

Assessing the Effects of Countries' Environmental Policy Stringency on Private Sector Eco-Innovation Performance

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The increasing global focus on environmental issues has led governments and public institutions to enforce stricter regulations in recent decades, pushing the private sector towards eco-friendly solutions and innovations. While some scholars posit that stringent environmental policies cause polluting industries to relocate to countries with less rigorous standards, other research emphasizes that government pressure is crucial for achieving environmental goals and reducing private-sector impacts.

This study assesses how environmental policy stringency influences eco-innovation performance in firms headquartered within a country. Using descriptive statistics and data from the COR&DIP database and the Environmental Policy Stringency (EPS) index provided by the OECD, the study finds a small positive effect of policy stringency on eco-innovation performance. It also underscores the importance of accurately analyzing historical environmental policies to gauge their impact on private sector innovation. The findings contribute to the literature on national environmental policies and eco-innovation, offering valuable insights for companies navigating environmental regulations and policymakers developing effective regulations to encourage green technologies.

INTRODUCTION

The increasing concern about environmental issues worldwide has pushed government and public institutions to create new regulations over the last few decades. These new regulations pressured the private sector to act toward eco-friendly solutions and find new ways to run their activities. Some scholars defending the so-called Pollution Haven Hypothesis argue that polluting industries relocate their activities to foreign countries while facing stringent environmental policies in countries with less strict ones (Duan & Jiang, 2021). However, the literature also identified government pressure as an essential element to meet environmental goals and reduce the impact of the private sector on the environment (Takalo et al., 2021). Indeed, some scholars view environmental policies as the primary driver of eco-innovation in the private sector. Private companies saw eco-innovation as the best way to keep earning profit while adjusting their business to the new regulations (Takalo et al., 2021). Thus, eco-innovation could stimulate the competitiveness of companies operating within a country with stringent environmental policies by reducing the cost of production and differentiating products and services (Sellitto et al., 2020).

Therefore, this paper attempts to analyze the effects of environmental policies on the eco-innovation activities of firms headquartered within a country. It uses the green patent filed within a country as an indicator of the private sector's eco-innovation activities and connects it to the Environmental Policy

Stringency (EPS) index. The study contributes an additional piece to the research regarding environmental regulation and eco-innovation of private companies.

The remainder of the paper is organized as follows: Section 2 reviews the literature on eco-innovation. Section 3 presents the literature about environmental policies. Section 4 introduces the methodology. Section 5 exposes and discusses the research results. Section 6 summarizes the main findings and concludes the article.

ECO-INNOVATION

Scholars have studied eco-innovation for decades. There exists a multiplicity of terminology that refers to the term eco-innovation, such as “green innovation,” “sustainable innovation,” or “environmental innovation (Sanchez-Henriquez & Pavez, 2021). More precisely, eco-innovation refers to the combination of two words: “Eco,” which means “environment-friendly, and “Innovation,” referring to introducing something new (Johl & Toha, 2021). Therefore, and in accordance with Takalo et al. (2021), eco-innovation could be defined as a process contributing to the creation of new products, processes, and production technologies that aim to reduce environmental risks such as pollution and the negative impact of the exploitation of natural resources. Researchers divided eco-innovation into different dimensions to more accurately analyze it. Renning et al. (2006) separated eco-innovation into two dimensions: technical and organizational eco-innovation. On their side, Kemp and Pearson (2008, pp. 10-11) extended these two dimensions into four dimensions: environmental technologies, including technologies for controlling and solving pollution problems; organizational eco-innovation, referring to the implementation of organizational method and management solving environmental issues in the productions and products; Product and service innovation referring to the offer of new environmental benefits to the consumers by improving services and products distribution; green system innovation related to proposing more environmentally-friendly systems of production and consumption. Other studies followed the OECD/Eurostat (2018) Oslo Manual to differentiate the types of eco-innovation with four dimensions: Product, Process, Organizational, and Marketing (Biscione et al., 2021; Maldonado-Guzman & Garza Reyes, 2020; Triguero et al., 2013). This shows that some scholars observe some similarities between traditional innovation and eco-innovation. However, on their side, Sobczak and Gluszczyk (2022, p.2) listed the main differences observed between traditional innovation and eco-innovation as follows:

- “Generating benefits (added value) for the entrepreneur and the consumer along with reducing the negative impact on the environment.
- Creating new business opportunities and environmental benefits.
- Harmonization with the idea of sustainable development.
- Reduction of negative impacts on the natural environment along with achieving the specific environmental performance.
- Taking into account both social and environmental issues.
- Creating benefits for the environment comparing to alternative solutions.
- Contributing to ecological balance.
- Reducing environmental risk throughout the life cycle in relation to alternative solutions.
- The lowest harmful consequences to physical, biological and cultural systems.
- Optimizing the satisfaction of human needs and ensuring a better quality of life while considering the aspects of environmental protection.
- The emergence of external social benefits resulting from the innovating R&D activities.
- Improvement of ecological parameters of products and processes.
- Striving to reduce burdens on the environment.”

The most dominant distinction between eco-innovation and innovation seems to be its environmental impacts. Despite the environmental aspect, it is noticeable that business opportunities and benefits for entrepreneurs and consumers remain an essential aspect of eco-innovation. An observation that reinforces the idea that eco-innovation is not only motivated by environmental results but also economic outcomes.

Multinational Corporations (MNCs) seem to be among the most critical actors in eco-innovation development. Indeed, according to Steenbergen and Saurav (2023), MNCs represent both a risk and an opportunity for climate change mitigation. In their view, MNCs have the capacity to invest in eco-innovation and encourage the transfer of green technologies within multiple countries. As MNCs are a significant emitter of global greenhouse gas emissions, they should attempt to develop green technologies and commit to decarbonizing the production and supply chain. Furthermore, as notified by Lash and Wellington (2007), climate change could induce several risks for companies that do not attempt to improve their climate competitiveness. The main dangers that companies could face are physical, reputational, litigation, product and technology, supply chain, and regulatory risks. Lash and Wellington (2007) insisted that the most prominent area of impact for businesses would be the regulatory risk, relying on the examples of the Kyoto Protocol and the European Union's Emissions Trading Scheme. Therefore, climate change represents both a risk for businesses that do not react and an excellent opportunity to stand out regarding sustainability factors. Indeed, many studies investigated the role of eco-innovation on the competitiveness of companies (Shafique et al., 2017; Sellitto et al., 2020; Borsatto & Amui, 2019; Yin et al., 2020). This research showed that companies with proactive eco-innovation would gain competitive advantages and strengthen their market position (Linde & Porter, 1995a; Tu & Yu, 2021). The competitive advantage of companies performing in eco-innovation would mostly come from reducing operating costs, differentiating their product and services, and creating a green corporate image (Sellitto et al., 2020; Tu & Yu, 2021). Eco-innovation allows companies to reach new markets with environmentally sensitive customers and to prevent new environmental policies that could harm the smooth operation of specific industries (Tu & Yu, 2021; Aguilera-Caracuel & Ortiz-de-Mandojana, 2013). Although eco-innovation enhances firms' economic performances and creates competitive advantage, some studies observe that green firms are not necessarily more performant than environmentally neutral companies (Fernando et al., 2009; Cordeiro & Sarkis, 1997). This observation could explain why companies do not yet have enough incentive to undertake eco-innovation activities. In this sense, Steenbergen and Saurav (2023) explain that only one out of four MNCs is committed to net-zero greenhouse gas emissions by 2050. It shows that MNCs are not concerned enough about the importance of decarbonization of their activities and the benefits of eco-innovation for climate change mitigation and economic performance.

Therefore, one could understand that eco-innovation faces some challenges and barriers specific to these types of innovation. Carrillo-Hermosilla et al. (2009, pp. 28) explain, "Some barriers are common to others general innovations, whereas others are specific to the environmental protection component which characterizes eco-innovation." The main barrier specific to eco-innovation seems to be the double externality. Eco-innovation faces a double difficulty in developing and spreading in the market and society as a double market failure pressures them (Carrillo-Hermosilla et al., 2009, p. 28). The first externality that discourages private companies from investing and developing eco-innovation includes the positive knowledge externalities that research and development bring. Indeed, companies that decide to internalize costs for eco-innovation develop a positive spillover of knowledge that could easily benefit competitors that do not invest in this kind of innovation.

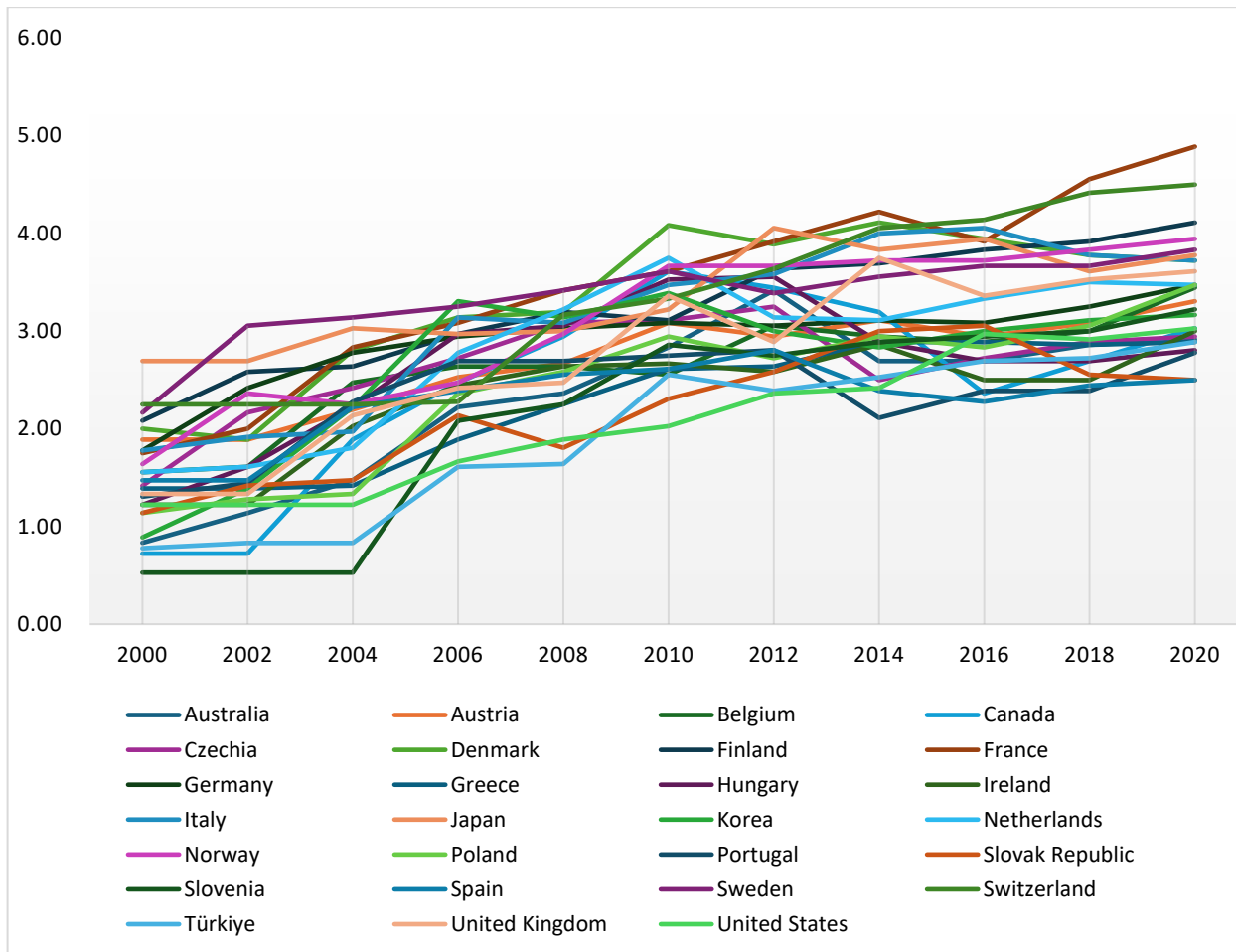
Additionally, environmental spillovers are produced by companies investing in eco-innovation, which benefits society mainly. Therefore, companies are not instinctively encouraged to pay for external costs (Rennings, 2000, pp. 325-326; Hojnik & Ruzzier, 2016, p. 32). Since this double externality problem reduces the incentive for companies to invest in eco-innovation, it encourages external factors such as the government and institutes to develop appropriate instruments to push the private sector to invest in eco-innovation. Consequently, it seems that companies' eco-innovation activities are driven by both internal factors such as resources, capabilities, and management (Du et al., 2018; Ma et al., 2018) and by external factors such as market demand, technological change, and governmental policies (Ghisetti & Rennings, 2014; Tu & Wu, 2021). Further studies attempted to link sustainability performance to the degree of internationalization of firms, with contrasting results. Indeed, Chiarvesio et al. (2015) and Aguilera-Caracuel et al. (2012) found a positive effect between the degree of internationalization of firms and the implementation of environmental programs and green strategies.

On the other hand, more recently, de Azevedo Rezende et al. (2021) could not find any relationship between companies' degree of internationalization and the improvement of green innovation and economic performance. Takalo et al. (2021) found many topics of interest related to green innovation in their systematic literature review. According to their study, many papers covering this theme with various purposes have evolved. The first research about green innovation focused on the impact and the advantages that could be derived from it (Takalo et al., 2021). Then, further studies analyzed the motives behind firms' active involvement in eco-innovation. Later, studies focused on the implementation of eco-innovation within firms and organizations and eventually linked eco-innovation to internal and external pressure (Takalo et al., 2021). Most studies regarding eco-innovation used the patent database as an essential indicator of the performance and output of eco-innovation activities (Urbaniec et al., 2021; León et al., 2018; Coussa et al., 2024). This paper will evaluate the eco-innovation performance of the 2000 most innovative companies using the COR&DIP database (OECD, 2021). The ratio of green patents over the total patents registered by companies will serve as the index of the eco-innovation performance of the most innovative firms in the world.

ENVIRONMENTAL POLICIES AND REGULATIONS

As mentioned above, environmental policy and regulation are major external drivers that pressure companies to participate in eco-innovation. Governments and regulators consequently have a role to play in stimulating companies to invest in sustainability activities such as eco-innovation (Steenbergen & Saurav, 2023). According to the World Bank's Global Investment Competitiveness Report 2021/2022 (GIC) survey, multinational enterprises (MNEs) are notably sensitive to environmental policies and government regulations regarding sustainability. MNEs who responded to the survey cited government pressure as the most significant incentive to become more sustainable (Steenbergen & Saurav, 2023). This pressure goes along with the fact that governments are increasingly moving toward environmentally friendly policies to minimize the influence on natural resources and the environment while maintaining suitable economic growth (Fang, 2023). In this sense, Figure 1 illustrates the development of the Environmental Policies Stringency (EPS) index within the OECD countries. As one can see, all OECD countries have increased their rigidity and strictness regarding environmental regulations. It shows that OECD countries' regulators are aware of their influence on companies' sustainable activities and can push the private sector to tackle environmental issues.

FIGURE 1
EVOLUTION OF THE ENVIRONMENTAL POLICY (EPS) INDEX FROM 2000 TO 2020



Source: Own elaboration based on data extracted from OECD 2024

The literature often categorizes environmental policies and regulations in many distinct ways. For instance, Zhang et al. (2022) classified environmental policies into two groups: market-based and nonmarket-based instruments. The market-based instruments include taxes and tradable permits on emissions, while the nonmarket-based instruments group measures such as subsidies on R&D for eco-innovation programs, emissions limits, and voluntary instruments (Zhang et al., 2022; Rastegar et al., 2024). On their side, Kruse et al. (2022) extended the categorization of environmental regulations with a third group focusing more on technology support, including all support from the government for new environmentally friendly technology, such as the R&D expenditure support, and support in the adoption of solar and wind energy technologies. A different study from Hille and Oelker (2023) expanded the classification of environmental policies even more with four groups. One group comprises all command-and-control policies, including all regulatory measures such as environmental laws and renewable portfolio standards. Like the other studies, the second group, market-based instruments, involves tariffs and carbon taxes. The third group of environmental policies, mixed instruments, includes command-and-control and market-based policies, such as renewable energy quotas with certificate trading. The last group is voluntary instruments, comprising initiatives or objectives like renewable energy targets (Hille & Oelker, 2023). These classifications demonstrate that governments and regulators have multiple ways to guide the private sector toward more sustainable practices and investment in eco-innovation activities.

A new framework, called the 5Ps, explaining the different ways policies could influence MNCs' sustainable development actions, was introduced by Steenbergen and Saurav (2023). According to the two authors, environmental policies could be divided into 5Ps, representing tools that help the government shape MNEs' actions on climate change. They built the 5Ps category as follows: (1) *Patrolling*, referring to monitoring emissions; (2) *Prescription*, including laws and regulations; (3) *Penalties* such as taxes; (4) *Payments*, comprising incentives and fiscal support; and finally, (5) *Persuasion*, which consists of corporate commitments and information (Steenbergen & Saurav, 2023). Furthermore, these 5Ps instruments could impact MNEs in 3 different scopes, as presented in Figure 2. First, it would encourage MNEs to reduce emissions-intensive production (scale), push MNEs to develop lower-carbon production methods (technology) and promote a shift in the national economy toward a low-carbon industrial structure.

FIGURE 2
SPECIFIC INSTRUMENTS TO IMPROVE MNEs' EFFECT ON CLIMATE CHANGE
(THE 5PS FRAMEWORK)

Domestic policy tools	Objectives to improve MNEs' effect on climate change mitigation		
	Scale channel Reduce carbon-intensive production	Technology channel Change production methods to reduce carbon intensity	Composition channel Shift economy toward a low-carbon industrial structure
Patrolling (monitoring emissions)	- Monitoring firm-level GHG emissions (scope 1, scope 2, and scope 3) - Voluntary reporting standards and environmental disclosure laws		
Prescription (laws and regulations)	- Environmental standards - Emission permits	- Environmental standards - Streamlined regulations for technology licensing, joint ventures, local sourcing	- Restrictive business/FDI regulation for polluting sectors - Liberalized business/FDI regulation for green sectors
Penalties (taxes and charges)	Environmental taxes	Environmental taxes	Higher income tax for polluting sectors
Payments (tax incentives and fiscal support)	Buyout plans	- Incentives for green R&D, skills training, capital upgrades - Incentives for technology licensing, JVs, supplier programs	Tax incentives for green sectors.
Persuasion (corporate commitment and information campaigns)	Corporate commitment campaigns	- Supply chain eco-certification - ESG/Impact investing - Investor aftercare on green reinvestment/supplier links	Green investment promotion and facilitation

Source: Steenbergen and Saurav, 2023, p.36

This classification of policies that attempts to improve the effect of MNEs on climate change mitigation reminds us that it is not simple to design the right policy balance. Indeed, countries must carefully choose policy instruments that allow MNEs to decarbonize their activities and collaborate with domestic firms to encourage the development of green technologies while avoiding insurmountable pressure that would push MNEs and their worthwhile capital, jobs, and technology out of the country.

In this sense, divergent opinions about environmental policies and regulations appeared in the literature. Porter and van der Linde (1995a) observed the emergence of the idea of a fixed trade-off between environment versus economic performance. Indeed, environmental policies could be seen as an additional cost for companies and harm competitiveness (Carrillo-Hermosilla et al., 2009). However, according to Porter and van der Linde (1995a, 1995b), environmental regulations could drive firms' productivity and competitiveness since they stimulate eco-innovation activities and push companies to create a first-mover environmental competitive advantage. The literature has analyzed the relationship between environmental regulation and firms' green innovation with mixed results. Some authors found a positive relationship (Zhu

et al., 2019; Xiang et al., 2020; Wang et al., 2022; Zhang et al., 2024), while other studies found a negative one (Guo et al., 2017; Feng et al., 2018; Li & Zeng, 2020). This mixed result shows that there are still some unknown areas regarding environmental policies and their effects on eco-innovation.

In this study, we will attempt to analyze the effect of countries' environmental policy stringency on the activities of MNEs and companies in eco-innovation. The following chapter will give insight into the methodology used to analyze the relationship between firms' eco-innovation and stringency in government environmental regulations. Therefore, the research question that we will attempt to answer is the following one:

Research question: *How does the stringency of countries' environmental policies influence the eco-innovation performance of private companies?*

METHODOLOGY

Two leading indicators were required to address this question. One indicator defines the degree of environmental policy stringency a country sets to influence the environmental activities within its domestic territory. The other indicator measures the eco-innovation activities and performances of companies headquartered within the country.

The first data used in this study came from the third version of the OECD COR&DIP database, which reports the patenting filing activities of the world's top 2000 corporate R&D investors from 2016 to 2018. This database was created by the European Commission's Joint Research Centre (EC-JRC) and the Organisation for Economic Co-operation and Development (OECD). This dataset allows us to check the innovation activities of MNEs based on their headquarters' location and identify the patents responding to climate change issues (Amoroso et al., 2021). Furthermore, analyzing the top 2000 R&D corporate investors seems pertinent, as they account for 87% of global private sector R&D expenditure and are responsible for 63% of patent filings across all technologies (Amoroso et al., 2021). Patent data are considered a crucial indicator of private companies' innovation activities since they measure the outcome of technological development efforts (Lindman & Söderholm, 2016; Rezende et al., 2019).

Furthermore, Lindman and Söderholm (2016) highlight the advantage of working with patents as a measure of innovation by stating that these data are easily accessible and can be divided into specific technological sectors. Therefore, this study used the COR&DIP dataset to measure the degree of eco-innovation in companies headquartered in a specific home country. To this end, the ratio of green patents to the total patents filed for each company indicated the degree of activity in eco-innovation.

The second data analyzed in this study is the Environmental Policy Stringency (EPS). The EPS is a country-specific and internationally comparable indicator of the stringency of environmental policy (OECD, 2024). It allowed us to evaluate the impact of environmental policies more precisely across countries and time. It was built by Botta and Koźluk (2014) and updated in 2022 by Kruse et al. (2022). The EPS index has been used in many empirical studies that assess the cross-country effect of strict environmental policies on environmental and economic outcomes (Kruse et al., 2022). It is measured with three sub-indices based on the instruments used by national governments. The first sub-index groups of instruments are the Market-Based Instruments (MBI) comprised of CO₂ Trading schemes, Renewable Energy Trading Schemes, CO₂ Taxes, Nitrogen Oxides (NO_x) Tax, Sulphur Oxides (SO_x) Tax, and Fuel Tax (Diesel). The second sub-index involved Non-Market Based Instruments (NMBI), which includes Emission Limit Value (ELV) for nitrogen oxides (NO_x), ELV for Sulphur Oxides (SO_x), ELV for Particulate Matter (PM), and Sulphur content limit for diesel. The third and last sub-index consists of all Technology Support (TS) policies, such as Public research and development expenditure (R&D) and renewable energy support for solar and wind (Kurse et al., 2022). Figure 3 illustrates the EPS index aggregation and weights.

FIGURE 3
EPS AGGREGATION AND WEIGHTS

Level 0		Level 1		Level 2	Level 3	Weight within Level 2	Weight in the overall index
EPS index	0.33	Non-Market based indicator	1.00		ELV NO _x	25%	8.25%
					ELV SO _x	25%	8.25%
					ELV PM	25%	8.25%
					Sulphur content limit for diesel	25%	8.25%
	0.33	Market based indicator	1.00		CO ₂ certificate	16.7%	5.5%
					Renewable energy certificates	16.7%	5.5%
					CO ₂ taxes	16.7%	5.5%
					NO _x taxes	16.7%	5.5%
					SO _x taxes	16.7%	5.5%
					Fuel taxes (diesel)	16.7%	5.5%
	0.33	Technology Support	0.50	Upstream support	R&D expenditure	100%	16.5%
			0.50	Adoption Support	Adoption support solar	50%	8.25%
					Adoption support wind	50%	8.25%

Source: Kurse et al., 2022

The EPS index helps assess the degree of stringency of a country's environmental policy applied to companies and MNEs based within it. This indicator helps to compare countries' environmental policy stringency and analyzes its effects on firms' eco-innovation behaviors.

Table 1 below presents summary statistics for the six key variables used in this study. The key variables are related to the environmental policy stringency performance of 22 countries and the eco-innovation of the private sector within them. These variables include the number of companies comprised in the ratio of green patents from 2016 to 2018, the actual green patent ratio from 2016-2018, the average EPS index from 1998-2018, the Compound Annual Growth Rate (CAGR) of the EPS index from 1998 to 2018, the EPS index growth rate over the same period, and the average EPS index for 2016-2018. Table 1 provides a comprehensive overview of the tendencies and dispersion of the critical variables related to the study.

TABLE 1
SUMMARY OF THE DATA

	N	Mean	SD	Min	Max
Number of companies	22	66.455	136.409	1	620
Green Patent Ratio 2016-2018	22	.113	0.052	0	.21
Average EPS index 1998-2018	22	2.592	0.438	1.713	3.204
EPS index CAGR 1998-2018	22	.051	0.019	.026	.091
EPS index Growth rate 1998-2018	22	1.882	1.147	.686	4.722
Average EPS Index 2016-2018	22	3.241	0.604	2.333	4.231

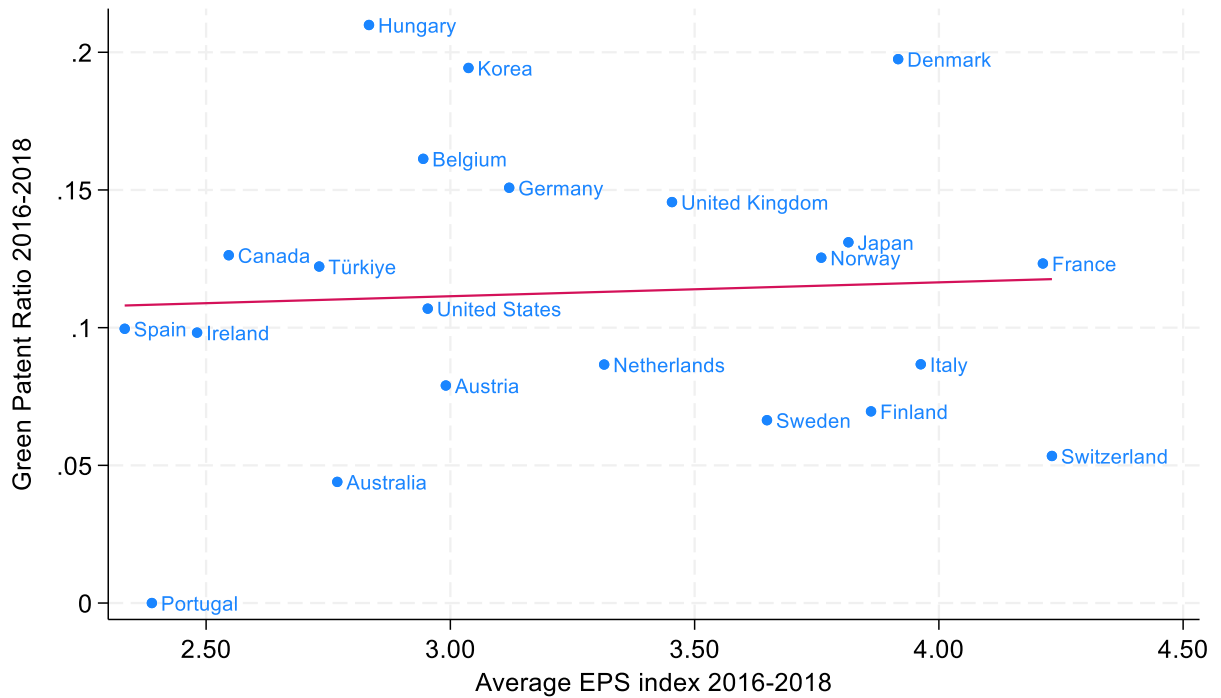
Source: Own elaboration based on OECD 2024

Therefore, to evaluate the relationship between the Environmental Policy Stringency and the eco-innovation activities of the private sector within a country, we linked together the two variables from the COR&DIP database and the EPS index. The relationship between each variable was analyzed thanks to a correlation matrix and illustrated in a scatter plot graph. The correlation matrix allowed us to determine the correction coefficient, also called Pearson's correlation coefficient (Kenton, 2022). It allows us to measure the association between two variables. It is measured on a scale from +1 to -1 (Kenton, 2022). When a variable increases as the other variable increases, the correlation between both variables is called positive and tends toward 1 (Kenton, 2022). On the contrary side, when a variable decreases as the other variable increases, the correlation is called negative and tends toward -1 (Kenton, 2022). A scatter plot brings a practical visual illustration of the data within a graph in which the continuous value of two variables is measured along two axes. Each observation is plotted by a point whose x-y coordinates are represented by the values of the two variables (Ghauri et al., 2020). This kind of graph helps to identify patterns in the data and shows if there is a (linear or non-linear) relationship between the variables.

RESULTS AND DISCUSSION

In the first step, we decided to observe the relationship between the current state of Environmental Policy Stringency and the degree of filed green patents within a country during the same period. As one can observe in Figure 4, there was no visual relationship between the average countries' EPS index from 2016 to 2018 and the degree of green patent filled during the same period. This is an observation that is confirmed by the correlation matrix. The correlation coefficient is only 0.0585, which suggests a weak positive linear relationship between the variables. Therefore, we assume that the ratio of green patents tends slightly to increase as the current state of environmental policy is stricter. However, since the correlation coefficient is not strong (0.0585), it is not considered consistent. It limits the reliability of explaining the ratio of green patents based on the current state of environmental policy stringency.

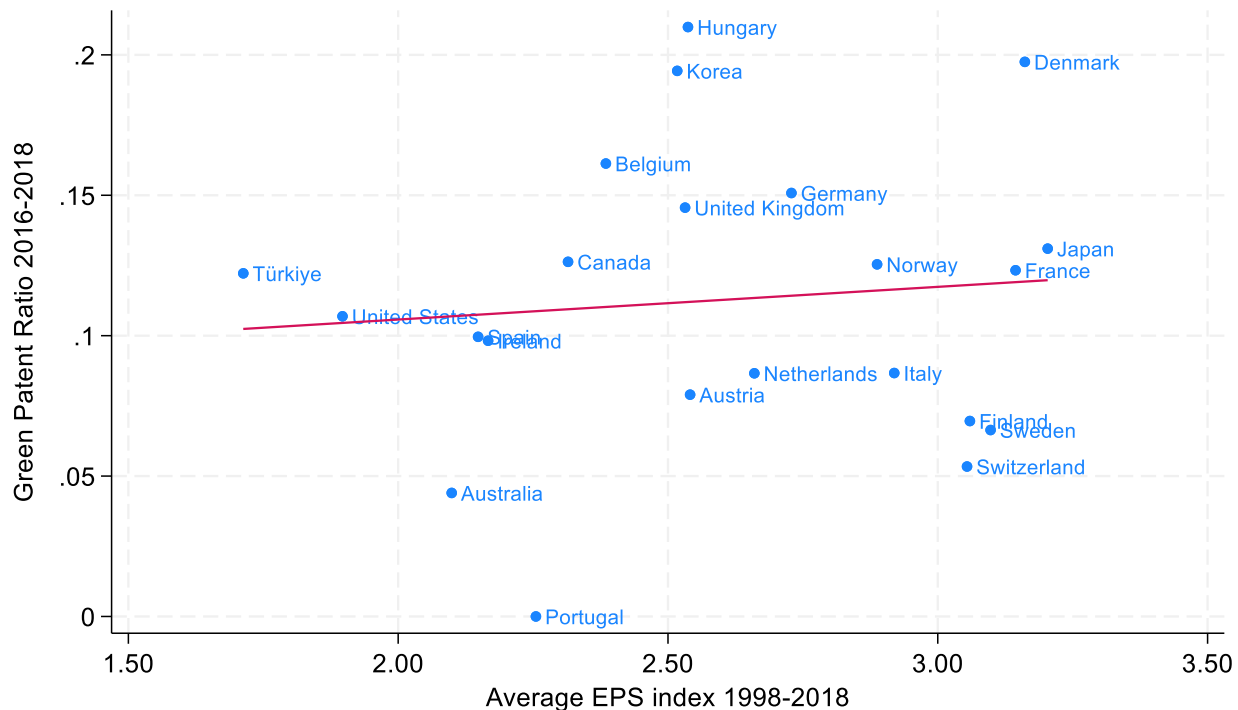
FIGURE 4
SCATTER PLOT OF THE AVERAGE EPS BETWEEN 2016-2018 FOR THE
SELECTED COUNTRIES



Note: The red line corresponds to the fitted values obtained from the linear prediction
Source: Own elaboration

In a second step, we analyzed the ratio of filled green patents and the state of environmental policy stringency over the 20 years before and during the observation period. Once again, the relationship between both variables does not seem to be precise. Figure 5 shows no visual associations between the ratio of filled green patents and the average state of environmental stringency policies for the 20 years before the observation period. An observation emphasized by the correlation matrix results in a weak correlation coefficient of 0.098. This result again shows a weak relationship between both variables, but the correlation coefficient is more robust than when observing the equivalent years. This means that, despite the weak relationship, there was an influence from previous years' environmental policy stringency on the ratio of green patent filling during the analyzed period. Therefore, it seemed interesting to have a deeper look into the evolution of environmental policy stringency before the period of observation of the green patent ratio.

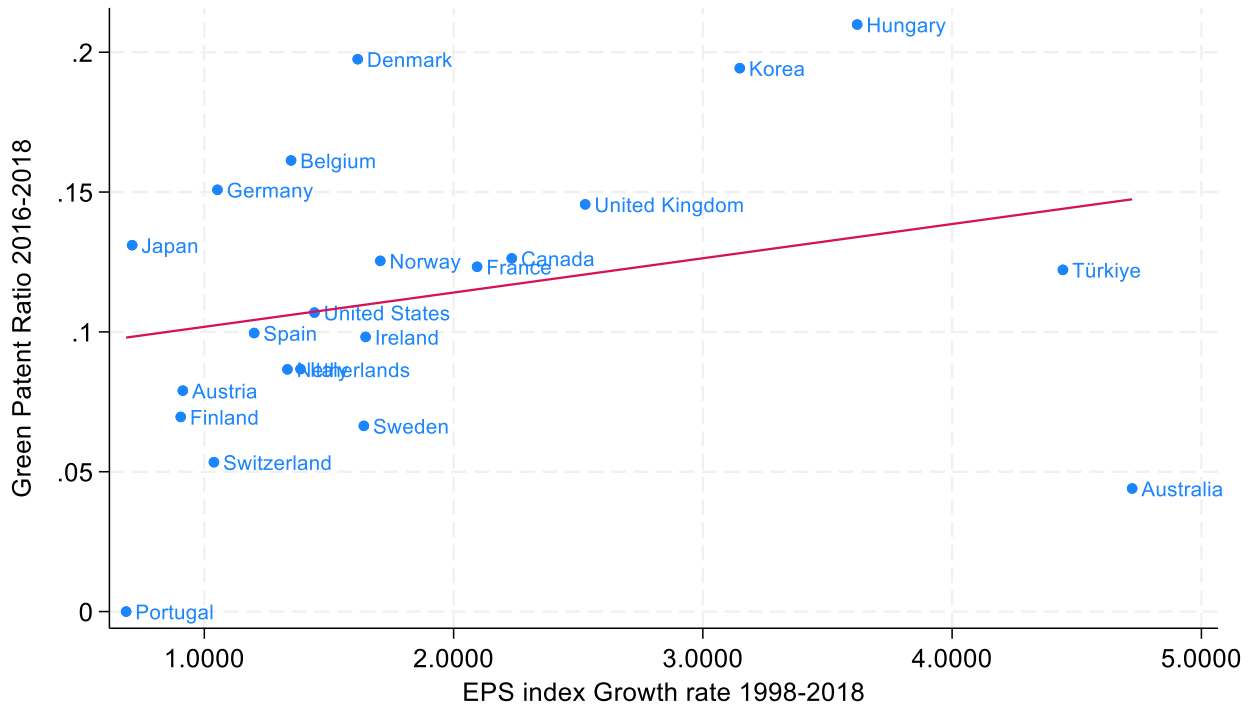
FIGURE 5
SCATTER PLOT OF THE AVERAGE EPS BETWEEN 1998 AND 2018 FOR THE
SELECTED COUNTRIES



Note: The red line corresponds to the fitted values obtained from the linear prediction
Source: Own elaboration

As seen above, these two results led to further study regarding the EPS index before the observation period. Indeed, in this third step, we analyzed the relationship between the total growth of the EPS index for the 20 years before the end of the observed period. It helps to understand the impact of the previous evolution of environmental policy stringency on firms' eco-innovation activities in 2016-2018. Looking at Figure 6, one can observe a slight tendency for both variables to move together. For this purpose, we again computed the correlation coefficient between the ratio of green innovation in 2016-2018 and the total growth or decline of the EPS index from 1998 to 2018. The correlation coefficient is still considered weak at 0.27, but shows a stronger association than the two results found above. Therefore, it suggests that the evolution of environmental policy stringency over the years has a more substantial influence on the eco-innovation activities of firms and MNEs within a country than the current state of the environmental policies.

FIGURE 6
SCATTER PLOT OF THE EPS GROWTH FROM 1998 TO 2018 FOR THE
SELECTED COUNTRIES



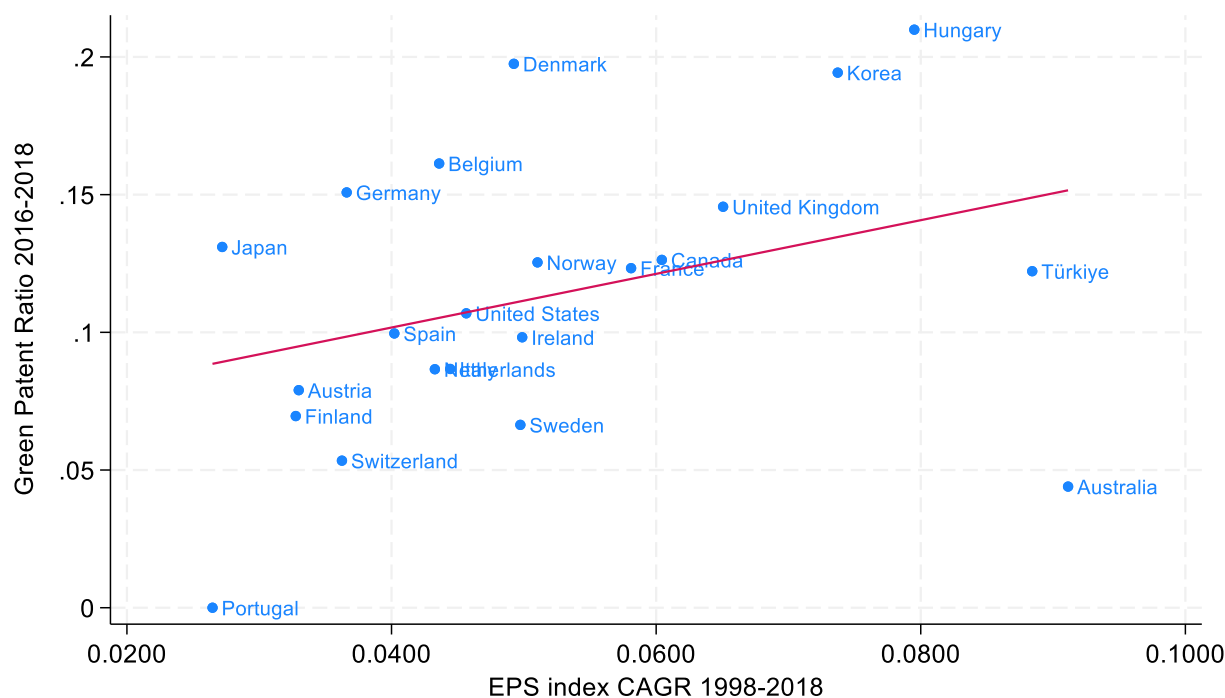
Note: The red line corresponds to the fitted values obtained from the linear prediction
Source: Own elaboration

In the last step, based on the previous result, we analyzed the yearly evolution of the EPS index to determine the ratio of green patents filled by companies and MNEs within a country. In this manner, we computed the compound annual growth rate (CAGR) for the 20 years before the observable period. The formula to calculate the CAGR is the following one (Jassy, 2023):

$$CAGR = \left(\frac{EV}{BV} \right)^{\frac{1}{n}} - 1 \quad (1)$$

Where EV corresponds to the ending value of the EPS index, BV represents the Beginning Value of the EPS index, and n is the number of years. The CAGR allows us to reasonably interpret the overall growth trend in the EPS over the 20 years before the analyzed period of 2016-2018. As for the three other results above, a scatter plot was built. Figure 7 illustrates the relationship between 1998-2018 CAGR EPS growth and the ratio of green patents filed between 2016-2018 by the 2000 most prominent inventors. There seems to be a slight positive tendency between both variables, reinforcing the idea that the long-term evolution of environmental policy stringency affects the ratio of green patents. Furthermore, the correlation coefficient of 0.3474 validated the visual tendency. In fact, this time, the correlation coefficient is considered moderate, which means that a part of the CAGR EPS between 1998 and 2018 could explain the ratio of green patents filed by the private sector within a country.

FIGURE 7
SCATTER PLOT OF THE CAGR OF EPS (1998-2018) FOR THE SELECTED COUNTRIES



Note: The red line corresponds to the fitted values obtained from the linear prediction

Source: Own elaboration

DISCUSSION

This study investigated the influence of countries' environmental policy stringency on the overall eco-innovation performance of the private sector. The result demonstrated a positive relationship between the strictness of environmental regulation and companies' performance in developing green technologies. Despite finding a weak positive relationship in the initial phase of the study, the correlation coefficient indicated a slightly small relationship between the EPS index and the ratio of green patents filed by the world's top 2000 companies. It shows that the private sector within a country is influenced and driven by government pressure led by solid national environmental policies.

Furthermore, positive relationships found in the second and third steps, between the average and growth of the EPS index and the eco-innovation performance, validated the fact that environmental policy stringency is not an indicator that scholars should compare in a specific and fixed period, but instead examine the effect of its evolution over time on the degree of green technology introduced by the private sector. In fact, despite a weak correlation, we could observe a stronger positive relationship when considering the previous year of the analyzed period. It reinforces the idea that higher eco-innovation performance in the private sector results from the evolution of the strict national environmental policies set by the government.

The final step of the study demonstrated that the consistency of the evolution of environmental policy stringency has the most vital relationship with the ratio of green patents filed by companies within the examined countries. Indeed, using the CAGR of the EPS index, we could find a moderate correlation between the CAGR of environmental policy stringency and the degree of filled green patents. This result provides two interesting insights. First, with consistent long-term growth in environmental policy stringency, companies are more likely to perform well in eco-innovation. It could be explained by the fact that companies, in their quest for profit, are attempting to anticipate future environmental regulations and

thus avoid performance degradation due to stricter environmental policies. This results in a higher performance of eco-innovation. Secondly, it gives interesting instructions for policymakers to look for stability and consistency while reinforcing environmental policies to allow businesses to anticipate and create technological responses to governmental environmental actions.

However, these results come with some limitations. Indeed, this study only analyzes the relationship between the EPS index and the ratio of green innovation in 22 countries. Extending this research to more countries could be more informal in validating the trend discovered. Additionally, the data about companies' patents varies significantly between countries. For instance, as shown in Table 1, some countries had only one firm in the top 2000 inventors, while others, such as the US, comprised 620 firms. This could reduce the significance of the results. Future studies could benefit from analyzing the same number of firms in each country. Furthermore, this study uses only descriptive statistics and could be strengthened by more advanced econometric models.

Future research could also be conducted to further analyze the impact of national environmental policy stringency on eco-innovation activities. These studies could be analyzed over a more extended period and comprise more countries. Furthermore, it could be interesting to further analyze the different instruments used to build efficient environmental policies, such as market-based instruments, non-market-based instruments, and technology support. Future studies on the subject could analyze which instruments are the most effective in improving the eco-innovation performance of firms within a country.

To summarize, despite its limitations, this study shows stronger relationships between the ratio of green patents and the evolution of environmental policies over time than with the current status of environmental policy stringency.

CONCLUSION

The purpose of this article was to define how environmental policy stringency influences the private sector eco-innovation performance within countries. The article used descriptive statistics to respond to the research question. The data employed in this study come from the COR&DIP database and the EPS index, both provided by the OECD. The study concluded that environmental policy stringency has a small positive effect on companies' eco-innovation performance. Furthermore, the study highlighted the importance of analyzing environmental policies over previous periods to understand the real impact they have on the private sector's eco-innovation performance. The article contributes to the literature on national environmental policies and eco-innovation activities of firms. It provides valuable insights for companies facing environmental policies and for policymakers who develop appropriate regulations to drive the private sector toward green technologies.

Additionally, it offers a better understanding of how scholars should study the impact of environmental policies by taking a broader view of the evolution of regulations over previous years. As discussed in the previous chapter, this study has some limitations. The main limitations stem from the data and the research methodology. Further study could develop more advanced econometric models to more accurately determine the relationship between governmental environmental policies and the private sector's eco-innovation activities.

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