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Do Environmental Policies Matter for Productivity Growth? Insights from New Cross-Country Measures of Environmental Policies

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By Silvia Albrizio, Enrico Botta, Tomasz Koźluk and Vera Zipperer

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ABSTRACT/RÉSUMÉ

Do Environmental Policies Matter for Productivity Growth? Insights from new Cross-Country Measures of Environmental Policies

Environmental policies address wellbeing and sustainability objectives, affecting firm and household behaviour. A newly developed, cross-country composite proxy of environmental policy stringency (EPS) shows that stringency has been increasing across OECD countries over the past two decades. However, the tightening environmental policies have had little effect on aggregate productivity, spurring primarily short-term adjustments. Nevertheless, they have led to various effects within the economy - the most technologically advanced industries and firms have seen a small increase in productivity, possibly being in the best position to adapt. Least productive firms have seen their productivity fall. Part of the effect is likely to have taken place through entry and exit of firms and relocation of activities. Finally, this project provides evidence on the anti-competitive bias of some aspects of environmental policies. The indicator of Burdens on the Economy due to Environmental Policies (BEEP) shows that barriers to entry and competition, and the consideration given to economic effects of environmental policies vary notably across countries, but that this variation is not related to the stringency of policies. Hence, to support both economic and environmental outcomes, stringent environmental policies can and should be implemented with minimum barriers to entry and competition.

JEL classification codes: Q58, Q50, O47.

Key words: environmental policies, environmental regulation, anti-competitive regulation, barriers to entry, multifactor productivity.

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Les politiques environnementales influent-elles sur la croissance de la productivité? Enseignements tirés de nouvelles mesures des politiques environnementales nationales

Les politiques environnementales sont axées sur des objectifs de bien-être et de durabilité, et influent sur le comportement des entreprises et des ménages. Un indice composite de rigueur des politiques environnementales, de couverture internationale, élaboré récemment montre que la rigueur de ces politiques s'est accentuée dans les pays de l'OCDE au cours des deux dernières décennies. Ce durcissement des politiques environnementales a cependant eu peu d'effets sur la productivité globale, entraînant essentiellement des ajustements à court terme. Néanmoins, cela a eu diverses répercussions dans les économies : les secteurs et les entreprises les plus avancés sur le plan technologique ont vu leur productivité progresser légèrement, peut-être parce qu'ils étaient les mieux placés pour s'adapter. À l'inverse, les entreprise dont la productivité était la plus faible ont vu celle-ci diminuer. Ces effets sont sans doute en partie liés à des entrées et sorties d'entreprises ainsi qu'à des transferts d'activités. Enfin, le projet fournit des éléments d'information sur les aspects anticoncurrentiels de la conception des politiques environnementales. L'indicateur de la charge imposée à l'économie par les politiques environnementales montre que ces obstacles varient sensiblement d'un pays à l'autre, mais que cette variation n'est pas liée à la rigueur des politiques. Par conséquent, pour favoriser la réalisation des objectifs visés tant sur le plan économique qu'écologique, il est possible et souhaitable d'appliquer des politiques environnementales rigoureuses tout en réduisant au minimum les obstacles à l'entrée préjudiciables à la concurrence qui en découlent.

Classification JEL: Q58, Q50, O47.

Mots clés: politiques environnementales, réglementation environnementale, réglementation anticoncurrentielle, obstacles à l'entrée, productivité multifactorielle.

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DO ENVIRONMENTAL POLICIES MATTER FOR PRODUCTIVITY GROWTH? INSIGHTS FROM NEW CROSS-COUNTRY MEASURES OF ENVIRONMENTAL POLICIES

By

Silvia Albrizio, Enrico Botta, Tomasz Koźluk and Vera Zipperer[1]

Box 1. Main findings

Over the past two decades, environmental policy stringency, defined as the explicit and implicit, policy-induced price of environmental externalities, has increased significantly in the OECD countries. A newly developed composite indicator of environmental policy stringency records increasingly stringent environmental policies in all the countries, but with notable differences in stringency levels - overall, and across different policy instruments.

Countries tend to opt for similar types of main policy instruments but differ notably across the stringency of market and non-market based instrument baskets. For example, the United Kingdom, Poland and Australia tend to show more relative stringency on market-based environmental policy instruments. Finland, Germany and Austria tend to have relatively more stringent non-market based policies, while in the other OECD countries the relative stringency is more balanced.

There is no empirical evidence of permanent effects of environmental policy tightening on multifactor productivity growth (MFP), positive or negative. Analysis based on a new cross-country dataset with unprecedented time-series coverage finds that all effects tend to fade away within less than five years.

No lasting harm to productivity levels is found at the macroeconomic, industry or firm levels. On the contrary, a tightening of environmental policies is followed by a temporary increase in productivity growth, leading an overall improvement in production efficiency for a large share of the manufacturing industries.

At the macro level, the anticipation of an environmental policy tightening may also temporarily slow productivity growth – possibly due to increased investment in preparation for an expected policy change. Productivity levels subsequently rebound due to the temporary acceleration in growth rates.

The temporary effects on productivity growth are not conditional on the stringency of environmental policies already in place, but may depend on the flexibility of the environmental policy instruments. In particular, market-based instruments tend to have a more robust positive effect on productivity growth.

Most advanced industries and firms see the largest gains in productivity levels, while less productive firms are likely to see negative effects. Highly productive firms, often the largest firms in the industry, may be best suited to profit rapidly from changing conditions – seizing new market opportunities, rapidly deploying new technologies or reaping previously overseen efficiency gains. They may also find it easier to outsource or relocate production abroad. Less advanced firms may need higher investments to comply with the new regulation, exhibiting a significant temporary fall in productivity growth.

Assuring a swift reallocation of capital and minimising barriers to entry are necessary conditions for the efficiency gains from environmental policy tightening to be translated into economic growth. A non-negligible part of the productivity gains is likely to come from the exit of the least-productive firms. To the extent such developments are not due to increased regulatory burdens and resources can be reallocated into fast growing firms, they can have a positive effect on overall economic outcomes.

1. This paper is part of the joint work of the Economics Department and Environment Directorate on Environmental Policies and Economic Outcomes. Tomasz Koźluk and Silvia Albrizio are members of the Economics Department and Environment Directorate of the OECD. Enrico Botta and Vera Zipperer were members of the Economics Department of the OECD at the time this paper was written. The authors would like to thank Jean-Luc Schneider, Simon Upton, Giuseppe Nicoletti, Shardul Agrawala, Nick Johnstone, Nathalie Girouard, Nils-Axel Braathen, Nicola Brandt, Ivan Hascic and Jehan Sauvage for their useful comments and suggestions. Special thanks go to Catherine Chapuis for statistical assistance and to Ines Gómez Palacio, Zoey Verdun and Sarah Michelson for editorial support.

Designing environmental policy interventions so as to avoid generating barriers to entry and competition can help achieve both environmental and economic objectives. Another OECD indicator based on countries' replies to a questionnaire measures to what extent environmental policy design unnecessarily increases fixed costs, imposes administrative burdens in permit and licensing procedures, results in the lack of coherent and consistent information or distorts competition via vintage-differentiated regulations or tax and subsidy policies related to historical performance.

Cross-country evidence suggests that high barriers to entry and competition are not a necessary feature of stringent environmental policies. The new OECD indicator shows that stringent environmental policies can be pursued in a way that is more competition-friendly, with relatively low administrative burdens and little discrimination against new entrants. Results point to examples such as the Netherlands, Austria, Switzerland and possibly the United Kingdom. On the other hand, in Greece, Italy, Hungary and Israel environmental policies do not appear particularly stringent, but could benefit from lower distortions to entry and competition.

1. Introduction

1. Environmental policies contribute to wellbeing and the long-term sustainability of growth. Their purpose is to achieve environmental objectives that markets fail to deliver, primarily by making pollution and, more generally environmental services, more costly in order to change both producer and consumer behaviour. In this respect, more stringent environmental policies can be seen as equivalent to higher costs of environmentally-harmful behaviour.

2. Several aspects of environmental policies have been hypothesised to have effects on economic activity. Stringency has been of primary interest, along with other design characteristics, such as flexibility, depth, predictability and competition-friendliness (Box 2). For the case of policy stringency, the empirical insights on these hypotheses has been weak and focused on specific policies in specific contexts (see for example, Koźluk and Zipperer, 2014). Empirical evidence concerning other design features of environmental policies has been lacking making it hard to draw policy relevant conclusions on these aspects. This has left the door open for interpretations that could often serve the interest of the firms and sectors targeted by the policies, to the detriment of economy-wide concerns – potentially both economic and environmental.

3. This paper makes a number of contributions to the debate on links between environmental policies and productivity growth:

- First, it introduces a time-series of composite cross-country indicators of environmental policy stringency (EPS). These indicators summarise actual policy data collected over two decades covering selected environmental policy instruments in OECD countries to arrive with a relative measure of overall policy stringency. The resulting measure is a proxy of the overall policy stringency, nevertheless has the widest coverage over time, countries and policies to date. It allows for broader, more general and longer-term cross-country comparisons and empirical analysis of economic effects of environmental policy stringency.

- Second, based on this new dataset a cross-country analysis on the effects of environmental policy stringency on productivity growth in OECD countries is conducted. This analysis exploits a broad cross-country dimension, as well as, assesses the effects over time – a novelty with respect to previous literature in this area. Furthermore, the analysis is conducted at three levels of aggregation: macro, industry and firm level to provide deeper insights on the nature of the effects and improve robustness. Finally, this exercise provides some tentative findings on channels through which environmental policy stringency may affect productivity growth and how effects may depend on some of the characteristics of policies.

- Third, the paper proposes an additional indicator to quantify specific design features and practices of environmental policies, which are likely to impose burdens to firm entry, competition and adoption of new technologies – labelled as the indicator of Burdens to the Economy due to

Environmental Policies (BEEP). The information is based on the responses to a cross-country OECD questionnaire annexed to the 2013 Product Market Regulation (PMR) exercise. It addresses the information gap on characteristics of environmental policies which are potentially relevant for longer-run growth. The indicator provides information on how barriers to competition are related to overall stringency of policies across countries.

4. While shedding new light on a number of key issues, this paper is unable to address all the outstanding questions, for example addressing details of environmental policy design and their effects on other economic outcomes. For this reason, it also suggests a number of follow-up areas of work, which can improve the understanding of the link between environmental policies and economic growth.

5. The paper starts with a description of a framework for assessing the productivity impacts of environmental policies and a review of existing evidence (Section 2). This is followed by a description of the new measures of environmental policy stringency (EPS indicator) and related barriers to entry and competition (BEEP indicator), and the performance of countries on these measures (Section 3). Section 4 uses the new stringency indicator and its subcomponents to assess the effects of environmental policies on productivity growth. A conclusion follows, sketching some ideas for future work.

Box 2. A number of design features of environmental policies matter for economic outcomes

The potential economic effects of environmental policies hinge on a number of interlinked characteristics of the instruments:

- *Policy stringency* is the "price" attributed to environmental externalities in response to the public-good nature of many environmental assets. The price can be explicit, such as in the form of a tax on externalities or pricing of pollution permits; or implicit, through standards, bans and restrictions on particular activities and substances – effectively attributing a prohibitively high implicit price to the externality. Higher subsidies to "green" activities can be seen as more stringent environmental policies, as they increase the opportunity costs of pollution. Similarly, policies addressing information and other market failures make the costs of environmental externalities more explicit.

- *Dynamic efficiency (or depth)* – is the extent to which a policy instrument gives continued incentives to search for cheaper abatement options (e.g. via innovation).

- *Flexibility* describes the extent to which the policy is prescriptive in determining whether firms (or consumers) can choose the way to reach the environmental objective. It is linked to dynamic efficiency, as flexible policy interventions should be better suited to accommodate new ideas, innovation and technology adoption.

- *Predictability* – the consistency, credibility and predictability of the policy signal can drive investment, innovation and eventually productivity growth. The certainty that the price of a particular externality will increase in the future provides stronger incentives to adopt long-term abatement strategies.

- *The competition-friendliness* aspects of environmental policies are less often recognised, but are potentially as important for overall economic outcomes as other product market regulations, such as in network sectors or services. Competition is a key component of the OECD's Green Growth Strategy (OECD, 2011) and minimising the distortions to a level playing field coming from the design and implementation of environmental policies can improve both economic and environmental outcomes. Lower barriers to entry and competition encourage innovation, adoption of cleaner technologies and entry of environmentally friendly business models.

Source: Koźluk, 2014; Johnstone and Hascic, 2009; De Serres et al., 2010.

2. Environmental policies and productivity: framework and existing evidence

6. Environmental policies can affect GDP per capita via a number of channels: productivity, capital intensity, labour participation and human capital. A rigorous classification of potential effects is a complex and still largely underdeveloped agenda. They depend on the assumed time horizon, the type of policy analysed, its design characteristics (including potential funding or revenue use and distributional impacts), the type of environmental benefits coming from the policy, trade openness and the elasticities of substitution between the environment, capital and labour (Fullerton and Heutel, 2007). Ultimately, the actual sign and magnitude of the effects on each of these channels is an empirical issue, which provides the main motivation for this paper.

7. A brief discussion of the effects of environmental policies may require abstracting from the potential longer-run economic implications of environmental improvements, such as through impacts on sustainability and health, which can have complex effects on each component of GDP per capita, including labour participation and even human capital (Miller and Vela, 2013). Even a relatively simple case, where environmental policy stringency is assumed to increase the relative price of environmental inputs with respect to capital and labour, allows the identification of several potential channels:

- *Effects on productivity and efficiency*. As discussed in more detail in the following section, effects on multi-factor productivity and its drivers, for example innovation, have been subject to a heated debate in environmental economics. On the one hand, proponents of the so-called Porter Hypothesis (Box 3), claim that environmental policies may improve incentives to innovate and seek previously overseen efficiency improvements. On the other hand, policies that provide incentives to redirect innovation resources to reduce the cost of environmental inputs - which are not accounted for in a traditional productivity measure - may mean an overall fall in measured productivity growth as fewer resources are channelled into "productive" innovation.

- *Effects on capital intensity.* The higher cost of the environmental input will affect the balance between these inputs, labour and capital – with effects depending on the substitutability among them, static and dynamic. For example, capital may be a substitute for environmental inputs – as in the case of abatement equipment or more pollution-efficient machines. At the same time, if polluting industries are more capital intensive, environmental policies curbing the activity of such industries, may actually decrease the capital-output ratio. A similar case can be made for labour, which may also be a substitute or complement to pollution.

- *Effects on labour participation.* Labour participation is unlikely to be directly affected in the short- to medium-term, with eventual second-order effects that can come from changes in real wages, induced through the other channels.

- *Effects on human capital.* Direct effects of environmental policies on human capital accumulation are fairly unlikely. Reallocation of specific types of human capital investment may potentially take place in the longer-term, in response to changing demand for skills.

8. The analysis in this paper focuses on multifactor productivity growth (MFP), which is a key determinant of long-term growth of output, income and living standards. Thus it takes a first step in shedding light on the effects of environmental policies on GDP per capita. Still, a fuller, better understanding of overall effects of policies on economic outcomes and the underlying channels necessitates the analysis of effects on all components of GDP per capita. While such an analysis is beyond the scope of this paper, it is proposed as a natural follow-up in the concluding section.

2.1 Costs or opportunities – implications of environmental policies

9. Environmental policies are seen either as imposing a net burden on production or as providing incentives to improve productivity. The first view has motivated many studies, initially centred on the United States and trying to relate the productivity slowdown of the 1970s to the introduction of more stringent environmental policies. Overall, results were inconclusive, with estimates of the contribution of environmental policies to the slowdown ranging from nil to a third of the slowdown in manufacturing sectors, with extreme values of one half in the electric utilities sector (see Christainsen and Haveman, 1981; Gray, 1987; Jaffe et al. 1995; for reviews). Most of the early studies suffered from serious methodological issues, namely poor identification strategies and flawed measurement of the environmental policy shocks.

10. The second view, also known as the Porter Hypothesis, suggests that "well-designed" environmental policies might actually enhance productivity and increase innovation, yielding not only environmental but also direct economic benefits (Box 3). The idea, focused on the firm level, is that policies can help managers to overcome market failures and behavioural biases and find unexploited profit opportunities. Under the so-called strong version of the hypothesis, the benefits from improved production can outweigh the costs of complying with the environmental policy measures.

Box 3. Porter's Hypothesis and some of the theoretical underpinnings

In the early 1990s, the debate around the economic impacts of environmental regulation gained new momentum through an article written by M. E. Porter. He claimed that properly designed environmental regulation can trigger innovation which in turn can decrease, and even offset the costs of pollution abatement and enhance competitiveness (Porter, 1991; Porter and van der Linde, 1995). Initially, the Porter Hypothesis was backed by anecdotal examples collected by the authors, without a rigorous theoretical explanation of the factors at work or any comprehensive empirical evidence – many of these were developed only subsequently (Ambec et al., 2013; Wagner, 2003).

Arguments backing Porter's Hypothesis are often behavioural - based on the idea that managers may be risk averse, myopic or rationally bounded and hence may not be able to realise all profitable investment opportunities. Other arguments include the presence of market failures, such as imperfect competition (due to first-mover advantage or barriers to entry), asymmetric information (where "green" products are not correctly valued by consumers), R&D spill-over effects (as innovation has a public good character and leads to underinvestment), and organisational failure (where managers are able to lie about the true abatement costs in order to secure extra personal profits). Hence, in each such case, environmental regulation may hence potentially induce investments which turn out to be profitable *ex post*.

In an attempt to better categorise empirical testing approaches, the Porter Hypothesis has been differentiated into weak, strong and narrow versions (Jaffe and Palmer, 1997):

- In *the weak version of the Porter Hypothesis* environmental regulation will lead to an increase in 'environmental innovation', that is more innovation directed at minimising the costs of the environmental input/output subject to regulation (as implied by Hicks, 1932). An increase in "environmental" innovation may come from a pure redirection of innovation efforts, without any net increase in the latter.
- In *the strong version,* the costs saved from innovation and the improved production processes will outweigh compliance costs, leading to increased productivity, profitability and competitiveness.
- In *the narrow version* more flexible environmental policy instruments - designed to target the outcome rather than the design of the production processes - are more likely to increase innovation and improve company performance.

Porter's original concept focused on firm-level activity, emphasising the potential "optimistic" aspects of gains in productivity, profitability and competitiveness gains induced by environmental regulations. Examples cited in the original work concerned mainly improvements in production processes through the development and adoption of new technologies and cost-savings. However, particularly at a more aggregate level, productivity improvements may actually come from the cut-back or outsourcing of less efficient activities and the exit of less efficient firms – with more general economic outcomes hinging on issues such as a swift reallocation of resources.

Source: Koźluk and Zipperer, 2014.

11. Porter's claims led to a second wave of studies exploring various ways to test his conjecture (see Ambec et al. 2012, for a review). Here as well, the results for productivity growth were not conclusive, with positive, negative or insignificant estimates depending on the study. Most of the studies at the plant and industry level focused on very specific policy measures - implying a lack of generality of conclusions from such studies – and many (in particular early) studies suffered from methodological problems such as failing to control for firm or industry characteristics. Even among the studies that used environmentally-adjusted measures of productivity, no consistent pattern was identified. The only robust finding concerns the effects on "environmental" innovation (Box 3; Brunnermeier and Cohen, 2003; Lanjouw and Mody, 1996). Still, the few studies considering proxies for overall business innovation generally find insignificant effects, indicating that environmental policies may only change the composition of innovation efforts (Jaffe and Palmer, 1997).[2]

12. A related way to cast the dilemma between costs and opportunities is whether the net effect of environmental policies is to stimulate or harm economic activity - both in the short- and long-term. Clearly, such policies set in motion structural adjustments that result in sun-setting of some activities and encourage the undertaking of some others. For example, in the absence of state intervention the market for some types of monitoring equipment, filters, municipal waste or wastewater treatment and other broadly defined environmental goods and services would be unlikely to exist or be up to scale (Adlung, 2009; OECD, 2013). More broadly, environmental policies may lead to spillovers across firms, industries and countries which have rarely been explored in empirical exercises – for instance, renewable energy support in a number of OECD countries has been found to have significant effects on the development of the photovoltaic industry in China (Cao and Groba, 2013). Finally, some types of economic activities can benefit from the environmental consequences of policies – for instance, industries using water as an input may benefit from the fact that water becomes cleaner, as they can reduce inputs devoted to water purification (Jaffe et al. 1995). Similarly, workers may become more productive if the adverse effects of air pollution on their health are curbed (Ostro, 1983 or more recently Graff Zivin and Neidel, 2012, 2014; Isen et al., 2014). The overall effect is ambiguous – with losses in some activities and productivity gains in others, partly related to the existence of scale economies arising from generated demand.

13. Two additional channels through which differences in environmental policies across countries can affect the balance between negative and positive short-term effects on productivity are the "leakage" of polluting activities to countries with laxer emission limits (the so-called "pollution haven" hypothesis) and possible "first mover advantages" in undertaking cleaner activities in countries where they are encouraged by stricter policies. In the longer-term, terms-of-trade adjustments can be expected to mitigate these effects. The discussion is complex and empirical results are fragile, not least because even a priori it is not clear what the aggregate productivity effects of such delocalisation or first-mover advantages would be in the domestic economy. An accurate analysis, which is beyond the scope of this study, would require taking into account productivity gains or losses through the whole global supply chain and accounting for technological differences across countries.

2.2 Methodological issues

14. To gauge the effects of environmental policies on productivity, the latter should, in principle, be defined to include environmental services.[3] Omitting the role of environmental services can lead to various

2 . Jaffe and Palmer (1997) themselves actually find an effect of increased Pollution Abatement and Control Expenditures (PACE) on total R&D spending, but not on patent outcomes.

3. Throughout this paper, environmental services are defined in line with the OECD Glossary, as the "qualitative functions of natural non-produced assets of land, water and air (including related ecosystem) and their biota." This encompasses "three basic types of environmental services: (a) disposal services, which reflect the functions of the natural environment as an absorptive sink for residuals, (b) productive

sources of bias. Productivity growth is measured as the difference in the growth of outputs and the growth in inputs, and to the extent that inputs from environmental services are unobserved, changes in their use will be falsely attributed to productivity changes. The solution is to develop "environmentally-adjusted" measures of productivity (Box 4). However, as attempts to adjust productivity for environmental services are only being developed, most studies, including this one, focus on conventionally-defined productivity. Moreover, available estimates tend to show that environmental services are likely to have a cost share that is shadowed by the costs of labour and capital, implying that the adjustment for environmental services may not actually be that large (Brandt et al., 2014).

Box 4. Accounting for environmental services – green MFP and other approaches

Environmental services, such as the use of natural inputs and sink services provided by the environment are ignored in traditional measures of productivity. In response, an increasing number of studies attempt to incorporate some of these services. Two methodologies dominate the literature - a distance function and an adjusted growth accounting framework.

In the distance function framework, quantity data on inputs, traditional outputs and "bad" outputs are used to determine the technological production frontier, describing all possible efficient input/output combinations. For each possible input-output combination, the distance function then measures the possible efficiency gain of moving from an inefficient point on to the frontier. Studies that evaluate the effects of environmental regulation on productivity often model three scenarios by varying the assumption about the bad output: free disposability of bad outputs; a constant level of bad outputs while good outputs increase; and a reduction of bad outputs at the same time as good output increases.

The second approach, based on a growth accounting framework, adjusts traditional productivity growth by the weighted difference of bad output and input growth. This requires assumptions on explicit shadow prices of pollutants (for an application, see Repetto et al., 1997 and Brandt et al., 2013 and 2014).

A key problem in applications of the above frameworks is linked to the choice of environmental "bads" and their implicit weights that depend on the underlying shadow prices – which can be time and location specific. It is not feasible to adjust for all environmental effects due to lack of understanding of the underlying environmental developments in many cases, but also due to the lack of data. This requires focusing on externalities that are the highest on policymakers' agenda (e.g. climate change, air and water pollution) and for which data are available. Studies tend to differ vastly in terms of shadow price assumptions, hindering comparability and generality of conclusions. Among bad output measures used are CO_2 emissions (Wu and Wang, 2008), a combination of air and water pollutants (Yörük and Zaim, 2005), air, water and toxic pollutant releases (Boyd and McClelland, 1999) and CO_2, NO_X and SO_X emissions (Brandt et al., 2014). Inevitably, such adjustments need to limit the bad outputs to a handful of environmental issues, meaning they may also hide an increase in other, non-measured environmental bads. Shadow prices of pollutants are rarely available and need to be estimated separately or proxied with observed prices, for example resulting from policies such as environmental taxes.

Both approaches are fragile to the underlying assumptions. In the distance function framework, Data Envelopment Analysis (DEA) allows calculating implicit shadow prices of pollutants, which are the basis for the productivity adjustment. As most of the studies do not report these prices, it is not possible to assess whether they take reasonable values.

Source: Koźluk and Zipperer, 2014.

15. Another source of potential mis-measurement comes from the impact of environmental policies on the stock of productive capital. Indeed, policies can accelerate the obsolescence of part of the capital stock – for instance if certain technologies or activities are no longer viable (Xepapadeas and de Zeeuw,

services, which reflect the economic functions of providing natural resource inputs and space for production and consumption, and (c) consumer or consumption services, which provide for physiological as well as recreational and related needs of human beings." These are also sometimes referred to as eco-system services, to avoid confusion with environmental goods and services (EGSS) – specific goods and services associated with various potential "environmental benefits" - used in the context of specific sectors and trade literature.

1999; Hamamoto, 2006). Since the scrapping rate used by national accountants for the calculation of the capital stock – and hence MFP growth – is usually assumed to be immune to such changes (Schreyer et al., 2011), the productive capital stock will tend to be overestimated. At the same time, environmental policies may also have the opposite effect to extend the life of some existing capital goods - for instance vintage-differentiated regulations (VDRs) and higher entry barriers can prolong the life of old and otherwise unviable plants, with the opposite effect on productivity measurement (see Nelson et al. 1993, Stavins, 2005 for the case of New Source Review in the US Clean Air Act; and Ahman et al., 2006 and Betz, Eichhammer and Schleich, 2004, for EU's Emission Trading Scheme).

16. The assessment of longer-term effects is an additional challenge. In particular, the contribution of environmental policies to the sustainability of productivity growth, through preserving the environment, may be beyond the scope of any empirical study, due to the long time horizon, lack of adequate data, problems in identifying a counterfactual and the uncertainty and knowledge gaps surrounding the impacts of environmental developments on the economy (OECD, 2013). In practice, most available papers focus on short-term effects on productivity and only a handful test for the significance of lags beyond two years (Koźluk and Zipperer, 2014).

17. A closely linked issue is the timing of effects. For example, an increase in the stringency of environmental policy can induce additional investments or expenses necessary for compliance – such as new plants and production lines, end-of-pipe cleaning equipment, measurement instruments or decisions to hire new staff. However, this expenditure may be made well in advance – before or upon the adoption of a new law - so that the appropriate equipment is in place once the law is enforced or at the time of the policy implementation. Investments may also take place *ex post*, due to adjustment periods, weak enforcement and adoption of temporary solutions to comply with the law. *Ex post* investments can also be induced by continued incentives coming from more dynamically-efficient policy instruments – e.g. a tax or a multi-year cap on emissions. Thus the effects of an increase in environmental policy stringency on productivity may be felt in advance or after its implementation, making it difficult to identify them empirically.

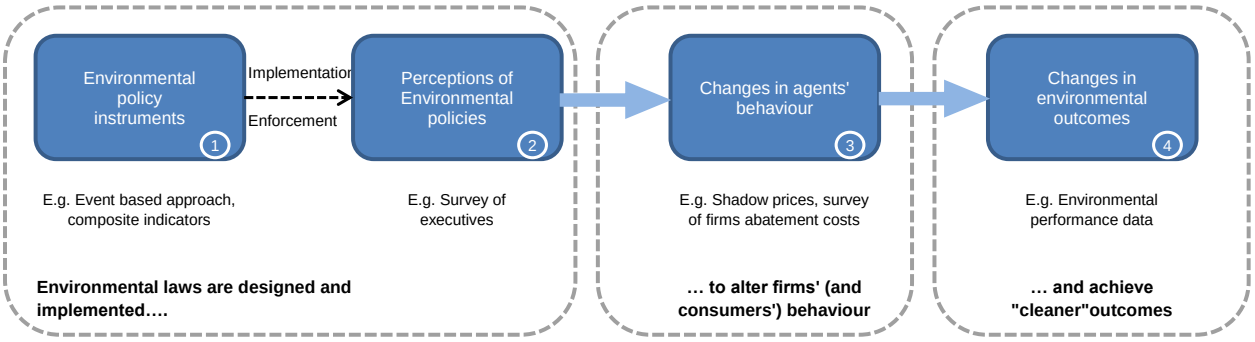
18. Finally, accounting for the design of policies is likely to be of importance for evaluating the economic effects of environmental measures (Box 2). The main challenges include disentangling the effects of various design characteristics, as well as, collecting and quantifying data on the design features.

3. Environmental policies in OECD countries – insights from new policy indexes

19. Measuring and comparing environmental policies can be executed at various points of the policy transmission channel – from the direct recording of laws all the way to the environmental outcomes they induce (Figure 1, following Botta and Koźluk, 2014). In the most popular empirical applications, *single policy event* measures prevail (bubble 1 in Figure 1) while *composite indicators of policies* are poorly available (Dasgupta et al., 1995; and EBRD, 2011; provide the only composite cross-country indexes, though no time series are available).

20. Survey-based *measures of perceived stringency* (bubble 2, Figure 1) respond to the need to cover enforcement of laws (World Economic Forum's Executive Opinion Survey is the most comprehensive source on managers' policy perceptions). The extent to which environmental policy stringency affects *firms' production and investment decisions* (bubble 3, Figure 1) and related measures can also serve as a proxy for *de facto* policy stringency. In this respect survey data on pollution abatement and control expenditures (PACE) and estimated shadow prices of pollutants are commonly used in the literature. Finally, *measures based on environmental outcomes* (bubble 4, Figure 1) include emission intensity of the economy (pure or conditional on the industry structure, as proposed by Brunel and Levinson, 2013) or landfilling rates for solid waste and wastewater treatment rates (Sauvage, 2014).

Figure 1. Framework for measuring environmental policy stringency



Source: Botta and Koźluk, 2014.

21. Attempts to measure environmental policies face many practical challenges (Botta and Koźluk, 2014):

- *Multidimensionality* is the central challenge of summarising information in a multitude of environmental (different media, pollutants, externalities and activities) and policy (instruments, exemptions, phase-in periods, accompanying measures, etc.) dimensions, each of them having different and often not easily interpretable implications for overall stringency.

- *Identification* relates to the ability of linking the observed changes in measures of stringency (for example those based on environmental outcomes or perceptions), to actual policies, rather than effects of other policies (such as in labour and financial markets or competition), market failures, outsourcing and trade, or country characteristics, such as exogenous comparative advantages and the level of development. It encompasses the issue of enforcement, where the differences between legislation and the actual strictness of policy may differ across countries.

- *Sampling and measurement error* are linked to the fact that the sample of industries subject to policies may be driven by the policies themselves. In a country with stringent environmental policies, highly polluting activities may be scarce and hence have a low weight in a respondent sample – hence the majority of respondents may not actually perceive policy as stringent or have high pollution abatement and control expenditures. At the same time, sectors scarcely concerned by environmental policies directly are likely not to perceive some of the indirect effects as effects of environmental policies (e.g. they may not attribute higher electricity prices to environmental policy stringency).

- *Data issues* concern the coverage and the potential of backtracking observations.

22. No measure is likely to be satisfactory in respect of all these challenges, and there are trade-offs among them. Hence, while an ideal measure does not exist (Brunel and Levinson, 2013), one striking gap among the available proxies is the lack of a composite index summarising selected "representative" environmental policies across countries and time – in the manner that the OECD's product market regulation indicators or employment protection legislation indicators summarise complex policies in their respective areas (Nicoletti et al., 2000).

3.1 The stringency of environmental policy instruments across OECD countries

23. This section describes the construction of a composite measure of environmental policy stringency (EPS) for the purpose of cross-country empirical analysis (Box 5). The policy instruments included in the indicator is largely data driven – the indicator covers primarily policies concerning climate and air pollutants, in the energy and transport sectors. The underlying assumption is that a stringent approach to environmental issues across a number of key pollutants, industries and media is representative of a more general preoccupation with environmental issues across all domains. Such an assumption, while not directly testable, is likely to be more viable when a large amount of instruments from broad and representative domains are included. Furthermore, as a robustness check, the results are cross-checked with additional variables, for which there is not enough data for full inclusion, but which are representative of important environmental domains (for example, water pollution norms; see Botta and Koźluk, 2014). Finally, the indicator is relatively stable with respect to the weighting and aggregation method. The resulting indicator has broader coverage than other available direct policy measures in terms of countries and time jointly. It can also be easily updated and expanded once relevant data become available. Country rankings and confidence intervals (reflecting the results of a random weighting exercise) are shown in Figure 3.

Box 5. A composite index to compare environmental policy stringency across time and countries

The policy indicator proposed in Botta and Koźluk (2014) builds on and expands previous data collection efforts at the OECD (including the Environmental Policy Instruments Database) and the IEA. It aggregates stringency across a number of selected environmental policies to form a composite measure of relative policy stringency across countries. The underlying objective is to achieve the broadest OECD country coverage starting in 1990, at the expense of restricting the dataset to key selected policy tools and areas. Overall, the indicator groups policies in industries of prime environmental importance and similar reliance across countries - energy sector policies (most of the tax measures, feed-in-tariffs, renewable energy certificates, R&D expenditures and emission limit values for coal-fired power plants), with two transport sector indicators and information on deposit and refund schemes. The main environmental domains covered are air pollution and climate.

For each instrument, stringency is defined as a higher implicit or explicit price put on the relevant environmental externality. This concerns “stick” type of policies punishing polluting behaviour – for example higher taxes or stricter standards are regarded as more stringent. Similarly, in the case of “carrot” type policies, rewarding “environmentally friendlier” activity, higher feed-in-tariffs or R&D subsidies are associated with higher stringency. Notably, in the case of the EU ETS, stringency is beyond the direct control of national policymakers. Furthermore, a number of popular policy instrument categories are not considered, due to problems in assessing stringency and obtaining relevant information (for example, voluntary approaches, labelling obligations and tax incentives for investment).

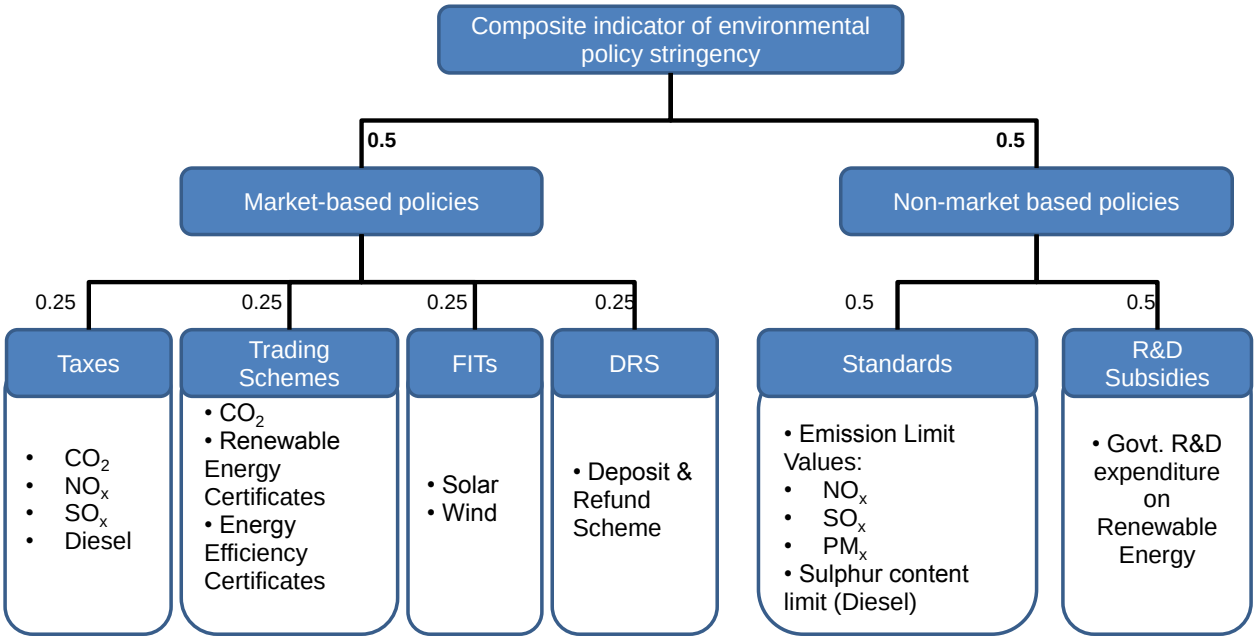
For each individual instrument, the quantitative, or qualitative, information is normalised (where relevant, e.g. for price data) and scored on a 0-6 scale based on a within-sample distribution (0 is assigned when the instrument is not present in a country). The thresholds for each bin are determined based on the stringency of the given measures across countries and time – implying that, for each instrument, stringency is measured relative to the entire distribution of the sample, rather than in absolute terms. The scores are then aggregated by instrument type (taxes, trading schemes, emission standards), instrument category (market-based and non-market based) and further on using equal weights at each stage (Figure 2). The indicator covers the years 1990-2012 for 25 OECD countries.

The scoring adopted differs from that for the OECD PMR, as it is relative – explicitly dependant on the distribution of individual policy stringency across time and countries. This has several advantages in the EPS context – in particular when looking at different environmental externalities and domains, which are not straightforward to compare – but also some disadvantages, for instance adding new countries and years to the sample may require a re-estimation of thresholds and bins and hence a reattribution of scores. For each policy instrument the variability of the distribution of stringency (pooled across countries and time) is imposed as similar due to scoring. In reality, instrument stringency distributions may differ, but there is no straightforward way to compare stringencies across different environmental domains and pollutants directly.

For the above reasons, the EPS measure should be treated and used as a proxy for aggregate environmental policy stringency, and Botta and Koźluk (2014) provide some evidence showing it performs well in this respect. However, disaggregating into low-level subcomponents may prove more problematic, as the main strength of the EPS indicator is based on the wealth of information from different environmental policy instruments.

Box 5. A composite index to compare environmental policy stringency across time and countries (*continued*)

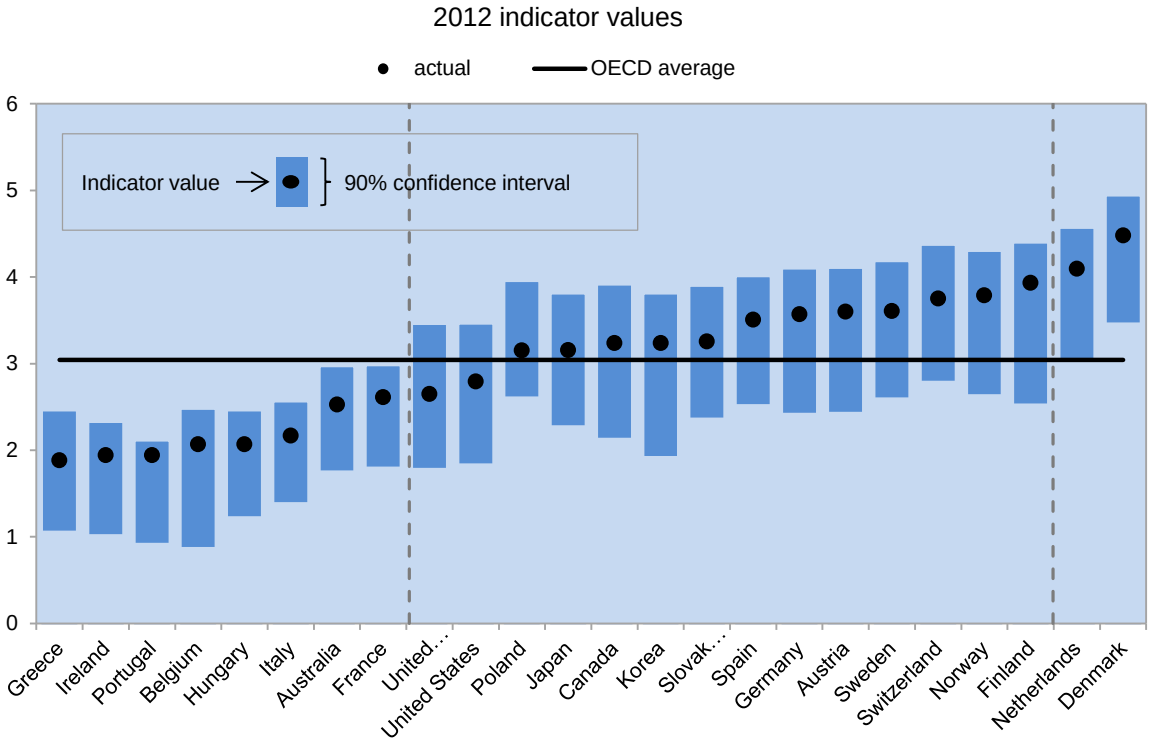
Figure 2. Aggregation structure of the composite indicator of environmental policy stringency



Note: FITs encompasses feed-in tariffs and feed-in premiums for renewable energy (wind and solar).

Source: Botta and Koźluk, 2014; OECD/EEA Environmental Policy Instruments www.oecd.org/env/policies/database.

Figure 3. The EPS indicator: country rankings and random weight intervals



Note: Random weights' generated 90% confidence intervals. The random weights are applied at the individual policy instrument level (within domains) and on the domains themselves in order to preserve the aggregation structure. For details see Botta and Koźluk (2014) and Woelfl et al. (2009). Vertical dotted lines separate countries significantly lower and higher than the OECD average.

Source: Botta and Koźluk, 2014.

24. The EPS indicator has, of course, drawbacks. The assumption on representativeness may not hold for all countries in a similar fashion. It will be invalid if a country uses very different instrument baskets, unevenly covered by the indicator – for example, a country resorting only to voluntary approaches would score zero on the EPS index. So would a country with no environmental policies in the covered domains (air pollution and climate) and sectors (energy and transport). In both cases, there could be a measurement issues as there could still be stringent environmental policies addressing broad environmental issues – not captured by the EPS indicator. Furthermore, inclusion of new policy instruments may not be straightforward in the case of increasingly specific instrument types. For similar reasons, lower-level subcomponents may also not be meaningful or representative of total EPS. Finally, the focus on *de jure* rather than *de facto* policies may complicate extensions to countries with large unofficial economies and weaker enforcement.

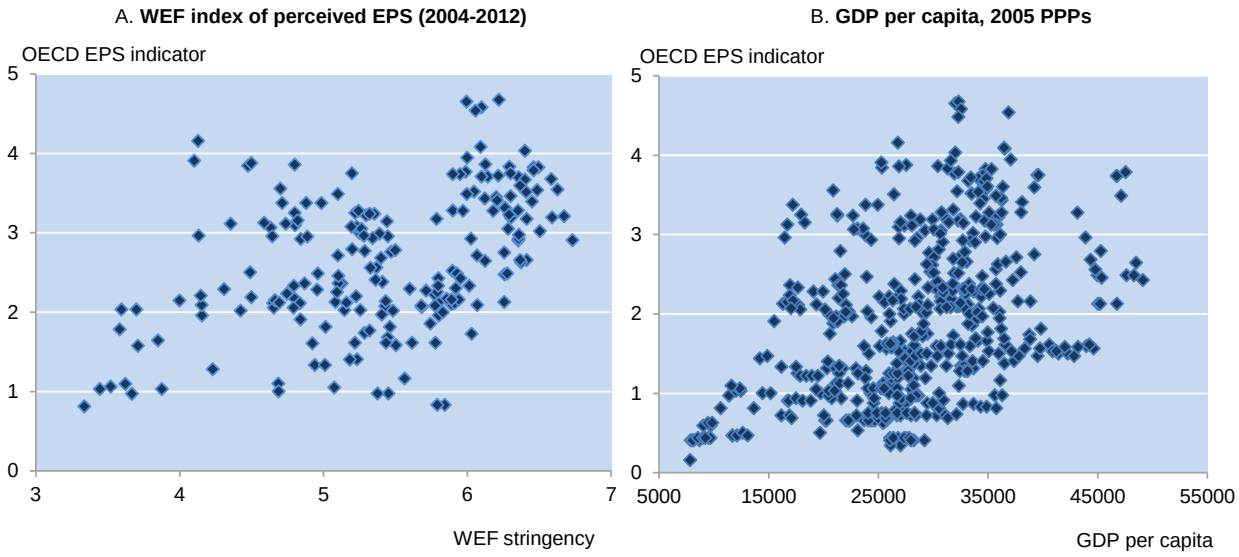
25. Nevertheless, the EPS index shows a number of encouraging empirical properties. It exhibits significant correlations with the World Economic Forum (WEF) index of perceived environmental policy stringency (0.44, Figure 4)[4] and EBRD's CLIMI index of climate policies (0.54) (EBRD, 2011) where samples overlap. The index also shows a positive significant correlation with GDP per capita (0.4) and significant correlations with selected measures of environmental performance (Botta and Koźluk, 2014).

4 . The correlation is significant at 99% confidence levels.

Interestingly, the correlations with "green" patent count indicators are highly significant at around 0.3, in particular for the market-based subcomponent (in line with the weak and narrow versions of the Porter Hypothesis – see Box 3).

Figure 4. EPS index: comparison with selected variables

2004-2012 sample, pooled across years and countries



Source: Botta and Koźluk, 2014.

26. Turning to the country rankings, the Nordic countries, the Netherlands, Switzerland, Germany and Austria exhibit the highest relative stringency (Figure 5). Turkey (available only till 2010), the peripheral EU countries and Belgium are at the other end of the distribution.

3.2 Market-based policies versus command and control policies

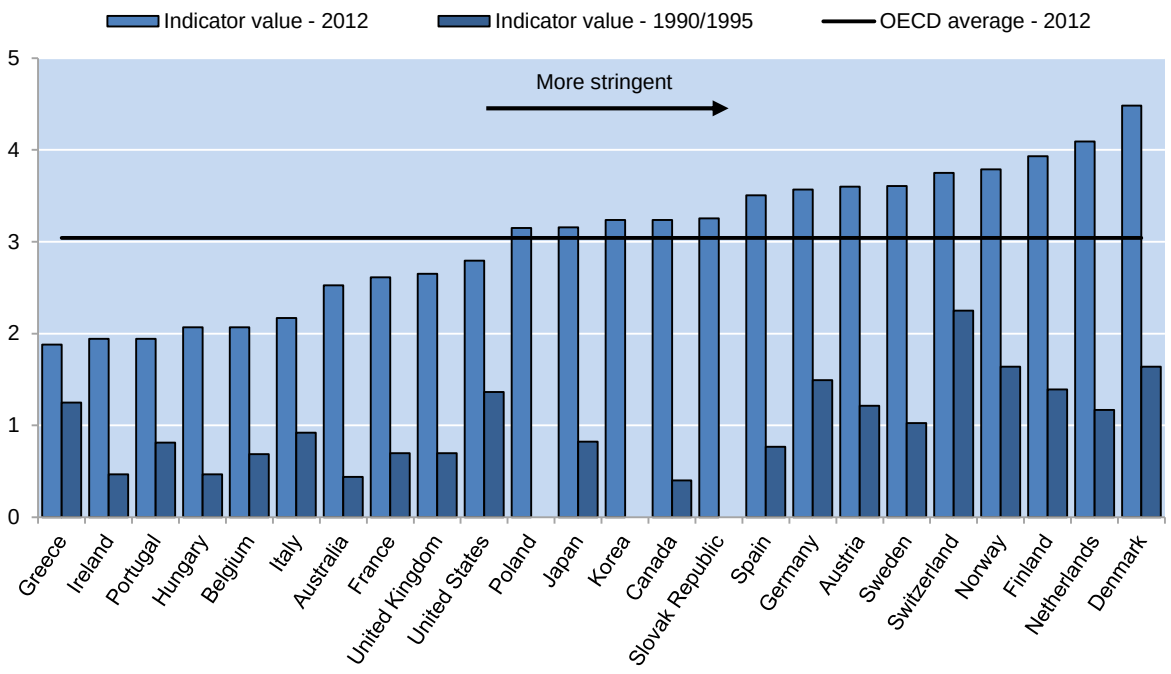
27. Well-designed market-based policies, such as taxes on externalities or cap-and-trade schemes, score better on dynamic efficiency than environmental standards, providing firms more flexibility in the way they adapt to the new environmental policy (De Serres et al., 2010).[5] As mentioned above, they also appear more closely correlated with "green" innovation proxies. In this respect, some tentative observations can be made. First, over the past two decades environmental policies have been increasing in average stringency on both market and non-market based dimensions (Figure 6, Panel A). The growth in stringency has been higher for market-based EPS, mainly due to the fact that there were few countries with market-based instruments beyond fuel taxation in the early 1990s, while the increase in non-market based EPS was due mainly to the tightening of policies (e.g. emission limit values, ELVs).[6] Looking across

5 . In practice the distinction between market and non-market instruments is too crude – for example, (crawling) performance standards can be geared to provide similar incentives as market-based instruments. Similarly, market-based technology-differentiated feed-in-tariffs or green certificates are rather inflexible.

6 . The decline in stringency for the market-based subcomponent in 2007 and 2013 reflects primarily the collapsing EU ETS permit price, and the decline in non-market based EPS (e.g. in 2007) is primarily due to R&D expenditure.

countries for 2012, market-based policy stringency dominates in the United Kingdom, Poland and Australia, while non-market-based stringency dominates in Finland, Austria and Germany. Other countries appear more balanced in the two dimensions.

Figure 5. The stringency of environmental policies has been increasing across the OECD

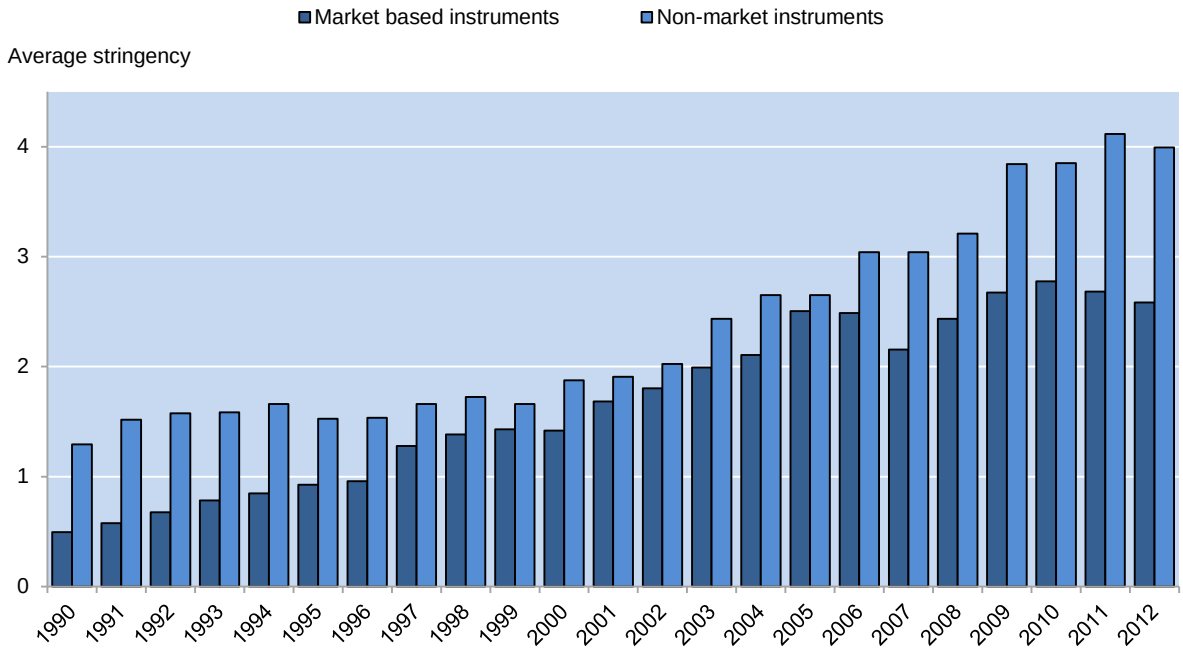


Note: 1990-95 values missing for Poland, the Slovak Republic and Korea.

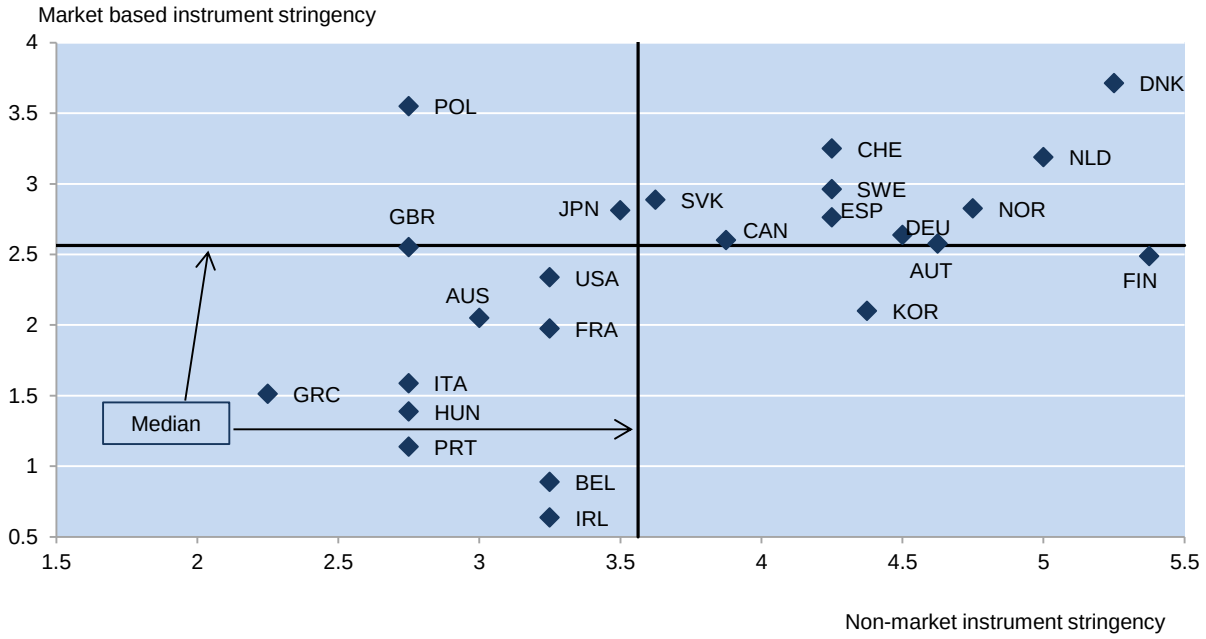
Source: Botta and Koźluk, 2014.

Figure 6. Market-based and command and control dimensions of the EPS indicator

A. **Market-based and non-market EPS components across time, fixed sub-sample OECD average**



B. **Relative stringency across market-based and non-market instruments in OECD countries, 2012**



Note: Panel A, Only countries available throughout the entire period are included.

Source: Botta and Koźluk, 2014.

3.3 Environmental policies and barriers to entry and competition – evidence from a questionnaire

28. Despite increasing attention to environmental policies over the past two decades, the competition-distortions of policy design have rarely been of direct interest in a cross-country analysis. Nevertheless, industrial surveys and case studies have provided evidence that environmental policies affect barriers to entry and that this effect differs across countries (OECD, 2006; World Bank, 2011 and 2014). In particular, the survey evidence seems dated and is unlikely to reflect the current state of environmental policy design (OECD, 2001 and 2008).[7]

29. The channels through which environmental policies can provide advantages to incumbent firms over (potential) new entrants are at least fivefold:

- Increased sunk costs associated with entry, which raise the risks for potential entrants and may encourage entry-deterring practices among incumbents.
- Administrative barriers that slow down the actual process of entry, aside from a monetary cost.
- Prescriptive regulations which may inhibit entrants with new ideas, which were unforeseen by the policy makers.
- Direct application of more stringent rules for entrants (e.g. vintage-differentiated regulations) and additional fixed costs, which discriminate against prospective entrants, for example due to the time and resources it takes to learn to comply with the regulation.
- "Rewards" based on historical performance – grandfathered emission rights, public procurement advantages, subsidies or tax breaks in return for improvements in environmental outcomes.

30. In general, environmental policy instruments concentrate on selected activities and sectors associated with "high" environmental impacts or risks, dealing with particular substances and technologies, and in particular locations. Consequently, most related administrative burdens and barriers to competition are unlikely to impact directly across all businesses.[8] Still, as proven for other regulatory impediments to competition, such as anti-competitive regulations in upstream network and service sectors, regulation can have significant knock-on effects on the entire economy (Conway et al. 2006; Bourlès et al., 2013). Hence, minimising the impediments to competition associated with environmental policies for the directly affected industries can trigger much broader overall effects.

31. The questionnaire annexed to the OECD Product Market Regulation Indicators' 2013 update, collected selected information on competition-related aspects of environmental policies which are summarised in a set of indicators of Burdens on the Economy due to Environmental Policies (BEEP, Box 6).[9] Interestingly, the country results appear to be uncorrelated with "similar" subcomponents

7 . These publications use data gathered through OECD industrial surveys conducted in 1998/9 and 2003 respectively.

8 . Notable exceptions may include environment-related aspects of zoning/land use regulations, which are beyond the scope of this paper (Koźluk, 2014). The OECD Environment Directorate is planning work to fill this gap in 2015-16.

9 . The questionnaire was sent out in January 2013 and underwent a two stage interactive review process. Answers have been received for 34 countries, including two non OECD (Croatia and South Africa). Finland and Luxembourg have not responded to the questionnaire.

of the PMR, the overall PMR, or World Bank Doing Business indicators, confirming that the indicator captures a dimension that is not already well covered (Koźluk, 2014).

Box 6. The indicator of Burdens on the Economy due to Environmental Policies (BEEP)

The information on the competition-related aspects of environmental policies gathered in 2013 via a cross-country questionnaire has been summarised in a set of composite indicators. The measured burdens are generally a result of national implementation of environmental policies, hence within the reach of national policymakers, even if in some cases related to supra-national policies, for example in the EU. The questions have been classified into two "mid-level" and four "low-level" categories, covering the following aspects:

- Barriers to entry and competition – aiming to capture direct characteristics of environmental policies and permits that may inhibit or slow down entry and provide an advantage to incumbents. These include:

  1. *Administrative burdens associated with permitting/licensing procedures* – grouping questions on the environmental permit-related administrative complexity that is faced by entrepreneurs opening a company. It resembles the *License and permit systems* and *Administrative burdens* in the *Barriers to entrepreneurship* indicators in the Product Market Regulation Indicator structure – which focus on regulations increasing the cost of entry. Questions include legal delays to the administrative response to a request for a permit/license, ease of access to all necessary information, forms to be filled in, and similar.

  2. *Direct impediments to competition* – aspects of environmental policies that can directly discriminate against new entrants. The most common forms are vintage-differentiated regulations (VDRs), where new entrants may face stricter environmental norms than incumbent firms. Similarly, direct subsidies and tax incentives can be more beneficial for incumbents than for young firms, for instance by being based on past performance or if young firms tend not to have profits. Questions for several selected industries are included.

- (Lack of) Evaluation of economic effects of environmental policies in policymaking – focusing on the potential implications for competition, entry and more generally economic outcomes of procedures applied in the environmental policy making process, *ex ante* and *ex post.* In this case lax evaluation requirements and practices are considered as (potentially) burdensome to competition. This is similar to the *Communication and simplification of rules and procedures* and some of the general (i.e. not sector-specific) aspects of the *Command and control regulations* indicator in the PMR, though the BEEP indicator goes into more detailed requirements:

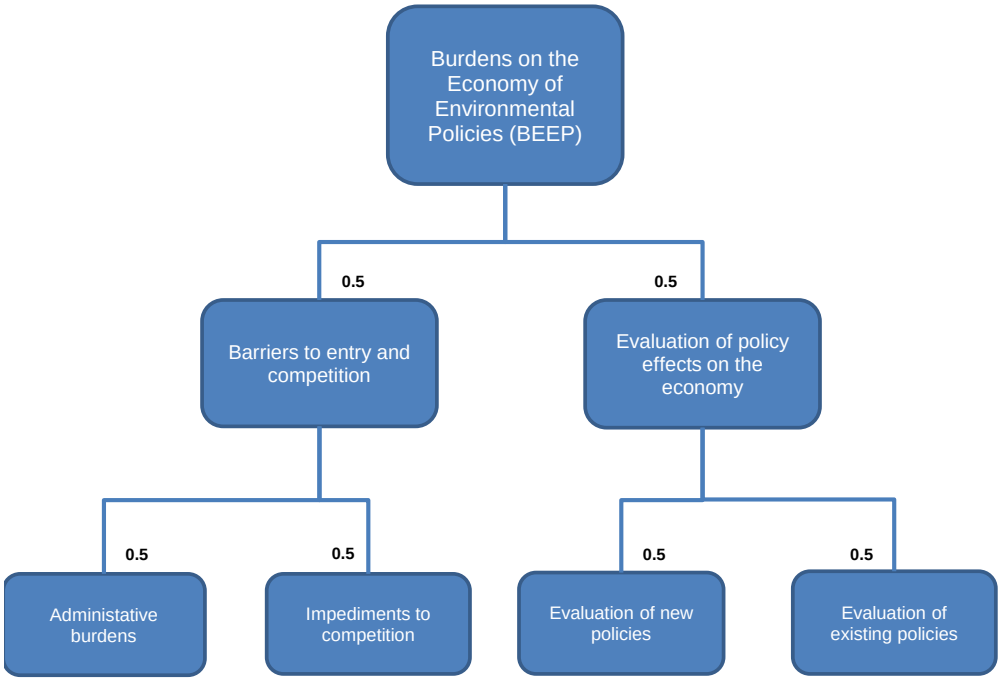
  3. *Evaluation of new policies* – summarises information on the process of new environmental policy making, in particular requirements to conduct *ex ante* analysis of various economic consequences of new policy proposals and choice of tools to achieve environmental goals.

  4. *Evaluation of existing policies* – captures the degree to which economic considerations are taken into account in reviewing the entire setup of existing policies: *ex post* evaluations of policies and policy setups, transparency and the responsiveness to stakeholders.

Voluntary approaches, information policies and land use regulations are not covered by the indicator, despite their relevance for competition, due to the difficulty of collecting and quantifying the relevant information. This may become possible in the future, as work on environmental aspects of land use regulations in the OECD progresses.

The low-level categories contain on average 12 questions each. Country responses were then scored, rescaled to a 0-6 scale and aggregated according to a simple, equally weighted structure (Figure 7). A random weights exercise demonstrates that the country ranking is robust to different weighting strategies.

Figure 7. Aggregation structure for the indicator of Burdens on the Economy due to Environmental Policies (BEEP)



Note: Aggregation uses equal weights of subcomponents.

Source: Koźluk, 2014.

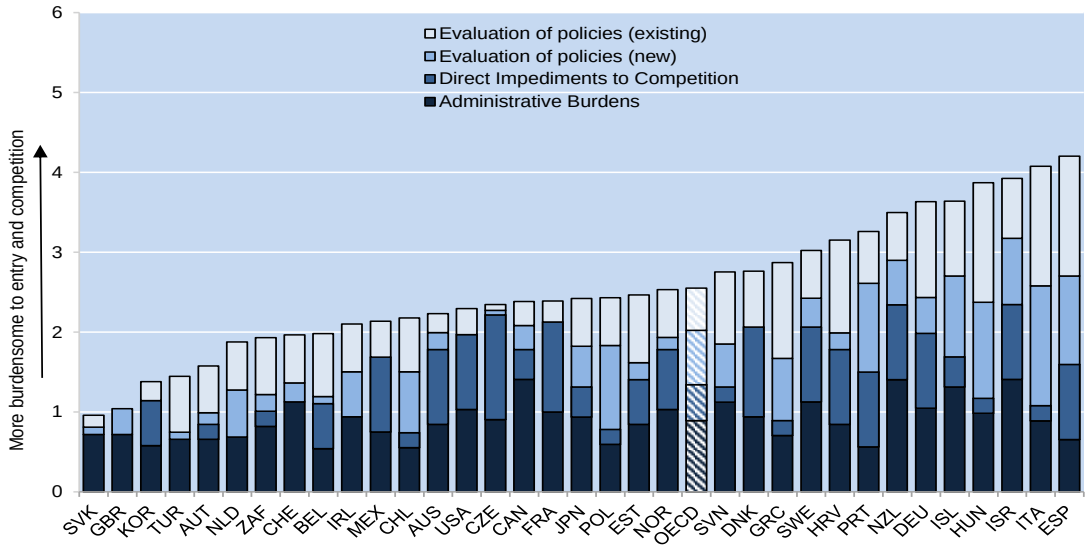
32. The proposed BEEP indicator provides only a snapshot of selected and simplified competition-related aspects, but puts a spotlight on some areas that could benefit from policy makers' attention in designing future environmental policy proposals or seeking to reform existing setups. Administrative burdens exhibit the least variation across countries, appearing the highest in New Zealand, Israel, Canada and Iceland – which score poorly on most questions regarding single contact points, single applications and integrated permits, etc. A number of countries score only slightly better – Switzerland, Sweden and Slovenia- suggesting there may be ways to facilitate business entry through reducing red-tape and improving the "business friendliness" of relevant government agencies and procedures.

33. Responses for a large number of countries indicate the prevalence of vintage-differentiated regulations and tax/subsidy measures that tend to discriminate between entrants and incumbents – these seem particularly common in the Czech Republic, Denmark and France, as well as Australia, Croatia, Germany, Israel, Mexico, New Zealand, Portugal, Spain and Sweden. Regarding the procedures and requirements for policy evaluation, practices tend to differ significantly across countries. Italy, Hungary, Spain, Greece, Iceland and Portugal appear to have the most room to gain from improvements in overall evaluation standards and practices. Croatia and Germany score well on evaluation of new policies and policy proposals, while poorly on practices to evaluate effects of existing legislation.

34. Good performance on the subcomponents summarising the evaluation of new (and existing) policies and proposals in terms of potential economic effects does not necessarily go in line with low

administrative barriers and impediments to competition. In fact, for a number of countries, particularly the Czech Republic, France, the United States, the Scandinavian countries and Australia, evaluation procedures score among the top in the sample, while environmental policies seem to be particularly burdensome for new entrants. One reason may be that for the mentioned countries, the good evaluation scores tend to be for the evaluation of new policies, while less so on procedures to look at the *ex post* performance of the existing policy setup. Another possible explanation could be that, while evaluations are in place, they have limited influence on the actual policy-making decisions or that they do not provide appropriate signals for policymakers.

Figure 8. The BEEP indicator: country rankings and subcomponents



Note: For the United States, it was not possible to establish a value for the question on the maximum legal length of permitting procedures (QA1.1.10, see Koźluk, 2014). For this reason a middle-range value was assumed to enable comparison on overall indicator values.

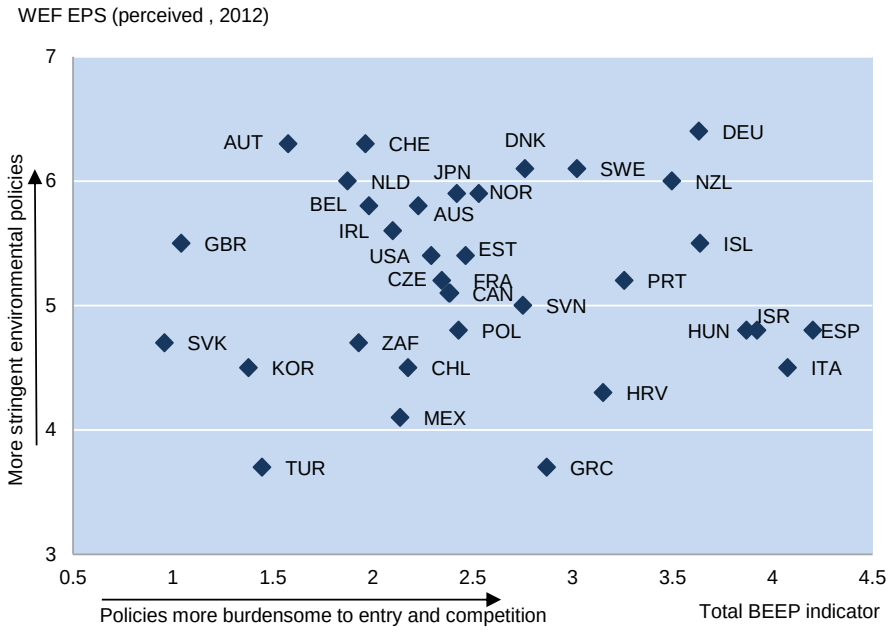
Source: Koźluk, 2014.

3.4 Environmental policies can be implemented without imposing high barriers to entry and competition

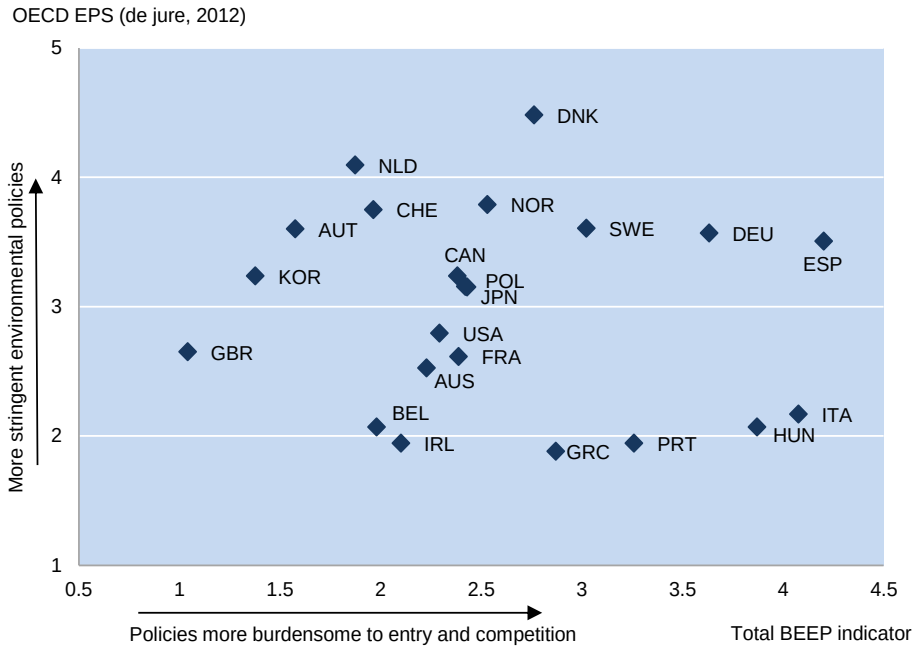
35. Simple correlations of the BEEP indicator with indicators of environmental policy stringency, such as the WEF indicator and the OECD EPS indicator described in the previous section are small and insignificant (Figure 9). This shows that stringent policies can be achieved without necessarily imposing high burdens to entry and competition. For instance, the Netherlands, Austria and Switzerland combine stringent environmental policies, according to both OECD and WEF EPS indices, with a competition-friendly stance of such policies, according to the BEEP indicator. The United Kingdom scores similarly, though slightly weaker in terms of the OECD EPS. The Nordic countries and Germany couple fairly stringent environmental policies with fairly high administrative burdens and measures that impede competition directly. By contrast, Italy, Hungary, Israel and Greece tend to stand out as having relatively lax environmental policies according to both the WEF and the OECD EPS indices (where available), while according to the BEEP indicator, could benefit from a more competition-friendly approach to policies. Nevertheless at this stage, the BEEP indicators cannot be used to explore the link between policies and outcomes as they describe the situation reported by member countries at beginning of 2013 and have no time-series dimension.

Figure 9. The BEEP indicator and measures of environmental policy stringency

A. **BEEP indicator and perceived environmental policy stringency (WEF)**



B. **BEEP indicator and environmental policy stringency (OECD EPS)**



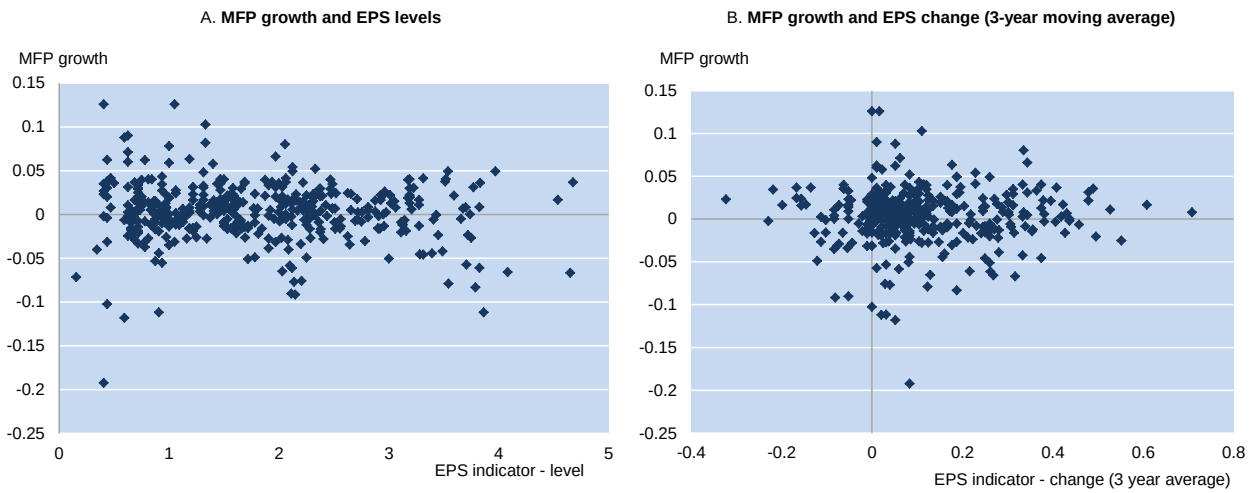
Note: Correlations between EPS and BEEP are 0.00 (Panel A) and -0.07 (Panel B), not significant at 90% level in both cases.

Source: Koźluk (2014).

4. Environmental policy stringency and productivity growth across OECD countries

36. Simple plots of productivity growth in relation to EPS – levels and changes - suggest no evident relationship at the macro level (Figure 10). At the same time, there is a clear link between the performance of high- and low-polluting industries and countries' EPS (Figure 11). In countries with low policy stringency, high-polluting industries perform better than low-polluting ones (with the distribution of MFP growth shifted to the right in Figure 11, Panel D),[10] while in case of stringent countries, the relationship is reversed: low-polluting industries outperform dirty industries (Panel C). Interestingly, low-polluting industries tend to exhibit higher MFP growth in more stringent countries (Panel B), while MFP growth for the high-polluting industries is slightly higher in tight EPS regimes (Panel A). As these simple relationships are not able to account for the time dimension of effects, possible simultaneity or country and industry characteristics, a more rigorous analysis is undertaken.

Figure 10. Correlations between EPS and MFP growth at the macro level

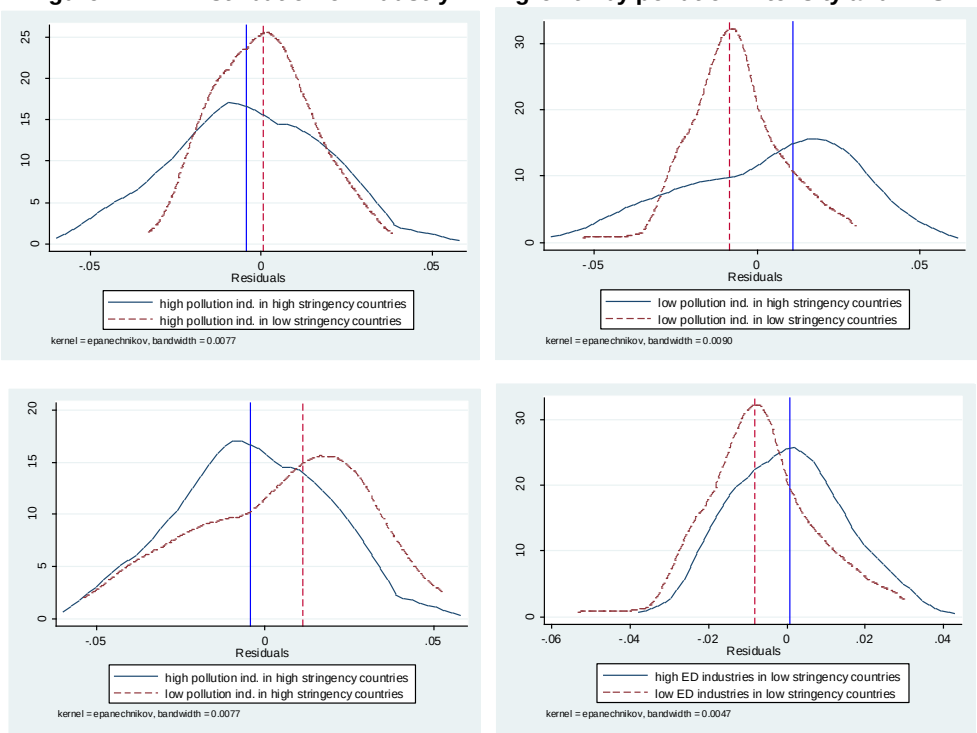


Note: pooled across countries and time.

Source: OECD calculations.

10 . Similar results can be drawn for countries based on policy tightening rather than levels.

Figure 11. Distribution of industry MFP growth by pollution intensity and EPS



Note: Kernel density estimates are estimated over annual MFP growth rates for country-industry pairs over 1990-2009. Panel A shows distributions of MFP growth of high-polluting industries in high and low EPS countries respectively. Panel B shows the same for low–polluting industries. Panel C shows distributions of MFP growth of high and low polluting industries in a high EPS country. Panel D shows the same in a low EPS country. Productivity data have been purged of cyclical effects, and productivity growth rates are defined as residuals from a country, time and industry fixed effect regression. Each kernel distribution function is estimated over the yearly observations on MFP growth in 3 countries (with either highest or lowest EPS, depending on the case) and 3 industries (either high or low ED). Vertical lines mark the median of the MFP growth distribution.

Source: Authors' calculations.

4.1 Empirical evidence using the new measure of environmental policy stringency

37. The newly developed EPS indicator, which proxies for environmental policy stringency, is applied in an empirical analysis at the macro, industry and firm level, over the longest possible subsample over the past two decades. The question focuses on the effect of a *change* in EPS on MFP growth - due to the time-series and construction properties of the variable and theoretical expectations discussed in Section 2. The exact econometric approach is summarised in Box 7 and details are presented in Albrizio et al. (2014).

Box 7. Empirical setup – the macro, industry and firm level

The empirical analysis is based on productivity models that allow for technology spill-over effects from technological leaders to countries (industries and firms) behind the frontier (Nicoletti and Scarpetta, 2003; Bourlès et al., 2013). The analysis is conducted at the macro, industry and firm level. The baseline specification estimated for the macro level is described by equation (1) below. In addition, the estimation at the industry and firm level allows for the effect of countries' environmental policy tightening to vary with the industry's environmental dependency and with the distance to the productivity frontier (equation 2[1]). The baseline specifications are:

$$(1) \qquad \Delta \ln MFP_{ct} = \alpha_1 + \sum_{j=-k}^{n} \alpha_{2j}(\Delta EPS_{ct-j}) + \alpha_3 gap_{ct-1} + \alpha_4 \Delta \ln \widetilde{MFP}_{ct} + \boldsymbol{x_{cit}\gamma} + \eta_t + \delta_c + \epsilon_{ct}$$

$$(2) \qquad \Delta \ln MFP_{cit} = \alpha_1 + \sum_{j=1}^{n} \alpha_{2j}\left(ED_{i\,1987}\Delta EPS_{ct-j}\right) + \sum_{j=1}^{n} \alpha_{3j}{}_{it-j} gap_{cit-1}\,(ED_{i\,1987}\Delta EPS_{ct-j}) + \alpha_4 gap_{cit-1} + \alpha_5 \Delta \ln \widetilde{MFP}_{it} + \boldsymbol{x_{cit}\gamma} + \eta_t + \delta_{ci} + \epsilon_{cit}$$

Where $\Delta lnMFP$ is the growth rate of multi-factor productivity[2], ΔEPS denotes the change in the indicator of environmental policy stringency (tested at different leads and lags).[3] At the industry and firm levels (equation 2) [2], the change in EPS is interacted with the pre-sample industry environmental dependence (ED) to account for the different degree of industry exposure to environmental policies as defined by the industry pollution intensity. The distance to frontier (gap) captures the technological catch-up, modelled as the distance in the level of MFP between the individual country and the leader. An additional non-linear effect of the change in EPS is allowed for by interacting the environmental policy stringency with the technological gap. $\Delta \ln \widetilde{MFP}$ denotes the MFP growth of the technological leader (technology pass-through), as defined in more detail in Albrizio et al. (2014). $\boldsymbol{x}$ represents, in the baseline specification, several control variables, such as the output gap, common time trend and a crisis dummy. Depending on the level of aggregation, additional control variables are included, as explained in Albrizio et al. (2014), Appendix 1. The subscripts c and i denote country and industry, while t denotes year. Different lag structures of the EPS variable have been tested, leading to the adoption of a 3-year moving average specification.

Fixed effects or least squared dummy variables, with clustered and robust standard errors, are used depending on the specification. The sample covers 23 OECD countries over 1990-2010 at the macro level, 17 OECD countries and 10 manufacturing sectors over 1990-2009 at the industry level and 11 OECD countries and 22 manufacturing sectors over the time period 2000-2009 at the firm level.

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[1] At the firm level, the dimensions of the variables are *'cift'* where c stands for country, i for industry, f for firm and t for time.

[2] MFP measures differ for the respective levels of analysis. At the macro level, MFP is derived from a standard production function which includes physical capital, human capital (based on average number of years of schooling across the population aged 25-64, (Bouis et al., 2011) and labour as production factors (taken from Johansson et al, 2013). At the industry level MFP estimates are constructed as residuals considering a standard capital-labour Cobb-Douglas production function. Calibration is based on the OECD STAN database and OECD Industry Productivity database, and growth rates are calculated as two-year moving averages. At the firm level the index of multifactor productivity is constructed using the ORBIS database and following the approach in Woodridge (2009). The OECD-ORBIS dataset has been developed by Gonnard and Ragoussi (2012) and Gal (2013) on the Bureau Van Dijk (BvD) ORBIS dataset. The data work underlying this note has been executed by the authors before November 2012.

[3] The analysis is based on the economy-wide version of the EPS index. See Botta and Koźluk (2014) for a detailed description of the indicator.

Source: Albrizio et al, (2014).

4.1.1 Empirical results and discussion

38. The bottom-line result of the empirical analysis is that an increase in stringency of environmental policies does not harm productivity growth or productivity levels – neither from the perspective of the entire economy nor from that of manufacturing industries (Table 1; see Albrizio et al., 2014, for detailed results). In fact, a tightening in environmental policy stringency is associated with a subsequent short-run increase in productivity growth, which translates into permanently higher MFP levels. This temporary

boost in productivity growth does not depend on whether the policy tightening takes place in countries with an already high level of environmental policy stringency or those with a relatively lax regime. [11]

Table 1. Estimation results for coefficients on EPS tightening at three levels of aggregation

Dependent variable: Multi-factor productivity growth(1)			
	Macro level	Industry level	Firm level
EPS tightening (lag)(2)	**0.0192****	**0.151*****	**0.147****
	(0.00891)	(0.0334)	(0.0715)
Effect of gap on EPS tightening(2)	-	**-0.203****	**-0.0788*****
		(0.0793)	(0.0232)
EPS tightening (lead) (3)	**-0.0109***	-	-
	(0.00599)		
Specification in Albrizio et al. (2014)	Table 1, specification 6	Table 2, specification 7	Table 3, specification 6

Robust and clustered standard errors in parentheses, significance levels are denoted by *, **, *** for 10%, 5% and 1% respectively.

(1) Selected estimations are reported for the longest possible sample in each specification. MFP is defined differently at different levels (see Box 5 for details).

(2) Defined as past 3-year lagged moving average of the change in EPS. At the industry and firm level, the change in EPS is interacted with the out-of-sample environmental dependence ratio (see Albrizio et al. 2014, for more details).

(3) Defined as 3-year leading moving average of the change in EPS. Excluded from industry to lack of significance. Firms' forward-looking behaviour was tested using one-year lead, due to the short length of firms data spells, but it was not found to be significant.

Source: Albrizio et al. (2014).

39. Industry-based evidence shows that the gain in productivity growth from a tightening in environmental stringency is highest for the most productive industries (Figure 12, Panel A). On the other hand, the least productive industries are not able to capture the positive short-run gains. This finding is reinforced at the firm level, where effects differ even more depending on technological advancement (Figure 12, Panel B). Only over a third of firms are able to reap some productivity gains after a tightening of environmental regulation. Two-thirds of the firm population – the less productive ones - face a negative effect on productivity growth in the short run.

40. There are several possible explanations for such an outcome. Highly productive firms, which are often the largest firms in the industry, may be best suited to profit rapidly from changing conditions – through seizing new market opportunities, rapid deployment of new technologies or reaping previously overseen efficiency gains (as implied by the Porter's Hypothesis). In practice, such effects may also take place through outsourcing and relocating production abroad. At the same time, the positive effect for most productive firms is likely to be reinforced by their technological advancement, as they can, on the one hand draw on the most advanced technologies already, and, on the other hand, are likely to have more resources to invest into R&D, for instance, in general anticipation of tightening. Less advanced firms may need higher investments to comply with the new regulation, for instance adopting cleaner technologies or exchanging equipment, hence exhibiting a temporary fall in productivity growth.

11. Results are robust to different specifications, subsamples and controls (see Albrizio et al., 2014, for details).

41. Less productive manufacturing firms tend also to be smaller and more stringent environmental policies may be putting them at a disadvantage, to which they are less capable of adjusting. While it can be efficient that unproductive firms drop out of the market because they are not profitable anymore, this is no longer the case should they be driven out of business because of the anti-competitive design of environmental regulation. For example, if a tightening of environmental policy stringency imposes unnecessary barriers to competition or additional administrative burdens (see Koźluk, 2014), this may eventually push smaller and less efficient firms out of activity, as well as, inhibit the entry of new, cleaner firms and technologies. This reasoning calls for particular attention when designing new environmental policies with respect to the effects on entry and the level playing field – and reinforces attempts to look at the design of environmental policies, such as the BEEP indicator presented above. It also calls for ensuring that overall entry/exit barriers do not inhibit a swift reallocation of capital, at the expense of the overall economic outcomes.

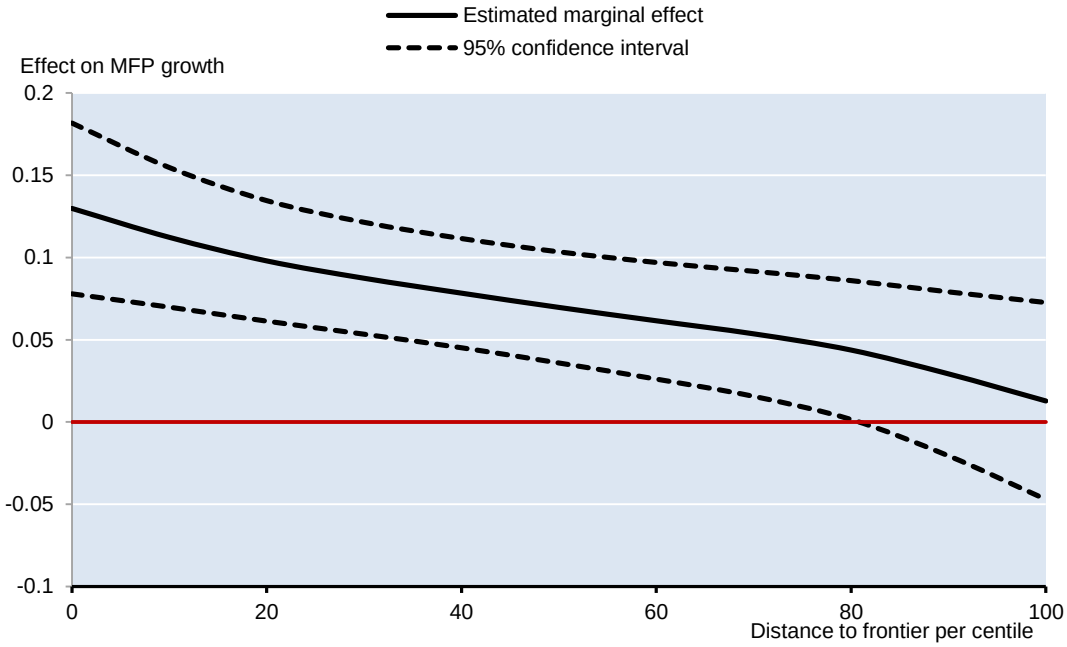
42. The corroboration of the industry results with firm-level evidence can also provide additional tentative conclusions on firm-level effects. A strong negative effect for a third of the firm sample, with no such negative effects at the industry level suggests that part of the adjustment, particularly for less technologically advanced firms, may take the form of firm exit. The exit of the least efficient firms would raise overall industry productivity, cancelling out the negative productivity effects observed in surviving less efficient firms. This conclusion is tentative, due to poor representativeness of small firms in the dataset and the inability to directly account for entry and exit using the ORBIS data.

43. Furthermore, evidence at the aggregate economy level suggests an additional negative anticipation effect upon the announcement of policies or in preparation for their implementation. Assuming that policy makers credibly announce the change of an environmental policy in advance of the implementation, firms may start investing into capital and labour in order to comply with the new policy before the actual implementation. The fact that this effect is only seen in the macro level analysis suggests that this anticipation may be driven by the sectors not included in the industry and firm panel. For instance, announcements of environmental policy tightening may drive large capital-intensive investments in the electricity sector.

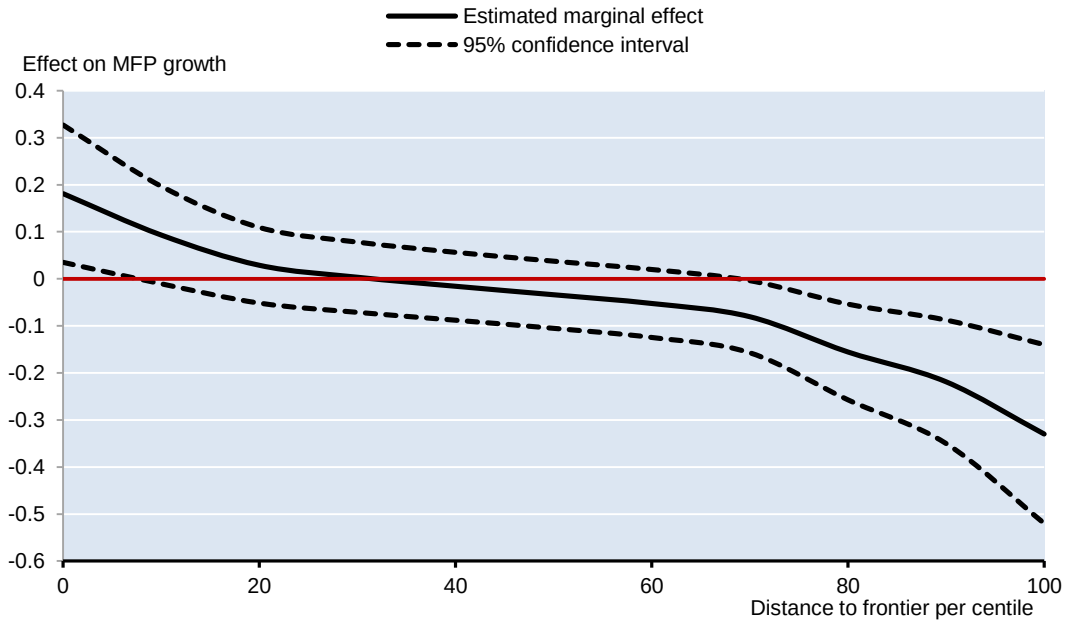
Figure 12. Marginal effects of EPS tightening across the distance to the frontier

EPS change (3-year moving average) - effect on MFP growth across percentiles of distance to frontier

A. **Industry-level estimates**



B. **Firm-level estimates**



Note: The figures show the marginal effect of a tightening of environmental policies on industry and firm-level productivity growth, respectively. The marginal effects are shown in relationship to the distance to the industry-level technological frontier, where industries (firms) closer to the frontier are more productive in terms of levels.

Source: Albrizio et al. (2014).

44. As mentioned, the effects of EPS changes on productivity growth are found to be temporary and relatively short-term at all three levels of aggregation. While this finding appears reliable as the study incorporates the longest currently available time series among existing cross-country studies, not all long-term effects may be captured. Firstly, as already mentioned, the potential gains from policies contributing to a sustainable natural environment may be too elusive to be picked-up even in a 20-year sample. Secondly, despite the relatively long time series, the major increases in measured EPS tend to occur in the second half of the sample. For example, some two-thirds of the policy tightening took place in the 2000s, largely due to new climate-related policies and a tightening of emission limit values – meaning that technically it may still be too early to capture their full effects. A further complication may come from the economic crisis in the second half of 2000s, which took a heavy toll on measured productivity and may have made disentangling the actual effects more difficult.

45. The results are generally robust to various tests and controls and provide some tentative insights on the differential effects of different environmental policy instruments. In particular, market-based environmental policy instruments appear to be more supportive of productivity growth. The positive effects on productivity are found to be more robust for EPS tightening through market-based instruments, supporting the claim that more flexible instruments score better in terms of productivity outcomes. Some additional tests are reported in Albrizio et al. (2014).

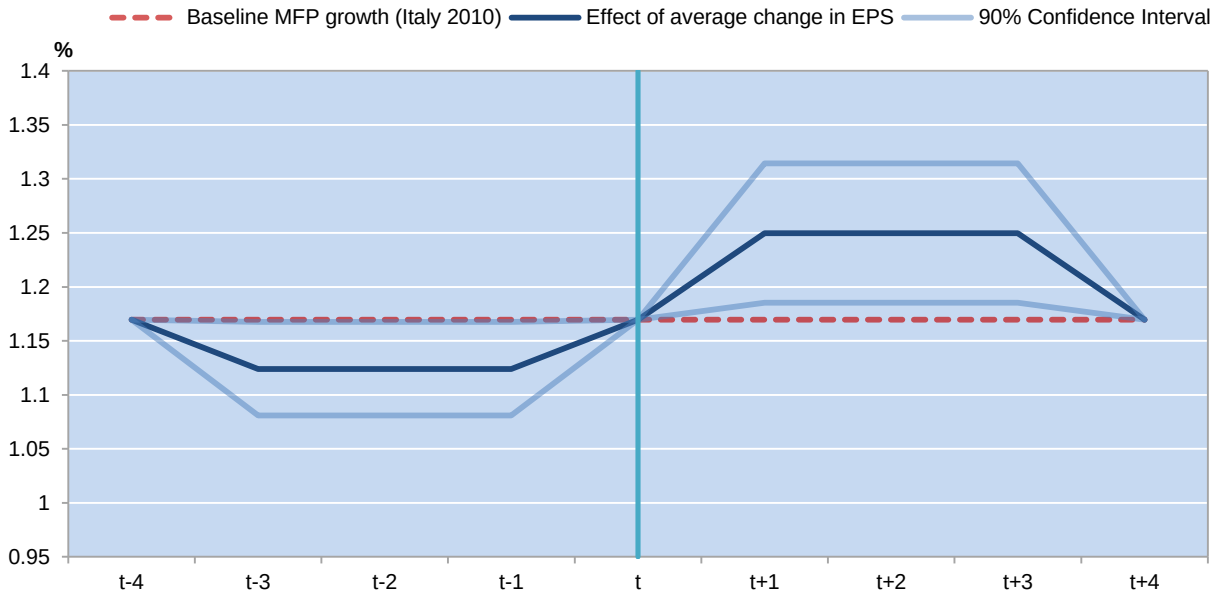
4.1.2 Magnitudes of estimated effects

46. In order to provide a notion of the magnitude of the estimated impacts, the effects of a one-off change in EPS have been simulated at the macro and industry levels. The simulation is based on a 0.12 point increase in the EPS level, being equivalent to the average annual growth in EPS across countries in the sample. It is also roughly equivalent to the difference in the average annual EPS increase between Greece (or Italy) and the more stringent countries such as Germany or the Nordic countries, over the entire sample.

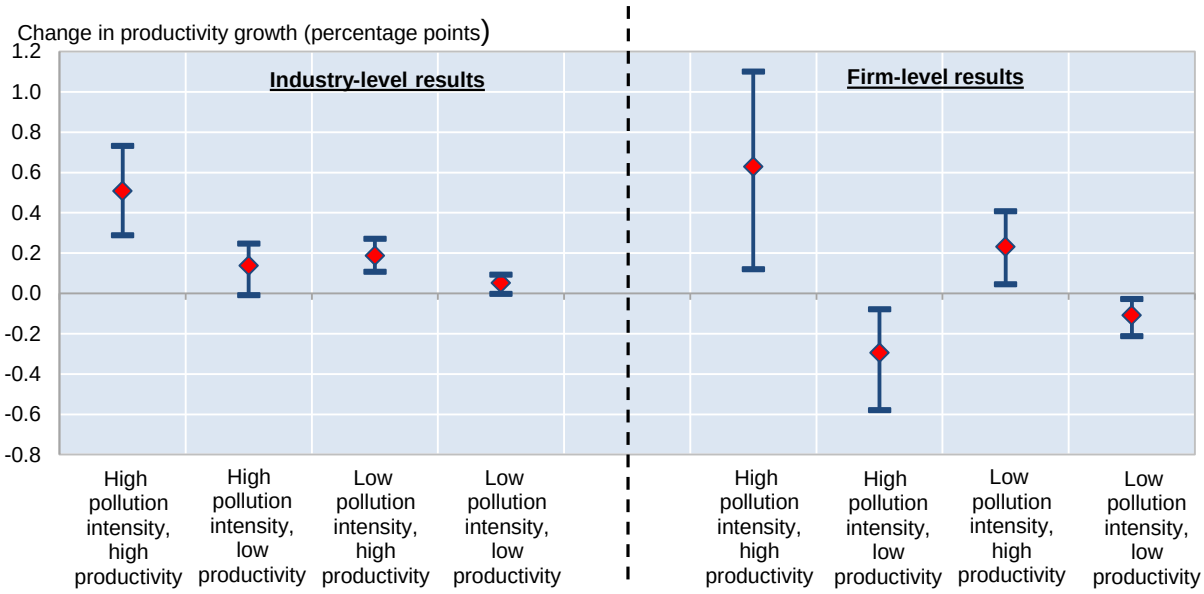
47. Graphic representations show that estimated effects are very small at the aggregate level – the negative announcement effect is offset by the positive lagged effects, implying an insignificant increase in aggregate MFP (at 90% confidence levels, Figure 13 Panel A). Hence, at the country level, there is no net productivity gain, while short-term fluctuations can be significant. Turning to the industry and firm level, the effects show that it is the high-polluting industries and firms that gain in terms of productivity, but only if they are among the most technologically advanced - experiencing up to a 1.5 percentage point increase in MFP levels (Figure 13, Panel B). The effects disappear as the level of technological advancement and pollution intensity (hence direct exposure to EPS) decline, eventually becoming insignificant at the industry level and negative at the firm level. The results from the different levels can be seen as consistent, in light of the relatively small and contracting share of manufacturing industries, in particular highly-polluting activities, in OECD countries throughout the sample.

Figure 13. Effects of EPS tightening on MFP growth – economic significance

A. **Country level – (Italy, 2010 productivity growth as a baseline)**



B. **Industry and firm level**



Note: Panel A, (1) One year effects of a median increase in environmental policy stringency, i.e. 0.12 change in the value of the EPS index in one single year (equivalent to the change in annual average tightening from the level in Italy or Greece to that of the Nordic countries). The absolute level of effect (in terms of percentage points of annual MFP growth) will be the same for all countries, regardless of their productivity growth. 90% confidence intervals are reported.

Panel B. (1) One year effects of a median increase in environmental policy stringency, i.e. 0.12 change in the value of the EPS index in one single year (equivalent to the change in annual average tightening from the level in Italy or Greece to that of the Nordic countries). Effects are estimated to last for three years after the policy change and then fade away. No lead effect is found. (2) High (low) pollution intensity is defined as an industry with the highest (lowest) pollution intensity on seven selected key pollutants with respect to value added. (3) High productivity is defined as the country-industry pair (or firm) on or close to the estimated global industry (or firm) productivity frontier. Low productivity is defined as country-industry pair (or firm) at the 75th percentile of distance to the global industry (or firm) productivity frontier. 90% confidence intervals are reported.

Source: Albrizio et al. (2014).

5. Conclusions and further extensions

48. In this paper, tightening of environmental policy stringency is found to have no longer-term effects on productivity growth, but the short-term effects may translate into a permanent increase in productivity levels in some industries. Short-term effects are found to be positive for technological leaders, while negative for low-productive firms. Still, they are unlikely to be large for the economy as a whole. Adjustments to accommodate the change in environmental policy stringency (EPS) are likely to be both within firms, through changes in production processes, as well as due to firm entry and exit. At the same time, evidence from the new OECD indicators of EPS and burdens on the economy of environmental policies (BEEP) shows that pursuing ambitious environmental objectives and stringent environmental policies does not necessarily require imposing restrictions to entry and competition.

49. Hence, the most important conclusions are twofold. First, stringent environmental policies should not be expected to have detrimental effects on productivity, in particular if policies are well-designed. Second, there is no evident trade-off between policy stringency and competition-friendliness. The design and implementation of stringent environmental policies can and should be geared toward paying due attention to barriers to entry and competition, making the greening of the economy consistent with continuing productivity growth.

50. These tentative insights from the new OECD environmental policy indicators are a step towards better understanding the interaction between environmental policies and the economy in order to formulate more concrete policy recommendations.

51. Several further extensions and follow-ups to this work can be envisaged:

- Broadening the analysis to economic outcomes beyond productivity growth – such as investment, employment, trade patterns (in particular the pollution haven hypothesis), FDI and firm location – to better understand the full economic impacts and channels of transmission. Also, extending the analysis to environmentally-adjusted MFP measures could provide more complete picture of productivity developments.

- Improving and extending the indicator on policy stringency – adding policy instruments and environmental domains, as well as extending the indicator coverage to other OECD and non-member countries - in order to test the robustness of the results when analyzing additional sectors and changes in environmental policy stringency over longer time horizons.

- Analysing the structural and political determinants of environmental policy reforms, instrument choice and design, to better understand the policy-making process. Insights from such work would shed further light on the issue of reverse causality in assessing the effects of environmental policies on economic outcomes and the role of country characteristics, such as industrial structure or level of development and help design environmental policies to overcome potential obstacles to reforms and their implementation.

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