Environmental sustainability orientation and ambidextrous green innovation: do the roles of women on corporate boards matter?

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Abstract

Purpose of the paper: *This study investigates the relationship between environmental sustainability orientation and green innovation ambidexterity and considers the role of women on corporate boards in moderating this relationship. To this end, a research model was developed according to the Natural Resource Based View Theory and the Upper Echelon Theory.*

Methodology*: A survey was conducted of 116 listed Italian companies with at least one female director holding a specified role. A moderated hierarchical regression was employed to test the research hypotheses.*

Findings*: Environmental sustainability orientation positively influences green exploitation innovation and exploration innovation. Moreover, the roles of women on corporate boards strengthen the effect of environmental sustainability orientation on green innovation ambidexterity.*

Research limits: *The size of the sample and its nature required prudence in generalizing the results to unlisted Italian companies.*

Practical implications*: Environmental sustainability orientation is an affordable solution to address the innovation paradox, since it contributes to a balance between exploitation and exploration activities. Moreover, a higher number of female directors should be present on the boards of firms that look to improve environmental sustainability by fostering green innovation ambidexterity.*

Originality of the paper*: Environmental sustainability orientation, green innovation ambidexterity, and women on corporate boards were contextually investigated for the first time. Thus, the study adds a more granular understanding of these constructs through a model that is theoretically derived and empirically examined.*

Key words: environmental orientation sustainability; women on corporate boards; green innovation ambidexterity; exploitation innovation; exploration innovation.

1. Introduction

Sustainable development is one of the greatest challenges of the twenty-first century. It arises from a growing awareness of the unsustainability of our dynamic and interconnected world due to, among others, environmental issues such as global warming, climate change resulting from fossil combustion, biodiversity loss, and the need for safe food.

All of these issues are increasingly destroying social, environmental, and economic value. It is worth noting that the speed and ubiquity of unexpected and disruptive critical events, such as the Covid-19 pandemic, have pointed out the pervasiveness of ecological emergencies. Thus, the global pandemic foregrounds the connections among different factors, such as human health and living conditions, threats to economic growth, and environmental degradation (natural resource consumption).

These issues have prompted global stakeholders to call for sustainable business models that are able to shift their focus from short-term value towards corporate environmental activities and their long-term outcomes (Ciasullo *et al.*, 2019; Eide *et al.*, 2020). In this sense, 2020 was a pivotal year for environmental challenges. In 2020, BlackRock (2022) CEO Larry Fink announced that his asset management company would seek to align its portfolio with a net zero economy according to the principle of environmental sustainability. This was supported by a commitment to disclosing environmental-related risks resulting from social, economic, and regulatory pressures.

In the current business climate - characterized by tough competition, rapid technological development, and the changing dynamics of consumer behaviour - innovation plays a pivotal role in contributing to businesses' long-term survival and competitiveness (Pisano, 2015; Ciasullo *et al.*, 2020). In this vein, ambidextrous innovation can support organizations' innovation processes, exploiting their established knowledge, and renewing their knowledge portfolio by searching for new opportunities (Levinthal and March, 1993; Jansen *et al.*, 2006).

The sustainability management literature maintains that green innovation, as a new innovation mode, offers a win-win solution for reducing the conflict between economic development and environmental protection (Leal-Rodríguez *et al.*, 2018). This is due to its peculiarities, which, on the one hand, deal with the ability to merge environmental, technological, legal, and ethical aims, and, on the other, with riskier and more expensive investments (Cainelli *et al.*, 2015). Even though scholars have investigated the antecedents of green innovation, including environmental ethics (Chang, 2011), green suppliers (Weng *et al.*, 2015), environmental regulation (Chan *et al.*, 2016; Zhang *et al.*, 2018), quality management (Li *et al.*, 2018), and absorptive capacity (Aboelmaged and Hashem, 2019), research on the link between environmental sustainability orientation (ESO) and green innovation remains scant. Despite a previous study (Ciasullo *et al.*, 2020) has revealed the existence of this link demonstrating that the board independence strengthens the relationship between environmental sustainability and innovation ambidexterity, further research is needed to understand if and how ESO affects exploitative and exploratory green innovation (Wang *et al.*, 2020).

Conceptually, ESO represents a corporate orientation that approaches business in an environmentally sustainable way (Roxas *et al.*, 2017). Thus, a company can develop and enact its ESO by integrating environmental issues into its corporate culture, decision-making processes, and strategic and business activities (Zwetsloot and van Marrewijk 2004; Linnenluecke and Griffiths 2013). In doing so, the board of directors is a key governing

body for addressing and disclosing environmental issues to both shareholders and other stakeholders (Shaukat *et al.*, 2016), as well as for starting green innovation projects (Berraies and Rejeb, 2019). The board's contribution to sustainability and innovation is linked to its characteristics, including its composition. Its structure is based on size, independence, and diversity. This latter attribute is related to the heterogeneity of its members in terms of gender, age, education, values, personalities, and ethnicity (Galia *et al.*, 2015; Cucari *et al.*, 2018). Board diversity is also considered a key corporate governance mechanism for improving the knowledge, deliberations, and skills needed to handle multi-dimensional and complex corporate issues. Of the different facets of diversity, board gender diversity has been approached as being based on strong social responsiveness to different stakeholder needs and as being able to boost corporate ethical conduct (Glass *et al.*, 2016; Nuber and Velte, 2021).

Board gender diversity, its effect on board functioning, and sustainability issues are at the forefront of issues for scholars, practitioners, and policymakers.

In particular, research in the fields of corporate governance and women on boards has been affected by two main issues.

The first deals with the connections between different sociocultural and psychological attributes and their effect on corporate social/environmental management in terms of performance, reporting, and disclosure. While board gender diversity and corporate social performance are relatively well-researched concepts, the relationship between board gender diversity and environmental performance is still under-investigated (Kassinis *et al.*, 2016; Orazalin *et al.*, 2020).

The second issue focuses on the link between female presence on boards and corporate propensity towards innovation. In this case, a large body of literature reports that gender diversity on boards can positively influence corporate commitment to innovation (Miller and Del Carmen Triana, 2009; Midavaine, Dolfsma, and Aalbers, 2016). Scholars have underlined that firms with a greater female presence among top managers tend to achieve greater success in innovation (Chen *et al.*, 2018). However, female characteristics on boards and their influence on environmental innovation ambidexterity still need further investigation (He *et al.*, 2019; Rejeb *et al.*, 2020; Konadu *et al.*, 2022).

To address these issues and advance the results of a prior study (Ciasullo *et al.*, 2020), this paper aims to further the understanding of the nexus between women's roles on corporate boards, environmental sustainability orientation, and green innovation ambidexterity. This can contribute to more effective responses to global pressures for strategic postures that combine corporate responsibility and competitiveness. To this end, the paper explores the links between environmental sustainability orientation (ESO) and ambidextrous green innovation (AGI) and considers women's roles on boards (WBR) and their ability to moderate these links. Thus, the following research questions arise:

RQ1: Is there a relationship between ESO and AGI?
RQ2: Does WBR affect the relationship between ESO and AGI?

Drawing on the natural-resource-based view (NRBV) theory and the upper echelon theory, a research model was developed highlighting the relationship between the following variables: ESO, AGI, and WBR. The research findings demonstrated the existence of a positive relationship between AGI and WBR, where the latter moderates the relationship itself. The proposed research model was tested with empirical observations collected from a sample of 116 listed Italian companies, based on a moderated hierarchical regression (Baron and Kenny, 1986).

This study offers interesting theoretical and practical implications. First, it addresses a research gap by merging ESO, AGI, and WBR in a single study. Second, quantitative evidence demonstrates that ESO is an antecedent in balancing exploitative and explorative green innovation, which contributes to achieving strategic outcomes and a long-lasting competitive advantage. Third, it found that being influenced by WBR, the effect of ESO on AGI grows along with a better integration of green exploitative and explorative innovation. Consequently, this confirms that women tend to be more sensitive to environmental issues.

This paper is organized as follows: Section 2 reviews the existing literature on ESO, AGI, and WBR. The theoretical background and research hypotheses are presented. Section 3 describes the method, and Section 4 presents the findings. Finally, Section 5 is dedicated to a discussion of the findings and to a presentation of the implications, limitations, and future research paths.

2. Literature review

2.1 Environmental Sustainability orientation (ESO) and ambidextrous green innovation (AGI)

The great challenges of environmental protection and sustainable development have put green innovation at the forefront of academia, industry, and society.

Green innovation refers to "all measures of relevant actors which develop new ideas, behaviours, products and processes, apply or introduce them, and which contribute to a reduction of environmental burdens or to ecologically specified sustainability targets" (Rennings and Rammer, 2011). Similarly, the Eco-Innovation Observatory (EIO) approaches green innovation as "the introduction of any new or significantly improved product (goods or services), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle" (EIO 2011, p. 7). These two definitions suggest that the main difference between innovation, as it is generally intended, and environmental or green innovation is the latter's orientation towards reducing the negative environmental impact of business activities.

Other peculiarities, such as growing technological complexity, intricate bureaucratic procedures that affect development times, growing operations costs (e.g., related to the environmental audit and assurance)

(Nidumolu *et al.*, 2009; Collins *et al.*, 2010), and a wide range of resources and capabilities (Tseng *et al.*, 2013) add uncertainty to green innovation compared with traditional innovation. However, research on the topic has demonstrated that green innovative companies tend to be more successful (Albort-Morant *et al.*, 2017) and achieve better overall performance than their competitors. This is due to their ability to gain operational advantages that increase performance efficiency (e.g., reducing energy or water use costs or generally reducing waste), market advantages that meet an even more green-oriented demand (e.g., stakeholder satisfaction and trust), and strategic advantages (e.g., more flexibility and competitiveness) (Parboteeah *et al.*, 2012; Akhtar *et al.*, 2020). Green innovation can be classified according to 1) its intensity and 2) its propensity to exploit existing knowledge or explore new knowledge (March, 1991). It follows that, on the one hand, exploitative green innovation relates to the implementation of existing environmental knowledge, capabilities, and practices to improve or change existing green products, services, and business processes. On the other hand, exploratory green innovation relates to the development of environmental knowledge and skills to create new, green-oriented markets, products, services, and processes (Chen, 2008; Chen and Chang, 2013; Leal-Rodríguez *et al.*, 2018).

Businesses should invest in both exploitative and explorative innovation because both contribute to performance improvement and to the businesses' own success (Gupta *et al.*, 2006; Cao *et al.*, 2009). Thus, an overemphasis on exploitative innovation can hint at an ability to adapt to change and can make knowledge obsolete, progressively reducing corporate competitiveness. At the same time, an overemphasis on explorative innovation can cause operational inefficiency and an increase in costs and negative returns, especially when companies act under uncertainty (Tsai and Huang, 2008). Avoiding these negative effects - known as "success trap" (resulting from excessive exploitation) and "failure trap" (resulting from excessive exploration) (Levinthal and March, 1993) - remains a challenge for companies. This challenge implies a need and opportunity to balance exploitative and explorative green strategies in the areas of energy saving, pollution prevention, and environmental quality improvement in one all-encompassing process. This will simultaneously boost economic, social, and ecological value. In other words, exploitative and explorative green innovations should complement one another; thus, balancing their actions would make it possible to merge short-term profits from exploitative innovation with long-term benefits from adaptation to external changes emerging from explorative innovation (Wang and Li, 2008; Schamberger *et al.*, 2013).

In a nutshell, green ambidexterity represents a core dynamic organizational capability that enables companies to add an environment-friendly orientation to their value creation processes (Albertini, 2021). In doing so, companies are also able to use innovation to strengthen their competitive advantage.

ESO implies that companies must integrate environmental issues into their corporate orientation and align and change their strategies to reflect this (Roxas *et al.*, 2017). In other words, ESO represents a firm-

level strategic construct that leads companies to engage in and commit to environmental issues, resources, activities, processes, and practices. This construct implies a strategic corporate orientation that is reflected in the ability to recognize opportunities for gaining economic, ecological, and societal value by engaging in green activities (Jiang *et al.*, 2018).

This implies that ESO is related to corporates' inclinations towards green activities aimed at innovating, improving proactiveness, and risk-taking. More specifically, innovativeness relates to companies' willingness to change current practices, products, and technologies to capture new green opportunities that often lead to the development and use of new resources. Proactiveness relates to companies' opportunity-seeking orientation, which is the ability to capture new opportunities coming from emerging market demands to gain a competitive advantage. Finally, risk-taking relates to companies' disposition towards investing in green initiatives with indeterminate returns (Brettel *et al.*, 2015).

Exploiting the "pillars" of ESO, such as innovativeness, proactiveness, and risk-taking, can allow to companies to actualise the ambidexterity ability in providing organizational dynamics capabilities essential to challenge short- and long- term changes and in catching new opportunities.

This study assumed the theoretical perspective of the NRBV to better understand the relationship between ESO and AGI. The NRBV (Hart, 1995) represents an extended form of the resource-based view (Barney, 1991) and hypothesizes that companies can gain a sustainable competitive advantage by challenging environmental issues. It also implies that natural constraints can be overcome by employing strategies for product stewardship, pollution prevention, clean technology, and sustainable development (Hart and Dowell, 2011). These strategies lay the foundation for innovations that can improve firms' environmental performance and competitive advantage (King and Lenox, 2002; De Stefano *et al.*, 2016). In this study the reduction of products' environmental impact led to product stewardship, while responsible waste management and the reduction of negative emissions lessened pollution. Finally, the conservation of natural resources and the use of renewable ones inspire management to follow the principles of sustainable development. By proactively promoting each of these strategies, companies focus their business on innovation that enables them to improve competitiveness as well as social and environmental well-being.

The aforementioned discussed arguments led to the formalization of the following hypothesis:

HP1: ESO has a significant positive impact on AGI.

2.2 Moderating effect of women roles on corporate boards

Green innovation ambidexterity builds its foundation on a strategic commitment, for which promotion the board of directors is essential. Thus, the latter can develop effective corporate governance pointing to environmental performance and performing different and interrelated roles (e.g., strategy, service, control). In this sense, diversity and related

board processes are key mechanisms for achieving ecologically and socially responsible governance, which is essential for grasping new business opportunities. Thus, assuming a corporate governance perspective, board diversity does not simply imply gender variety within the board, but it also implies the way in which the different characteristics and expertise of board members contribute to its processes, decision-making, and outcomes.

In recent decades, the promotion of gender equality in boards' composition has attracted growing interest from policymakers, scholars, and the public (Reguera-Alvarado *et al.*, 2017). In particular, the increasing number of women on boards is a mandatory target on many international policymakers' agendas (e.g., quota laws in Italy, Spain, Iceland, France, and Germany, and EU 2026 targets). The application of specific penalties for punishing non-compliance testifies to the importance of the topic. However, it is worth noting that even though the number of female directors is constantly growing, this growth remains limited, and a balanced gender ratio has not been reached (Montera, 2013; Amorelli and García-Sánchez, 2021). To counteract this situation, most research on the topic has underlined that female presence on boards generally results in a different approach to governance and decision-making and has a positive influence on strategic decisions, such as those related to green innovation.

In this vein, the upper echelon theory maintains that corporate performance results from top management's strategic decisions, which are usually made according to their personal background (Hambrick and Mason, 1984; Gyapong, *et al.*, 2021).

This implies that 1) the role of boards of directors is essential for strategic development and implementation, and 2) directors' sociodemographic traits highly influence their decision-making processes. It follows that their unique values, experiences, personalities, and psychological traits adds different perspectives to decision-making, for example, improving communication and taking a critical approach to problems (Nadeem, *et al.*, 2017). This implies that diversity in board composition is crucial for environmental business practices, especially in terms of decisions related to innovation and resource allocation. According to the upper echelon theory, previous research investigated women's distinctive and common traits, underlining that they tend to be more affectionate, helpful, kind, sympathetic, interpersonally sensitive, and concerned about others' welfare than men (Eagly, *et al.*, 2003). Empirical evidence supports this finding for both the general population and corporate executives (Post *et al.*, 2011).

Inter alia, differences also exist between female and male directors' core values. Principally, the former tends to be not only more benevolent and universally concerned but also less power-oriented than the latter (Adams and Funk, 2012).

More specifically, female directors are characterized by a strong orientation towards corporate social responsibility as well as a strong ethical vision and environmental values. Another well-established trait of female leaders is their orientation towards cooperation and collaboration (Eagly, *et al.*, 2003). Female directors tend to be more willing to invest in green innovation thanks to their positive attitude towards collaboration and participative behaviours, which boost managers' engagement in

balancing exploitative and explorative innovation. This can also constrain executives' opportunistic behaviours typical of agency theory. In a similar vein, Griffins et. al. (2021) maintain that female directors can reduce the agency problem related to excessive risk-taking and short-term focus, which can negatively affect corporate orientation towards innovation.

Another important female trait is their relational orientation (Galbreath, 2011). They tend to be more open to mutual understanding, especially about relationships with more influential stakeholders. In this vein, Hussain *et al.* (2018) underlined that female board representatives tend to strengthen stakeholder relationships. This supports managers' initiative and experimentation, as well as their willingness to share information (Arzubiaga *et al.*, 2018; Gul *et al.*, 2011) and prevents them from focusing on exploitation to the detriment of exploration. Acting as a concrete governance mechanism, female directors can share strategic information because they are able to collect and leverage valuable knowledge assets, which can nurture corporate creativity and innovation-driven activities (Campbell and Mínguez-Vera, 2008). Moreover, female presence on boards adds qualities such as, among others, a stronger alignment towards information disclosure, more flexibility, readiness, and problem-solving and team-building abilities. All of these characteristics are essential for a firm to compete in unpredictable scenarios (Vieito, 2012; Liao *et al.*, 2015).

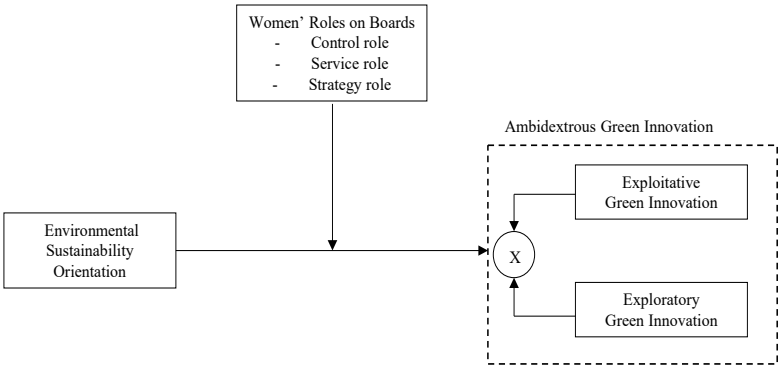
These qualities perhaps allow executive women to act effectively by following divergent thinking processes and making different strategic choices, such as green innovation. This is possible because they can create a collaborative atmosphere that encourages open conversations among a board's members (Bear *et al.*, 2010). In this vein, as an effective strategic mechanism, female executives can solve cognitive conflict among team members by using divergent thinking and assuming an orientation that strategically influences social and environmental issues.

The analysed research led to the following hypothesis:

HP2: WBR positively moderates the relationship between ESO and AGI.

Fig. 1: depicts the research model and hypotheses at the core of this study

Fig. 1: Research model



Source: Own elaboration

3. Method

3.1 Sample selection

This analysis was conducted using quantitative methods and involved a sample of Italian companies listed on the Milan Stock Exchange. These companies were selected because of the openness and accessibility of their corporate governance information. Moreover, they represent an interesting setting for investigating innovation because their stock quotations provide funds for innovating and, in so doing, for promoting a positive brand image among international investors (Rejeb *et al.*, 2020).

The analysis focused on listed Italian companies to remove any negative effect from cross-national variability. Moreover, listed companies are usually large and are evaluated according to environmental, social, and governance (ESG) ratings (Cucari *et al.*, 2018; Clementino and Perkins, 2020).

Using the Orbis database, a total of 326 listed Italian companies with at least one female director holding a specified role were identified. The formula for a finite population was used to calculate the final sample size. It follows that 1) it was considered satisfactory to set a confidence level at 95% (standard value of 1.96), 2) a standard deviation of 0.5 resulted from a pilot survey conducted on a small number of units, and 3) 5% was considered the allowable error. After this, the representative sample of the analysed population was 211 companies (units), which were mostly large (55.2%) and active in the manufacturing sector (50.6%), and the remainder in the service sector to firms and to persons (43.3%) and services exclusively to persons (6.1%).

3.2 Data collection and analysis

Data were collected over a three-month period (December 2019 to March 2020) using a survey aligned with the research purpose. Participants were selected by consulting the Orbis database and surfing corporate websites. They comprised senior environmental managers, R&D managers, board members, and board secretaries, who were first contacted via LinkedIn and then received information via email about the research project and about participation in the online survey. The survey was created and administered using the Qualtrics platform. It was written in Italian, and it included 33 closed questions, organized into 5 sections. The first contained a brief description of the survey's aim, the researchers' identities, the average time needed to fill it out, and the policies for data use and privacy. The second section was made up of 6 questions, 3 of which aimed at shaping the sample profile (industry/sector, board size, and presence of a corporate social responsibility or CSR committee), and the remaining 3 at shaping the respondents' profile (age, education, and years of seniority in the top management team or TMT). The next section was built around 4 questions dealing with ESO and 5 questions dealing with environmental dynamism.

The fourth section was made up of 8 questions dedicated to AGI, with 4 for each type of innovation. Finally, the fifth section included 10 questions

on WBR. Before launching the full-scale formal survey, a pilot test was conducted involving a convenience sample of 20 executives to evaluate the response latency and check question comprehension (Lavrakas, 2008).

A total of 118 responses were collected, of which 2 were rejected due to their incompleteness or to some response set bias. It follows that 116 valid responses were collected, representing a response rate of 54.9%. The collected data were analysed through a moderated hierarchical regression performed using the SPSS v22 software package.

3.3 Measures

Independent variable. ESO is considered the independent variable of the model. Drawing on the sustainability orientation scale of Jagani and Hong (2022), the environmental sustainability orientation measurement is taken into consideration in line with the research purpose. It includes four items (Table 1) that were scored on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Tab. 1: Measurement items

Environmental Sustainability orientation (ESO) (adapted from Jagani and Hong, 2022) ESO1 - Our firm has strategic plans to minimize hazardous waste throughout work processes ESO2 - Our firm communicates green sourcing policies for all suppliers ESO3 - Our firm provides education and training for responsible stewardship of raw materials ESO4 - Our firm supports achieving broad environmental goals (e.g., combat climate change)
Exploitative green innovation (EIGI) (adopted from Wang *et al.*, 2020) EIGI1 - Our firm actively improves current green products, processes and services EIGI2 - Our firm actively adjusts current green products, processes and services EIGI3 - Our firm actively strengthens current green market EIGI4 - Our firm actively strengthens current green technology
Exploratory green innovation (ERGI) (adopted from Wang *et al.*, 2020) ERGI1 - Our firm actively adopts new green products, processes and services ERGI2 - Our firm actively exploits new green products, processes and services ERGI3 - Our firm actively discovers new green market ERGI4 - Our firm actively enters new green technology
Women Board's roles (adapted from Rejeb *et al.*, 2020) *Strategy role (STR)* STR1 - In our firm, women on board formulate and/or approve strategy STR2 -In our firm, women on board define business vision, mission statement and long-term objectives STR3 - In our firm, women on board identify new strategic opportunities *Control role (CR)* CR1 - In our firm, women on board monitor management performance CR2 - In our firm, women on board increase shareholder value CR3 - In our firm, women on board evaluate and reward top management CR4 - In our firm, women on board appoint new managers *Service role (SVR)* SVR1 - In our firm, women on board advise management team SVR2 - In our firm, women on board establish network and maintain relations with the environment SVR3 - In our firm, women on board assist and motive management team
Environmental Dynamism (adopted from Jansen *et al.*, 2006) ED1 - Environmental changes in our local market are intense ED2 - Our clients regularly ask for new products and services ED3 - In our local market, changes are taking place continuously ED4 - In a year, our market has changed a lot ED5 - In our market, the volumes of products and services to be delivered change fast and often

Source: Own elaboration

Dependent variable. Ambidextrous green innovation was the dependent variable of the model. It is measured by two dimensions of exploitative (EIGI) and exploratory (ERGI) green innovation, as adopted from Wang *et al.* (2020) (Tab. 1). The dimensions of ambidextrous green innovation were measured using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Moderating variables. Women's roles on boards were the moderating variable of the model. The relative scale was adopted from Rejeb *et al.* (2020). It includes strategy (three items), control (four items), and service (three items) roles (Table 1), which were scored on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Control variables. To support the robustness of research findings and improve their explanatory strength, control variables were added by grouping three categories (i.e., contextual factors, firm level, and internal factors) that the literature considers as factors affecting green innovation (He and Jiang, 2019). Regarding contextual factors, we controlled for environmental dynamism because environmental aspects matter in the context of innovation ambidexterity (Jansen *et al.*, 2006; Lavie *et al.*, 2010). To measure environmental dynamism, Jansen *et al.*'s (2006) scale was adopted. It includes 5 items (Table 1) that were scored on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). At the firm level, we controlled for board size - assessed by the logarithm of the total number of directors (Duque-Grisales *et al.*, 2020) - because prior studies have considered its influence on ambidextrous innovation (Raisch and Birkinshaw, 2008; Berraies and Rejeb, 2019). The CSR committee was also controlled for - as a dummy variable which takes the value of 1 if the company has a CSR committee and 0 otherwise - since it enhances awareness of environmental issues (Liao *et al.*, 2015). Regarding the internal factors, we controlled for TMT tenure, education, and age, which are linked to the successful adoption and implementation of policies related to environmental sustainability (Naranjo-Gil, 2016; Wiengarten *et al.*, 2017). TMT tenure was assessed by the number of months respondents had worked as part of a TMT (Lubatkin *et al.*, 2006). TMT education is evaluated in terms of primary school, high school, undergraduate, master's, and PhD, while TMT age is measured by the years of TMT's members (Jahanshahi and Brem, 2017).

3.4 Reliability and validity

The Cronbach's alpha value of every variable is well above the cut-off point of 0.7, indicating that our theoretical constructs exhibit good internal reliability (Nunnally, 1978). In addition, convergent validity is ensured, as demonstrated by (1) the composite reliability (CR) that exceeds 0.7; (2) the average variance extracted (AVE) for each construct that exceeds 0.5; and (3) the CR that is higher than the AVE for each construct (Hair *et al.*, 1998) (see Table 2).

Tab. 2: Reliability and construct validity

Variables	Cronbach's α	AVE	CR
ESO	0.90	0.68	0.76
EIGI	0.85	0.73	0.91
ERGI	0.91	0.62	0.83
STR	0.93	0.59	0.78
CR	0.92	0.64	0.77
SVR	0.96	0.82	0.95

Note. AVE = average variance extracted; CR = composite reliability

Source: Own elaboration

4. Results

Descriptive statistics and correlations for each of study variables are reported in Table 3. The modest correlation coefficients of the variables suggest that multicollinearity should not be an issue.

Tab. 3: Descriptive statistics and correlation matrix

Variables	M	SD	1	2	3	4	5	6
1. ESO	4.91	1.18	1					
2. EIGI	0.52	0.50	0.125*	1				
3. ERGI	5.31	0.99	0.236**	0.257**	1			
4. STR	0.49	0.50	0.067	0.050	0.155	1		
5. CR	8.74	17.80	0.175**	0.167**	0.030	0.106	1	
6. SVR	0.49	0.50	0.067	0.050	0.155	0.069	−0.121*	1

**p < 0.01; *p < 0.05.

Note. M = mean; SD = standard deviation

Source: Own elaboration

Prior to the regression analyses the independent and moderator variables were mean-centred according to the recommendations of Aiken and West (1991). In doing so, problems of multicollinearity between the explanatory variables and the interaction terms are eliminated and more easily interpretable estimations can be obtained. To test the hypotheses, a moderated hierarchical regression was used (Baron and Kenny, 1986). The results are reported in Table 4 and Table 5 according to the four steps for each dimension of ambidextrous green innovation. In particular, the variables were introduced as Cohen *et al.* (2003) suggested: first the control variables (Model 1), then the independent variable (Model 2), followed by the moderator variables (Model 3), and finally the variables representing the interaction effects (Model 4).

Tab. 4: Results of regression analysis of EIGI

Variables	EIGI			
	Model 1	Model 2	Model 3	Model 4
Board size	0.18*	0.24**	0.17**	0.22*
CSR committee	0.12	0.29**	0.15	0.08
TMT tenure	0.07	-0.13	0.11	0.04
TMT age	-0.20	0.05	0.09	0.30**
TMT education	0.10	0.09	0.12	0.24*
Environmental dynamism	0.31**	0.19***	0.24**	0.16***
ESO		0.33***	0.25*	0.22**
STR			0.08	0.01
CR			0.03	0.06
SVR			-0.09	0.13
ESO x STR				0.27***
ESO x CR				0.38*
ESO x SVR				0.32**
F	1.356	19.080	0.048	2.776
R^2	0.059	0.143	0.143	0.156

*p < 0.10. **p < 0.05. ***p < 0.01.
Note. Standardized coefficients are reported

Source: Own elaboration

Tab. 5: Results of regression analysis of ERGI

Variables	EIGI			
	Model 1	Model 2	Model 3	Model 4
Board size	0.20**	0.17*	0.21***	0.19**
CSR committee	0.16	0.26***	0.18	0.11
TMT tenure	0.10	0.08	-0.05	0.07
TMT age	-0.01	0.03	0.08	0.28*
TMT education	0.06	-0.16	0.02	0.25**
Environmental dynamism	0.34***	0.25**	0.31**	0.24*
ESO		0.29*	0.20***	0.23**
STR			0.15	-0.22
CR			0.08	0.10
SVR			0.03	0.11
ESO x STR				0.34**
ESO x CR				0.29*
ESO x SVR				0.36***
F	1.701	17.772	0.045	5.887
R^2	0.073	0.151	0.151	0.176

*p < 0.10. **p < 0.05. ***p < 0.01.
Note. Standardized coefficients are reported

Source: Own elaboration

Model 1 of Tables 4 and 5 highlights a positive and significant influence of board size for both exploitative ($\beta = 0.18$, $p < 0.10$) and exploratory ($\beta = 0.20$, $p < 0.05$) green innovation. A larger board size seems to lead to the achievement of ambidextrous green innovation. In addition, environmental turbulence has a statistically significant influence on exploitative ($\beta = 0.31$, $p < 0.05$) and exploratory ($\beta = 0.34$, $p < 0.01$) green innovation, indicating that the contextual dynamism pushes boards to pursue ambidextrous green innovation.

Model 2 allowed us to test Hypothesis 1. A positive relationship between environmental sustainability orientation and exploitative green innovation ($\beta = 0.33$, $p < 0.01$) (Table 4) and between environmental sustainability orientation and exploratory green innovation ($\beta = 0.29$, $p < 0.10$) (Table 5) can be observed by confirming Hypothesis 1. An increase in environmental sustainability orientation will thus enhance a firm's opportunities to pursue green innovation in an ambidextrous way. Further, the variable of CSR committee in this model shows a positive, statistically significant influence on exploitative ($\beta = 0.29$, $p < 0.05$) (Table 4) and exploratory ($\beta = 0.26$, $p < 0.01$) (Table 5) green innovation, indicating that the presence of a CSR committee influences the development of ambidextrous green innovation in the listed Italian companies.

In Model 3, the variables of the strategy, control, and service roles of women on corporate boards are added and show no direct significant effect of these roles on either exploitative or exploratory green innovation. Thus, the interaction effect of women's roles on boards with environmental sustainability orientation and ambidextrous green innovation is expected to be significant.

Model 4 introduces the interaction of women's roles on boards with environmental sustainability orientation and ambidextrous green innovation. The results indicate the presence of a pure moderating effect of women's roles on boards on the main relationship, since the direct effect of this variable on exploitative or exploratory green innovation is not significant, whereas the interaction terms for exploitative green innovation (ESO x STR: $\beta = 0.27$; $p < 0.01$; ESO x CR: $\beta = 0.38$; $p < 0.10$; ESO x SVR: $\beta = 0.32$; $p < 0.05$) (Table 4) and exploratory green innovation ESO x STR: $\beta = 0.34$; $p < 0.05$; ESO x CR: $\beta = 0.29$; $p < 0.10$; ESO x SVR: $\beta = 0.36$; $p < 0.01$) (Table 5) are significant. Thus, Hypothesis 2 is confirmed, since women's roles on boards increase the positive effect of environmental sustainability orientation on ambidextrous green innovation. Further, the variables of TMT age and education in this model show a positive, statistically significant influence on the relationship between environmental sustainability orientation and exploitative or exploratory green innovation (TMT age: $\beta = 0.30$, $p < 0.05$; TMT education: $\beta = 0.24$, $p < 0.10$) (Table 4) and exploratory (TMT age: $\beta = 0.28$, $p < 0.10$; TMT education: $\beta = 0.25$, $p < 0.05$) (Table 5) green innovation. These results indicate that the presence on boards of older women and those with higher education is important to enhance ambidextrous green innovation.

5. Discussion and conclusion

This study aims to shed further light on the influence that environmental sustainability orientation plays on ambidextrous green innovation by investigating the moderating effect that a board's roles, and in particular female members, have on this relationship.

The originality of this research lies in approaching these themes that are so essential for the current socio-economic dynamics in an integrated way and thus contributing to bridging two major research gaps. Indeed, on

the one hand this paper responds to the call for further empirical research on the relationship between sustainability orientation and ambidexterity innovation (Sulphey and Alkahthani, 2017) and on the other, to a recent call for further theoretical research on sources of environmental sustainability orientation (Ameer and Khan, 2022). Therefore, through the empirical implementation of a research model built upon a review of the extant literature, this paper offers a more granular comprehension of environmental sustainability, ambidexterity innovation, and gender diversity on boards.

Drawing on theoretical insights from the natural-resource-based view and the upper echelon theory, this research demonstrates that ESO positively affects ambidextrous green innovation. This prediction is strongly supported by the results empirically achieved. Thus, ESO not only acts as a lever of sustainability performance, but also as an antecedent to balance green exploitative and exploratory innovation. It follows that ESO represents a strategic mechanism to solve tensions related to the exploitation-exploration paradox in firms' innovations (Zeng *et al.*, 2017). This is due to its capability to boost the joint pursuit of these two contradictory activities. However, this balance does not represent a bland compromise, but rather an excellent integration of exploitation and exploration (Andriopoulos and Lewis, 2009) in which women's roles on boards are essential for balancing the two dimensions of green innovation. Research findings demonstrated that ESO influence on ambidextrous green innovation grows together with the growth of female roles on boards.

Female directors contribute to a board's service role, making the relationship between ESO and the two dimensions of green innovation stronger.

In this sense, women on boards shape relational leadership by adopting more participative and democratic styles than their male counterparts. This creates a climate that is supportive of innovation. Moreover, the presence on boards of older women and those with higher education enhances boards' commitment to sustainability. These two elements lead to valuable governance mechanisms that increase corporates' capacity to scan green opportunities, which has the effect of favouring ambidextrous green innovation. Indeed, the strategic role makes the relationship between ESO and explorative green innovation stronger. In line with previous research, gender diversity on boards represents a pool of resources because a growing heterogeneity leads to more knowledge, competencies, and skills (Amran *et al.*, 2014; Cucari *et al.*, 2018) that are useful for environmental sustainability and for ambidexterity innovation.

Therefore, advancing research on the topic has led to a definition of female executives as "eco-influencers" of other board members because they boost creativity and promote new ideas, thus encouraging environmentally and sustainability-oriented decision-making processes. Moreover, in balancing the two dimensions of innovation, gender diversity can act as a turning point in solving conflicting interests and opposing visions in top management teams. This becomes possible by nurturing a more agile decision-making environment characterized by better information sharing and a stronger commitment to the organization. It follows that

even though gender diversity can contribute to proactive environmental strategies, its implementation depends on an embedded corporate environmental sustainability orientation among all the board's members. Indeed, the research findings emphasize that the control role affects only the relationship between ESO and exploitative green innovation. This shows that agency problems have not yet been solved, especially in terms of male executives' opportunistic behaviour.

Drawing on these considerations, it is worth noting that it is not the structural dimension of the board but rather the quality of the related governance mechanisms that affects green ambidextrous innovation. This is in line with scholars who underlined that women, by offering boards a wider and more varied approach, contribute to the enactment of innovation strategies to solve tensions and reduce the conflict between economic development and environmental protection (Konadu *et al.*, 2022).

This paper offers three main theoretical implications. First, NRBV theory and upper echelon theory represent the theoretical basis of this research, while most previous studies on environmental issues and corporate governance have adopted a single theoretical lens (Luo and Tang, 2014; McGuinness *et al.*, 2017). Thereby, a more focused approach is embraced that better explains the relationship between natural environmental constraints, specific governance characteristics, and exploitative and explorative green innovation. Second, the research contributes to the literature on corporate governance by emphasizing the importance of women's roles on boards as valuable mechanisms of governance to boost the effect of ESO on ambidextrous innovation. Thus, the most important tasks in charge of women executives enhance the contribution of ESO to the implementation of the two types of green innovation. Third, this research contributes to the innovation management literature. This comes from the empirical evidence that led us to consider ESO as a new antecedent of ambidextrous green innovation as a key corporate dynamic capability.

Finally, this study also offers interesting managerial implications. It suggests that companies willing to improve the effectiveness of their environmental decisions by fostering innovation tend to pay more attention to board composition. Particularly, women who perform service roles should be recruited onto boards because their alternative viewpoints and fresh strategic perspectives on ESO support male executive directors' engagement in exploratory innovative projects rather than in exploitative ones. In doing so, female executives promote decision-making processes that can boost the achievement of an organization's competitive edge. This emphasizes the current strategic perspective, which focuses on the need for agile decision-making. Therefore, according to research findings on strategic decisions and resource allocation processes, top executives must merge proactivity and sustainability through adaptation tactics and long-term commitments.

In addition, the study demonstrates that CSR committee does not influence the ambidextrous green innovation when there are women on corporate boards thus suggesting that female directors influence various board decisions and particularly decisions to implement in practice environmental projects. Thus, business practitioners and policymakers

should leverage on the female presence in the governance structure because of their ethical, moral, and social values that affect a social oriented view of businesses and a responsible management, thus encouraging the CSR engagement of firms regardless of whether CSR committees exist or do not. Accordingly, women on board could act as insurance mechanism both for sustainable investors in allocating their capital or investing into green portfolio, and for a broad range of stakeholders to resolve social threats, like environmental ones, gaining more trust from them.

Despite these contributions and implications, this research is not without limitations. First, the survey was conducted on just 116 listed Italian businesses. Consequently, the sample size and its nature can affect the findings' generalizability to unlisted Italian firms. Second, future research should design cross-country studies to compare the relationship between ESO, ambidextrous green innovation, and women's roles on boards in different national and international settings.

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