The Effect of Board Gender Diversity and Environmental Responsibility on Innovation: Evidence from the Top-Patenting Firms

Derek Ruth
Dominican University, USA

Sui Sui*
Toronto Metropolitan University, Canada

Today, firms face joint pressures to increase the representation of women at the highest levels of their organizations, and to be more environmentally responsible. Still, the impact of these movements on firm performance is less clear. Through the lens of the Attraction-Selection-Attrition (ASA) Cycle, this study looks at the impact of Board Gender Diversity (BGD) and Environmental Responsibility on Innovative Output as measured by patents. Using a longitudinal sample of the top-patenting firms at the United States Patent and Trademark Office, we find that both BGD and Environmental Responsibility lead to higher levels of Innovative Output, and BGD positively moderates the relationship between Environmental Responsibility and Innovative Output. This paper contributes to existing literature by highlighting the need to consider BGD and Environmental Responsibility at the same time when considering their implications on firm performance. We also expand the scope of the ASA Cycle to include overall firm performance with respect to innovation.

Keywords: board gender diversity; CSR; ESG; innovation; patenting; environmental responsibility, top-patenting Firms

*: Corresponding author. Both authors contributed equally.

Introduction

Firms and their stakeholders alike have been placing increased importance on having women in upper-level firm leadership. Women now represent a growing majority of college graduates and represent a large proportion of the overall workforce, so the failure to recruit or promote women to the highest levels of organizations means that firms are not drawing from the entire talent pool (Setó, 2015). Several countries–Belgium, France, Germany, Iceland, India, Israel, Italy, Norway, Spain and the United Kingdom–have undertaken legislation to increase the representation of women on Boards of Directors for publicly traded companies (World Bank Group, 2015; Sila et al., 2016), a measure called Board Gender Diversity (BGD). The pressure to increase BGD includes both societal and firm-level performance motivations. Societally, the presence of more

women at top levels of organizations will provide incentives for other women to join the workforce and work toward higher organizational levels themselves. At the firm level, having higher levels of BGD may positively affect firm performance.

Firms also face increasing pressure to address climate change and care for the environment by being more environmentally responsible. Like BGD, the pressure to be environmentally responsible is promoted in some countries via legislation; in addition, shareholders are pressuring firms to be environmentally responsible. Internationally, the Paris Agreement for the 2030 Agenda for Social Development calls for an investment of 6.9 trillion dollars annually in development and infrastructure (Antoncic, 2021). Financial instruments that invest exclusively in environmentally responsible companies and outside pressure to divest from companies that are not environmentally friendly also incentivize firms to be more environmentally responsible. By 2021, an estimated $2.3 trillion had been invested in Environmental, Social and Governance (ESG) funds (Antoncic, 2021; Murugaboopathy & Jessop, 2021). While there is undoubtedly pressure for firms to be more environmentally responsible, the impact of being more environmentally responsible on firm performance is less clear.

In addition to the direct impacts of BGD and Environmental Responsibility on firm performance, we are also interested in their joint impact. An established stream of literature on gender differences shows that women, in general, are more likely to be environmentally responsible or ecologically conscious (e.g., MacDonald & Hara, 1994; Laroche & Barbaro-Forleo, 2001; Shauki, 2011; Park et al., 2012, Setó, 2015). In a study that looked specifically at BGD and environmental violations, Liu (2018) found fewer environmental violations among firms with higher levels of BGD, while a study of Chinese firms found that BGD improves Corporate Social Responsibility (Wang et al., 2021). Since the decision to pursue Environmental Responsibility is heavily determined by the Board of Directors, it seems likely that Environmental Responsibility and firm performance may be linked through a moderating effect.

The Attraction-Selection-Attrition (ASA) Cycle (Schneider, 1987; Schneider et al., 1995) holds that people will be attracted to apply to and work for organizations that share similar characteristics and values to themselves. Organizations will select and hire people who share the values of the organization. The ASA Cycle also predicts that attrition will be more common among employees who do not share the same values and characteristics of the organization. Since both BGD and Environmental Responsibility are observable and reflective of a firm's efforts and values, we expect that the ASA Cycle may be a significant driver of the relationships among BGD, Environmental Responsibility, and Innovative Output.

Both streams of research have focused heavily on financial measures of firm performance but here we focus on a different and less-explored measure of firm performance: innovation. Innovation is widely acknowledged to be important for firms to achieve and sustain a competitive advantage (e.g., Rosenkopf & Nerkar 2001; Teece, Pisano & Shuen, 1997), and innovations contribute to firm profitability (Nelson, 1995).

Our key research questions in this paper are: (1) What is the effect of Board Gender Diversity on firm innovation? (2) What is the effect of Environmental Responsibility on firm innovation? and

(3) Does Board Gender Diversity moderate the impact of Environmental Responsibility on firm innovation? To answer these questions, we constructed a unique longitudinal sample of 895 firms that are among the highest-patenting organizations by linking the databases of the United States Patent and Trademark Office (USPTO), Thomson-Reuters Eikon, and BoardEx. Our results indicate that both BGD and Environmental Responsibility lead to higher levels of firm innovation, and that BGD positively moderates the relationship between Environmental Responsibility and innovation.

This paper offers three main contributions to existing research. First, we expand the scope of performance implications of BGD and Environmental Responsibility beyond financial measures in general and specifically to innovation. Since financial measures do not capture all aspects of firm effectiveness, it is worthwhile exploring alternate performance measures like innovation, particularly in firms that depend heavily on innovation for their continued success. Second, we argue that both BGD and Environmental Responsibility should be considered together when assessing firm performance, since both variables interact with each other and with Innovative Output. Finally, we further expand the scope of the ASA Cycle beyond the overall retention of like-minded employees to include the impact of BGD and Environmental Responsibility on overall firm performance with respect to innovation.

The remainder of the paper includes four sections. In Theory and Hypotheses, we review existing literature and develop a series of three hypotheses. In Data and Methods, we outline our sample, variables, and statistical methods used to test our hypotheses. The Results section reports the findings of the test of our hypotheses. In Discussion and Conclusions, we discuss the implications of our results and their relevance to both researchers and practitioners.

Theory and Hypotheses

We focus on innovation in this study because it is a key firm activity with significant performance implications. While the importance of innovation has always existed, the more recent pressure for firms to add women to their Boards of Directors and to be more environmentally friendly, while admirable, may have a significant impact on firm innovation. Since these separate and joint impacts are relatively unexplored in the literature, we believe this study is both timely and important.

In the context of Corporate Social Responsibility (CSR) research and its impact on firm performance, most studies have focused on financial measures of firm performance. In a review of existing literature on the impact of CSR on Firm Performance, Kong et al., 2020, found mixed results in empirical studies of the CSR-Performance link, with 34% of firms showing only a partial link and 38% of firms finding no evidence of a link to performance. These inconclusive results led the authors to call for two ways to improve the quality of empirical studies: to consider non-financial performance outcomes, and to include control variables, including R&D spending (Kong et al., 2020). This study answers both calls. Figure 1 (below) lays out our conceptual framework and hypotheses, which are explained below.

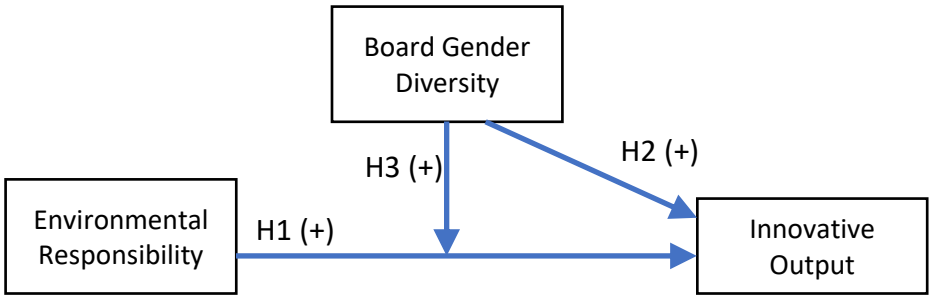


Figure 1. Conceptual Framework

Board Gender Diversity and Innovation

For publicly traded firms, there is separation of management and control, and the Board of Directors acts in the interest of shareholders to guide strategic decisions and ensure the firm's long-term viability. Among firm activities, innovation stands out for the long-term nature of the gap between initial efforts to innovate and the financial payoff, so it seems logical that the Board of Directors will play a key role in guiding innovation efforts (Griffin, Li & Xu, 2021). In this study, we use patents as a measure of Innovative Output; patents require years of research to obtain, which is followed by years of product development before a salable product is available. The Board of Directors is distinct from lower-level firm management in its strategic decision-making and long-term view; management tends to have a shorter-term focus on day-to-day operations and quarterly earnings, which is why we focus here on the Board of Directors.

Research from a variety of fields has shown gender differences in behavior, including that woman tend to have a more long-term orientation (Silverman, 2003; Croson & Gneezy, 2009; Griffin, et al., 2021), can lead organizations to be more creative (Stahl et al., 2009) and more successful in the international markets (Sui, Morgan & Baum, 2022), all of which are necessary for innovation. According to the ASA Cycle (Schneider, 1987; Schneider et al., 1995), people are attracted to work for and stay in organizations that generally share similar attributes as they themselves hold. Since innovation depends heavily on the employees that firms hire and retain, BGD should enhance the ability to attract female managers and employees by increasing the pool of intellectual capital from which a firm can select new employees, and by improving their retention. If this is true, having more women on the Board of Directors should enhance a firm's ability to innovate.

Few studies have examined the link between BGD and Innovative Output as measured by patents and, with one exception, have tended to focus on a single country or region. In a large sample of international firms, Griffin et al. (2021) found that higher BGD was associated with more patents and higher innovative efficiency. A study by Hernández-Lara and Gonzales-Bustos (2020) that compared family and non-family Spanish firms found mixed results for the influence of BGD on

innovation, depending on the family status of the firm and the directors. In a sample of Australian firms, Vafaei et al. (2021) found a positive and significant link between BGD and innovation. Although not unanimous in their findings, these studies and the ASA Cycle led us to our first hypothesis below:

H1: Board Gender Diversity has a positive effect on Innovative Output.

Environmental Responsibility and Innovation

In stakeholder theory (Freeman, 1984), firms that develop trusting relationships with a variety of external stakeholders will be rewarded with higher levels of performance (Squires and Elnahla, 2020). Studies looking at the impact of Environmental Responsibility on firms' financial performance have had mixed results. However, Burke and Logsdon (1996) maintain that more general CSR programs can have strategic benefits that are not immediately revealed in financial performance. Since firms belong to the communities in which they operate, they have a vested interest in not destroying those communities or their natural resources (Benn and Kramar, 2011). We believe Environmental Responsibility represents a uniquely important component of CSR that firms can use to build stakeholder relationships. Although CSR and Environmental Responsibility are thought of as a net good for society, the impacts of these efforts on firm performance are less clear. For example, multiple reviews of studies looking at the impact of overall CSR performance on financial performance found no definitive relationship with financial performance (e.g., Perrini et al., 2011; Goyal et al., 2013; Lee & Roh, 2012; Duygu & Gor, 2014).

Looking only at the CSR pillar of Environmental Responsibility, few studies have considered its impact on firm performance and few papers have considered the specific case of firm innovation as a measure of firm performance. However, several studies have shown a link between green innovation and Environmental Responsibility. In a study of Taiwanese firms, Huang and Li (2017) found separate impacts for innovation of green products and green processes on Environmental Responsibility and firm performance. However, they did not look at the direct effect of Environmental Responsibility on overall firm performance as we do here. A study of publicly traded Chinese firms by Li et al. (2020) found that firm innovation was a mediator between Environmental Responsibility and overall firm performance. Here, we believe that Environmental Responsibility will have a positive effect on overall firm innovation.

Second, we focus here on Innovative Output rather than financial performance. Studies of CSR efforts on firm performance have focused mainly on financial measures and these results have been mixed. Considering alternative measures of firm performance – called firm effectiveness by Richard et al. (2009) – might help uncover important relationships not revealed in financial analyses. We propose that Environmental Responsibility will enhance external stakeholder relationships, making it easier to attract and hire talented employees and easier to access the external resources and capabilities needed to innovate. The ASA Cycle reinforces this idea, suggesting that Environmental Responsibility may help not just with hiring talented employees but with retaining them (Schneider, 1987; Schneider et al., 1995), which leads to our second hypothesis:

H2: Environmental Responsibility has a positive effect on Innovative Output.

Moderating Effect of BGD on Environmental Responsibility and Innovation

Having established above the case for the direct effects of BGD and Environmental Responsibility on Innovative Output, we turn now to the relationship between BGD and Environmental Responsibility. Prior research has shown considerable evidence indicating that women are more likely than men to be environmentally responsible (Zhang et al., 2012). At the firm level, prior research has shown that firms with higher levels of BGD are less likely to have environmental violations (Liu, 2018).

While the dependent variable of interest here is overall firm Innovative Output, other studies have looked at the more specific case of green or environmental innovation (e.g., Nadeem, et al., 2020; He & Jiang, 2019) and generally found a positive relationship between BGD and environmentally focused or green innovation. Empirically, this alludes to a potential moderating relationship between BGD and Environmental Responsibility for their influence on overall firm innovation. From the theoretical perspective of the ASA Cycle, we expect higher levels of BGD to positively affect the relationship between Environmental Responsibility and Innovative Output for two reasons. First, with women as top decision-makers on the Board of Directors, we expect higher levels of Environmental Responsibility as female board members are attracted to join and value the Environmental Responsibility they share with their firms. Higher levels of BGD should make it easier to attract, select, and retain (Schneider, 1987) other employees who also value Environmental Responsibility and, in turn, help the firm be more innovative, which will strengthen the relationship between Environmental Responsibility and Innovative Output (Schneider, 1987; Schneider et al., 1995). Given the assumption that higher levels of BGD lead to both higher levels of innovation and higher levels of Environmental Responsibility, we expect a multiplicative effect, meaning that BGD positively moderates the relationship between Environmental Responsibility and Innovative Output, which leads to our third and final hypothesis:

> *H3: Board Gender Diversity positively moderates the relationship between a firm's Environmental Responsibility and its Innovative Output.*

Methods

Testing our hypotheses requires a representative sample of firms with accurately documented innovation outputs, Environmental Responsibilities, and board diversity information. We obtained such a sample by linking three primary sources of data: the USPTO list of top-patenting organizations, Thomson-Reuters Eikon, and BoardEx. The USPTO is the largest repository of filed patents in the United States (US) and half of the issued patents were associated with non-US organizations (Abadi & Pecht, 2020). Specifically, a firm must have 40 or more patents to be included in the USPTO list of top-patenting firms. Although this cutoff is arbitrary, all firms included are among the top-patenting firms in the world at the USPTO. Since we are interested here in Innovative Output in the form of patents, all firms included in the sample have expended considerable time and resources to acquire those patents, and Innovative Output is important to firm strategy. From the USPTO, we collected information on the number of patents a firm received in each year between 2007 and 2015. We linked the USPTO data to the Thomson-Reuters Eikon Database, which contains environmental, social, corporate governance, and financial information for a representative sample of firms worldwide for a large variety of sectors (Eduardo & Aguilera-

Caracuel, 2021). Finally, we linked the above database to BoardEx, which provides information about the characteristics of Boards of Directors such as the genders of the board members (Richard, Triana, & Zhang, 2022). After accounting for missing information and other problematic entries, the final merged data consisted of 895 firm-year observations for 160 unique firms.

Variables and Measurements

Our dependent variable, Innovative Output, is constructed on the count of patents USPTO issues to a company in each calendar. A small portion of the organizations in the sample were very prolific, producing several thousand patents per year, while others had fewer than one hundred. Because of the skewness of the patents variable, we used the log transformation of the count of patents to measure Innovative Output (Arts, Hou, & Gomez, 2021).

Independent Variables

Board Gender Diversity is the proportion of each company's Board of Directors who are women, with scores ranging from 0 to 1. Environmental Responsibility is measured by the Environmental Pillar Score from the Thomson-Reuters' ESG Scores. Specifically, Environmental Responsibility reflects a firm's performance in (1) resource use, such as reduced use of energy or water eco-efficient solutions; (2) emissions, such as reduce environmental emissions; and (3) innovation, such as new environmental technologies, eco-designed products, relative to its industry peers (Thomson-Reuters, 2017). Environmental Responsibility values range from 0 to 1, with 1 as the highest score.

Control Variables

A firm's Social Responsibility and Governance Responsibility is controlled based on Thomson-Reuters' ESG Scores. Specifically, Social Responsibility reflects a firm's commitment to the workforce, human rights, community, and product responsibility, while Governance Responsibility reflects a firm's commitment to management, shareholders, and CSR strategy. We also control a firm's ESG Controversies, a proprietary measure from Thomson-Reuters, and track firm involvement in ongoing ESG-related scandals, such as lawsuits, fines, and legislation disputes.

Since Boards of Directors vary in size, we include the Number of Directors as a control. Larger companies have more resources to put toward innovation, so we control firm size using the Log of Total Assets. Besides being larger, higher-performing firms may have more slack resources for innovation activities, so we control firm performance using Return on Assets. Since higher R&D spending has been associated with higher levels of innovation (Dobrzański, Bobowski, Chrysostome, Velinov, & Strouhal, 2021; Morgan, Sui, & Baum, 2018), we control for R&D Intensity. Although our sample includes firms from many industries, the vast majority are from the manufacturing sector. We control for inter-industry variation with a dummy variable Manufacturing that takes the value of 1 if a firm's primary North American Industry Classification System (NAICS) number is in the manufacturing industry. Non-US Headquarters is a dummy variable that takes 1 for companies headquartered outside the United States. Finally, we used dummy variables to control for the fiscal years since a firm's Innovative Output depends on macroeconomic conditions (Sui, Baum, & Malhotra, 2019).

Estimation Methods

Our dependent variable Innovative Output is measured by the log value of the count of patents a firm received each year. This information is collected from the USPTO, and includes only companies with 40 or more patents. With the minimum number of patents at 40 (the log of which is 1.602), Innovative Output is truncated with values of 1.602 and higher. As suggested by Simar and Wilson (2007), truncated regression analysis (Lu, Kweh, & Huang, 2014; Ryu & Sueyoshi, 2021) is most appropriate to test our hypotheses.

We recognized the potential for self-selection bias in our study as all the observations in our sample are high-patenting organizations with 40 or more patents (one criteria for the USPTO database). Therefore, following established research (e.g., Morgan, Sui, & Malhotra, 2021), we used Heckman's (1979) two-step selection model to address these potential issues. Based on the entire sample of all firms that reported Environmental Responsibility and BGD, we assigned a dummy variable Patent that equals 1 if a firm reported patents in a fiscal year and 0 otherwise. We ran a probit model and estimated the firm's probability of reporting patents on the ESG score, BGD, Number of Directors, industry, and year dummies. We calculated the inverse Mills ratio (IMR) and included it in our regression analysis.

Results

Table 1 (below) reports the means, standard deviation, and correlations for study variables. Note that Innovative Output is positively correlated with BGD and Environmental Responsibility. On average, the Innovative Output is 179 (exponential value of 5.189) for each firm, which confirms that our sample firms are high-patenting firms. The average BGD in our sample is 15.1% (SD = 0.083). Specifically, over 25% of the observations have a BGD of less than 9.1%, 50% have a BGD of less than 14.3%, and only 25% have a BGD of 21.4% or higher. The average Environmental Responsibility of our sample firms is 0.218 (SD = 0.078).

Table 1: **Descriptive statistics and bivariate correlations**

		1	2	3	4	5	6	7	8	9	10	11	12
1	Innovative Output	1											
2	BGD	0.242*	1										
3	Environmental Responsibility	0.382*	0.250*	1									
4	Social Responsibility	0.328*	0.335*	0.497*	1								
5	Governance Responsibility	0.363*	0.278*	0.435*	0.403*	1							
6	ESG Controversies	-0.358*	-0.240*	-0.375*	-0.374*	-0.305*	1						
7	Number of Directors	0.140*	0.211*	0.398*	0.462*	0.283*	-0.233*	1					
8	Return on Assets	0.124*	0.016	0.195*	0.151*	0.165*	-0.055	0.015	1				
9	Log of Total Assets	0.514*	0.387*	0.507*	0.478*	0.498*	-0.466*	0.462*	0.136*	1			
10	R&D Intensity	0.012	-0.200*	-0.171*	-0.199*	-0.185*	0.123*	-0.304*	-0.157*	-0.458*	1		
11	Manufacturing	-0.071	-0.125*	-0.093	0.013	0.064	0.066	0.104	-0.095	-0.009	-0.012	1	
12	Non-US Headquarters	0.124*	-0.085	-0.037	0.021	0.040	0.029	0.028	0.012	-0.006	0.015	0.076	1
	Mean	5.189	0.151	0.218	0.236	0.189	0.341	10.264	9.446	23.136	0.082	0.785	0.082
	SD	1.101	0.098	0.078	0.076	0.056	0.268	2.085	8.129	1.392	0.077	0.411	0.274

N=895; *p<0.01

Results for Hypothesis Testing

Moving to our main analyses, Table 2 (below) reports the regression results for our hypotheses tests. Model 1 is the baseline model and does not include Environmental Responsibility or BGD. Model 2 includes BGD, Model 3 includes Environmental Responsibility, and Model 4 includes both BGD and Environmental Responsibility. Model 5 includes both BGD and Environmental Responsibility, and their interaction variable.

Hypothesis 1 posits that BGD has a positive effect on Innovative Output. Model 2 shows that the coefficient of BGD is positive and statistically significant (β=1.418, p =0.010). A one standard deviation increase in BGD increases a firm's number of patents by 19, on average. Thus, Hypothesis 1 is supported.

Hypothesis 2 posits that Environmental Responsibility has a positive effect on Innovative Output. Model 3 shows that the coefficient of Environmental Responsibility is positive and statistically significant (β =1.752, p =0.039). A one standard deviation increase in Environmental Responsibility increases a firm's number of patents by 16, on average. Thus, Hypothesis 2 is supported.

Hypothesis 3 proposes that the effect of Environmental Responsibility on Innovative Output will be higher if a firm has a more gender-diversified board. Model 5 shows the coefficient of the

interaction between Environmental Responsibility and BGD is positive and statistically significant (β =19.586, p=0.004). Thus, Hypothesis 3 is also supported. Table 3 summarizes the results of our hypotheses with corresponding statistics.

Table 2: Truncated regression of Innovative Output.

	Dependent Variable: Innovative Output$_{(t)}$				
Independent Variables	(1)	(2)	(3)	(4)	(5)
BGD		**1.428*****		**1.332****	**-3.203***
		(2.59)		(2.42)	(-1.91)
Environmental Responsibility			**1.752****	**1.733****	**-1.219**
			(2.07)	(2.04)	(-0.93)
BGD * Environmental Responsibility					**19.586*****
					(2.91)
Social Responsibility	**0.930**	**0.739**	**0.184**	**-0.102**	**0.0572**
	(1.01)	(0.80)	(0.18)	(-0.10)	(0.06)
Governance Responsibility	**1.838***	**1.632***	**1.543**	**1.282**	**1.020**
	(1.87)	(1.66)	(1.56)	(1.29)	(1.04)
ESG Controversies	**-0.196**	**-0.184**	**-0.190**	**-0.179**	**-0.261**
	(-1.00)	(-0.94)	(-0.97)	(-0.91)	(-1.34)
Number of Directors	**-0.150*****	**-0.151*****	**-0.152*****	**-0.153*****	**-0.144*****
	(-5.81)	(-5.86)	(-5.90)	(-5.97)	(-5.67)
Return on Assets	**0.0184*****	**0.0187*****	**0.0170*****	**0.0172*****	**0.0157*****
	(3.20)	(3.28)	(2.95)	(3.00)	(2.77)
Log of Total Assets	**0.790*****	**0.769*****	**0.768*****	**0.743*****	**0.725*****
	(14.05)	(13.63)	(13.47)	(12.95)	(12.79)
R&D Intensity	**6.461*****	**6.487*****	**6.322*****	**6.331*****	**5.996*****
	(10.14)	(10.22)	(9.87)	(9.94)	(9.47)
Manufacture	**-0.246****	**-0.224****	**-0.228****	**-0.202***	**-0.211****
	(-2.38)	(-2.17)	(-2.20)	(-1.95)	(-2.06)
Non-US Headquarters	**0.860*****	**0.901*****	**0.885*****	**0.932*****	**0.940*****
	(6.08)	(6.34)	(6.23)	(6.52)	(6.66)
IMR	0.128	**0.146**	**0.120**	0.139	0.137
	(0.93)	(1.07)	(0.88)	(1.02)	(1.02)
Constant	**-12.88*****	**-12.54*****	**-12.45*****	**-12.04*****	**-10.94*****
	(-10.31)	(-10.06)	(-9.88)	(-9.56)	(-8.56)
Sigma	1.012***	1.009***	1.011***	1.007***	0.996***
	(28.58)	(28.63)	(28.61)	(28.67)	(28.80)
Log likelihood	-998.735	-990.561	-991.767	-988.413	-984.244
Wald chi2	394.49	412.26	407.74	412.82	432.58

Firm-year observations = 895; Firm observations = 160; z value in parentheses. Independent variables are lagged by one year. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

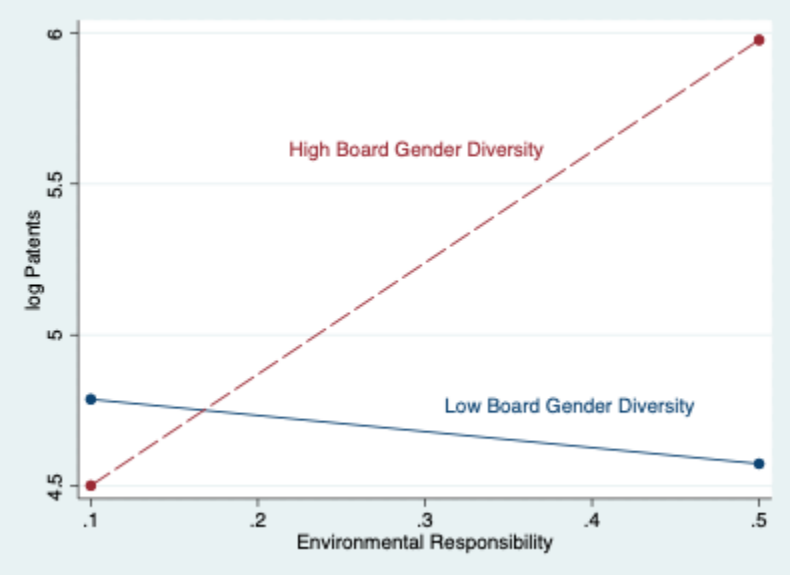
To facilitate interpretation, we plotted the hypothesized moderating effect of BGD in Figure 2 (below). In the plot, we separate firms into two groups: firms with high BGD (mean plus one standard deviation of BGD, which is 0.249) and low BGD (mean minus one standard deviation of BGD, which is 0.053). The plot reveals that the effect of Environmental Responsibility on Innovative Output is positive for firms that have high BGD but negative for firms with low BGD.

Table 3: Summary of the findings

Hypothesis	Coefficient	z value	P value	Result
H1	1.428	2.59	0.010	Supported
H2	1.752	2.07	0.039	Supported
H3	19.586	2.91	0.004	Supported

Our results for the control variables are mostly in line with existing literature. All models in Table 2 show that firms with higher Return on Assets (better financial performance), higher Log of Total Assets (larger size), higher R&D Intensity, lower Number of Directors, non-US headquarters (foreign firms), and non-manufacturing industry are more likely to have higher Innovative Outputs.

Figure 2: Interaction plots for BGD and Environmental Responsibility



Reliability and Validity

To ensure the reliability and validity of our data, and the robustness of our results, we took the following steps. First, we performed outlier analysis and data cleaning to inspect the extreme values that could have a strong influence on our statistical analysis. Second, we checked the variance inflation factors (VIF) of our dependent variables, which were found to range from 1 to 3.34. These results suggest that our sample does not have the issues of multicollinearity. Third, in our analysis, instead of using log-transformed patents, we used the original values; instead of using 1-year lagged values, we used 2-year lagged values of Environmental Responsibility and BGD. Fourth, we exclude firms whose headquarters are not in the US. Finally, we used the Poisson panel regression analysis instead of the truncated regression analysis. After making changes in step 3, our results remain consistent with our original results.

Discussion and Conclusion

As outlined at the beginning of the paper, our central research questions focus on the direct impacts of BGD and Environment Responsibility on firm innovation, and whether BGD moderates the relationship between Environmental Responsibility and innovation. Theoretically, we propose that these relationships are driven by the ASA Cycle (Schneider, 1987) such that both BGD and Environmental Responsibility help firms to attract, select, and retain employees who share those values, and those employees, in turn, will drive overall firm Innovative Output. Overall, our findings suggest that both BGD and Environmental Responsibility lead to higher levels of Innovative Output as measured by patenting. Both findings are important as efforts to increase the representation of women in top management and efforts to be environmentally responsible are often portrayed as neutral or even harmful to firm performance. Here, we show strong evidence that both BGD and Environmental Responsibility enhance firm performance in terms of innovation. The positive moderation suggests that firms need not choose between increasing BGD or Environmental Responsibility; rather, they should be pursued together.

Implications for Researchers

Much of the research on the impact of firm characteristics on Innovative Output has focused on firm-level financial measures. A major contribution of this paper is to encourage researchers to look at non-financial firm performance metrics when looking at BGD and/or Environmental Responsibility. Here, we used innovation as a metric of firm effectiveness, but our results raise the possibility that other measures be considered as well. Innovation could be measured in different ways, such as by including new product introductions or patent impacts, rather than just a count of patents. Future studies could consider a variety of measures of firm effectiveness, such as brand image or customer perceptions.

Implications for Practitioners

Our results indicate that both BGD and Environmental Responsibility increase Innovative Output. For firms that emphasize innovation and protect innovation via patents, our findings indicate that having more women on their Board of Directors and having more Environmental Responsibility can lead to higher levels of innovation, and these measures can even reinforce each other. So, while higher BGD may have internal benefits on the workforce, we show here a direct link between BGD and firm performance in terms of Innovative Output. Being more environmentally responsible is often seen as something that is admirable and necessary, but also potentially detrimental to firm performance. In sharp contrast, firms in this study with higher levels of Environmental Responsibility had higher levels of Innovative Output. In other words, firms did well by doing good for the environment.

Limitations

Our sample was confined to top-patenting firms and the dependent variable Innovative Output was constructed from a count of patents. Although it seems plausible that firms with fewer patents than the sample firms would also experience gains from BGD and Environmental Responsibility, future studies would have to confirm this. Since our measure of Innovative Output used only patents, we cannot generalize to non-patenting firms, even if they are innovative in other ways. Future studies

could look at non-patent measures of innovation to see if this relationship still holds. Although all firms must innovate to remain competitive, there may be something about BGD that is uniquely valuable in the production of patentable technologies that may not translate to other forms of innovation.

Empirically, we tried to improve the generalizability of our results. Our raw dependent variable was truncated at 40 patents because the USPTO only aggregated and published a list of firms with 40 or more patents during the sample window. We chose the log transformation of the raw count variable due to the heavily right-skewed dependent variable: a few firms generate thousands of patents, whereas most, even the top-patenting firms in our sample, generate fewer than a hundred. Thus, the log transformation reduced the chance that our results were being driven by outliers at the far right of the dependent variable. Our use of truncated regression helped us control for those firms not captured in the sample (i.e., those with fewer than 40 patents), increasing the likelihood that our results would hold up among the lesser-patenting firms. While we presented results of a truncated regression here, the results were robust to other specifications and the significance of our findings were subject to more conservative estimators here than when using untransformed, untruncated methods.

Future Directions and conclusion

Our measure of Innovative Output relies on a raw count of patents as a measure of Innovative Output, but it may be useful in future research to collect more detailed data on the individual patents. Patent application data would allow researchers to consider the impact of patents produced, often measured by forwarding citations, as well as technology breadth and depth as measured by technology classes. In addition to looking at patents in more detail, future studies could consider different measures of Innovative Output, including the introduction of new products, process innovations, and other ideas not captured or protected by patents. Although we focused here on BGD, future studies should consider the impact of other forms of diversity such as age, education, and culture.

We conceptualized our hypotheses using the ASA Cycle (Schneider, 1987), but our empirical data cannot conclusively tease out the exact mechanism driving the observed relationships tested. Future studies could look more deeply at this question, perhaps considering the use of qualitative surveys of employees and managers to determine motivations and behaviors of employees and how that drives the relationships among BGD, Environmental Responsibility, and Innovative Output.

Our findings suggest that firms using patents to protect their innovation can improve their Innovative Output through higher levels of BGD and Environmental Responsibility. This paper expands the scope of the ASA Cycle theory into the firm-level performance of Innovative Output as driven by BGD and Environmental Responsibility. While prior studies have considered the separate impacts of BGD and Environmental Responsibility on firm performance, ours is among the first to consider their joint impact, particularly on Innovative Output. The positive moderation revealed here suggests an amplifying effect of doing both together, and this is a significant contribution to the literature with implications for practitioners and researchers alike.

References

Abadi, H. H. N., & Pecht, M (2020). "Artificial intelligence trends based on the patents granted by the united states patent and trademark office", IEEE Access, 8, 81633-81643.

Arts, S., Hou, J., & Gomez, J. C (2021). "Natural language processing to identify the creation and impact of new technologies in patent text: Code, data, and new measures", Research Policy, 50(2), 104144.

Antoncic, D. M (2021). "Is ESG investing contributing to transitioning to a sustainable economy or to the greatest misallocations of capital and a missed opportunity?", Journal of Risk Management in Financial Institutions, 15(1), 6–12.

Benn S, Kramar R (2011). "Editorial: Introduction and interviews. Educating for sustainability and CSR: What is the role of business schools?", Journal of Management & Organization, 17(5), 574–582.

Burke L, Logsdon JM (1996). "How corporate social responsibility pays off.", Long Range Planning, 29(4), 495–502.

Croson, R. and Gneezy, U (2009). "Gender differences in preferences", Journal of Economic Literature, 47, 448–474

Dobrzański, P., Bobowski, S., Chrysostome, E., Velinov, E., & Strouhal, J (2021). "Toward Innovation-Driven Competitiveness Across African Countries: An Analysis of Efficiency of R&D Expenditures", Journal of Competitiveness, 13(1).

Duygu, A., & Gor, A (2014). "Analyzing the effects of corporate social responsibility level on the financial of companies: An application on BIST corporate governance index included companies", International Journal of Management Economics and Business, 10(23), 227–242.

Eduardo, D. G., & Aguilera-Caracuel, J (2021). "Environmental, Social and Governance (ESG) Scores and Financial Performance of Multilatinas: Moderating Effects of Geographic International Diversification and Financial Slack", Journal of Business Ethics, 168(2), 315-334.

Freeman RE (1984). "Strategic Management: A Stakeholder Approach", Pitman: Boston.

Goyal, P., Rahman, Z., & Kazmi, A. A (2013). "Corporate sustainability performance and firm performance research: Literature review and future research agenda", Management Decision, 51(2), 361-379.

Griffin, D., Li, K., & Xu, T (2021). "Board gender diversity and corporate innovation: International evidence", Journal of Financial and Quantitative Analysis, 56(1), 123-154.

He, X., & Jiang, S (2019). "Does gender diversity matter for green innovation?", Business Strategy and the Environment, 28(7), 1341-1356.

Hernández-Lara, A. B., & Gonzales-Bustos, J. P. (2020). "The influence of family businesses and women directors on innovation", Applied Economics, 52(1), 36–51. https://doi.org/10.1080/00036846.2019.1638496

Huang, J.-W., & Li, Y.-H (2017). "Green Innovation and Performance: The View of Organizational Capability and Social Reciprocity", Journal of Business Ethics, 145(2), 309–324.

Kong, Y., Antwi, A. A., & Bawuah, J (2020). "A systematic review of the business case for corporate social responsibility and firm performance", Corporate Social Responsibility & Environmental Management, 27(2), 444–454.

Laroche M, Bergeron J, Barbaro-Forleo G (2001). "Targeting consumers who are willing to pay more for environmentally friendly products", Journal of Consumer Marketing , 18(6), 503–521.

Lee, J., & Roh, J (2012). "Revisiting corporate reputation and firm performance link. Benchmarking:", An International Journal, 19(4/5), 649–664.

Li, Z., Liao, G., & Albitar, K (2020). "Does corporate environmental responsibility engagement affect firm value? The mediating role of corporate innovation", Business Strategy & the Environment, 29(3), 1045–1055.

Liu, C (2018). "Are women greener? Corporate gender diversity and environmental violations", Journal of Corporate Finance, 52, 118–142.

Lu, W. M., Kweh, Q. L., & Huang, C. L (2014). "Intellectual capital and national innovation systems performance", Knowledge-based systems, 71, 201-210.

MacDonald WL, Hara N (1994). "Gender differences in environmental concern among college students", Sex Roles, 33(5/6), 369–74.

Murugaboopathy, P. & Jessop, S., (2021). "Global sustainable fund assets hit record $2.3 tln in Q2, says Morningstar", available at https://www.reuters.com/business/sustainable-business/global-sustainable-fund-assets-hit-record-23-tlnq2-says-morningstar-2021-07-27/

Nadeem, M., Bahadar, S., Gull, A. A., & Iqbal, U (2020). "Are women eco-friendly? Board gender diversity and environmental innovation", Business Strategy & the Environment, 29(8), 3146–3161.

Nelson, R. R (1995). "Recent evolutionary theorizing about economic change", Journal of Economic Literature, 33(1), 48–90.

Park, S.-J., Choi, S., & Kim, E.-J (2012). "The relationships between socio-demographic variables and concerns about environmental sustainability", Corporate Social Responsibility & Environmental Management, 19(6), 343–354.

Perrini, F., Russo, A., Tencati, A., & Vurro, C (2011). "Deconstructing the relationship between corporate social and financial performance", Journal of Business Ethics, 102(1), 59–76.

Richard, P. J., Devinney, T. M., Yip, G. S., & Johnson, G (2009). "Measuring organizational performance: Towards methodological best practice", Journal of Management, 35(3), 718–804.

Rosenkopf, L., & Nerkar, A (2001). "Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry", Strategic Management Journal, 22(4), 287–306.

Ryu, Y., & Sueyoshi, T. (2021). "Examining the Relationship between the Economic Performance of Technology-Based Small Suppliers and Socially Sustainable Procurement", Sustainability, 13(13), 7220.

Schneider, B (1987). "The People Make the Place", Personnel Psychology, 40(3), 437–453.

Schneider, B., Goldstein, H. W., & Smith, D. B (1995). "The Asa Framework: An Update", Personnel Psychology, 48(4), 747–773.

Setó, P. D, (2015). "The relationship between women directors and corporate social responsibility", Corporate Social Responsibility & Environmental Management, 22(6), 334–345.

Shauki E (2011). "Perceptions on corporate social responsibility: A study in capturing public confidence", Corporate Social Responsibility and Environmental Management, 18(3), 200–208.

Sila, V., Gonzalez, A., & Hagendorff, J (2016). "Women on board: Does boardroom gender diversity affect firm risk?", Journal of Corporate Finance, 36(Supplement C), 26-53.

Silverman, I. W (2003). "Gender differences in delay of gratification: A meta-analysis", Sex Roles, 49, 451–463.

Simar, L., & Wilson, P. W (2007). "Estimation and inference in two-stage, semi-parametric models of production processes". Journal of econometrics, 136(1), 31-64.

Squires, B. and Elnahla, N., 2020. The roles played by boards of directors: an integration of the agency and stakeholder theories. *Transnational Corporations Review*, *12*(2), pp.126-139.

Sui, S., Baum, M. and Malhotra, S (2019). "How home-peers affect the export market exit of small firms: Evidence from Canadian exporters", Entrepreneurship Theory and Practice, 43(5), 1018-1045.

Sui, S., Morgan, H. M., & Baum, M. (2022). "Differences between women-and men-owned export businesses: are women-owned export businesses more financially successful when they adopt an intensive export strategy?", Journal of Small Business & Entrepreneurship, 1-18.

Stahl, G. K., Maznevski, M. L., Voigt, A., & Jonsen, K (2009). "Unraveling the effects of cultural diversity in teams: A meta-analysis of research on multicultural work groups", Journal of International Business Studies, 20, 1–20.

Teece, D. J., Pisano, G., & Shuen, A (1997). "Dynamic capabilities and strategic management", Strategic Vafaei, A., Henry, D., Ahmed, K., & Alipour, M (2021). "Board diversity: female director participation and corporate innovation", International Journal of Accounting & Information Management, 29(2), 247–279.

Thomson Reuters. (2017). "Thomson Reuters ESG scores". (March.) Available at: https://www.esade.edu/itemsweb/biblioteca/bbdd/inbbdd/ archivos/Thomson_Reuters _ESG_Scores.pdf

Wang, Y., Wilson, C., & Li, Y (2021). "Gender attitudes and the effect of board gender diversity on corporate environmental responsibility", Emerging Markets Review, 47, June (no page numbers).

World Bank Group. (2015). "Women, Business, and the Law 2016: Getting to Equal", World Bank. available at https://thedocs.worldbank.org/en/doc/810421519921949813-0050022015/original/WomenBusinessandtheLaw2016.pdf

Zhang JQ, Zhu H, Ding H (2012). "Board composition and corporate social responsibility: an empirical investigation in the Post Sarbanes–Oxley Era", Journal of Business Ethics, 114(3), 381-392.