company's pro-environmental behavior is expected to be positive.

The focus of this research is on the top management team, and therefore it is appropriate to look into the skills and characteristics of women that have leadership positions. As it was discussed earlier, ecological innovations require knowledge intensive resources, which compels companies to look for ideas outside of the company constraints. At the same time corporates should be disposed to share resources and ideas to help improving the environmental threat in the society.

1.4.2 Social role theory of leadership

We can anticipate that the specific nature of eco-innovations require unique management capabilities and aspirations. Pro-environmental innovations demand knowledge intensive resources, therefore particular competencies are required to obtain these resources. Companies are compelled to look for ideas outside of the organization's constraints such as governmental institutions, NGO's and customers (Yarahmadi & Higgins, 2012). On the other hand, corporates that are in possession of required skills and knowledge should be disposed to share resources and ideas to help improving the environmental threat in the society.

Social role theory can recognize the driver of this specific type of innovation. It is a psychological theory that refers to gender differences and similarities in social behavior (Eagly and Wood, 2016). The theory portrays the particularities of females leadership style. Firstly, women are proven to have a more democratic style of management (Eagly & Johnson, 1990), that promote group participation in the decision making process. Females tend to encourage participation opposed to the hierarchical leadership style, which allows them to think things through and minimize possibilities for mistakes (Rosener, 2011). Secondly, at the top pf the management ladder, women are disposed to share information and power, which is believed to increase the general communication and effectiveness of problem-solving within the company (Rosener, 2011). In the third place, women leaders tend to energize others, that can increase the enthusiasm of a particular idea or belief among the other directors (Rosener, 2011).

These distinct leadership skills are advantageous in management concerning environmental issues. Eco-innovations involve challenging processes which could demand a change in the entire production operations. Therefore the existence of an interactive management style, that facilitates power-sharing and the ability to excite others makes the implementation of alternative innovations becomes more feasible.

Based on the gender socialization theory and the social theory of leadership, the overall effect of board gender diversity is expected to be positively related with eco-innovation. Following, the formulation of hypothesis 1 is:

H1: There is a positive relationship between board gender diversity and the likelihood of firms to eco-innovate.

1.4.3 Critical mass theory

Research on board gender diversity raises the following question: what should be the minimum amount/ratio of women in the board to make a difference in the decision making processes? The Critical mass theory sheds some light on the participation of women on corporate board. The theory acknowledges that proportions of group member with different demographic profiles matter, because they shape interaction dynamics (Kanter, 1977). According to Kanter (1977), four group types can be identified based on the proportional representation of different identities. First are the *uniform* groups (100:0) , in which all the members of the board of directors are males. Second are the *skewed* groups (85:15), where there is a large dominance of one kind of people within the group. The minority of population, also called “tokens” is too small to generate a powerful enough alliance to have an effect on the culture. Next are the *titled* groups (65:35), where minority members are can form alliances and change the direction of the group. Fourth are the *balanced* groups (60:40; 50:50), where the focus is shifted from aggregated categories, such as sex, to the individual's capabilities (Kanter, 1977).

Skewed groups can be problematic, as the findings of the previous literature state that small amount of women on the board would have a limited influence on the decision making processes in the company, because they will be outnumbered by male directors (Westphal & Milton, 2000). An increase in the group proportion would minimized this risk. Therefore, it is believed that a certain threshold of gender diversity is needed in order for the minority population to make a change within the group. The results of the prior empirical research show that a "critical mass" of three or more female directors have a significant influence on firm performance (Joecks et al., 2013; Post et al., 2011), firm innovativeness (Torchia et al., 2011), corporate social responsibility (Amorelli & García-Sánchez, 2020) and environmental innovation (Konadu et al., 2022).

According to the critical mass theory there should be at least three women on the board of directors so that a significant impact of women's implication is made. Therefore, I can establish the second hypothesis as follows:

H3: Only when there are at least three females on the board, there is a positive effect of board gender diversity on eco-innovations.

2 Data and methodological approach

In this section a detailed explanation of the data and methodological approach can be found. It includes the operationalization of dependent, dependent and control variables. Moreover, a description of the sample determination, data collection and data source can be found. Finally, the estimated regression model, the endogeneity and causality tests will be discussed.

2.1 Data

The time frame used in the research is between 2002-2020. The reason for this particular period of time is that data on publicly listed companies is not consistently available before 2002. The data is obtained from three different data sources: Orbis IP, Eikon and BoardEx. These databases are accessible to the students of Radboud University and contain all required data for this thesis. Orbis IP is used to obtain the initial sample. BoardEx is used to identify information on the board characteristics of each firm. Eikon is used to identify firm-specific characteristics. The data of all three data sets is merged in Stata based on the respective ISIN (International Securities Identification Number) codes. ISIN uniquely identifies a firm, which gave the possibility to match each firm in all data sets.

Orbis IP is used to identify the initial sample. It is a patent database of private and public companies around the world, comprising 131 million patents and patent applications and more than 2 million patent holders. It is used for combining company information with patent data. The "green" patents were filtered out with the help of the World Intellectual Property Organization (WIPO), that provided the International Patent Classification (IPC) codes for "alternative energy production" patents. The sample started with 117 listed firms (with respective ISIN) available on Orbis IP, with a total of 9,521 green patents.

The second step involved downloading the company details and board characteristics of European firm using BoardEX dataset. The matching process was depending on the available companies with green patents from 2002 to 2020. In Stata, I started with including the sample from BoardEX, on company details resulting in 253,614 observations. The next step involved including the data of board characteristics, and merging process of the two data sets. Next, the duplicated information such that only one information per company is kept each year was removed. After this step there were 2,122 observations left. Finally, I added the data set which included company information on green patents. After merging all data sets, the companies with missing values on board gender diversity or green patents was removed. In the end, 108 companies and 1,693 observations remained.

2.2 Dependent variable

Technological innovations can divided in product and process innovations (Rennings & Rammer, 2011). The former focuses on the improvement of product life-cycle, quality and design in compliance with environmental requirements (Noci & Verganti, 1999). The latter ensures that the output is produced with less input (Kemp & Pearson, 2007). Furthermore in the literature is stated that the two are closely correlated, the green product innovation intermediates the relationship between the green process innovation and financial performance (Xie et al., 2019).

In this study the focus is on the measurement of the intermediator: green product innovation, which comes from the firm's determinants of market benefits.

The most common method of measuring the eco-innovation variable in the prior studies is the use of surveys (Galia et al., 2015; Horbach & Jacob, 2018; Kemp & Pearson, 2007; Pan et al., 2020). In line with limitations that this method provides such as: lack of objectivity, low rates of respondents (Kemp & Pearson, 2007), and the complexity of finding the available data of surveys, this study will not consider this method. Additionally, prior literature uses other measurements such as environmental innovation scores available in different data sets and reports (Garcia-Sanchez et al., 2021; Nadeem et al., 2020; Orazalin & Mahmood, 2021; Wang et al., 2021), carbon performances of the companies (Konadu et al., 2022), and number of environmental lawsuits (Liu, 2018).

Following the previous literature that is focused on the environmental innovation (Fabrizi et al., 2018; He & Jiang, 2019; Kemp & Pearson, 2007; Liu et al., 2021) this research considered using the "green patents" as a measure of eco-innovations. Every patent provides a detailed description of the invention according to the International Patent Classification (IPC). The companies need to present valid proof to the organizations in charge, that their products are environmentally sustainable and deserve to be patented as environmental friendly technologies (Kemp & Pearson, 2007). Therefore green patents are a measurement of companies' efficiency in production processes that contribute to a sustainable development and green growth.

In this study, I was able to identify eco-patents related to "alternative energy production". My identification strategy of green patents involved contacting directly the Department for Economics and Data Analytics of WIPO. They provided me with the technical fields related to the "alternative energy production" and the IPCs related to these fields. Subsequently, the green patents of companies were found in the Oribis IP database conform the IPCs. I was able to identify 9521 units of green patents of the listed firms over the period of 2002-2020. The dependent variable (GP) is measured by the total number of green patents obtained each year by each company. The related IPC and technical fields can be found in the Table 7.1 in the appendix.

2.3 Independent variable

Board gender diversity is the explanatory variable. In conformity with the existent literature (He & Jiang, 2019; Konadu et al., 2022; Nadeem et al., 2020; Orazalin & Mahmood, 2021; Wang et al., 2021) the board gender diversity variable is measured as the ratio of total number of women to the total number of directors at the end of a given year (RatioBGD).

To test the critical mass theory hypothesis, three measures of gender diversity are included. The theory suggests that there should be at least three women on board for the gender diversity to generate a positive effect (Joecks et al., 2013; Yarram & Adapa, 2021). Therefore, three dummy variables are included: presence of at least one female on board (OneBGD); presence of at least two women on board (TwoBGD); presence of at least 3 women on board (ThreeBGD), which takes the value of one if the statement is true, and zero otherwise. In conformity with the theory, only the dummy representing the threshold of three women on board should generate positive coefficients.

2.4 Control variables

To avoid biased results we control for several variables influencing the probability to eco-innovate. These variables are divided into board distinctive characteristics and firm distinctive characteristics. The former includes board size (BoardSize), CEO duality (Duality), the age of the company (FirmAge), and the average age of directors (Age). The latter includes R&D expenditures (RD), foreign sales (FS), and size (Size) at the end of each year.

In the corporate governance literature the findings suggest that small sized boards are better at cooperation and communication which leads to a refined corporate management (Ahmed et al., 2006). On the other hand Haque and Ntim (2018) and De Villiers et al. (2011) found that larger board size lead to an improved environmental performance. Walls et al. (2012) showed a positive relationship between board size and environmental firm performance. To control for these possibilities the board size (BoardSize) as a control variable is included. It is measured as the natural logarithm of the number of directors on the board.

Second significant aspect of corporate governance is the CEO duality, that is, when CEO is also the chair of the board (COB). The role separation of the COB and the CEO has an influence on the board dynamics affecting the efficiency of the board and the firm (Kakabadse & Kakabadse, 2007). The study of Webb (2004) shows a negative relation between CEO duality and corporate social responsibility, while De Villiers et al. (2011) finds that CEO duality leads to a better environmental performance. I control for the effect of role duality with a binary variable (Duality), which takes the value of one if the CEO is also the COB and zero otherwise.

The third factor that was considered in the study involves the average age of directors (Age). According to Wiersema and Bantel (1992), there is a positive relationship between a corporate's willingness to embrace changes and the lower average age. The age variable is measured as the natural logarithm of the average age of directors.

With respect to the firm distinctive characteristics, prior literature has linked the corporate ecological performance to the firm age. Older firms have a positive effect on environmental innovations, as they have more experience and a higher possibility of developing the required infrastructure for the environmental management system (Mohan-Neill, 1995). To control for this effect the firm age variable (FirmAge) is introduced and it is measured as the natural logarithm of the number of years since the firm has been founded.

A substantial incentive for companies to follow an environmentally friendly management system is public pressure (Hillary, 2004). The study of Hillary (2004) on European firms finds that small and medium-sized enterprises (SMEs) have lower visibility, which minimizes public demand for green products, and lowers the efforts to address environmental issues. SMEs have problems with a lack of human resources in terms of skills and financial resources to implement environmental changes (Dahlmann et al., 2008). On the other hand, large companies are more visible to the large public and are sensitive to the stockholders which play as an inducement to adopt eco-friendly solutions (Baylis et al., 1998). To account for the size effect a control variable (Size) is added. The distribution of the total number of employees was skewed towards the right, therefore to achieve more normally distributed data, the size variable is measured by the natural logarithm of the total number of employees in the company.

According to Alam et al. (2019) research and development investment (R&D) investment has a positive effect in reducing environmental impacts. The R&D objective is increasing production efficiency with minimal energy consumption, and the transition towards greener energy systems

(Alam et al., 2019). At the same time, R&D increases external knowledge absorption and accumulation (Cohen & Levinthal, 1990), which is substantial for the eco-innovative activities (Ghisetti et al., 2015). To control for this effect, the R&D variable is added (RD). To manage the right-skewness, the natural logarithm of total R&D expenditures is added.

Finally, a driver for innovative ecological products is competitiveness (Porter & Van der Linde, 1995). Considering that foreign competition stimulates eco-innovation (Scott, 1997) a control variable measuring foreign sales was added (FS). It is calculated as natural the logarithm of the total foreign sales.

2.5 Overview variables

The description of the dependent, independent and control variables can be found in Table 1. All variables are built manually in Stata or Excel. At the same time, Table 3.1 contains the databases I used to retrieve all the variables.

TABLE 2-1DEFINITIONS AND MEASUREMENTS OF ALL VARIABLES

Abbreviation	Variable	Measurement	Data Source
GP	Level of eco-innovation	Total number of green patents	ORBIS IP
RatioBGD	Board gender diversity	The ratio of females directors on the board, calculated as the total number of women divided by the total number of directors on the board	BoardEx
OneBGD	Board gender diversity (critical mass theory)	A dummy variable that takes the value of 1 if there is at least one woman on board and 0 otherwise	BoardEx
TwoBGD	Board gender diversity (critical mass theory)	A dummy variable that takes the value of 1 if there is at least two women on board and 0 otherwise	BoardEx
ThreeBGD	Board gender diversity (critical mass theory)	A dummy variable that takes the value of 1 if there is at least three women on board and 0 otherwise	BoardEx
BoardSize	Board size	Measured as the natural logarithm of total number of directors on board	BoardEx
Duality	CEO duality	A dummy variable that takes the value of 1 if the CEO is also the chairman of the board and 0 otherwise	BoardEx
FirmAge	The age of the company since it was founded	Natural logarithm of the number of years since the firm has been founded	Eikon
Age	The directors' age	The natural logarithm of the average age of directors	BoardEx
Size	The firm size	The natural logarithm of the total number of employees	Eikon
RD	R&D expenditures	Natural logarithm of total R&D expenditures	Eikon
FS	Foreign sales	Natural logarithm of total foreign sales	Eikon

2.6 Method

The sample in this thesis represents a panel or longitudinal data set in which firm-based information is observed across time. Hsiao (2007) states that panel data has several advantages over cross-sectional or time-series data. Firstly, longitudinal data sets contains more degrees of freedom and less multicollinearity. Secondly, it provides a higher potential for capturing the human behavior, by controlling the impact of omitted variables, uncovering dynamic relationship and generating better prediction for individual outcomes by pooling the data. And finally, panel data simplifies the statistical inference.

Panel data is widely used in the prior literature on board gender diversity and eco-innovations (He & Jiang, 2019; Konadu et al., 2022; Orazalin & Mahmood, 2021). In order for the appropriate estimation method to be determined, Hausman-test is conducted. The null hypothesis states that the Fixed effects coefficients are not significantly different from the Random effects coefficients. In other words, it tests whether the unique errors and the regressors are correlated in the model. The Hausman-test statistics, shown in the Table 7.2 in the appendix, turned out to be insignificant, which means that the Random effect model is the appropriate regression to be used instead of the Fixed effects. The following regression equation is proposed to test the study hypotheses:

$$GP_{it} = \alpha_0 + \beta_1 RatioBGD_{it} + \beta_2 OneBGD_{it} + \beta_3 TwoBGD_{it} + \beta_4 ThreeBGD_{it} + \beta_5 BoardSize_{it} + \beta_6 Duality_{it} + \beta_7 FirmAge_{it} + \beta_8 Age_{it} + \beta_9 RD_{it} + \beta_{10} FS_{it} + \beta_{11} Size_{it} + \epsilon_{it}$$

where GP_{it} represents the eco-innovation level using green patents of alternative energy production; $RatioBGD_{it}$ represents board gender diversity; $OneBGD_{it}, TwoBGD_{it}, ThreeBGD_{it}$ are dummy variables that indicate where there is a minimum of one, two and respectively three women on the board; $BoardSize_{it}$ represents the total number of board members; $Duality_{it}$ is dummy variable indicated whether the CEO is also the chairman; $FirmAge_{it}$ represents the firm age; Age_{it} represents the average age of the total directors on board; RD_{it} indicate the R&D expenditures; FS_{it} represent the foreign sales and ϵ_{it} indicates the error term per observation. Further, *i* indicates the firm unit and *t* stands for the point of time unit.

3 Results

This chapter incorporates the following sections. Firstly, the analysis of the descriptive statistics are made. It is followed by an examination of the Ordinary Least Squares (OLS) assumptions. Finally, the results of the regressions are presented with the respective rejection/acceptance of the hypothesis.

3.1 Descriptive analysis

The industry-wide distribution of the sample can be found in the Table 4.1. It covers the total number of firms that belong to each industry. It can be pointed out that the manufacturing sector dominates the sample with 71.30% of the total firms. Table 7.3 in the appendix discloses the overview of all the countries of which companies are integrated in the study. It can be observed that Germany (25.95%) and France (14.81%) contain together a disproportionate amount of 40% of the total available companies.

TABLE 3-1 SAMPLE DISTRIBUTION BASED ON INDUSTRY

Industry	No. of firms	Percentage	Cumulative
Agriculture, forestry and fishing	1	0.93	0.9
Mining and quarrying	9	8.33	9.2
Manufacturing	77	71.30	80.5
Electricity, gas, steam and air conditioning supply	8	7.41	87.9
Construction	2	1.85	89.8
Transportation and storage	2	1.85	91.6
Information and communication	4	3.70	95.3
Financial and insurance activities	1	0.93	96.3
Professional, scientific and technical activities	3	2.78	99.0
Public administration and defence; compulsory social security	1	0.93	100.00
Total	108	100.00	

The summary statistics of the sample is displayed in the Table 4.2, which covers the information on the main variables, the total number of firms (detected by ISIN codes), the total number of years and, total number of female representation. The data is reported before the variables were log-normally distributed and winsorized. With regards to the dependent variable (GP), the maximum green patents gained per year represent 167 units, and the average green patents obtained is 3.527 units per year. Moreover, from the total amount of green patents available (6381 units), Germany holds the majority which consists of 51.76% (3303 units).

In respect to the main independent variable (RatioBGD), it was found that the average percentage of female representation on corporate boards is 18.6% for the full sample. Moreover the maximum number of gender diversity represent 12 women. It can also be notices that the maximum board size (BoardSize) represents a number of 36 directors, with an average of 14 members. The reported statistics for the average age of the directors (Age) is approximatively 58 years.

With respect to the firm characteristics, the average age of the firm since it was founded is 70 years. The average size represents 65,895 employees, which means that the companies reported in the sample represent large enterprises. The average R&D expenditures represent 833,269,000 Euros, and finally the average foreign sales statistics represent 15,700,000,000 Euros.

TABLE 3-2 DESCRIPTIVE STATISTICS ON RESEARCH VARIABLES

Variables	Obs.	Mean	S.D.	Min	Max
Isin	1,693	54.834	32.99	1	108
Year	1,693	2011.726	5.391	2002	2020
GP	1,693	3.527	11.761	0	167
TotalFemale	1,693	2.464	2.069	0	12
RatioBGD	1,693	0.186	0.146	0	0.583
OneBGD	1,693	0.812	0.391	0	1
TwoBGD	1,693	0.611	0.488	0	1
ThreeBGD	1,693	0.452	0.498	0	1
BoardSize	1,693	13.946	5.851	1	36
Duality	1,693	0.371	0.483	0	1
Age	1,693	57.55	3.555	43.222	75
FirmAge	1,693	69.562	49.309	0	193
Size	1,629	65,895.23	89,148.92	29	671,205
RD	1,420	833,269	1,622,447	0	1.86e+07
FS	1,623	1.57e+07	2.53e+07	0	2.04e+08

Note: The women gender diversity (RatioBGD) is expressed in percentage; board size is expressed in number of people; age is expressed in number of years; size is expressed in number of employees; the foreign sales (FS) and R&D expenditures (RD) are expressed in thousands of Euros.

3.2 Ordinary Least Squared assumptions

This section examines whether the data meet the assumptions underlying OLS regression. The first assumption is related to the normality distribution of all variables. In order to achieve normality, variables were modified by taking the natural logarithm of their original value. This modification involves two implications. Firstly, it converts the absolute values into percentage points, therefore allowing for better comparison across companies with different sizes. Secondly, it deals with the possible outliers, that could disproportionally influence the regression. Consequently, the following variables were log-normally transformed using the natural logarithm:

board size, the average age of directors, the firm age, the firm size, the foreign sales and R&D expenditures. I could not perform the same strategy for the green patents variable, as there is significant number of data with zero value and, by taking the natural logarithm of zero, the variable will end up with multiple missing values.

After conducting multiple tests to identify outliers and influential data[3], two firms could be distinguished in every analysis. The closer investigation of the data revealed that one of the two companies had in total 3,140 green patents, which represents 32.98% of the total amount. Next, two OLS regressions were conducted with and without the outlier. The regression equations showed extreme differences. Therefore, the respective company was removed from the data set, as it represented a point of major concern to influence the overall findings. Consequently, the sample remained with 107 companies.

In addition, the winsorizing technique was used to modify the other outliers. This method allows for transformation of statistics by limiting the extreme values. The dependent and independent variables were winsorized at the 1^{st} and 99^{th} percentiles (Wang et al., 2021).

Table 4.3 reports the Pearson correlation coefficients among all independent variables of this thesis. It takes the value of one to indicate perfect correlations, and zero to indicate no correlation between two explanatory variables. None of the coefficients amongst the independent variables exceed 0.80, which is an acceptable threshold as argued by (Gujarathi, 2022, p. 359). The highest correlation within independent variables is between gender diversity (RatioBGD) and the gender binary variables (TwoBGD, ThreeBGD) with 0.792 and 0.773 respectively. However, such correlation level is reasonable, because the dummy variables and the gender diversity ratio were constructed using the same source, i.e. number of female directors. The next highest correlation is between R&D expenditures (RD) and company size (Size), and it equals to 0.861. Considering that this value exceeds the 0.80 threshold (Konadu et al., 2022), a variance inflation factor (VIF) test is exercised to see if multicollinearity can be an issue. The test examines whether there is no high correlation between the two control variables which can result in unreliable statistical inferences. According to James et al. (2013, p. 102) the VIF value that exceeds 5 or 10 becomes

[3] The analysis involved looking at the scatterplots and partial-regression plot matrix, examination of studentized residuals and leverage.

problematic, and can indicate multicollinearity. The VIF test, which can be found in Table 7.4 in the appendix, shows that gender diversity (RatioBGD) has the VIF value of 5.59, the foreign sales variable (FS) has a value of 5.17, while the firm size variable (Size), has the value of 6.07. Given that variables have a value less than 10 and are close to 5, multicollinearity is not considered an issue in this study.

TABLE 3-3 MATRIX OF CORRELATIONS

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
(1) RatioBGD	1.000										
(2) OneBGD	0.615	1.000									
(3) TwoBGD	0.793	0.603	1.000								
(4) ThreeBGD	0.773	0.437	0.725	1.000							
(5) BoardSize	-0.137	0.195	0.105	0.178	1.000						
(6) Duality	-0.046	0.000	0.035	0.049	0.236	1.000					
(7) Age	-0.088	-0.091	-0.107	-0.106	-0.088	0.054	1.000				
(8) FirmAge	0.095	0.144	0.082	0.123	0.146	0.008	0.047	1.000			
(9) Size	-0.029	0.103	0.082	0.111	0.472	0.090	0.087	0.052	1.000		
(10) RD	-0.009	0.047	0.094	0.133	0.365	0.008	0.132	0.096	0.715	1.000	
(11) FS	0.109	0.133	0.177	0.185	0.391	0.052	0.127	0.058	0.861	0.693	1.000

However, the model proved to have heteroscedasticity and autocorrelation problems[4]. The model in the thesis is serial through time, therefore it increases the probability of the residuals being serially correlated. To be able to minimize the potential risk of biased results, the clustered standard errors were added to the random effect regression (Hoechle, 2007). The errors were clustered by country.

3.3 Empirical results

To examine the relationship between board gender diversity and eco-innovation, random effect (RE) estimations are conducted. The regression results are presented in Table 4.4. Column one

[4] White's test was used to test for heteroscedastic errors. A regression with the residual as a dependent variable and the lagged residual as an independent variable was used to test for autocorrelation.

indicates a positive coefficient of 3.404 of board gender diversity at 5% significance level. As such, hypothesis 1, which states that there is a positive relationship between an increased women representation and environmental innovation involving alternative energy production systems, cannot be rejected. The results bring additional consistency to the prior findings on corporate governance and environmental innovations (He & Jiang, 2019; Nadeem et al., 2020). Moreover, the findings can be explained from the perspective of the resource dependence theory, the gender socialization theory, and social role theory of leadership. The exclusive qualities of women bring diversity to the decision-making processes in terms of environmental care.

However, I failed to find significant results in support of the critical mass theory. All the coefficients of the three binary variables related to gender diversity are positive, but insignificant. Therefore, the estimations do not present acceptable results to support the critical mass theory, which states that there should be at least three women on the board of directors to generate impact on decision making.

Concerning control variables involving board characteristics, only the binary variable examining the CEO Duality (Duality) shows a significant negative relationship at 10% significance level. Therefore, the findings suggest that the instance where the CEO is also the chairman of the company affects the eco-innovation levels adversely. On the side of firm characteristics, only research and development expenditures (RD) show a significant positive relationship with eco-innovations.

TABLE 3-4 RANDOM EFFECTS REGRESSION

	(1)	(2)	(3)	(4)
	GP_1	**GP_1**	**GP_1**	**GP_1**
VARIABLES				
RatioBGD	3.404**			
	(1.458)			
OneBGD		0.0791		
		(0.192)		
TwoBGD			0.383	
			(0.252)	
ThreeBGD				0.655
				(0.485)
BoardSize	0.489	0.255	0.266	0.171
	(1.486)	(1.540)	(1.536)	(1.581)
Age	4.489	4.047	4.275	4.282
	(5.426)	(5.330)	(5.390)	(5.308)
FirmAge	-0.493	-0.124	-0.251	-0.333
	(1.008)	(1.021)	(0.989)	(1.062)
Size	0.269	-0.0413	0.0575	0.138
	(0.409)	(0.417)	(0.413)	(0.335)
RD	0.487*	0.539**	0.515**	0.479*
	(0.253)	(0.261)	(0.256)	(0.253)
FS	0.582	0.876	0.792	0.731
	(0.609)	(0.600)	(0.608)	(0.538)
Duality	-1.724*	-1.674*	-1.707*	-1.712*
	(0.974)	(0.931)	(0.948)	(0.952)
Constant	-31.88	-32.37	-32.42	-31.40
	(21.27)	(21.82)	(21.52)	(20.20)
Observations	1,375	1,375	1,375	1,375

This table presents results of the impact of gender diversity on eco-innovations. All variables are defined in Table 3.1. Robust standard errors, which are clustered at the country level, are reported in the parenthesis. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

3.3.1 Endogeneity

Relationships such as board gender diversity and corporate environmental practices may exhibit endogeneity concerns (Adams, 2016). These issues usually arise from three reasons. Firstly, the omitted variables that can have an effect on the female inclusion in the board and lead to deceptive correlations. Revers causality is the second important problem. For instance, eco-innovation level, which directly relates to the company's environmental behavior can influence the women's decision to choose the respective firm, therefore the relationship being reversed. At the same time, more environmentally-friendly organizations can encourage a gender balanced board. Third issue includes self-selection bias which can compromise the interpretation of the results.

According to Adams (2016), firm fixed effects can be used to minimize omitted variable bias. Therefore, as a robustness check, the fixed effects estimation was conducted. The results presented in Table 4.5 show a similar result as that of random effects regression. Board gender diversity expressed in percentage of women on board has a positive, linear relationship with environmental innovations of a company. CEO duality also indicates a similar relationship as in the random effects estimation, with a negative coefficient.

TABLE 3-5 FIXED EFFECT REGRESSION

VARIABLES	(1) GP_1	(2) GP_1	(3) GP_1	(4) GP_1
RatioBGD	4.344*			
	(2.401)			
OneBGD		0.129		
		(0.327)		
TwoBGD			0.484	
			(0.397)	
ThreeBGD				0.824
				(0.636)
BoardSize	-1.202	-1.373	-1.393	-1.558
	(1.686)	(1.663)	(1.682)	(1.786)
Age	6.164	5.084	5.568	5.660
	(6.400)	(5.969)	(6.193)	(6.119)
FirmAge	-1.018	-0.125	-0.436	-0.611
	(2.057)	(1.833)	(1.903)	(1.966)
Size	0.250	-0.125	-0.00819	0.0900
	(0.369)	(0.391)	(0.356)	(0.320)
RD	0.331	0.433	0.392	0.327
	(0.616)	(0.590)	(0.616)	(0.658)
FS	0.423	0.729	0.654	0.583
	(0.690)	(0.698)	(0.701)	(0.657)
Duality	-1.886*	-1.818*	-1.863*	-1.868*
	(1.033)	(0.984)	(1.014)	(0.999)
Constant	-27.52	-27.71	-28.10	-26.55
	(22.21)	(22.85)	(22.60)	(21.11)
Observations	1,375	1,375	1,375	1,375
R-squared	0.025	0.019	0.020	0.022

All variables are defined in Table 3.1. Robust standard errors, which are clustered at the country level, are reported in the parenthesis. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

3.3.2 Additional tests

In the main model, the standard errors are clustered conform countries. As a robustness check, random effects regression is estimated with clustering residuals conform the industry type, therefore controlling for the industry effect. Results are displayed in Table 5.5 in the appendix. By assuming that residuals are random across industries, the random effects estimated different results compared to the main model. It can be noticed that board gender diversity has a positive, yet insignificant coefficient. At the same time, the binary variable for board gender diversity expressed as at least three women on board shows a positive relationship with 10% significance level. These results come in disagreement with the main model estimations and bring some support for the critical mass theory hypothesis. CEO duality shows a systematic negative relationship with eco-innovations, only this time at a 1% level of significance. An additional finding is the negative effect of the director's age and eco-innovations.

4 Discussion and conclusion

As a result of neglecting the ecological threats, Europe reached a point of high environmental concerns, such as climate change, land degradation, and nature pollution. Companies that prioritize economic prosperity over the development of products that do not harm the environment are an accomplice to these environmental disasters. With respect to this issue, this paper investigates whether board composition in terms of female representation influences corporate environmental innovations in Europe. It brings theoretical insights and empirical evidence to board gender diversity subject, as well as environmental innovation practices. To my knowledge, the thesis contributes to the existing literature by being the first to use green patents as a measurement of eco-innovation of European firms, in a linkage to board gender diversity.

Based on a sample of European firms over the period of 2002-2020, the findings of this paper support the view that board gender diversity can have an impact on minimizing a company's negative spillovers by encouraging the development of eco-innovations. At the same time, the study did not find a significant relationship between the minimum number of three females and eco-innovations. The final and robust finding is that CEO duality negatively impacts green innovations. Therefore, if the CEO is also the chairman of the board, the company is less associated with environmental innovations.

In light of persistent gender biases (Kirsch, 2018), the findings of this paper can serve as evidence to the corporate boards about the importance of women's inclusion, as an added value to the ecological footprint. At the same time, these findings may be of interest to policymakers, that want to encourage and increase the environmental social responsibility of firms through innovations.

Due to resource boundaries, the thesis does have potential limitations, which also can serve an as opportunity for future research. Firstly, the sample of the thesis turned out to include only large enterprises, therefore the findings can be attributed only to large companies. The fact that the dependent variable depends on green patents led to excluding the small and medium-sized firms. The reason is that green patents require intensive capital and human resources, which large enterprises are able to address.

Secondly, even though I was able to find a link between gender diversity and eco-innovations, there is still the question "how?" which wasn't empirically researched. Future research can look into the mechanism through which women affect the eco-innovative conduct.

And finally, the random effect model was able to cluster the sample by country, but there is a need for a thorough analysis of the country effect. For example, management teams that belong to countries with progressive thinking can promote female participation and inclusion in the decision-making processes. Contrary, boards that belong to societies with gender discriminative attributes, can hinder female involvement in corporate decision-making. Therefore, even though the board would have some percentage of female representation, it would not affect the outcomes.

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6 Appendix

TABLE 6-1 THE GREEN PATENTS IPC CODES

Sector	IPC	Field
Alternative Energy Production	F03G 5/%	Devices for producing mechanical power from muscle energy
Alternative Energy Production	H01M 4/86	Fuel cells
Alternative Energy Production	H01M 4/88	Fuel cells
Alternative Energy Production	H01M 4/90	Fuel cells
Alternative Energy Production	H01M 4/92	Fuel cells
Alternative Energy Production	H01M 4/94	Fuel cells
Alternative Energy Production	H01M 4/96	Fuel cells
Alternative Energy Production	H01M 4/98	Fuel cells
Alternative Energy Production	H01M 8/%	Fuel cells
Alternative Energy Production	H01M 12/%	Fuel cells
Alternative Energy Production	F24T%	Geothermal energy
Alternative Energy Production	C10L 3/%	Integrated gasification combined cycle (IGCC)
Alternative Energy Production	F02C 3/28	Integrated gasification combined cycle (IGCC)
Alternative Energy Production	F03G 7/05	Ocean thermal energy conversion (OTEC)
Alternative Energy Production	F24V 30/%	Other production or use of heat, not derived from combustion, e.g. natural heat
Alternative Energy Production	F24V 40/%	Other production or use of heat, not derived from combustion, e.g. natural heat
Alternative Energy Production	F24V 50/%	Other production or use of heat, not derived from combustion, e.g. natural heat
Alternative Energy Production	C10B 53/%	Pyrolysis or gasification of biomass
Alternative Energy Production	C10J%	Pyrolysis or gasification of biomass
Alternative Energy Production	F24S%	Solar energy
Alternative Energy Production	H02S%	Solar energy
Alternative Energy Production	F03D%	Wind energy

TABLE 6-2 HAUSMAN SPECIFICATION TEST

	Coef.
Chi-square test value	14.075
P-value	.08

TABLE 6-3 OVERVIEW OF THE SAMPLE BASED ON COUNTRIES

Country	No. of firms	Percentage	Cumulative
Austria	4	3.70	3.70
Belgium	3	2.78	6.48
Denmark	2	1.85	8.33
Finland	8	7.41	15.74
France	16	14.81	30.56
Germany	28	25.93	56.48
Hungary	1	0.93	57.41
Italy	7	6.48	63.89
Luxembourg	2	1.85	56.74
Netherlands	3	2.78	68.52
Norway	7	6.48	75.00
Russian Federation	3	2.78	77.78
Spain	5	4.63	82.41
Sweden	7	6.48	88.89
Switzerland	8	7.41	96.30
Turkey	4	3.70	100.00
Total	108	100.00	

TABLE 6-4 VIF CORRELATION TABLE

	VIF	1/VIF
Size	6.07	.165
RatioBGD	5.591	.179
FS	5.168	.193
ThreeBGD	3.494	.286
TwoBGD	3.179	.315
RD	2.32	.431
BoardSize	2.076	.482
OneBGD	1.964	.509
Age	1.134	.882
Duality	1.087	.92
FirmAge	1.061	.942
Mean VIF	3.013	.

TABLE 6-5 RANDOM EFFECTS REGRESSION

VARIABLES	**(1)** **GP_1**	**(2)** **GP_1**	**(3)** **GP_1**	**(4)** **GP_1**
RatioBGD	3.404			
	(2.496)			
OneBGD		0.0791		
		(0.363)		
TwoBGD			0.383	
			(0.262)	
ThreeBGD				0.655*
				(0.392)
BoardSize	0.489	0.255	0.266	0.171
	(0.592)	(0.375)	(0.424)	(0.377)
Age	4.489	4.047	4.275	4.282
	(6.922)	(6.616)	(6.768)	(6.859)
FrimAge	-0.493**	-0.124	-0.251	-0.333*
	(0.229)	(0.184)	(0.216)	(0.200)
Size	0.269	-0.0413	0.0575	0.138
	(0.224)	(0.138)	(0.147)	(0.157)
RD	0.487**	0.539***	0.515***	0.479**
	(0.202)	(0.185)	(0.188)	(0.201)
FS	0.582	0.876***	0.792***	0.731**
	(0.392)	(0.303)	(0.289)	(0.292)
Duality	-1.724***	-1.674***	-1.707***	-1.712***
	(0.186)	(0.199)	(0.196)	(0.188)
Constant	-31.88	-32.37	-32.42	-31.40
	(25.17)	(24.64)	(25.18)	(24.94)
Observations	1,375	1,375	1,375	1,375

All variables are defined in Table 3.1. Robust standard errors, which are clustered at the industry level, are reported in the parenthesis. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.