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Influence of CSR on air pollution: analysis of environmental regulation and eco-innovation effects

Abstract

Air pollution is one of the most serious environmental problems affecting the general population's health and wellbeing. This article analyses the role companies and public-sector institutions play in reducing air pollution. Corporations are motivated by a social commitment and the need to improve their productive processes, while public bodies endeavour to reduce air pollution to improve citizens' quality of life. Our paper drills down into the impact of eco-innovation as a mechanism for companies to achieve this dual aim. We look at a set of 31 countries between 2006 and 2013, using fixed-effects OLS panel data methodology. The results corroborate the positive influence of CSR on reducing air pollution. Furthermore, this influence is particularly reinforced when environmental regulation is developed. Finally, we observe that eco-innovations have a mediating effect on the relationship between sustainable firms and air pollution.

Keywords

Air pollution; CSR; eco-innovation; environmental regulation

1. Introduction

Reducing environmental pollution has a positive impact on the health of the general population and increases life expectancy (Lewison, 2008). According to the World Health Organization (2017), air pollution has multiple effects, both short and long term, on people's health. In particular, urban pollution appears to raise the likelihood that they will suffer acute respiratory diseases such as pneumonia, and chronic conditions, such as lung cancer and cardiovascular illnesses (Lewison, 2008). Moreover, this kind of pollution is directly linked to an increase in premature deaths (Lelieveld et al., 2015). In fact, it is estimated that air pollution caused the premature deaths of 5.5 million people around the world in 2013 (GBD, 2016) and that the number of deaths from it is forecast to increase from aproximately 3 million in 2010 to 6-9 million per year by 2060 (OECD, 2016).

Society's concern about air pollution has led to greater environmental demands being placed on corporations and other public and private bodies. That is why all stakeholders – corporations, consumers, public authorities, non-governmental organisations (NGOs) and society as a whole – need to get involved in minimising their impact on the environment and setting the ground rules for a more sustainable economy and society, which, therefore, improves people's quality of life. Eco-innovation, understood as an effort to reduce harm to the environment from human activities such as production and consumption (OECD, 2010a), plays an important role in this new paradigm of efficiency and sustainability. In fact, in the past few years, many technologies designed to minimise negative impacts on the natural environment have been developed and patented, in areas such as air pollution and climate change (OECD, 2011).

Despite existing studies on the development and effects of eco-innovations on the environment (Duch-Brown & Costa-Campi, 2015; Goetzke et al., 2012; Song & Yu, 2018) and available data about the effect of air pollution on people's quality of life (Burnett et al., 2014), very little research has directly analysed the role of eco-innovations in reducing pollution. Previous studies such as Carrión-Flores & Innes (2010) have investigated the part eco-innovation has played in bringing down toxic atmospheric emissions in the United States, and the Beltrán-Esteve & Picazo-Tadeo (2015) paper looks at how eco-innovations can help to reduce air pollution in the transport sector. However, as far as we are aware, there are no studies analysing the effects of eco-innovations on air pollution emanating from fixed or stationary sources (power plants, oil refineries, chemical industries, factories, printing works, etc.) that apply to several countries, rather than just one.

Moreover, it is necessary to analyse the role that corporations in a country play in reducing air pollution. On the one hand, it is clearly accepted that in environments where there are numerous firms involved in Corporate Social Responsibility (CSR) programs and projects, there is more awareness of and sensitivity to air pollution. Furthermore, such environments tend to be more engaged with developing and implementing these eco-technologies (OECD, 2010b). The development of eco-innovations, as a result of greater social and environmental awareness on the part of corporations, will be an important factor in understanding one the main mechanisms a firm has for reducing pollution. Likewise, the need to tackle climate change problems has led the governments of many countries to pass regulations on this subject (Bagayev & Lochard, 2017). Previous research studies indicate that greater environmental regulation would have a positive impact on reducing pollution and, at the same time, would trigger a step change among the country's companies in terms of "environmental proactivity" (Garcés-Ayerbe & Cañón-de-Francia, 2017; Zhang et al., 2008). Furthermore, by these actions, governments try to create more sensitive environments with regard to social and environmental problems, and send signals to corporations that they should strengthen their commitment to environmental issues (Delmas & Toffel, 2008; Li et al., 2017). Finally, as Del Río et al. (2016) argue, previous analysis of eco-innovation has focused on specific countries or geographical areas and the existence of international comparative studies is practically anecdotal. Additionally, these authors point out that there is a lack of studies that use panel data models, even though this type of model might be worthwhile for several reasons. In order to fill these gaps in the research, we have carried out a longitudinal study by using panel data methodology including 31 countries from 2006 to 2013.

This paper has three main purposes. First, we endeavour to analyse whether the existence of a larger number of socially responsible companies in a territory contributes to reducing the pollution levels of that territory. Second, we hope to investigate the key mechanism available to these companies for reducing pollution. This includes looking at whether the development and use of eco-innovations focusing on fixed or stationary sources of polluting emissions reduces air pollution and, as such, the number of airborne particles (specifically, suspended particulate matter equal or under 2.5 micrograms per m3) to which the general population is exposed. Finally, taking into account institutional efforts to create more engaged and sensitive environments, we explore the effect of environmental regulation on the commitment to reduce the levels of pollution by firms located at such environments. According to our findings, environments with more firms engaged in sustainability projects produce more eco-

innovations, contributing to reduced air pollution. Finally, our results show that tighter regulation creates an incentive for agents located in these sensitive environments to reduce air pollution.

The paper is structured as follows: First, it presents the conceptual background and the main hypotheses. Next, it describes the sample, variables and methodology used. After that, it presents the main results. Finally, it discusses the principal conclusions, as well as the study's implications and limitations, and suggests promising avenues for future research.

2. Conceptual background

2.1. Socially responsible corporations and air pollution in the country

Ever since Freeman's seminal definition of stakeholder as "*any group or individual who can affect or is affected by the achievement of the organization's objectives*" (1984, p. 46), stakeholder theory has been increasing in importance. Unlike most management theories, which separate business decisions from ethical issues (Freeman, 1994), stakeholder theory is grounded on (1) the integration of both spheres, and (2) the responsibility principle, which states that "*most people, most of the time, want to, and do, accept responsibility for the effects of their actions on others*" (Freeman et al., 2010: 8-9). In this sense, considering the second part of the stakeholder definition, that is, the fact of being affected by a firm's activities, the environment of a country or a region is of key importance.

Usually, the environment suffers from externalities of business operations, pollution being one of the most important ones. Specifically, focusing on air pollution, its effects should be tackled by the different agents involved, and particularly by corporations, given their potential impact on the environment and on society as a whole. The need to include these environmental considerations, as well as a range of social issues, in corporate management and leadership has spurred a remarkable growth of CSR in the past few decades, both in academic and professional circles (Crane et al., 2008; Dobers, 2009). This can be viewed as a series of actions a company takes on its own initiative with the aim of furthering a social good, above and beyond that firm's own interests and what is legally required of it. (Barnett, 2007; McWilliams & Siegel, 2001). Traditionally it was believed that in order for CSR to be developed, it was crucial that there be a potentially positive economic-financial impact taking four main forms (Kurucz, Colbert & Wheeler, 2008): (1) cost and risk reduction (Barnett, 2007; Jensen, 2002); (2) increased legitimacy and enhanced reputation (Fombrun & Shanley,

1990; Porter & Kramer, 2006); (3) creation of competitive advantage (Barnett, 2007); and (4) creation of win-win situations that generate synergic, social and economic value, enabling both the company and society to prosper (Falck & Heblich, 2007).

CSR may also be rooted in institutional, organisational or individual considerations (Aguinis & Glavas, 2012). At an institutional level, some of the determinants for CSR include the existence of regulation (Fineman & Clarke, 1996), CSR standards and certificates (Christmann & Taylor, 2006), and the country's sociocultural context (Brammer et al, 2009). At an organisational level, meanwhile, the specific corporate variables influencing CSR initiatives can be the company's size (Orlitzky, 2001) or its corporate governance structures (Johnson & Greening, 1999). Finally, at an individual level, issues such as employee and management values (Mudrack, 2007) or stakeholders' perceptions of CSR (Rupp et al, 2006), are an important predictive factor regarding the extent to which these practices are carried out.

Specifically, with the national context as our reference point, we can look at CSR as a process forming part of the value-retention strategies created in a particular country (Boulouta & Pitelis, 2014). In order for such national-level strategies to be effective, a political conception of CSR, with firms contributing to regulation and providing public goods (Scherer & Palazzo, 2007, 2011) ought to be considered. Thus, socially responsible firms, whose existence represents a *sine qua non* condition to create a more socially responsible economy (Leadbeater, 1991), should not only be addressees of regulations but also active participants in public will formation processes and in global environmental and social challenges (Scherer & Palazzo, 2007). In this sense, the fact that there are more companies that are committed to social and environmental issues can have a decisive positive impact by helping society to increase its trust in the world of business and to upgrade its social capital (Boulouta & Pitelis, 2014).

Whatever the territory being analysed and in which companies find themselves, a key characteristic of those wishing to be acknowledged as socially responsible is the consideration of a triple bottom line in their business (Elkington, 1998). These corporations have to bear in mind not only their financial performance but also their social and environmental records. There is a tendency to find that companies with better environmental track records are more honest, reliable and ethical in their dealings (Du et al., 2017). Turning to environmental management, we see that several indicators have been built and a host of research conducted (Aragón-Correa & Sharma, 2003) demonstrating the growing importance of this issue and, generally, companies' potential impact on the environment.

Air pollution from companies' emissions tends to be included as one of the key negative components of their social and environmental behaviour (Liang & Renneboog, 2017). From a nationwide standpoint, although there are other agents contributing to air pollution in a specific territory, the part corporations play is decisive. Thus, it is generally acknowledged that factory emissions are one of the main polluting agents, exposing the population to airborne particles that are potentially harmful to health. It is therefore critical that all groups contributing to air pollution in a given country make a commitment to try to reduce it. Here it is helpful to emphasise the role of large corporations in this field. First, if interest in achieving a standout social and environmental performance can become widespread among a country's most visible corporations, there can be a significant effect on the institutional ecosystem when it comes to sustainability (Boulouta & Pitelis, 2014). The fact that business leaders are leading by example can make a difference, reinforcing awareness among the different stakeholders, making a substantial contribution to improving the environment in general, and reducing air pollution, in particular. It follows that, if there are more companies that voluntarily commit to limiting their contaminating emissions, even going beyond the recommendations made in international protocols and treaties, and these companies involve their stakeholders in these behaviours, the latter group will be motivated to action. For example, if the largest companies in a sector invest in reducing or controlling their emissions, this environmentally responsible behaviour can become a benchmark for competitors such that it creates a virtuous circle. Similarly, socially responsible companies can extend their commitment to reducing contaminating atmospheric emissions by requiring their suppliers to comply with certain minimum standards in this area if they want to be hired. Finally, the fact that companies inform consumers that their final product has been produced with a manufacturing process that minimises harm to the atmosphere can attract those who are concerned about social and environmental issues. It can also drive consumers in general to become aware that even corporations, sometimes seen as purely economic agents, are making commitments in this field.

So, starting with a larger number of socially responsible companies in an economy, and considering the positive stimulus that their actions and behaviour can trigger among different members of society in terms of reducing air pollution, the following hypothesis can be posited:

H1. The presence of a greater number of socially responsible firms in a country will reduce the level of air pollution to which that country's population will be exposed.

2.2. The impact of environmental regulation on pollution

Most countries have significantly extended their environmental regulation and strengthened regulatory standards over the past four decades (Lei et al., 2017). The need to tackle climate change problems has led governments in a range of countries to pass regulation in this area (Bagayev & Lochard, 2017). The main goal is to foster strategic emerging industries such as energy saving and environmental protection, latest-generation information technology, biology, high-end equipment manufacturing, and creation of new materials that reduce exposure to air pollution (Yuan et al., 2016). One result of this environmental concern has been that not only governments and public bodies, but also corporations, have invested their efforts in reducing pollution (Kassinis & Vafeas, 2002). Public institutions and governments try to generate a more sensitive and engaged setting in which firms' social and environmental awareness will increase, thus creating incentive for various agents and companies to reduce pollution. The main instrument that public institutions have to create such settings is laws and other government actions.

Based on the second CSR principle put forward by Carroll (1979), some studies indicate that environmental policy, laws and regulations that are precisely aimed at environmental protection and air pollution above all, restrict companies' scope for activity on this issue (Guo et al., 2017). Nevertheless, following the environmental proactivity theory supported by numerous authors (Garcés-Ayerbe & Cañón-de-Francia, 2017; Zhang et al., 2008), most previous studies show that having a larger number of environmental laws would have a positive effect in reducing pollution, would create sensitivity to the environment and would increase buy-in on the part of corporations operating in the country. In both cases, the importance of having environmental regulation is clear (Germani et al., 2014). Greater commitment from all public agents (legislators, governments, etc.), can encourage companies and citizens to behave in an environmentally responsible manner. According to the signalling theory (Spence, 1973) which has been widely applied in describing behaviour when two individuals or groups have access to different levels of information (Connelly et al., 2011), public agents may be sending signals to corporations as to where they should make their social investments (Delmas & Toffel, 2008; Li et al., 2017). A company can then weigh up whether to invest more resources in environmental areas, with the aim of responding to the

needs suggested by public agents, and at the same time bolster its image as a responsible firm with a social commitment to protecting the environment (Berrone et al., 2013). Alternatively, this additional environmental effort on the part of companies may be a result of governments' legislative initiatives. Specifically, environmental regulation not only obligates companies to comply with a particular law, but may also encourage them to take action that goes further, in order to protect themselves from possible legislative changes in the future. Finally, the country's environmental regulation enables environmental performance to improve (Li et al., 2017), given that companies' efforts not only imply an enhancement of their reputations, but also an improvement in their productive processes and, in any event, greater pollution reduction (Berrone et al., 2013). Therefore, we present our next hypothesis:

H2. Environmental regulation negatively moderates the relationship between socially responsible firms and exposure to air pollution on the part of a country's population.

2.3. The role of eco-innovation in the country's air pollution

The socially responsible companies of a given country can influence the levels of air pollution to which that country's population is exposed, through the use of various mechanisms at its disposal. They include the development of training and information campaigns to create awareness of the serious environmental problems resulting from unsustainable consumption, or investment in improvements to manufacturing processes to achieve production methods that are more respectful of the environment. However, of all the available mechanisms, we should point to the key role played by eco-innovation, understood as "any form of innovation aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment or achieving a more efficient and responsible use of natural resources, including energy" (European Comission, 2017, p. 2). According to Hojnik & Ruzzier (2016), eco-innovation can lead companies to better environmental performance. They also argue that managerial sustainable concern is one of the most important key drivers in the implementation of eco-innovation processes in businesses. For that reason, eco-innovation might be the next logical step for socially responsible companies to improve their contribution to the environment in which they develop their business activity. In general, it can be assumed that in any country, corporations are the benchmark agents of innovation (OECD, 2010b). There are many opportunities for innovation designed to generate value and tackle environmental problems, but to be successful this innovation must be encouraged with appropriate policies and the right background conditions (OECD, 2011). A

basic requirement for eco-innovation on the part of socially responsible companies is sound management of existing relationships between these companies and their stakeholders (Berkhout, 2014; Guoyou et al., 2013). In fact, most of the innovative ideas in this field tend to spring from networks in which suppliers, social movements, entrepreneurs, clients, NGOs and users can contribute in one way or another (Nicholls & Murdock, 2011).

Nowadays, we are starting to see the importance of eco-innovation as a facilitator of change to a more sustainable pattern of behaviour from both individuals and organizations, which we are beginning to perceive as a new form of in-company strategic management (Carrillo-Hermosilla et al., 2009). Therefore, eco-innovation increasingly forms part of companies' CSR strategy, as they become aware of its advantages related to environmental care and business sustainability (Triguero et al., 2013). As Nidumolu et al. (2009) argue, those companies, which are sustainability-oriented, can achieve a competitive advantage that is difficult for competitors to imitate. Companies that invest in development of eco-innovations, focusing on improving their processes and manufacturing systems, etc., also tend to be rewarded with a boost in competitiveness and performance (Bermúdez-Edo et al., 2017). Furthermore, as Tamayo-Obergozo et al. (2017) argue, companies can obtain a series of internal and external benefits stemming from eco-innovation. Internal benefits include enhanced image and reputation, reduction in costs of use, improvement in process efficiency and increased market share and sales. External benefits pertain principally to cross-border transferability of eco-innovation and its outcomes, which is key to addressing environmental problems (Bayer & Urpelainen, 2013), social improvements and environmental improvements.

In the past few years, companies in many countries have developed eco-innovations in several areas: (1) air contamination from combustion plants and motor vehicles, (2) effects of climate change caused by different industries, and (3) Greenhouse Gas Emissions (OECD, 2017). We can find some examples of these eco-innovations in studies such as Betts (2002), which analyses how certain companies have developed more sustainable technologies to better monitor air pollution; Carrión-Flores & Innes (2010), which investigates the role eco-innovation plays in reducing toxic emissions into the atmosphere; and Beltrán-Esteve & Picazo-Tadeo (2015), which analyses how the transport industry has been notching up gains in atmospheric emission reduction via eco-innovations.

Thus, if the companies of a given country have to develop eco-innovations and we bear in mind, as mentioned above, that these eco-innovations bring not only economic benefits but

also social and environmental advantages, it is reasonable to suppose that a country with a larger number of socially responsible companies will tend to a greater degree to develop eco-innovations that contribute to improving atmospheric conditions and therefore its citizens' quality of life. Accordingly, we state our final hypothesis:

H3: Eco-innovation exercises a mediating effect on the influence that the number of socially responsible firms in a country has on the level of air pollution to which its population is exposed.

Taking into account our three hypotheses, a conceptual model is shown (Figure 1) in order to offer a general overview and to facilitate the understanding of the paper.

Figure 1

3. SAMPLE, VARIABLES AND METHODOLOGY

3.1. Sample

The database used in this study contains data from most of the OECD (Organization for Economic Cooperation and Development) countries between 2006 and 2013. We have excluded Chile, Israel, Korea, Switzerland and Turkey from the dataset because of the lack of information for the variables considered. We have also omitted those countries for which information for one or more of the variables used was not available, so as not to have data missing from our estimates and to be able to use the same sample size in all the models. The final sample was made up of 31 countries and 213 observations.

The main information came from two databases: the OECD (http://stats.oecd.org/) and the United Nations Global Compact (GC) databases (https://www.unglobalcompact.org/). We have also considered countries' environmental legislative frameworks.

3.2. Measurement of variables

Dependent variable. Exposure to air pollution by country population (EXPO) is one of society's key problems. Governments in many countries nowadays are aware of this issue and invest significant resources in fighting it (Bagayev & Lochard, 2017). According to the World Health Organization (2017), exposure to fine particulate matter – $PM_{2.5}$ (defined as

atmospheric particles with an aerodynamic diameter equal or smaller than 2.5μm/m^3, which includes suspended particulate matter, respirable particles and inhalable coarse particles) has potentially the most significant adverse effects on health in comparison with other pollutants. These particles are more dangerous than the larger ones (PM_{10}, which have an aerodynamic diameter equal to or smaller than 10μm) because (1) they are composed of more toxic elements (for example, heavy metals and organic compounds) that are very harmful to health; (2) they are lighter and stay longer in the air, which prolongs their effects, and (3) because they are smaller they are 100% breathable, traveling deep into the lungs and causing serious diseases (Linares & Díaz, 2008). In this regard, several studies (Burnett et al., 2014; Cohen et al., 2005; Forouzanfar et al, 2015; Lim et al., 2012; Pope et al., 2002) have shown that $PM_{2.5}$ is responsible for more than 90% of global premature mortality from outdoor air pollution linked to ischaemic heart disease, stroke, lung cancer and chronic obstructive pulmonary disease. People's exposure to $PM_{2.5}$ has been identified as an OECD Green Growth headline indicator and for that reason and because of previously mentioned arguments, we considered this to be an appropriate indicator of the level of exposure to air pollution. Specifically, this indicator was developed from Van Donkelaar et al. (2016). It was derived using satellite observations and a chemical transport model, calibrated to global ground-based measurements using Geographically Weighted Regression at a resolution of 0.01°. The underlying population data, Gridded Population of the World, version 4 (GPWv4) are taken from the Socioeconomic Data and Applications Center (SEDAC) at NASA. The underlying boundary geometries are taken from the Global Administrative Unit Layers (GAUL) developed by the FAO (United Nations Food and Agriculture Organisation), and the OECD's Territorial Classification, where available. The OECD provides a database for this indicator, and recommends using a 3-year moving average at least, to achieve a correct estimation. Moreover, this indicator has been used and tested several times in previous studies (Demeke et al., 2018; Pautrel, 2009), all of which recognise the relevance of this indicator.

Independent variable. The proportion of firms participating in the GC is the main explanatory variable (SRFIRM) of the proposed model and was collected from this programme's website (https://www.unglobalcompact.org). GC, as a CSR mechanism (Cetindamar & Husoy, 2007), is highly visible as one of the best known business-related codes and principles (Waddock, 2008). It has attracted the attention of many corporations worldwide (Arevalo et al., 2013) and is well regarded by investors (Coulmont & Berthelot, 2015). GC represents a human-rights based approach to CSR (Waddock, 2008). Thus, GC takes two basic perspectives

(Arevalo et al., 2013): First, it prescribes a set of 10 principles relating to human rights, labour, environment and anti-corruption as guidelines for CSR engagement; and second, it offers learning and discussion platforms for companies and NGOs, where information can be shared on CSR development and cooperation issues. Furthermore, as the largest voluntary corporate responsibility programme in the world (Coulmont & Berthelot, 2015), GC has a significant geographic range (covering more than 130 countries) and the moral legitimacy and political backing of the United Nations, with its 193 member-states. For these reasons, and according to Cetindamar & Husoy (2007), we considered this measure to be a relevant proxy for a company's environmental engagement. Specifically, our variable is constructed as a ratio between the total firms adhered to the United Nations GC in any specific country and the total firms registered in that country.

Moderator variable. Environmental regulation (ENVLAW) is the model's moderating variable. We considered the total number of current environmental laws per country and per year (as a logarithm). This was measured on the basis of a country's environmental behaviour, that country's willingness to solve environmental problems and its efforts to promote this environmental behaviour with its own citizens and firms. In particular, we considered the total current environmental laws by country and year. This information was obtained from the websites of each country's environment ministry. Several papers evaluate the impact of environmental regulation on air pollution and the implications that regulation has on the agents of the country (Feng & Liao, 2016; Wilnhammer et al., 2017).

Mediator variable. Eco-innovation (ECOIN) was considered the mediating variable of the analysis. Specifically, we looked at an output indicator for environmental innovation, instead of input measures on innovative efforts. Eco-innovation shows the real effects, which we find more robust inasmuch as it reflects tested and specific knowledge of firms and countries (Guo et al., 2017; Roscoe et al., 2016). Previous literature focused on the impact that this type of innovation has on environmental performance, on a firm's reputation and on its market value (Costantini et al., 2017). However, although there are many papers emphasising that innovation is the main mechanism available to firms for effective environmental action, there are very few that analyse the impact on air pollution (Guo et al., 2017). More specifically, we used the total patents focused on emission abatement from stationary sources (e.g. SOx, NOx, PM emissions from combustion plants) as a percentage of the total patents from selected environment-related technologies (Peris-Ortiz et al., 2017). This information was obtained from the database of the OECD (http://stats.oecd.org/).

Control variables. We considered several variables that might affect both eco-innovation and exposure to air pollution and have been used in previous empirical studies: environmental taxes, climate innovation efforts, expenditure on health, and gross domestic product. Environmentally related taxes (TAX) are an important instrument for governments to shape relative prices of goods and services. The characteristics of such taxes included in the database (e.g. revenue, tax base, tax rates, exemptions, etc.) were used to construct the environmentally related tax revenues broken down by environmental domain. Additionally, the data were cross-validated and supplemented by revenue statistics from the OECD tax statistics database and official national sources according to previous studies (Alexeev et al., 2016), which have also used them to measure and analyse the implications on the social sphere. Climate innovation efforts (CLIMIN) were measured as the ratio between the total patents related to climate change in agriculture (quantity and quality of crops) biodiversity, etc. (except those patents related to atmospheric and water pollution) and the total selected environment-related technologies (Veefkind et al., 2012). Expenditure on health (EXPHE) was measured as the current expenditure on health as a share of gross domestic product (Narayan & Narayan, 2008). Finally, gross domestic product (GDP) was measured as the gross domestic product per capita (England, 1998). We also included annual dummies to analyse whether the years considered in our sample had the same effect on the dependent variables (i.e., EXPO and ECOIN, respectively). Natural purification (FOREST) was derived by dividing a country's total area under forest by the country's total land area, and multiplying by 100. The forest area refers to lands with groups of natural or planted trees of at least 5 meters in situ, whether for productive or non-productive uses, and excludes populations in agricultural production systems (for example, in fruit and vegetable plantations), agroforestry systems and trees in urban parks and gardens. We obtained this information from the World Bank Indicator (https://datos.bancomundial.org/indicador/AG.LND.FRST.ZS)

Finally, we should mention that in order to control for possible endogeneity, first between ECOIN and SRFIRM, and second between EXPO and ECOIN, all the explanatory variables were lagged by one year.

3.3. Methodology

In order to test the hypotheses presented in the theoretical background, pooled OLS (Ordinary Least Squares) regressions clustered at the country level were used with the STATA12

programme[1]. Initially, the possibility of employing a panel data methodology, such as the two-step difference GMM (Generalized Method of Moments) model drawn up for dynamic panel data models by Arellano & Bond (1991), was considered. However, as our number of countries is not as large, this methodology was not applied because the results would not have been reliable, given that the number of instruments would be larger than the number of countries.

To test Hypothesis 2, it was necessary to carry out several regression analyses to check the influence of SRFIRM on EXPO and the moderation of ENVLAW. Hypothesis 3 was tested with regressions following the steps established by Baron & Kenny (1986). Tests of significance and resampling to determine whether SRFIRM had a (direct or indirect) effect (through ECOIN) on EXPO were also carried out.

4. RESULTS[2]

Table 1 shows the descriptive statistics while Table 2 lists the correlation coefficients of the variables used in the regression analyses. Several correlation coefficients show a statistically significant correlation. However, considering the empirical rule of Kleinbaum et al. (1998), an analysis of the variance inflation factors (VIF) indicated that there was no evidence of multicollinearity because in no case was VIF above 10, with a mean value around 1, indicating that multicollinearity is not a concern for our analysis.

Table 1

Table 2

Table 3 summarises the results of the regression and moderation analyses. Model 1 shows the effect of SRFIRM on EXPO, controlling for country characteristics and annual dummy variables. According to the results, the presence of SRFIRM in one country has a negative effect on EXPO ($t=-2.74.$; $p<0.01$), corroborating Hypothesis 1. It means that the engagement of socially responsible firms in a country tends to reduce its level of contamination.

Table 3

[1] The cluster option also implies the estimation of robust standard errors.
[2] Robustness check is collected in the appendix.

The coefficient for ENVLAW reflected the existence of a significant and negative effect on EXPO, which means that any moderation could be described as quasi-moderation. Finally, to reveal the moderating effect, a term of interaction comprising the product of the variable representing SRFIRM and ENVLAW was included in the regression. As shown in Model 2 (Table 3), the interaction term was significant ($t=-2.17$, $p<0.05$), indicating that ENVLAW has an amplifying effect on the relationship between SRFIRM and EXPO, thus corroborating Hypothesis 2. Consequently, the presence of socially responsible firms affects exposure to pollution but ultimately that effect will depend on the territory's environmental laws.

In Table 3, SRFIRM (Model 3) was used to explain ECOIN. Furthermore, Hypothesis 3 considered the existence of a mediating effect on the part of eco-innovations in the relationship between socially responsible firms and exposure to pollution. Following Baron & Kenny (1986), in order to check whether this mediation exists, it was necessary for SRFIRM to be significant in the regressions on EXPO and on ECOIN, and this was shown with models 1 and 3 (Table 3). This criterion also had to be met when we introduced socially responsible firms and eco-innovation variables in the same regression on value, for the former to be non-significant or less significant and the latter to have a significant influence, as shown in Model 4 (Table 3). More specifically, following Zhao et al. (2010) our results suggest a complementary mediation, given that the mediated effect and the direct effect both exist and point in the same direction, supporting our hypothesis.

This result is consistent with the social impact hypothesis (Preston & O'Bannon, 1997), and is in line with several previous empirical studies (Carrillo-Hermosilla et al., 2009) because SRFIRM has a positive effect on ECOIN and, as shown above, eco-innovations affect EXPO. The negative impact of eco-innovations on exposure to pollution may be explained because the specific knowledge and innovation output of these eco-innovations are transferred faster to countries and societies and reduce the level of pollution (Bayer & Urpelainen, 2013). More specifically, the presence of socially responsible firms may help reduce a country's air pollution (Betts, 2002; Carrión-Flores & Innes, 2010). There are many mechanisms to improve air quality, one of them being eco-innovation. Socially responsible companies are more focused than other firms on satisfying social and stakeholders' needs and they usually put significant resources toward improving the conditions of society and the environment. Private firms are sometimes the principal investors in environmental innovations and the main producers of them (OECD, 2010b).

5. CONCLUSIONS, IMPLICATIONS, LIMITATIONS AND FURTHER RESEARCH

This paper has focused on the study of fixed or stationary sources as one of the major causes of air pollution emissions affecting the wellbeing of the population. The analysis looks at the important role played by both corporations and public institutions, for a group of countries, in the reduction of air pollution emanating from these sources. In the case of companies, the study considers how, when they are motivated by the expectation of achieving improvements in their productive processes and by a social commitment, they can contribute to reducing air pollution. In the case of public institutions, the study highlights the key role they play, through current environmental regulation, in reducing the exposure to air pollution suffered by the populations of different countries. The paper also investigates how eco-innovation, one of the main instruments available to companies for helping to improve the environment, performs an essential role in reducing air contamination.

The results from this research allow us to reach the following conclusions. First, the presence of socially responsible firms in a country contributes to reducing that country's air pollution, which is in line with previous studies highlighting the potential impact of corporations on the environment generally (Aragón-Correa & Sharma, 2003). Thus, if there are companies interested in improving not only their financial results, but also society (in this case, by reducing the amount of pollutant atmospheric emissions) in a given territory, this circumstance will contribute to a large degree to a better quality of life for their citizens. Second, our study provides empirical proof that eco-innovations, as one of the key mechanisms that exist to lessen harm to the environment, account in part for corporations' impact on reducing air pollution (Betts, 2002; Carrión-Flores & Innes, 2010). Thus, it seems that the effort a country's firms make to introduce eco-innovations helps to improve the population's quality of life. These findings can and should serve as encouragement for socially responsible firms, concerned about satisfying the needs and claims of their stakeholders, to continue investing in the development of eco-innovations. Finally, in terms of public sector participation, our study confirms that current environmental regulation in a given country incentivises more than it dissuades that country's corporations to invest greater resources in reducing the air contamination to which citizens are exposed. This result is consistent with previous research (Garcés-Ayerbe & Cañón-de-Francia, 2017; Germani et al., 2014; Zhang et al., 2008). Thus, it seems that the existence of laws that regulate activities negatively affecting the atmosphere should not only be interpreted as an instrument with

which companies must comply, but also as a stimulus for socially responsible firms to ramp up their commitment to the territory in which they are operating.

In view of the above, some theoretical and professional implications can be underlined. First, in the context of stakeholder theory (Freeman et al., 2010), our research emphasises the fact that when approaching a specific issue, in this case air pollution reduction, the influence of the different parties involved ought to be taken into account. Here, it has been found that private and public agents have an effect on lowering air pollution emissions, so that improving people's quality of life requires a joint effort by all stakeholders. This circumstance of positive effects from public and private participation is in line with previous works on waste management (Yuan et al., 2013), sustainable urban logistics (Gonzalez-Feliu et al., 2016) and agricultural systems innovations (Hall, 2006). It also highlights the idea of private and public stakeholders bringing different resources and capabilities to a collaborative effort (Koontz & Johnson, 2004). Thus, for theoretical research model building, it generally may be advisable to include variables reflecting the influence of various stakeholders when intending to explain phenomena characterized by public-private intervention.

With regard to CSR literature, our findings have two potential implications. On the one hand, due to the important effect public and private agents' conduct has on social and environmental matters -- specifically on reduction of air pollution emissions -- the political notion of CSR (Scherer & Palazzo, 2007) could be particularly relevant. In this sense, it can be crucial to have the coordinated collaboration of public policy makers, as democratic representatives of people's interests and claims, and of corporations, as agents with better insights for dealing with some specific issues. For example, in a joint effort to design regulation of social and environmental matters, the societal concerns that need to be better addressed can be targeted by the public policy makers, and the more effective mechanisms to cope with them can be identified from the private perspective. On the other hand, considering the positive effects on social and environmental outcomes at a national level when there is an increasing number of socially responsible companies in a country, it can be inferred that a greater presence of CSR-sensitive firms may also help shape their competitive environment at an industry level. If more socially responsible behaviours by corporations are observed in a particular industry, the norms, values, and beliefs prevalent in that industry can be modified. Thus, basically considering relational motives for CSR (Aguilera et al., 2007), non-CSR-sensitive companies are likely to engage in social and environmental practices to imitate their socially responsible

peers in order to preserve their social legitimacy, and to ensure their long-term survival and social license to operate (see Aguilera et al., 2007).

We can therefore make a practical recommendation to public administrations, inasmuch as they represent their citizens' interests in their area of responsibility, and will be interested in reducing air pollution in their territory. In accordance with this paper, governments should be aware of the vital role played by socially responsible companies in environmental issues in general, and in reducing air pollution in particular. If policy makers want to improve their citizens' quality of life, they should design incentives for companies to become more socially and environmentally responsible. For example, there could be tax breaks for companies that reach certain objectives according to established environmental indicators; or, outstanding social and environmental conduct could be a pre-requirement in order to bid for public tenders. Policy makers will also have to continue developing and enforcing demanding and "joined-up" environmental regulation, which has been proven to strengthen the relationship between the presence of socially responsible companies and reduced air pollution.

Finally, we can make a recommendation to those companies that are most committed to society, and are very interested in making a difference and improving the environment. Corporations need to be aware that one of the principal mechanisms available for reducing air pollution is to develop eco-innovations. Whether on their own or in partnership with institutions such as universities and research centres, or taking part in joint business programmes such as Eco-Patent Commons (Ziegler et al., 2014), the most socially responsible firms can implement eco-innovations that contribute significantly to improving the environment. Moreover, this recommendation to develop and implement eco-innovations can be extended even to firms that are not CSR sensitive. In this paper, we have underlined the fact that eco-innovations have to improve the environment, but this pre-condition does not entail a poor economic performance derived from such eco-innovations. On the contrary, if we assume that companies' stakeholders will tend to be more aware of social and environmental issues, eco-innovations could potentially create value or generate a competitive advantage for firms in different industries.

With regard to this study's limitations and further research avenues, our sample can be considered as a limitation in that it is restricted to OECD countries. The impossibility of collecting information on all the selected variables for countries outside the OECD means that it is not feasible to include developing countries. Nevertheless, the results and conclusions can be generalised and extrapolated to similar contexts. Therefore, it would be useful to validate

the proposed model in the case of pollutant emissions into the atmosphere from mobile sources (cars, buses, lorries and other non-fixed machinery with combustion engines). Similarly, another future line of research could consist of validating this model, considering as a dependent variable other types of environment-related problems, such as water pollution or waste generation. Finally, bearing in mind that this project concentrates on a certain group of countries, it might be of interest in the future to widen the country sample, focusing on countries with higher levels of air pollution.

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TABLES

Table 1. Summary statistics[a]

	Mean	Robust Stand. Dev.	Minimum	Maximum
EXPO	12.476	4.968	3.030	26.372
SRFIRM	-10.495	1.266	-13.783	-7.059
ECOIN	-3.204	0.588	-4.824	-1.099
ENVLAW	2.378	0.847	0	3.871
FOREST	34.845	17.462	0.364	73.112
TAX	2.293	0.924	-1.555	5.087
CLIMIN	2567.018	6515.464	1	30978
EXPHE	8.799	1.933	4.918	16.397
GDP	0.828	3.549	-14.552	10.941

[a]n=213

Table 2. Correlation matrix[a]

		1	2	3	4	5	6	7	8	9
1.	EXPO	1								
2.	SRFIRM	-0.324**	1							
3.	ECOIN	-0.330**	0.140†	1						
4.	ENVLAW	-0.376**	0.104	0.017	1					
5.	CLIMIN	-0.037	-0.015	-0.195**	0.344**	1				
6.	FOREST	0.006	0.140†	-0.018	0.270**	0.240**	1			
7.	TAX	0.090	0.186*	-0.143*	-0.014	-0.367**	-0.087	1		
8.	EXPHE	-0.216**	0.188*	-0.297**	0.102	0.546**	-0.108	-0.074	1	
9.	GDP	0.022	-0.226**	0.065	0.005	-0.025	0.048	-0.029	-0.238	1

[a]n=213 † p<0.10; * p<0.05 ** p<0.01

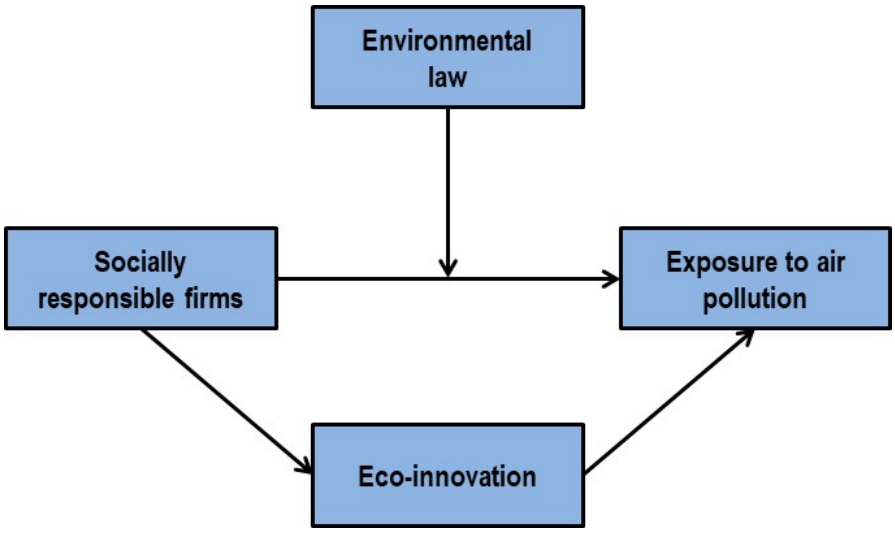
Table 3. Results of regression analysis: Moderation and Mediation[a]

	Model 1	Model 2	Model 3	Model 4
SRFIRM	-2.74**	-0.10	2.11*	-1.85†
	(0.537)	(0.569)	(0.774)	(0.619)
ECOIN				-2.20*
				(1.124)
ENVLAW		-3.25**		
		(2.917)		
SRFIRM x ENVLAW		-2.17*		
		(0.267)		
FOREST	-0.23	0.44	-0.38	-0.58
	(0.049)	(0.043)	(0.005)	(0.042)
TAX	1.86†	3.55**	-2.73**	1.65†
	(0.952)	(0.882)	(0.094)	(0.840)
CLIMIN	0.80	3.15**	0.02	0.93
	(0.0002)	(0.0001)	(0.00002)	(0.0002)
EXPHE	-0.91	-1.68†	-1.54	-1.45
	(0.518)	(0.496)	(0.082)	(0.514)
GDP	0.12	1.81†	1.15	0.12
	(0.248)	(0.160)	(0.016)	(0.222)
Annual effect	Yes	Yes	Yes	Yes
R^2	0.22	0.54	0.24	0.33
F	4.99**	7.22**	3.94**	3.35**

[a]DV: EXPO (Models 1, 2 and 4) and ECOIN (Model 3); T values reported, robust standard errors in parentheses; n=213; † p<0.10; * p<0.05; ** p<0.01

FIGURES

Figure 1. Conceptual model



Appendix

Robustness section

We controlled for the robustness of our results in several ways. First, we used another proxy for our key independent variable, socially responsible firms. We looked at the proportion of firms that present reports in line with Global Reporting Initiative (GRI) standards out of the total number of firms in a specific country. Previous studies show the relevance of GRI as an indicator of the extent of firms' social responsibility (Fernandez-Feijoo et al., 2014; Marimon et al., 2012; Prado-Lorenzo et al., 2009). The adoption of GRI guidelines indicates a higher level of harmonisation with these international reports and support for worldwide benchmarking. Thus, firms whose reports are GRI-compliant disclose the same indicators (in number and manner), which makes it easier to compare companies and years. This increases the relevance and usefulness of such information (Alonso-Almeida et al., 2014; Willis, 2003). GRI reports provide an alternative source for analysing the influence of SRFIRM on EXPO. Thus, the analysis confirms all the relationships and hypotheses proposed (Table 4). However, in this case, these relationships are less significant and the coefficients are lower. The principal explanation is that firms that merely present reports according to GRI standards are less committed to their stakeholders than firms that also abide by the GC. Previous studies show that although both variables are referenced to CSR, GC are more restrictive and tend to better reflect firms' commitment.

Table 4

Second, we repeated our estimations using OLS, considering all country-year observations as a pool and using Stata 12.0 and SPSS 24.0 versions. Results with both statistical packages were similar to previous outcomes, with the effects of direct relationships, moderation and mediation unchanged, and still significant.

Finally, graphical analyses (Aiken & West, 1991) were carried out to understand moderation and mediation results better. To measure moderation, providing the significance of the effect of interaction, a line graph (Graph 1) was developed using ModGraph (Jose, 2013a). This graph shows three regression lines for EXPO based on SRFIRMS, corresponding to three values determined for the moderating variable (ENVLAW). According to Graph 1, the

number of environmental laws in a specific country is seen significantly to moderate the relationship between the presence of socially responsible firms and the people's exposure to air pollution. This negative relationship is stronger when socially responsible firms are located in a country with more environmental laws and weaker when the opposite is the case.

Graph 1

In the case of mediation analysis, before representing the mediation model as a figure, we conducted the Sobel test (Sobel, 1982) to determine the significance of the mediating effect. The Z value verifies a significant partial mediation (Z = -1.521, p=0.013). Then, we used MedGraph (Jose, 2013b) to investigate the degree of direct and indirect influence SRFIRMS has on EXPO to interpret the results better. As we can see in Figure 2, the size of the indirect effect compared with the direct effect is not very strong in relative terms, accounting for 16.3% of the total.

Figure 2

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TABLES, GRAPHS AND FIGURES

Table 4. Results of regression analysis: Moderation and Mediation[a] with GRI

	Model 1	Model 2	Model 3	Model 4
SRFIRM	-4.96**	-1.32	2.16*	-4.67**
	(0.530)	(0.603)	(0.085)	(0.515)
ECOIN				-1.78†
				(1.038)
ENVLAW		-2.88**		
		(2.473)		
SRFIRM x ENVLAW		-1.91†		
		(0.221)		
FOREST	-0.09	0.08	-0.29	-0.21
	(0.049)	(0.047)	(0.004)	(0.045)
TAX	1.49	2.17*	-1.82†	1.56
	(0.977)	(1.002)	(0.088)	(0.893)
CLIMIN	0.92	2.55*	0.12	1.23
	(0.0001)	(0.0001)	(0.00002)	(0.0001)
EXPHE	-0.82	-1.28	-1.54	-1.41
	(0.474)	(0.531)	(0.079)	(0.457)
GDP	0.26	1.03	1.51	0.26
	(0.236)	(0.172)	(0.014)	(0.219)
Annual effect considered	Yes	Yes	Yes	Yes
R^2	0.35	0.53	0.23	0.46
F	13.90**	18.69**	7.20**	8.84**

[a]DV: EXPO (Models 1, 2 and 4) and ECOIN (Model 3); T values reported, robust standard errors in parentheses; n=213; † p<0.10; * p<0.05; ** p<0.01

Graph 1. Moderation: Graphical analysis

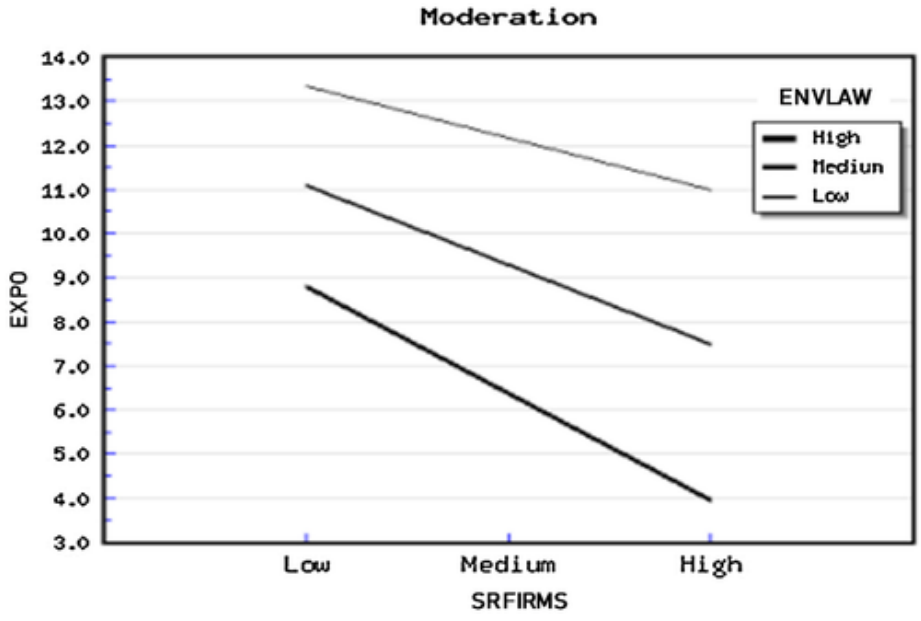

Figure 2. Mediation: Graphical analysis