Board Diversity and Greenhouse Gas Emissions Efficiency: Evidence from Latin America

1 Introduction

Ecological issues are increasingly a significant factor in business decisions is becoming more important for companies (García Martín & Herrero, 2020). An overload of greenhouse gases in the atmosphere contributes to climate change and global warming, leading to changes in food security, a rapid shrinking of the planet green cover and an increase in the Earth's temperature (Al-Qahtani & Elgharbawy, 2020). In this line, there is a concern with more sustainable practices driven by external factors, such as non-governmental organizations, customers and supply chain partners, and by internal factors, such as management, resources and motivation (Cordeiro et al., 2020). Therefore, companies are gradually adopting sustainable practices and making environmental issues central to their strategies (Burkhardt et al., 2020).

Growing concern about corporate governance after a series of corporate scandals has meant that the board of directors to play a vital role in environmental performance (Moussa et al., 2020). Board diversity can be viewed as a structural phenomenon addressing board independence, CEO independence and director ownership, or a demographic phenomenon comprising ethnicity, gender, and age (Hoang et al., 2018) and diverse boards benefit from different perspectives to better perform their duties (Baker et al., 2020). In this context, board diversity is a good corporate governance practice, which encourages firms to improve environmental performance (Al-Qahtani & Elgharbawy, 2020).

A substantial amount of literature addresses a strong empirical link between board diversity and environmental performance (Lu & Herremans, 2019; Zaid et al., 2020) In general, the empirical evidence suggests a positive relationship the gender diversity (Biswas et al., 2018; Cordeiro et al., 2020; Lu & Herremans, 2019; Tingbani et al., 2020; Wasiuzzaman & Wan Mohammad, 2020), board specific skills diversity (Al-Qahtani & Elgharbawy, 2020; Arayssi & Jizi, 2019; Harjoto et al., 2015; Helfaya & Moussa, 2017) and board independence diversity (Biswas et al., 2018; Endrikat et al., 2020; Formigoni et al., 2020; Husted & Sousa-Filho, 2017; Mascena et al., 2020; Shaukat et al., 2016; Shu & Chiang, 2020) on the environmental performance.

The objective of the paper is to analyze the influence of board diversity (gender diversity, board independence diversity and board skill diversity) on the greenhouse gas emissions efficiency. Theoretically, the effect of board diversity on greenhouse gas emissions efficiency can be explained using a number of theories. First, agency theory (Jensen & Meckling, 1976) is based on the contractual relationship between principals and agents, agents act on the principals' behalf to serve the interests of the principals (Kumala & Siregar, 2020). Second, resource dependency theory (Pfeffer & Salancik, 1978) see firms working in an open system that needs to exchange and acquire resources to survive, thereby creating a dependency between firms and the external environment (Cordeiro et al., 2020) and new resources and capabilities must be developed or acquired by firms to improve their performance on issues like reducing greenhouse gas emissions (Lu et al., 2020). Third, upper echelon theory (Hambrick & Mason, 1984) posits that some characteristics of managers such as age, education level and past experiences are key factors for implementing strategic policies (Shahab et al., 2020)

The study collects data from 287 firms in Latin America over a 5-year period (2015-2019). The study contributes to the literature in several aspects. First, Latin America comprises one of the most valuable ecosystems on the planet, with a region four times larger than Western and Eastern Europe combined (Gallego-Álvarez et al., 2018) and the study investigates the impact of board diversity on the greenhouse gas emissions efficiency in Latin America firms. Second, the study uses a multi-theoretical perspective, including agency, resource dependency, and upper echelons theories. Finally, data was obtained from Thomson Reuters database.

Thomson Reuters database provides environmental, social and governance (ESG) information of firms from stock market filings and annual company reports (Burkhardt et al., 2020).

The remainder of the paper is organized as follows. Section 2 reviews the literature and develops the relevant research hypotheses. The research design is presented in Section 3. Section 4 reports the empirical results. Finally, Section 5 concludes the paper.

2 Literature review and hypotheses development

2.1 Climate change strategies: Perspectives in Latin America

Climate change have become frequent in several parts of the world in recent years (Wimbadi & Djalante, 2020). Economic growth must be sustainable without association with greenhouse gas emissions, because the impacts of climate change must be taken into account (Lamperti et al., 2020) and organizations adopt low-carbon practice strategies to tackle climate change (Lopes de Sousa Jabbour et al., 2020). Therefore, reducing greenhouse gas emissions brings benefits to the environment and social and economic improvements (Chowdhury et al., 2020)

In Latin America, greenhouse gas emissions increased 0.7% between 1990 (3,414 MtCO2eq) and 2020 (4,020 MtCO2eq) (Koengkan & Fuinhas, 2020). Latin American countries are very vulnerable to the effects of climate change, these countries present extreme and unpredictable climatic events, negatively affecting the economy and the well-being of their populations (Román-Collado & Morales-Carrión, 2018) and climate change strategies such as the Emissions Trading Scheme (ETS) are taking shape in the Latin America (Oliveira et al., 2020). Further, the Latin American countries with the highest representation in terms of GDP (Brazil, Colombia, Mexico and Argentina) and CO2 emissions are very dependent on fossil fuels such as oil and as most of the CO2 emissions are energy related, the transition to a green economy has become fundamental (Román-Collado & Morales-Carrión, 2018).

2.2 Gender diversity and greenhouse gas emissions efficiency

According to resource dependence theory, a diverse board will have a range of skills, experience, knowledge and culture that will enhance the general performance of the board (Azam et al., 2019) and help decision-make process (Kolev & McNamara, 2020). In this line, women directors connect a firm to important components of its environment because they currently constitute a significant part of human capital (Al-Qahtani & Elgharbawy, 2020). Therefore, gender diversity can bring resources and advice that influence board decisions in mitigating global environmental challenges and adopting sustainable environmental policies and programs (Haque & Jones, 2020).

From the upper echelon theory perspective, gender board diversity can affect firm strategy because men and women can have different characteristics (Činčalová & Hedija, 2020). The presence of women directors can improve the effectiveness of the board and thus facilitate strategic changes of firms in environmental practices (He & Jiang, 2019). In this context, a greater presence of women on the board can be associated to a better social and environmental behavior of the company because women are more aligned with the social and environmental corporate performance (Byron & Post, 2016). Therefore, women directors in upper echelons can encourage the board to make relevant decisions on environmental issues, improving environmental performance and greenhouse gas emission efficiency (Uyar et al., 2020).

According to agency theory, gender diversity can be viewed as a corporate governance mechanism of and its presence provides more robust decision-making that can drive to better performance (Al-Jaifi, 2020). The presence of women directors could act as a mechanism to control and supervision the activity of a board (Jarboui et al., 2020). In this line, women directors are more likely to attend board meetings than male directors, thus providing better board monitoring (Jain & Zaman, 2020). Therefore, gender diversity improves the firm's engagement in social and environmental activities, because it plays a key role in monitoring managers and enhancing the independence of the board of directors (Gallego-Álvarez & Pucheta-Martínez, 2020; Zaid et al., 2020).

Previous studies revealed a positive and significant relationship between gender diversity and environmental performance (Biswas et al., 2018; Cordeiro et al., 2020; Lu & Herremans, 2019; Tingbani et al., 2020; Wasiuzzaman & Wan Mohammad, 2020). In line with theoretical discussions and prior empirical findings, the following hypothesis is proposed:

Hypothesis 1: There is positive relationship between gender diversity and greenhouse gas emissions efficiency

2.3 Board specific skills diversity and greenhouse gas emissions efficiency

According to the resource dependency theory, there is a link between the firm and its external resources, which influences the appointment of directors with important skills and competencies to the firm (Badu & Appiah, 2017). Skills board members acquired over time are determined by the board members' exposure, experience and level of education (Ozordi et al., 2019). Board skills diversity allows for greater board resources and better board decisions on environmental issues (Al-Qahtani & Elgharbawy, 2020). Board members with specific skills are more effective because they have specific knowledge and skills (Gallego-Álvarez & Pucheta-Martínez, 2020).

Empirically, Al-Qahtani and Elgharbawy (2020), Arayssi and Jizi (2019), Harjoto et al., (2015) and Helfaya & Moussa (2017) found a significant positive relationship between board specific skills and environmental performance. In line with theoretical discussions and prior empirical findings, the following hypothesis is proposed:

Hypothesis 2: There is positive relationship between board specific skills diversity and greenhouse gas emissions efficiency

2.4 Board independence diversity and greenhouse gas emissions efficiency

In line with the agency theory, corporate governance mechanisms, such as board independence, offer more efficiency in addressing agency problems than any other governance mechanism (Al-Gamrh et al., 2020). Independent directors provide more objective advice than insiders because they are non-executive directors external to the organization and there is no financial influence on its behavior (García Martín & Herrero, 2020). In this regard, independent directors have incentives to increase board effectiveness because their reputation and capital value are associated with their decision making (Shu & Chiang, 2020). Independent directors have a key role in corporate governance and the business decision making process (Colakoglu et al., 2020). Therefore, according to agency theory, independent directors should be a majority on the board because they effectively monitor agents' decisions and help reduce agency costs (Naciti, 2019).

Biswas et al. (2018), Endrikat et al., (2020), Formigoni et al., (2020), Husted and Sousa-Filho (2017), Mascena et al., (2020), Shaukat et al., (2016) and Shu and Chiang (2020) determined that board independence diversity positively influences environmental performance. In line with theoretical discussions and prior empirical findings, the following hypothesis is proposed:

Hypothesis 3: There is positive relationship between board independence diversity and greenhouse gas emissions efficiency

3 Research Design

3.1 Sample selection and data sources

Our sample is composed of 1047 firm-year observations from 287 firms from Argentina, Brazil, Chile, Colombia, Mexico, and Peru between 2015 and 2019. Argentina, Brazil, Chile, Colombia, Mexico and Peru were selected because they belong to the Morgan Stanley Capital International (MSCI) Emerging Markets Latin America Index, created in 1990, which quarterly captures information from companies in six Latin American countries: Argentina, Brazil, Chile, Colombia, Mexico and Peru (MSCI, 2020). Our data set is made up of information from the Thomson Reuters Eikon database. Table 1 illustrates the sector classification used in this analysis, based on the Global Industry Classification Standard (GICS).

Table 1

Sample distribution by sector of activity and countries

Sector	Countries						
	Argentina	Brazil	Chile	Colombia	México	Peru	Total
Automobiles & Components	0	4	0	0	4	0	8
Banks	18	25	20	18	20	9	110
Capital Goods	7	15	18	5	9	8	62
Commercial & Professional Services	0	4	0	0	0	0	4
Consumer Durables & Apparel	8	34	4	0	8	0	54
Diversified Financials	4	9	9	14	9	4	49
Energy	14	18	4	4	4	0	44
Food & Staples Retailing	4	9	4	5	9	4	35
Food, Beverage & Tobacco	14	28	15	4	34	18	113
Health Care Equipment & Services	0	14	0	0	0	0	14
Household & Personal Products	0	4	0	0	5	0	9
Insurance	0	15	0	0	4	0	19
Materials	15	44	14	8	38	36	155
Media & Entertainment	7	4	0	0	8	0	19
Pharmaceuticals, Biotechnology & Life Sciences	3	4	0	0	4	0	11
Real Estate	8	14	4	0	7	4	37
Retailing	4	23	7	4	5	0	43
Software & Services	4	10	4	0	0	0	18
Telecommunication Services	4	14	4	4	4	0	30
Transportation	7	24	11	0	24	4	70
Utilities	27	60	34	14	4	12	151
Total	148	372	152	80	196	99	1047

As is evident from the data in Table 1, the sample comprised twenty-one activity sectors. Firms belonging to the materials sector represent 155 observations (14,8%), followed by the utilities and food, beverage and tobacco sectors at 151 (14,4%) and 113 (10,7%) observations, respectively. The sector with the lowest representation was commercial and professional services with 4 observations (3%). In reference to countries, Brazil is the country with the most observations with 372 (35,5%), followed by Mexico and Argentina with 196 (18,7%) and 148 (14,1%) observations, respectively.

3.2 Variables measurement

3.2.1 Dependent variable

Greenhouse gas emissions efficiency is presented in this study as the dependent variable, in line with previous studies (Bui et al., 2020; Qian & Schaltegger, 2017), this variable is calculated as logarithm of the ratio between greenhouse gas emissions of scope 1 (direct emissions), in tons of CO2 equivalent - tCO2e, and the gross revenue, thus measuring greenhouse gas emissions efficiency. The variable has an inverse relationship, the lower, more efficient is the firm, for example, if two firms have same gross revenue in a given year, the firm with the lowest greenhouse gas emissions this year is the most efficient, with a lower value in the relationship between greenhouse gas emissions and gross revenue (our dependent variable). Greenhouse gas emissions efficiency can help assess firms' performance in reducing carbon emissions, environmental performance and optimizing low carbon operations (Bui et al., 2020).

3.2.2 Independent variables

In this study we adopted dimensions of board diversity. Gender diversity, board specific skills diversity and board independence diversity were introduced in our regression model to examine their influence on the greenhouse gas emissions efficiency in the Latin America firms. To compute the Blau index we employed the following equation:

Blau index formula: $\mathbf{1 - \sum_{i-1}^{n} P_i^2}$

where:

P_i = the proportion of boardroom members in each category in the ith group.

n = the number of different categories.

$\sum$ = the sum of the calculations from category 1 to category n.

We used the Blau index to measure dimensions of board diversity. Blau index ranges from 0, if there is no diversity to 0.5, if the proportion of category members is exactly the same (Zaid et al., 2020) and provides greater robustness to the board diversity, because it presents maximum value when diversity, in fact, is maximum (Campbell & Mínguez-Vera, 2008).

3.2.3 Control Variables

A review of past empirical research allowed considering several control variables in this analysis. The board size in line with Beji et al., (2020), Endrikat et al., (2020), Gallego-Álvarez and Pucheta-Martínez (2020) and Zaid et al., (2020) was calculated as the total number of directors on boards. The second control variable was company performance, proxied with market capitalization of common stock plus book value liabilities divided by the book value of total assets (Aggarwal et al., 2019; M C Pucheta-Martínez et al., 2019; María Consuelo Pucheta-Martínez et al., 2020). Profitability in line with García-Sánchez (2020) was measured as income after taxes for the fiscal period divided by total assets. Furthermore, leverage, was also controlled, measured as debt over total assets (Olthuis & van den Oever, 2020; Orazalin, 2020; Orazalin & Baydauletov, 2020; M C Pucheta-Martínez et al., 2019; María Consuelo Pucheta-Martínez et al., 2020). Finally, the company size was calculated as natural logarithm of total assets (Orazalin, 2020; Orazalin & Baydauletov, 2020; María Consuelo Pucheta-Martínez et al., 2020). See the variables description in Table 2.

Table 2

Variables description

Variable name	Variable name	Model name	Proxy
Dependent	Greenhouse gas emissions efficiency	GGE	Natural logarithm (Greenhouse gas emissions/Gross Revenue)
Independent	Gender diversity	GED	$-\sum_{i-1}^{n} P_i^2$, where P_i is the proportion of boardroom members in each category and n is the number of different categories
Independent	Board specific skills diversity	BSSD	$-\sum_{i-1}^{n} P_i^2$, where P_i is the proportion of boardroom members in each category and n is the number of different categories.
Independent	Board independence diversity	BID	$-\sum_{i-1}^{n} P_i^2$, where P_i is the proportion of boardroom members in each category and n is the number of different categories.
Control	Board size	BSIZE	Total number of board members
Control	Company performance	QTOBIN	Market capitalization of common stock plus book value liabilities/book value of total assets.
Control	Profitability	ROA	Income after taxes for the fiscal period/Total assets
Control	Leverage	LEV	Total debt/Total assets
Control	Firm size	FSIZE	Natural logarithm of total assets

3.3 Empirical model

The hypothesis proposed will be estimated with the following model:

$$GGE_{i,t} = \beta_0 + \beta_1 GED_{i,t} + \beta_2 BSSD_{i,t} + \beta_3 BID_{i,t} + \beta_4 BSIZE_{i,t} + \beta_5 QTOBIN_{i,t} + \beta_6 ROA_{i,t} + \beta_7 LEV_{i,t} + \beta_8 TAM_{i,t} + \varepsilon \quad (1)$$

where, GGE is the greenhouse gas emissions efficiency, measured using natural logarithm greenhouse emissions divided by gross revenue. GED is the gender diversity, calculated using Blau index. BSSD is the board specific skills diversity, measured using Blau index. BID is the board independence diversity, calculated using Blau index. BSIZE is the board size, measured using total number of directors. QTOBIN is the company performance, calculated using market capitalization of common stock plus book value liabilities divided by book value of total assets. ROA is the profitability, measured using income after taxes for the fiscal period divided by total assets. LEV is the leverage, calculated using total debt divided by total assets. FSIZE is the firm size, measured using natural logarithm of total assets. β_0 the constant, i represents firm, t represents time dimension (years), β_1 to β_8 are the regression coefficients, ε is a vector of the stochastic error term.

4.1 Results

4.1 Descriptive statics

Table 3 reports a summary of the descriptive statistics for all variables considered in the study model. The average greenhouse gas emissions efficiency is -9,207 with an SD of 2,322, and it ranges from -15,882 to -4,251.

Table 3

Descriptive statics

Variables	N	Mean	SD	Minimum	Maximum
GGE	801	-9,207	2,322	-15,882	-4,251
GED	801	0,125	0,136	0	0,5
BSSD	801	0,328	0,157	0	0,5
BID	801	0,353	0,157	0	0,5
BSIZE	801	10,089	3,717	2	25
QTOBIN	801	0,281	0,234	0	5,369
ROA	801	0,071	0,110	-1,178	0,838
LEV	801	0,281	0,234	0	0,883
FSIZE	801	22,107	1,734	5,697	26,795

Notes: GGE is the greenhouse gas emissions efficiency, measured using natural logarithm greenhouse emissions divided by gross revenue. GED is the gender diversity, calculated using Blau index. BSSD is the board specific skills diversity, measured using Blau index. BID is the board independence diversity, calculated using Blau index. BSIZE is the board size, measured using total number of directors, QTOBIN is the company performance, calculated using market capitalization of common stock plus book value liabilities divided by book value of total assets. ROA is the profitability, measured using income after taxes for the fiscal period divided by total assets. LEV is the leverage, calculated using total debt divided by total assets. FSIZE is the firm size, measured using natural logarithm of total assets.

The average level of Blau gender is 12,5% which is similar to 13% reported by Zaid et al., (2020) using the Blau index, higher than 9% and 4% reported by Khan et al., (2019) and Lu and Herremans (2019) , respectively, and less than 18,03% reported by Burkhardt et al., (2020), and it ranges from 0 to 0,5. The mean value of board specific skills diversity is 0,32 and it ranges from 0 to 0,5. Blau independence has a mean value of 0,353 and it varies between 0 and 0,5.

4.2 Multivariate analysis

We test our hypotheses using the generalized method of moments (GMM) system estimator appropriate for relatively short periods (Blundell & Bond, 1998). The GMM estimator, unlike other procedures, is efficient and consistent because it tackles the unobservable heterogeneity, γi, which is modeled as an individual effect and is eliminated with the first differences of the variables (Gallego-Álvarez & Pucheta-Martínez, 2020). This estimator contains two level equations that require instrumental variables in order to remove the correlation between explanatory variables and residuals (Naciti, 2019). GMM allows consistent estimates by controlling fixed effects, unobserved heterogeneity, endogeneity, and simultaneity, moreover, partially eliminates the requirement for external instruments (Lin et al., 2020). Panel data modeling has been associated with heteroscedasticity and endogeneity issues of the explanatory variables and to deal with these issues, the GMM system allows a lagged dependent variable as the endogenous variable (Elsalih et al., 2020). Further, this technique is used in social science because it presents several advantages, such as, it avoids unobservable heterogeneity resulting from specific characteristics of each firm that are constant in time, eliminating the risk of biased results and it allows controlling the possible endogeneity of independent variables (Pérez-Cornejo et al., 2020).

All the model specifications pass the AR (2) test analyzes the non-serial correlation between the error terms and validity of the instruments and the Hansen test of overidentifying restriction is performed to verify the existence of correlation between the instruments and the error term. The Hansen test for over-identification of restrictions explores the lack of correlation between the instruments and the error term testing the validity of the model specifications (Crisóstomo et al., 2020; Crisóstomo & de Freitas Brandão, 2019). Table 4 presents the findings of all the models.

Table 4

Results of the generalized method of moments GMM

Variables	Model 1		Model 2		Model 3		Model 4	
	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value
GGE $_{(t-1)}$	-0,045	0,647	-0,004	0,869	-0,014	0,875	-0,045	0,717
GED	-4,583	0,049**					-5,883	0,005**
BSSD			1,221	0,289			1,220	0,275
BID					0,874	0,286	0,979	0,337
BSIZE	0,104	0,110	0,098	0,142	0,080	0,171	0,113	0,101
QTOBIN	-0,261	0,006**	-0,298	0,001***	-0,304	0,003**	-0,241	0,005**
ROA	1,488	0,628	-0,199	0,945	0,529	0,859	0,887	0,773
LEV	3,078	0,028**	3,124	0,014**	3,111	0,017**	3,166	0,026**
FSIZE	0,081	0,628	0,023	0,889	0,052	0,753	0,071	0,725
Year dummy	Yes		Yes		Yes		Yes	
No. of firms	279		279		279		279	
No. of observ	968		968		968		968	
Instruments	29		29		29		29	
Wald x^2 test	65,81	0,000***	51,08	0,000***	34,96	0,000***	65,56	0,000***
AR (1)	-0,78	0,434	-1,30	0,195	-0,97	0,370	-0,133	0,183
AR (2)	-0,59	0,583	-1,45	0,147	-1,81	0,310	1,59	0,113
Hansen test	19,14	0,383	19,17	0,319	20,12	0,326	21,56	0,425

Notes: GGE is the greenhouse gas emissions efficiency, measured using natural logarithm greenhouse emissions divided by gross revenue. GED is the gender diversity, calculated using Blau index. GGE $_{(t-1)}$ is the one-year lagged value of greenhouse gas emissions efficiency, measured using natural logarithm greenhouse emissions divided by gross revenue. GED is the gender diversity, calculated using Blau index. BSSD is the board specific skills diversity, measured using Blau index. BID is the board independence diversity, calculated using Blau index. BSIZE is the board size, measured using total number of directors, QTOBIN is the company performance, calculated using market capitalization of common stock plus book value liabilities divided by book value of total assets. ROA is the profitability, measured using income after taxes for the fiscal period divided by total assets. LEV is the leverage, calculated using total debt divided by total assets. FSIZE is the firm size, measured using natural logarithm of total assets. Models are estimated by two step system generalized method of moments (GMM). *, ** and *** statistically significant at 0.10, 0.05 and 0.01 levels, respectively.

The GMM model is well specified because the p-value for the AR (2) test is not statistically significant. The AR (2) test shows if there is a second-order serial correlation in the first difference residuals (Gallego-Álvarez, 2019; M C Pucheta-Martínez et al., 2019). In all our models, the null hypothesis of serial correlation was not rejected, therefore, second-order serial correlation is not a concern. Hansen test of over-identification is performed to verify the correlation between the instruments and the error term (Crisóstomo & de Freitas Brandão, 2019), the null hypothesis of this test is that the instruments are valid "exogenous" (Zaid et al., 2020). The p-value of the Hansen test of overidentifying in all models ranges from 0.319 to 0.425, indicating that we cannot reject the hypothesis and that the validity of the instruments has been verified in all models.

Our dependent variable has an inverse relationship, the lower its value, the more efficient the firm is. In Model 1, we explore how gender diversity affects greenhouse gas emissions efficiency. Model 2 analyzes the impact of board specific skills on greenhouse gas emissions efficiency. In Model 3 we examine the association between the board independence diversity in greenhouse gas emissions efficiency.

In Model 1, we explore the influence of gender diversity on the greenhouse gases emissions efficiency. Our results indicate a negative and significant coefficient (coefficient = -4.583; p = 0.049). This result supports Hypothesis 1 and corroborates the findings of Biswas et al. (2018), Cordeiro et al., (2020), Lu and Herremans (2019), Tingbani et al., (2020) and Wasiuzzaman and Wan Mohammad (2020) that gender diversity has a positive impact on greenhouse gas emissions efficiency. Our result is also consistent with the theoretical predictions that gender diversity brings resources that help in the decision-making process and in the sustainable environmental programs policy (resource dependence theory), improve the board's effectiveness by encouraging better environmental performance (upper echelons theory) and is a mechanism of corporate governance that allows the board's independence and better environmental performance (agency theory).

Moving to model 2, we examine the association between board specific skills and greenhouse gas emissions efficiency. The findings reveal a positive and insignificant coefficient (coefficient = 1,221; p = 0, 289) of board specific skills diversity on greenhouse gas emissions efficiency, implying that Hypothesis 2 is not supported. Our result does not provide support for the resource dependency theory which says that the board specific skills diversity provides for greater board effectiveness and decisions in line with environmental issues.

Model 3 analyses the effect of board independence diversity on the greenhouse gas emissions efficiency. The variable the board independence diversity provides a positive sign and not statistically significant (coefficient = 0,874; p = 0,286), thus that Hypothesis 3 is not supported. Our results show that board diversity is not a determinant factor on greenhouse gas emissions efficiency, i.e. it does not support the idea of agency theory that independent directors play a key role in corporate governance and are efficient in resolving agency conflicts. This result is consistent with the empirical findings of García Martín and Herrero (2020) and Prado-Lorenzo & Garcia-Sanchez (2010).

4.3 Additional analysis

In this section, several tests were employed to examine the robustness of our findings. We applied the Shannon index as alternative measure of board gender diversity, board specific diversity and board independence diversity. Shannon index has properties similar to the Blau index, however, it is more sensitive to difference in board composition because it is a logarithmic measure of diversity (Baumgärtner, 2006; Unite et al., 2019). To compute the Shannon index, we employed the following equation:

Shannon index formula: $-\sum_{i=1}^{n} \quad P_i . lnP_i$

where:

P_i = the proportion of boardroom members in each category in the ith group.

n = the number of different categories.

$\sum$ = the sum of the calculations from category 1 to category n.

The minimum value for the Shannon index is zero, as there is no logarithm of zero, zero value is adopted in cases where there is no diversity and the maximum value is 0.69 when the proportion is the same, according to previous studies (Aggarwal et al., 2019; Unite et al., 2019; Zaid et al., 2020). Table 5 presents the findings of all the models.

Table 5

Results of the generalized method of moments GMM

Variables	Model 1		Model 2		Model 3		Model 4	
	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value
GGE $_{(t-1)}$	-0,042	0,669	-0,005	0,960	-0,013	0,881	-0,041	0,745
GED	-3,020	0,025**					-3,942	0,002**

BSSD			0,911	0,334			0,955	0,299
BID					0,689	0,214	0,798	0,243
BSIZE	0,111	0,088*	0,104	0,109	0,086	0,165	0,132	0,057*
QTOBIN	-0,258	0,008**	-0,298	0,001***	-0,304	0,003**	-0,237	0,007**
ROA	1,292	0,675	-0,209	0,942	0,503	0,865	0,596	0,844
LEV	3,096	0,026**	3,136	0,013**	3,126	0,017**	3,217	0,023**
FSIZE	0,068	0,724	0,019	0,909	0,048	0,775	0,046	0,821
Year dummy	Yes		Yes		Yes		Yes	
No. of firms	279		279		279		279	
No. of observ	968		968		968		968	
Instruments	29		29		29		29	
Wald x^2 test	67,97	0,000***	50,73	0,000***	35,65	0,000***	67,45	0,000***
AR (1)	-1,07	0,285	-1,21	0,266	-0,97	0,330	-1,56	0,118
AR (2)	-0,43	0,670	-1,44	0,149	-1,79	0,073	1,56	0,118
Hansen test	19,23	0,378	18,87	0,336	20,12	0,282	20,50	0,490

Notes: GGE is the greenhouse gas emissions efficiency, measured using natural logarithm greenhouse emissions divided by gross revenue. GED is the gender diversity, calculated using Shannon index. GGE $_{(t-1)}$ is the one-year lagged value of greenhouse gas emissions efficiency, measured using natural logarithm greenhouse emissions divided by gross revenue. GED is the gender diversity, calculated using Shannon index. BSSD is the board specific skills diversity, measured using Shannon index. BID is the board independence diversity, calculated using Shannon index. BSIZE is the board size, measured using total number of directors, QTOBIN is the company performance, calculated using market capitalization of common stock plus book value liabilities divided by book value of total assets. ROA is the profitability, measured using income after taxes for the fiscal period divided by total assets. LEV is the leverage, calculated using total debt divided by total assets. FSIZE is the firm size, measured using natural logarithm of total assets. Models are estimated by two step system generalized method of moments (GMM). *, ** and *** statistically significant at 0.10, 0.05 and 0.01 levels, respectively.

The results in Table 5 are similar to those reported in Table 4 and confirm that gender diversity positively affects greenhouse gas emissions efficiency, i.e., companies with greater gender diversity are more efficient in relation to greenhouse gas emissions. Our results also confirm that board specific skills diversity and board independence diversity do not affect the efficiency of greenhouse gas emissions. The summary of hypotheses is presented in Table 6.

Table 6

Summary of hypotheses

Hypothesis	Variable name	Expected sign	Actual sign	Level of support
Hypothesis 1: There is positive relationship between gender diversity and greenhouse gas emissions efficiency	GED	(-)	(-)	Supported
Hypothesis 2: There is positive relationship between board specific skills diversity and greenhouse gas emissions efficiency	BSSD	(-)	(0)	Not Supported
Hypothesis 3: There is positive relationship between board independence diversity and greenhouse gas emissions efficiency	BID	(-)	(0)	Not Supported

In summary, the results confirm that gender diversity helps to promote environmental initiatives. The results are consistent with agency, upper echelons and resource dependency theories, and underline that greater gender diversity in the board of directors brings important resources in promoting sustainable development, as well as reducing agency conflict.

5 Conclusions

This study analyzes the link between board diversity and greenhouse gas emissions efficiency. Using a data of 287 Latin America firms over a 5-year period (2015-2019), we employ two-step system GMM to test study hypotheses. We measure greenhouse emissions efficiency as logarithm of the ratio between greenhouse gas emissions of scope 1 (direct emissions), in tons of CO2 equivalent - tCO2e, and the gross revenue. We also use the Blau index to measure board diversity (gender diversity, board specific skills diversity and board independence diversity).

We find a positive and significant relationship between gender diversity and greenhouse gas emissions efficiency in Latin America firms. This result is consistent with agency, upper echelons and resource dependency theories. A negative and insignificant relationship between board specific skills and greenhouse gas emissions efficiency was also found. In addition, we noted a negative and insignificant relationship between board independence diversity and greenhouse gas emissions efficiency.

This study suffers of some limitations. We studied board diversity in terms of gender, board specific skills and board independence diversity. Future research could focus on nationality, age and background. We also noted that few firms disclose their indirect emissions, i.e. scopes 2 and 3, this represents a difficulty in measuring greenhouse gas emissions. Future research could incorporate information from scopes 2 and 3.

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