CARBON ACCOUNTING AND CARBON MANAGEMENT IN DEVELOPING ECONOMIES

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Área Temática: Responsabilidad Social Corporativa

Palabras clave: GHG; carbon emissions; disclosure; HDI; emerging and developing economies.

Research Workshop 1: Agenda 2030 para el desarrollo sostenible: colaboración público – privada.

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Abstract:

This article explores the driving forces for carbon reporting as well as carbon reduction management in emerging and developing countries. To our knowledge, this is the first paper to look into this phenomenon in emerging and developing countries from Asia, Africa and America. The evidence obtained is valuable as it can help standard-setters in these geographical areas to promote actions in the field of corporate governance to increase transparency. The methodology employed uses logit and linear panel data models. Our results show that the carbon reporting decision is positively related to the fact that the company is located in Africa or America, it publishes a sustainability report, and has some corporate governance attributes. As regards carbon reduction management, evidence is obtained that for direct emissions only CSR reporting is significant, whereas for energy indirect emissions there is a significant positive relationship with the female percentage of executives and a negative link with board size and increase in revenues.

1. Introduction

Climate change is definitely one of the most important problems in the global agenda today. In fact, the United Nations in its 2030 Agenda for Sustainable Development (UN General Assembly, 2015) sets Sustainable Development Goal 13 aiming to combat global warming.

Environmental lobbies are pressing firms to take proactive measures towards the environment as well as governments to set new regulations on greenhouse gas (GHG) emissions (Reid and Toffel, 2009). In this sense, the Paris Agreement in force since November 2016 represents the acknowledgement across the international community of this threat, as well as the countries' commitment to keep the global temperature rise below 2 degrees Celsius this century. Signatories are therefore expected to adopt long-term climate strategies framed by national policies in order to facilitate the transition towards a decarbonized economy (Rüdinger *et al.*, 2018). A clear pronouncement of this commitment is evidenced by the enactment at the Spanish Sustainable Economy Law 2011 mandates state-owned corporations and public business entities attached to the central government (Article 35) to adapt their strategic plans to implement seven policies integrate carbon emissions performance and environmental protection into public procurement (Larrinaga and Luque-Vilchez, 2018).

Recent research shows the progress on climate change-related legislation around the world, even in low-income countries (Nachmany *et al.*, 2017), which demonstrates growing awareness amongst governments to take action to reduce carbon emissions. Because of the increasing attention paid to GHG emissions by many diverse stakeholders, having a proactive strategy towards the environment, and more

specifically reporting GHG emissions, has become of the outmost importance for entities to maintain their corporate image in response to stakeholders' demands and to legitimize themselves (Kilic *et al.*, 2019).

However, the academic debate on this topic has been mostly focused on developed western economies. There seems to be a gap regarding emerging and developing countries, where research is still scarce or limited to descriptive studies both in terms of sustainability reporting and, even more specifically, carbon accounting (Hopper *et al.*, 2017; Alshbili *et al.*, 2018; Shirodkar *et al.*, 2018).

This paper aims to provide an understanding on how the driving forces for carbon accounting and management differ amongst companies from emerging and developing countries. Note that their economies represent 85.6% of the global population, contributing to 58,7% of the global GDP, which is expected to increase even higher, given their projected GDP annual growth rates at 4.7% and 4.8% in 2019 and 2023 as opposed to only 2.1% and 1.5% for the advanced economies (International Monetary Fund - IMF, 2018). Research on these regions is crucial as the adverse consequences associated to rising global temperatures like catastrophic climate events often happen in low-income countries with low capacity to address their effects (IMF, 2017). In addition, these parts of the world are home for nature treasures in planet Earth which must be preserved. Otherwise, deforestation and severe exploitation of natural resources leading to the economic growth of these regions may lead to a steep increase of their carbon emissions with not only local, but also global devastating effects. Therefore, academic contributions that help to raise the awareness of this type of environmental concerns in these geographical regions and identify positive and innovative trends in this field are extremely timely and valuable. Hence, this type of research may promote more sustainable behavior amongst companies and make governments and people reflect on the power that their actions may have on this global issue.

This is a multi-region comparative study exploring the driving forces for carbon reporting as well as carbon reduction management, using logit and linear panel data models. It analyzes the impact of the sustainable profile as well as financial and corporate governance characteristics in the levels of GHG emissions in companies from emerging and developing countries to provide evidence on how businesses engage with the practice of carbon accounting and, moreover, with a carbon emissions reduction strategy. The findings obtained show that the carbon reporting decision is positively related to being located in Africa or America (as opposed to Asia), publishing a sustainability report, and having certain corporate governance attributes such as a CSR committee and an executive compensation policy based on environmental and social performance. Regarding the driving forces leading to a reduction of carbon emissions, evidence is obtained that for direct emissions (Scope 1) only sustainability reporting is significant, whereas for electricity indirect emissions (Scope 2) there is a significant positive relationship with the female percentage of executives and a negative link with board size and increase in revenues.

To our knowledge, this is the first paper to look into this phenomenon in emerging and developing countries following the UN classification based on the Human

Development Index (HDI), with a sample covering the continents of Asia, Africa and America. This index was created to emphasize that the development of a country should not only be assessed on the grounds of economic growth but also on the quality of life and capabilities of the people (Obst, 2015; Chatterjee and Mitra, 2017). Therefore, HDI takes into account three dimensions of human development – i.e., income, health and access to education. The overall trend of the index shows important improvements as out of the 189 countries for which the HDI is calculated, in 2018 only 38 countries fall in the low HDI group, whereas in 2010, it was 49 countries (UNDP, 2018).

In summary, this article seeks to contribute to literature by examining the reasons behind the decision to report on carbon emissions and their evolution, finding that companies in emerging and developing countries are more likely to disclose carbon emissions (and sometimes even reduce them) if they also publish a sustainability report and maintain certain corporate governance structures and policies that are more responsible towards the environment. This evidence calls on the governments in power to consider the convenience to introduce specific measures in those fields in order to help reduce GHGs and mitigate the effects of climate change.

The remainder of this study is structured as follows. The next section describes the legal framework on climate change in the emerging and developing economies included in our sample; the third section discusses extant literature and develops the hypotheses of the study; the fourth section presents the sample and methodology, followed by the discussion of results section. Finally, the paper closes with the conclusions section.

2. Legal frameworks on climate change in emerging and developing countries.

Nowadays, there are over 1,200 climate change-related laws around the world, especially regarding climate resilience as socio-ecological systems can actually stabilize back to equilibrium and because of preventive action. Even low-income countries are increasingly engaged in the enforcement of this type of legislation (Nachmany, *et al.*, 2017). All these legal initiatives demonstrate growing awareness amongst politicians of the need to reduce GHG emissions and pursue efforts to curb the temperature increase. This is in line with Grauel and Gotthardt (2016), who find that environmental regulations and legal origin are extremely relevant explanatory factors for participation in the Carbon Disclosure Project (CDP) and that voluntary carbon emissions disclosure by its members seems quite likely in emerging countries (such as China or Russia), which tend to tighten their environmental legal frameworks while liberalizing their economies.

Therefore, in the next table (Table 1) we present the number laws and policies by the developing and emerging countries in our sample so as to highlight their commitments to climate change mitigation, based on the information provided by the Grantham Research Institute on Climate Change and the Environment (2019).

Table 1. Descriptive data on climate and development issues for the countries in the sample

Countries	* Ranking of CO2 emissions	*Emissions (MtCO2)	**Climate- related Laws and Policies	***HDI
AFRICA				
Egypt	27	219	6	113
Morocco	54	63	9	122
Senegal	107	9,3	11	165
South Africa	14	456	5	111
AMERICA				
Brazil	13	476	17	79
Colombia	45	81	17	89
México	11	490	13	74
Panamá	106	10	10	66
Perú	52	65	15	86
ASIA				
Bangladesh	43	88	10	138
China	1	9839	9	86
India	3	2467	10	129
Indonesia	12	487	21	115
Philippines	37	128	16	111
Thailand	20	331	10	86
Turkey	15	448	12	65
Vietnam	30	199	15	116

Source: *Global Carbon Atlas platform (2017 data), **Grantham Research Institute on Climate Change and the Environment, ***United Nations (2016 data, as taken into account to select the countries in the sample).

3. Theoretical Framework, Literature Review and Hypotheses Development

The stakeholder theory, institutional theory and the legitimacy theory are often cited to frame research not only about general CSR reporting, but also on GHG emissions (Freedman and Jaggi, 2005; Liesen *et al.*, 2015; Qian and Schaltegger, 2017).

Suchman (1995) defines legitimacy as a generalized assumption that the firm's behaviour is desirable or appropriate within the frame of socially constructed norms and beliefs, so companies report on sustainability in order to respond to this kind of expectations, or even pressures from stakeholders (Yunus *et al.*, 2016). Institutional theory (DiMaggio and Powell, 1983) focus on why all organizations tend to behave the same and has become a popular frame for climate change studies (Ntim and Soobaroyen, 2013; Hollindale *et al.*, 2017; Daddi *et al.*, 2018). Stakeholder-agency theory can also justify that corporate governance helps to the alignment of managerial and stakeholder interests regarding GHG emission disclosure (Tauringana and Chithambo, 2015). This framework extends the principal – agent relationships of the agency theory, highlighting the enlargement of fiduciary duties of the board of directors

to take into account stakeholders other than shareholders (Kock *et al.*, 2012). In fact, management and stakeholder interests may diverge from stakeholders' who might show greater preference or concern for environmental issues, rather than managers. This divergence is due to the long-term investment required by environmental initiatives conflicting with managerial goals normally set within the short-term horizon, as well as by certain stakeholders' with no direct interest in financial returns. Nonetheless, existing evidence showing the positive impact of environmental performance on a firm's financial performance may help align managerial and stakeholder interests regarding environmental and climate change initiatives, but perhaps only up to a certain level (Kock *et al.*, 2012).

There is a plethora of studies that reveal sustainability practices in advanced economies. In fact, the past decade has witnessed a momentum of CSR practices in Western countries to improve social and environmental performance of organizations. However, CSR research in developing countries is comparatively scarce, yet evolving into a distinctive domain of study within management, with its own nuances and peculiarities as a platform for the generation of knowledge (Jamali and Karam, 2018). As a consequence, specific research on sustainability in emerging and developing countries should take into account that their business settings can substantially differ from those found in advanced economies (Hopper *et al.*, 2017; Jamali *et al.*, 2017).

Several studies compare, though, sustainability reporting in developed and developing countries. For instance, Ali *et al.* (2017), through content analysis of 76 articles and a survey, review the factors for CSR disclosure (company size, profitability, industry sector, and corporate governance mechanisms) finding that in developing countries, sustainability reports are more influenced by powerful stakeholders external to the company than in developed economies - e.g., foreign investors or buyers, international media and regulatory bodies such as the World Bank.

CSR research based in a specific emerging or developing country is valuable in the sense that it reveals particular conditions that quite probably do not fit in a Western economy but may be extended to other similarly developed or neighbor countries. For instance, and specifically, in the Bangladeshi context, several studies discuss issues on governance and sustainability, engagement of stakeholders and weaknesses in CSR monitoring. Through interviews to NGOs, the media, regulatory authorities, government departments, shareholders, trade union leaders and customers, Hossain *et al.* (2016) reveal that corruption and politics, lack of coordination and government initiatives and unsatisfactory enforcement of laws are perceived as major barriers that hinder CSR. In the same country, Hossain *et al.* (2017) find that companies report CSR information to reactively reduce pressure from powerful stakeholders –e.g., international investors and government agencies- and that a director's proactive motivation is the main determinant of CSR. Beddewela and Fairbrass (2016) find that in Sri Lanka there is an instrumental use of CSR activities by companies, with a view to take political advantage, especially to enhance their relationships with the state and other important institutional stakeholders. In the case of Mauritius where a corporate governance code was enacted in 2004 (Mahadeo and Soobaroyen, 2016), the government's unusual policy of creating a CSR 'levy' in 2009, provides a very special setting to analyse CSR reporting by CSR foundations, revealing deficiencies in the monitoring and control systems (Sannassee *et al.*, 2017).

In Egypt, there is recent evidence of significant influence of internal corporate governance on CSR practices, whereas legal regulations and stakeholder pressure are

not, contrary to findings from Western economies where firms are often externally motivated to invest in CSR (El-Bassiouny and Letmathe, 2018). In China, CSR reports have proliferated in the last decade, mostly due to regulatory requirements such as the 2008 mandate by Stock Exchanges and the Assets Supervision and Administration Commission of the State Council yet not because managers really associate CSR with benefits to the corporate image (Yu and Rowe, 2017).

Nevertheless, more research is needed to gain a better and more comprehensive understanding about sustainability practices within businesses operating in emerging and developing countries, specifically from a strategic and decision-making perspective regarding carbon reporting and performance.

Moreover, and refining the field of sustainability practices to carbon emissions, in spite of the burgeoning research on GHG disclosure (Freedman and Jaggi, 2005; Matsumura *et al.,* 2014; Liesen *et al.*, 2015; González-González and Zamora, 2016a; Belkhir *et al.*, 2017; Qian and Schaltegger, 2017; Broadstock *et al.*, 2018), just to mention a few), there is still a paucity of articles on the role of corporate governance in GHG disclosures (Prado-Lorenzo and Garcia-Sanchez, 2010; Liao *et al.*, 2015; Tauringana and Chithambo, 2015; Yunus *et al.*, 2016; Ben-Amar *et al.*, 2017; Haque, 2017; Hollindale *et al.*, 2017; Krishnamurti and Velayutham 2018). However, again, most of this type of research does not address the specific context of emerging and developing economies. For instance, González-González and Zamora (2016b) compare and interpret the results of the cases of four large Spanish companies that operate in different organizational areas analyze the organizational approaches and patterns for the presentation of reports that communicate their environmental information, concluding that the carbon reporting approach is attributed to components of the institutional context (regulatory, normative and cognitive), along with the adoption pattern used by organizations to control their carbon emissions (substantive or symbolic). Using a sample from the FTSE Global 500 companies surveyed by the CDP regarding GHG monitoring in 2007, the pioneer study by Prado-Lorenzo and Garcia-Sanchez (2010) find that the duality of functions of the CEO has a significant positive impact on the dissemination of GHG information, but the diversity of the board and its level of independence is not always significant. Zamora-Ramírez et al. (2016) with a sample of companies listed on the Madrid Stock Exchange and participants in the CDP, analyse whether the disclosure of GHG emissions information and the climate change strategies of these companies provide information for the market and whether this event has value relevance. The results show that companies' participation in the PDC translates into good news for the market, as well as being an attribute variable in the valuation of companies.

Tauringana and Chithambo (2015) investigate the effect of the United Kingdom (UK) 2009 guidance on GHG disclosure with a sample comprising 215 UK listed companies from 2008–2011, concluding that the 2009 guidance has had a significant effect on the level of GHG disclosure, and that corporate governance mechanisms (board size, director ownership, and ownership concentration) also affect the extent of GHG information disclosure. Similarly, Liao *et al.* (2015) also use a sample with the largest UK companies, finding a significant positive association between the existence of a CSR committee, gender diversity and independence of the board with the propensity to disclose GHG information as well as its extension.

In the same line of research, Yunus *et al.* (2016) with a sample with the largest 200 Australian companies find that carbon disclosures are positively affected by the existence of a CSR committee, board size and board independence. Also in Australia, Hollindale *et al.* (2017) reveal that firms with several female directors in the board provide higher quality carbon disclosures and Krishnamurti and Velayutham (2018) find that having a risk management committee does not affect GHG disclosure levels. Ben-Amar *et al.* (2017) with a sample of CDP Canadian firms over the period 2008–2014, evidence that voluntary climate change disclosure increases with board gender diversity. Haque (2017) in UK, for the period 2002-2014, find that board independence, environmental-social-governance (ESG) based compensation policy and board gender diversity have positive associations with carbon reduction initiatives, but no significant effect on the actual reductions of carbon emissions.

Along the same lines, a few studies in developing economies setting analyze some corporate governance variables. As regards research in the African context, Kılıç and Kuzey (2019) with a sample of Turkish listed companies during 2011-2015 find that the higher independence of the boards leads to higher likelihood to respond to the CDP, and that the board nationality diversity and the existence of a CSR committee positively affect the propensity to disclose carbon emissions and the extent of those disclosures. Using also a sample of listed Turkish firms surveyed by the CDP, Akbaş and Canikli (2019) find that firm size, institutional ownership and market value are positively related, while board size is negatively related to carbon disclosures. Moving to Asia, Kalu *et al.* (2016) identify that social and financial factors are significant determinants for carbon disclosure in real estate companies listed in Malaysia. Rahman *et al.* (2017) also in Malaysia evidence that board size is a significant driver for carbon reporting decisions, whereas board independence and CEO duality are not significant. Yanto *et al.* (2017) using a sample of Indonesian manufacturing companies find that the level of carbon disclosures is influenced by board size, but not by leverage or profitability. In the American continent, Cordova *et al.* (2018) find that carbon reporting is significantly influenced by the company's size, CSR reporting, existence of a CSR committee, and belonging to the telecom, utilities, and consumer discretionary sectors, whereas being based in Chile or Peru has negative impact on the carbon reporting decision.

Comparing developed with developing economies, Luo *et al.* (2013) conclude that shortage of resources is one reason for the lack of commitment to carbon disclosure and mitigation in the latter.

As regards the emerging topic of carbon performance management, literature is even more scarce. Qian and Schaltegger (2017) using a sample covering 2008-2012 from the Global Fortune 500 companies in the CDP find that the change in carbon disclosure levels is positively associated with a subsequent change in carbon performance, confirming that carbon reporting motivates companies and improves their carbon performance. Nonetheless, in high energy-intensive firms the impact of changes in carbon disclosure on performance is relatively weaker. Haque and Ntim (2018) find that UK firms with poor corporate governance attributes have weaker carbon performance, and more specifically that the variable board size has a positive impact on actual carbon emissions, whereas ESG compensation policy and board independence are not significant. Biswas *et al.* (2018) find that in a sample of Australian firms the emissions reductions (based on Thomson Reuters score) is positively related to gender, CSR committee, board independence, company size, number of years listed in the stock exchanges and negatively with ROA.

In the context of developing countries, Ganda and Milodson (2018), examine the effect of carbon emissions (Scope 1, Scope 2, and both Scope 1 and 2) on financial performance, based on 2015 CDP reports from 63 South African companies, finding a negative relationship between carbon emissions and corporate financial performance. In South America, Cordova et al. (2018) evidence that company's size, the existence of a CSR committee, and the disclosure of a sustainability report lead to a decrease in carbon emissions levels.

Considering the above arguments, the following hypotheses are put forward:

Hypothesis 1a. Companies' decision to report carbon emissions is influenced by the sustainable profile of the company (proxied by the publication of a CSR report).

If a company is committed to sustainability reporting, it can be expected to have a higher likelihood to disclose carbon emissions, as evidenced by Cordova et al. (2018) in the context of Latin American countries, even though in the Western economies that relationship is not significant (Belkhir, 2017).

Hypothesis 2a. Companies' decision to report carbon emissions is influenced by the corporate governance attributes of the company.

Corporate Governance structure is proxied by the existence of a CSR committee, executive gender diversity, CEO duality, an executive compensation policy based on environmental and social performance and board size.

Existence of a sustainability committee has been found significant for carbon reporting in South America (Cordova et al., 2018), in UK (Liao et al., 2015) or in Australia (Yunus et al., 2016), yet contrary to lack of significance obtained by Krishnamurti and Velayutham (2018). Gender diversity can be expected to make the GHG disclosures more likely according to the evidence by Ben-Amar et al. (2017) in Canada, Hollindale et al. (2017) in Australia, Haque (2017) in UK, in spite of not significant evidence obtained by Prado-Lorenzo and Garcia-Sanchez (2010). CEO duality is found significant by Prado-Lorenzo and Garcia-Sanchez (2010), but according to Rahman et al. (2017) it is not significant in Malaysia. Board size is found positively significant by Tauringana and Chithambo (2015) in UK, Yunus et al. (2016) in Australia, Rahman et al. (2017) in Malaysia, Yanto et al. (2017) in Indonesia but negatively in Akbaş and Canikli (2019) in Turkey. Finally, an executive compensation policy based on environmental and social performance policy is significant for carbon reporting according to Haque (2017) in UK.

Hypothesis 3a. Companies' decision to report carbon emissions is influenced by corporate characteristics such as size, return on equity, return on assets, increases in assets and increases revenues, leverage, and sector. These factors are normally taken into account as control variables in research exploring sustainability reporting behavior (Sierra-García et al., 2014 and Zorio-Grima et al., 2015, among many) and carbon reporting.

In developing countries, the carbon reporting decision is associated with firm size (Yanto et al., 2017 in Indonesia; Cordova et al., 2018, in South America; Akbaş and Canikli, 2019 in Turkey). However, the latter does find leverage or profitability as significant drivers for the carbon reporting decision. Industrial sector has also been found significant in Cordova et al. (2018).

Hypothesis 4a. Companies' decision to report carbon emissions is influenced by continent where the company operates.

According to the legal initiatives explained in section 2 and prior studies in specific countries presented in section 3, one might expect that companies from Africa, and Latin America might have different likelihood to report carbon emissions than those from Asia- note that in China carbon reductions commitments are established depending on economic growth (as well as in Vietnam) which is the real priority, whereas normally the rest of the countries fix a reduction goal referring to a past year baseline. Also note that existing research highlights that South Africa has been in the forefront of corporate governance advances and integrated reporting (Baboukardos and Rimmel, 2016), and several studies highlight that Latin American companies have rather acceptable levels of CSR reporting and assurance (Sierra-García *et al.*, 2014; Zorio-Grima *et al.*, 2015). However, in Southeast Asia evidence suggests that firms are reluctant to report on child labor, human rights and corruption (Arena *et al.*, 2018) so probably one can also expect low probability of reporting carbon emission in Asia as compared to Africa and America.

In terms of carbon performance management (proxied by the yearly variation of carbon emissions), we put forward the following hypotheses:

Hypothesis 1b. Companies' carbon performance management is influenced by the sustainable profile of the company (proxied by the publication of a CSR report).

Some authors find evidence that publication of a CSR report is a significant factor for the reduction in carbon emissions in developing countries- such as Cordova *et al.* (2018) in the South American context or Orazalin and Mahmood (2018) who argue that sustainability reporting in Russia has improved environmental performance even though there is also evidence that it could rather lead to an increase in other type of settings - as evidenced for instance by Belkhir *et al.* (2016), with a sample with 40 companies from all the world reporting to the Global Reporting Initiative.

Hypothesis 2b. Companies' carbon performance management is influenced by the corporate governance attributes of the company, proxied by the existence of a CSR committee, executive gender diversity, CEO duality, executive ESG compensation policy and board size.

Companies with a CSR committee (Biswas *et al.*, 2018 for Australia; Cordova *et al.*, 2018 for the South American context), as well as gender diversity (Biswas *et al.*, 2018) tend to reduce carbon emissions, whereas board size has a positive impact on actual carbon emissions (Haque and Ntim, 2018 in the UK). Note that ESG compensation policy and board independence are not significant according to the latter.

Hypothesis 3b. Companies' carbon performance management is influenced by corporate characteristics such as size, increases in assets and increases revenues, leverage, return on equity, return on assets and sector. Again, we consider these factors as control variables following extant research.

Company's size has been found to be a driver for emissions reductions according to Cordova *et al.* (2018), even though this study does not provide conclusive results on other corporate characteristics. Ganda and Milodzon (2018) find evidence of a negative relationship between carbon emissions and corporate financial performance in South Africa. Other authors have explored the causality between emissions performance and economic performance in other type of contexts (Hassan and Romilly, 2018; Bradstock *et al.*, 2018).

Hypothesis 4b. Companies' carbon performance management is influenced by the continent where the company operates.

As explained in Hypothesis 4a, the different legal framework may explain different behavior depending on the region.

4. Sample and Methods

This paper works with a sample of listed companies located in emerging and developing economies. For identifying those countries, we take the human development index (HDI) which classifies the countries depending on different political, economic and social factors affecting the life conditions of the citizens. Those countries with an HDI in 2016 higher than 60 are classified as emerging and developing countries, and are therefore considered for the analysis.

Data were downloaded from Eikon database (Thomson Reuters) resulting in an unbalanced panel data with a total of 1213 observations for the largest companies with headquarters from 3 continents (Asia, America and Africa)- with market capitalization higher than 2500 million US dollars. Our study considers a four-year period from 2013 to 2016, but some companies do not have complete information for the whole period under analysis (unbalanced panel). Companies' financial data were retrieved from the consolidated financial statements, using the same currency (millions of US dollars).

The CO_2 emissions are measured in different categories; total CO_2 and CO_2 equivalent emissions in tons, Scope 1 emissions are direct emissions, and Scope 2 emissions are indirect emissions from energy consumption.

According to the hypotheses of our study, we consider two different dependent variables to be explained by the models. Firstly, the reporting decision is measured with a dichotomous variable taking value 1 when the firm reports the CO_2 emission in that period, and zero otherwise. Missing information for carbon emissions has been categorized as zero, assuming that the public has no easy access to it due to a non-transparent reporting policy in this field. The variable is computed for the three types of emissions under consideration, that is *report_co2t, report_scope1* and *report_scope2*. Note that some companies report total CO_2 emissions, but avoid the disclosure of the scopes 1 and 2.

Regarding carbon performance management, we consider the annual variation (in tons) for the total CO_2 emissions, Scope 1 and Scope 2 emissions (*var_tco2, var_scope1* and *var_scope2*). The annual variations are calculated as the difference between the emissions in year *t* minus the emissions in year *t -1*.

As independent variables, we consider financial and control variables as well as sustainability and corporate governance variables, and the region.

The size is proxied by the logarithm of total assets (*logassets*). Some financial ratios are computed every period: Return on Assets (*roa*), which is calculated as $(NetIncome/TotalAssets) \times 100$; Return on Equity (*roe*), which is calculated as $(NetIncome/TotalEquity) \times 100$; leverage as $(TotalLiabilities/TotalAssets) \times 100$; increase in assets (*incrassets*) obtained as $((TotalAssets_{t+1} - TotalAssets_t)/TotalAssets_t) \times 100$; and increase in revenues (*incrrevenue*) obtained as $((TotalRevenues_{t+1} - TotalRevenues_t)/TotalRevenues_t) \times 100$, where $TotalRevenues_t$ represents the revenue from all of a company's operating activities after deducting any sales adjustments and their equivalents in the fiscal year *t*.

For the sector, stemming from the Primary Global Industry Classification Standard (GICS) sector for every firm we define and compute a new sector variable (*sector_total*). In order to reduce the number of sectors, in terms of total emission, we identify the most polluting sectors (Energy, Materials and Utilities) as those with total emission above the average (without considering the Materials sector emissions in the calculation of the average). Finally, we compute the variable *sector_total* taking value 1 when the company belongs to a very polluting sector, and zero otherwise. As can be seen in Table 2, 22% of the companies in the sample belong to a very polluting sector.

As regards the sustainability profile of the company, CSR takes the value 1 when the company publishes a separate CSR report or includes a CSR section on its annual report. Regarding sustainability concern, the variable *CSRcommittee* is equal to 1 when the company has a CSR committee in that period. As can be seen in Table 2, 71% of the observations have a CSR report.

As regards to the corporate governance attributes, four variables are considered *executive_gender*, *ceo_duality*, *boardsize* and *policy_exec*. The *executive_gender* states the percentage of female executives in the fiscal year; the *ceo_duality* takes the value 1 when the CEO simultaneously chairs the board or the chairman of the board has been the CEO of the company. The variable *boardsize* informs about the total number of the board members at the end of the fiscal year and *policy_exec* takes the value 1 when the company has a ESG performance oriented compensation policy. As can be seen in Table 2, 57% of the companies have a CSR committee, 14% have a ESG performance oriented policy, 28% have CEO duality.

The sample is composed of firms with different financial structure (Table 2). Descriptive statistics can be found for the dependent and independent variables described above (Table 2). The sample size is considerably reduced for the carbon reduction models since annual variations are calculated taking into account only the firms reporting emissions at least for two consecutive years.

[Table 2 about here]

For the sake of clarity, table 3 shows the sample composition by continent and GICS sector. As regards to the total sample, 47%, 40% and 39% of the observations include data for the Total CO2, Scope 1 and Scope2 emissions, respectively. Focusing on the continents distribution, Asia contributes with 73% (881/1213) of the observations and America and Africa with the 18% (225/1213) and 9% (107/1213), respectively. However, only the 36% of the Asian firms report Total CO2 meanwhile 93% of African firms report that information.

As regards to the sector composition of those companies reporting CO2 emissions information, the most represented sector is Materials (22%) while financials is the less represented (1%).

[Table 3 about here]

As the sample comprises panel data, logistic panel models as well as linear panel models have been computed using Stata 12. We use Haussmann test for selecting between fix effects and random effects of two significant models. Fixed effects will be preferred when the test is significant (p-value < 0.05) and random effects otherwise.

5. Results.

5.1 Models on the CO2 Reporting Decision

The three models are statistically globally significant at 1% and random effect (RE). Specificity is the percentage of firms that do no report CO2 emissions that have been correctly classified by the model. On the other hand, sensitivity measures the ability of the model to correctly classify the firms that are reporting CO2 emissions.

The models correctly classified more than 70% of firms not reporting CO2 emissions (specificity), with a sensitivity that is always higher than 75% when identifying the firms reporting CO2 emissions. The default limit point of the calculated probability is set to 30% (0.3).

The results are discussed according to the odds ratio. The odds ratio is a measure of how much higher/lower the probability that an event will happen is than the probability that it will not occur. As regards to the decision of reporting carbon emissions, publishing a CSR report positive significantly relates to the probability of report that information. Particularly, those firms reporting CSR information have 111, 30 and 44 times more probability of carbon reporting compared to the probability of not reporting CO2 total emission, Scope 1 and Scope 2 emissions, respectively.

In addition, having a CSR committee positively increases the probability of reporting information of carbon emissions for the three measures (total emissions, Scope 1, and Scope 2). As regards to the other corporate governance variables, CEO chairman duality does not evidence any significant effect. However, ESG executive compensation policy as well as board size significantly positively increases the probability of reporting information of carbon emissions for the three measures (total emissions, Scope 1, and Scope 2). As regards the total emissions, the probability of reporting that information in companies with executive compensation policy is 14.11 times more than the probability of not reporting. In addition, also for total emissions, every percentage point that the percentage of female executive increases the probability of reporting that information increases a 4% (odds ratio=1.04) compared to the probability of not reporting.

As regards the financial variables, only increase in assets is significant and for the total emissions. The variable evidences a negative effect on the probability of reporting total carbon emissions. This way, the probability of not reporting that information is 1.01 times higher than the probability of reporting for every percentage point of increase of the total assets. Note that it has been obtained as the inverse of the odds ratio (0.99-1).

The sector does not evidence significant relation for any of the three measures. The continent where the headquarters is located is significantly related to the probability of reporting the emissions. Compared with the benchmark (Asia), companies located in America have a significantly higher probability of reporting the CO2 emissions. As regards the total emissions, the probability of reporting that information in companies from America is 29.62 times more than the probability of not reporting. For the case of the companies located in Africa, the probability of reporting total emissions is 90.39 times the probability of not reporting, probably due to the influence of South African firms.

[Table 4 about here]

5.2 Models on the Yearly Variation of CO2 Emissions

In this section, we present linear panel data models for the variation of carbon emissions. Note that the model of variation of total emissions is non-significant since the variable Total CO2 is measured in different ways depending on the firm. Some firms include within Total CO2 emissions the emissions of Scope 3, while other companies only include emissions of Scope 1 and 2.

Model of variation of Scope 1 is a fixed effects (FE) model and for variation of Scope 2 is a random effects (RE) model. The residuals of the models have been estimated under conditions of robustness. These models consider only those companies reporting carbon emissions. As a consequence, the variable continent has been omitted in the FE model due to perfect collinearity.

Note also that these two models are significant (Table 5), and that the standard error of the significant variables is smaller than the estimated coefficient; thus, no traits of estimation problems are identified in the parameters caused by multicollinearity.

[Table 5 about here]

Our results reveal that disclosing a sustainability report leads to more sustainable behavior in the sense of a decrease in the level of Scope 1 emissions (Table 5). However, the existence of a CSR committee does not significantly affect the CO2 emissions.

As regards Scope 2, increases in revenues significantly lead to higher emissions. In other words, in developing economies firms that are growing in terms of revenues, are also increasing in average their emissions.

In addition, two other variables have a significant effect on the annual variation of Scope 2 emissions. The percentage of executive gender diversity significantly decreases the scope 2 emissions, suggesting that establishing gender diversity policies can lead to a more sustainable behavior. However, board size is positively related with Scope 2, which implies that those firms with bigger boards are significantly increasing their indirect emissions.

6. Conclusions

Transparency in carbon reporting and carbon emissions reduction strategy can be seen as two rather atypical, yet increasingly adopted practices in emerging and developing countries (Luo *et al.*, 2013). Research as the one we present here is valuable in the sense that those policies can serve as legitimizing tools, responding to the increasing information demands from a wide range of stakeholders, as well as help to create isomorphic trends amongst companies in this field, which will finally lead to improvements in environmental behavior, with not only local but also global effects.

In fact, our results reveal that publishing a CSR report significantly relates to a higher probability of carbon reporting (in all the scopes considered) as well as to a decrease in the level of Scope 1 emissions.

Given the complexity of institutional contexts in developing countries and the scarcity of studies of the impact of corporate governance characteristics, this study

makes an important contribution as it provides a more comprehensive approach to carbon reporting and carbon performance management on how the corporate governance attributes influence decisions to report on or manage the level of carbon emissions. In this sense our findings show that having a CSR committee, ESG executive compensation policies as well as board size, significantly increases the probability of reporting information on carbon emissions for the three measures under consideration (total emissions, Scope 1, and Scope 2). Nevertheless, the existence of a CSR committee does not have a significant impact in the reduction of carbon emissions, as gender diversity does regarding indirect emissions as opposed to board size, which is significantly associated with an increase in this type of emissions.

Our findings suggest that establishing gender diversity policies can lead to a more sustainable behavior. The evidence obtained is consistent with stakeholder theory, suggesting that a diversified and independent board may balance a firm's financial and non-financial goals with limited resources (Liao, 2015).

Regarding the financial variables, only the increase in assets is negatively significant for reporting total emissions. As regards Scope 2, increases in the revenues significantly increase the indirect emissions. In other words, in the developing countries those firms that are growing in the terms of revenues are also increasing in average their indirect emissions.

Belonging to a polluting sector does not evidence significant relationships for reporting any of the three carbon measures. The continent where the headquarters is located is significantly related to the probability of reporting the emissions. Compared with the benchmark (Asia), companies located in America and Africa have a significantly higher probability of reporting the CO2 emissions. This result may be influenced by the fact that listed South African firms are required to submit an integrated annual report as approved by the King III report (Baboukardos and Rimmel, 2016).

In general, the environmental performance, as measured by greenhouse gas emissions, plays a crucial role in the formulation of business strategy at the firm level and government environmental policy at national and international levels. In fact, the measurement and subsequent dissemination of environmental information is expected to lead to significant impacts on improving the quality of environmental management in developing countries.

These results have important implications for governments and national agencies, suggesting that maybe non-mandatory guidance (which can very effective according to Tauringana and Chithambo, 2015) as well as mandatory requirements might be introduced in the national agenda of developing economies where CSR should be key to accelerate transition into a developed economy (Chatterjee and Mitra, 2017).

Future avenues of research can include the effect in developing economies of carbon reporting and carbon reduction management in the capital markets reaction (volatility and liquidity) (in line with Baboukardos 2017 and 2018; Krishnamurti and Velayutham, 2018), types of ownwership (Alshbili *et al.*, 2018), effect on CSR rating agencies (Saadaoui and Soobaroyen, 2018) or even the relationship with foreign subsidiaries (Shirodkar *et al.*, 2018).

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Table 2. Descriptive statistics.

Independent Variables	N	Mean	Std. Dev.	Min	Max
totalassets	1213	14349.05	32266.02	86.91	387676.00
logassets	1213	3.76	0.56	1.94	5.59
totalequity	1213	5599.68	15452.38	-279.34	189538.40
netincome	1213	653.17	1707.86	-11450.59	23494.56
totalrevenue	1213	10298.14	31233.85	5.68	475793.00
totalliabilities	1213	8749.37	18387.24	19.82	199738.00
**roa	1213	7.37	7.00	-30.20	45.58
**roe	1213	16.11	17.71	-147.98	135.85
**leverage	1213	54.94	19.05	6.96	123.66
incrassets	1213	7.58	29.74	-63.57	594.07
incrrevenue	1213	-27.47	898.17	-31239.00	99.69
*sector_total	1213	0.22	0.41	0.00	1.00
*csrcommittee	1213	0.57	0.50	0.00	1.00
*csr	1213	0.71	0.45	0.00	1.00
*policy_exec	1213	0.14	0.35	0.00	1.00
*ceo_duality	1213	0.28	0.45	0.00	1.00
executive_gender	1213	11.46	12.63	0.00	60.00
boardsize	1213	11.04	3.38	3.00	25.00
Dependent variables					
co2total	571	66000000.00	1420000000.00	1.81	34000000000.00
scope1	485	6626480.00	23600000.00	0.56	250000000.00
scope2	480	638161.60	1407691.00	0.00	15300000.00
*Reporting_co2t	1213	0.47	0.50	0.00	1.00
*Reporting_scope1	1213	0.40	0.49	0.00	1.00
*Reporting_scope2	1213	0.39	0.49	0.00	1.00
var_co2t	484	-70000000.00	1550000000.00	-34000000000.00	36200000.00
var_scope1	421	324640.80	2283461.00	-2900000.00	35000000.00
var_scope2	415	25718.52	395715.30	-3496000.00	3708400.00

Note: * indicates dummy variable. ** indicates accounting ratio. Raw financial information variables are
measured in millions US dollars. Carbon variables are measured in tons.

Table 3. Sample composition.

CONTINENT	N	Reports total CO2	%	Reports Scope1	%	Reports Scope 2	%
AFRICA	107	99	93%	84	79%	82	77%
ASIA	881	321	36%	269	31%	262	30%
AMERICA	225	151	67%	132	59%	131	58%
TOTAL	1213	571	47%	485	40%	475	39%

	CO2 TOTAL			SCOPE1			SCOPE 2		
	MEAN	SD	%	MEAN	SD	%	MEAN	SD	%
Consumer Discretionary	4675533	1300000	12%	4597567	1300000	12%	497329	209597	12%
Consumer Staples	16400000	7100000	16%	16500000	7900000	15%	1910333	835006	16%
Energy	8984029	5700000	9%	8774695	5800000	10%	555162	395986	10%
Financials	19369	87560	1%	4857	14267	1%	19779	73293	1%
Health Care	1001229	569102	4%	1201869	605490	3%	102097	126459	3%
Industrials	8962250	4600000	16%	8800495	4000000	14%	470503	372621	13%
Information Technology	429690	357673	6%	176591	78557	7%	284217	287851	7%
Materials	3070000000	280000000	22%	8023492	6100000	24%	1221860	1072171	24%
Telecommunication Services	6107496	3700000	8%	4967856	2000000	8%	3201498	1224126	8%
Utilities	75500000	34000000	6%	79200000	38000000	7%	174306	159344	5%

Note: CO2 emissions are measured in tons.

Table 4. Logit panel data models for the probability of reporting CO2 emissions.

		REPORTS CO2_TOTAL					REPORTS SCOPE 1					REPORTS SCOPE 2				
		coef	Odds ratio	STD dev. Err	Z	P-value	coef	Odds ratio	STD dev. Err	Z	P-value	coef	Odds ratio	STD dev. Err	Z	P-value
H1	csr	4.71	111.23	0.65	7.25	0.00***	3.42	30.51	0.63	5.40	0.00***	3.80	44.57	0.70	5.40	0.00***
H2	CSRcommittee	2.13	8.44	0.48	4.48	0.00***	2.68	14.59	0.47	5.68	0.00***	2.40	11.06	0.49	4.88	0.00***
	Executive_gender	0.04	1.04	0.02	1.83	0.07*	0.01	1.01	0.02	0.63	0.53	-0.01	0.99	0.02	-0.25	0.80
	ceo_duality	0.54	1.72	0.49	1.11	0.27	0.47	1.60	0.46	1.03	0.31	0.71	2.03	0.49	1.46	0.15
	boardsize	0.13	1.14	0.07	1.76	0.08*	0.12	1.13	0.07	1.87	0.06*	0.13	1.14	0.07	1.87	0.06*
	Policy_exec	2.65	14.11	0.84	3.16	0.00***	1.99	7.29	0.65	3.06	0.00***	2.28	9.82	0.69	3.32	0.00***
H3	logassets	-0.27	0.76	0.57	-0.48	0.63	0.03	1.03	0.51	0.06	0.95	-0.33	0.72	0.55	-0.60	0.55
	roa	0.09	1.09	0.08	1.11	0.27	0.01	1.02	0.07	0.22	0.83	0.02	1.02	0.07	0.23	0.82
	roe	-0.03	0.97	0.03	-1.28	0.20	-0.01	0.99	0.02	-0.24	0.81	-0.01	0.99	0.02	-0.33	0.74
	leverage	0.01	1.01	0.02	0.72	0.47	0.00	1.00	0.02	0.24	0.81	0.01	1.01	0.02	0.45	0.65
	incrassets	-0.01	0.99	0.01	-1.97	0.05*	-0.01	0.99	0.01	-1.19	0.23	0.00	1.00	0.01	-0.70	0.48
	incrrevenue	0.00	1.00	0.00	0.41	0.68	0.00	1.00	0.00	0.10	0.92	0.00	1.00	0.00	0.07	0.94
	sector_total	0.68	1.97	0.49	1.39	0.17	0.54	1.72	0.44	1.22	0.22	0.44	1.55	0.47	0.93	0.35
H4	america	3.39	29.62	0.74	4.57	0.00***	2.80	16.40	0.68	4.11	0.00***	3.01	20.29	0.73	4.12	0.00***
	africa	4.50	90.39	1.27	3.54	0.00***	3.12	22.57	1.01	3.09	0.00***	3.04	21.00	1.06	2.87	0.00***
	N	1213					1213					1213				
	number of groups	330					330					330				
	Specificity	72.27%					77.47%					79.54%				
	Sensitivity	87.74%					83.51%					75.16%				
	LR Chi2	127.35					118.97					110.29				
	p>Chi2	0					0					0				

Note: ***,**, and * are statistically significant at 1%, 5%, and 10%, respectively. Specificity and sensitivity are calculated for the default limit point of the calculated probability set to 30% (0.3). Benchmark for continent dummies is Asia.

Table 5. Panel data models for the variations of CO2 emissions

		VARIATION SCOPE 1				VARIATION SCOPE 2			
		coef	STD dev. Err	Z	P-value	coef	STD dev. Err	Z	P-value
H1	csr	-1.01E+06	3.34E+05	-3.02	0.00***	-2.82E+04	3.98E+04	-0.71	0.48
H2	CSRcommittee	-7.02E+05	4.57E+05	-1.54	0.13	-2.13E+04	3.08E+04	-0.69	0.49
	Executive_gender	-1.19E+04	1.18E+04	-1.01	0.32	-1.91E+03	9.44E+02	-2.03	0.04**
	ceo_duality	-1.19E+06	1.07E+06	-1.11	0.27	2.51E+03	6.15E+04	0.04	0.97
	boardsize	-1.35E+05	1.41E+05	-0.95	0.34	1.53E+04	6.74E+03	2.27	0.02**
	Policy_exec	-5.34E+03	2.21E+05	-0.02	0.98	-4.35E+04	2.77E+04	-1.57	0.12
H3	logassets	-1.90E+05	7.61E+05	-0.25	0.80	-4.44E+04	4.09E+04	-1.09	0.28
	roa	2.49E+04	1.64E+04	1.52	0.13	5.89E+02	3.15E+03	0.19	0.85
	roe	-6.51E+03	4.11E+03	-1.58	0.12	2.28E+02	7.83E+02	0.29	0.77
	leverage	1.29E+04	1.01E+04	1.28	0.20	5.48E+02	6.72E+02	0.82	0.42
	incrassets	-2.94E+03	2.60E+03	-1.13	0.26	6.12E+02	7.73E+02	0.79	0.43
	incrrevenue	5.94E+02	3.53E+02	1.68	0.10	5.01E+02	8.65E+01	5.79	0.00***
	sector_total	-2.32E+05	3.22E+05	-0.72	0.47	-9.21E+03	3.80E+04	-0.24	0.81
H4	america	0.00E+00	(omitted)			3.91E+04	5.31E+04	0.74	0.46
	africa	0.00E+00	(omitted)			-7.48E+03	2.95E+04	-0.25	0.80
	N	421				415			
	number of groups	137				133			
	R2 within	0.07				0.01			
	R2 between	0.00				0.17			
	R2 oveall	0.00				0.04			
	Wald Chi2	1.67				88.36			
	p>Chi2	0.07				0.00			

Note: ***,**, and * are statistically significant at 1%, 5%, and 10%, respectively. Benchmark for continent dummies is Asia.

Journal of Finance and Accounting/Revista Española de Financiación y Contabilidad, Vol. 45 No. 2, pp. 231-265.

Zorio-Grima, A., García-Benau, M.A. and Sierra-García, L. (2015), "Sustainability report assurance in Spain and Latin America", *Innovar*, doi: 10.15446/innovar.v25n1spe.53361.