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Donatella Baiardi and Maria Gaia Soana

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Macroeconomic and microeconomic environmental and energy policies: are they effective for improving the environmental performance of listed companies?

Donatella Baiardi*

*University of Parma, Center for European Studies (CefES),
Rimini Centre for Economic Analysis (RCEA), Italy
email: donatella.baiardi@unipr.it

Maria Gaia Soana**

**University of Parma, Italy
email: mariagaia.soana@unipr.it

ABSTRACT

We empirically investigate the effectiveness of environmental and energy policies, complying with legal requirements or followed voluntarily by firms, on the pro-environmental efforts of 63 listed firms in Italy in the years 2008-2019. Our research design combines macroeconomic data referring to general policies for reducing air emissions, renewable energy interventions and energy efficiency measures with analogous policies applied at firm level on voluntary basis. The empirical analysis is performed in a panel data context by means of propensity score matching with multiple treatments, which allows us to test the effectiveness of (1) macroeconomic policies on firm environmental performance; (2) microeconomic policies on firm environmental performance, and (3) the coexistence of macroeconomic and microeconomic policies on firm environmental performance. Our results show that the effectiveness of these interventions, applied either separately or jointly, depends on the type of indicator used to proxy firm environmental performance. In particular, we find that the social costs of climate change are not internalized by listed companies, and that macroeconomic interventions are an excellent tool to implement because they are effective to fight climate change where voluntary actions fail and are also complementary to voluntary actions, since they support their effectiveness.

Keywords: Firm environmental performance; General policies for reducing air emissions, Renewable energy policies; Energy efficiency policies; Propensity score matching with multiple treatments; Italian listed companies;

1. Introduction

Nowadays, climate change mitigation is a priority around the world. A healthy environment plays a key role in the 17 Sustainable Development Goals (SDGs) adopted in 2015 by the United Nations to achieve a better and more sustainable future for the planet by 2030 (United Nations, 2015). A peculiar attention has been put on clean and affordable energy and on taking urgent actions to combat climate change and its impacts.

The Paris Climate Conference in December 2015 was an important step on this process, and led to the first ever legally binding global climate agreement to be approved and adopted by 196 countries worldwide. It committed to making various interventions in order to limit global temperature increase to less than 2° C, and led to increasing pressure to reduce carbon emissions from fossil fuels on high carbon emitting countries (Alam et al., 2019; Bang et al., 2019). In this context, the European Union has made many efforts to design efficient environmental programmes and to promote the integration of environmental and sustainable energy policies.[1]

In order to support the implementation of the SDGs for a cleaner and healthier planet in the future, a wide range of actors beyond nations need to be involved, including public and private companies as well as their consumers and investors. In fact, given that greenhouse gas emissions are mainly a byproduct of production activities, companies are often held to be one of the main causes of worldwide environmental problems (Costa-Campi et al., 2017). Many enterprises are responding by focussing more on the environmental impacts of their business and taking active roles in environmental management (Walker and Wan, 2012).

Moreover, consumers are today more concerned about the environmental impact of products and services. Marketing managers recognise the strategic importance of 'green' consumers and strive for competitive advantage from an environmentally-friendly image of their firm. Financial markets have also become more sensitive to environmental issues (Alonso-Almeida et al., 2014). On one hand, retail investors have begun to demand specialized green finance products and stocks issued by companies monitoring the environmental impact of their business. On the other hand, many asset managers, acknowledging the importance of environmental risk, are increasingly integrating environmental, social and governance (ESG) aspects into their portfolio choices.

The environment is a particularly important issue for listed companies, because financial markets are currently very sensitive to the risk of climate change. Public and private listed companies can use a variety of instruments to encourage environmentally-friendly behaviour. Among them, a strategic role is played by the adoption of voluntary internal policies.

Despite their importance, there are few papers in the empirical literature studying the effectiveness of internal policies for improving firm environmental performance, and no clear conclusions of their effectiveness have been reached (Kube et al., 2019). Some researchers have indeed demonstrated that government support in environmental and

[1] For example, the '2030 Climate & Energy Framework' recommends cutting at least 40 per cent of greenhouse gas emissions by 2030 compared to 1990. With regard to the energy markets, the key targets for 2030 are at least 32 per cent renewable energy and at least 32.5 per cent improvement in energy efficiency (https://ec.europa.eu/clima/policies/strategies/2030_en).

energy fields can reinforce the impact of internal voluntary policies (Arimura et al., 2019), while other studies suggest that environmental and energy measures required by *law* rather than followed voluntarily by *firm choice* are more effective in reducing greenhouse emissions (Kube et al., 2019). However, to the best of our knowledge, no study to date has empirically tested the effectiveness of mandatory and voluntary policies jointly.

The aim of this paper is thus to assess the effectiveness of environmental and energy policies, either implemented to comply with legal requirements or by firm choice, on the pro-environmental efforts of 63 Italian listed firms in the years 2008-2019.

From an environmental point of view, the case of Italy is of particular interest for many reasons. It is the fourth-largest emitter of greenhouse gases in the European Union (IEA, 2016), and also shows strong and persistent regional differences (Ghisetti and Quatraro, 2013), which affect company approaches to sustainability issues (Gazzola et al., 2020). This is consistent with the structure of our sample. Most of the listed firms are located in the Po Valley, in the North of Italy, which is one of the most heavily polluted areas in the world, while others have their headquarters in Sardinia, an island known worldwide for the beauty of its nature and low pollution levels.

In order to assess the effectiveness of environmental and energy policies, measuring firm environmental performance is a key issue and listed companies adopt specific environmental indicators for this purpose. In our analysis, corporate environmental performance is proxied by means of a quantitative variable measuring CO_2 emissions generated by each enterprise, and two qualitative variables capturing the company's steps towards an environmentally-friendly production process and management system.

Italy is also a very interesting case in terms of climate and energy policies. On one hand, many firms in Italy, and especially listed companies, have adopted voluntary environmental policies since the 1990s. On the other hand, following the principle of subsidiarity, by which European directives are transposed into each member state, regional authorities have responsibility for this kind of intervention and thus legislate in compliance with state guidelines, thus laying down mandatory climate and energy policy for firms.[2] Moreover, regions have become the key players in terms of climate goals, especially since the 2001 reform of the Italian Constitution and the 2008 global financial crisis (Comodi et al., 2012; Baiardi, 2020).

Our paper considers three distinct categories of *macroeconomic policy* applied on a *regional* scale, which are independently analysed and classified as follows: *(i)* general policies for reducing air emissions, *(ii)* renewable energy interventions and *(iii)* energy efficiency measures. Similar environmental policies can also be implemented at firm level on voluntary basis (*microeconomic* or *internal policies*). Regional and internal interventions can be applied as mutually exclusive strategies,[3] so that a firm is only subject to regional policy or only implements internal policy, or as joint strategies, so that firm-specific policies coexist with regional policies.

[2] For more details on this process, see Sarrica et al. (2018).

[3] Note that in this paper, we use the terms macroeconomic policies and regional policies interchangeably, given that Regions are the key players in terms of climate and energy policies in Italy. Similarly, the terms microeconomic policies, internal policies and voluntary actions are used interchangeably to indicate interventions implemented at firm level.

Our study aims to test the effectiveness of: (1) macroeconomic policies on firm environmental performance, (2) microeconomic policies on firm environmental performance, and (3) the coexistence of macroeconomic and microeconomic policies on firm environmental performance. Unlike previous literature focuses on voluntary actions adopted by listed firms, to the best of our knowledge, this paper is the first to consider the impact of macroeconomic policies and their possible coexistence with voluntary policies.

Our results show that the effectiveness of regional and internal environmental and energy policies, applied either separately or jointly, depends on the type of indicator used to proxy firm environmental performance. In particular, the social costs of climate change are not internalized by listed companies, and only macroeconomic policies are effective when environmental performance is measured in terms of CO_2 emissions. But when firm environmental performance is proxied by qualitative indexes, i.e. company effectiveness in reducing emissions and its overall environmental rating, our findings show that a combination of regional and internal policies is a *win-win* strategy. These evidences confirm that macroeconomic interventions are an excellent tool to implement because they fight climate change effectively even where voluntary actions fail and also they are complementary to, and support the effectiveness of, voluntary actions.

The paper is structured as follows. Section 2 gives a historical overview of corporate environmental disclosure. Section 3 presents the methodology employed in the empirical analysis, and Section 4 introduces the data. Section 5 describes the main empirical results, which are discussed in Section 6. Finally, Section 7 briefly concludes with some remarks on policy implications.

2. A historical overview of the role of corporate environmental disclosure

Increasing concern about environmental degradation and the challenges of a low-carbon and climate-resilient economy have led to increasing regulatory attention to environmental problems, particularly greenhouse gas emission reduction and sustainable energy. Private and public companies have thus become increasingly aware of the environmental impact of their business (Walker and Wan, 2012; Costa-Campi et al., 2017; Alam et al., 2019; Kube et al., 2019).

The environment is a particularly important issue for listed companies, because financial markets are key to the transformation to a sustainable economy. Climate related information is a crucial tool for enabling listed companies to assess the risks of the potentially negative impact of their business activities on the environment, and the risks that climate change can in turn pose for their business. In the following subsections we thus provide an overview of the evolution of corporate environmental disclosure worldwide, with a specific focus on the Italian case.

2.1. The evolution of corporate environmental disclosure

Since the early 1990s, as well as applying mandatory environmental policies, listed companies have also adopted *voluntary* Environmental Management Systems (EMS), i.e. formal policies and procedures that define how an organization manages its potential impacts on the environment and the health and welfare of people who depend on it (Arimura et al., 2008). EMSs are now widely used and offer advantages to companies which commit to improving environmental performance (Frondel et al., 2005; Iraldo et al., 2009). The most popular EMSs include the adoption of voluntary internal policies, agreements promoted by trade associations, certification or labelling schemes, nomination of employees responsible for environmental issues, environmental training programs, and the development of Corporate Environmental Reporting (CER).

Corporate Environmental Reporting entails communication to corporate stakeholders about company environmental performance (Tommasetti et al., 2020). CER has been characterized by significant changes over time in terms of its quantitative and qualitative content and formats (Othman and Ameer, 2009). More specifically, since the early 1970s, some large companies have published annual reports including information on environmental issues. In the 1970s and 1980s, developing countries produced mainly narrative reports (Williams, 1999; Othman and Ameer, 2009), while developed countries quickly recognized the importance of quantitative information and gave more attention to specific voluntary environmental indicators (Niskala and Pretes, 1995; Holland and Foo, 2003). However, it was often difficult to compare the environmental performance of different companies because there was too much variation between indicators (Beets and Souther, 1999).

The initial lack of standardisation in environmental disclosure led to a call for more effective reference models (Saviano et al., 2017), and since the late 1990s, environmental certification frameworks and standards have been introduced at international level (for a detail review see Siew, 2015). Some of these focus specifically on environmental disclosure, while others are global environmental, social and governance tools which include an environmental section. Frameworks are principles or guidelines assisting companies in disclosure. Standards are more formal documents which present requirements and characteristics that firms should use to achieve their sustainable goals.

The reporting framework currently most widely used among international listed companies is the Global Reporting Initiative (GRI) (Alonso-Almeida, 2014; Siew et al., 2015; Büyükozkan and Karabulut, 2018). It was launched in 1997 and provides a series of hierarchical indicators for efficiently reporting the ESG impact of a company. GRI is continuously updated and has today reached its 4th version. Among environmental frameworks, the Carbon Disclosure Project (CDP, 2014) is currently the most widely used by large corporations worldwide (Büyükozkan and Karabulut, 2018). It is a disclosure platform which defines sets of indicators for companies in sustainable water use, tackling climate change, managing deforestation risks and mitigating environmental risks related to supply chain.

Among standards for encouraging companies to adopt sustainable policies and report their implementation, the 1999 UN Global Compact was the pioneer. It outlines ten principles in the areas of human rights, labour, environment and anti-corruption. Three specific principles are related to the environment: a precautionary approach to environmental challenges, promoting greater environmental responsibility and developing environmentally-friendly technologies. Among the environmentally specific standards, ISO 14001 is a certification that encourages companies to plan environmental strategy and states requirements for environmental management. Today it is the most widely used standard on the financial market (Riaz and Saeed, 2019).

Previous literature has investigated the impact of adopting different voluntary environmental frameworks and standards on company environmental performance at an international level. Various studies show that the implementation of GRI (Bernard et al., 2015) and ISO 14001 (Russo, 2009; Arimura et al., 2011; Nishitani et al., 2012) can contribute to improving firm environmental performance of reporting companies, especially in lowering pollution levels.

Nowadays, the key role of companies and financial institutions in the transition to a low carbon and climate-resilient economy means that improvements in the quantity, quality and comparability of environmental disclosures are urgently required to meet the needs of investors and other stakeholders.

In fact, financial markets are currently highly focused on ESG concerns, both in the USA (US SIF, 2020) and Europe (Eurosif, 2018). Retail investors are paying increasing attention to ESG aspects, seeking greater transparency into how companies are addressing environmental issues (Berry and Yeung, 2013; Gutsche and Ziegler, 2019; Lagerkvist et al., 2020). Moreover, many institutional investors, and especially large asset managers, are today following the worldwide trend towards adopting ESG principles (Eccles et al., 2017).[4] In this context, quantifying specific environmental performance indicators, monitoring their evolution and, in general, communicating them to stakeholders has become crucial to the investment industry and to listed companies in general (Eccles et al., 2017).

2.2. Corporate environmental disclosure in Italy

Although CER originated and developed on a voluntary basis, it is important to note that large companies in Italy are also required to comply with certain regulatory requirements. Specifically, the European Directive 2014/95/EU, known as the Non-Financial Reporting Directive (NFRD), was transposed into Italian law by Legislative Decree No. 254 of December 30, 2016, and has been in force since January 25, 2017. The NFRD requires public-interest companies, including banks, insurance companies and listed firms with more than 500 employees to disclose information on how they manage social and environmental challenges. The aim of the directive is to help company stakeholders, such as investors, consumers, and policy makers, to assess the non-financial performance of large firms, thus encouraging them to develop a responsible approach to business.

So since 2017, large Italian companies have included a non-financial statement in their annual report, containing information about environmental protection. Italian law specifies that the non-financial statement must report at least the following information in the environmental section: greenhouse gas emissions and polluting emissions into the atmosphere, the use of energy and water resources and the impact on the environment and on health and safety. Risk factors and other significant environmental and health risk factors must also be reported.

The NFRD gives companies a great deal of flexibility in the adoption of environmental reporting indicators. The European Commission published specific non-mandatory guidelines on non-financial reporting in 2017 and 2019 (European Commission, 2017,

[4] ESG investing accounted for about 33 per cent of the total assets under professional management in the US in 2020 (US SIF, 2020).

2019) in order to help companies to disclose environmental information, but companies are also permitted to use other international frameworks and standards, such as those described in Subsection 2.1 to produce their non-financial statements.

Previous studies show that because of its coercive nature, mandatory reporting on environmental issues contributes to the standardization of practice (Husted and Salazar, 2006; Venturelli et al., 2017) and sometimes also to raising the quality of disclosure (Crawford and Williams, 2010). In this context, Italy provides interesting indications. The recent introduction of the NFRD in fact produced an increase in the number of published environmental reports (Balluchi et al., 2020). Moreover, the Observatory on Non-Financial Disclosures and Sustainable Practices (2019) shows that 200 Italian companies published their non-financial statements in 2019 and all of them adopted the GRI reporting standard. It is also worth noting that the environmental dimension generally covers CO_2 emissions, consumption of energy resources and/or water, company environment protection policies and the rate of material recycled or disposed of sustainably, and on average accounts for about 11 per cent of the document.

3. Methodology

Propensity score matching is frequently used to compare participants and non-participants in policy evaluation (Sánchez-Braza and Pablo-Romero, 2014; Wang et al., 2019). The core of this procedure is the treatment indicator, which is a dummy capturing the implementation (or not) of the policy of interest.

Our empirical framework is characterized by the presence of three distinct categories of environmental and sustainable energy policies, which are considered independently and classified as follows: *(i)* general policies for reducing air emissions, *(ii)* renewable energy interventions and *(iii)* energy efficiency measures. These three types of policy can be implemented as regional (*macroeconomic*) policy or as internal voluntary (*microeconomic*) policy, or they can be applied as mutually exclusive strategies. A firm can thus be subject only to regional policy, or implement only internal policy, or firm-specific policies may coexist with regional policies.

Our empirical analysis thus distinguishes the presence of two treatments, corresponding to the two levels of application (regional and internal) of each policy category. Following Lechner (2001, 2002), we thus employ a more generalized version of propensity score matching which isolates the effects of multiple treatments on the variable of interest.

More specifically, the acronyms R and F are respectively used to indicate regional policy and firm-specific policy. For each policy category (*i*)-(*iii*), four mutually exclusive groups of policy (P) are defined as follows:

1. P_0: no policies are applied;
2. P_R: the firm does not implement any internal policy but is located in a region implementing policies;
3. P_F: internal policies are implemented but the firm is located in a region which does not apply any policy;
4. $P_{R,F}$: the firm implements internal policies and is also located in a region applying policies.

Three distinct treatment indicators, related to the three categories of policy (*i*)-(*iii*) reported above, are built. They take values equal to 0, 1, 2 and 3 if P_0, P_R, P_F and $P_{R,F}$ respectively hold. As a consequence, for each type of intervention (*i*)-(*iii*), our empirical analysis aims to compare the effects of these four mutually exclusive strategies P_0, P_R, P_F and $P_{R,F}$ on various indicators of firm environmental performance.

Next, for each type of intervention (*i*)-(*iii*), average treatment effects on the population ($ATTs$) are estimated in the following seven pairwise comparisons:

- P_R/P_0: regional policies *versus* no policy;
- P_R/P_F: regional policies *versus* firm internal policies;
- P_F/P_R: firm internal policies *versus* regional policies;
- P_F/P_0: firm internal policies *versus* no policy;
- $P_{R,F}/P_F$: regional policies implemented together with firm internal policies *versus* firm internal policies;
- $P_{R,F}/P_R$: regional policies implemented together with firm internal policies *versus* regional policies;
- $P_{R,F}/P_0$: regional policies implemented together with firm internal policies *versus* no policy;

The pairwise comparison of the effects of treatment *m* and *l* can thus be defined as:

$$ATT_{m,l} = E(Y^m - Y^l|P = m) = E(Y^m|P = m) - E(Y^l|P = m) \quad (1)$$

where $ATT_{m,l}$ denotes the expected average effect of treatment *m* relative to treatment *l* for each firm randomly selected from the population receiving treatment *m*, *Y* is firm environmental performance, and *P* represents the four mutually exclusive policies described above.

The term $E(Y^m|P = m)$ is not observable. In order to overcome this identification problem, under the conditional independence assumption, Equation (1) is rewritten as follows:

$$ATT_{m,l} = E(Y^m|P = m) - E_X\{E(Y^l\,|X, P = l|P = m)\} \quad (2)$$

where *Y* is assumed to be independent of the treatment, and is conditional on a set of observable covariates (*X*) which represent the main macroeconomic features of the region where the firm is located, together with some variables capturing firm-specific characteristics. Equation (2) shows that the outcome of firms receiving treatment *m* can be proxied by the outcome of others undergoing treatment *l*, as they have similar characteristics. The only difference between these two groups of matched firms is the implementation (or not) of certain types of regional and/or internal policies.

Traditionally, in the empirical literature, matching is obtained by using the probability of each firm of implementing and/or being subject to certain policies, i.e. the specific treatment *m,* conditional on the values taken by a vector of covariates (*X*):

$$p^m(X) = Prob(P = m|X) \quad (3)$$

The probability introduced by Equation (3) is commonly defined as a propensity score (Rosenbaum and Rubin, 1983). In our framework, it is estimated using a multinomial probit model, while matching conditions are obtained using the nearest neighbor matching method.

Therefore, by jointly considering Equations (2) and (3), we obtain Equation (4), which is the core of our estimation strategy:

$$ATT_{m,l} = E(Y^m|P = m)E_{p^m(X),p^l(X)}E(Y^l|P^m(X), P^l(X), P = l)|P = m) \qquad (4)$$

Finally, in each of the seven pairwise comparisons, we evaluate the quality of the matching procedure between our treated and untreated firms by testing the so-called balancing hypothesis. We can thus verify whether the observations with the same propensity scores have the same distribution of observable characteristics, independent of the treatment.

4. Data

The empirical analysis is performed by means of a panel dataset composed by 63 Italian listed firms in the period 2008-2019. Regional (macroeconomic) and firm-specific (microeconomic) data are considered jointly. These series are described in detail in the following subsections.

4.1. The dependent variables

Three measures capturing different aspects of firm environmental performance are considered: CO_2 equivalent emissions (hereafter CO_2 emissions),[5] the Emission Category Score, and the Environmental Pillar Score. They are extracted from the database Refinitiv® Eikon-Datastream, Section ESG Scores.

CO_2 emissions are generated and emitted by each firm. They are measured in tonnes and represent the negative externality of the industrial process on the environment. They are computed by considering direct and indirect greenhouse gas emissions classified into Scope 1 and 2 by IPCC (2006),[6] which are the gases mainly responsible for global warming and climate change.[7,] Following the impetus given by the Kyoto Protocol to the 2016 Paris Agreement on curbing CO_2 emissions globally, many industrial and developing countries are currently attempting to reduce CO_2 emissions. This is crucial for listed firms which are now required to take corporate social responsibility initiatives, promote sustainable business development and enhance their reputation on financial markets (Kjaerheim, 2005; Bang et al., 2019).

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[5] The expression 'CO_2 equivalent' refers to different greenhouse gases measured in a common unit, i.e. the amount of CO_2 which would have the equivalent Global Warming Potential (GWP). GWP is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of CO_2. GWP is 1 for CO_2, and a quantity of greenhouse gas can be expressed as CO_2 equivalent by multiplying the amount of the gas by its GWP.

[6] Specifically, "*'Scope 1' indicates direct greenhouse gas emissions that are from sources owned or controlled by the reporting entity. 'Scope 2' indicates indirect emissions associated with the production of electricity, heat, or steam purchased by the reporting entity*" (Allwood et al., 2014, p. 1260).

[7] The following gases are considered: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCS), perfluorinated compounds (PFCS), sulfur hexafluoride (SF_6) and nitrogen triflouride (NF_3). These are the gases mainly responsible for global warming and climate change.

The Emission Category Score and the Environmental Pillar Score capture respectively the efforts of listed companies to minimize their environmental impact and improve their global environmental performance.

More precisely, the Emission Category Score measures company commitment and effectiveness in reducing emissions in production and operational processes. It represents firm attempts to make production processes environmentally-friendly in line with recent recommendations by governments and policymakers for reducing pollution and achieving a cleaner energy era. The Environmental Pillar Score measures the firm's environmental rating and, more generally, its global environmental performance. It represents firm attempts to establish an efficient environmental management system. It allows listed companies to enhance their environmentally-friendly image in the eyes of investors, and to gain comparative advantage from the allocation of their resources to environmentally-friendly business activities.

The Emission Category Score and the Environmental Pillar Score range from 0 to 100 and are calculated using voluntary information published in the company environmental reports. It is worth noting that although the use of quantitative data, such as CO_2 equivalent emissions, might be preferable (Iraldo et al. 2009), the use of self-reporting qualitative data, such as the Emission Category Score and the Environmental Pillar Score, is not uncommon in the empirical literature (Babakri et al., 2004; Berla, 2007; Bang et al., 2019).

4.2. Policy variables

Three distinct types of environmental and energy policy, implemented at regional and at firm level, are considered. They are classified as follows: *(i)* general policies for reducing air emissions, *(ii)* renewable energy interventions and *(iii)* energy efficiency measures.

With regard to regional (macroeconomic) policies, data are retrieved from the database `*Air quality improvement measures*', compiled by the Italian Institute for Environmental Protection and Research (ISPRA) for the years 2008-2011. Specifically, we consider interventions classified as '*Industrial plant emissions control*', '*Renewable energy policies*', and '*Energy efficiency sources*'. These three categories correspond to our policy classifications (*i*)-(*iii*) and capture regional interventions for reducing air emissions and promoting the use of renewable energy and energy efficiency measures.

We also consider the same type of interventions implemented at firm level on a voluntary basis. These data are obtained from Refinitiv® Eikon-Datastream, Section ESG Scores. We consider the variables '*Policy Emissions*', '*Resource Reduction Policy*' and '*Policy Energy Efficiency*', which are associated with our three types of policy (*i*)-(*iii*). More precisely, the first series captures firm actions to reduce air emissions and answers the question '*Does the company have a policy to improve emission reduction?*'. The second variable captures firm implementation of renewable energy initiatives and answers the question '*Does the company have a policy to reduce the use of natural resources or to reduce the environmental impact of its supply chain?*'. The third series captures firm implementation of energy efficiency measures and answers the question '*Does the company have a policy to improve its energy efficiency?*'.

We next build three treatment indicators with reference to cases (*i*)-(*iii*), identifying the status of each firm for the four mutually exclusive strategies P_0, P_E, P_R and $P_{E,}$ (see Section 3). Consider, for example, general policies for reducing air emissions (Case *i*): the treatment indicator associated with this policy category is equal to 0 if the firm does not implement internal policies and it is located in a region which does not implement any policy. It is equal to 1 if the firm does not implement any internal policy but is located in a region which implement environmental policies, and is equal to 2 if the firm applies internal policies and is located in a region which does not implement any policy. Lastly, the index is equal to 3 if the firm implements internal policies and is located in a region applying environmental policies.[8] We then compute three distinct dummies corresponding to the status 1, 2 and 3 of this treatment indicator. The treatment indicators and the connected sets of dummies are built following the same criteria for renewable energy and energy efficiency interventions (Cases *ii* and *iii*). These three sets of dummies are then used for the estimation of the average treatment effects reported in Section 5.

4.3. Explanatory variables

There are many factors which can influence the implementation of environmental and energy policies at regional and firm level. In our empirical analysis, two distinct sets of explanatory variables, capturing regional heterogeneities and firm-specific features, are included in the multinominal probit model as covariates.

The first set of explanatory variables represents the main macroeconomic characteristics of the twenty Italian regions where each listed firm has its headquarters. These series are GDP per inhabitant, measured in terms of Purchasing Power Standard, and unemployment rate. These data are retrieved from Eurostat (regional statistics). In particular, per capita GDP indicates the level of development of each region, for which we expect a positive effect on policy interventions. The unemployment rate is generally considered as a job creation engine which leads a local authority to promote environmental and energy policies. So far, the empirical literature has found mixed results for this indicator. The positive impact of energy policies on employment and welfare appears to be limited, and in some cases, strictly negative (Böhringer et al., 2013). Similarly, Rivers (2013) shows that renewable energy policies lead to an increase (instead of a decrease) in the unemployment rate.

The second set of explanatory variables refers to firm-specific characteristics. These variables are: liquidity, profitability and firm size. Liquidity is measured by inventories: the lower inventories, the higher company liquidity. Profitability is proxied using Return on Equity (ROE). The index is calculated as the ratio between net income and total equity: the higher ROE, the higher company profitability. Lastly, firm size is proxied by total assets: the higher total assets, the higher the size. All these variables are retrieved from Refinitiv® Eikon-Datastream and are measured in euros.

To our knowledge, no previous literature investigates the impact of liquidity, profitability and size on listed firm environmental performance. We expect that more profitable and more liquid companies will show better environmental performance, as they have more economic and financial resources to invest in environmental sustainability initiatives, and

[8] For more details, see Table A.1 in Appendix A.

a positive relationship between firm size and environmental performance is thus assumed. In fact, as described in Subsection 2.2, Directive 2014/95/EU requires companies with more than 500 employees to disclose environmental information. Because they are under a mandatory reporting constraint, larger firms should be more incentivized to improve their environmental performance than smaller ones.

5. Empirical results

5.1. Preliminary evidence

5.1.1. Stylized facts

Various factors, including macroeconomic conditions, industrial structure, changes in production patterns and in firm business affect the implementation of sustainable environmental and energy policies from a macroeconomic and a microeconomic point of view.

Figure 1 maps the distribution of the sample across Italy. Our 63 listed companies have their headquarters in nine regions, located in the north and in the center of the country. Lombardy exhibits the highest concentration of firms (39.68 per cent of the total), followed by Emilia Romagna, Lazio, Piedmont and Veneto (15.87, 14.29, 7.94 and 6.35 per cent, respectively). The remaining 15.87 per cent of companies have their headquarters in Tuscany, Liguria, Friuli Venezia Giulia, Sardinia and Marche.

Figure 1 about here

Most of the nine regions are among the most polluted of the country in the last decade. If we consider carbon dioxide (CO_2), methane (CH_4) and nitrous oxides (N_2O), the primary drivers of climate change, they are concentrated in Lombardy, Emilia Romagna, Lazio, Piedmont and Veneto.[9] These regions are also the top areas in Italy in terms of per capita GDP and employment rates in 2018.[10]

Focusing on the nine regions where our 63 listed firms have their headquarters, we focus on the three policy categories applied on a regional scale, either alternatively or jointly, in the years 2008-2011. It is found that only in Lombardy and Liguria have the three kinds of policy been implemented at the same time. General policies for reducing air emissions have been applied alone in Emilia-Romagna, Friuli Venezia Giulia, Lazio and Veneto. Piedmont and Marche have implemented two types of policy: specifically, general policies for reducing air emissions and energy efficiency measures in Piedmont and renewable energy and energy efficiency measures in Marche. Further details are provided in the Appendix, Table A.2.

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[9] For example, Lombardy is the most polluted region in terms of CO_2 and CH_4 emissions (35,314 and 337.53 Mg, respectively), and, together with Veneto, it also exhibits a very bad performance in terms of N_2O emissions (14.44 and 16.13 Mg, respectively). In general, Lombardy, Emilia Romagna, Lazio, Piedmont and Veneto are among the top six, seven and eight most polluted regions in terms of N_2O, CH_4 and CO_2 emissions in 2015, respectively (data source: *Inventaria* by ISPRA).

[10] More specifically, with respect to per capita GDP (in purchasing power standard) in 2018, Lombardy records 39,200 euro per inhabitant, followed by Emilia Romagna (36,800), Lazio (34,100), Veneto (33,800), and Piedmont (31,900). With respect to unemployment rate, the lowest values are recorded in Emilia Romagna (5.5 per cent), Lombardy and Veneto (each 5.6 per cent) in 2018.

For each policy category (*i*)-(*iii*), we classify listed companies into four mutually exclusive groups, according to the type of policy applied (see Section 3): regional policy adopters, internal policy adopters, regional and internal policy adopters, and no policy adopters. Stylized facts are reported in Table 1.

Table 1 about here

Looking at Case (*i*), firms adopting regional policy are located in the most developed regions, and they exhibit the highest per capita GDP and the lowest unemployment rate of the sample. These companies are characterized by low emission levels, but also by a weak environmental performance in terms of Emission Category Score and Environmental Pillar Score. Moreover, regional policy adopters show the most promising liquidity conditions among the sample, along with low profitability and small size.

On the other hand, firms adopting internal policy in Case (ii) are located in regions with the worst macroeconomic scenario. They are also the worst polluting firms, and show the highest CO_2 emissions of the sample. However, they exhibit good environmental performance in terms of the Emission Category Score and the Environmental Pillar Score. Internal policy adopters also show the best profitability, the worst liquidity conditions and are of medium size.

Firms implementing both regional and internal policy (Case iii) are big, profitable and liquid listed firms. Their headquarters are located in developed regions, and they show the best environmental performance in terms of firm commitment to reducing emissions and environmental rating. They are however the second most polluting companies of the sample.

Lastly, firms implementing no policy are mainly similar to regional policy adopters except in profitability, which can even be negative.

Renewable energy and energy efficiency policies yield similar results (Cases *ii* and *iii*).

5.1.2. Estimates of the propensity scores

The next step of the empirical analysis is to estimate a multinominal probit model for each policy category (Tables 2-4). For Cases (*i*)-(*iii*), the dependent variable identifies the status of each firm for the four mutually exclusive strategies P_0, P_E, P_R and $P_{E,}$ (see Section 3 and Subsection 4.2).

Tables 2, 3 and 4

Almost all significant variables included in the estimation exhibit the expected signs (see Subsection 4.3). In particular, with regard to the main macroeconomic characteristics of each region, per capita GDP is always positive and highly significant, with internal policy adopters as the only exception. The highest coefficients are observed for regional policy adopters, with renewable energy policies as the most remarkable case (Table 3). So it appears that economic growth boosts especially interventions on a regional scale.

The estimated parameters related to the unemployment rate are positive and statistically different from zero only for internal policy adopters in the cases of general policies for reducing air emissions and policies for energy efficiency (Tables 2 and 4, respectively).

This suggests that the impact of these policies is unclear in terms of employment improvements, as shown by previous empirical literature reported in Subsection 4.3.

Focusing on the main firm-specific characteristics of our sample, liquidity is negative and mainly statistically significant only when general policies for reducing air emissions are analyzed (Table 3). Size is mostly statistically significant only when renewable and energy efficiency policies are implemented (Tables 3 and 4). With regard to profitability, the estimated coefficient is always positive, but its statistical significance is rather mixed.

Overall, our results show that per capita GDP is the most relevant macroeconomic factor for the implementation of environmental and energy policies on a regional scale, and on a regional and firm scale together. The role of the unemployment rate depends however on the type of internal policy implemented. The specific impact of liquidity, profitability and size varies according to the type of policy. In fact, liquidity conditions matter in the case of general regional and internal policies for reducing air emissions, while firm size is important in the case of renewable and energy efficiency measures. In the case of energy efficiency policy, profits are relevant especially when policy is implemented either at firm level or at regional and internal level combined.

For each policy category (*i*)-(*iii*), estimates shown in Tables 2, 3 and 4 are used to compute the propensity scores associated with each listed company. The propensity scores are used to estimate the average treatment effects (ATTs), introduced by Equation (4), and computed by means of the nearest neighbor algorithm as matching technique.[11] The estimated treatment effects are reported as a percentage of the untreated outcome means, in order to measure the effectiveness of the different combinations of policies in terms of firm environmental performance. These results are reported and discussed in the following subsections.

Finally, for each policy category (Cases *i-iii*) and for each environmental performance indicator, we test the quality of the matching between treated firms (i.e., firms subject to only one type of policy or both) and control firms (i.e., firms not subject to any kind of policies or applying only one type of policy) by means of the conventional balancing hypothesis. Our results, reported in Table 5, indicate that observations with the same propensity score have the same distribution of observable characteristics, of the treatment, since in general the median standardized bias collapses significantly after matching (Rosenbaum and Rubin, 1983).

Table 5 about here

5.2 The effects of the three distinct types of environmental and energy policy on firm environmental performance

5.2.1. CO_2 emissions

[11] We employed the variants 'common support' and 'without replacement' to avoid any matching bias and to improve matching quality. The matching procedure is computed with Stata 14.0 using the routine described by Leuven and Sianesi (2003).

In this subsection we describe the results related to the impact of sustainable environmental and energy policies on CO_2 emissions, which capture the negative externalities of industrial processes on the environment.

As noted by ESMAP (2018, 2020), the implementation of sustainable environmental and energy policies is crucial in terms of global development and climate change agenda. In our framework, this implies that they should first play a key role in *reducing* the level of emissions generated and emitted by firms, with positive repercussions on environmental conditions. Equation (4) thus represents the differences in terms of CO_2 emissions between the treated companies and the matched ones. The three distinct policy categories are expected to have a *negative* average effect on emissions. The main findings are reported in Table 6.

Table 6 about here

Table 6 shows that the three types of policy are effective when applied on a regional scale, and the estimated coefficients are negative, as expected, and highly statistically different from zero. This holds when comparing firms located in regions implementing environmental and energy policies with others located in regions that do not adopt any kind of policy (P_R/P_0), and when comparing firms located in regions applying these policies with firms that only implement internal interventions (P_R/P_F). The three types of policy are more effective in the former situation (P_R/P_0).

Comparing firms applying internal policies with firms which are only subject to regional policies (P_F/P_R) or with those not subject to any kind of policy (P_F/P_0), no policies are successful in reducing emissions. These results are in line with Pizer et al. (2011) and Kube et al. (2019), who find that voluntary programs to reduce on greenhouse gases have no effect on firm emissions in the USA and in Germany respectively. Moreover, our results show that energy efficiency measures can even significantly raise CO_2 emissions instead of reducing them. A similar finding is obtained by Kim and Lyon (2011) when analyzing the impacts of firms' strategic disclosure of greenhouse gas reductions to the American government, showing that program participants have sometimes reported an increase in CO_2 intensity rather than the expected reduction.

Lastly, comparing joint application of regional and internal policies with the situation where only internal policies, or only regional policies, or no policies are implemented (P_{RF}/P_F, P_{RF}/P_R and P_{RF}/P_0, respectively), renewable energy policies are especially effective, since their effect is negative and always statistically significant in all circumstances. Moreover, in this case, the estimated coefficients are higher than those for only internal or only regional policies, with the policy strategy P_{RF}/P_0 as the most noticeable case.

5.2.2. Emission Category Score and Environmental Pillar Score

Following the procedure described in the previous subsection, we consider the impact of sustainable environmental and energy policies on two additional indicators of firm environmental performance: the Emission Category Score and the Environmental Pillar Score. These two scores proxy company steps towards an environmentally-friendly production process and an efficient environmental management system, respectively.

Equation (4) captures the differences in terms of firm environmental performance between the treated companies and the matched ones, and the three distinct policy categories are expected to have a *positive* average effect on these two indicators. The main results are reported in Tables 7 and 8.

Tables 7 and 8 about here

On the one hand, our findings show that, when policies are implemented only on a regional scale, i.e. P_R/P_0 and P_R/P_F, the estimated effect on firm environmental effort is negative. This counterintuitive result is robust independently of the type of policy category analyzed and independently of the indicator employed. Specifically, in absolute terms, the strongest impact is mainly observed when general policies for reducing air emissions are analyzed (Case *i*), and the lowest impact in the case of energy efficiency policies (Case *iii*). These findings suggest that environmental and energy policies are not the tool to implement for improving firm environmental performance.

On the other hand, when applied at firm level, general policies for reducing air emissions are substantially ineffective, while *energy* policies are successful. In fact, when the policy comparisons P_F/P_R and P_F/P_0 are considered, the estimated coefficients are mainly positive, as expected, and statistically different from zero. However, there are some differences. When the Emission Category Score is considered (Table 7), estimated coefficients are positive in the case of energy efficiency policies, while renewable energy policies are effective only when comparing firms applying internal policies with respect to those ones that are not subject to any kind of policy (P_F/P_0). For the Environmental Pillar Score (Table 8), however, renewable energy policies are more effective than energy efficiency policies in both policy comparisons P_F/P_R and P_F/P_0.

In general, the co-presence of regional and internal policies has a positive significant impact on firm environmental performance. The average improvement is particularly significant (80 and 62 per cent) when general policies for reducing air emissions are considered. Focusing on the energy market, energy efficiency interventions are generally more effective than renewable energy policies (Tables 7 and 8, respectively). Moreover, with regard to the Emission Category Score (Table 7), the average effect of energy efficiency measures is almost double the estimated effect of renewable energy policies when P_{RF}/P_F and P_{RF}/P_0 are compared.

6. Discussion

Several considerations can be made about the results described in the previous section. The results demonstrate that the effectiveness of regional and internal environmental and energy policies, applied either separately or jointly, depends on the type of proxy used to measure firm environmental performance. In other words, there is no a '*one size that fits all*' approach, because the effectiveness of these policies depends on their goal.

For example, in a situation where environmental and sustainable energy policies are implemented only on a regional scale or only at internal level, regional policies are effective when environmental performance is measured in terms of CO_2 emissions, but internal policies are not. The exact opposite occurs when firm environmental performance is measured in terms of its attempts to achieve an environmentally-friendly production process and efficient environmental management system: internal policies are effective and regional policies are not.

These results offer new insights into the effectiveness of voluntary management programs on listed firm environmental performance. Extant literature in fact offers little evidence for success of voluntary initiatives aimed at reducing greenhouse gases, which generally appear to fail the expected emission decrease (Pizer et al., 2011; Kim and Lyon, 2011; Sugino et al., 2013). In this context, our finding shows that this goal can be reached by applying macroeconomic instead of microeconomic policies. To the best of our knowledge, this result is new in the literature. It supports the intuitions provided by Kube et al. (2019), stating that measures implemented by *law*, rather than by *choice*, should potentially have a stronger effect in terms of environmental improvements and cost savings. Moreover, as suggested by Fisher-Vanden and Thorburn (2011), this evidence is supported by the fact that corporate commitments to reduce greenhouse gas emissions to an extent conflict with maximization of firm value.

When considering other indicators of environmentally-friendly production and management choices, however, voluntary schemes lead to the desired result, i.e. they improve listed company environmental performance. This is particularly the case when renewable energy policies and energy efficiency measures are implemented.[12] This finding confirms those of previous literature, which generally show a positive influence of voluntary programs on environmental performance when it is measured by means of firm surveys with self-reported evidence (Rennings et al., 2006) or manager perceptions of program effectiveness (Iraldo et al., 2009).

This may be due to the fact that increasingly stringent governmental regulations have made listed companies more aware of their environmental weaknesses. Listed firms frequently portrayed as one of the main causes of pollution in the world (Costa-Campi et al., 2017), and so particularly subject to public pressure and aware of consumer attention to environmental issues. As a consequence, many listed firms are actively adopting environmental management strategies (Walker and Wan, 2012).

Listed firms often face however a trade-off between environmental and economic issues, and have to choose between most suitable policies to ameliorate their environmental performance on the one hand, and the best strategies to maximize their financial performance on the other. This is why internal policies are effective in improving environmentally-friendly production process and making environmental management systems efficient. In these cases, given their consciousness about their strengths and weaknesses, listed firms are more strongly stimulated towards higher environmental performance in setting environmental targets. It is not by chance that the most effective types of voluntary internal policy are those covering specific issues, i.e. renewable and efficiency energy interventions.

Lastly, consider the situation where environmental and sustainable energy policies are implemented *jointly* on a regional and internal scale. This policy mix is generally successful, and many governments now promote voluntary actions to encourage companies to be more environmentally-friendly (Arimura et al., 2011). Moreover, this

[12] Note that general policies for reducing air emissions are (weakly) statistically significant only in the case of the Environmental Pillar Score.

policy mix can be a solution of the well-known trade-off between the implementation of macroeconomic and microeconomic policies. The trade-off is based on the assumption that financial resources for macroeconomic policies subtract financial resources for microeconomic policies, which are generally considered by firms to be less costly than traditional command-and-control systems (Arimura et al., 2011; Fisher-Vanden and Thorburn, 2011).

There are however certain differences between the three types of intervention.[13] In the case of emission reduction, a combination of regional and internal renewable energy policies is particularly effective. If the focus shifts on improving listed company's efforts towards an environmentally-friendly production process and an efficient environmental management system, on the other hand, a combination of regional and internal policy is particularly effective in the case of general policies for reducing air emissions and energy efficiency policies.

7. Conclusions and policy implications

This paper empirically investigates the effectiveness of three distinct types of environmental and energy policies on listed firm pro-environmental efforts. Such policies have been implemented in Italy at both regional and internal levels, as mutually exclusive strategies, so that a listed company can thus be subject to only regional interventions or only internal interventions, or to both regional and internal interventions at the same time, when firm-specific policies coexist with regional policies.

In this study the three distinct categories of policy are considered separately. Our empirical analysis uses propensity score matching with multiple treatments. This methodology makes it possible to distinguish the presence of two treatments, corresponding to the two levels of application (regional and internal) of each policy category.

Our findings demonstrate that, when firm environmental performance is measured in terms of CO_2 emissions, the social costs of climate change are not internalized by listed companies. Listed firms not applying internal policies, but subject to regional environmental and/or energy policies, in fact reduce their emissions, with a positive impact on environmental quality. It is worth noting that macroeconomic policies are generally designed to improve environmental quality at the aggregate level. They in fact aim to correct throughout an entire area the negative externalities produced by gas emissions, for which companies are often held to be mainly responsible. In this perspective, these interventions reduce CO_2 emissions as expected, since this indicator is monitored not only at a firm level, but also on a global scale.

However, when environmental performance is proxied by more firm-subjective data (Emission Category Score and Environmental Pillar Score), our results show that a combination of regional and internal general policies aiming to reduce air emissions is a *win-win* strategy. This finding confirms that macroeconomic interventions are an

[13] Specifically, general policies for reducing air emissions are effective only when firm environmental performance is measured by the Emission Category Score and the Environmental Pillar Score. For interventions in the energy market, efficiency policies are always effective independently of the environmental performance indicator, while renewable energy policies are especially effective when firm environmental impact is measured in terms of CO_2 emissions and in terms of Emission Category Score.

excellent tool to implement since they are effective to fight climate change where voluntary actions fail, and they are complementary to voluntary actions, as they support their effectiveness.

This combination of regional and internal policies is also recommended in the case of sustainable energy policies, independently of the type of indicator of firm environmental performance. This further confirms the importance of macroeconomic policies because, as noted by ESMAP (2020), it takes time to meet higher energy standards and lower energy consumption. Our findings suggest that this shortcoming could be solved, at least partially, by promoting macroeconomic policies together with microeconomic-voluntary actions, which are complementary and particularly effective, especially in the energy market.

Finally, in the light of the rapid devolution of legislative and regulatory powers to Regions, Provinces, and Municipalities in Italy, our results demonstrate that the promotion of actions and initiatives fostering a closer collaboration between local authorities and industrial sector is mandatory for planning sustainable environmental and energy policies. For reaching this ambitious goal, it is worth noting the crucial role of a large audience of actors, not limited to nations and public and private companies, but also enlarged to their stakeholders, and especially to consumers and investors. Consumer awareness of the dangers of climate change is in fact higher than ever before as shown in the 2020 Global Risks Perception Survey, where respondents ranked climate change and related environmental issues among the top five risks (World Economic Forum's Global Risks Report, 2020). Investors thus need to make choices that take into account the environmental impacts of companies. To do this, they need to be constantly updated on the environmental performance of listed companies as well as the evolution of climate regulations and scientific discoveries relating to global warming and its impact on human wellbeing.

References

Alam, Md.S., Atif, M., Chien-Chi., C., Soytaş, U., (2019). Does corporate R&D investment affect firm environmental performance? Evidence from G-6 countries. Energy Economics, 78, 401–411.

Allwood J. M., V. Bosetti, N. K. Dubash, L. Gómez-Echeverri, C. von Stechow, (2014). Glossary. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Alonso-Almeida, M., Llach, J., Marimon, F., (2014). A closer look at the 'Global Reporting Initiative' Sustainability Reporting as a tool to implement environmental and social policies: a worldwide sector analysis, Corporate Social Responsibility and Environmental Management, 21, 318-335.

Arimura, T.H., Hibikid, A., Katayama, H., (2008). Is a voluntary approach an effective environmental policy instrument? A case for environmental management systems. Journal of Environmental Economics and Management, 55, 281–295.

Arimura, T.H., Darnall, H., Katayama, H., (2011). Is ISO14001 a gateway to more advanced voluntary action? The case of green supply chain management. Journal of Environmental Economics and Management, 61, 170-182.

Arimura, T. H., Kaneko, S., Managi, S., Shinkuma, T., Yamamoto, M., Yoshida, Y. (2019). Political economy of voluntary approaches: A lesson from environmental policies in Japan. Economic Analysis and Policy, 64, 41-53.

Baiardi, D., (2020). Do sustainable energy policies matter for reducing air pollution? Energy Policy, 140, 111364.

Balluchi, F., Furlotti, K., Torelli, R., (2020). Italy towards mandatory sustainability reporting. Voluntary corporate social responsibility disclosure of Italian companies and Legislative Decree 254/2016 statements. A quantitative analysis of the last 10 years, Sustainability and Law, Mauerhofer, Rupo and Tarquinio (Eds), Springer, 257-274.

Bang, Y-Y., Leeb, D., S., Lim, S-R., (2019). Analysis of corporate CO_2 and energy cost efficiency: The role of performance indicators and effective environmental reporting. Energy Policy, 133, 110897.

Babakri, K., A., Bennett, R., A., Rao, S., Franchetti, M., (2004). Recycling performance of firms before and after adoption of the ISO 14001 standard. Journal of Cleaner Production, 12, 633-637.

Barla. P., (2007). ISO 14001 certification and environmental performance in Quebec's pulp and paper industry. Journal of Environmental Economics and Management, 53, 291–306.

Beets, S., D., Souther, C., C., (1999), Corporate environmental reports: the need for standards and an environmental assurance service. Accounting Horizons, 13, 129-145.

Bernard, S., Abdelgadir, S., Belkhir, L., (2015). Does GRI Reporting impact environmental sustainability? An industry-specific analysis of CO_2 emissions performance between reporting and non-reporting companies, Journal of Sustainable Development, 8, 190-205.

Berry, R.H., Yeung, F., (2013). Are investors willing to sacrifice cash for morality? Journal of Business Ethics, 117, 477–492.

Böhringer, C., Keller, A., van der Werf, E., (2013). Are green hopes too rosy? Employment and welfare impacts of renewable energy promotion. Energy Economics, 36, 277–285.

Büyükozkan, G., Karabulut, Y., (2018), Sustainability performance evaluation: literature review and future directions, Journal of Environmental Management, 217, 253-267.

Comodi, G., Cioccolanti, L., Polonara, F., Brandoni, C., (2012). Local authorities in the context of energy and climate policy. Energy Policy, 51, 737–748.

Costa-Campi, M., T., García-Quevedo, J., Martínez-Ros, E., (2017). What are the determinants of investment in environmental R&D? Energy Policy, 104, 455–465.

Crawford, E.P., Williams, C.C., (2010). Should corporate social reporting be voluntary or mandatory? Evidence from the banking sector in France and the United States, Corporate Governance, 10, 512–526.

Eccles, R.G., Kastrapeli, M.D., Potter, S.J., (2017). How to integrate ESG into investment decision-making: results of a global survey of institutional investors, Journal of Applied Corporate Finance, 29, 125-133.

Energy Sector Management Assistance Program (ESMAP), (2018). Regulatory Indicators for Sustainable Energy. Washington, DC: World Bank.

Energy Sector Management Assistance Program (ESMAP), (2020). Regulatory Indicators for Sustainable Energy (RISE) Sustaining the Momentum. Washington, DC: World Bank.

European Commission, (2017). Communication from the Commission - Guidelines on non-financial reporting (methodology for reporting non-financial information) C/2017/4234.

European Commission, (2019). Communication from the Commission - Guidelines on non-financial reporting: Supplement on reporting climate-related information C/2019/4490.

Eurosif, (2018). European SRI study 2018, https://www.eurosif.org/wp-content/uploads/2018/11/European-SRI-2018-Study-LR.pdf.

Fisher-Vanden, K., Thorburn, K., S., (2011). Voluntary corporate environmental initiatives and shareholder wealth. Journal of Environmental Economics and Management, 62, 430-445.

Frondel M., Horbach J., Rennings K., Requate, T., (2005). Environmental policy tools and firm-level management practices: empirical evidence for Germany, RWI Mitteilungen Quarterly 54/55, Issue 2.

Gazzola, P., Pezzetti, R., Amelio, S., Grechi, D., (2020). Non-Financial information disclosure in Italian public interest companies: a sustainability reporting perspective, Sustainability, 12, 6063.

Ghisetti, C., Quatraro, F., (2013). Beyond Inducement in Climate Change: Does Environmental Performance Spur Environmental Technologies? A Regional Analysis of Cross-Sectoral Differences. Ecological Economics, 96, 99-113.

Gutsche, G., Ziegler, A., Which private investors are willing to pay for sustainable investments? Empirical evidence from stated choice experiments. Journal of Banking and Finance, 102, 193–214.

Holland, L., Foo, Y., B., (2003). Differences in environmental reporting practices in the UK and the USA: the legal and regulatory context. The British Accounting Review, 35, 1-18.

Husted, B.W., de Jesus Salazar, J., (2006). Taking Friedman seriously: maximizing profits and social performance. Journal of Management Studies, 43, 75–91.

Kjaerheim, G., (2005). Cleaner production and sustainability. Journal of Cleaner Production, 13, 329-339.

Kim, E.-H., Lyon, T., (2011). Strategic environmental disclosure: evidence from the DOE's voluntary greenhouse gas registry. Journal of Environmental Economics and Management, 61, 311–326.

Kube, R., von Graevenitz, K., Löschel, A., Massier, P., (2019). Do voluntary environmental programs reduce emissions? EMAS in the German manufacturing sector. Energy Economics, 84, 104558.

IEA, (2016). Energy Policies of IEA Countries - Italy, 2016 Review. International Energy Agency, Paris, France.

IPCC, (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Iraldo, F., Testa, F., Frey, M., (2009). Is an environmental management system ableto influence environmental and competitive performance? The case of the eco-management and audit scheme (EMAS) in the European Union. Journal of Cleaner Production, 17, 1444-1452.

Lagerkvist, C.J., Edenbrandt, A.K., Tibbelin, I., Wahlstedt, Y., (2020). Preferences for sustainable and responsible equity funds - A choice experiment with Swedish private investors. Journal of Behavioral and Experimental Finance, 28, 100406.

Lechner, M., (2001). Identification and estimation of causal effects of multiple treatments under the conditional independence assumption. Econometric evaluation of labour market policies, 4358.

Lechner, M., (2002). Some practical issues in the evaluation of heterogeneous labour market programmes by matching methods. Journal of the Royal Statistical Society: Series A (Statistics in Society), 165, 5982.

Leuven, E., Sianesi, B., (2003). Psmatch2: Stata module to perform full mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing. Software http://ideas.repec.org/c/boc/bocode/s432001.html.

Niskala M., Pretes M., (1995). Environmental reporting in Finland: a note on the use of annual reports. Accounting, Organization and Society, 20, 457-466.

Nishitani, K., Kaneko, S., Fujii, H., Komatsu, S., (2012). Are firms' voluntary environmental management activities beneficial for the environment and business? An empirical study focusing on Japanese manufacturing firms. Journal of Environmental Management, 105, 121-130.

Observatory on Non-Financial Disclosures and Sustainable Practices (2019), Report 2019, available at: http://www.osservatoriodnf.it/doc/report-2019-en.pdf

Othman, R., Ameer, R., (2009). Corporate social and environmental reporting: where are we heading? A survey of the literature. International Journal of Disclosure and Governance vol. 6, 298-320.

Pizer, W.A., Morgenstern, R., Shih, J.-S., (2011). The performance of industrial sec-tor voluntary climate programs: climate Wise and 1605(b). Energy Policy, 39, 7907–7916.

Rennings, K., Ziegler, A., Ankele, K., Hoffmann, E., (2006). The influence of different characteristics of the EU environmental management and auditing scheme on technical environmental innovations and economic performance. Ecological Economics, 57, 45–59.

Riaz, H., Saeed, A., (2019). Impact of environmental policy on firm's market performance: the case of ISO 14001. Corporate Social Responsibility and Environmental Management, 27, 681-693.

Rivers, N., (2013). Renewable energy and unemployment: A general equilibrium analysis. Resource and Energy Economics, 35, 467–485.

Rosenbaum, P., R., Rubin, D., B., (1983). The central role of the propensity score in observational studies for causal effects. Biometrika, 70, 4155.

Russo, M.V., (2009). Explaining the impact of ISO 14001 on emission performance: a dynamic capabilities perspective on process and learning. Business Strategy and the Environment, 18, 307-319.

Sánchez-Braza, A., Pablo-Romero, M., (2014). Evaluation of property tax bonus to promote solar thermal systems in Andalusia (Spain). Energy Policy, 67, 832-843.

Sarrica, M., Biddau, F., Brondi, S., Cottone, P., Mazzara, B.M., (2018). A multi-scale examination of public discourse on energy sustainability in Italy: Empirical evidence and policy implications. Energy Policy, 114, 444-454.

Saviano M., Barile S., Spohrer J., Caputo F., (2017). A service research contribution to the global challenge of sustainability. Journal of Service Theory Practice, 27, 951-976.

Siew, R.Y.J., (2015). A review of corporate sustainability reporting tools (SRTs). Journal of Environmental Management, 164, 180-195.

Sugino, M., Arimura T., H., Morgenstern, R. D., (2013). The effects of alternative carbon mitigation policieson Japanese industries. Energy Policy, 62, 1254-1267.

Tommasetti A., Del Bene L., Maione G., Leoni G. (2020), Environmental reporting, accountability and governance of local governments: an Italian multiple case study. African Journal of Business Management, 14, 229-242.

United Nations, (2015). Transforming our world: the 2030 agenda for sustainable development, Resolution 70/1 adopted by the General Assembly on 25 September 2015.

US SIF, (2020), Report on US sustainable, responsible and impact investing trends 2020, https://www.ussif.org/files/US%20SIF%20Trends%20Report%202020%20Executive%20Summary.pdf.

Venturelli, A., Caputo, F., Cosma, S., Leopizzi, R., Pizzi, S., (2017). Directive 2014/95/EU: are Italian companies already compliant? Sustainability, 9, 1-19.

Wang, H., Chen, Z., Wu, X., Nie, X., (2019). Can a carbon trading system promote the transformation of a low-carbon economy under the framework of the porter hypothesis? Empirical analysis based on the PSM-DID method. Energy Policy, 129, 930-938.

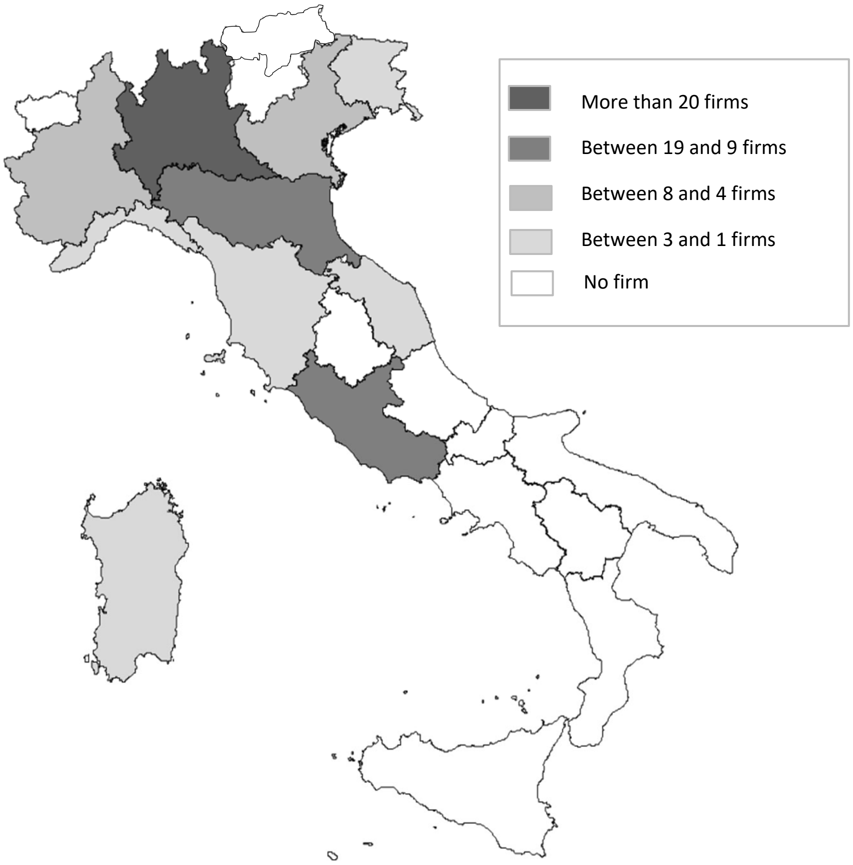
Walker, K., Wan, F., (2012). The harm of symbolic actions and green-washing: corporate actions and communications on environmental performance and their financial implications. Journal of Business Ethics, 109, 227–242.

Williams S. M. (1999), Voluntary environmental and social accounting disclosure practices in the Asia-Pacific region: an international empirical test of political economy theory. International Journal of Accounting, 34, 209-238.

World Economic Forum, (2020). The Global Risks Report 2020. http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf.

Figure

Figure 1 - Sample firms in the Italian regions



Notes: Author's elaboration on Refinitiv® Eikon-Datastream

Tables

Table 1: Comparison of observable policy adopters' characteristics – Average values for the period 2008-2019

	Macroeconomic conditions		*Firm environmental performance*			*Firm-specific characteristics*		
	Per capita GDP	*Unemployment rate*	*CO_2 emissions*	*Emission Category Score*	*Environmental Pillar Score*	*Liquidity*	*Profitability*	*Firm size*
Case (i) - General policies for reducing air emissions								
Regional policy adopters	33,902	5.08	51,028	29.19	32.70	6.21	4.51	30,200,000
Internal policy adopters	27,650	9.37	19,400,000	73.60	71.11	21.91	10.05	60,400,000
Regional and internal policy adopters	33,745	6.08	7,617,035	83.00	78.43	14.64	8.03	144,000,000
No policy adopters	28,280	7.26	145,793	30.28	31.37	18.62	-51.37	35,800,000
Case (ii) - Renewable energy interventions								
Regional policy adopters	35,740	4.95	515,564	24.50	26.90	7.29	8.72	27,700,000
Internal policy adopters	30,108	7.54	17,100,000	78.48	77.16	15.11	6.46	149,000,000
Regional and internal policy adopters	35,436	4.97	1,155,868	72.24	75.42	16.48	7.86	113,000,000
No policy adopters	30,267	5.88	-	29.34	29.19	1.21	-21.13	50,900,000
Case (iii) - Energy efficiency interventions								
Regional policy adopters	34,963	5.15	1,544,676	28.40	31.96	10.28	11.87	17,200,000
Internal policy adopters	31,105	7.56	19,400,000	77.61	76.76	10.27	8.44	89,900,000
Regional and internal policy adopters	34,504	5.43	1,733,244	80.64	77.57	16.28	9.25	162,000,000
No policy adopters	29,581	6.42	-	30.11	30.29	1.41	-19.02	45,600,000

Notes: Author's elaboration on Refinitiv® Eikon-Datastream, ISPRA and ISTAT data. Liquidity, profitability and firm size are proxied by means of the following variables: inventories, ROE and total assets.

Table 2: Multinominal probit regression on estimating the propensity scores when considering general policies for reducing air emissions (Case *i*)

	Regional policy adopters	**Internal policy adopters**	**Regional and internal policy adopters**
Per capita GDP	2.1229**	0.4161	2.0221**
	(0.9350)	(1.1107)	(0.9063)
Unemployment rate	0.8535	2.7705**	1.7640
	(1.1813)	(1.2224)	(1.1428)
Liquidity	-2.1030***	-1.4107*	-0.9023
	(0.7052)	(0.7278)	(0.6332)
Profitability	0.4262	1.9452*	0.6039
	(0.3628)	(1.0558)	(0.3690)
Firm size	-1.1076	0.2354	0.8805
	(1.0187)	(0.8239)	(0.7151)
Constant	2.3680	1.8701	4.0967***
	(1.5146)	(1.5731)	(1.4757)
Observations	117	117	117

Notes: Standard errors are in parentheses. A *(**)[***] indicates significance at the 10(5)[1] percentage level. Explanatory variables are standardized. Liquidity, profitability and firm size are proxied by means of the following variables: inventories, ROE and total assets.

Table 3: Multinominal probit regression on estimating the propensity scores when considering renewable energy interventions (Case *ii*)

	Regional policy adopters	**Internal policy adopters**	**Regional and internal policy adopters**
Per capita GDP	8.1191*	1.3019	3.8928**
	(4.3567)	(1.5250)	(1.6694)
Unemployment rate	-2.0749	0.4919	-3.3521
	(2.3085)	(0.8391)	(2.0438)
Liquidity	23.2160	23.6583	25.2632
	(17.9578)	(17.9285)	(17.9510)
Profitability	1.3548*	0.6399	0.7288
	(0.7465)	(0.5554)	(0.6726)
Firm size	-2.4406	1.6099*	1.8831*
	(2.0399)	(0.8414)	(1.0526)
Constant	13.0981	20.3763	17.9629
	(15.5035)	(14.7759)	(14.8626)
Observations	105	105	105

Notes: Standard errors are in parentheses. A *(**)[***] indicates significance at the 10(5)[1] percentage level. Explanatory variables are standardized. Liquidity, profitability and firm size are proxied by means of the following variables: inventories, ROE and total assets.

Table 4: Multinominal probit regression on estimating the propensity scores when considering energy efficiency interventions (Case *iii*)

	Regional policy adopters	**Internal policy adopters**	**Regional and internal policy adopters**
Per capita GDP	1.6472***	0.0133	1.5683***
	(0.5082)	(0.5053)	(0.4624)
Unemployment rate	-0.0476	1.4508*	-0.0844
	(0.8689)	(0.7435)	(0.8638)
Liquidity	45.8156	45.3455	46.8271
	(46.1834)	(46.1858)	(46.1821)
Profitability	1.3641	1.2370*	1.4350*
	(0.8471)	(0.7318)	(0.8078)
Firm size	-2.0816	1.0471	1.9502**
	(1.6583)	(0.8626)	(0.8806)
Constant	37.4221	38.8668	38.7129
	(38.5612)	(38.5667)	(38.5428)
Observations	118	118	118

Notes: Standard errors are in parentheses. A *(**)[***] indicates significance at the 10(5)[1] percentage level. Explanatory variables are standardized. Liquidity, profitability and firm size are proxied by means of the following variables: inventories, ROE and total assets.

Table 5: Testing the balancing hypothesis for the nearest neighbor matching in the three policy categories (*i*)-(*iii*)

	***Case (i)* General policies for reducing air emissions**			***Case (ii)* Renewable energy interventions**			***Case (iii)* Energy efficiency interventions**		
	Mean Bias		**Reduction in bias**	**Mean Bias**		**Reduction in bias**	**Mean Bias**		**Reduction in bias**
	Unmatched	**Matched**	**%**	**Unmatched**	**Matched**	**%**	**Unmatched**	**Matched**	**%**
P_R/P_0	25.40	0.80	96.70	76.90	0.00	100.00	63.30	0.00	100.00
P_R/P_F	50.70	0.40	99.20	125.60	0.10	99.90	104.40	0.00	100.00
P_F/P_R	93.70	0.10	99.90	122.60	0.00	100.00	103.90	0.00	100.00
P_F/P_0	46.60	0.10	99.70	14.10	0.50	96.60	12.40	0.70	94.20
P_{RF}/P_F	26.70	2.20	91.70	141.50	0.30	99.80	109.10	0.50	99.50
P_{RF}/P_R	76.40	0.30	99.60	17.40	2.40	85.90	2.40	2.00	19.20
P_{RF}/P_0	18.60	5.10	72.30	91.80	0.00	100.00	65.90	0.60	99.10

Notes: The performance of these tests is the same independently of the three dependent variables employed in the empirical analysis.

Table 6: The multiple treatment effects of environmental and energy policies applied at regional level and at firm level (alternatively or jointly) on CO_2 emissions

Treated/control	***Case (i)*** ***General policies for reducing air emissions***	***Case (ii)*** ***Renewable energy interventions***	***Case (iii)*** ***Energy efficiency interventions***
P_R/P_0	-1.7645**	-1.6601**	-1.6214**
	(0.7381)	(0.7030)	(0.6977)
P_R/P_F	-1.4162**	-1.4542**	-1.4979**
	(0.5496)	(0.6275)	(0.5859)
P_F/P_R	0.2539	6.5281	1.1499*
	(5.5526)	(8.1305)	(0.6142)
P_F/P_0	8.2054	0.1053	4.2895***
	(6.2401)	(11.3154)	(1.5937)
P_{RF}/P_F	-0.5248***	-1.3236**	0.0293
	(1.7068)	(0.6276)	(1.0855)
P_{RF}/P_R	-0.9465	-1.5504**	-1.0599*
	(4.1923)	(0.7058)	(0.6199)
P_{RF}/P_0	0.5779	-4.2102***	-2.5246**
	(0.8549)	(1.5026)	(1.1703)

Notes: The estimated treatment effects are reported as a percentage of the untreated outcome means. Robust standard errors under parenthesis. A *, **, *** indicates significance at 10, 5, 1 per cent level. Liquidity, profitability and firm size are proxied by means of the following variables: inventories, ROE and total assets.

Table 7: The multiple treatment effects of environmental and energy policies applied at regional level and at firm level (alternatively or jointly) on the Emission Category Score

Treated/control	***Case (i)*** ***General policies for reducing air emissions***	***Case (ii)*** ***Renewable energy interventions***	***Case (iii)*** ***Energy efficiency interventions***
P_R/P_0	-0.8755***	-0.7942***	-0.7451***
	(0.0737)	(0.0777)	(0.0748)
P_R/P_F	-0.8152***	-0.7342***	-0.5677***
	(0.0993)	(0.0647)	(0.0985)
P_F/P_R	0.2384	0.0450	0.3378***
	(0.1884)	(0.2743)	(0.0735)
P_F/P_0	0.0294	0.3572***	0.2595***
	(0.1805)	(0.0890)	(0.0789)
P_{RF}/P_F	0.8133***	0.3572**	0.6069***
	(0.0799)	(0.1293)	(0.0649)
P_{RF}/P_R	0.7682***	0.3959**	0.3195***
	(0.0612)	(0.1914)	(0.0980)
P_{RF}/P_0	0.8231***	0.2227*	0.4263***
	(0.0816)	(0.1153)	(0.0871)

Notes: The estimated treatment effects are reported as a percentage of the untreated outcome means. Robust standard errors under parenthesis. A *, **, *** indicates significance at 10, 5, 1 per cent level.

Table 8: The multiple treatment effects of environmental and energy policies applied at regional level and at firm level (alternatively or jointly) on Environmental Pillar Score

Treated/control	***Case (i)*** ***General policies for reducing air emissions***	***Case (ii)*** ***Renewable energy interventions***	***Case (iii)*** ***Energy efficiency interventions***
P_R/P_0	-0.6865***	-0.6672***	-0.6089***
	(0.0613)	(0.0601)	(0.0483)
P_R/P_F	-0.6509***	-0.6793***	-0.5740***
	(0.0480)	(0.0478)	(0.0609)
P_F/P_R	-0.0182	0.3971***	0.3322***
	(0.1332)	(0.0718)	(0.0564)
P_F/P_0	0.1556*	0.3589***	0.3002***
	(0.0859)	(0.0912)	(0.0683)
P_{RF}/P_F	0.6199***	0.2525	0.4086***
	(0.0587)	(0.1850)	(0.0802)
P_{RF}/P_R	0.6025***	0.1303	0.3998***
	(0.0587)	(0.2680)	(0.0691)
P_{RF}/P_0	0.6354***	0.2266***	0.3064***
	(0.0717)	(0.1157)	(0.0951)

Notes: The estimated treatment effects are reported as a percentage of the untreated outcome means. Robust standard errors under parenthesis. A *, **, *** indicates significance at 10, 5, 1 per cent level.

Appendix A

Table A.1 – The treatment indicator for each policy category (*i*)-(*iii*)

Policy group	*Value*	*Data Source*
		Case (i) - General policies for reducing air emissions
P_0	0	No policy
P_R	1	'Industrial plant emissions control' by ISPRA
P_F	2	'Policy Emissions' by Thomson Reuters Datastream
$P_{R,F}$	3	'Industrial plant emissions control' by ISPRA and 'Policy Emissions' by Thomson Reuters Datastream
		Case (ii) - Renewable energy interventions
P_0	0	No policy
P_R	1	'Renewable energy policies' by ISPRA
P_F	2	'Resource Reduction Policy' by Thomson Reuters Datastream
$P_{R,F}$	3	'Renewable energy policies' by ISPRA and 'Resource Reduction Policy' by Thomson Reuters Datastream
		Case (iii) - Energy efficiency interventions
P_0	0	No policy
P_R	1	'Energy efficiency sources' by ISPRA
P_F	2	'Policy Energy Efficiency' by Thomson Reuters Datastream
$P_{R,F}$	3	'Energy efficiency sources' by ISPRA and 'Policy Energy Efficiency' by Thomson Reuters Datastream

Notes: For each policy category (*i*), (*ii*) and (*iii*), each value of the treatment indicator, corresponding to each group of policy, is associated to its data source.

Table A.2 – The three policy categories implemented in the nine regions where firms have their headquarters in the years 2008-2011

Case (i) - General policies for reducing air emissions
Lombardy, Friuli Venezia Giulia, Emilia Romagna, Liguria, Lazio, Piedmont and Veneto
Case (ii) - Renewable energy interventions
Lombardy, Liguria and Marche
Case (iii) - Energy efficiency interventions
Lombardy, Liguria, Marche and Piedmont

Notes: Author's elaboration on ISPRA data.