LUISS

Dipartimento di Impresa e Management

Corso di Laurea Magistrale in Strategic Management (LM-77)

Cattedra di Dinamiche Industriali

The impact of Environmental Regulation and Networks on international competitiveness: an empirical analysis

RELATRICE

Prof.ssa Valentina Meliciani

CORRELATRICE

Prof.ssa Francesca Lotti

CANDIDATA

Annarita D'Amato

Matr. 754341

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CHAPTER I

1. INTRODUCTION

Today climate change is probably the most relevant issue because it represents a threat to us. It has a lot of consequences on the environment that surrounds us and on our well-being such as: the progressive increase in temperatures, the growing of the level of seas and oceans and the occurrence of extreme climatic events with greater frequency and intensity such as floods, heat waves or fires. These phenomena can cause damage to infrastructure, production plants, agricultural production, and the entire economic system in general, as well as having serious bad consequences for human health. In particular, the risk of damage occurring as a result of extreme events related to climate change is called physical risk. According to the IPCC (Intergovernmental Panel on Climate Change) of the United Nations, if the increase in global temperature were to exceed 2°C compared to pre-industrial levels, the physical risk would increase to such an extent as to cause an irreversible and catastrophic change, which would put entire populations at risk. According to the scientific community, the increase in average temperature must be contained and stabilized at around 1.5 °C by the end of this century. To achieve this goal, it is necessary to reduce drastically greenhouse gas emissions immediately so that to avoid any change to the climate because of human activities by 2050. In order to reach this aim, also important changes related to production processes from an economic point of view are needed and it is very demanding and expensive to modify them. In fact, it is necessary to transform profoundly our ways of producing and consuming. To do this, huge investments in technology and infrastructure are required, with the purpose to try to contribute to preserving future generations from the climate catastrophe.[1]

The international community is working hard to reach global binding agreements through annual conferences, called Conference of the Parties (COP). Thanks to them, the commitments of the richest countries, which are also those that have contributed most to the accumulation of greenhouse gases in the atmosphere over time, provide financial support to developing countries to bear the cost of the transition to carbon neutrality.[2] So, the transition process towards more sustainable development models is also accompanied by the rapid growth of sustainable finance, an ecosystem in which operators take into account environmental, social

[1]IPCC, 2023: Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115

[2] UNFCCC, 2006: United Nations Framework Convention on Climate Change: Handbook. Bonn, Germany: Climate Change Secretariat, (pag. 27)

and governance issues (known by the acronym ESG) in their investment decisions.[3] To date, numerous environmental protocols have been established with the aim of protecting life on the Earth and ensuring the survival of future generations of the different species that inhabit the planet. These protocols can be conceived as national and international agreements and each of them has a legal support. In fact, they are based on the application of different laws and regulations which guarantee the correct achievement of the goals they have set. Therefore, various international governmental organizations, such as the United Nations (UN) and the World Trade Organization (WTO), are in charge of managing and reviewing the legal and mandatory compliance with environmental protocols from all countries that have participated and committed to their goals. The Kyoto Protocol is perhaps the best known and represents an international agreement drafted by the UNFCCC or the United Nations Framework Convention on Climate Change. Specifically, 187 countries from around the world have pledged to reduce emissions of 6 of the main GHGs or greenhouse gases that cause the great acceleration of global warming. The Kyoto Protocol, so called from the city of Kyoto, in Japan, where it was drafted, dates back to 1990, although it did not come into effect until 2005. However, as regards the fight against climate change, it is important to mention also the Paris Agreement, signed in 2015, which represents a binding universal pact related to this matter.[4] The most important body interested in containing climate change is the Organization for Economic Co-operation and Development (OECD). Therefore, the OECD presents itself as the point of reference for governments that cooperate at an international level in order to promote strategies and practices aimed at implementing policies that give shape to continuous social, economic and above all sustainable growth that is one of the primary goals of developed countries. In particular, an important contribution is due to what was defined as sustainable development, that is to be intended as an action program for people, the planet and prosperity, in the 2030 Agenda. Signed in September 2015 by the governments of the 193 countries members of the UN, it incorporates 17 Sustainable Development Goals into a major action program for a total of 169 'targets'. The official launch of the Sustainable Development Goals coincided with the beginning of 2016 and countries committed to achieving them by 2030. The Development Goals represent common development ones on a set of issues important to general growing such as the fight against poverty, the eradication of hunger and the fight against climate change. They are 'Common goals' in the sense that they concern all countries and all individuals: no one is excluded, and

[3]N. Voulvoulis, T. Giakoumis, C. Hunt, V. Kioupi, N. Petrou, I. Souliotis, C. Vaghela, WIH. binti Wan Rosely (July 2022), "Systems thinking as a paradigm shift for sustainability transformation", Global Environmental Change, Volume 75, 102544 (pag.1)

[4]CRS Report, (January 2020), "The United Nations Framework Convention on Climate Change, the Kyoto Protocol, and the Paris Agreement: A Summary", R46204 (pag. 1-5)

they have to proceed all together along the path to be followed to take the world towards sustainability.[5]

However, if, on one hand, many countries, especially the industrialized ones, are trying to proceed towards the ecological transition, others continue to show constant resistance in implementing adequate environmental policies. The underlying reason for this opposition is mainly of an economic nature: in general, environmental restrictions tend to negatively influence the productivity of companies, with indirect and unfavorable effects on their competitiveness and the one of different sectors and countries.

In this regard, the objective of this thesis is to investigate the relationship between environmental regulation (RA), environmental European networks and international competitiveness, on the basis of a ten-year debate and without a universally shared conclusion in the literature, which sees two opposing points of view. In fact, on one side, traditionalist scholars affirm that environmental regulation determines an increase in costs and a consequent worsening of competitiveness. The Pollution Haven Hypothesis fits in this vein asserting that as restrictions increase within a country, companies will tend to move their production to areas with lax environmental policies, determining the birth of pollution havens. On the other side, the supporters of the revisionist current, including the economist Michael Porter, believe that well-designed environmental policies can lead to positive performances in both environmental and economic area, thanks to innovative processes induced by the same policies. The first part of this thesis will be dedicated primarily to the study of the two theories examined: the Pollution Haven Hypothesis and Porter's hypotheses, from the point of view of economic literature. The second part of the paper sets out the objective and the research questions first. Then it outlines the methodology used to focus on an empirical analysis, aimed at testing Porter's strong hypothesis, conducted on a sample of 15 countries belonging to the OECD, in a time horizon between 2003 and 2016. The Fixed Effects Panel Model was selected as the econometric model, performed using the GRETL econometric software. This analysis, whose data were collected from the database on the OECD official website and then adequately adjusted to make a comparison among possible countries, is preceded by a series of descriptive statistics related to the main variables used in the model: exports of green products, the EPS index, the participation of the selected countries to European green Networks, green patents, investments, population and unit labor costs. Finally, in the last part of the thesis, the conclusions and the main results of the conducted analysis will be presented, showing the presence of complementarity between environmental regulation and networks as drivers of international competitiveness.

[5]OECD (2016) "An OECD Action Plan on the Sustainable Development Goals", OECD Council[C(2016)166/REV2] (pag.3-5)

CHAPTER II

2. LITERATURE REVIEW

This paragraph will discuss the connections between environmental regulation and international competitiveness, environmental networks and international competitiveness and complementary studies related to them. The theoretical impact of environmental regulation on firm competitiveness is unclear. The main theories on which this relationship is based will be examined and the so-called Porter hypotheses take a different stance: the claim is that tougher environmental regulation can provide an incentive for firms to develop new and less expensive ways of reducing pollution or even completely revolutionizing their method of production so that pollutant elimination can be achieved while reducing costs (Dechezlepretre e Sato, 2017, *"The impacts of Environmental Regulations on Competitiveness",* The University of Chicago Press, pag. 183). This claim implies that the policies promoted to achieve a greener, cleaner, carbon-neutral world can potentially increase profitability. So, a focus will be placed on Porter's strong hypothesis, which appears to be the most questioned one by the various studies considered among the weak and narrow hypotheses. As regards environmental networks, they will be taken into account in the second paragraph in order to explain how they relate to performance, and thus to international companies' competitiveness. Finally, considering the most recent theoretical and empirical studies, the final paragraph of the chapter will discuss about various studies to clarify the link between environmental regulation, environmental networks and competitiveness. This review of the literature will help to frame the thesis' research questions and the contribution we hope to make to the advancement of knowledge on the subject.

2.1 The relationships between environmental regulation and the international competitiveness: the Pollution Haven hypothesis and the Porter Hypothesis

Nowadays the need to combine economic growth and environmental requirements is strongly felt. In order to promote a sustainable growth taking into account the urgency to face the climate change, several suggestions have been made but regulatory instruments have been considered by different countries in terms of additional costs and consequently having adverse effects on competitiveness. In addition to this, in periods of crisis such as the one caused by the outbreak of the war in Ukraine, the fear of the lack of gas and electricity and their consequently rising price have led to put apart the environmental issues, even restoring the use of carbon fossil fuels. So, the gap between environmental needs and economic competitiveness could appear increased confirming the traditional vision of the existence of a certain controversial relationship between them which is at the basis of the Pollution Haven hypothesis. However, a different vision of the problem can emerge from the theory of Porter and van der Linde (1995a) supporting a dynamic view of the impact of environmental policies on innovation and structural

change. According to them, environmental regulation may promote new products and processes (Porter's weak hypothesis). In particular, environmental policies based on market instruments (Porter's narrow hypothesis) may also positively influence firms and countries competitiveness (Porter's strong hypothesis). So, two are the main theories related to regulation and competitiveness in economic literature: the Pollution Haven Hypothesis and the Porter Hypothesis (Dou and Han, 2019). According to the "traditionalist" vision of the neoclassical environmental economy, the purpose of environmental regulation (ER) is to correct market failure through the elimination of a negative external aspect internalizing its costs in firms. On the other hand, according to the "revisionist" view, the improvement of the environmental performance is a possible source of competitive advantage. In fact, more efficient processes become possible. As a consequence, productivity improves, and new market opportunities come true. This is the theory proposed by Michael Porter and Claas van de Linde in their 1995 paper *"Toward a New Conception of Environment-Competitiveness Relationship"* where the so-called "Porter Hypotheses" (PH) (Porter and van der Linde, 1995a) is outlined. They also underline that traditional theories consider static the relationship between environment and competitiveness because the elements of the economic field such as technology, products and processes are seen as fixed. That is why regulation is seen in terms of cost increases, and consequently like a loss of competitiveness. On the contrary, the two authors say that: *"the new paradigm of international competitiveness is a dynamic model based on innovation"* (Porter & van der Linde, 1995a, pag.97). So, according to them, solutions based on innovation are able to promote both environmentalism and competitiveness (Porter & van der Linde, 1995a; Borghesi, S., Costantini, V., Crespi, F. et al., 2013). Jaffe and Palmer (1997) suggested to subdivide PH into three versions: "weak", "strong" and "narrow". According to the weak hypothesis (PHW), environmental regulation will have a positive effect on competitiveness so that to minimize the costs of environmental input/output subject to regulation. In addition to this, the strong version (PHS) supports the idea that the greater innovation and improvement of production processes will not affect costs because the ones due to environmental regulation will be offset by the increasing productivity, making use of different competitiveness indicators such as labor productivity, total factor productivity, competitiveness on international markets and so on, as well as the units of analysis (companies, sectors, countries).

Not all the studies confirm PH such as Rubashkina, Galeotti, & Verdolini, 2015, and only some of them report positive results such as Costantini & Mazzanti, 2011,Martìnez-Zarzoso, Bengochea-Morancho, & Morales-Lage, 2019 and De Santis, Esposito, &JonaLasinio, 2021. In particular, Costantini & Mazzanti (2011) take in exam how the competitiveness of EU exports has been influenced by environmental regulation and innovation, analyzing Porter's version of the relationship between ER and international trade. The two authors divide the

strong version of the PH into strong and strictly strong. The result of their analysis and strictly strong version is that environmental innovation efforts promote green exports (Costantini & Mazzanti, 2011). Finally, we can affirm that the theoretical effect of environmental regulation on firm competitiveness is unclear. Economists generally agreed that oppressive government regulation, related to environmental one, was a major contributor to the poor economic performance. Porter's hypothesis, on the other hand, takes a different position: the claim is that tougher environmental regulation can provide an incentive for firms to develop new and less expensive ways of reducing pollution, or even completely revolutionizing their method of production, so that pollutant elimination can be achieved while reducing costs. This claim implies that policies aimed at achieving a greener, cleaner, carbon-neutral world can potentially increase profitability.

2.2 About Porter's hypothesis

The Porter hypothesis (PH) asserts that polluting firms can benefit from environmental policies, arguing that well-designed and stringent environmental regulation can stimulate innovations, which in turn increase the productivity of firms or the product value for end users (Porter 1991). The strong version of the Porter hypothesis affirms that environmental regulation can lead to an increase in firm competitiveness, thus offsetting additional regulatory cost. In particular, according to Porter (1991), *"Strict environmental regulations do not inevitably hinder competitive advantage against rivals; indeed, they often enhance it."*[6] He went on to suggest various mechanisms by which environmental regulations might enhance competitiveness, such as reduction in the use of costly chemicals or lower waste disposal costs. The traditional view of environmental regulation held virtually by all economists until that time was that requiring firms to reduce an externality like pollution necessarily restricted their options and thus by definition reduced their profits. After all, if profitable opportunities existed to reduce pollution, profit-maximizing firms would already be taking advantage of those opportunities. Over the times, much has been written about what has since become known simply as the Porter Hypothesis (PH) and conflicting evidence can be found between alternative theories that might explain the PH, and oftentimes a misunderstanding of what the PH does and does not say. The traditional view among economists and managers concerning environmental protection is that environmental regulations (ER) is unproductive from a business perspective because of taxes and tradable permits charge firms for their emissions pollution. This traditional vision was challenged by a number of analysts, notably Professor Michael Porter (Porter 1991) and his coauthor van der Linde (Porter and van der Linde 1995). Based on case studies, the

[6]Stefan Ambec, Mark A. Cohen, Stewart Elgie, and Paul Lanoie (January 2011), "The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness?", *Resources for the Future Discussion*, Paper No. 11-01 (pag.1)

authors consider pollution a waste of resources and on the contrary a reduction in pollution is seen as an input to an improvement in the productivity with which resources are used. Appropriate designed environmental regulations, in particular market-based instrument such as taxes or cap-and-trade emissions allowances, can *"trigger innovation that may partially or more than fully offset the costs of complying with them"* in some instances (Porter and van der Linde 1995, 98).

The Porter Hypothesis has been considered successfully in political debate, especially in the United States, in order to persuade the business community to accept environmental regulations but there is much confusion in the literature about what the Porter Hypothesis actually states. A subdivision of the PH into its component parts has been supported and can help to make it clearer. So, according to the theory first properly designed, environmental regulation may encourage innovation. This has often been called the "weak" version of the PH (see Jaffe and Palmer 1997), because it does not suggest any opinion about innovation in the sense that it cannot be defined good or bad for firms. The second part of the PH is that environmental regulation often increases firm competitiveness. This is often called the "strong" version of the PH. Finally, in the part known as the "narrow" version of the PH, it is noted that flexible regulatory policies incentivize innovation and for this reason they are better than prescriptive forms of regulation.

So, the three versions of Porter's Hypotheses can be summarized as follows:

"*Weak"* version of PH	"Environmental Regulation may encourage innovation"
"Strong" version of PH	"Environmental Regulation often increases firm competitiveness"
"Narrow" version of PH	"Flexible Regulatory Policies incentivize innovation and consequently they are better prescriptive forms of regulation"

Source: personally made, realized on the basis of the information contained in the article "The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? Stefan Ambec, Mark A. Cohen, Stewart Elgie and Paul Lanoie (2001).

An abundant economics literature on the theoretical bases underlying the Porter Hypothesis has been developed over the time. Two approaches emerge. The first one is based on the assumption

of profit-maximizing firms in the light of the emerging organizational and behavioral economics literature. The rationality of the firm is driven by its manager, who has motivations and objectives other than profit maximization. He or she might be risk-averse (Kennedy 1994), resistant to any costly change (Aghion et al. 1997; Ambec and Barla 2007), or rationally bounded (Gabel and Sinclair-Desgagné 1998). The second one reconciles the PH vision with profit maximization by assuming a "market failure". Simpson and Bradford (1996) show that a government may provide a strategic advantage to its domestic industry by imposing a more stringent environmental regulation.

Many researchers have also analyzed the Porter Hypothesis empirically. Three approaches emerge from this empirical literature. The first intends to test the "weak" version of the PH. However, as Porter and van der Linde (1995, 98) make clear, innovation is not just technological change and can take various forms, including *"a products or service's design, the segments it serves, how it is produced, how it is marketed and how it is supported."* (Stefan Ambec, Mark A. Cohen, Stewart Elgie, and Paul Lanoie, January 2011, pag.7-9). The second empirical approach assesses the impact of environmental regulation on the business performance of the firm. The firm's business performance is often measured by its productivity. Lanoie et al. (2010) combine both approaches, assessing for the first time the whole Porter causality chain. The data come from a unique OECD survey carried out with more than 4,000 companies located in seven industrialized countries. A third approach to evaluating the PH is to examine competition among nations which returns to the original hypothesis of Porter that environmental regulation will enhance a country's competitiveness.

It is clear from both the original Porter writings and empirical evidence to date that both innovation and competitiveness outcomes depend significantly on the context. The PH itself was premised on flexible, market-based regulation and not rigid command-and-control regulation. As mentioned by Porter, the type of regulatory instrument is an important premise of the PH. As Porter and van der Linde (1995, 110) argue:

"If environmental standards are to foster the innovation offsets that arise from new technologies and approaches to production, they should adhere to three principles: first, they must create the maximum opportunity for innovation, leaving the approach to innovation to industry and not the standard-setting agency; second, regulations should foster continuous improvement, rather than locking in any particular technology; third, the regulatory process should leave as little room as possible for uncertainty at every stage. "(Stefan Ambec, Mark A. Cohen, Stewart Elgie, and Paul Lanoie, January 2011, pag.10).

On one side, market-based and flexible instruments such as emissions taxes or tradable allowances, or performance standards, help innovation more than technological standards,

because they leave more freedom to firms on the technological solution to minimize compliance costs.

On the other side, industrial and patent policies might complement environmental regulation to protect the environment at lowest cost to firms. Environmental regulations might help firms overcome their organizational inertia by forcing them to review the organization of production and their business model.

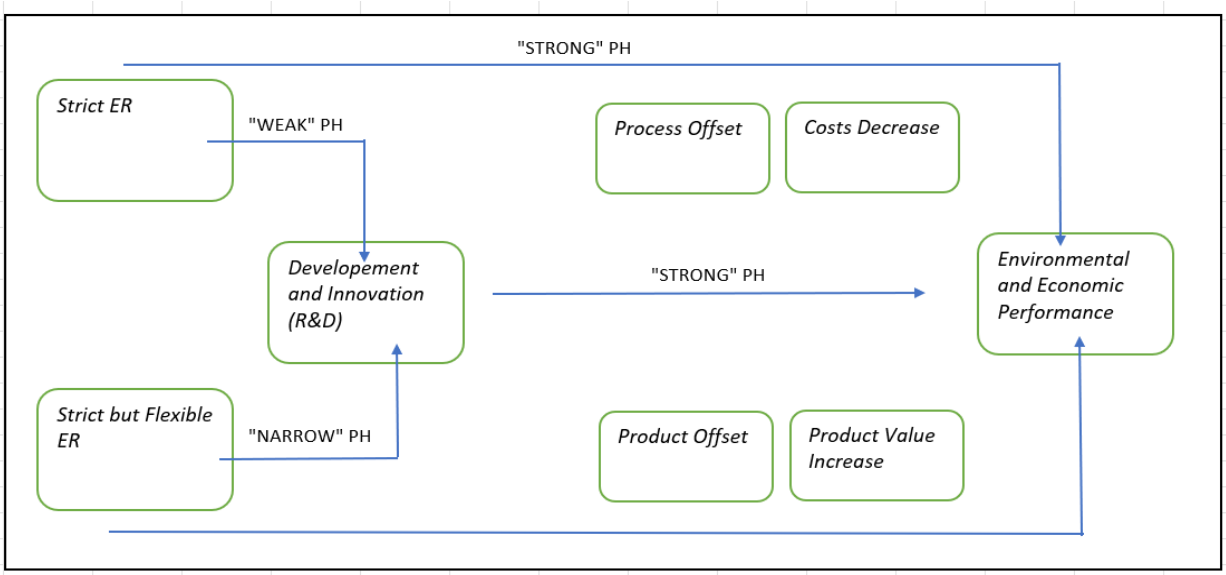
The PH continues to stimulate academic research and policy debates. First, on the theoretical side, it turns out that the theoretical arguments that could justify the PH are now more solid than they appeared at first in the heated debate that took place in 1995, in the Journal of Economic Perspectives (Palmer et al. 1995). On the empirical side, on one hand, the evidence about the "weak" version of the hypothesis (stricter regulation leads to more innovation) is also fairly well established. On the other hand, the empirical evidence on the strong version (stricter regulation enhances business performance) is mixed, with more recent studies providing more supportive results. Porter and van der Linde (1995) identify five reasons in particular that can explain the positive effects of environmental regulation on innovation and competitiveness. According to them they are the following:

1. Environmental Regulation may alert companies to possible inefficiencies of resources and potential technological improvements;
2. ER can increase corporate awareness because of the focus on gathering information;
3. ER reduces uncertainties, especially about the usefulness, importance and cost of investments to face environmental issues;
4. ER creates pressure that motivates innovation and progress;
5. ER smooths out transition conditions.

Actually, during the transition period aiming at solutions based on innovation, regulation has the ability to ensure that a firm does not gain positions opportunistically by avoiding environmental investments. However, the two authors also add that innovation cannot always offset the cost of compliance completely, especially in the short term, before the learning can reduce the cost of innovation-based solutions (Porter & van der Linde, 1995).

At this point it is clear that the fundamental rationale of the Porter Hypotheses is to identify and describe a causal relationship between environmental policy (strict, yet flexible at the same time), green innovation and corporate performance. The available empirical evidence has focused on the analysis of three fundamental variables: innovation (associated with corporate Research & Development), performance business and environmental performance, all dependent on environmental (policy) regulation.

The following scheme shows the causal relationships of PH as proposed by the contribution of Jaffe and Palmer (1997).



Source: personally made, realized on the basis of the information contained in the article Jaffe, A., Palmer, K., 1997. Environmental regulation and innovation: a panel data study. Review of Economics and Statistics 79 (4), 610–619.

In conclusion, by suggesting that better protection of the environment could lead to *"win–win"* solutions for the whole of society, Porter has certainly contributed to open the minds of many people, leading to significant environmental and economic improvements. Nowadays, sustainable development is also a priority for European Member States, which are progressively adopting stricter market and non-market regulations for environmental policy.

2.3 The strategic role of Environmental Networks

Environmental regulation can affect innovation (weak Porter's hypothesis) and competitiveness (strong Porter's hypothesis), but green innovation and environmental targets involve more competences to reach appreciable results where networks can have a fundamental role, more important than the one related to other kinds of target.

Talking about networks in general, it is possible to distinguish some relevant features. First of all, networking involves the importance of collaboration between the various component entities (companies, research institutions and university) in order to improve any kind of process generally involved in industries or firms. A study by Junghyun Yoon, Sanghyun Sung and Dongwoo Ryu,2019, titled "The Role of Networks in Improving International Performance and Competitiveness: A Perspective View of Open Innovation" analyzes data from 356 small and medium-sized exporters (SMEs) in the manufacturing or technology industries in South Korea using structural equation modeling. It is assumed that international network embeddedness acts as a moderator in the relationship between internationalization and related variables. SMEs use

networks to overcome inherent constraints such as a lack of resources. As a result, SMEs want to build and expand their international networks in order to carry out successful internationalization or accelerate international marketing activities. This study addresses why SMEs want to create international networks and conceptualizes the role of international network embeddedness in terms of information management, cultural difference, and proximity in improving SMEs' international performance and competitiveness in order to contribute to researchers who want to study internationalization.

Import-export firms use networks as representative tools to achieve internationalization in uncertain business environments, allowing cooperation in a variety of routes and types to achieve strategic goals. According to Lee (2020), prior research on the internationalization of import-export firms focused on network formation to sustain existing relationships or to create new relationships due to the benefits of addressing inefficiency problems caused by diseconomies of scale and uncertainty. Through these dense networks and strong ties, organizations can gain more sustainable competitive advantages than competitors (Yoon, Sung, Ryu, 2020, pag.2). As a result, this study considers the ability to collect and manage useful information about successful internationalization to be the second most important factor in embedding international networks, because firms must use information systems in the modern information era to establish an international network. According to Moon (2020), one of the major determinants of international partnerships or networks is information sharing, which assists firms in achieving common goals. Li and Atuahene-Gima (2020) proposed efficient information sharing as a possible cooperative strategy for entering international markets based on online networks. Networks assist exporters in acquiring more useful information about targeted international markets in order to reduce export risks (Yoon, Sung, Ryu, 2020, pag.3).

Musteen (2010) discovered that an international network is important in accelerating internationalization and improving international performance in a study of 155 Czech SMEs. Sepulveda and Gabrielsson (2020) investigated exporters' network development as an internal growth resource in the business-to-business context and discovered a meaningful correlation between resource accumulation and network development, as well as that network development leads to more opportunities to improve internationalization performance.

Finally, cultural differences are another important factor influencing international network formation in a global market. Thomas and Mueller (2000) argued that, with the exception of some business-related issues, widely disparate cultural backgrounds cause numerous difficulties. If exporters are enabled to understand and overcome cultural differences, they will never form positive international partnerships or networks as the differences may negatively impact communication, creating bottlenecks in a cooperative network. As a consequence,

mutual understanding between cultures can have a significant impact on international network formation and embeddedness.

As regards the environmental field, networks can become a place of innovation where the creation of knowledge is essential to improve the competitive position (Powell and Grodal, 2006). The literature on networks' role in environmental innovation is newer and less developed than that one on regulation. It is based on the idea that environmental innovations require more diverse sources of knowledge than other types of innovations (Horbach et al., 2013). That is why the participation of companies in research networks is to be considered a strategic element for the development of new innovative technologies where the concept of innovation represents the means by which environmental regulation can have positive effects on competitiveness. At the same time, as argued by Kemp (2001), environmental innovation is the modified set of processes, techniques or systems which eliminate or reduce environmental damage. A similar perspective can be also found in Kemp and Pearson, 2007(pag.7) where environmental innovations are specifically defined as the production, assimilation or exploitation of a product, production process, service or methods of management or business that is new to the organization and which results throughout its life cycle in a reduction of environmental risk, of pollution and other negative impacts of resource use (including energy use) compared to relevant alternatives. Also, the OECD has provided a definition of environmental innovation which is related to the same idea while focusing the difference from the innovation generically understood. So, it is conceived as an innovation that reflects the reduction of the environmental impact and not limited to product innovation, process, marketing techniques and organizational models, but also including innovation in social and institutional structures[7].

Thanks to cooperation due to Environmental Networks, the technological development of the processes and high-quality products, where EI is involved, are increased. So, environmentally innovative firms collaborate on innovation with external partners to a greater extent than other innovative firms, according to empirical analyses (De Marchi, 2012; De Marchi and Grandinetti, 2013; Cainelli et al., 2015), and the breadth of the firm's knowledge sourcing has a positive effect on environmental innovation. That is why environmental networks are thought to lead to the realization of the so called "win-win" Porter's strategy, involving the relationship between firms and research centers through which the interaction between different kinds of knowledge, such as the theoretical one related to universities and research centers, and the other practical one related to firms, can be reached. As a consequence, the environmental innovation

[7]OECD, "Sustainable Manufacturing and eco innovation: framework, practices and measurement – Synthesis Report" 2009, (p. 13)

blesses corporates: it reduces the environmental impact of production while also increasing business performance.

Nowadays the establishment of cross-country (Balland et al. 2019) and cross-regional (Di Cagno et al. 2021) research networks is a key goal of the EU Framework Programs for Research and Innovation. Environmentally related (or green) research networks are built using EU open data from projects with green components. There are some thematic priorities that are used in particular: FP5-EESD (1998-2002), FP6-SUSTDEV (2002-2006), FP7-ENERGY, FP7-ENVIRONMENT, FP7-TRANSPORT (1998-2002), (2007 – 2014). The selection of these programs is based on two criteria, as stated by Fabrizi et al. (2018):

1) they are strongly related to the environmental goal;

2) they emphasize the importance of technological development in achieving environmental goals (see also Fabrizi et al 2018).

As they rely on market strategies that are linked to product innovation, environment-related networks (or eco-networks) can be viewed as a type of open eco-innovation. In fact, green infrastructure should be viewed as a component of the Environmental Network, which can also be viewed as a tool for the visualization and study of environmental problems in the pursuit of sustainable alternatives, providing businesses with the opportunity to improve their social, ecological, and financial footprint in a world striving for a lower carbon footprint.

2.4 The complementarity between Environmental Regulation and Research Networks

The development of environmental regulations has attracted the interest of the government, shareholders, and the general public to limit the damage caused by production and business activities to the environment. This term refers to the relevant policies and measures of the government to reduce pollution and promote green producing by restricting the production and operation activities of firms. In the face of a conflict between production growth and environmental protection, environmental regulation has become the only means of achieving long-term development. The question about whether research networks and regulations are complementary policy tools arises. Effectively, because of the presence of multiple and self-enforcing market failures in the environmental domain (Jaffe et al., 2005; Johnstone et al., 2010a, 2010b; Lehmann, 2012), networks and regulations can be considered complementary policy tools for Environmental Innovations. This has policy implications because the existence of complementarities suggests that environmental policies should be conceived as industrial and innovative ones as well as regulation policies to be more effective. Complementarity can emerge from a variety of sources: to begin, environmental innovations generate the so-called "dual externality" (or "double externality"), which means that they reduce the negative externality of pollution while also generating knowledge spillovers involving both green and standard innovation processes (Jaffe et al., 2003; Rennings, 2000). Second, EIs can involve

cumulative learning mechanisms in which they can be the source or the result of standard innovations (Horbach, 2008; Guarini, 2015). Third, the interaction of standard and green technologies can generate scope economies (Johnstone et al., 2008). As a result, the distinction between standard and environmental innovation processes can be blurred.

In addition to this, there are three main results supporting the importance of joint initiatives and complementarities for reconciling environmental goals with the performance of firms and their international competitiveness: first, research networks positively impact on green exports; second, they are complementary to green innovation, pointing to the importance of green absorptive capacity to benefit better from cooperation; third, all institutional sectors involved in the networks (firms, universities and public research centers) play a positive role for green competitiveness and their joint impact is significantly larger than the single one (Andrea Fabrizi, Giulio Guarini, Valentina Meliciani, 2023).

In conclusion, by utilizing Environmental Regulation and Research Network relationships, a new venture can obtain access to vital resources, capabilities and information missing in the firm, resulting in entrepreneurial opportunities. If a new venture is entrepreneurially oriented, then it would be more innovative, proactive, and risk-taking, which in turn would improve its performance (Sari Roinen, 2008).

Until now, only few studies have concentrated on the relationship between Environmental Regulation and Research Networks. The purpose of this thesis is also to contribute to this kind of embryonic literature, where the framework programs of the European Union are meant as network, in order to take into account, the effect of Environmental Regulation and Research Networks on the innovation of different countries. Then the aim will be to focus the mechanism underlying the weak Porter's hypothesis to also investigate the importance of networks for testing Porter's strong hypothesis.

2.5 The variables employed to do the analysis of the complementarity among Environmental Regulation, Research Networks and the competitiveness: an introduction

In order to examine complementarity between Environmental Regulation and Research Networks related to the competitiveness, some major variables can be taken into account such as: Green Products Exports, the countries participation to EU Green Projects and Stringency.

Markets for green products are growing significantly faster than conventional products, and present important opportunities for developing and least developed countries. UNCTAD's National Green Export Reviews help countries identify green export opportunities and develop and implement a targeted action plan. For example tools that can help countries harness green exports were described at a learning session organized by UNCTAD in partnership with Fairtrade America and the ABS Capacity Development Initiative at the United Nations High-

Level Political Forum (HLPF) on the Sustainable Development Goals in New York on 13 July 2018.[8] Certification and labelling schemes known as voluntary sustainability standards (VSS) can be mentioned among them. They represent a market tool that can harness green trade for development.[9]

On the other side, proponents of 'green growth' have argued that domestic promotion of 'green' energy will generate improved comparative advantage in export markets for high-technology goods such as wind turbines or solar cells. Furthermore, domestic renewable energy promotion is more likely to translate into improved international competitiveness if a country already possesses skills, technologies, and industrial sectors closely related to the sector in question. So, net of historical competitiveness and domestic market size, green industrial policy functions best when capitalizing on pre-existing industrial capacities, rather than trying to create them.[10]

However, when we talk about green import and export, a key element towards a green growth strategy is represented by eco-innovation whose studies have grown and consolidated over the last 15 years. These studies have contributed to the integration of economics, management, and environmental sciences. In recent years, the role of eco-innovations (EI) has been incorporated into policy formulations that attempt to reconcile economic and environmental performance. The actual European circular economy action plan focuses on new business models based on product and process EI that should create new markets, new sectors, new products, new social willingness to pay for greener and more recyclable goods. In fact, to improve environmental and economic performance, radical innovations, new business models, and new consumer behaviors, including new jobs and better resource use, are required. Larson and colleagues (Crespi, Mazzanti e Managi, 2016, pag.139) look at the evolution of green technologies, with special attention devoted to the role played by large multinational firms. They show that the Kyoto Protocol has deeply transformed the framework into which firms operate, inducing a massive trend in favor of the diffusion of green energy technologies (Crespi, Mazzanti e Managi, 2016, pag.139).

Ding et al. (Crespi, Mazzanti e Managi, 2016, pag.139) studied if a relationship between green technological change (measured as stock of green patents) and both CO2 emissions and emission efficiency exists. To investigate this relation, they employed a rich panel covering 95 Italian provinces from 1990 to 2010. The main results suggest that green technology has not

[8]UNCTAD, (2018), "Green exports can meet both economic and environmental needs", UNCTAD's National Green Export Reviews

[9]Denny Thame, (September 2017), "VOLUNTARY SUSTAINABILITY STANDARDS, Leopoldianum (pp.35-45)

[10]Mark Huberty & Georg Zachmann, 2011. "Green exports and the global product space- Prospects for EU industrial policy," Working Papers 556, Bruegel

yet played a significant role in promoting environmental protection, although it improved significantly environmental productivity.

The analysis provided by Crespi (Crespi, Mazzanti e Managi, 2016, pag.140) offers a general assessment of the difficulties in implementing an effective policy design related to green exports due to policy complexity reasons. In particular, in his contribution Crespi argues that the green transformation of the economies can be conceptualized as the outcome of an emergent system property and highlights the difficulties related to the development of an integrated framework of policy instruments that accounts for their mutual interaction by acknowledging the inherent complexity of system dynamics. In this respect, the paper elaborates the concept of Green Transition System, suggesting the importance of activating learning and adaptive mechanisms involving private agents, stakeholders, policy makers and scholars interested and involved in the transition process.

According to the article “The impact of environmental research networks on green exports: an analysis of a sample of European countries” (2023) by Andrea Fabrizi, Giulio Guarini, Valentina Meliciani, environmental innovation, and research networks impact positively on green exports. They have a complementary effect highlighting the importance of green absorptive capacity. Moreover, all institutions related to the green competitiveness are involved in the networks such as firms, universities and public research centers. In particular, universities play the most important role among them.

On one side, potential conflicts of interests among countries characterized by different economic and social contexts may arise, due to different green policies and objectives; on the other side, there are important potential externalities, economies of scale and economies of scope, that can be generated through an efficient green technological cooperation. They are necessary to overcome the large initial costs associated to the ecological transition. To face this problem, the European Commission has been promoting the countries participation to EU Green Projects and sustaining initiatives of cooperation in the research and innovation areas, the multiannual and multi-thematic so called Framework Programs (FP), involving all institutional research sectors. Their aim is to generate new knowledge and implement it in order to help the business practices and production processes to improve the performances and competitiveness of firms in the global market, through the creation of cross-country and cross region research networks constructed using EU open data.

Finally, going back to the third highlighted variable, Stringency can be defined as the "cost" imposed on polluting or other environmentally harmful activity for individual policy instruments as well as for overall environmental policy. Tobias Kruse, Antoine Dechezleprêtre, Rudy Saffar, and Leo Roberte’s paper "Measuring Environmental Policy Stringency in OECD Countries: A Composite Index Approach" examines the major challenges in developing

indicators of environmental policy stringency over three decades, from 1990 to 2020, across 40 countries and 13 policy instruments, with a focus on climate change and air pollution mitigation policies. The methodology used to construct measures of environmental policies and the performance of OECD countries over time is then described, with a focus on the evolution of market-based and non-market policies.[11]

The main challenges in measuring the stringency of environmental regulations are multidimensionality, sampling, identification (and enforcement), and a lack of data (Brunel and Levinson, 2013; Koluk and Zipperer, 2014):

- multi-dimensionality is determined by the intersection of the various planes of environmental regulations (environmental multi-dimensionality) with the multitude of possible policy instruments (policy design multi-dimensionality;
- multidimensionality is linked to sampling;
- the final issue is a lack of data. This factor is frequently cited as one of the reasons for preferring one type of stringency measure to one another.[12]

CHAPTER III

3. The effects of environmental regulation and environmental networks on Green Products Exports: an empirical analysis on a sample of European countries

Considering the variables described in the second chapter, the objective of the third one of the thesis is to conduct an empirical analysis on the effects, considered both individually and jointly, that environmental regulation and environmental networks could have on the competitiveness of firms, measured through the exports of green products. This is relevant since studies about the relationship involving environmental regulation, environmental networks and the competitiveness of firms have not yet been carried out considering the variable of green exports. Furthermore, the effects of market-based and non-market-based policies on competitiveness are differentiated in the analysis. Specifically, in this paragraph the objectives and research questions to which we want to give an answer will be set out; the methodology of the analysis will be illustrated; a review of the descriptive statistics in relation to the variables taken into consideration in the research and an econometric analysis will be outlined. In conclusion, the main results of this analysis and a discussion about them will be reported also referring to policy implications.

[11] Tobias Kruse, Antoine Dechezleprêtre, Rudy Saffar, Leo Robert (2022) "Measuring environmental policy stringency in OECD countries: An update of the OECD composite EPS indicator", © OECD, pp.57

[12] Enrico Botta, Tomasz Koźluk (2014) "Measuring Environmental Policy Stringency in OECD Countries: A Composite Index Approach", © OECD

3.1 Goals and Research Questions

The focus of the analysis will be to understand how exports of green products react to the complementarity between the different levels of international environmental regulation and the countries' participation to the green Networks, starting from some studies that have demonstrated the possible positive effects of environmental regulation on the competitiveness of firms, in particular through their ability to generate green innovation. Firstly, the contribution of the authors Andrea Fabrizi, Giulio Guarini, Valentina Meliciani through two of their papers (2018[13]and 2023[14]) will be taken into account. In the one dating back to 2018, the authors demonstrated and discussed how the "weak" version of the Porter Hypotheses found support in the sample analyzed during the development of the proposed analysis. In the article, the authors differentiated the effects of environmental policy on competitiveness by referring to the so-called market-based and non-market-based regulation typologies. Thinking of the three Porter Hypotheses, the "strong" one has always been, and still is today, the most discussed, which does not always manage to find great support, sometimes leaving room for the opposite scenario, namely the Pollution Heaven Hypothesis. Following the approach of the above-mentioned article, the analysis that is there suggested is also configured as a "panel" type analysis, in which both a spatial (15 "cross-country") and a temporal dimension are taken as reference (in fact, a time span ranging from 2003 to 2016 will be analyzed). Competitiveness, as anticipated, is measured through the Exports of Green products, which constitutes the dependent variable in the analysis conducted. An adequate description of it will be provided in the following paragraph. Instead, as regards the degree of rigor of environmental regulation in the various countries included in the reference sample, it was decided to use the OECD EPS index, making a distinction between the market EPS index and the non-market EPS index. Adequate specifications will also be provided for this index in the following paragraphs. Some more inherent control variables have also been inserted here in addition to the ones considered to carry out the analysis.

The research questions to which we will try to give an answer by conducting the analysis are:

[13]Fabrizi, A. – G. Guarini – V. Meliciani (2018), "Green patents, regulatory policies and research network policies", Research Policy, vol. 47(6)

[14]Andrea Fabrizi, Giulio Guarini, Valentina Meliciani (2023), "The impact of environmental research networks on green exports: an analysis of a sample of European countries", Research Policy, Elsevier

RQ1. Is there a relationship between environmental regulation, environmental networks, and green exports? Can the "strong" version of the Porter Hypotheses be considered valid in this case?

RQ 2. How do the Exports of Green Products respond to the different levels of environmental regulation that exist at an international level, considering the regulatory instruments adopted (market based and non-market based one)?

RQ 3. Can there be a complementarity between environmental regulation and environmental networks? What effect can this have on competitiveness (measured through green exports)?

The innovative aspect of the conducted analysis is because of there are still no literature studies about the mechanisms connecting Green Products Exports to the complementarity between environmental regulation and environmental networks. European environmental energy policies have contributed to the environment improvement. However, important climate environmental challenges are still unresolved. Innovations related to the environment are required to face them. They are characterized by a high degree of complexity and different types of knowledge coming from universities, research centers and firms are needed. The relationship between legislation and a better environmental matter knowledge can help to find solutions to solve urgent environmental problems.

Furthermore, the idea of analyzing the complementarity theme derives also from the idea to investigate and research whether the "strong" version of the Porter Hypotheses can be supported by the data provided by the selected sample. In fact, there are divergent and sometimes conflicting studies to support it, as already underlined in the second chapter of this paper. Therefore, the complementarity study is to be intended as the main contribution to the literature.

3.2 Methodology adopted for the empirical analysis

Taking as reference the contribution of Fabrizi, Guarini and Meliciani (2018), it is possible to identify four equations in order to answer the elaborated research questions. These ones connect the dependent variable of competitiveness and the Exports of Green products to the independent variables considered which are:

- the degree of stringency of environmental regulations;
- the participation in European Green Network.

Furthermore, the equations take also into account some control variables such as:

- the population;
- the Unit Labor Costs;

- Green Patents;
- Investments.

Therefore, the Exports of Green Products acquire the quality of proxy of the competitiveness of companies at an international level, a fundamental characteristic for testing the strong version of the Porter Hypotheses. Instead, the independent variables are the degree of rigor of environmental regulation (whose measurement we will use the so-called Environmental Policy Stringency Index for) and the degree of participation in European networks or projects by companies at an international level. Furthermore, it was decided also to consider the EPS index at a second level of aggregation, consequently distinguishing between the two macro-categories which identify the market-based EPS index, on one hand, and the non-market-based EPS index, on the other one.

In order to empirically analyze the direct impact of green product Exports on international environmental competitiveness, the four equations that have been worked out are:

1) $lnEnvEXPSH_{i,t} = ln\alpha_1 POP_{i,t} + ln\alpha_2 ULC_{i,t} + ln\alpha_3 EPAT\_POP_{i,t} + ln\alpha_4 INV_{i,t} + ln\alpha_5 EnvNET_{i,t} + ln\alpha_6 EPS_{i,t} + \eta_i + \mu_t + \nu_{i,t}$
2) $lnEnvEXPSH_{i,t} = ln\alpha_1 POP_{i,t} + ln\alpha_2 ULC_{i,t} + ln\alpha_3 EPAT\_POP_{i,t} + ln\alpha_4 INV_{i,t} + ln\alpha_5 EnvNET_{i,t} + ln\alpha_6 EPS_{i,t} + \alpha_7(lnEPS_{i,t} * ln\alpha_5 EnvNET_{i,t}) + \eta_i + \mu_t + \nu_{i,t}$
3) $lnEnvEXPSH_{i,t} = ln\alpha_1 POP_{i,t} + ln\alpha_2 ULC_{i,t} + ln\alpha_3 EPAT\_POP_{i,t} + ln\alpha_4 INV_{i,t} + ln\alpha_5 EnvNET_{i,t} + ln\alpha_6 EPSMB_{i,t} + ln\alpha_7 EPSNMB_{i,t} + \eta_i + \mu_t + \nu_{i,t}$
4) $lnEnvEXPSH_{i,t} = ln\alpha_1 POP_{i,t} + ln\alpha_2 ULC_{i,t} + ln\alpha_3 EPAT\_POP_{i,t} + ln\alpha_4 INV_{i,t} + ln\alpha_5 EnvNET_{i,t} + ln\alpha_6 EPSMB_{i,t} + \alpha_7(lnEPSMB_{i,t} * lnEnvNET_{i,t}) + ln\alpha_8 EPSNMB_{i,t} + \alpha_9(lnEPSNMB * lnEnvNET_{i,t}) + \eta_i + \mu_t + \nu_{i,t}$

The element i = 1, ….,15 stands for European countries and t = 2003…, 2016 refers to years. The countries and time interval of the analysis mostly depend on the availability of OECD data on environmental export goods.

The variable EnvEXPSH is environmental (or green) goods export market shares in current USD. The variable POP refers to the Populationof a given country, the variableULC represents the unit labor costs expressed as the ratio of total labor compensation per hour worked to output per hour worked, EPAT_POP is the green triadic patents intensity, INV are the countries investments in Green Exports andEnvNET stands for the standardized total number of members of green research networks promoted by the European Community. Then,the index "EPS" has been inserted. In the second equation it was considered in relation to the participation in

networks through the index (lnEPS*lnEnvNET). In equations 3 and 4, the indices "EPSMB" (EPS Market-Based) and “EPSNMB” (EPS Non-Market-Based) respectively represent the degree of rigor of market-based environmental policies and the degree of rigor of non-market based environmental policies based on market instruments. In the last equation, the indices (lnEPSMB*lnEnvNET) and (lnEPSNMB*lnEnvNET) represent the interact of the environmental policy with the degree of participation in the green research networks, in order to consider the joint effect of those two variables. Finally, the elements $\eta_i + \mu_t + \nu_{i,t}$ are respectivelythe country effects, the time effect and a stochastic error.

According to Steerlink (2005), the Environmental (or green) goods export variable is obtained by aggregating eleven categories of environmental goods: 1. Air pollution control; 2. Environmental monitoring, analysis and assessment equipment; 3. Management of solid and hazardous waste and recycling systems; 4. Noise and vibration abatement;5. Waste water management and potable water treatment; 6.Cleaner resource, efficient technologies and products; 7. Environmentally preferable products based on and use or disposal characteristics; 8. Clean up or remediation of soil and water; 9. Heat and energy management; 10. Natural resources protection and 11. Renewable energy plant.[15]

In order to find answers to the proposed research questions, and therefore in order to achieve the main objectives of this paper, a specific econometric analysis software, which is GRETL, will be used for the analysis. The analysis object of this thesis is proposed as a panel type analysis, in which both a spatial dimension (cross-country) and a temporal dimension will be taken into consideration.

3.3. Data and descriptive statistics

3.3.1 Green Products Exports

Green Product Exports represent the competitiveness variable in the conducted Linear Regression Model.

Considering the competitiveness of green products exporter countries, according to a study conducted by economists at the University of Oxford who used a new indicator they created, which attributes an associated complexity score to each product (Green Complexity Index), Italy ranks 2nd (after Germany) in the list of countries with the greatest potential to export green products overall in a competitive manner. By building a new comprehensive dataset of traded

[15]Andrea Fabrizi, Giulio Guarini, Valentina Meliciani (Working Paper 1/2023) “The impact of environmental research networks on green exports: an analysis of a sample of European countries”, pag.7

green products and drawing on economic complexity methods (PCI), they ranked the countries with the greatest potential to export green products competitively overall.[16]

"As the world moves towards a greener and cleaner competitive landscape, the ability to produce and export environmentally friendly products will become increasingly important," said Penny Mealy, Research Fellow at the Institute for New Economic Thinking of Oxford Martin School (INET Oxford).[17]

Data from the World Trade Organization (WTO), Organization for Economic Co-operation and Development (OECD), and Asia-Pacific Economic Cooperation (APEC) green product classifications, ranked countries' current green manufacturing capabilities. Drawing on economic complexity methods (PCI) they gave each of these products a score indicating how technologically sophisticated it is, for example, bicycle frames score lower than the optics used for concentrated solar power. Economists have shown that countries that export more complex products tend to experience faster growth.

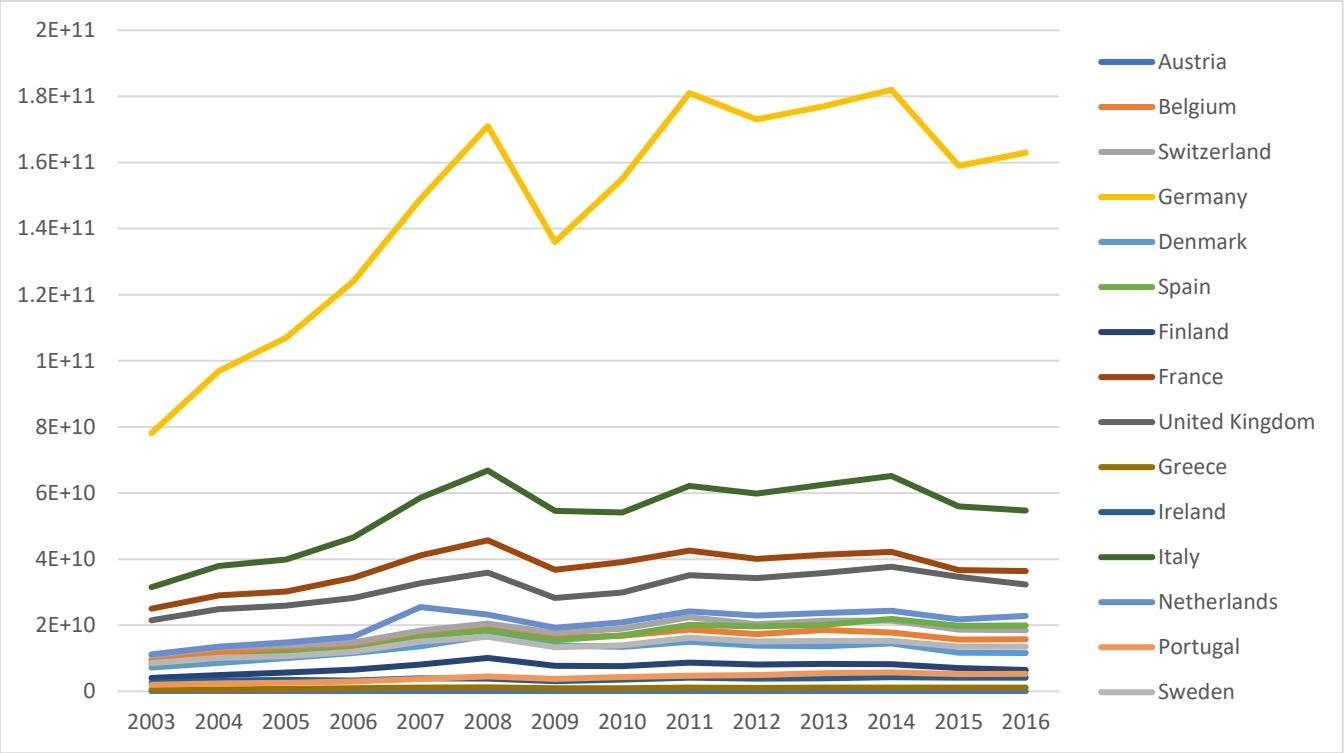
Based on this database, the researchers created a new indicator, the Green Complexity Index (GCI), which shows which countries are able to export the greenest and most complex products, finding that even countries with high GDP per capita, such as Germany, the United States and the United Kingdom, often tended to rank higher in terms of green production capacity. Germany, Italy, China and India stand out with much higher GCI scores relative to their per capita GDP, suggesting that their current manufacturing capacities are more geared towards the green economy than other countries with similar living standards (Mealy, Teytelboym, 2017, pp. 2-10).

Below there are the descriptive graphs useful for a better understanding of the trend that Green Product Exports have followed during the years considered in the analysis in the respective countries, in order to have greater clarity of the data included in the analysis carried out.

[16]Statista Research Department (2022), "Exports and Imports in Italy – Statistic and Facts"

[17]Penny Mealy, Alexander Teytelboym (2017), "Economic Complexity and the Green Economy, SSRN Electronic Journal, pag,2

Trend of Green Product Exports for each country under analysis



Source: personally made, realized on the basis of the OECD data

As it can be seen from the following graph, during the period from 2003 to 2016, the country that focused more than the others on green exports was Germany. In the early 2000s, Germany was a country characterized by low growth (on average one percentage point lower than the rest of the Eurozone) and by high unemployment rates (around 10%) as it still discounted the heavy costs of reunification. By contrast, in 2019, just before the pandemic, Germany constituted over 25% of the EU economy, GDP had average annual growth of 2% since 2010 (compared to 1.4% for the Eurozone), and the unemployment rate did not exceed 5%. German growth is linked to the consolidation of an economic model strongly devoted to exports. Behind the high added value of German exports there are also many European intermediate or semi-finished products and, especially in key sectors, there is a strong Italian component.[18] The results of a ranking about some indicators published on the OECD Green Growth database demonstrates that Italy ranks 2nd among countries capable of exporting greener and more complex products having a highly advanced green production capacity that it could exploit as the global demand for these products increases. The indicators taken into account are: the GCI which estimates the current green manufacturing capabilities of a country, the GCP providing

[18]Antonio Villafranca, Davide Tentori (2021) "Germania: regina dell'export anche dopo Merkel?", ISPI (Istituto per gli studi di Politica Internazionale)

an indication of which countries are best placed to expand their green manufacturing capabilities into new green products in the future, and the ECI which indicates countries demonstrating exports of technologically sophisticated products by per capita GDP and future growth rates.[19] The result of this ranking can be confirmed also in this graph.

3.3.2 Environmental Regulation Stringency

Different approaches have been taken to assess the stringency of environmental policies. Dasgupta et al. (1995) created an index of environmental regulations based on UN Conference on Environment and Development reports.[20]

Within its annual survey, the World Economic Forum (WEF) asks a number of questions about environmental regulations in an attempt to gauge business executives' perceptions. Esty and Porter (2005) used these data, along with information on the broader economic and legal context from the Environmental Sustainability Indicators (ESI) project, to develop a measure that summarizes a country's overall environmental regulatory system (Environmental Regulatory Regime Index - ERRI). Policy composite indicators are created by aggregating individual indicators into a single measure using an underlying analytical model.

However, EPS is the most well-known indicator. As regards it, policy stringency is defined as a higher, explicit or implicit, cost of polluting or environmentally harmful behavior. Enrico Botta and Tomasz Koluk's paper "Measuring Environmental Policy Stringency in OECD Countries: A Composite Index Approach" develops two composite indicators of environmental policy stringency. As a first step, an EPS indicator focusing on the energy sector is created. In a subsequent step, the first indicator is expanded to include three additional policy instruments from outside the energy sector in an attempt to proxy the economy-wide stance of environmental policy stringency. In practice, the indicator focuses on policies applied to electricity generation, though many of them are also applied to other sectors.

3.3.3 The EPS index

The EPS index (Environmental Policy Stringency Index) measures the degree of stringency of environmental regulations. It is an OECD index, used to compare the different levels of environmental regulations among boarding countries (Kozluk and Zipperer, 2014). For this reason, it is appropriate to the analysis object of this elaborate. In fact, it should be noted that the analysis was carried out as a "panel" analysis, in which variables in both spatial dimension (15 OECD countries) and size were examined over time (period 2003-2016). When

[19]Penny Mealy, Alexander Teytelboym (2022) “Economic complexity and the green economy”, Research Policy, Article 103948

[20]Susmita Dasgupta, David Wheeler, Ashoka Mody and Subhendu Roy (2013), “Environmental Regulation and Development: A Cross-Country Empirical Analysis, POLICY RESEARCH WORKING PAPERS, pag.6

the attempt to quantify the degree of stringency of environmental policy in a specific country is made, several issues arise, including multidimensionality, sample, identification, and data scarcity. Instead, the degree of stringency of a specific environmental policy is best understood when it is referred to the explicit or implicit price on polluting or harmful environment behavior (Botta and Kozluk, 2014). So, the previously presented definition of EPS is simple to understand when it refers to market instruments such as taxation or pollution limits. On the contrary, it becomes more difficult to interpret when it refers to subsidy instruments such as feed-in tariffs.

The Environmental Policy Stringency Index can range between 0 and 6. The value 0 represents virtually no environmental regulation, whereas the value 6 represents the highest level of rigor in environmental policies. The term "rigor" refers to 14 different environmental policy instruments, the majority of which are concerned with climate and air or water pollution. The instruments mentioned are valued and aggregated into composite EPS ratios. In fact, two EPS indices are proposed: one for the energy sector and one that is used as a proxy (economy-wide). However, the aggregation procedure for both EPS indices is identical, and follows a single multi-level procedure, as described below:

1) the first level of aggregation refers to the grouping of indicators by a single instrument (for example, a carbon taxation system) essentially;

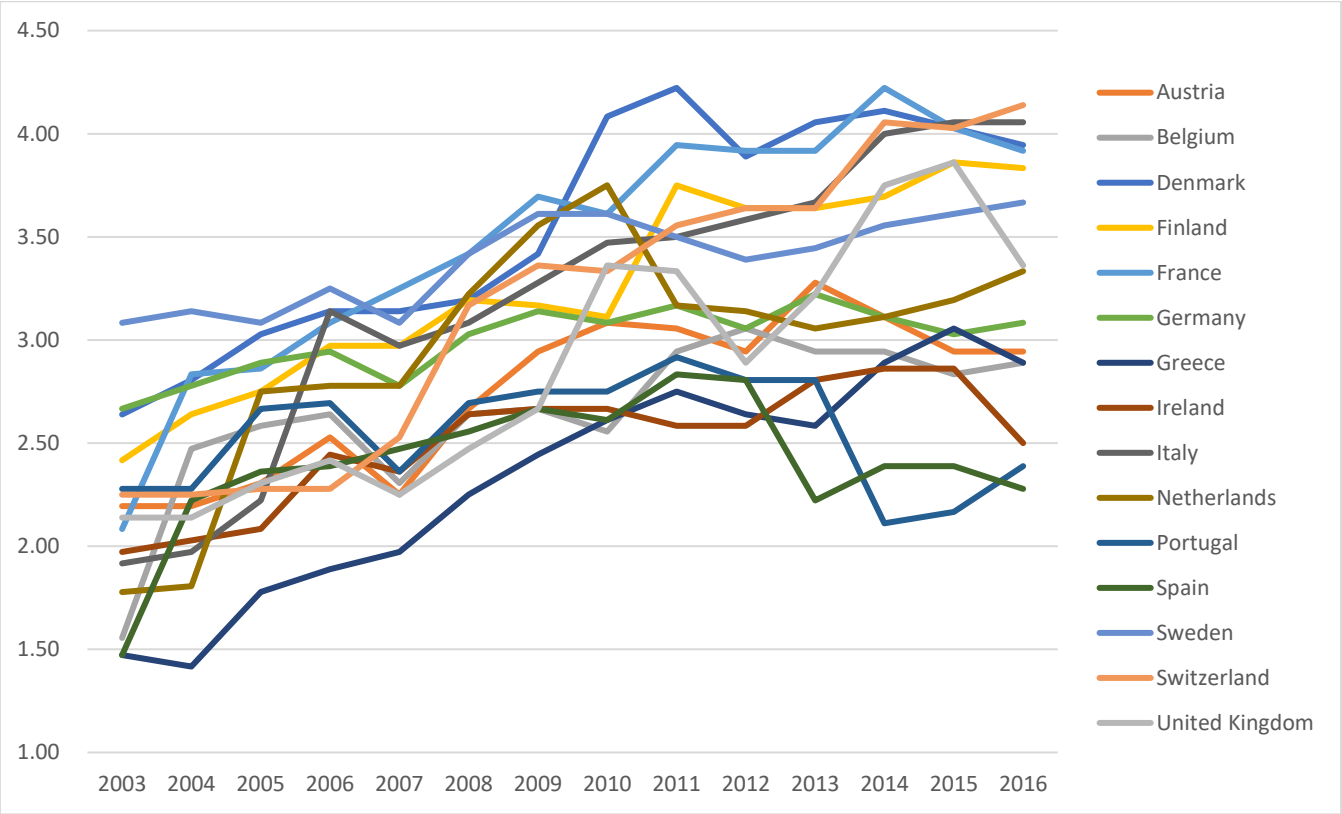
2)at an intermediate level of aggregation, there is a collection of mid-level indicators that are consistent with a specific type of instrument such as "environmental taxes";

3) finally, at a second level of aggregation, the indicators obtained are classified into the two larger categories previously discussed in detail: "market-based" and "non-market-based".

The obtained sub-components can also be used and aggregated in various ways, resulting in instruments that group policies for the sanctioning of polluting behaviors, on one hand, and, on the other hand, policies rewarding activities that respect the environment.

Below, some graphs show the trend of the EPS Index for each country under analysis for the different levels of aggregation.

Trend of the EPS Index for each country under analysis

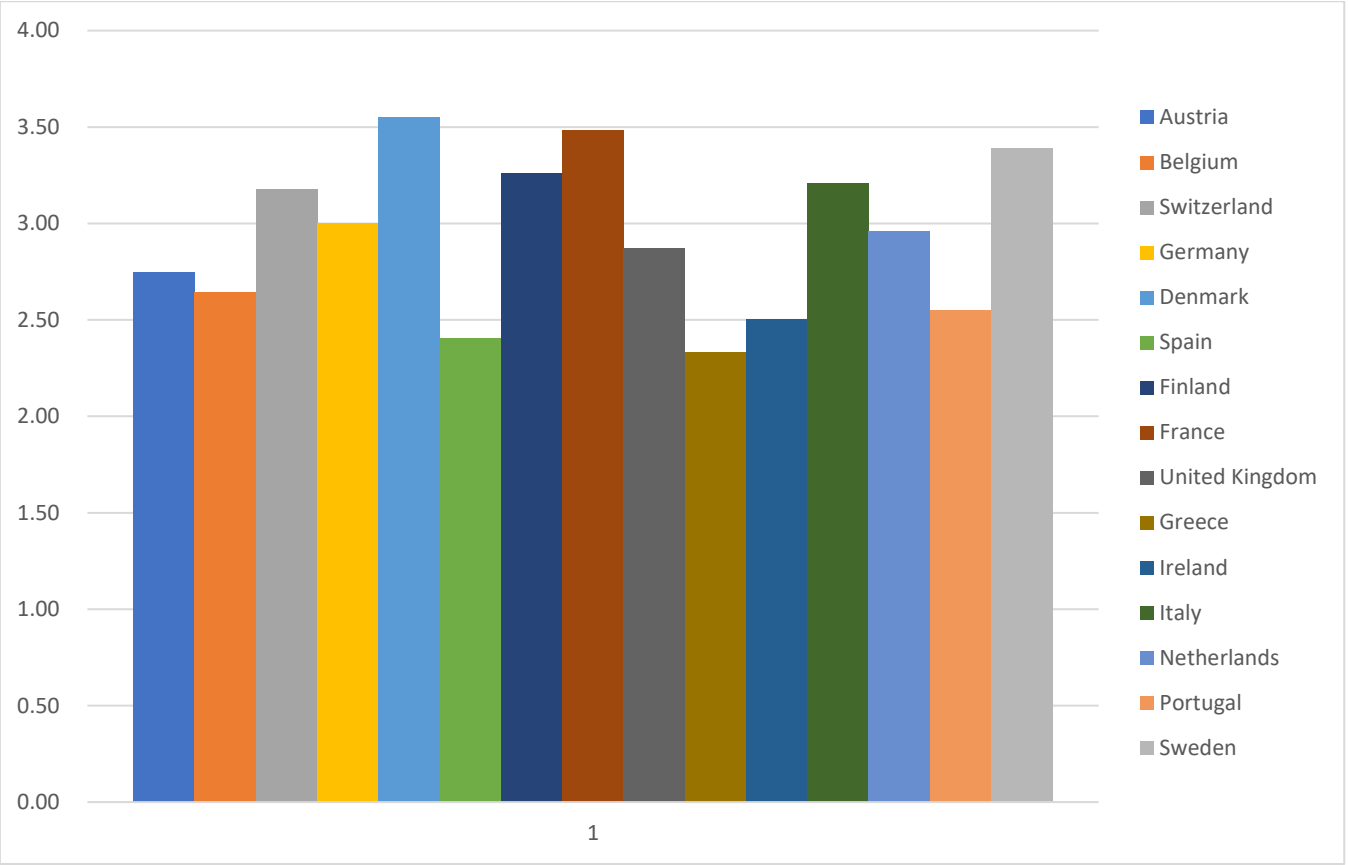


Source: personally made, realized on the basis of the OECD data

As it can be easily seen from the graph, Denmark was the country (among those taken into consideration) which not only recorded the strongest growth but also settled on the highest value of the EPS index, with an average score around 4, in the years considered. Furthermore, it is interesting to note that the value of the index has progressively increased for most of the countries included in the sample starting from 2003. This is a clear symptom of an increasingly growing attention to environmental policy, in line with what was established in the European Strategy.

The following graph showing the average value of the EPS index calculated for each country, included in the sample involved in this report, can be considered to understand better what has been explained before.

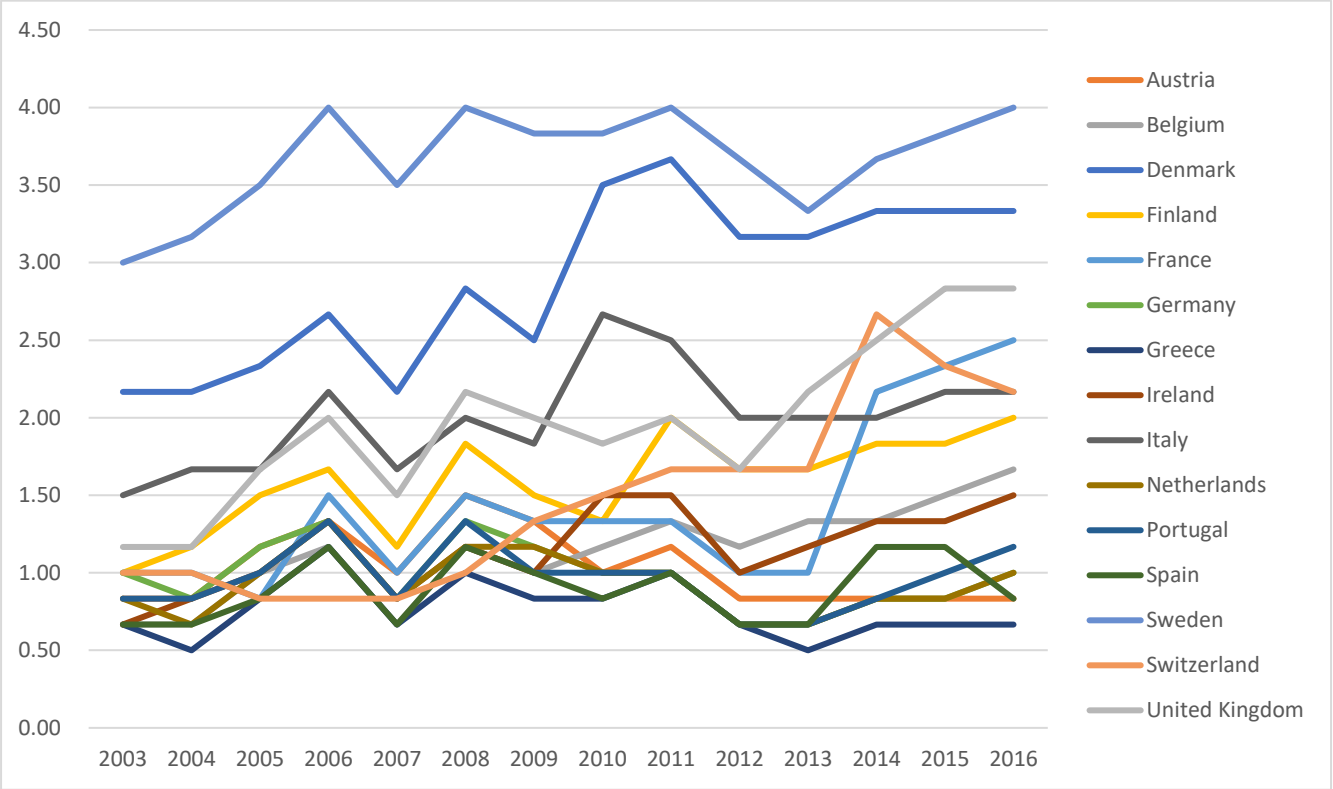
Average value of the EPS index for each country under analysis



Source: personally made, realized on the basis of the OECD data

Denmark reaches the highest value, compared to all the other countries included in the sample, also in this case. Nonetheless, it can also be easily seen graphically that the average values of the EPS Index of most of the countries taken into consideration in the analysis remain at fairly high levels, in line with the environmental policy strategy mentioned above. As previously anticipated, in this analysis the Environmental Policy Stringency Index will be used at a second level of aggregation, thus considering the distinction between market-based and non-market-based EPS.

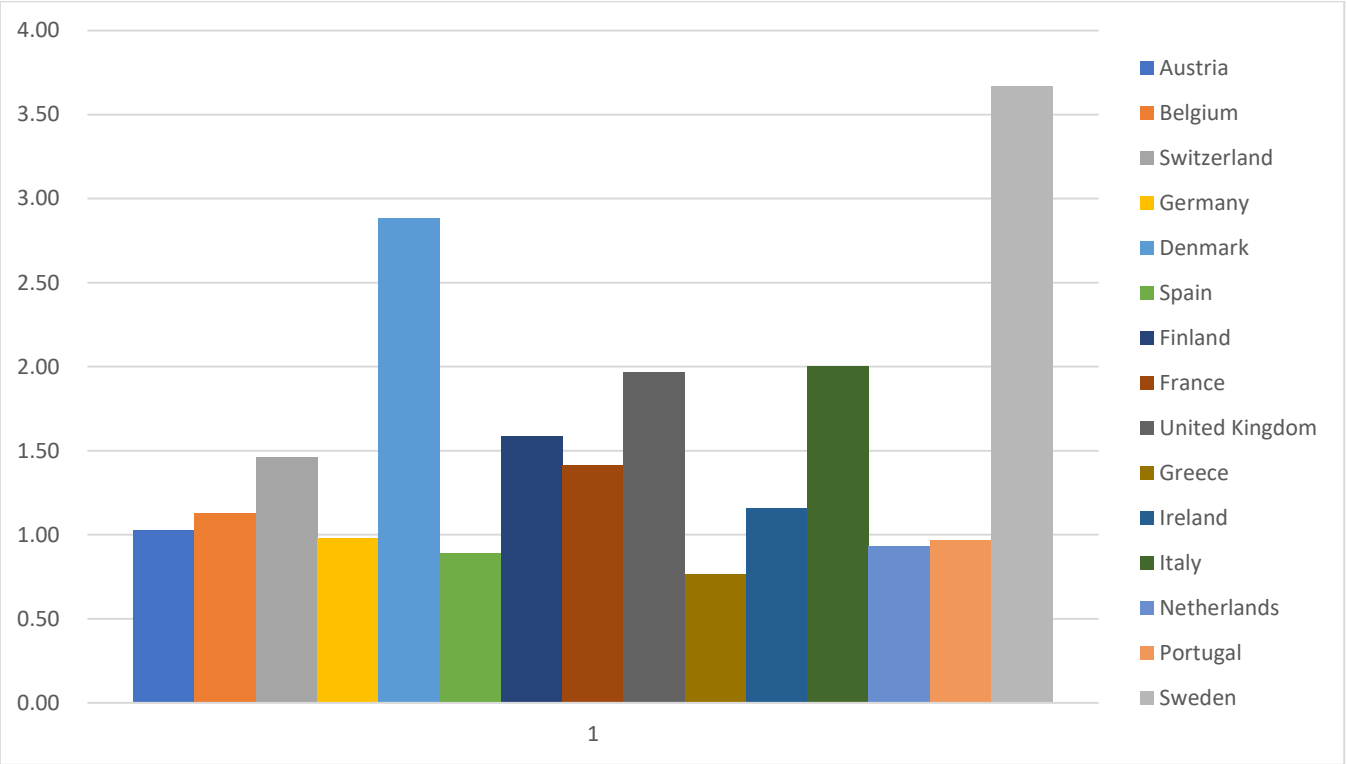
Trend of the MARKET-BASED EPS Index for each country under analysis



Source: personally made, realized on the basis of the OECD data

The highest values were achieved by Sweden followed by Denmark, but it also confirms that these northern countries in particular are characterized by a greater environmental rigor also as regards market-based environmental policy instruments.

Average value of the MARKET-BASED EPS index for each country under analysis

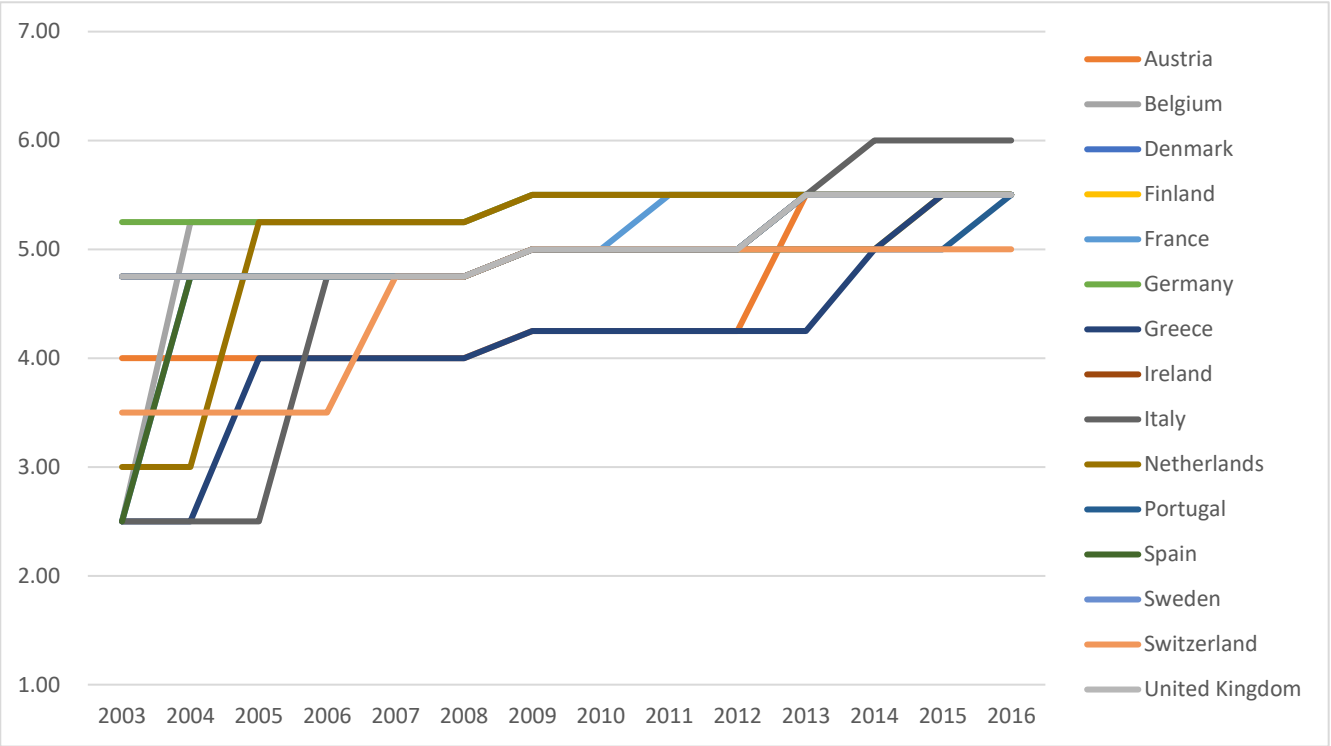


Source: personally made, realized on the basis of the OECD data

Taking into consideration the average value of the Market-Based Environmental Policy Stringency Index for the period 2003-2016, Sweden obtains the highest value compared to all the other countries. Differently from the EPS Index presented previously, the gap between the average value of Sweden and that one of the other countries included in the sample is quite evident except for Denmark. In fact, it can be noted that the average value of Sweden is very close to that of Denmark. This is probably due to the greater use of market-based environmental policy instruments, such as the taxation imposed on polluting emissions.

At least, the following graphs analyze the considered countries' Non-Market EPS Index data.

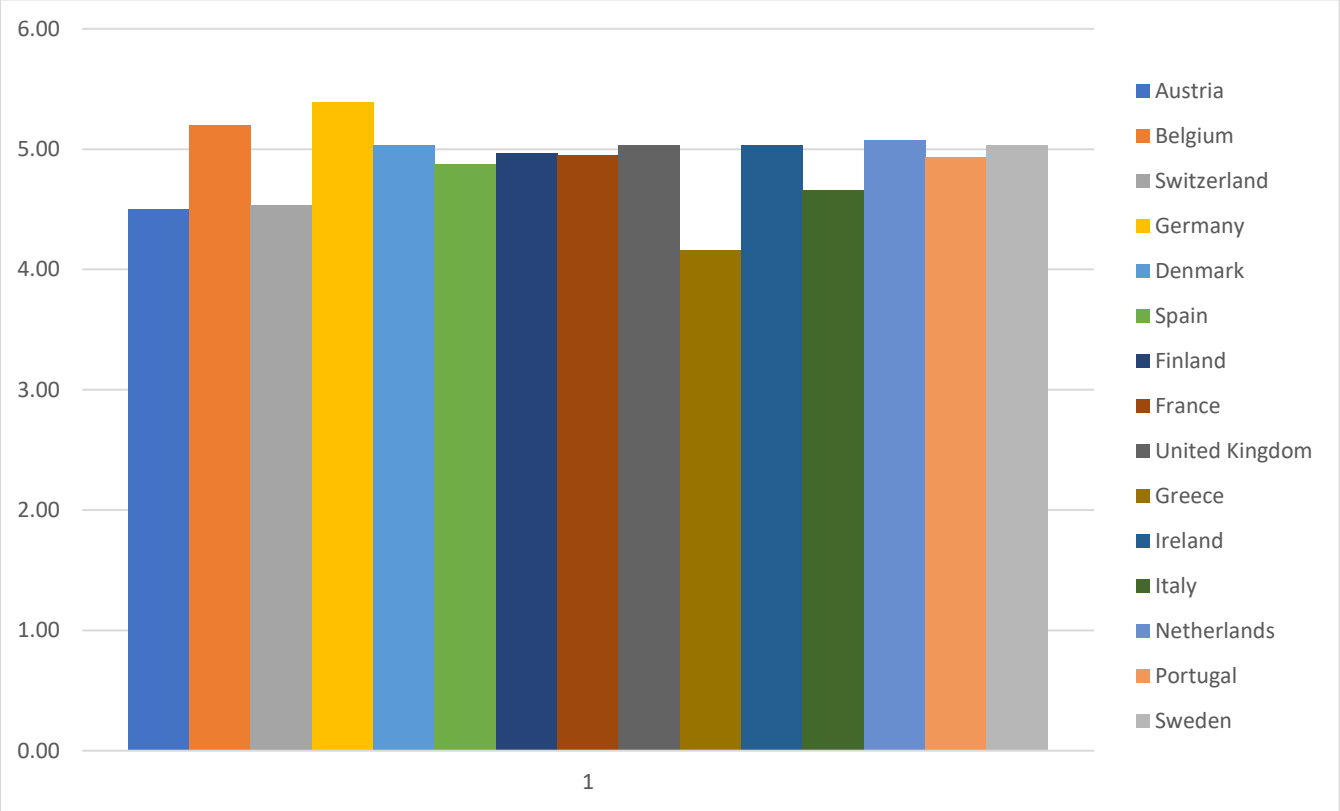
Trend of the NON-MARKET BASED EPS Index for each country under analysis



Source personally made, on the basis of the OECD data

In this latter case, some northern countries (Germany, Denmark, Finland, Sweden and Netherlands) present very similar values that are sometimes the same. This overlapping of values is presumably due to the aligned policies recently developed by those countries. But, from 2013 to 2016 Italy reaches the highest value as non-market EPS, even if it is not a northern country.

Average value of the NON-MARKET-BASED EPS index for each country under analysis



Source: personally made, realized on the basis of the OECD data

The graph related to average values confirms what was highlighted in the previous one. So, they present similar situations: in Northern European countries the level of rigor of environmental policies is based mostly on non-market environmental policy instruments such as subsidies on polluting emissions or rules about them.

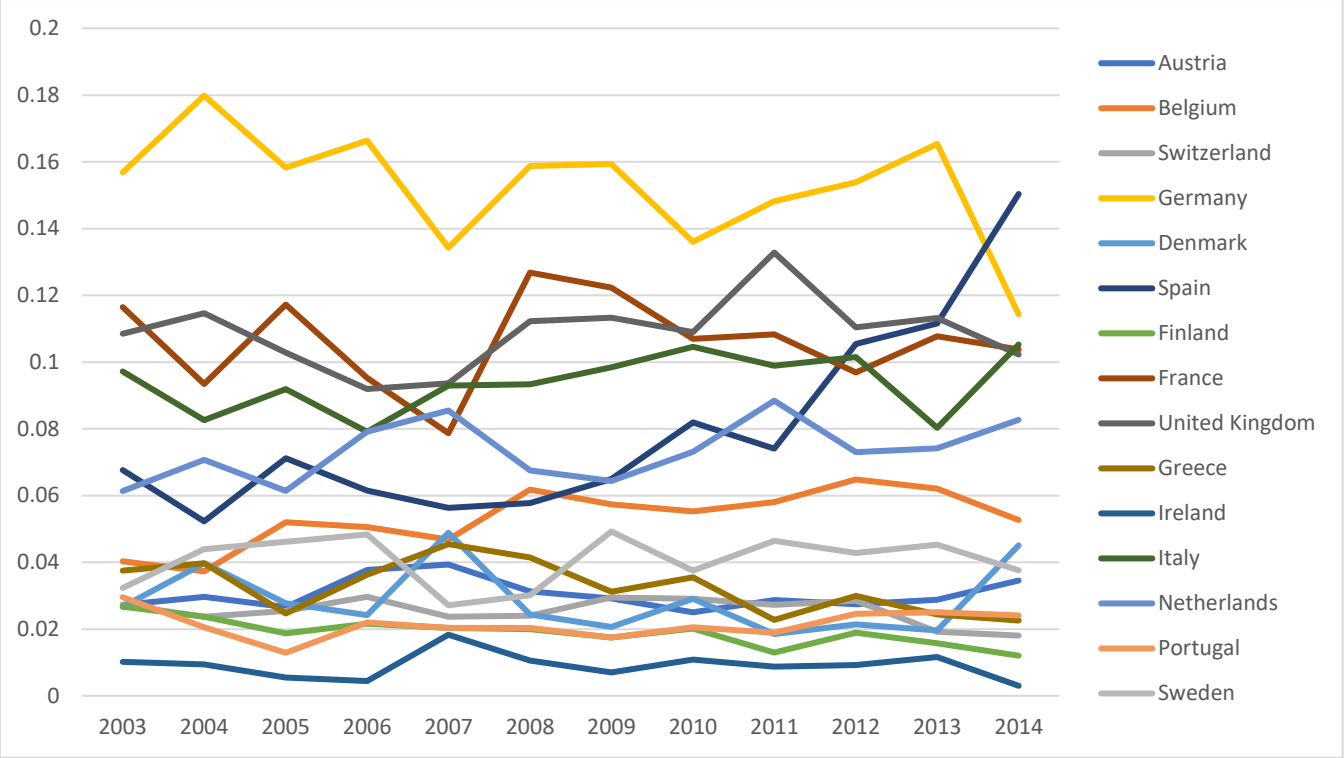
3.3.4 Participation to EU green projects

The results of this paper show also the positive impact of green research networks on international environmental competitiveness, confirming the studies about the advantages of eco-open innovation in terms of economic competitiveness. According to the results, green research networks positively impact on environmental exports, and they interact positively with the green absorptive capacity. The policy implications are multiple: at international level the achievement of SDGs is strictly linked to the implementation of green technological cooperation that permits to generate a win-win strategy with improvements in terms of both environmental sustainability and international competitiveness; at a national level, governments should support the international cooperation activities of universities because they generate important spillovers for business and government sectors.

According to this, through the conducted Regression Model it will be see the correlation between the two variables mentioned (the stringency of environmental policy and the European Green Network) and then the results will be commented.

The following graph shows the trend of the countries as regards their participation in the European green networks over the considered time and then there will be shown the correlation between the participation in the European green networks and the Non-Market EPS Index, because of their correlation.

Trend of Participation in the European Environmental Networks for each country under analysis

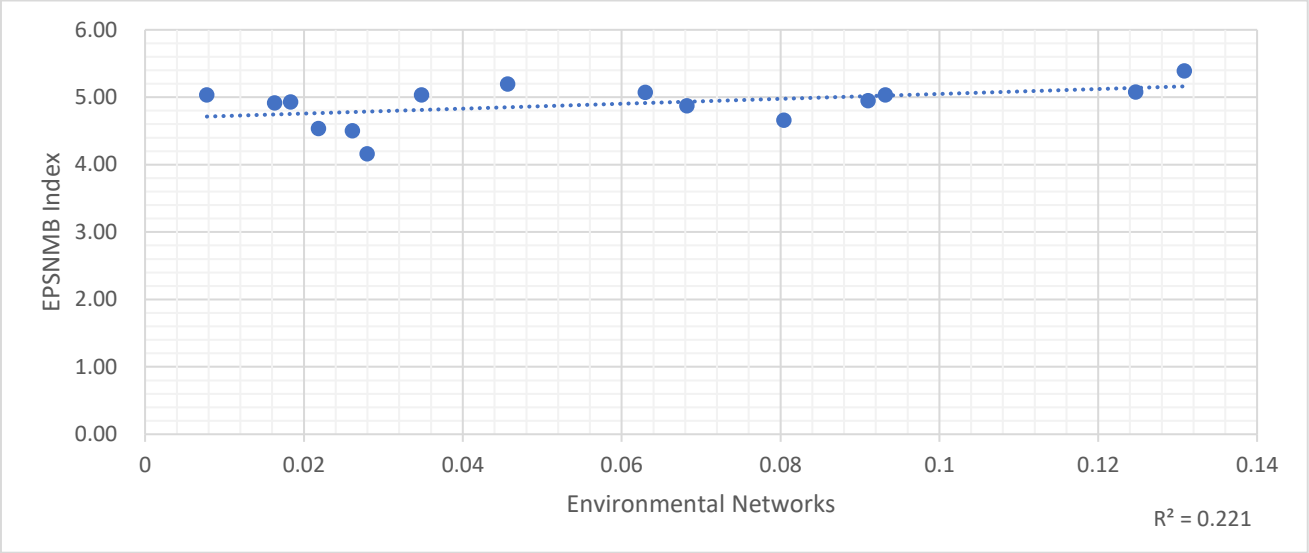


Source: personally made, realized on the basis of the OECD data

The following graph shows the trend of the countries considered in relation to their participation in European environmental networks. Germany seems to be the most active country in terms of participation in networks because of its high values, followed by France and England.

As regards the correlation between the environmental networks and the environmental regulation index, precisely in the form of non-market EPS, the linear regression carried out shows how the networks present a greater correlation precisely with the EPS in this form, compared to the ones in the EPS in its complete and market-based form.

Linear correlation line among Non-Market EPS Index and countries' participation in European green networks



Source: personally made, realized on the basis of the OECD data

This graph shows the correlation between the degree of stringent regulation and the one of participation in European networks of the countries considered in the analysis. Precisely, only the NON-MARKET-BASED level of regulation has been taken into account because it is more correlated to networks and exports, compared to the other forms of environmental regulation, in the Linear Regression Model. In fact, it can be seen how the data related to the two variables referred to the 15 countries are close to the correlation line. Also, the R-squared correct value, that is not influenced by random factors, confirms the adaptability of data to the linear regression model.

3.3.5 The control variables

In order to conduct the analysis, some control variables were taken into consideration. In general, a control variable can be defined as any factor that is controlled or held constantly during the analysis and is certainly important because it could have an effect on the results.

The control variables chosen in the analysis are four and will be explained below in more detailed way. They have been chosen as they seem to be more suitable to the topic of the analysis. The control variables are:

- the population;
- the Unit Labor Costs;
- Green Patents;
- Investments

Population

This kind of indicator shows the number of people that generally live in an area. Total population includes national armed forces stationed abroad; merchant seamen at sea; diplomatic personnel located abroad; civilian aliens' resident in the country; displaced people resident in the country. Population projections are a common demographic tool. They provide a basis for other statistical projections, helping governments in their decision making. This indicator is measured in terms of annual growth rate and in thousands of people.[21]

Unit Labor Costs

Labor productivity growth is a key dimension of economic performance and an essential driver of changes in living standards. Growth in gross domestic product (GDP) per capita can be broken down into growth in labor productivity, measured as growth in GDP per hour worked, and changes in the extent of laborutilization, measured as changes in hours worked per capita. High labor productivity growth can reflect greater use of capital, and/or a decrease in the employment of low-productivity workers, or general efficiency gains and innovation.

Unit Labor Costs are often viewed as a broad measure of international price competitiveness. This indicator is measured in percentage changes and indices.[22] The unit labor costs indicator provides data on the average cost of labor per unit of output produced for OECD member countries and aggregate country classifications. The data used to create the indicator comes from the OECD's Annual Economic Outlook report, which forecasts economic trends by OECD analysts.

Green Patents

According to Desheng et al. (2021), the patent indicator reflects better the technology innovation achievement performed by the firms compared to the other indicators. In 1996, Lanjouw and Mody introduced patent data to study green technology innovation for the first time. Patent data in green technologies (GTs) has been considered a good proxy for green innovation (Ghisellini et al., 2017; Acs et al., 2002; Hall et al., 1986; Kemp and Pearson, 2007) since that time. The methods to classify and identify patents in green technologies are diversified and essentially based on four criteria: classification based on the codes (e.g., IPC - International Patent Classification and CPC - Cooperative Patent Classification); keywords; combination of both search techniques; manual selection. It is necessary to determine how to identify a potential "green patent". Several studies consider a patent protecting a "green" technology if the patent includes at least one green technology code (UIBM 2021; Wipo 2018; Barbieri et al., 2020; Probst et al., 2021; Ghisetti, 2017).[23]

[21]OECD (2023), Population (Indicator)
[22] OECD (2023), Unit LabourCosts (indicator)
[23]OECD (2023), Green Patents (indicator).

Below the three methodologies developed by the international organizations to search patents on environmental-related technologies are schematized, the so-called "green patents":

Organisation	Codification Methodology	CPC codes	IPC codes
EPO	Y02/Y045 Tagging scheme		Not applicable
WIPO&UNFCC	IPC Green Inventory	Not applicable	
OECD	ENV-TECH		

Source: personally made, realized based on the information contained in the paper OECD Green Growth Indicators, Database documentation (2023).

Investments

The OECD Investment Policy Reviews present an overview of investment trends and policies in the countries. This can include investment policy, investment promotion and facilitation, competition, trade, taxation, corporate governance, finance, infrastructure, developing human resources, policies to promote responsible business conduct, investment in support of green growth, and broader issues of public governance. Investment is central variable to growth and sustainable development. It expands an economy's productive capacity and drives job creation and income growth. Boosting investment can support demand in the short-to-medium term while increasing potential growth rates through supply-side effects in the medium-to-long-term. Most investment is undertaken by domestic firms, but international investment can provide additional advantages beyond its contribution to capital accumulation. It can serve as a conduit for the local diffusion of technology and expertise such as through the creation of local supplier linkages and by providing improved access to international markets. The financial crisis has led to less investment, especially in developed countries where boosting investment for growth remains a priority. Private investment in small and medium-sized enterprises and in sectors such as strategic infrastructure is particularly essential. So, the OECD is working to mobilize public and private investment to support resilient, sustainable, green, and inclusive growth which benefits the whole of society. The OECD's Policy Framework for Investment (PFI) can be a powerful tool to help governments to mobilize the private investment that supports steady economic growth and sustainable development. The PFI looks at the investment climate from a broad perspective. It is not just about increasing investment but about maximizing the economic and social returns.[24]

[24]OECD (2023), Investments (indicator).

4. Results of Empirical Analysis

The thesis tries to verify the validity of Porter's strong hypothesis, widely discussed in the literature review, through an empirical analysis on a sample of 15 countries belonging to the OECD, in a period between 2003 and 2016. The econometric model Panel with Fixed Effects, performed using the GRETL software, was used for the analysis. The results obtained are very interesting and the linear regression models, performed following the equations elaborated in chapter 2, are shown in the different following tables. As regards the first research question (RQ1), about the possible link among environmental regulation, environmental networks and green exports, the results confirm the positive relationship between the two independent variables and the dependent variable of exports. As shown in the Model 1, these variables are significant, confirming Porters' strong Hypothesis. But it can be seen how also the innovation variables, as green patents, and investments, are significant for the exports. This significance of innovation variables on exports, and consequently on competitiveness, also supports Porter's strong hypothesis.

Model 1: Fixed Effects, using 177 observations, including 15 cross section units.

Dependent Variable: lnENVEXP

Robust standard errors (HAC)

	Coefficient	*Std. Error*	*t Ratio*	*p-value*	
const	15,2198	0,827912	18,38	6,96e-041	***
lnPOP	0,0384899	0,0237765	1,619	0,1075	
lnULC	0,338918	0,152576	2,221	0,0278	**
lnEPATPOP	0,326982	0,0323616	10,10	8,86e-019	***
lnINV	0,771217	0,0665520	11,59	8,56e-023	***
lnEnvNET	0,0973445	0,0470700	2,068	0,0403	**
EPS	0,852815	0,239634	3,559	0,0005	***

Statistics			
Average dependent variable	23,39613	Dipendent variable RMS	1,158468
residual sum of squares	27,57503	Regression S.E.	0,420432
RSquare	0,883256	Adjusted RSquare	0,868289
F (20, 156)	59,01274	P-value (F)	2,99e-62
Log-verisimilitude	-86,60946	Akaike criterion	215,2189
Schwarz criterion	281,9181	Hannan-Quinn	242,2695
rho	0,113907	Durbin-Watson	1,632645

group intercepts difference test –

null hypothesis: groups have a common intercept.

Test statistics: F (14, 156) = 0,353395

p-value = P (F (14,156) > 0,353395) = 0,985018

As regards the second research question (RQ2), which sets the objective to verify the relationship between green exports and the different levels of environmental regulation at an international level, the obtained results of the equations are similar for the regulation levels. Considering the EPS in its complete form, as it can be seen from Model 2, is very significant, thus confirming the validity of Porter's strong hypothesis. But it emerges that the relationship between environmental regulation and green exports is significant for the Market-based and non-Market based EPS too. The previous table (Model 1) and the following one (Model 2), which represent the first and the third constructed equations, show the significance of the aforementioned levels of regulation.

Model 2: Fixed Effects, using 177 observations, including 15 cross section units

Dependent Variable: lnENVEXP

Robust standard errors (HAC)

	Coefficient	*Std. Error*	*t Ratio*	*p-value*	
const	14,6644	0,788804	18,59	2,66e-041	***
lnPOP	0,032521	0,0226443	1,436	0,1530	
lnULC	0,592389	0,266296	2,225	0,0276	**
lnEPATPOP	0,339828	0,0293699	11,57	1,04e-022	***
lnINV	0,806401	0,0812600	9,924	2,83e-018	***
lnEnvNET	0,064043	0,0537841	1,191	O,2356	
EPSMB	0,085484	0,0421820	2,027	0,0444	**
EPSNMB	0,807507	0,201778	4,002	9,71e-05	***

Statistics			
Average dependent variable	23,39613	Dipendent variable RMS	1,158468
residual sum of squares	27,61880	Regression S.E.	0,422121
RSquare	0,883071	Adjusted RSquare	0,867228
F (21, 155)	55,74215	P-value (F)	2,63e-61
Log-verisimilitude	-86,74981	Akaike criterion	217,4996
Schwarz criterion	287,3749	Hannan-Quinn	245,8383
rho	0,163328	Durbin-Watson	1,548875

group intercepts difference test –

null hypothesis: groups have a common intercept.

Test statistics: F(14, 155) = 0,409051

p-value = P(F(14,155) > 0, 409051) = 0,970395

So, a positive relationship between green Exports and Regulation is required to confirm the strong Porter's Hypothesis. Instead, the output rejects the validity of the Pollution Haven Hypothesis because of a positive and statistically significant relationship between green exports and environmental regulation. So, the Strong Porter's Hypothesis, according to which environmental regulation increases competitiveness, is clearly supported.

About the third research question (RQ3), which aims verify the existence of a potential complementarity between environmental regulation and networks and its link with green exports, the tables below (Model 3) confirm that there may be complementarity, being significant the two variables policy mix, that is the interaction between them. In particular, the policy-mix P-Value refers precisely to the joint significance of several variables and indicates the presence of a good complementarity between the two independent variables, being low. Also, the P-Value of the test with the F (Fischer) is low. Market and non-market EPS in particular are linked to environmental networks and consequently the union of the two has a positive effect on exports and therefore on competitiveness. The following graphs shows this condition and represent the second and the fourth constructed equations.

Model 3: Fixed Effects, using 177 observations, including 15 cross section units

Dependent Variable: lnENVEXP

Robust standard errors (HAC)

	Coefficient	*Std. Error*	*t Ratio*	*p-value*	
const	15,9020	0,883605	18,00	8,37e-040	***
lnPOP	0,0380161	0,0245011	1,552	0,1228	
lnULC	0,557648	0,182276	3,059	0,0026	***
lnEPATPOP	0,334149	0,0307752	10,86	8,84e-021	***
lnINV	0,718578	0,0779540	9,218	2,07e-016	***
lnEnvNET	-0,007961	0,0533326	-0,1493	0,8815	
EPS	0,181570	0,0830164	2,187	0,0302	**
EPSEnvNET	1,08617	0,486631	2,232	0,0270	**

Statistics			
Average dependent variable	23,39613	Dipendent variable RMS	1,158468
residual sum of squares	28,19993	Regression S.E.	0,426538
RSquare	0,880610	Adjusted RSquare	0,864435
F (21, 155)	54,44134	P-value (F)	1,29e-60
Log-verisimilitude	-88,59264	Akaike criterion	221,1853
Schwarz criterion	291,0606	Hannan-Quinn	249,5240
Rho	0,121633	Durbin-Watson	1,626968

group interceptsdifference test –

null hypothesis: groups have a common intercept.

Test statistics: F(14, 155) = 0,30149

p-value = P(F(14,155) > 0,30149) = 0,993181

Model 4: Fixed Effects, using 177 observations, including 15 cross section units

Dependent Variable: lnENVEXP

Robust standard errors (HAC)

	Coefficient	*Std. Error*	*t Ratio*	*p-value*	
const	24,1794	0,771550	31,34	3,29e-069	***
lnPOP	0,174616	0,0529654	3,297	0,0012	***
lnULC	1,3714	0,434585	3,123	0,0021	***
lnEPATPOP	0,389682	0,0399805	9,747	7,95e-018	***
lnEnvNET	0,132373	0,0947205	1,398	0,1642	
EPSMB	-0,401167	0,0861994	-4,654	6,91e-06	***
EPSMBEnvNET	8,38722	1,94036	4,323	2,74e-05	***

Statistics			
Average dependent variable	23,39613	Dipendent variable RMS	1,158468
residual sum of squares	41,92277	Regression S.E.	0,518397
RSquare	0,822512	Adjusted RSquare	0,799757
F (20, 156)	36,14660	P-value (F)	2,46e-48
Log-verisimilitude	-123,6838	Akaike criterion	289,3675
Schwarz criterion	356,0667	Hannan-Quinn	316,4181
Rho	0,101361	Durbin-Watson	1,685092

group intercepts difference test –

null hypothesis: groups have a common intercept.

Test statistics: F (14, 156) = 0,521856

p-value = P (F (14,155) > 0, 521856) = 0,917689

Disaggregating the environmental stringency indicator (EPS) into market and non-market EPS it emerged that it was not possible to find a significant relationship between environmental restrictions, networks, and green exports from the analysis, when only the market-based EPS was considered.

Model 5: Fixed Effects, using 177 observations, including 15 cross section units

Dependent Variable: lnENVEXP

Robust standard errors (HAC)

	Coefficient	*Std. Error*	*t Ratio*	*p-value*	
Const	22,9741	0,845039	27,19	4,59e-061	***
lnPOP	0,178635	0,0483509	3,695	0,0003	***
lnULC	0,675722	0,336217	2,010	0,0462	**
lnEPATPOP	0,360007	0,0395440	9,104	3,93e-016	***
lnEnvNET	0,161929	0,0792985	2,042	0,0428	**
EPSNMB	0,007678	0,0801176	0,09584	0,9238	
EPSNMBEnvNET	2,16028	0,489480	4,413	1,89e-05	***

Statistics			
Average dependent variable	23,39613	Dipendent variable RMS	1,158468
residual sum of squares	41,25504	Regression S.E.	0,514252
RSquare	0,825339	Adjusted RSquare	0,802946
F (20, 156)	36,85790	P-value (F)	7,27e-49
Log-verisimilitude	-122,2628	Akaike criterion	286,5256
Schwarz criterion	353,2245	Hannan-Quinn	313,5762
Rho	0,007683	Durbin-Watson	1,869870

group interceptsdifference test –

null hypothesis: groups have a common intercept.

Test statistics: F(14, 156) = 0,294311

p-value = P(F(14,156) > 0, 294311) = 0,998978

As regards demonstrating the existence of complementarity between networks market-based regulation, on one side, and networks and non-market regulation, on the other side, the investment variable has been included for robustness in the text. However, the results are almost similar independently of this variable. As the graph above shows (Model 5), the policy mix between EPS non-market based and Networks variables turns out to be meaningful.

Finally, a positive and significant relationship emerges among environmental regulation, networks, and exports, when EPS in its full value and non-market EPS are considered in the model, thus confirming not only the Porter's Hypothesis in its strong version, but also rejecting the Pollution Haven Hypothesis consequently.

CONCLUSIONS

The purpose of this paper was to analyze the relationship among environmental regulation, environmental networks and the union of the two variables with the competitiveness of countries, represented by the export of green products, focusing in particular on the strong version of the Porter's Hypothesis. According to what was widely illustrated in the paper, it has to be remembered that PHS has always been the subject of debates and conflicting opinions, especially considering the numerous empirical studies related to it, characterized by completely different results. In general, there are two completely different way of thinking. The first is more traditional and supports the "Pollution Heaven Hypothesis". According to it, companies would be attracted by economic realities where environmental regulation is very weak. So, they do not have necessary to bear the costs to comply with strict environmental rules. The second version is revisionist. It supports Porter's Hypothesis and states that an adequate environmental regulation stimulates companies to innovate in a sustainable and lasting way, creating a competitive and last advantage which will lead to a greater competitiveness on the market. This paper therefore aimed to make clearer the debates just exposed, analyzing a sample of 15 European countries over a period of 14 years (2003-2016). During the empirical analysis, the aim was to understand better the dynamics linking environmental regulation (measured through the EPS index) to corporate competitiveness (measured through green exports), and how different levels of environmental regulation could affect the export ability of a country. The results highlighted some very interesting scenarios, which made it possible to answer the research questions proposed in the paper. As regards the general environmental regulation (RQ 1), the results are satisfying because they are related to the environmental networks involvement. Environmental regulation also has a positive effect on exports. The positive and significant effect becomes evident when environmental regulation (EPS) interacts with the other considered variables. Therefore, it may be said that environmental regulation has a positive and significant effect on green exports in those countries where attention to the environment is greater and the concentration of green patents is higher. Instead, as regards any divergent effects of environmental regulation on Exports (QR 2), the results of the analysis highlighted significant values for environmental policies based on market and non-market instruments. Finally, as regards the third research question (RQ3), the regression has demonstrated that there exists a complementarity between environmental EPS Regulation and Networks. The policy-mix between these variables can have a positive effect on firms' competitiveness.

The analysis intends to contribute not only to the economic and managerial/entrepreneurial fabric of European countries, but also to the governmental and above all social aspect, trying to

encourage all the institutions to achieve the sustainable development objectives that Europe has set out to reach a lasting, stable and above all sustainable growth.

As for future developments, data from 2016 to 2020 are now available on the OECD website. It would be interesting to analyze how environmental legislation has evolved in Europe until today, the existence of other possible types of networks in environmental matter and how OECD countries react to them in future works.

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