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Summary

We study green specialisation across EU countries and detailed 4-digit industrial sectors over the period of 1995-2015 by harmonizing product-level data (PRODCOM). We propose a new list of green goods that refines lists proposed by international organizations by excluding goods with double usage. Our analysis reveals important structural characteristics of green specialisation in the manufacturing sector. First, green production is highly concentrated, with 13 out of 119 4-digit industries, which are high-tech and account for nearly 95% of the total. Second, green and polluting productions do not occur in the same sectors, and countries specialise in either green or brown sectors. Third, our econometric analysis identifies three key drivers of green specialisation: (i) first-mover advantage and high persistence of green specialisation, (ii) complementarity with non-green capabilities and (iii) the degree of diversification of green capabilities. Importantly, once we control for these drivers, environmental policies are not anymore positively associated with green specialisation.

Keywords: green goods, green specialisation, environmental policies, complementarity, path dependency

JEL Classification: Q55, L60, O44

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Anatomy of Green Specialisation: Evidence from EU Production Data, 1995-2015

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Abstract

We study green specialisation across EU countries and detailed 4-digit industrial sectors over the period of 1995-2015 by harmonizing product-level data (PRODCOM). We propose a new list of green goods that refines lists proposed by international organizations by excluding goods with double usage. Our analysis reveals important structural characteristics of green specialisation in the manufacturing sector. First, green production is highly concentrated, with 13 out of 119 4-digit industries, which are high-tech and account for nearly 95% of the total. Second, green and polluting productions do not occur in the same sectors, and countries specialise in either green or brown sectors. Third, our econometric analysis identifies three key drivers of green specialisation: (i) first-mover advantage and high persistence of green specialisation, (ii) complementarity with non-green capabilities and (iii) the degree of diversification of green capabilities. Importantly, once we control for these drivers, environmental policies are not anymore positively associated with green specialisation.

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1. Introduction

This paper provides new evidence of the production and specialisation of environmentally friendly goods across manufacturing sectors and European countries over the period of 1995-2015. Understanding the evolution and drivers of comparative advantage in green production is particularly important in light of the growing policy interest around the so-called green economy as a way to reconcile economic growth with environmental preservation and climate change mitigation. This recently culminated in the launch of the European Green Deal by the European Commission in response to the COVID-19 pandemic (Helm, 2020; Chen et al., 2020). Developing a first-mover advantage in the green economy was also a strategic goal of the generous fiscal stimulus implemented by President Obama after the great recession, the so-called American Recovery and Reinvestment Act, which sought to build US technological leadership in new high-demand products such as electric cars and PV panels (Agrawala et al., 2020; Popp et al., 2021).

Despite its key strategic role in a country's future competitiveness (Frankhauser et al 2013), data constraints have so far limited the scope of empirical research on the green economy. The first contribution of our paper is presented in Section 2 where we construct a time-consistent measure of green production that varies at the country-year-sector (detailed 4-digit NACE rev. 2 sectors) level. To this aim, we harmonize a product-level dataset compiled by Eurostat for the manufacturing sector, called PRODCOM, using the methodology proposed by Van Beveren, Bernard and Vandenbussche (2012). To measure green production, we first select candidate lists of green products that have been proposed during recent international negotiations at the World Trade Organization (WTO), as well as by the OECD. We then refine these lists by eliminating green goods with double usages to reach a favourite list of green goods.

Previous works have used product-level data at the country level to study trade patterns in green production, we discuss further down the advantages that PRODCOM presents with respect to trade data. To the best or our knowledge, our new dataset is the first that allows to study green production (rather than just trade) along three dimensions: country, year and very detailed sectors. Using this dataset, our papers contributes to the existing literature on green specialization (Mealy and Teytelboym, 2020; Perruchas et al. 2020; Barbieri et al., 2020) by highlighting the importance of observing the fine-grained structure of production across sectors and countries to understand specialisation patterns.

Our paper also contributes to the literature on green technological change and environmental innovation by considering the stage of production rather than of invention. Empirical work on environmental innovation has mostly used patents (e.g., Popp, 2002; Nesta et al., 2014; Calel and Dechezleprêtre, 2016) or self-reported measures of firm innovation (Horbach et al, 2007, Frondel et al, 2012) to build a proxy of green vs. non-green specialisation (Perruchas et al., 2020). While most climate (e.g. Nordhaus and Boyer, 2000) and endogenous growth models (e.g. Bovenberg and Smulders, 1995) give prominent importance to R&D-driven environmental innovation, the beneficial effects of green specialisation in terms of improved environmental quality, job creation and economic growth depend on where production is located (diffusion stage) rather than on where knowledge is created (innovation stage). Additionally, it is well known in both growth theory (Romer, 1990) and innovation studies (Arrow, 1971, Hatch and Mowery, 1998, Clarke 2006) that learning by doing, which depends on cumulative production, is an equally important channels of knowledge creation, especially for low-carbon energy technologies (Jamasb, 2007; Rubin et al., 2015). Overall, green patents and production allow to capture two complementary channels of the process of building a green comparative advantage.

Focusing on the evolution and structure of green production in Europe, we explore both the industry- and country-level heterogeneity contained in the PRODCOM data. In Section 3, we focus on industry-level dynamics, with two key findings standing out from our analysis. First, green production is extremely concentrated in a set of high-tech industries mostly producing capital goods. At the 2-digit level, 9 out of 26 manufacturing industries have positive green production. However, of the 119 4-digit industries contained in those green 2-digit industries, only 21 are green, and 13 of those represent 94.9% of the total green production. We call these 13 industries high-green-potential industries and make them the focus of our analysis. We show that green production is concentrated in few industries and that a very granular dataset such as the one assembled in this paper is crucial when it comes to studying green specialisation. We also show that green production is just 2-2.5% of total manufacturing production in Europe, which is in the ballpark of the most precise US measures of the green economy (Elliott and Lindley, 2017; Vona et al., 2019). This offers additional reasons for using a granular dataset to study such a small portion of manufacturing production. Furthermore, we find that polluting and green production occur in two separate sets of industries. Consequently, the sectors bearing the cost of pollution taxes and standards are different from those that receive the bulk of the subsidies for the green economy.

Our granular dataset very clearly underscores this difference in the sectoral exposure to environmental policies, echoing the current debate on green recovery packages (e.g., Agrawala et al., 2020; Popp et al., 2021).

To investigate the distribution of green and polluting specialisation across countries, in Section 4 we use a country-level Balassa index for revealed comparative advantage to measure green and brown specialisation and identify the possible leaders of the green transition. As expected, Northern countries, especially Denmark, Sweden and Germany (along with Austria), exhibit a persistent green comparative advantage. In contrast, lower income countries, such as Greece, Romania and Bulgaria and some traditionally industrial economies, such as Italy and Belgium, have retained a specialisation in polluting production. Importantly, we show that these divergent patterns are correlated with the OECD indicator of environmental policy stringency.

In Section 5, we examine the drivers of green specialisation at the country-industry level. Our empirical approach builds on a standard framework (Midelfart-Knarvik *et al*., 2000; Nicoletti *et al.*, 2020) that has been used in the literature to shed light on specialisation in pollution intensive production as well as the role of environmental policies (Mulatu *et al.*, 2010). We enrich this framework by considering three structural characteristics that have been studied by the recent empirical literature on green innovation: i. path dependency and persistency of first-mover advantage (e.g., Aghion *et al.*, 2016); ii. complementarity with non-green capabilities (e.g., Perruchas, et al., 2020); and iii. diversification of the knowledge base (e.g., Colombelli and Quatraro, 2019). We find that environmental policies play no role in sustaining green specialization once we properly account for path dependency and other structural drivers. Consistent with the descriptive evidence, green specialisation exhibits path dependency, confirming the importance of first-mover advantages. Our regressions also reveal a complementarity between green and non-green specialisation within the same narrowly defined 4-digit industry, although the magnitude of the association is much smaller than the persistency of the lead start advantage. Finally, diversifying the portfolio of green products with comparative advantage is also important for sustaining green specialisation. In Section 6, we summarize our main findings and provide future research avenues.

2. A new measure of green production

This section is organized as follows. In Section 2.1, we discuss the conceptual issues in measuring green production. In Section 2.2, we present our main source of data, PRODCOM and we illustrate how to use PRODCOM to measure green production. Finally, Section 2.3 validates our favourite list of green products – which we refer to as the PRODCOM list henceforth – against other lists.

2.1 Conceptual issues

The definition of green production presents several conceptual challenges related to the theoretical understanding of what "green" or "environmentally friendly" means and how such definitions can be operationalized in the data.

The first conceptual issue is whether we consider an activity (i.e., a product or a service) green in terms of the effective pollution content of its production (*process approach*) or in terms of its potential to minimize the harmful impacts of production on the environment (*output approach*). The first approach is intuitive: it uses direct and indirect pollution generated in producing a good as measure of the inverse of the product greenness. The problem with this approach is that data limitations make it difficult to devise a measure of the pollution content of products that varies across countries and years (Sato, 2014). Input-output methodology has been used to overcome these issues and build new datasets assessing the environmental footprint of production. These datasets, however, include a limited number of countries, years and highly aggregated sectors, yielding rather different estimates of pollution impacts of production (Rodrigues *et al.*, 2018).

The output approach emphasizes the potential of certain products to be beneficial for the environment, and it is the preferred approach for defining most lists of green products or activities. For instance, both the Green Goods and Services Survey (GGS) of the Bureau of Labor Statistics in the US (e.g., Elliott and Lindley, 2017) and the Eurostat definitions of green products (Eurostat, 2016) use an output-based approach. To illustrate the difference between these two approaches, one can consider wind turbines: even though they fulfil an unequivocally green function, the process, emission-based, approach would not consider them very green due to the high pollution intensity of the iron that is necessary for their production.

Naturally, the green transition will hinge on both a significant reduction of emissions embodied in production processes – i.e. a "process approach" – and the diffusion of products that will have beneficial impact on the environment either by reducing the environmental impact of other production processes, and/or through remediation activities, i.e. an "output approach". In this work, we focus on the latter approach. In line with this choice, our main conceptual challenge is the identification of which functions or tasks are particularly beneficial to the environment. This remains far from straightforward: products fulfil functions that differ in their potential for reducing pollution based on their underlying technology, such as end-of-pipe and integrated technologies (Frondel et al., 2007).[1] A crucial conceptual issue here is that the same product can have different usages and thus different environmental impacts. For example, pipes and water tanks may be considered green when used for water and waste management purposes, but they will not be green when used for other activities (Steenblik, 2005), such as textile production that involves intensive water consumption. Altogether, these issues make it difficult to find a widely accepted conceptual definition of what a green product is. Operationalizing a definition of green products is even more difficult because standard statistical classifications are not designed to separate environmentally friendly products (Steenblik, 2005; Sauvage, 2014). This increases the likelihood that a green products' list contains false negatives (products that are environmentally friendly but are excluded from the list) and false positives (products that are not environmentally friendly but that are nonetheless included). This paper proposes to mitigate the data shortcomings and conceptual ambiguities discussed above using a new dataset, PRODCOM, where product codes and descriptions are available at a highly disaggregated level.

2.2 Measuring green production using the PRODCOM data

The dataset. In the PRODCOM dataset, Eurostat collects very detailed information on manufacturing production values in Europe, covering on average, 4,288 single products per year. The dataset is available for the years between 1995 and 2015 for the core European countries, while detailed data on production in Eastern European countries has been collected from 2001 onwards.[2]

[1] End-of-pipe technologies limit pollution from production processes without changing these processes in essence (e.g., waste-water treatment, catalytic converters or exhaust-gas cleaning equipment). Integrated technologies prevent pollution at the source, replacing less clean technologies: wind turbines are a clear example of this kind of product.

[2] Countries for which data from 1995 on is available include: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain, Sweden and the United Kingdom. From 2001 on, our data include: Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, Romania, Slovakia and Slovenia. Poland is included from 2003 onwards.

For the purpose of identifying green production across countries and industries, PRODCOM presents two practical advantages. First, the data are easily linkable to existing lists of green products. Second, the PRODCOM product classification is nested within the European industrial classification NACE: each PRODCOM code has eight digits, the first four of which correspond to NACE industry codes. This feature allows assigning each product to a 4- (and 2-digit) industry and computing the industry's share of green production.

PRODCOM also presents some significant challenges, which we detail in Appendix A.1. These include an unbalanced coverage of countries and product over time, and especially the fact that PRODCOM codes are updated yearly. We deal with this latter challenge using the methodology developed by Van Beveren, Bernard and Vandenbussche (2012) (VBBV henceforth) to harmonize the PRODCOM data over time. In a nutshell, the VBBV methodology identifies chains of product codes, which change over time due to statistical reclassification, and attributes a "synthetic code" to each chain that does not change over time, thus allowing to obtain a consistent measure of production at the fine-grained sectoral level (4-digit). Combined with the list of green products we discuss further down, the VVBV methodology allows us to identify synthetic codes, which we classify as either green (g) or not green (ng) and then to allocate these products to 4-digit NACE rev. 2 industries. For each industry, we compute the share of green production as follows:

$$Gsh_{ijt} = \frac{\sum_g y_{ijt,g}}{\sum_g y_{ijt,g} + \sum_{ng} y_{ijt,ng}},$$

where we divide the production of green goods in country i, industry j at time t, by the sum of both green and non-green production in the same country-industry-year combination.

Defining a favourite list of green products. A key step of our analysis is to define a favourite list of green goods to implement the harmonization procedure described above. The choice of such list among the several lists available is not easy for the reasons mentioned in Section 2.1. Historically, such lists emerged as part of international negotiations to reduce the tariffs on a set of goods that are crucial for low-carbon transitions and sustainable development in general (WTO, 2001; APEC, 2012). The rationale for this is the idea that reducing tariffs on green products will reduce their cost and thus favour their diffusion (World Bank, 2007; Hufbauer and Kim, 2011), especially in developing countries (Dutz and Sharma, 2012; World Bank, 2012).

However, in pursuing the important goal of reducing tariffs for green products, political economy considerations added another source of ambiguity to the conceptual issues to define what is green.

Indeed, each country negotiates "green" tariff reductions on the goods for which they have a comparative advantage rather than on truly green goods (Balineau and de Melo 2011; de Melo and Solleder, 2018). The resulting disagreement on a final list of green goods was one of the reasons the trade negotiations on environmental goods were interrupted in 2016 (European Commission, 2019).[3]

This notwithstanding, the negotiation process has produced several lists of green goods. The most comprehensive is the Combined List of Environmental Goods (CLEG) of the OECD, which is a union of three lists: the Plurilateral Environmental Goods and Services (PEGS) list developed by the OECD itself, the list negotiated within the Asian Pacific Economic Cooperation (APEC) forum and the list agreed upon by the so-called WTO Friends group. These lists are compiled using the Harmonized System (HS), the most widely used product classification system for trade across countries. Importantly, Eurostat provides a crosswalk between the HS and PRODCOM codes, which allows mapping the HS-based list to the PRODCOM dataset.

Additionally, although there is no official list of green products compiled by Eurostat, the list of the German Statistical Office follows the Eurostat criteria to define environmental goods.[4] We consider the union of the CLEG and German lists to provide a list of potential green goods consisting of 902 products. We refine this broad list to reach our favourite PRODCOM list of green goods by excluding goods with multiple usages. In doing so, we review the product descriptions of the PRODCOM codes and exclude products with both green and non-green usages, such as tanks, industrial ovens, baskets, and mats. Among the goods with double usages, we retain only those related to the monitoring and analysis of environmental variables such as thermostats and apparatus equipment for meteorology and the chemical analysis of water. These products are included in all three lists composing the CLEG list, indicating a consensus around their green potential.

Our cleaning procedure leaves us with 221 (from 4,288 products included in the PRODCOM data and 902 products from the union of the CLEG and German lists) green products.

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[3] For instance, bicycles have been at the centre of controversy between China and the European Union.

[4] Environment protection activities "have as their main purpose the prevention, reduction and elimination of pollution and of any other degradation of the environment" and resource management, i.e., the "preservation, maintenance and enhancement of the stock of natural resources and therefore the safeguarding of those resources against depletion" (Eurostat, 2016, p.15). This narrow definition excludes products that do not match any criterion but that reduce environmental impacts in other sectors, such as LEDs.

Advantages of production data. The other lists we use, in the next subsection, as comparison of our own are largely based on trade data, while we rely on production data. It is therefore important to highlight the key advantages of this choice. We focus here on approaches that have relied on the use of secondary data, rather than the collection of original data through surveys.

First, a vast literature uses trade data and a variety of existing lists of green products that have emerged from the policy debate around tariff reduction for green products (He *et al.*, 2015; Cantore and Cheng, 2018; Fraccascia, Giannoccaro and Albino, 2018; Tamini and Sorgho, 2018; Mealy and Teytelboym, 2020) and their effects on emission reduction (Zugravu-Soilita, 2018, 2019). Indeed, we also rely on such lists to build our own list, as discussed further below. However, trade represents only a small portion of an economy and exporting firms are a non-random sample of large and highly productive firms (Melitz, 2002; Bernard et. al 2007, 2012). As a result, using data on total production, rather than just the subsection of production that is exported, is likely to provide a more representative and accurate picture of how green production is distributed across countries and industries.

Second, another well-established strand of literature has relied on data on patenting activity (Jaffe and Palmer, 1997; Popp, 2002; Nesta *et al.*, 2014; Calel and Dechezleprêtre, 2016; Sbardella *et al.*, 2018; Perruchas *et al.*, 2020). A key advantage of using patents is that patent classification explicitly identifies green patents – e.g., the tag Y02 provided by the European Patent Office (EPO). However, patent data refers to where knowledge is created, but not so much on where production actually takes place and where green jobs are created (Vona et al., 2019). Moreover, and crucially, patent data only captures codified knowledge, while the literature on innovation studies has shown that other non-codified ways of learning are also crucial to economic activity (Cowan et al. 2000, Johnson et al. 2002, Balconi et al. 2007). In this respect, PRODCOM data provides a reliable output measure of the green economy able to capture such learning effects.

Third, an interesting approach is taken by Shapira et al (2014), who develop a set of key search terms that identify green production and then use these terms to identify green firms based on their reported business description in a database compiled by Bureau van Dijk for the UK. Using firm data can indeed provide a comprehensive picture but such data is usually not available, with consistent coverage, across countries and usually do not capture a statistically representative sample of the economy. PRODCOM data in contrast is an administrative source of data, offering reliable comparisons across industries and countries.

Finally, it also possible to rely on a combination of trade, patent and production data. Frankhauser et. al (2013) do so, in order to identify potential winners of the "green race". This is very much in line with our own approach. Frankhauser et. al (2013) combine a wide range of sources 110 industries, across 8 countries over only two years (2005-07). Using PRODCOM data we have information across most European countries, over a much longer period (1995-2015) and identify green products starting from over 4,000 products rather than 110 industries. Moreover, our measure of green production is continuous, rather than binary, providing a much more nuanced picture of the green economy.

Note that all the approaches above only look at the manufacturing sector, leaving service industries aside. Unfortunately, PRODCOM data offers no remedy to this limitation as it only covers the manufacturing industry. Moreover, it is also important to note that PRODCOM data only covers European countries, while other works using patent and trade data, cover much broader groups of countries. While this is a drawback of PRODCOM data, Europe represents a large share of green production worldwide and observing green production at such granular level of industry-country-year aggregation more than compensates for this shortcoming.

2.3 Comparisons with other lists of green products

While it is not possible to prove unequivocally that our list is the most adequate to identify green products, the comparison with other lists allows to highlight some key advantages. We compare here our favourite PRODCOM list with five broader lists (CLEG, German list, APEC, PEG and WTO2009) and two narrower lists (WTO Core and Core CLEG). We discuss each of these lists in greater details in Table A.1 of the Appendix A.2.

[Table 1 here]

To carry out this comparison, in Table 1 we correlate vectors of dummy variables indicating the presence of a certain product in a given list. While the correlation across broader lists (PEGS, APEC, WTO2009 and CLEG) is quite high, narrower lists, such as the WTO Core and Core CLEG lists, are weakly correlated with each other. For instance, the WTO Core and Core CLEG lists share only one green product, i.e., spectrometers using optical radiation. Our favourite PRODCOM list correlates rather strongly with the WTO2009 list (with a correlation coefficient of 0.49), as well as its narrow version, the WTO Core list (0.3) and with the PEGS list (0.58). We also find a strong correlation coefficient (0.45) between our PRODCOM list and a Core list that we define as a union of the WTO Core and Core CLEG lists. This implies that our favourite PRODCOM list identifies a large portion of products that are included in either of the two most restrictive lists, which reassures us regarding the credibility of our list. To give a few examples, these products include end-of-pipe technologies such as machinery for purifying gases and liquids as well as integrated technologies such as solar cells and monitoring equipment for physical and chemical analysis.

Figure 1 visually shows the overlap between our favourite PRODCOM list, the broadest CLEG list, German list and the narrowest Core list. We find that 79 out of 147 products from the German list that are not included in any other list and that the CLEG has several products, 512 out of 819, that are not part of other lists. Such products include multi-usage products such as tanks, industrial ovens and machinery for sorting and grinding material.

[Figure 1 here]

The narrow Core list is fully contained in the CLEG list, but it also shares products with the German list and our favourite PRODCOM list. While this suggests that there is a consensus around products included in the Core list, we find that important green products are not included in the Core list. Indeed, the Core list focuses on products whose function is to directly combat pollution through the use of end-of-pipe technologies (i.e., water and waste management equipment) rather than on key integrated technologies (such as wind turbines). It also leaves out secondary environmental products that offer more environmentally sustainable mobility options – such as bicycles – and environmental monitoring equipment.[5]

In conclusion, our favourite PRODCOM list seems more accurate than other available lists. On the one hand, broader lists, such as the CLEG, German and APEC lists, include products with

[5] Gas turbines are included in the WTO list and so are also part of our PRODCOM list. Clearly, their treatment is problematic. On the one hand, they are a transition technology, so they can be considered green. On the other hand, they produce GHG emissions, so they are brown. Because of this, we chose to exclude them from our list.

multiple non-green usages. On the other hand, narrower lists leave out integrated technologies such as wind turbines, electric cars, and environmental monitoring equipment. The PRODCOM list that we have compiled strikes a balance between these two extremes by focusing on single-usage products and by including both products that directly affect the environment and products that provide greener production processes that reduce pollution across other industries. In section D of the Appendix, we also replicate our main results using the CLEG list and discuss this additional set of results in the Appendix. We choose the CLEG list as term of comparison because it is a well-established and broad list that includes several multi-usage products. To be clear, our aim is not to argue that multiple-usage products have no role to play in achieving the transition to a greener economy, but to identify a list of core key green products that are with no doubt the basis of green specialisation. This reflects the conceptual issues discussed throughout this section, especially the extent to which multiple usage products such as industrial ovens, tanks or sinks can be considered green goods. For these reasons, we prefer our favourite list of green goods.

In general, our results using the CLEG list do confirm that green production is highly concentrated in few industries, as well as the importance of first-mover advantages. Nevertheless, they also lead to estimates of the share of the green economy that are well above other benchmarks existing in the literature (for the US, e.g., Elliott and Lindley, 2017; Vona *et al.*, 2019), further validating our choice of a favourite list that excludes them.

3. Green production across industries

We begin by exploring the industry dimension of the data using the share of green production relative to total production as key statistics. We show in what follows that using such measure allows us to capture the high degree of heterogeneity in green production across and within industries.

3.1 Aggregated industries: green vs. brown production

In Table 2, we first explore the variability of green production across 2-digits industries. This higher level of aggregation allows the comparison of the output-based and process- (emission-) based definitions of green production. We report the mean and standard deviation of green shares for each industry, as well as the average GHG intensity. As mentioned in Section 2.2, the number of countries included in the PRODCOM data is unbalanced, thus for the sectoral analysis, we focus on 2005, 2010 and 2015, where we have information for a balanced panel of countries.

We find that green production is highly concentrated in a few industries. While most 2-digit sectors (17 out of 26) have no production of green goods, four industries emerge as the key players in the green transition: i. Computer, electronic and optical equipment, which includes photovoltaic panels; ii. Electrical equipment, which includes equipment for the control and distribution of electricity; iii. Machinery and equipment, which includes wind turbines; and iv. Other transport equipment, which includes railway stocks. Remarkably, these four industries represent 85% of the total green production (column 6). Within these four industries, we also observe a rather high coefficient of variation (standard deviation), which indicates a high degree of heterogeneity in green production across countries. Over time, average green shares increase in all the four greenest industries, which contrasts with the stability of the average green share in other green industries.

[Table 2 here]

Importantly, the four industries with a high green potential have a number of other characteristics that the scholarship and policy makers have considered of strategic interest for industrial policy in general. First, they are all high- or medium-high tech industries (Eurostat, 2015; Galindo-Rueda and Verger, 2016 - see also in Appendix E for a list of high-tech industries[6]) that typically have large job multipliers in local labour markets (Moretti, 2010; Vona, Marin and Consoli, 2019) and are conducive to economic growth (Mcmillan, Rodrik and Verduzco-Gallo, 2014; Szirmai and Verspagen, 2015). Second, specialisation in these sectors requires a strong pool of pre-existing capabilities (Hidalgo *et al.*, 2007; Mealy and Teytelboym, 2020), particularly engineering and technical skills that are prevalent in green jobs (Vona *et al.*, 2018).

To carry out the comparison between an output-based and a process-based definition of green production, the last column of Table 2 reports greenhouse gas (GHG) intensity for the same 2-digit manufacturing industries. We rely on the environmental accounts of the World Input-Output Database (WIOD) that include the energy and GHG content of domestic production of each 2-digit industry for 15 countries between 1995 and 2009. We compute GHG (CO_2, N_2O and CH_4, aggregated according to their global warming potential) intensity as the sum of direct and indirect

[6] The only exception is sector repair and installation of machinery and equipment (NACE rev. 2 industry 33).

emissions per unit of value added from each industry, country and year. A well-known cluster of brown industries stands out in terms of total (direct and indirect) emissions (Wiebe and Yamano, 2016; de Vries and Ferrarini, 2017): coke and refined petroleum products, other non-metallic mineral products, chemicals and chemical products, basic pharmaceutical products and pharmaceutical preparations, and basic metals and the manufacturing of fabricated metal products, except machinery. In the remainder of this paper, we treat the entire production process of these brown industries as polluting (see Appendix B and Marin and Vona, 2019, for details).

Remarkably, comparing columns 3 to 5 with column 8 of Table 2, we observe that there is a clear inverse relation between green production and pollution intensity. This fact has two main implications. First, from a conceptual point of view, the process- and output-based approaches to defining green goods capture different aspects of the green economy but are not in contradiction with each other and in fact end up identifying similar "green" industries. Second, the two approaches are complementary for analysing policy impacts and understanding the distributional effects of environmental policies. While the competitiveness of brown industries is potentially harmed by an increase in environmental policy stringency (Dechezleprêtre and Sato, 2017), green sectors benefit from the indirect demand for pollution abatement equipment, technical know-how and integrated technologies (Horbach, Rammer and Rennings, 2012; Vona, Marin and Consoli, 2019).[7]

Overall, the two well-known channels through which environmental policies affect competitiveness, namely, the cost channel (eventually leading to relocating polluting industries abroad, the pollution haven hypothesis) and the innovation channel (the so-called Porter hypothesis; Ambec *et al.*, 2013), impact different sets of industries. The evidence we present in this section is very aggregate, due to the challenges in obtaining reliable measures of emission content at a high level of granularity. It should be noted that the lack of overlap between green and

[7] When we use a broader set of green products, such as the CLEG list, we find that core green industries from Table 2 still rank among the top green industries. We also find that fabricated metal products, (exc. machinery) and other non-metallic mineral products also exhibit large green shares of production. This is the result of the CLEG list including multiple use products such as tanks, taps and plastic containers that can be used for water and waste management purposes but also have a high emission content. This is discussed more at length in Appendix D – see in particular Table D.1. Despite these, our results confirm that green production is still heavily concentrated in few industries, with little overlap with polluting industries.

GHG-intensive industries at such aggregate level may mask substantial heterogeneity at the product-level.[8]

However, our evidence suggests that ambitious environmental policy may also have large distributional effects, depending on country's productive structures. The winners of such policies, i.e., countries with a comparative advantage in green industries, are expected to be different from the losers, i.e., countries with a comparative advantage in brown industries. While in this paper we focus on the presentation of the data and the identification of a few structural characteristics of green specialisation, the green PRODCOM dataset is suitable to examine policy relevant issues such as the distributional effects of European policies (i.e. the Green New Deal or the EU-Emission Trading Scheme) or the policy drivers of green specialisation, in general.

3.2 Disaggregated industries: identifying high-green-potential industries

We compare green and polluting production at 2 digits of aggregation due to data constraints related to measures of pollution intensity. However, the high level of disaggregation of the PRODCOM data allows us to compute the shares of green production for 4-digit industries. This is important for further understanding which specific industries green production is concentrated in.

[Table 3 here]

Table 3 reports statistics on 4-digit industries with a green production greater than zero in at least one year and confirms that green production is also highly concentrated at the 4-digit level. Of the 119 4-digit industries among the 2-digit industries with a green production greater than zero, only 21 are green. Moreover, we find that 11 out of these 21 industries have a maximum green production of 100%, i.e., for at least one country and year, green production was the entirety of the industry's production.

After ranking industries by their average share of green production, we observe a first group of eight extremely green industries, from "bicycle and invalid carriage manufacturing" to "non-domestic cooling and ventilation equipment manufacturing". For these industries, the average

[8] Although at the aggregate level we do not observe any trade-off, it may be that, for some specific green products such as wind turbines, there can be a trade-off between the environmental impact of producing green products and the environmental benefits that such products will yield. Studying such trade-offs at the product level require more detailed data that, to the best of our knowledge, are only available for India (i.e. Barrows and Ollivier, 2018) and it is well beyond the scope of this study.

green share is above 20% and is not distant from the median, so outliers do not drive the results. Moreover, there is always at least one industry with a country-year observation with 100% green production, and the absolute long-term changes tend to be positive, with the exception of production in railway and non-domestic cooling and ventilation. Finally, these industries represent 73.9% of total green production. We then observe a second group of five industries, including the production of LEDs and PV panels (in "electronic components manufacturing") and wind turbines (manufacturing of engines and turbines), that represent another 21% of the total green production. The remaining eight industries account for 5.1% of the total green production and always have mean shares of green production below 0.04; thus, they can be considered marginally or indirectly green (like metal industries).[9]

In the remainder of the paper, we study green specialisation focusing on the 13 industries included in the first two groups, which we call *high-green-potential industries*. These industries appear the most relevant to understanding how green specialisation has evolved in EU countries over the last two decades. However, for the sake of completeness, Appendix D replicates the main analyses of Section 4 for the full set of green industries (in particular, see Figures D.1, D.2 and D.3).

4. Specialisation patterns in green production

In this section, we exploit the cross-country variation in our data to study specialisation in green production across countries and industries. Taking stock from the results of the previous section, we analyse green and non-green production within the narrow group of high-green-potential industries.

Our analysis pays specific attention to two issues. First, what are the green leaders that have successfully specialised in green production and, second, whether green specialisation is persistent over time. If this is the case, countries enjoying a first-mover advantage are best placed to benefit from environmental policies (Frankhauser et al. 2013). This is something that should be borne in mind when implementing the New Green Deal so that pre-existing green specialisation is not only reinforced but, rather, new paths towards this are made available.

[9] In Figure C.1 and Figure C.2 in Appendix C, we show that high-green-potential products represent a large share of total green production across all countries and all years.

To provide a first glance at these important issues, we compare the share of green production in high-green-potential industries across countries to detect the leaders of the green transition in Europe and the extent to which their advantage is persistent over time. In Figure 2, we plot the evolution of the 3-year moving average of green production shares grouping countries based on size and geographic position to look at large (panel A), small (panel B) and Eastern European (panel C) countries. As a benchmark, each panel includes the European (weighted on turnover) average of green shares across all available countries in each year.[10]

Green production shares in high-green-potential industries rarely exceed 4% of countries' total production, with an average just above 2% (consistent with the most reliable estimates of the green economy for the US, e.g., Elliott and Lindley, 2017; Vona et al., 2019) and the exception of Denmark, which peaks at 9.5% in 2015. Using CLEG products we obtain instead an EU average green share of production around 10% (Figure D.6 in the Appendix) which is clearly off target relative to the US benchmark. In terms of country rankings, those with the largest shares of green production are Denmark, Germany, the UK, Sweden and Austria. Because green production is concentrated in high-tech sectors, this finding resonates with the fact that specialisation in such sectors is highly persistent and path dependent. All leaders are high-income countries that are at the technological frontier and have strong capabilities in high-tech industries,[11] while Eastern European countries have green shares below the average EU share and no evident increasing trend. This suggests that engineering and technical competences, which are typically core capabilities for high-green-potential industries, may be easily reused in green production, a hypothesis that we will explore in the econometric analysis.

Not surprisingly, we also find high persistency in the green shares of production, which may be due to the fact that we observe a modest increase in the share of green production over the time period considered. Indeed, the green production share increases by only 12.5% over the period between 1995 and 2015 (i.e. the share changes from 0.02 to 0.0225). Explaining the lack of widespread diffusion of green production is beyond the scope of this work, but the rapid rise of China as a manufacturing powerhouse can contribute to explain this pattern. (Algieri, Aquino and

[10] In comparing this with the shares of green production reported in Table 2 and 3, it is important to stress that Figure 2 reports country-level shares, while Table 3 reports the shares of green production within each industry. It is then not surprising that while we find that the green share of production in the high-green-potential industries fluctuates between 8% and 79%, at the country level, green shares are much lower, hovering between 2% and 4%.

[11] We explore in greater detail countries' specialisation in green production at the product level in Appendix C, Table C1. Broadly speaking, we find that the top three green products are remarkably similar across countries.

Succurro, 2011; Sawhney and Kahn, 2012; Liu and Goldstein, 2013). It is however worth pointing out that these rather limited changes in shares of green production at the country level hide a quite large growth in absolute terms across industries and countries. On average green industries have seen an increase of over €136M over the period 2005-15. This is largely driven, however by very high values at the top of the distribution, while more than 75% of the country-industries saw their green production increase of just over €71M, confirming the idea that green production, and especially its acceleration is concentrated in only few countries and industries in Europe.

[Figure 2 here]

Green shares of production are informative about the importance that green goods have in industrial production, but do not capture green specialisation as they do not entail a comparison with a benchmark. Revealed Comparative Advantage (RCA) indexes are the most popular approach for defining whether a country is specialised or not in a given production or technology (Balassa, 1965; Cole, Elliott, and Shimamoto, 2005; Hidalgo *et al.*, 2007; Petralia, Balland, and Morrison, 2017). The RCA index is computed as follows:

$$RCA_{ijt} = \frac{y_{ijt} / \sum_j y_{ijt}}{\sum_i y_{ijt} / \sum_j \sum_i y_{ijt}}, \qquad (3)$$

where y_{ijt} is the production of sector *j* in country *i*. The index normalizes the production share of sector *j* in country *i* by dividing it by the production share of sector *j* across all countries. Note that the economically significant threshold in this index is the point of unity, which means that values between 0 and 1 represent non-specialisation, while RCA values above 1 show specialisation. As a result of this asymmetry, statistical analyses using Balassa's RCA measure may give too much weight to values above one (Dalum, Laursen and Villumsen, 1998; Cole, Elliott and Shimamoto, 2005; Yu, Cai and Leung, 2009). To fix this, Laursen (1998) proposes to either take the logarithm of the RCA or to bound it between -1 and 1, making the RCA symmetric RCA around 0: $SRCA_{ijt} = (RCA_{ijt} - 1)/(RCA_{ijt} + 1)$. In what follows we use the symmetrical RCA for descriptive purposes, while we resort to the logarithm in our econometric analysis in order to interpret the results in terms of elasticities.

Next, we explore here the correlation between the average green RCA by country and the OECD index of environmental policy stringency (EPS henceforth) for market-based policies, which are usually more effective in stimulating the diffusion of green goods and technologies.[12] The green RCA is computed by treating green production from high-green-potential industries as a unique sector, i.e., y_{ijt} is the total green production from all high-green-potential industries for each country i. In Figure 3, we plot these correlations for selected years, the takeaway is that the unconditional correlation between green RCA and EPS is strong and positive, but slightly decreasing over time. In 2001, the EPS index exhibits a correlation of 0.34 with the green RCA, which decreased to 0.19 in 2015. The fact that the strength of this relationship decreases over time is noteworthy. As means of conjecture to explain this, firms can successfully redirect their production towards green goods only to a certain extent when strong incumbents are already present in the market. As a result, countries' green specialisation relative to other countries becomes less and less reactive to policies over time because green specialisation is highly persistent. Obviously, this speculative statement should be qualified and confirmed in an econometric analysis of the drivers of green specialisation. This is exactly the goal of the analyses conducted in the next section.

[Figure 3 here]

In Appendix D we also show the same figure using CLEG products to identify green production. We find the relationship between green specialisation and environmental policy to weaken, with correlation coefficients between 0.09 and 0.14. This suggests that when we take a broader definition of green production this becomes less sensitive to environmental policies. This offers, in our view, further support to the fact that ridding our list of multiple-usage products captures green production in a more accurate way or, at any rate, more closely to the target of environmental policies.

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[12] We thank Tobias Kruse of the OECD for providing us the updated series of EPS data.

Finally, in order to understand the winners and losers of EU environmental policies, we also correlate the green RCA with the brown RCA. The brown RCA is computed by treating all polluting industries defined in Table 2 as a single sector and by considering all of their production as "polluting". In Figure 4, we plot green and brown RCA for selected years dividing countries into four quadrants. We choose 2001 as our earliest year because the PRODCOM data are not available for Eastern European countries in previous years. Countries in the top-left quadrant have an RCA in green production but not in polluting production. The top-right quadrant shows countries with an RCA in both types of production, the bottom-right shows countries with an RCA only in polluting production and the bottom-left shows countries with an RCA in neither type of production.

[Figure 4 here]

The number of countries with a green RCA (i.e., those above the horizontal dashed line) slowly increases between 2001 and 2010 (with Austria joining Sweden, Germany and Denmark) but remains quite stable overall, with only Denmark experiencing a noticeable increase over time. Specialisation in polluting industries shows less dispersion than green specialisation, with most countries clustered around 0 (the vertical dashed line). Overall, brown specialisation emerges in countries with lower income per capita (such as Romania, Bulgaria, Greece) as well as in some traditionally industrial economies (such as Italy and Belgium). It is also remarkable, that Germany, along with Austria, seems to increase its specialisation in polluting production. Despite this, the green and brown RCAs are negatively correlated, indicating that they often occur in different countries with an estimated slope always beyond -0.39.[13] This evidence, together with the fact that the green leaders are mostly high-income countries, indicates that the effect of EU environmental policies, such as the European Green Deal, may exacerbate the gap between the core and the periphery of Europe in green sectors that will be strategic for future economic development. It is therefore important, when it comes to providing a large fiscal push for the green economy, that more attention is given to helping countries lagging behind in green specialisation, in order for

[13] As we show in Appendix D, this relationship becomes essentially flat when we use the CLEG list for green products, this is of course in line with the fact that with this list there is more overlap between green and polluting production and therefore the divide between the two becomes less neat.

them to develop a comparative advantage in some specific green products. Our econometric analysis contributes to this debate by exploring the extent to which green specialisation is related to previous competences in similar products to provide insights on the design of green industrial policies for laggard countries. In the next section presents the results of a multivariate regression analysis at the sector-by-country level.

5. Drivers of green specialisation

To examine the drivers of green specialisation, our starting point is the canonical empirical framework in the literature on the drivers of specialisation (Midelfart-Knarvik et al., 2000; Nicoletti et al., 2020). In its simplest form, this framework compares the influence of two main sources of comparative advantages: (i) abundance of productive factors, stemming from the Heckscher-Ohlin (HO) theoretical framework; (ii) market access and economies of scale, in line with new economic geography (NEG) theory. The empirical implementation relies on a shift-share measurement framework (Rajan and Zingales, 1998). More specifically, HO- (and NEG-[14]) drivers are included in the analysis by interacting a measure of industry-level intensity of a given productive factor and a measure of country-level abundance of such factor. Endogeneity concerns are mitigated in this framework because industry-level characteristics are taken as cross-country averages and fixed over time, while country-level drivers vary over time. However, as well-known in the econometric literature (Angirst and Pischke, 2009), solving multiple endogeneity problems is exceedingly difficult in reduced-form regressions because it is not possible to build a well-defined counterfactual for each endogenous variable. Overall, the estimates presented in this section should be interpreted as theory-driven correlations rather than causal effects.

5.1 Empirical Specification

Mulatu et al. (2010) expand the empirical framework of Midelfart-Knarvik et al. (2000) to study the patterns of specialisation of polluting industries and the emergence of pollution havens within the EU area. Their key variable of interest is the sectoral pollution (or energy) intensity interacted with proxies of environmental regulation (or energy prices) at the country level. With this aim, the

[14] For instance, the optimal scale of a sector can be inferred using the average number of employees of all firms in that sector across EU countries, and this variable is interacted with manufacturing output.

authors consider a cross-section of 16 manufacturing industries in 13 countries and exploit across industries variation in pollution exposure to estimate the role of environmental policies on industry location.

As highlighted in the descriptive section of the paper, our analysis of the drivers moves from different premises, we therefore adapt the canonical approach to our case. First, green production is highly concentrated in a few high-green potential sectors where, however, it often remains a small fraction of total production. In order to avoid misleading comparisons with sectors that do not capture the aspects of the green transition studied in this paper, we limit the analysis of the drivers to high-green potential sectors. Second, we show in section 3.1 that the sectors with a high green potential are not among the carbon-intensive ones, thus we use a measure of exposure to environmental policies that is based on the potential greenness of the sector, i.e. the average green share of production for each 4-digit NACE rev. 2 industry. Finally, because high-green potential sectors are often high-to-medium tech, it is important to take stock from the existing literature on the drivers of specialisation in high-technology green sectors. More specifically, we add three drivers that have been examined by the literature on green innovation using patents: i. path dependency (e.g., Aghion *et* al., 2016), which is also in line with our descriptive evidence; ii. complementarity with proximate capabilities (e.g., Perruchas et al., 2020), which resonates with the literature showing that specialisation in one product is related to specialisation in other "similar" products (Hidalgo et al., 2007; Mealy and Teytelboym, 2020); iii. diversification of the knowledge base (e.g., Colombelli and Quatraro, 2019), which increases the scope for recombinant innovations (Weitzman, 1998).

To summarize this discussion, we begin with an econometric model that adapt the specification of Mulatu et al. (2010) over the period 2005-2015:[15]

$$\ln(RCA^{g}_{ij,t}) = \alpha + \sum_{k} \gamma_k \times \bar{\phi}_j \times X_{it} + \tau_t + \varepsilon_{ijt} \quad (4)$$

where ε_{ijt} is the error term, X_{it} are the country-level drivers explained below and time dummies τ_t that absorb common shocks for the EU countries.

[15] Most Eastern European countries enter in our dataset in 2001, with the exception of Poland, which is included only from 2003 onwards. As a consequence, focusing on the years 2005-2015 allows us to have a balanced panel and to compute pre-sample means for all countries.

Our dependent variable is the index of revealed green comparative advantage index, $RCA^{g}_{ij,t}$. While the intuition underlying this index is the same as explained in the previous sections, there are two key differences that are worth being explained here.

First, while in the previous section we used an RCA at the country level, the variable $RCA^{g}_{ij,t}$ varies by country i, sector j and time *t.* This means that while the RCA in previous sections considered green production as a single industry, here we are exploiting the full potential of our data and we look at specialisation in both green and non-green production across countries *and* industries. We therefore compute an RCA at the country-industry level for each high-green-potential industry based on its green and non-green production, as follows:

$$RCA^{k}{}_{ij,t} = \frac{y^{k}_{ijt} \Big/ \sum_j y_{ij,t}}{\sum_i y^{k}_{ij,t} \Big/ \sum_j \sum_i y_{ij,t}} \qquad (5)$$

where $k = g$ (green) or ng (non-green, i.e., $y^{ng}_{ij,t} = y_{ij,t} - y^{g}_{ij,t}$).[16] We refer to these two measures as green and non-green RCA, respectively. The main intuition behind this index is that we normalise the share that green production represents in total production in industry j in country i, by the share of green production in total production in industry j across all countries. In our econometric application, we use the log of the asymmetric $RCA^{g}_{ij,t}$: this has the benefit of dealing with the skewedness of the index, reducing its asymmetry (Dalum *et al.*, 1998, Soete and Verspagen, 1994) and also making the interpretation of the coefficients in terms of elasticity possible.

In this basic specification that closely follows Mulatu et al. (2010), our main explanatory variables combine time-invariant industry characteristics $\bar{\phi}_j$ and country characteristics X_{it} that vary over time. To capture the impact of environmental policies on green specialisation, we interact the average green production share of the sector in Europe with the EPS index of policy stringency in market-based environmental policies used in the previous section. For the impact of factor endowment, we consider capital intensity, skilled labour intensity and technological intensity.

[16] Note that here we only look at high-green potential industries, none of which can be considered as GHG-intensive. Therefore, when we compute green and non-green RCAs at the industry level, we are comparing the green and non-green production *within* the same green industry. The non-green RCA is thus different from the polluting RCA of Figure 5, which is based on the production of GHG-intensive industries shown in Table 2 and computed at the country-level.

Capital intensity is measured as the ratio between investments in tangible assets and total employment of the 4-digit sector (source Structure of Business Survey, SBS, of Eurostat) and it is interacted with the log of the investment in tangible, non-residential, assets over total employment of each country-year (source EUKLEMS-INTANProd data). For sectoral high-skill intensity, we use US Bureau of Labor Statistics OES data as there are no data at such level of sectoral aggregation for the EU. The share of high-skill labour is computed as the ratio between employment in abstract occupations and total sectoral employment in the US, and then linked to EU sectors using a crosswalk between NAICS and NACE provided by Eurostat. Sectoral skill intensity is then interacted with the share of workers with tertiary education of each country-year. Technology is captured with the interaction of the share of R&D personnel and researchers in total active population from Eurostat and a dummy taking value 1 for high- and medium-high tech manufacturing industries, following Eurostat's definition based on R&D expenditure, which we report in Table E.5 in the appendix.[17] Finally, we also include proxies for economies of scale as potential drivers in line with the NEG literature. We capture this as the interaction between total manufacturing output at the country-year level (EUKLEMS-INTANProd data) and the log of the average number of employees per plant across industries (SBS data). See Tables E.2 and E.3 in the Appendix for detailed descriptive statistics and data sources on these variables.

In our favourite specification, we progressively add to equation 4 the three key drivers identified by the literature on green technology as important for green specialisation, i.e. path dependency, complementarity with non-green capabilities and diversification of capabilities. In doing so, we estimate variants of the following equation:

$$\ln(RCA^{g}_{ij,t}) = \alpha + \sum_{k} \gamma_k \times \bar{\phi}_j \times X_{it} + \sum_{t} \beta_t \times \ln(\overline{RCA}^{g}_{ij,t_0}) + \gamma \ln\left(RCA^{ng}_{ij,t-1}\right) + \delta \ln\left(\#RCA^{g}_{ij,t-1}\right) + \vartheta \ln\left(\#RCA^{ng}_{ij,t-1}\right) + \tau_t + \varepsilon_{ijt} \tag{6}$$

The main proxy of path dependency in green specialisation is the pre-sample mean of the green RCA ($\overline{RCA}^{g}_{ij,t0}$) computed for the years 2001-2004. We interact the pre-sample mean of green RCA with time dummies to assess how persistent a "first-mover advantage" is over time. This

[17] We have also replicated this analysis using patents as a share of output, results are available upon request.

approach is also more consistent with the notion of path dependency than using the lagged dependent variable, as in standard dynamic models.

Inspired by the recent literature that has constructed the product space to map similarities – i.e. proximity in the product space – among products (Hidalgo et al., 2007; Mealy and Teytelboym, 2020), we measure the degree of complementarity between green and non-green capabilities using the level of non-green RCA within the same four-digit sector and lagged by one year ($RCA_{ij,t-1}^{ng}$).[18] Taking the level of non-green specialisation within the same detailed 4-digit sector represents a natural way to measure capabilities that are similar to green ones. Note that the effect of having a stronger non-green RCA on green specialisation is unclear ex-ante. It can be positive if the non-green capabilities can be replicated and successfully used to create a green comparative advantage within the same sector. It can be negative if there is competition between the green and non-green uses of a similar pool of capabilities. While determining which effect would prevail is an empirical issue that we will explore through equation 6, the unconditional correlation between green $RCA_{ij,t}^{g}$ and non-green $RCA_{ij,t}^{ng}$ is rather high (0.5). Thus, we expect stronger non-green capabilities within the same sector to be a driver of green comparative advantage.

Finally, we capture green (non-green) diversification in a country's capabilities within a particular sector with the number of green (non-green) products with an RCA>1, i.e., above the threshold designating a country as having a comparative advantage for that product at time $t-1$ ($\#RCA_{ij,t-1}^{g}$ and $\#RCA_{ij,t-1}^{ng}$ for green and non-green diversification, respectively). To account for skewness in this measure, we take the log of both these variables.[19] We argue, in line with the well-established literature on structural change, that countries specialise in products based on their productive capabilities (Hidalgo *et al.*, 2007; Hidalgo and Hausmann, 2009), and therefore, the number of green goods produced with an RCA within each country-industry, will capture the breadth of green productive capabilities.

[18] We use this approach rather than building a fully-fledged measure of product proximity based on product-space approaches (see Hidalgo et al. 2007). This is because such proximity measures would be built using co-occurrence in green and non-green RCA. This makes it not suitable to be used in an econometric analysis of the drivers, since correlation between green and non-green specialisation would exist by construction, due to the way proximity is computed.

[19] We deal with the case in which the number of products is 0 by adding 1 so that the log transformation does not yield missing values.

5.2 Results

Table 4 contains the main result of our econometric analysis. We begin with the specification where only the controls of the canonical model are included (equation 4), then we progressively add the other variables capturing path-dependency, non-green capabilities and diversification (equation 6). The last column is our favourite specification where we also include country fixed effects to equation 6 to account for unobservable differences in policies and institutions that may be correlated with the green RCA. As in Mulatu et al. (2010), for the variables of the canonical model the interpretation requires computing the marginal effect of country-level driver (e.g. university graduates) in correspondence to different percentiles of industry-level characteristics (i.e. share of highly skilled workers). For sake of space, we present such calculations in Table E.9 and E.10 of the Appendix, for both our favourite specification of column 5 and the canonical specification of column 1.

Column 1 presents the results of the canonical specification. The bottom line is that none of the standard drivers matter for green specialisation. This conclusion is confirmed when we compute the marginal effects of the drivers at different percentiles of industry characteristics (Table E.9). The only exception is the EPS index, for which the marginal effect increases together with the share of green production of the industry, suggesting that green policies may at best reinforce existing patterns of green specialisation. While the effect of the interaction term is only nearly significant (p-value=0.105) in the basic specification of Column 1, Table E.9 shows that the EPS index becomes statistically significant already at the median of the green industry share and keeps increasing until the last decile. However, the association between the index of environmental policy and the green RCA becomes smaller when adding the controls for path-dependency, non-green capabilities and diversification (columns 2-5). In our favourite specification from column 5, Table E.10 shows that the EPS never passes the threshold above which its effect on green specialisation becomes statistically significant, thus the effect of environmental policies is fully absorbed by other structural factors.

Two, not mutually exclusive but untestable, explanations can account for this result. First, there is measurement error in our proxies of the drivers that leads to an attenuation bias. The skill intensity, for instance, is obtained from US data through a cross-walk between the US and the EU industry classification that includes several many-to-many matches and is not perfect. Second, the variation in the industry characteristics is much smaller in our subsample of high-green potential industries compared to the sample of all manufacturing industries used by Mulatu et al. (2010). Table E.5 confirms this conjecture by reporting the standard deviation and the coefficient of variation of three industry characteristics (skill,capital intensity and the average number of employees per plant) for high-green potential industries and all manufacturing industries. The subsample of high-green potential industries exhibits much less variability in the industry characteristics (which are used to estimate the effect of country-level drivers) compared to the entire sample of manufacturing industries.

Column 2 considers a specification where we add the pre-sample mean of the green RCA, which is our proxy for first-mover advantage. The pre-sample mean is interacted with time dummies to estimate the speed at which the pre-2004 advantage fades away. The persistency of such advantage is remarkable: the elasticity of the pre-2004 green RCA is 0.92 after one year and 0.69 after eleven years. As we progressively add other variables in columns 3, 4 and 5, we observe a parallel decline of the influence of the first-mover advantage. In the most comprehensive specification of column 5, the elasticity of the initial advantage is still 0.74 after one year and 0.52 after eleven years. This implies that, conditional on the other covariates that are also correlated with long-term structural factors and thus with first-mover advantage, a one standard deviation in the log of the initial green advantage (3.31, see Table E.1) continues to explain as much as a 50.9% of one standard deviation in the log of the green RCA (3.39, see Table E.1) after eleven years.[20] Overall, the first implication of our analysis is that green specialisation is highly persistent and policy interventions can do little, especially in countries without an existing expertise in green industries.

In column 3, we highlight our second main finding. Green and non-green specialisation reinforce each other as highlighted by the positive and statistically significant coefficient of the non-green RCA. The quantitative impact is not negligible, conditional on other factors: a one standard deviation increase in the log of non-green specialisation (2.855) in high-green potential industries explains as much as 16% of one standard deviation in the log of green RCA (3.388). This association becomes quantitatively smaller as we add the proxies of diversification (column 4) and country fixed effect (column 5). In this most comprehensive specification, the non-green RCA still explains 10% of one standard deviation of the green RCA. The similarity between green and non-green competences within a narrowly defined domain (i.e. technology field, sector or occupation)

[20] This number is obtained by multiplying the coefficient of the log of the green RCA PSM after 11 years (0.522) by its standard deviation (3.31) and dividing it by a standard deviation in the log of the green RCA (3.39).

resonates with previous findings of Perruchas et al. (2020) using patents, Mealy and Teytelboym (2019) using export data and Vona et al. (2018) using skill data. Because building such capabilities takes time and depends on structural strengths of a country's industrial system, the complementarity of green and non-green capabilities helps explain the persistency in green specialisation.

In column 4, we include the proxies of diversification in green and non-green productions. We find that the number of green products with an RCA is positively and significantly correlated with the average green RCA of the industry. A one standard deviation change in the number of green products with RCA explains as much as 21.1% of a standard deviation in the green RCA. Note that such correlation should be interpreted conditional on all the other covariates including the initial green RCA. Furthermore, non-green diversification is positively associated with an increase in the green RCA of the industry, although the coefficient is far from statistically significant at conventional level. Since the number of products with a non-green RCA is mechanically correlated with the non-green RCA, it is not surprising to detect a decline in the coefficient associated with the non-green RCA in columns 4 and 5. This last set of results suggests that diversifying the set of capabilities is important for maintaining a comparative advantage in green production. Yet, because only a few countries have green products with a revealed comparative advantage, the diversification channel is not easily accessible for laggard countries that want to catch up with leaders.

In the appendix, we conduct a series of robustness checks of these results. First, results hold when we consider all green sectors (TableE.6). The main notable difference is the positive and significant effect of the interaction between environmental policies and the average green share of production of the industry in the favourite specification of column 5. Thus, a policy stimulus is more effective if there is more variability in the set of industries included in the estimation sample. Second, weighting the regressions using the average industry turnover does not alter the main results, but again reinforces the effect of policies in greener sectors (Table E7). The effect of the non-green RCA is also estimated less precisely in our favourite specification, leading to non-statistically significant relationship between green and non-green specialisation. Finally, we conduct the same analysis using the CLEG list (Table E.8). Importantly, results on the main drivers (pre-sample mean of the green RCA, non-green RCA and diversification proxies) are qualitatively similar to those obtained using our favourite list, although the estimated elasticities are somewhat smaller.

6. Conclusions

This paper presents new stylized facts on the structure and evolution of specialisation in green productions by assembling a new dataset based on the PRODCOM dataset of Eurostat, which allows for the first time to examine variation in green production across detailed sectors (4-digit NACE), countries (in the EU) and over several years (1995-2015). We construct a favourite list of green products by cleaning existing lists proposed during recent international negotiations at the WTO to reduce tariffs for such products. Our main criterion is to exclude green goods with double usages from our final list, as this is the most challenging issue in the debate on the definition of what is green.

Our first finding is that there is virtually no overlap between green production and the (direct and indirect) GHG-intensity across two-digit NACE industries. This result has two important implications. In the debate on the definition of what is green, the process and output-based approaches capture different aspects of the green economy. Naturally, both will be important to achieve the green transition. The paper strives to include both these approaches in its analysis, although data constraints on emissions content of production only make this possible at a coarser level of aggregation (2 digits of NACE) than what is available within PRODCOM. Despite the high level of aggregation, the analysis of the revealed green and brown comparative advantage indicates that European countries tend to specialise either in green or brown sectors.

The second result is that green production is highly concentrated in a few sectors despite an average increase of 12.5% (from 2% to 2.25%) over the considered period: out of 119 4-digit manufacturing sectors, 13 of them represent 95% of European green production and are those where green production has been most diffused.

Third, we rely on revealed comparative advantage measures and find that that green leaders are high-income countries where high-to-medium tech manufacturing industries were already strong and environmental policies were more stringent. Taken together with the divergent country specialisation on green and brown sectors, this result raises the concern that the EU green deal plan may exacerbate existing cross-country inequality. In light of this, it is important that green policy interventions also strive to develop new pathways to achieve green specialisation and do not simply reward pre-existing comparative advantages.

Last, we examine the drivers of green specialisation comparing the role of standard Heckscher-Ohlin drivers, environmental policies and other structural determinants of green specialisation considered as important in the literature on environmental innovation. Once we control for path dependency and other structural variables, we find this not to be associated with more stringent environmental policies. In contrast, our results highlight a remarkable persistence in green specialisation suggesting that first-mover advantage may be an important factor at play. Moreover, within similar 4-digit industries, green and non-green specialisations complement and reinforce each other. The role of such complementarities is clearly smaller than that of path dependency but corroborates the descriptive analysis pointing to the pre-existing advantage in certain high-to-medium tech sectors. Finally, diversifying the portfolio of green products with comparative advantage is important for sustaining green specialisation.

A shortcoming of our analysis is that the data are limited to European countries. Because the index of comparative advantage is relative in nature and depends on the number of countries available in the data, there is limited cross-country variation in our data. This is compensated by the fact that we can study production at a highly detailed level of resolution and that our data include all production and not just export flows.

Another limitation of the PRODCOM data is that it only covers the production of manufactured goods and thus excludes the service sector. Leaving services out of our analysis also means ignoring the largest part of European economies, some of which, such as knowledge intensive business sectors, may have a significant enabling role in the green economy. Finally, our analysis identifies green products based on their potential to benefit the environment, and comparison with pollution intensity production is possible only at 2 digits of aggregation. Future research will greatly benefit from more disaggregated information on the pollution content of production so that both output and process approaches can be used within the same analytical framework.

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Tables and Figures

Table 1: Correlation table among green product lists.

	(1) CLEG	(2) WTO 2009	(3) PEGS	(4) *PRODCOM (favourite)*	(5) APEC	(6) German list	(7) Core (WTO + CLEG)	(8) WTO Core	(9) CLEG Core
CLEG	1								
WTO 2009	0.84**	1							
PEGS	0.73**	0.47**	1						
PRODCOM (favourite)	0.49**	0.31**	0.58**	**1**					
APEC	0.46**	0.49**	0.41**	0.31**	1				
German list	0.16**	0.15**	0.14**	0.12**	0.17**	1			
Core (WTO + CLEG)	0.37**	0.37**	0.35**	0.45**	0.44**	0.13**	1		
WTO Core	0.29**	0.25**	0.27**	0.3**	0.16**	0.04**	0.77**	1	
CLEG Core	0.23**	0.28**	0.24**	0.35**	0.51**	0.16**	0.65**	0.03**	1
Number of goods	819	604	470	221	206	147	123	78	47

Notes: authors' own calculation on PRODCOM data. The table reports correlation coefficients of dummy variables indicating the presence of a certain product in a given list across different lists. The last row reports the number of PRODCOM product codes within each green product list. For further details about the lists of green goods, see Appendix A. *p<0.05 ** p<0.01.

Table 2: Green and polluting production by 2-digit industries.

(1) NACE	(2) Label	(3) Mean green share 2005	(4) Mean green share 2010	(5) Mean green share 2015	(6) Share of total green production	(7) Absolute Change 2005-2015	(8) Average GHG intensity
28	Manufacture of machinery and equipment n.e.c.	0.074 (0.068)	0.084 (0.083)	0.096 (0.098)	0.28	0.022	0.54
27	Manufacture of electrical equipment	0.108 (0.166)	0.103 (0.078)	0.162 (0.217)	0.22	0.054	0.30
26	Manufacture of computer, electronic and optical products	0.069 (0.06)	0.121 (0.131)	0.103 (0.076)	0.22	0.034	0.30
30	Manufacture of other transport equipment	0.281 (0.292)	0.346 (0.318)	0.38 (0.334)	0.13	0.098	0.61
33	Repair and installation of machinery and equipment	0.022 (0.031)	0.033 (0.024)	0.028 (0.026)	0.04	0.006	0.74
29	Manufacture of motor vehicles, trailers and semi-trailers	0.002 (0.01)	0.007 (0.031)	0.003 (0.011)	0.01	0.001	0.61
31	Furniture	0 (0)	0 (0)	0 (0)	0	0	0.74
32	Other manufacturing	0 (0)	0 (0)	0 (0)	0	0	0.74
16	Products of wood, cork, straw, plaiting	0 (0)	0 (0)	0 (0)	0	0	0.88
22	Rubber and plastic products	0 (0)	0 (0)	0 (0)	0	0	0.94
13	Textiles	0 (0)	0 (0)	0 (0)	0	0	0.97
14	Wearing apparel	0 (0)	0 (0)	0 (0)	0	0	0.97
15	Leather and related products	0 (0)	0 (0)	0 (0)	0	0	0.97
17	Paper and paper products	0 (0)	0 (0)	0 (0)	0	0	1.18
18	Printing and reproduction of recorded media	0 (0)	0 (0)	0 (0)	0	0	1.18
10	Food products	0 (0)	0 (0)	0 (0)	0	0	1.45
11	Beverages	0 (0)	0 (0)	0 (0)	0	0	1.45
12	Tobacco products	0 (0)	0 (0)	0 (0)	0	0	1.45
	Polluting industries						
19	Coke and refined petroleum products	.	0 (0)	0 (0)	0	.	44.99
23	Other non-metallic mineral products	0.029 (0.029)	0.033 (0.022)	0.033 (0.026)	0.05	0.003	7.78
20	Chemicals and chemical products	0 (0)	0 (0)	0 (0)	0	0	5.11
21	Basic pharma. products, preparations	0 (0)	0 (0)	0 (0)	0	0	5.11
25	Fabricated metal products, exc. machinery	0.018 (0.018)	0.019 (0.016)	0.017 (0.014)	0.05	-0.001	4.23
24	Basic metals	0.006 (0.021)	0.007 (0.023)	0.008 (0.03)	0.01	0.002	4.23

Notes: Authors' elaboration on PRODCOM data. Production values are deflated to have data at constant prices, with 2010 as base year. The definition of green products used here is explained in Section 2 (PRODCOM in Figure 1). Columns 3 to 5 report the mean green share of production with the standard deviation in brackets of each industry for the years 2005,2010 and 2015, respectively. Coke and refined petroleum products is not included in PRODCOM until 2005, as PRODCOM coverage is not stable over time and doesn't include fuel related products. Column 6 reports the share that green production of each industry represents in total green production. Absolute changes 2005-2015 refer to industries' average green shares of production. Polluting industries are identified as the 5 industries with the highest average GHG intensity computed with WIOD, for further detail see Appendix B.

Table 3: Distribution of green production shares across green industries at 4 digits NACE

(1) NACE	(2) Label	(3) Mean	(4) Median	(5) Max	(6) Standard deviation	(7) Change 1995-2015	(8) Change 2001-2015	(9) Share of green production
High green potential industries								
3092	Manufacture of bicycles and invalid carriages	0.78	0.82	1	0.24	0.11	0.14	3.12
3020	Manufacture of railway locomotives and rolling stock	0.71	0.80	1	0.28	-0.08	-0.06	9.99
2530	Manufacture of steam generators, except central heating hot water boilers	0.55	0.54	1	0.35	0.21	0.34	1.91
2312	Shaping and processing of flat glass	0.4	0.34	1	0.30	0.04	0.07	4.83
2712	Manufacture of electricity distribution and control apparatus	0.39	0.34	1	0.23	0.03	0.03	16.86
2651	Manufacture of instruments and appliances for measuring, testing, etc.	0.37	0.37	1	0.19	0.04	-0.04	18.29
2829	Manufacture of other general-purpose machinery n.e.c.	0.29	0.24	1	0.22	0.12	0.16	7.75
2825	Manufacture of non-domestic cooling and ventilation equipment	0.28	0.28	1	0.18	-0.07	-0.04	11.18
2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0.21	0.07	1	0.30	0.14	0.06	8.61
2611	Manufacture of electronic components	0.14	0.01	1	0.27	0.13	0.13	3.85
2740	Manufacture of electric lighting equipment	0.13	0.12	0.66	0.10	0.00	-0.04	3.48
2752	Manufacture of non-electric domestic appliances	0.11	0.03	0.50	0.14	-0.03	0.02	1.05
3320	Installation of industrial machinery and equipment	0.08	0.06	0.67	0.08	0.08	0.05	3.98
Marginally green industries								
2410	Manufacture of basic iron and steel and of ferro-alloys	0.04	0.00	1.00	0.18	0.03	-0.06	0.65
2751	Manufacture of electric domestic appliances	0.04	0.00	0.91	0.11	0.00	0.04	0.48
2511	Manufacture of metal structures and parts of structures	0.03	0.03	0.19	0.03	-0.02	0.00	2.09
2599	Manufacture of other fabricated metal products n.e.c.	0.02	0.01	0.29	0.04	0.00	0.00	0.62
2351	Manufacture of cement	0.01	0.00	0.34	0.05	0.01	-0.01	0.24
2910	Manufacture of motor vehicles	0.01	0.00	0.51	0.04	0.01	0.00	0.79
2899	Manufacture of other special-purpose machinery n.e.c.	0.002	0.00	0.10	0.01	0.01	0.01	0.20
2711	Manufacture of electric motors, generators and transformers	0.0005	0.00	0.04	0.00	0.00	0.00	0.03

Notes: Authors' elaboration on PRODCOM data. Production values are deflated to have data at constant prices, with 2010 as base year. The definition of green products used here is explained in section 2 and it is the one called PRODCOM in Figure 1. Average, median, maximum and standard deviation are computed over all available countries and years (1995-2015), columns 7 and 8 report changes in the average green share for 1995-2015 and 2001-2015 respectively. The last column reports for each industry the share it represents in total green production across all industries, countries and years.

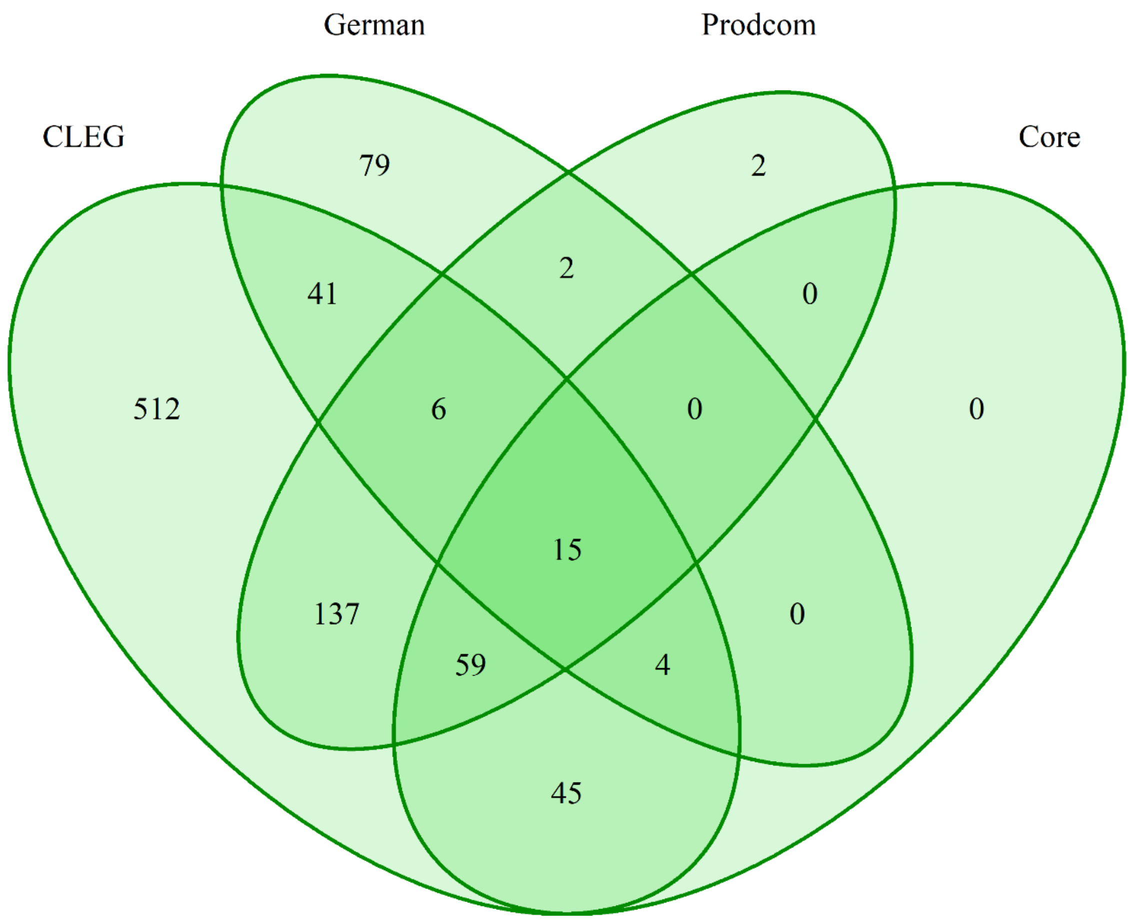
Table 4: Drivers of green specialisation.

	(1)	(2)	(3)	(4)	(5)
Country environmental policies	0.176	-0.489	-0.353	-0.368	-0.0875
	(0.454)	(0.324)	(0.321)	(0.279)	(0.204)
Industry environmental policies	-2.585	-2.177	-0.401	-0.234	-0.816
	(2.284)	(1.371)	(1.397)	(1.262)	(1.218)
Country env. Policies * Industry env. policies	1.642	1.207*	0.663	0.565	0.686
	(1.008)	(0.711)	(0.679)	(0.571)	(0.566)
Population (log)	1.883***	1.434***	1.232***	1.212***	3.514
	(0.653)	(0.464)	(0.424)	(0.399)	(4.799)
Country capital intensity	-0.346	1.517	1.427	1.160	1.172
	(1.815)	(1.150)	(1.132)	(1.071)	(1.229)
Industry capital intensity	-0.809	0.187	0.236	0.256	0.146
	(0.646)	(0.432)	(0.417)	(0.421)	(0.414)
Country capital intensity * Industry capital intensity	0.211	-0.168	-0.185	-0.132	-0.100
	(0.339)	(0.231)	(0.223)	(0.220)	(0.214)
Country skills	-0.449	-0.890	-0.829	-0.716	-0.828
	(1.511)	(0.958)	(0.929)	(0.869)	(1.026)
Industry skills	-0.151	-0.0842	-0.123	-0.174	-0.153
	(0.302)	(0.166)	(0.170)	(0.162)	(0.148)
Country skills * Industry skills	0.0255	0.0255	0.0364	0.0430	0.0365
	(0.0888)	(0.0508)	(0.0512)	(0.0483)	(0.0447)
Country technology	-0.628	0.153	0.108	0.249	0.171
	(1.284)	(0.781)	(0.730)	(0.666)	(0.739)
Industry technology	6.094	2.077	1.858	-0.0161	0.586
	(5.463)	(3.137)	(2.855)	(2.640)	(2.505)
Country technology * Industry technology	1.235	0.480	0.447	0.0338	0.155
	(1.175)	(0.690)	(0.638)	(0.586)	(0.552)
Country scale	-2.350**	-1.389**	-1.153**	-1.177**	-0.577
	(1.104)	(0.615)	(0.565)	(0.537)	(1.142)
Industry scale	-10.65	-1.065	-0.283	0.163	-0.0703
	(6.666)	(3.371)	(3.242)	(2.846)	(2.391)
Country scale * Industry scale	0.381	0.0252	-0.00566	-0.0176	-0.0112
	(0.251)	(0.128)	(0.123)	(0.108)	(0.0906)
Non-green RCA (log, t-1)			0.190***	0.124**	0.117**
			(0.0571)	(0.0540)	(0.0505)
Number of green products with RCA (log, t-1)				1.245***	1.202***
				(0.222)	(0.201)
Number of non-green products with RCA (log t-1)				0.230	0.0202
				(0.148)	(0.137)
2005 * PSM RGA (ln)		0.924***	0.834***	0.744***	0.737***
		(0.0349)	(0.0494)	(0.0521)	(0.0526)
2006 * PSM RGA (ln)		0.879***	0.792***	0.707***	0.698***
		(0.0421)	(0.0583)	(0.0614)	(0.0611)
2007 * PSM RGA (ln)		0.802***	0.710***	0.631***	0.623***
		(0.0562)	(0.0735)	(0.0761)	(0.0794)
2008 * PSM RGA (ln)		0.798***	0.717***	0.638***	0.628***
		(0.0591)	(0.0734)	(0.0746)	(0.0788)
2009 * PSM RGA (ln)		0.764***	0.689***	0.609***	0.595***

		(0.0604)	(0.0725)	(0.0712)	(0.0746)
2010 * PSM RGA (ln)		0.768***	0.708***	0.622***	0.601***
		(0.0602)	(0.0662)	(0.0679)	(0.0710)
2011 * PSM RGA (ln)		0.781***	0.728***	0.642***	0.618***
		(0.0604)	(0.0640)	(0.0658)	(0.0696)
2012 * PSM RGA (ln)		0.756***	0.700***	0.623***	0.600***
		(0.0646)	(0.0673)	(0.0664)	(0.0698)
2013 * PSM RGA (ln)		0.718***	0.655***	0.580***	0.555***
		(0.0682)	(0.0725)	(0.0734)	(0.0757)
2014 * PSM RGA (ln)		0.686***	0.624***	0.551***	0.521***
		(0.0726)	(0.0746)	(0.0767)	(0.0777)
2015 * PSM RGA (ln)		0.686***	0.617***	0.549***	0.522***
		(0.0695)	(0.0735)	(0.0741)	(0.0742)
Constant	32.34	15.58	12.26	12.20	-40.71
	(26.68)	(14.90)	(14.19)	(12.82)	(94.86)
Observations	2,444	2,444	2,444	2,444	2,444
R-squared	0.232	0.634	0.649	0.688	0.708
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	Yes

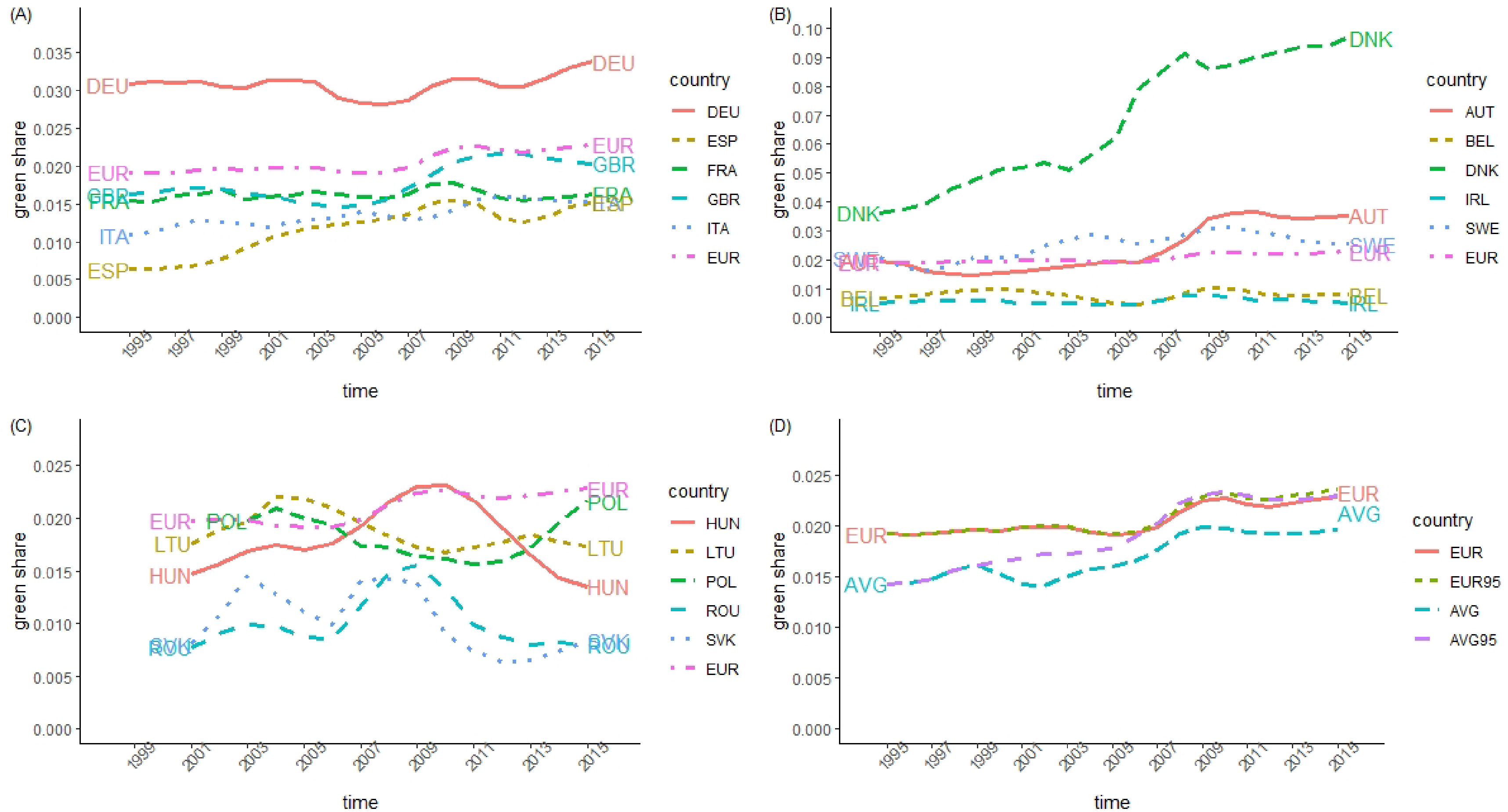
Notes: Pre-sample mean computed for the years 2001-2004, for Poland only for 2003-2004 due to data constraints. Production values are deflated to have data at constant prices, with 2010 as base year. All RGA explanatory variables, except the pre-sample mean, are lagged by one year. Variable names are simplified for space's sake, Table E.4 reports full details. Estimation time span is 2005-2015. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Overlap of PRODCOM product codes among selected lists of green goods.



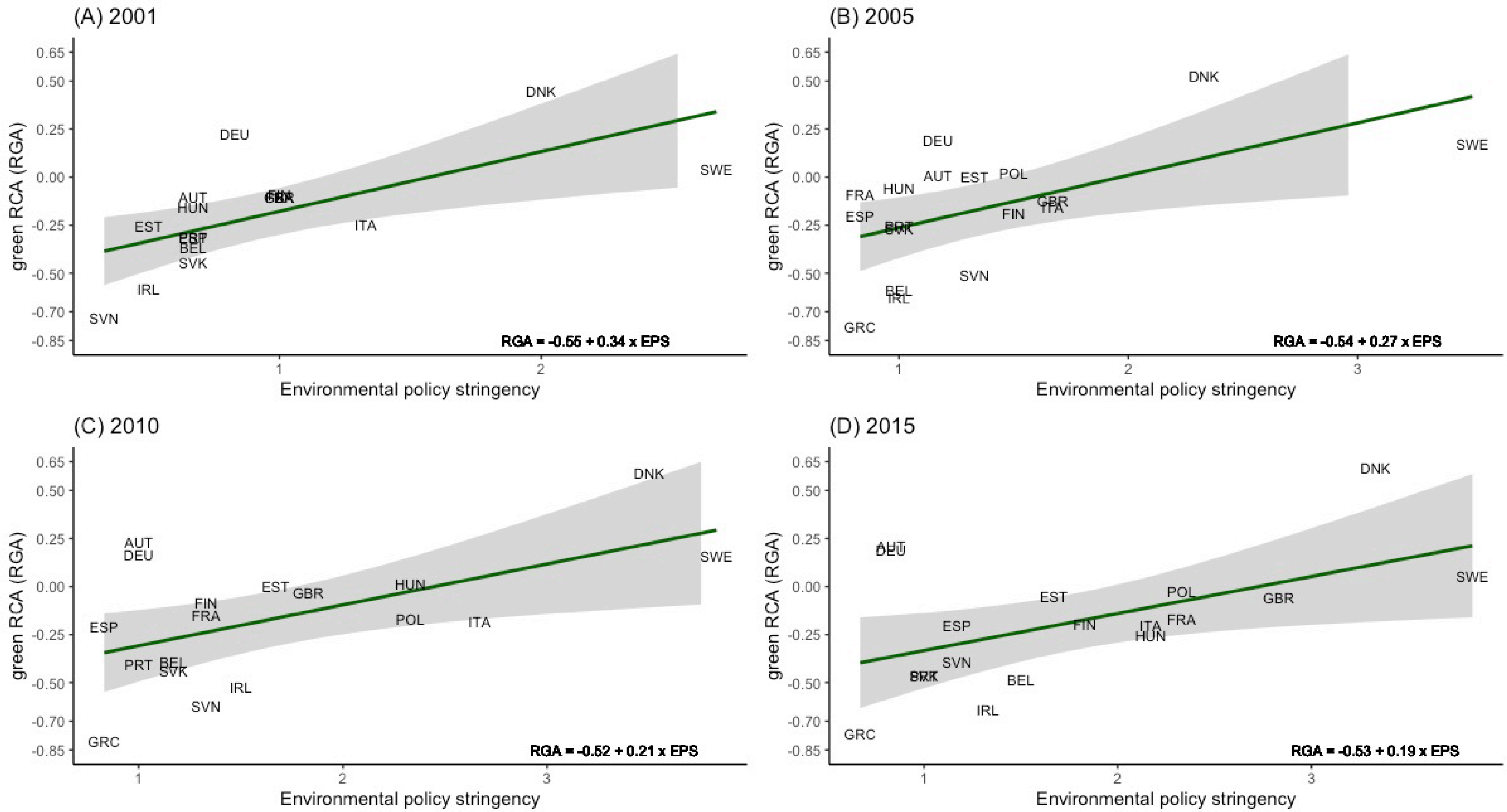
Notes: Authors' elaboration on PRODCOM data. The figure depicts the overlap among four existing lists of green goods, the numbers represent the number of PRODCOM product code that fall within each category. For further details about the lists of green goods see Appendix A.

Figure 2: Evolution of green production shares for selected European countries



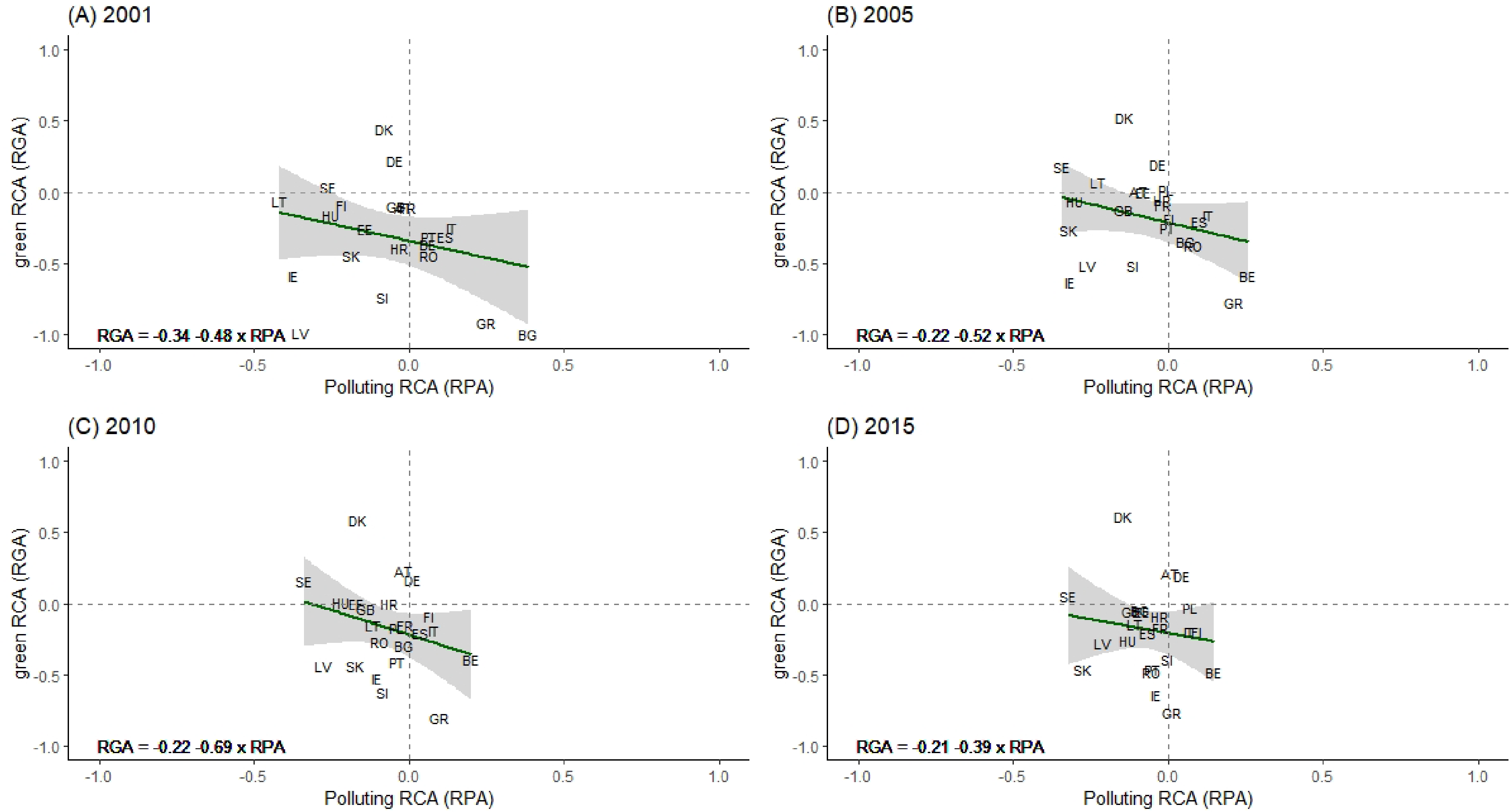
Notes: Panel A, B and C report green production shares over time for large, small and Eastern European countries, respectively. These have been smoothened by taking 3-years moving averages. Production values are deflated to have data at constant prices, with 2010 as base year. We only use green production from high-green potential industries as identified in Table 3. EUR is the European green shares across all available countries in each year. In panel D, we compare it with the unweighted average (AVG) across countries. Because data on Eastern countries is available only from 2001 onwards, and 2003 onwards for Poland, we report both these measures computed for each year for all available countries as well as only for countries for which we have a balanced panel since 1995, i.e.: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain, Sweden, United Kingdom, (EUR95 and AVG95, respectively).

Figure 3: Green RCA and environmental policy stringency across countries and over time.



Notes: Authors' elaboration on PRODCOM data and OECD for the index of environmental policy stringency (EPS) for market-based policies. We plot countries' green RCA and the EPS, developed by the OECD. Green RCA is based solely on green production from high-green potential industries, as identified in Table 3. Production values are deflated to have data at constant prices, with 2010 as base year. The RCAs are computed following formula 3 are made symmetrical around 0 and bounded between -1 and 1, the value of 0 indicates therefore whether a country has successfully specialised in green production. We also report the coefficient of a regression of green RCA on the EPS index for each year.

Figure 4: Green and polluting RCA across countries and over time.



Notes: Authors' elaboration on PRODCOM data. We plot countries' green and polluting RCA. Green RCA are based solely on green production from high-green potential industries, as identified in Table 3. Polluting production is total production from polluting industries identified in Table 2. Production values are deflated to have data at constant prices, with 2010 as base year. The RCAs are computed following formula 3 are made symmetrical around 0 and bounded between -1 and 1, the value of 0 indicates therefore whether a country has successfully specialised in green production. We also report the coefficient of a regression of green RCA on polluting RCA for each year.

Appendix (for online publication)

A. Data

This Appendix is divided in two sections that both discuss in more detail how we go about identifying green products to compute green shares of production. First, we argue in the main text why it is important to use production data and what advantages such a data source presents compared to previous work. We present here a detailed discussion of the features and limitations, and we overcome these, of our source of data, i.e. PRODCOM.

Second, we also compare our preferred list of green products with other existing ones and provide the full list of products that we end up including as green products so that other researchers may use these in their work.

A.1 PRODCOM data

PRODCOM sets itself apart from other datasets because it provides information on sold production (rather than just trade) at a very high level of disaggregation[21] across many European countries over a considerable period of time. However, the use of the PRODCOM data also presents three important challenges. The first is that the product coverage changes over time due to the entry and exit of products.[22] Second, product codes change over time due to constant statistical redefinition, with multiple product codes merging into a single new code or one code splitting into several new or existing codes. Third, in 2008, there was a change in industry classification (from NACE rev. 1 to NACE rev. 2), with some products changing industries at the 4-digit level between the two versions. As a result, by aggregating data at the 4-digit industry level, as we do in this study, the combination of changes in product codes and of industry classification may conflate genuine changes in production within an industry with a mere statistical reassignment of products to industries.

We deal with these issues using the Van Beveren, Bernard and Vandenbussche (2012) (VBBV) methodology to harmonize the PRODCOM data over time. The methodology identifies chains of

[21] The coverage and number of product codes in the PRODCOM data varies yearly; the average number of 8-digit product codes contained in the PRODCOM data between 1995 and 2015 is 4,288.

[22] While entries and exits concern few products across all sectors, it should be noted that fuel and coke related products are excluded from the PRODCOM data until 2005, leading to no information on the production of the whole 2-digit sector "coke and refined petrol".

product codes that changes over time due to statistical reclassification and attributes a "synthetic code" to each chain that does not change over time. A key advantage of this methodology is that it solves problematic issues in the crosswalk from NACE rev. 1 to NACE rev. 2.[23] Indeed, each of these synthetic codes can be easily paired with a NACE rev. 2 industry code at the 4-digit level, since these are the first 4 digits of the PRODCOM codes from 2008 onwards. Because the synthetic codes do not change over time, we can allocate production values (at constant prices[24]) to NACE rev. 2 industries for the years preceding their introduction, covering the whole timespan of the PRODCOM data (1995-2015).

Another key advantage of the VBBV procedure is that it yields a time-consistent measure of green production, taking into account that green products may split into a green and a non-green product or merged with a non-green product. An example in the PRODCOM dataset is wind turbines. Until 2007, wind turbines were classified under a residual heading "generating sets n.e.c.", which contained both green and non-green products. Only after 2008 did the code split into a non-green product, "generating sets (excluding wind powered and powered by spark-ignition internal combustion piston engine)", and a green product, "generating sets, wind-powered". As a consequence, we have information on the production of wind-powered generating sets only after the year in which the split occurred (2008), while before then, wind turbines were lumped together with other generating sets. A similar issue applies when a green and non-green product are merged into a unique synthetic code.[25]

To deal with this additional challenge and impute the missing data on green production (e.g., wind turbines before 2008), we first compute the average (country-product specific) share of the green production of the synthetic code that merged or split over the three years after (before) the merge (split). We then allocate production proportionally to this share in the years in which we cannot distinguish between green and non-green production. Finally, the PRODCOM data has some missing values at the product level, due to inconsistencies in the countries' reporting to Eurostat. Whenever possible we impute these by applying the average growth rate to fill the years between

[23] Eurostat provides a crosswalk between the two versions of NACE. However, such crosswalk is imperfect as it entails many-to-many correspondences with some NACE rev 1 industries splitting and/or merging into NACE rev 2 industries.

[24] We match our data to the EUKLEMS dataset, which contains industry-country specific price deflators at 2-digits NACE classification. We use these deflators to obtain production values at constant price. We use 2010 as base year.

[25] Among the products that we identify as green, which are explained in details in section 2.3, 82 out of 221 green products are affected by this issue.

two non-missing observations. The issue remains unfortunately for trailing and leading missing values (i.e. those country-product-year combinations for which we have no non-missing observations either before or after). This is however mitigated by the fact that our analysis is carried out at 4-digits NACE rev. 2. Unless all products underlying a given NACE 4-digit code are all missing (as it is the case, for example for Poland before 2003) we perform our aggregations treating the missing values as zeros.

A.2 Lists of green products

In this Appendix, we provide additional information on the lists used to identify our favourite PRODCOM list and for the validation analysis of Section 2.4. As we detail in Section 2 our universe of potential lists is the union of the CLEG list and German list. CLEG is the result of the union of three broader lists of the Asia and Pacific Economic Cooperation (APEC) forum, WTO Friends' list and Plurilateral Environmental Goods and Services (PEGS).

In 2012, the APEC members have committed to reduce tariffs on green goods to 5% at the most, in the Vladivostok declaration (APEC, 2012).[26] The APEC list is one of the most commonly used list in investigating the role of trade in green products on pollution (Zugravu-Soilita, 2018; Mealy and Teytelboym, 2019). Negotiations within the WTO have led to the creation of several lists, of which the WTO Friends' list from 2009 and its more narrow subset WTO core have also received considerable attention (Sauvage, 2014; Mealy and Teytelboym, 2019). Finally, the PEGS list has been developed by the OECD in preparation for the Toronto G20 summit in 2010 and among the three lists included in CLEG is the only one that is not the outcome of international trade negotiations, which as we have discussed in Section 2 can impact what products are included in the final list.

As we have discussed in the main text, a key challenge with these product lists is that the HS classification is not designed to isolate green products and therefore there is the risk that green and non-green products may be lumped together under the same product code. In other words, it is possible that a given product code may cover both green and non-green products. In order to deal with this the OECD has relied on experts' advice and has examined all products codes included in the CLEG list to identify those that are less likely to be affected by this issue. OECD experts have

[26] APEC members are: Australia, Brunei, Canada, Indonesia, Japan, South Korea, Malaysia, New Zealand, Philippines, Singapore, Thailand, the United States, Taiwan, Hong Kong, China, Mexico, Papua New Guinea, Chile, Peru, Russia and Vietnam.

provided an estimate of the proportion of trade flows taking place under each product code that corresponds to trade of green goods. They have used two thresholds, 2/3 and 1/3 to put forward two narrow lists: CLEG Core and CLEG Core Plus, respectively.

To give an example of how these two lists treat products differently, we can think of vacuum pumps that include both pumps that can be used for environmentally friendly functions, such as water management, as well as in other production processes that have no positive impact on the environment. In this specific case the OECD experts have estimated that more than 33% but less than 66% of all traded vacuum pumps are actually used to fulfil environmental activities. Therefore, the OECD has included this product in the CLEG Core plus list but not in the CLEG Core. In light of this ambiguity, vacuum pumps are not included in our own list, as they do not respect the criterium of no multiple usage.

To recap, we have a set of broad lists (CLEG, WTO2009, APEC, PEGS and German list) and a set of narrow lists (CLEG Core, CLEG Core Plus and WTO Core). This multitude of lists reflects the lack of agreement on a definition of green products. We present all the lists we have discussed here in Table A.1.

Table A.1 – Green lists

List	Year	N. of Products	Description	Negotiated	Organization
CLEG	2014	819	The list has been compiled by Sauvage (2014) merging WTO Friends, PEGS and APEC.	No	OEDC
WTO Friends	2009	604	This list has been negotiated by a smaller group of high-income economies within the WTO	Yes	WTO
PEGS	2010	470	The list has been compiled by OECD with a focus on renewable energies	No	OECD
APEC	2012	206	Countries member of APEC have negotiated this list agreeing to reduce tariffs on the products included down to at least 5%	Yes	APEC
WTO Core	2011	78	This is more restrictive list that has been negotiated within WTO during negotiations towards a comprehensive free trade agreement on environmental goods.	Yes	WTO
CLEG Core Plus	2014	163	This is a more restrictive version of CLEG compiled by OECD experts with the aim of dealing with the issue of multiple usage. It only includes product codes for which at least 1/3 of the associated trade flows consists of green products.	No	OECD
CLEG Core	2014	47	This is an even more restrictive version of CLEG compiled by OECD experts with the aim of dealing with the issue of multiple usage. It only includes product codes for which at least 60% of the associated trade flows consists of green products.	No	OECD
German list	2009	147	The list has been compiled by Germany's statistical office in accordance with Eurostat's criteria of environmental protection and resource management.	No	German National Statistical Office

Notes: Authors' elaboration on PRODCOM data. For each list we report its name, the year in which it was compiled, the number of PRODCOM codes it contains, a brief description of the list, whether it is the outcome of trade negotiations and which organization has compiled it. All lists in the table are based on the HS product classification, except for Germany's list that is compiled with PRODCOM product codes. To obtain the number of products for each list we have relied on crosswalks between HS and Eurostat's Combined Nomenclature (CN) and between PRODCOM and CN, provided by Eurostat.

Table A.2 – List of green products

PRODCOM code	Synthetic code	PRODCOM label
24107500	3063.2008	Railway material (of steel)
25112200	3493.2008	Iron or steel towers and lattice masts
25301150	3204.2008	Vapour generating boilers (including hybrid boilers) (excluding central heating hot water boilers capable of producing low pressure steam, watertube boilers)
25301230	3206.2008	Auxiliary plant for use with boilers of HS 8402 or 8403
25301330	3208.2008	Parts of vapour generating boilers and super-heater water boilers
25991131	3431.2008	Sanitary ware and parts of sanitary ware of iron or steel
25992910	1.2010	Railway or tramway track fixtures and fittings and parts thereof
26112220	4245.2008	Semiconductor light emitting diodes (LEDs)
26112240	4246.2008	Photosensitive semiconductor devices; solar cells, photodiodes, photo-transistors, etc.
26121330	2880.2008	Multiple-walled insulating units of glass
26511200	46.2017	Theodolites and tachymetres (tachometers); other surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances
26511215	46.2017	Electronic rangefinders, theodolites, tacheometers and photogrammetrical instruments and appliances
26511235	46.2017	Electronic instruments and apparatus for meteorological, hydrological and geophysical purposes (excluding compasses)
26511239	46.2017	Other electronic instruments, n.e.c.
26511270	46.2017	Surveying (including photogrammetrical surveying), hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances (excluding levels and compasses), non-electronic; rangefinders, non-electronic
26511280	46.2017	Non electronic surveying (including photogrammatrical surveying), hydrographic, oceanographic, hydrological, meteorological or geophysical instruments and appliances (excluding rangefinders, levels and compasses),
26514100	49.2008	Instruments and apparatus for measuring or detecting ionising radiations
26514200	49.2008	Cathode-ray oscilloscopes and cathode-ray oscillographs
26514300	49.2017	Instruments for measuring electrical quantities without a recording device
26514310	49.2017	Multimeters without recording device
26514330	49.2017	Electronic instruments and apparatus for measuring or checking voltage, current, resistance or electrical power, without recording device (excluding multimeters, and oscilloscopes and oscillographs)
26514355	49.2017	Voltmeters without recording device
26514359	49.2017	Non-electronic instruments and apparatus, for measuring or checking voltage, current, resistance or power, without a recording device (excluding multimeters, voltmeters)
26514530	53.2017	Instruments and apparatus, with a recording device, for measuring or checking electric gains (excluding gas, liquid or electricity supply or production meters)
26514555	53.2017	Electronic instruments and apparatus, without a recording device, for measuring or checking electric gains (excluding gas, liquid or electricity supply or production meters)
26514559	53.2017	Non-electronic instruments and apparatus, without a recording device, for measuring or checking electrical gains (excluding multimeters, voltmeters)
26515110	4362.2008	Thermometers, liquid-filled, for direct reading, not combined with other instruments (excluding clinical or veterinary thermometers)
26515135	4363.2008	Electronic thermometers and pyrometers, not combined with other instruments (excluding liquid filled)

26515139	4364.2008	Thermometers, not combined with other instruments and not liquid filled, n.e.c.
26515235	4368.2008	Electronic flow meters (excluding supply meters, hydrometric paddlewheels)
26515239	4369.2008	Electronic instruments and apparatus for measuring or checking the level of liquids
26515255	4370.2008	Non-electronic flow meters (excluding supply meters, hydrometric paddlewheels)
26515313	4377.2008	Electronic gas or smoke analysers
26515319	4378.2008	Non-electronic gas or smoke analysers
26515330	4380.2008	Spectrometers, spectrophotometers... using optical radiations
26515350	128.2016	Instruments and apparatus using optical radiations, n.e.c.
26515381	4382.2008	Electronic ph and rh meters, other apparatus for measuring conductivity and electrochemical quantities (including use laboratory/field environment, use process monitoring/control)
26516350	4389.2008	Liquid supply or production meters (including calibrated) (excluding pumps)
26516370	4390.2008	Electricity supply or production meters (including calibrated) (excluding voltmeters, ammeters, wattmeters and the like)
26516500	4404.2008	Hydraulic or pneumatic automatic regulating or controlling instruments and apparatus
26516620	4396.2008	Test benches
26516650	61.2017	Electronic instruments, appliances and machines for measuring or checking geometrical quantities (including comparators, coordinate measuring machines (CMMs))
26516683	61.2017	Other instruments, appliances, for measuring or checking geometrical quantities
26517015	4401.2008	Electronic thermostats
26517019	4402.2008	Non-electronic thermostats
26518200	910.2008	Parts and accessories for the goods of 26.51.12, 26.51.32, 26.51.33, 26.51.4 and 26.51.5; microtomes; parts n.e.c.
26518550	4411.2008	Parts and accessories for automatic regulating or controlling instruments and apparatus
26702450	128.2016	Other instruments and apparatus using optical radiation (UV, visible, IR)
26702490	20.2016	Exposure meters, stroboscopes, optical instruments, appliances and machines for inspecting semiconductor wafers or devices or for inspecting photomasks or reticles used in manufacturing semiconductor devices, profile projectors and other optical instruments, appliances and machines for measuring or checking
27108230	3063.2008	Steel; iron or cast iron rails excl. current-conducting; with parts of non-ferrous metal - screws; bolts; nuts; rivets and spikes used for fixing track construction materials; assembled track
27108250	3063.2008	Iron or steel sleepers (crossties); rolled fish-plates and sole plates and check-rails (excl. screws; bolts; nuts; rivets and spikes used for fixing track construction materials)
27109230	3063.2008	Railway material (of steel)
27123130	4157.2008	Numerical control panels with built-in automatic data-processing machine for a voltage <= 1 kV
27123150	4158.2008	Programmable memory controllers for a voltage <= 1 kV
27123170	4159.2008	Other bases for electric control, distribution of electricity, voltage > 1000 V
27356200	3063.2008	Railway or tramway materials of steel or iron; not hot rolled
27401250	4175.2008	Tungsten halogen filament lamps for motorcycles and motor vehicles (excluding ultraviolet and infrared lamps)
27401293	4177.2008	Tungsten halogen filament lamps, for a voltage > 100 V (excluding ultraviolet and infra-red lamps, for motorcycles and motor vehicles)

27401295	4177.2008	Tungsten halogen filament lamps for a voltage <= 100 V (excluding ultraviolet and infrared lamps, for motorcycles and motor vehicles)
27401510	4180.2008	Fluorescent hot cathode discharge lamps, with double ended cap (excluding ultraviolet lamps)
27401530	4181.2008	Fluorescent hot cathode discharge lamps (excluding ultraviolet lamps, with double ended cap)
27402200	4184.2008	Electric table, desk, bedside, or floor-standing lamps
27403090	73.2016	Electric lamps and lighting fittings, of plastic and other materials, of a kind used for filament lamps and tubular lamps, including lighting sets for Christmas trees
27403200	73.2016	Lighting sets for Christmas trees
27403930	73.2016	Electric lamps and lighting fittings, of plastic and other materials, of a kind used for filament lamps and tubular fluorescent lamps
27512190	4045.2008	Other electromechanical appliances
27512690	4056.2008	Other electric space heaters
27521400	4075.2008	Non-electric instantaneous or storage water heaters
28112130	24.2010	Steam turbines and other vapour turbines (excluding for electricity generation)
28112150	24.2010	Steam turbines for electricity generation
28112160	24.2010	Steam turbines and other vapour turbines
28112200	3493.2008	Iron or steel towers and lattice masts
28112400	171.2008	Generating sets, wind-powered
28113100	3495.2008	Parts for steam turbines and other vapour turbines
28113200	3496.2008	Parts for hydraulic turbines and water wheels (including regulators)
28251130	3649.2008	Heat exchange units
28251380	3659.2008	Heat pumps other than air conditioning machines of HS 8415
28251410	3661.2008	Machinery and apparatus for filtering or purifying air (excluding intake filters for internal combustion engines)
28251420	35.2010	Machinery and apparatus for filtering or purifying gases by a liquid process (excluding intake air filters for internal combustion engines, machinery and apparatus for filtering or purifying air)
28251430	35.2010	Machinery and apparatus for filtering and purifying gases (other than air and excl. those which operate using a catalytic process, and isotope separators)
28251440	3663.2008	Machinery and apparatus for filtering or purifying gases by catalytic process (excluding intake air filters for internal combustion engines, machinery and apparatus for filtering or purifying air)
28251450	7.2017	Machinery and apparatus for filtering and purifying gases with stainless steel housing, and with inlet and outlet tube bores with inside diameters not exceeding 1,3 cm (excluding intake filters for internal combustion engines)
28251470	35.2010	Machinery and apparatus for filtering or purifying gases including for filtering dust from gases (excluding air filters for internal combustion engines, using liquid or catalytic process)
28291100	682.2008	Producer gas or water gas generators; acetylene gas generators and the like; distilling or rectifying plant
28291230	3675.2008	Machinery and apparatus for filtering or purifying water
28291270	3677.2008	Machinery and apparatus for solid-liquid separation/ purification excluding for water and beverages, centrifuges and centrifugal dryers, oil/petrol filters for internal combustion engines
28298250	3702.2008	Parts for filtering and purifying machinery and apparatus, for liquids or gases (excluding for centrifuges and centrifugal dryers)
28301150	3204.2008	Vapour generating boilers (including hybrid boilers) (excluding central heating hot water boilers capable of producing low pressure steam, watertube boilers)

28301230	3206.2008	Auxiliary plan for use with boilers of 84.02 or 84.03, used
28301330	3208.2008	Parts of vapour generating boilers and super-heater water boilers
28992020	4022.2008	Machines and apparatus used solely or principally for the manufacture of semiconductor boules or wafers
28992060	4023.2008	Machines and apparatus used solely or principally for the manufacture of flat panel displays
28993945	4024.2008	Machines and apparatus used solely or principally for a) the manufacture or repair of masks and reticles, b) assembling semiconductor devices or electronic integrated circuits, and c) lifting, handling, loading or unloading of boules, wafers, semiconductor devices, electronic integrated circuits and flat panel displays
29102400	10.2017	Other motor vehicles for the transport of persons (excluding vehicles for transporting >=� 10 persons, snowmobiles, golf cars and similar vehicles)
29102410	10.2017	Motor vehicles, with both spark-ignition or compression-ignition internal combustion reciprocating piston engine and electric motor as motors for propulsion, other than those capable of being charged by plugging to external source of electric power
29102430	10.2017	Motor vehicles, with both spark-ignition or compression-ignition internal combustion reciprocating piston engine and electric motor as motors for propulsion, capable of being charged by plugging to external source of electric power
29102450	10.2017	Motor vehicles, with only electric motor for propulsion
29102490	10.2017	Other motor vehicles for the transport of persons (excluding vehicles with only electric motor for propulsion , vehicles for transporting > 10 persons, snowmobiles, golf cars and similar vehicles)
29105200	4462.2008	Motor vehicles specially designed for travelling on snow, golf cars and similar vehicles
29112130	24.2010	Steam turbines and other vapour turbines (excl. for electricity generation)
29112150	24.2010	Steam turbines for generation of electricity
29112200	3493.2008	Hydraulic turbines and water wheels
29113100	3495.2008	Parts for steam turbines and other vapour turbines
29113200	3496.2008	Parts of hydraulic turbines; water wheels incl. regulators
29231375	3659.2008	Absorption heat pumps
29231380	3659.2008	Heat pumps other than air conditioning machines of HS 8415
29231410	3661.2008	Machinery and apparatus for filtering or purifying air
29231420	35.2010	Machinery and apparatus for filtering or purifying gases by a liquid process excl. intake air filters for internal combustion engines; machinery and apparatus for filtering or purifying air
29231430	35.2010	Machinery filtering or purifying gases; by electrostatic process
29231440	3663.2008	Machinery and apparatus for filtering/purifying gases by catalytic process excluding intake air filters for internal combustion engines, machinery and apparatus for filtering/purifying air
29231450	35.2010	Machinery filtering or purifying gases; by thermic process
29231460	35.2010	Machinery filtering or purifying gases; other
29231470	35.2010	Machinery filtering or purifying gases
29241130	682.2008	Producer gas or water gas generators, acetylene and similar water process gas generators
29241150	682.2008	Distilling or rectifying plant
29241230	3675.2008	Machinery and apparatus for filtering/ purifying water
29241270	3677.2008	Machinery and apparatus for filtering/ purifying liquids; for chemical industry

29245250	3702.2008	Parts for filtering and purifying machinery and apparatus, for liquids or gases (excluding for centrifuges and centrifugal dryers)
29562582	4022.2008	Machines and apparatus used solely or principally for the manufacture of semiconductor boules or wafers
29562586	4023.2008	Machines and apparatus used solely or principally for the manufacture of flat panel displays
29562588	4024.2008	Machines and apparatus used solely or principally for a) the manufacture or repair of masks and reticles, b) assembling semiconductor devices or electronic integrated circuits, and c) lifting, handling, loading or unloading of boules, wafers, semiconductors.
29721400	4075.2008	Instantaneuous water heater apparatus non-electric
30201100	4497.2008	Rail locomotives powered from an external source of electricity
30201200	4498.2008	Diesel-electric locomotives
30201300	1021.2008	Other rail locomotives; locomotive tenders
30202000	1023.2008	Self-propelled railway or tramway coaches, vans and trucks, except maintenance or service vehicles
30203100	4499.2008	Railway or tramway maintenance or service vehicles (including workshops, cranes, ballast tampers, track-liners, testing coaches and track inspection vehicles)
30203200	4500.2008	Rail/tramway passenger coaches; luggage vans, post office coaches and other special purpose rail/tramway coaches excluding rail/tramway maintenance/service vehicles, self-propelled
30203300	1025.2008	Railway or tramway goods vans and wagons, not self-propelled
30204030	4501.2008	Parts of locomotives or rolling stock
30921000	57.2012	Bicycles and other cycles (incl. delivery tricycles), non-motorized
30921030	57.2012	Non-motorized bicycles and other cycles, without ball bearings (including delivery tricycles)
30921050	57.2012	Non-motorized bicycles and other cycles with ball bearings (including delivery tricycles)
30923010	1040.2008	Frames and forks, for bicycles
30923030	59.2012	Parts of frames, front forks, brakes, coaster braking hubs, hub brakes, pedals crank-gear and free-wheel sprocket-wheels for bicycles, other non-motorized cycles and sidecars
30923060	59.2012	Parts and accessories of bicycles and other cycles, not motorised (excl. frames and front forks).
30923090	59.2012	Other parts and accessories of bicycles and other cycles, not motorised
31203150	4158.2008	Programmable memory controllers; voltage <= 1000 V
31203170	4159.2008	Meter mounting boards and installation panels; voltage <= 1000 V
31501230	4177.2008	Tungsten halogen filament lamps (excl. ultra-violet; infra-red): for projectors
31501250	4175.2008	Tungsten halogen filament lamps for motorcycles and motor vehicles (excl. ultraviolet and infrared lamps)
31501293	4177.2008	Tungsten halogen filament lamps; for a voltage > 100 V (excl. ultraviolet and infra-red lamps; for motorcycles and motor vehicles)
31501295	4177.2008	Other tungsten halogen lamps; <= 100 V
31501510	4180.2008	Fluorescent hot cathode discharge lamps, with double ended cap (excluding ultraviolet lamps)
31501530	4181.2008	Fluorescent hot cathode discharge lamps (excl. ultraviolet lamps, with double ended cap)
31502200	4184.2008	Electric table; desk; bedside or floor-standing lamps
31503430	73.2016	Electric lamps and lighting fittings, of plastic and other materials, of a kind used for filament lamps and tubular fluorescent lamps

32105235	4245.2008	Semiconductor light emitting diodes (LEDs)
32105237	4246.2008	Photosensitive semiconductor devices; solar cells, photodiodes, phototransistors, etc.
33201215	46.2017	Electronic surveying & hydrographic instr.& appliances (incl. rangefinders; levels; theodolites & tacheometers; photogrammetrical instr.& appliances; excl. compasses)
33201219	46.2017	Non-electronic surveying, hydrographic instr. and appliances (including rangefinders, levels, theodolites and tacheometers, photogrammetrical instr. and appliances; excluding compasses)
33201235	46.2017	Electronic instruments and apparatus for meteorological, hydrological and geophysical purposes (excl. compasses)
33201253	46.2017	Instruments and appliances used in geodesy; topography; surveying...
33201255	46.2017	Non-electronic meteorological; hydrological and geophysical instruments and apparatus (excl. compasses)
33201257	46.2017	Non-electronic surveying, hydro-, oceanographic instr./appliances (excluding rangefinders, levels, theodolites, tacheometers, photogrammetrical instr./app., compasses)
33203900	49.2008	Installation of other special-purpose machinery n.e.c.
33204100	49.2008	Installation of medical and surgical equipment
33204200	49.2008	Cathode-ray oscilloscopes and cathode-ray oscillographs
33204330	49.2017	Instruments and apparatus, for measuring or checking voltage: electronic
33204355	49.2017	Voltmeters
33204359	49.2017	Instruments and apparatus; for measuring or checking voltage: others
33205119	4362.2008	Other thermometers, not with other instruments, liquid, for direct reading
33205135	4363.2008	Thermometers; not combined with other instruments and not liquid filled; electronic
33205139	4364.2008	Thermometers, not combined with other instruments and not liquid filled, n.e.c.
33205313	4377.2008	Electronic gas or smoke analysers
33205319	4378.2008	Non-electronic gas or smoke analysers
33205330	4380.2008	Spectrometers, spectrophotometers using optical radiations
33205340	129.2016	Exposure meters
33205350	128.2016	Instruments and apparatus using optical radiations; n.e.c.
33205381	4382.2008	Electronic ph & rh meters; other apparatus for measuring conductivity & electrochemical quantities (incl. use laboratory/field environment; use process monitoring/control)
33205385	129.2016	Viscometers, porosimeters and expansion meters
33205389	129.2016	Other instruments and apparatus for physical and chemical analysis
33206350	4389.2008	Liquid supply or production meters (incl. calibrated) (excl. pumps)
33206370	4390.2008	Electricity supply or production meters (incl. calibrated) (excl. voltmeters; ammeters; wattmeters and the like)
33206550	61.2017	Electronic instruments...measuring; checking geometrical quantities: 3 D
33206583	61.2017	Other instruments, appliances, for measuring or checking geometrical quantities
33206589	61.2017	Other instruments; appliances and machines for measuring or checking
33207015	4401.2008	Electronic thermostats
33207019	4402.2008	Non-electronic thermostats
33207050	4404.2008	Hydraulic or pneumatic automatic regulating or controlling instruments and apparatus

33208120	910.2008	Parts and accessories for surveying, geodesy, topography, levelling, photogrammetrical, hydro-, oceanographic, hydro-, meteorological, geophysical instruments excl. compasses
33208143	910.2008	Parts and accessories for hydrometers and similar floating instruments, thermometers, pyrometers, barometers, hygrometers and psychrometers, recording or not, and any combination of these instruments
33208145	910.2008	Parts and accessories of instruments and apparatus for measuring or checking the variables of liquids or gases (excl. for supply or production meters)
33208147	910.2008	Microtomes, and parts and accessories
33209100	49.2008	Installation of instruments and apparatus for measuring; checking; testing; navigating and other purposes
34102430	10.2017	Vehicles with an electric motor, for the transport of persons (excl. vehicles for transporting >= 10 persons, snowmobiles, golf cars and similar vehicles)
34102490	10.2017	Other motor vehicles for carrying people (excluding vehicles for transporting >= 10 persons, snowmobiles, golf cars and similar vehicles, electrically powered)
34105300	4462.2008	Vehicles for travelling on snow; golf cars; etc; with engines
35201100	4497.2008	Rail locomotives powered from an external source of electricity
35201200	4498.2008	Diesel-electric locomotives; =< 1000 kW power continuous rating
35201330	1021.2008	Rail locomotives powered by electric accumulators
35201390	1021.2008	Rail locomotives and locomotive tenders (excl. locomotives powered from an external source of electricity, locomotives powered by electric accumulators, diesel-electric locomotives)
35202030	1023.2008	Self-propelled railway coaches... powered by external electricity
35202090	1023.2008	Self-propelled railway or tramway coaches; vans and trucks; (diesel)
35203100	4499.2008	Railway or tramway maintenance or service vehicles (including workshops, cranes, ballast tampers, track-liners, testing coaches and track inspection vehicles)
35203200	4500.2008	Railway passenger coaches for speed =< 250 km/h; local
35203330	1025.2008	Tank wagons and the like; not self-propelled
35203350	1025.2008	Rail-or tramway goods vans & wagons; not self-propelled (incl. self-discharging and open vans & wagons) with non-removable sides; height > 60 cm; & other wagons
35204030	4501.2008	Parts of locomotives or rolling stock
35204055	1.2010	Railway or tramway track fixtures and fittings, and mechanical or electromechanical signalling, safety or traffic control equipment
35204058	1.2010	Parts of railway or tramway track fixtures and fittings; and for electromechanical signalling; safety or traffic control equipment
35204059	4502.2008	Mechanical (and electromechanical) signalling; safety or traffic control equipement (excluding equipment and material for track)
35421030	57.2012	Bicycles and other cycles; not motorized; without ball bearings
35421050	57.2012	Mountain bike
35422013	1040.2008	Frames for bicycles, other non-motorized cycles and sidecars (excluding parts of frames)
35422015	1040.2008	Front forks for bicycles; other non-motorized cycles and sidecars (excl. parts of front forks)
35422019	59.2012	parts of cycles
35422023	59.2012	Wheel rims for bicycles other non-motorized cycles and sidecars
35422025	59.2012	Wheel spokes for bicycles; other non-motorized cycles and sidecars
35422027	59.2012	Hubs without free-wheel or braking device for bicycles, other non-motorized cycles and sidecars
35422033	59.2012	Coaster braking hubs and hub brakes

35422039	59.2012	Brakes for bicycles and other non-motorized cycles (excl. coaster braking hubs and hub brakes)
35422040	59.2012	Saddles for bicycles and other non-motorized cycles
35422053	59.2012	Pedals
35422055	59.2012	Crank-gear
35422063	59.2012	Handlebars
35422065	59.2012	Luggage-carriers for bicycles and other non-motorized cycles
35422067	59.2012	Derailleur gears for bicycles and other non-motorized cycles
35431200	4532.2008	Parts and accessories of invalid carriages
40301003	61.2005	Heat - heating plants (heat produced by heating plants using fossil fuels; biomass or waste; sold to third parties)
40301005	62.2005	Heat - geothermal (heat produced in geothermal fields; sold to third parties)

Note: authors' elaboration on PRODCOM data. PRODCOM codes are in the first column, while synthetic codes refer to the codes that have been created as the outcome of the VBBV procedure to create time-constant codes that allow comparing production over time.

B. More details on polluting industries

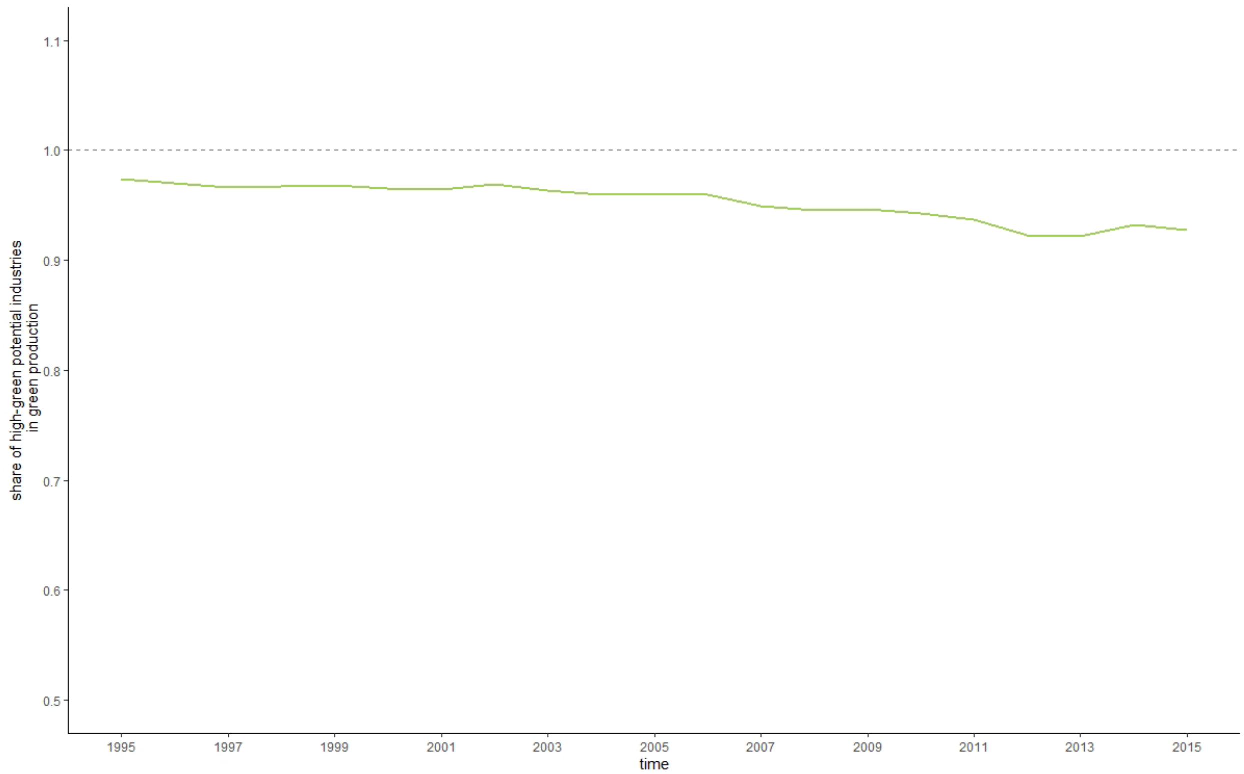
We compute our measure of polluting industry using the 2013 WIOD release, which includes information on countries' and industries' greenhouse gas (GHG) emissions as well as energy intensity. We follow Marin and Vona (2019) and compute GHG (C02, N20 and CH4, aggregated according to their global warming potential) intensity as the sum of direct and indirect GHG emissions per unit of value added of each industry, country and year. Direct emissions are those associated to the production of each sector, indirect emissions are those embodied in the purchases of electricity from the power sector of each industry (which we compute using input-output technical coefficients).

The WIOD classifies industries using the ISIC rev 3.1, for which an official crosswalk only exists with NACE rev. 1, given the high level of aggregation (less than two digits NACE rev.2), it is also straightforward to match WIOD data with NACE rev. 2 industries, which is based on ISIC rev. 4. Because of the high level of aggregation of WIOD we consider that the entire production of brown industries is polluting. However, we exploit our fine-grained data at the 4-digit level data to slightly refine this coarse classification of brown industries by excluding the processing of nuclear fuel from basic metal manufacturing and the production of pharmaceutical products and preparation from the chemical sector. The pharmaceutical and chemical sector have the same pollution intensity in the WIOD data, because the two sectors are lumped together in the ISIC rev. 3 industry classification. However, chemical industries are well-known to be significantly more polluting than pharmaceutical ones. The processing of nuclear fuel is contained within basic metals manufacturing at 2-digits of the NACE rev. 2 classification, so we identify the corresponding 4-digit code (2446) in PRODCOM and we exclude it from our computation of polluting production.

C. More results on green production

Figure C.1 plots the evolution over time of the share of green production from high-green potential industries in total green production. Despite a mildly decreasing trend, high-green potential industries account for the majority of green production in our observed time period. On average, 96% of green production is concentrated in 13 out of 235 4-digit NACE industries.

Figure C.1: High-green potential industries' share of total green production over time



Notes: Authors' elaboration on PRODCOM data. Production values are deflated to have data at constant prices, with 2010 as base year. We report the evolution over time of the share of green production from high-green potential industries, as identified in Table 3 as a share of total green production based on the list of green products PRODCOM discussed in Section 2.

In Figure C.2 we plot this same measure for selected countries, finding some heterogeneity. We find in particular that high-green potential industries in Denmark and Poland represent an increasing share of green production, while there is a decreasing trend for France. There are also countries like Germany and Italy that are closer to the European share we observe in Figure C.1. Overall green production from high-green potential industries never represents less than 78% of the country's total green production in any of the countries considered here, confirming that high-green potential industries account for the bulk of green production.

Figure C.2: Share of green production from high-green potential industries in total green production for selected countries and Europe.

Notes: Authors' elaboration on PRODCOM data. Production values are deflated to have data at constant prices, with 2010 as base year. We report for selected countries the evolution over time of the share that green production from high-green potential industries, as identified in Table 3 represents of total green production based on the list of green products PRODCOM discussed in Section 2.

To illustrate which are the most important green products for each country, Table C.1 presents the top three green products and their share in total green production for each country. Remarkably, we find that top products are rather similar across countries. They mostly concern integrated technologies for renewable energy, appliances to increase energy efficiency, as well as insulating material.

Table C.1: Top three green products across countries and shares of green production.

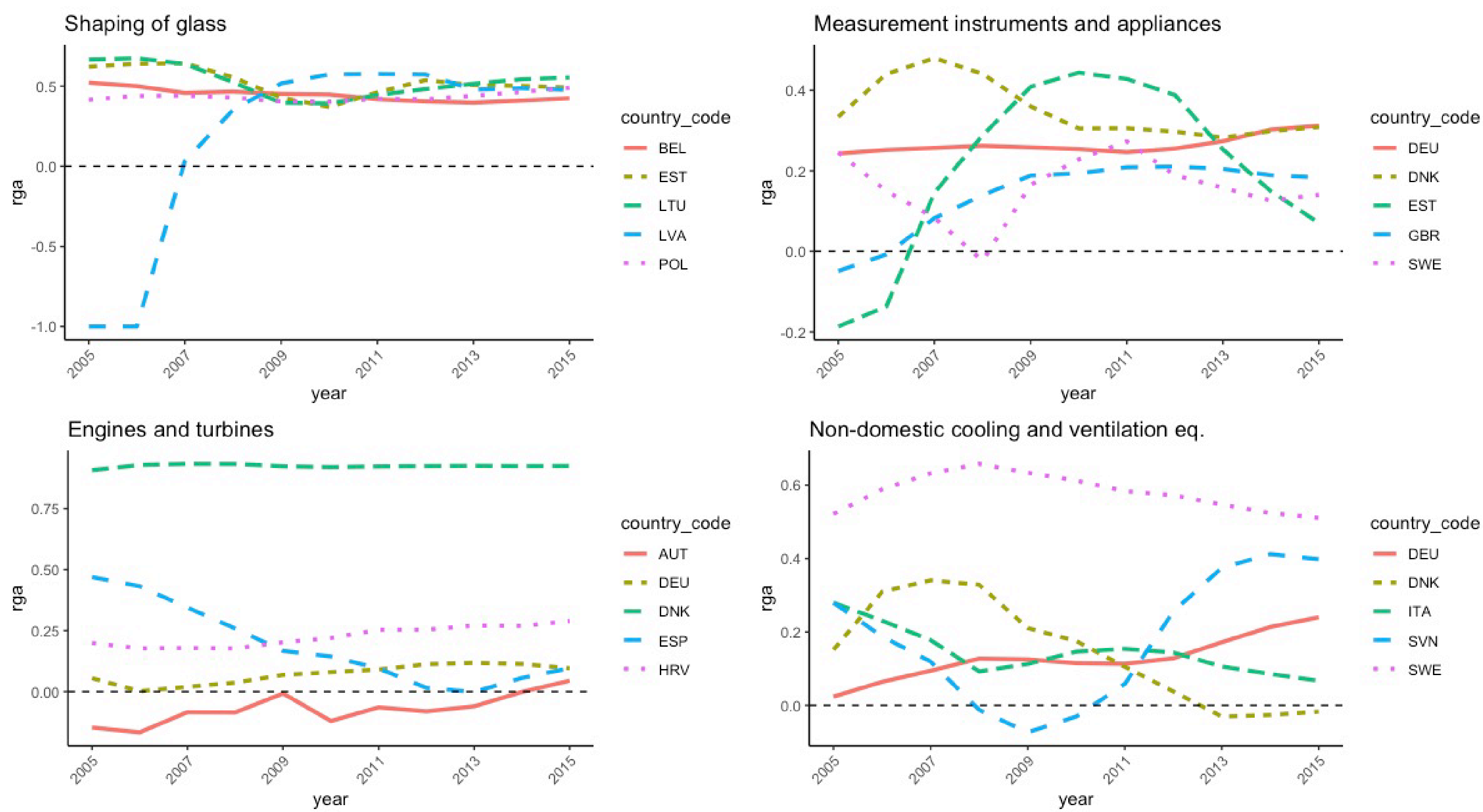
Country	First product	Second product	Third product	Share of total green production
Austria	Programmable memory controllers for a voltage <=1,000V	Other bases for electric control, distribution of electricity, voltage <=1,000 V	Railway material (of steel)	0.00784
Belgium	Multiple-walled insulating units of glass	Other bases for electric control, distribution of electricity, voltage >1,000 V	Bicycles and other cycles (including delivery tricycles), non-motorised	0.00459
Bulgaria	Non-motorized bicycles and other cycles with ball bearings (including delivery tricycles)	Other bases for electric control, distribution of electricity, voltage >1,000 V	Multiple-walled insulating units of glass	9.00E-04
Croatia	Parts for steam turbines and other vapour turbines	Photosensitive semiconductor devices; solar cells, photo-diodes, photo-transistors, etc	Other bases for electric control, distribution of electricity, voltage >1,000V	0.00069
Denmark	Programmable memory controllers for a voltage <= 1,00V	Generating sets (excluding wind-powered and powered by spark-ignition internal combustion piston engine)	Parts of vapour generating boilers and super-heater water boilers	0.00614
Estonia	Other bases for electric control, distribution of electricity, voltage >1,000V	Multiple-walled insulating units of glass	Parts and accessories for automatic regulating or controlling instruments and apparatus	0.00074
Finland	Other bases for electric control, distribution of electricity, voltage ² 1 000 V	Heat exchange units	Machinery and apparatus for solid-liquid separation/ purification excluding for water and beverages, centrifuges and centrifugal dryers, oil/petrol filters for internal combustion engines	0.00714
France	Other bases for electric control, distribution of electricity, voltage <= 1,000 V	Heat exchange units	Multiple-walled insulating units of glass	0.02979
Germany	Other bases for electric control, distribution of electricity, voltage >1,000 V	Programmable memory controllers for a voltage <= 1,000 V	Photosensitive semiconductor devices; solar cells, photo-diodes, photo-transistors, etc	0.11252
Greece	Other bases for electric control, distribution of electricity, voltage <=1,000 V	Bicycles and other cycles (including delivery tricycles), non-motorised	Vapour generating boilers (including hybrid boilers) (excluding central heating hot water boilers capable of producing low pressure steam, watertube boilers)	0.00025
Hungary	Photosensitive semiconductor devices; solar cells, photo-diodes, photo-transistors, etc.	Other bases for electric control, distribution of electricity, voltage >1,000 V	Heat exchange units	0.00359
Ireland	Machinery and apparatus for filtering or purifying water	Other bases for electric control, distribution of electricity, voltage >1,000 V	Parts for filtering and purifying machinery and apparatus, for liquids or gases (excluding for centrifuges and centrifugal dryers)	0.00251

Italy	Heat exchange units	Machinery and apparatus for filtering or purifying air (excluding intake filters for internal combustion engines)	Rail locomotives powered from an external source of electricity	0.03106
Latvia	Other bases for electric control, distribution of electricity, voltage >1,000 V	Multiple-walled insulating units of glass	Machinery and apparatus for filtering or purifying water	0.00024
Lithuania	Non-motorized bicycles and other cycles with ball bearings (including delivery tricycles)	Multiple-walled insulating units of glass	Other bases for electric control, distribution of electricity, voltage >1,000 V	8.00E-04
Poland	Multiple-walled insulating units of glass	Other bases for electric control, distribution of electricity, voltage <=1,000 V	Parts for steam turbines and other vapour turbines	0.00694
Portugal	Non-motorized bicycles and other cycles with ball bearings (including delivery tricycles)	Other bases for electric control, distribution of electricity, voltage >1,000 V	Multiple-walled insulating units of glass	0.00278
Romania	Multiple-walled insulating units of glass	Railway or tramway goods vans and wagons, not self-propelled	Other bases for electric control, distribution of electricity, voltage >1,000 V	0.00139
Slovakia	Other bases for electric control, distribution of electricity, voltage <= 1000 V	Heat exchange units	Multiple-walled insulating units of glass	9.00E-04
Slovenia	Machinery and apparatus for filtering or purifying air (excluding intake filters for internal combustion engines)	Multiple-walled insulating units of glass	Heat exchange units	0.00028
Spain	Other bases for electric control, distribution of electricity, voltage <=1,000 V	Generating sets (excluding wind-powered and powered by spark-ignition internal combustion piston engine)	Photosensitive semiconductor devices; solar cells, photo-diodes, photo-transistors, etc	0.01028
Sweden	Heat exchange units	Instruments and apparatus using optical radiations, n.e.c.	Other bases for electric control, distribution of electricity, voltage >1,000 V	0.0098
United Kingdom	Other bases for electric control, distribution of electricity, voltage >1,000 V	Multiple-walled insulating units of glass	Machinery and apparatus for filtering or purifying air (excluding intake filters for internal combustion engines)	0.02145

Notes: Authors' elaboration on PRODCOM data. The table reports for each country the three green products with largest green production and the total share of green production that these three products combined represent in countries' total green production. Products are identified here with the synthetic, time-invariant product codes derived from VBBV methodology.

In section 5, we drill down and construct green RCA at the 4-digit level. To provide some concrete examples of these RCAs, we present here the evolution of RCAs over time for a selection of four industries that contain key green products: the shaping of glass (which includes insulating glass panels), electronic components (which include photovoltaic cells), engines and turbines (which include of course wind turbines too) and non-domestic cooling and ventilation equipment (including heat exchange units). We choose to focus on the countries that are the top five countries for green RCA in 2015 and look at how their specialisation has evolved over the previous 10 years. Overall, we find a high level of heterogeneity both across countries and industries. On the one hand, some leaders can easily be identified such as Denmark in the production of wind turbines (bottom left panel), Sweden's green specialisation in non-domestic cooling and ventilation equipment (bottom right panel), Germany and Denmark in measurement appliances (top right panel). On the other hand, it is remarkable how some other countries seem to experience rapid increases in green RCA. This is the case for example for Estonia in the production of green measurement appliances, such as electronic instruments and apparatus for meteorological, hydrological, and geophysical purposes, and apparatus for measuring or checking electrical gains. We also observe large increases for Slovenia and Germany for non-domestic cooling and ventilation equipment. Concerning the latter, Denmark experiences a constant decline, ending below the threshold of zero. This is interesting because, despite not having a green RCA in this sector in 2015, Denmark is still among the top 5 countries for green RCA. These findings highlight once again how green production – and by reflection green specialisation – is highly concentrated in few countries and that countries exhibit heterogeneous patterns across sectors.

Figure C.5: Evolution of green RCA for a selection of 4-digit industries.



Notes: authors' elaboration on PRODCOM data. For each sector we map the evolution of the green RCA of the five countries that had the highest green RCA in 2015 in each industry. In order to improve readability of the figure we use the symmetrical version of the RCA, which is therefore bound between -1 and +1 with 0 being the economically significant threshold above which a country-industry is deemed to have a green RCA.

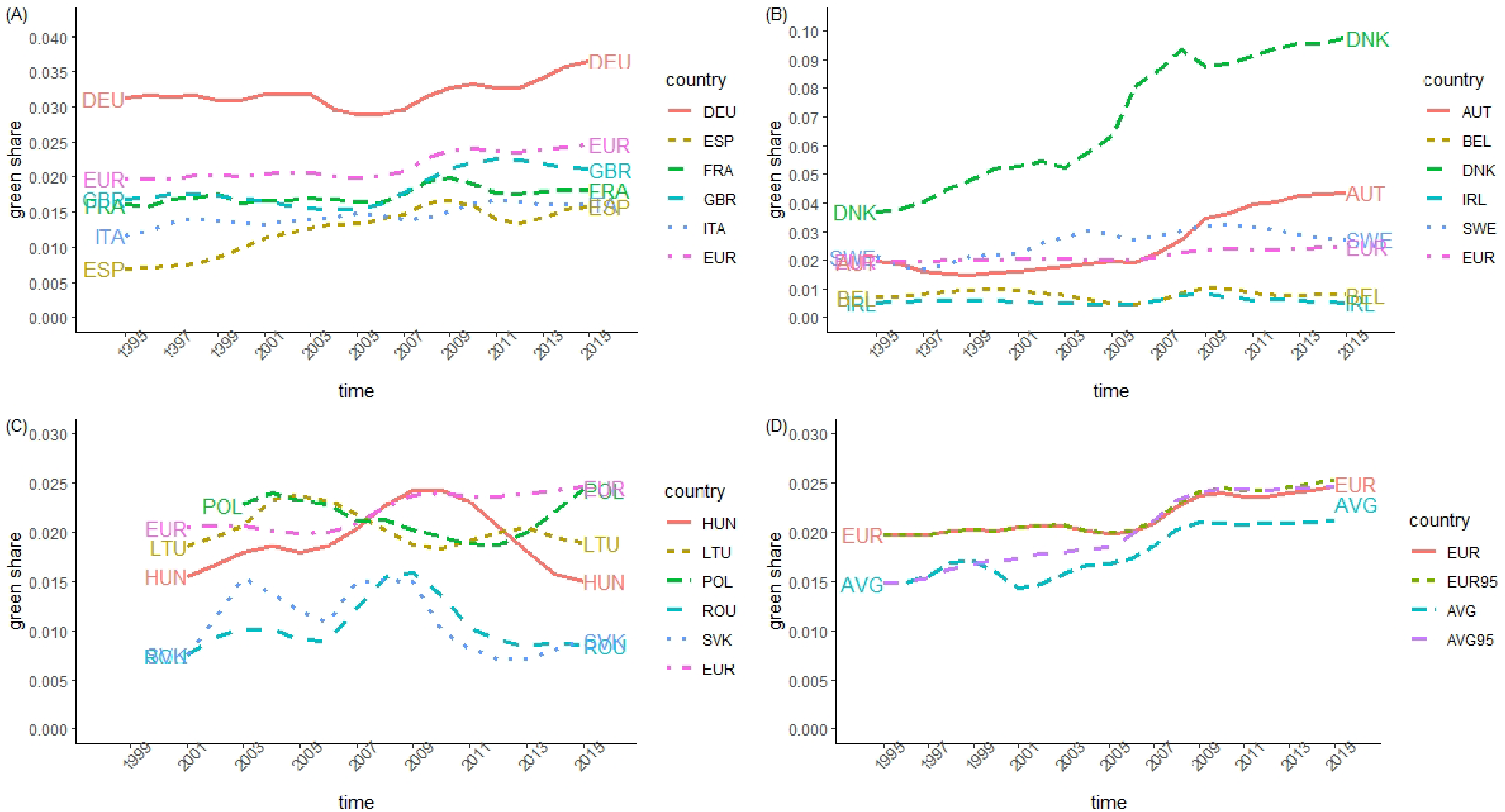
D. Robustness checks using all green industries and CLEG as alternative list.

In this Appendix we report robustness checks on our analysis in Section 4, using all green industries identified in Table 2 in the main text (subsection D.1) or the CLEG list of green products, which includes multiple usage goods (subsection D.2). Overall, we find qualitatively similar results, so we only focus on commenting the differences with respect to the main results of the main text.

D.1 – Robustness checks using all green industries from our favourite classification

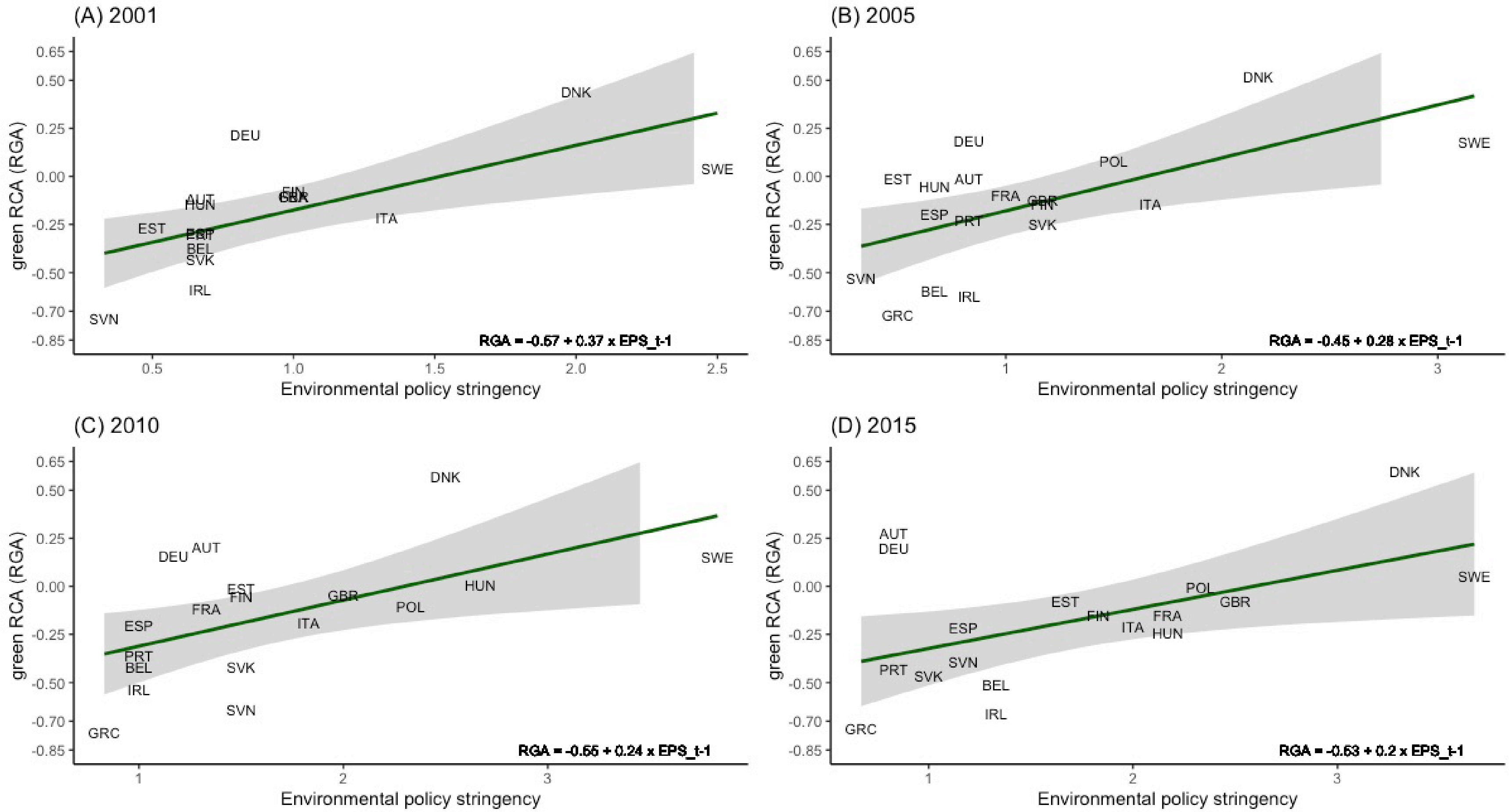
We replicate the results of section 4 using all green industries rather than only high-green potential. An industry is defined as green if at least one country exhibits green production greater than zero in at least one year.. In Figure D.1 to D.3 we replicate Figure 2 to 4 of the main text, respectively, finding very similar results. This is not surprising as high-green potential account for 96% of total green production and because neither of these figures are production-weighted averages. Thus, the inclusion of marginally green industries with little green production volumes leads to negligible changes in aggregated statistics on the green production share and the average green RCA.

Figure D.1: Evolution of green production shares for selected European countries for all green industries.



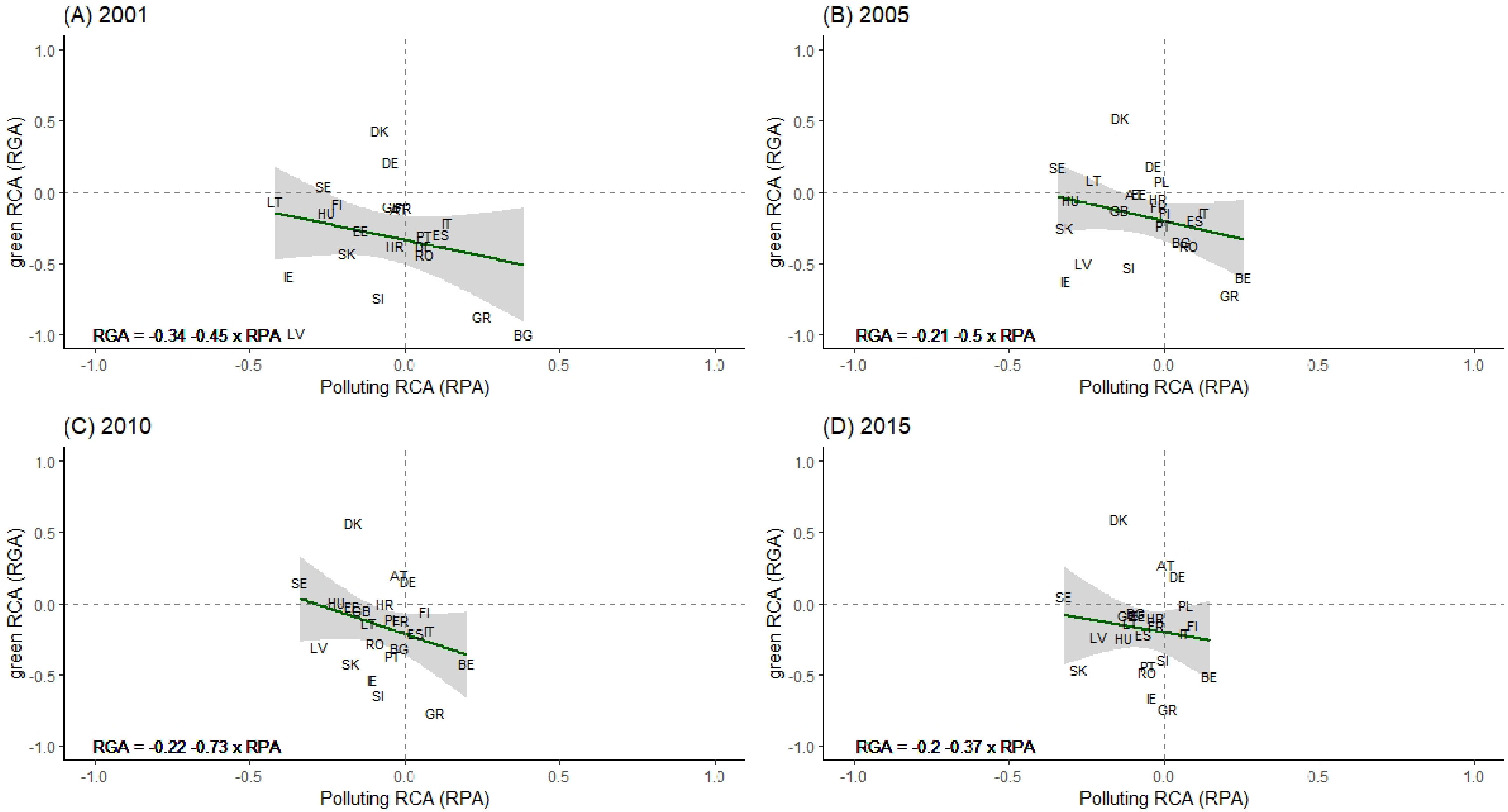
Notes: Authors' elaboration on PRODCOM data. Production values are deflated to have data at constant prices, with 2010 as base year. Panel A, B and C report green production shares over time for large, small and Eastern countries respectively, these have been smoothened by taking 3-years moving averages. We only use green production from all green industries from Table 3 in the main text. EUR is the European green shares across all available countries in each year. In panel D, we compare it with the unweighted average (AVG) across countries. Because data on Eastern countries is available only from 2001 onwards, and 2003 onwards for Poland, we report both these measures computed for each year for all available countries as well as only for countries for which we have a balanced panel since 1995, i.e.: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain, Sweden, United Kingdom, (EUR95 and AVG95, respectively).

Figure D.2: Green RCA and environmental policy stringency across countries and over time, using green production from all green industries.



Notes: Authors' elaboration on PRODCOM data and OECD for the index of environmental policy stringency (EPS) for market-based policies. We plot countries' green RCA and the EPS, developed by the OECD. Green RCA is based on green production from all green industries, as identified in Table 3. Production values are deflated to have data at constant prices, with 2010 as base year. The RCAs are computed following formula 3 are made symmetrical around 0 and bounded between -1 and 1, the value of 0 indicates therefore whether a country has successfully specialised in green production. We also report the coefficient of a regression of green RCA on the EPS index for each year.

Figure D.3: Green and polluting RCA across countries and over time, using green production from all green industries.



Notes: Authors' elaboration on PRODCOM data. We plot countries' green and polluting RCA. Green RCA is based on green production from all green industries, as identified in Table 3. Polluting production is total production from polluting industries identified in Table 2. Production values are deflated to have data at constant prices, with 2010 as base year. The RCAs are computed following equation 3 and are made symmetrical around 0 and bounded between -1 and 1, the value of 0 indicates therefore whether a country has, on average, successfully specialised in green production. We also report the coefficient of a regression of green RCA on polluting RCA for each year.

D.2 – Robustness checks using CLEG as a list for green production

As would be expected, using the CLEG classification leads to substantial changes in the main results. This is due to the fact that the CLEG classification is much broader and less able to identify core green productions than our favourite classification. The CLEG list includes many multiple-usage products, such as containers, pipes, taps, valves and furnaces that can be used for water and waste management purposes.

In Table D.1 we focus on the relationship between green and polluting production. It should be noted that, while the CLEG classification is broader than ours, it still uses an "output" approach that can be contrasted with the "process" approach, which is based on the GHG intensity of the industry. . Using the CLEG classification, we find that some polluting industries – notably the manufacture of fabricated metal products and of other non-metallic mineral products – is rank among the greenest industries in terms of share of green production. Despite this, industries that were identified as the greenest with our favoured classification still rank at the top – see e.g. the manufacture of machinery and equipment, of electrical equipment, electronic components and of transport equipment.

A similar conclusion can be drawn when looking at Table D.2, which replicates Table 3 looking at the distribution of green production at 4-digits NACE industries. The greenest, in terms of average green share are the manufacture of steel drums as well as taps and valves. Other products that have at least one country-sector that produces all green products in at least one year include the manufacture of ovens, furnaces and furnace burners. While these products have some clear application in the context of waste management activities it is consider these as green as other key products such as wind turbines, insulating glass panels or photovoltaic cells.

The evidence emerging from this additional robustness check suggests that both classification identify a similar core of green products, but that the inclusion of multiple-use products in CLEG also leads to some additional noise of products that can indeed be used to carry out green functions, such as waste and water management, but that despite this have no intrinsic environmentally friendly application.

When we look at trends in green shares across countries, in Figure D.4, we find overall rather similar trends as what we observe in Figure 3: Germany, Denmark are clear leaders in green production, while France, Italy, UK and Poland hover around the EU average. It is however remarkable that using CLEG as a green classification, and therefore including multiple usage products too, leads to a much larger share of green production across all countries. The EU average is close to 10% towards the end of our observed period and therefore much higher than other estimates in the literature (for the US, e.g., Elliott and Lindley, 2017; Vona *et al.*, 2019).

Figure D.5 and D.6 replicate Figures 4 and 5. When using CLEG to identify green production we find that the relationship between green RCA and market-based EPS is still positive but weaker than when using our favourite list. Similarly, and perhaps more strikingly, the correlation between country-level green RCA and polluting RCA is essentially flat when we use CLEG as a list of green products. The key conclusion of this is therefore that the CLEG list does not capture a specialisation profile that is particularly reactive to environmental policies or specialisation in polluting production across countries.

Table D.1 – Green and polluting production by 2-digit industries, with CLEG classification.

(1) NACE	(2) Label	(3) Mean green share 2005	(4) Mean green share 2010	(5) Mean green share 2015	(6) Share of total green production	(7) Absolute Change 2005-2015	(8) Average GHG intensity	(9) Polluting Industry
28	Manufacture of machinery and equipment n.e.c.	0.277 (0.107)	0.29 (0.12)	0.319 (0.137)	0.32	0.042	0.54	No
27	Manufacture of electrical equipment	0.357 (0.204)	0.348 (0.141)	0.406 (0.21)	0.18	0.05	0.3	No
25	Manufacture of fabricated metal products, except machinery and equipment.	0.335 (0.143)	0.306 (0.122)	0.299 (0.13)	0.17	-0.036	4.23	Yes
26	Manufacture of computer, electronic and optical products.	0.129 (0.122)	0.209 (0.171)	0.226 (0.144)	0.1	0.097	0.3	No
23	Manufacture of other non-metallic mineral products.	0.245 (0.132)	0.239 (0.119)	0.261 (0.133)	0.09	0.016	7.78	Yes
22	Manufacture of rubber and plastic products.	0.105 (0.049)	0.109 (0.052)	0.117 (0.065)	0.05	0.011	0.94	No
30	Manufacture of other transport equipment.	0.285 (0.293)	0.351 (0.318)	0.387 (0.333)	0.03	0.102	0.61	No
29	Manufacture of motor vehicles, trailers and semi-trailers.	0.084 (0.151)	0.036 (0.052)	0.024 (0.021)	0.02	-0.06	0.61	No
33	Repair and installation of machinery and equipment.	0.051 (0.059)	0.045 (0.035)	0.039 (0.042)	0.02	-0.012	0.74	No
24	Manufacture of basic metals.	0.051 (0.042)	0.032 (0.031)	0.07 (0.115)	0.01	0.019	4.23	Yes
10	Manufacture of food products.	0 (0)	0 (0)	0 (0)	0	0	1.45	No
11	Manufacture of beverages.	0 (0)	0 (0)	0 (0)	0	0	1.45	No
12	Manufacture of tobacco products.	0 (0)	0 (0)	0 (0)	0	0	1.45	No
13	Manufacture of textiles.	0.033 (0.086)	0.038 (0.082)	0.024 (0.035)	0	-0.009	0.97	No
14	Manufacture of wearing apparel.	0 (0)	0 (0)	0 (0)	0	0	0.97	No
15	Manufacture of leather and related products.	0 (0)	0 (0)	0 (0)	0	0	0.97	No
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials.	0.016 (0.024)	0.017 (0.024)	0.018 (0.03)	0	0.002	0.88	No
17	Manufacture of paper and paper products.	0 (0)	0 (0)	0 (0)	0	0	1.18	No
18	Printing and reproduction of recorded media.	0 (0)	0 (0)	0 (0)	0	0	1.18	No
19	Manufacture of coke and refined petroleum products.	.	0 (0)	0 (0)	0	.	44.99	No
20	Manufacture of chemicals and chemical products.	0.003 (0.011)	0 (0)	0 (0)	0	-0.003	5.11	Yes
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations.	0 (0)	0 (0)	0 (0)	0	0	5.11	Yes
31	Manufacture of furniture.	0 (0)	0 (0)	0 (0)	0	0	0.74	No
32	Other manufacturing.	0.001 (0.003)	0 (0.002)	0 (0.002)	0	0	0.74	No

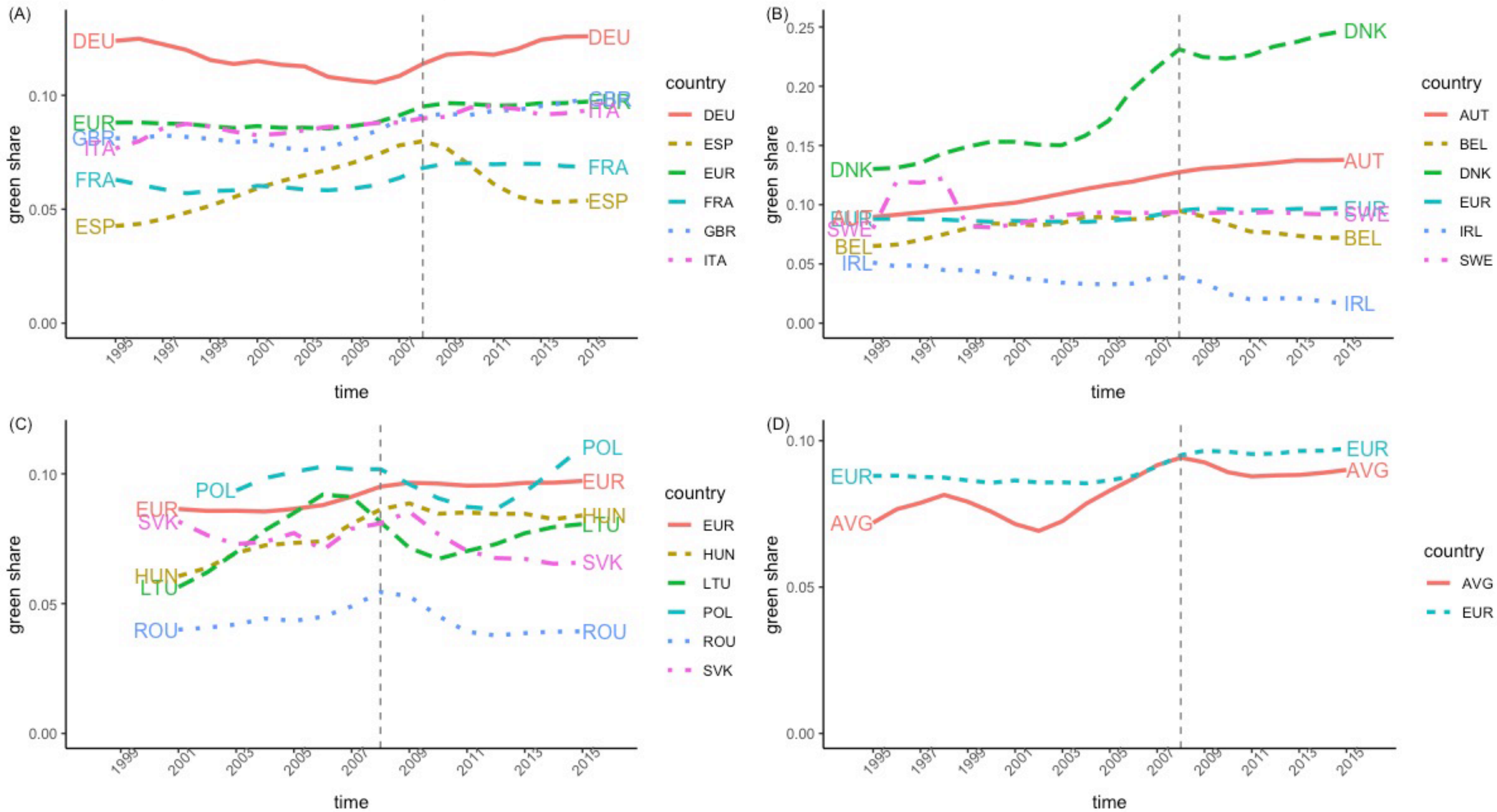
Notes: Authors' elaboration on PRODCOM data. Production values are deflated to have data at constant prices, with 2010 as base year. The definition of green products used here is explained in Section 2 (CLEG in Figure 1). Columns 3 to 5 report the mean green share of production with the standard deviation in brackets of each industry for the years 2005,2010 and 2015, respectively. Coke and refined petroleum products is not included in PRODCOM until 2005, as PRODCOM coverage is not stable over time and doesn't include fuel related products. Column 6 reports the share that green production of each industry represents in total green production. Absolute changes 2005-2015 refer to industries' average green shares of production. Polluting industries are identified in column 9 as the 5 industries with the highest average GHG intensity computed with WIOD, for further detail see Appendix B.

Table D.2: Distribution of green production shares across 4 digits NACE CLEG industries.

(1) NACE	(2) Label	(3) Mean	(4) Median	(5) Max	(6) Standard deviation	(7) Change 1995-2015	(8) Change 2001-2015	(9) Share of green production
2591	Manufacture of steel drums and similar containers	1.00	1.00	1.00	0.00	0.00	0.00	0.59
2814	Manufacture of other taps and valves	1.00	1.00	1.00	0.00	0.00	0.00	5.64
2361	Manufacture of concrete products for construction purposes	0.91	0.97	1.00	0.15	0.04	0.02	5.74
3092	Manufacture of bicycles and invalid carriages	0.79	0.82	1.00	0.24	0.11	0.14	0.75
2651	Manufacture of instruments and appliances for measuring, testing and navigation	0.77	0.81	1.00	0.20	0.04	0.06	8.51
3020	Manufacture of railway locomotives and rolling stock	0.75	0.84	1.00	0.26	-0.13	-0.02	2.45
2511	Manufacture of metal structures and parts of structures	0.72	0.74	1.00	0.15	-0.05	-0.01	11.85
2821	Manufacture of ovens, furnaces and furnace burners	0.69	0.83	1.00	0.32	-0.16	-0.14	0.7
2342	Manufacture of ceramic sanitary fixtures	0.65	0.91	1.00	0.42	-0.10	-0.05	0.36
2752	Manufacture of non-electric domestic appliances	0.65	0.65	1.00	0.23	0.04	0.13	0.91
2711	Manufacture of electric motors, generators and transformers	0.64	0.63	1.00	0.23	0.01	0.00	5.95
1622	Manufacture of assembled parquet floors	0.64	0.66	0.67	0.04	0.01	0.02	0.29
2813	Manufacture of other pumps and compressors	0.63	0.71	1.00	0.25	-0.04	-0.06	4.48
2740	Manufacture of electric lighting equipment	0.63	0.65	1.00	0.23	-0.05	-0.07	3.28
2530	Manufacture of steam generators, except central heating hot water boilers	0.60	0.66	1.00	0.35	0.22	0.31	0.5
2825	Manufacture of non-domestic cooling and ventilation equipment	0.51	0.55	1.00	0.24	-0.02	0.00	4.94
2899	Manufacture of other special-purpose machinery n.e.c.	0.49	0.50	0.83	0.18	0.15	0.07	3.84
2670	Manufacture of optical instruments and photographic equipment	0.47	0.37	1.00	0.35	0.19	0.14	0.44
2433	Cold forming or folding	0.47	0.48	1.00	0.28	0.20	0.07	0.73
2312	Shaping and processing of flat glass	0.46	0.40	1.00	0.29	0.00	0.08	1.34
2712	Manufacture of electricity distribution and control apparatus	0.45	0.43	1.00	0.23	0.04	0.03	4.81
2812	Manufacture of fluid power equipment	0.43	0.34	1.00	0.34	0.23	0.16	1.02
2529	Manufacture of other tanks, reservoirs and containers of metal	0.42	0.38	1.00	0.18	0.00	-0.03	0.76
2829	Manufacture of other general-purpose machinery n.e.c.	0.41	0.40	1.00	0.23	0.14	0.18	3.4
2221	Manufacture of plastic plates, sheets, tubes and profiles	0.41	0.37	1.00	0.19	0.17	0.04	4.55
2790	Manufacture of other electrical equipment	0.40	0.37	1.00	0.27	0.01	-0.02	2.35
2365	Manufacture of fibre cement	0.39	0.22	1.00	0.42	0.34	0.28	0.06
2599	Manufacture of other fabricated metal products n.e.c.	0.38	0.35	0.97	0.20	0.21	0.04	3.04
2815	Manufacture of bearings, gears, gearing and driving elements	0.36	0.31	1.00	0.31	-0.30	-0.06	3.11
1394	Manufacture of cordage, rope, twine and netting	0.32	0.23	1.00	0.31	-0.07	-0.01	0.06
2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	0.29	0.19	1.00	0.31	0.19	0.10	3.24
2592	Manufacture of light metal packaging	0.23	0.14	1.00	0.27	0.04	-0.10	0.59
2841	Manufacture of metal forming machinery	0.23	0.14	1.00	0.25	0.12	0.08	0.56
2720	Manufacture of batteries and accumulators	0.21	0.05	1.00	0.29	0.00	0.08	0.35
2920	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	0.20	0.19	0.60	0.14	-0.04	-0.05	1.24
2314	Manufacture of glass fibres	0.20	0.06	1.00	0.25	0.12	0.08	0.19
1395	Manufacture of non-wovens and articles made from non-wovens, except apparel	0.18	0.14	0.50	0.16	-0.05	-0.03	0.15
2399	Manufacture of other non-metallic mineral products n.e.c.	0.15	0.03	1.00	0.20	0.01	0.05	0.68
3320	Installation of industrial machinery and equipment	0.14	0.12	0.67	0.13	0.06	0.00	1.8
2611	Manufacture of electronic components	0.14	0.01	1.00	0.27	0.13	0.13	0.92
2751	Manufacture of electric domestic appliances	0.11	0.04	1.00	0.18	-0.03	0.00	0.68
2822	Manufacture of lifting and handling equipment	0.06	0.04	0.51	0.07	-0.03	0.02	0.64
2892	Manufacture of machinery for mining, quarrying and construction	0.06	0.04	0.33	0.07	-0.03	0.00	0.44
2351	Manufacture of cement	0.06	0.00	0.71	0.14	-0.03	-0.05	0.37
2223	Manufacture of builders-ware of plastic	0.06	0.03	0.58	0.07	-0.02	0.04	0.37
2910	Manufacture of motor vehicles	0.05	0.00	0.60	0.13	-0.04	-0.03	0.68
2410	Manufacture of basic iron and steel and of ferro-alloys	0.04	0.00	1.00	0.18	0.03	-0.06	0.16
2420	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	0.04	0.00	0.53	0.08	0.06	0.06	0.24
2451	Casting of iron	0.01	0.00	1.00	0.09	0.05	0.05	0.07
1629	Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials	0.01	0.00	0.20	0.02	-0.01	0.00	0.04
2060	Manufacture of man-made fibres	0.00	0.00	1.00	0.06	0.00	0.00	0
2059	Manufacture of other chemical products n.e.c.	0.00	0.00	0.15	0.02	0.00	0.00	0.1
3250	Manufacture of medical and dental instruments and supplies	0.00	0.00	0.02	0.00	0.00	0.00	0.04

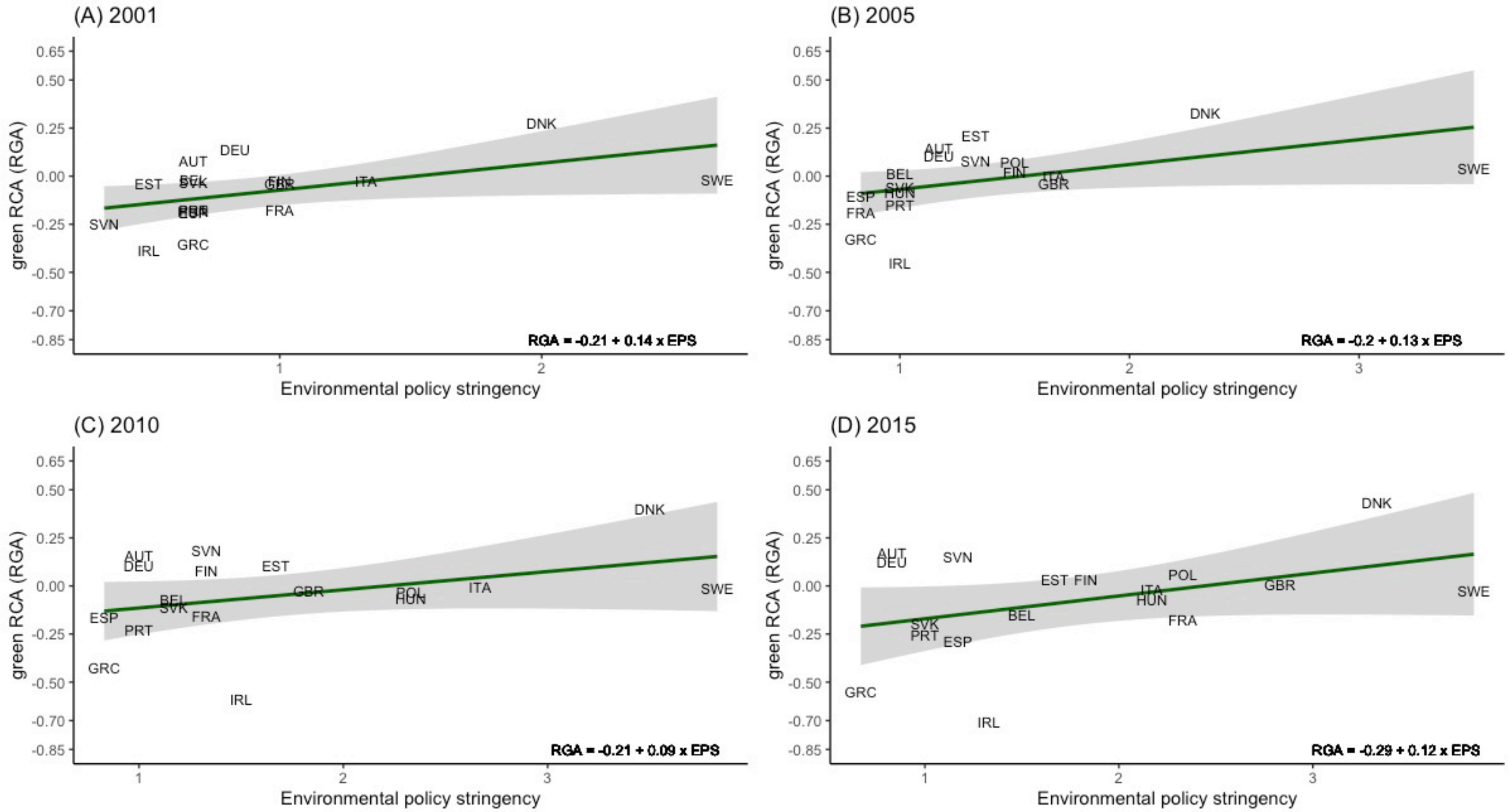
Notes: Authors' elaboration on PRODCOM data. Production values are deflated to have data at constant prices, with 2010 as base year. The definition of green products used here is explained in section 2 and it is the one called CLEG in Figure 1. Average, median, maximum and standard deviation are computed over all available countries and years (1995-2015), columns 7 and 8 report changes in the average green share for 1995-2015 and 2001-2015 respectively. The last column reports for each industry the share it represents in total green production across all industries, countries and years.

Figure D.4: Evolution of green production shares for selected European countries for CLEG industries.



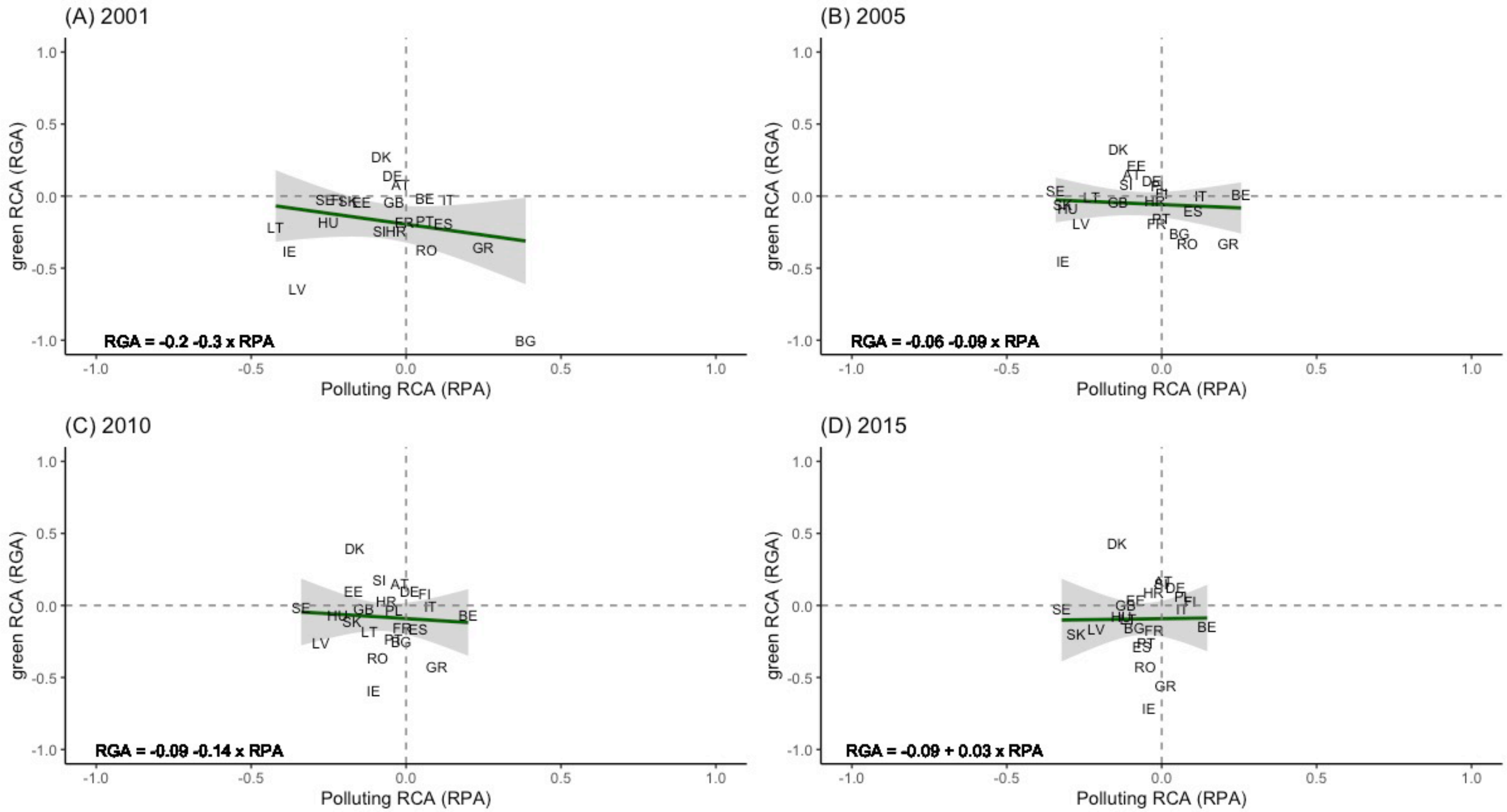
Notes: Authors' elaboration on PRODCOM data. Production values are deflated to have data at constant prices, with 2010 as base year. Panel A, B and C report green production shares over time for large, small and Eastern countries respectively, these have been smoothened by taking 3-years moving averages. We only use green production CLEG products. EUR is the European green shares across all available countries in each year. In panel D, we compare it with the unweighted average (AVG) across countries. Because data on Eastern countries is available only from 2001 onwards, and 2003 onwards for Poland, we report both these measures computed for each year for all available countries as well as only for countries for which we have a balanced panel since 1995, i.e.: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Spain, Sweden, United Kingdom, (EUR and AVG, respectively).

Figure D.5: Green RCA and environmental policy stringency across countries and over time, using CLEG classification.



Notes: Authors' elaboration on PRODCOM data and OECD for the index of environmental policy stringency (EPS) for market-based policies. We plot countries' green RCA and EPS, developed by the OECD. Green RCA is based on green production from CLEG list. Production values are deflated to have data at constant prices, with 2010 as base year. The RCAs are computed following formula 3 are made symmetrical around 0 and bounded between -1 and 1, the value of 0 indicates therefore whether a country has successfully specialised in green production. We also report the coefficient of a regression of green RCA on the EPS index for each year.

Figure D.6: Green and polluting RCA across countries and over time, using green production from all green industries.



Notes: Authors' elaboration on PRODCOM data. We plot countries' green and polluting RCA. Green RCA is based on green production of CLEG list. Polluting production is total production from polluting industries identified in Table 2. Production values are deflated to have data at constant prices, with 2010 as base year. The RCAs are computed following equation 3 and are made symmetrical around 0 and bounded between -1 and 1, the value of 0 indicates therefore whether a country has, on average, successfully specialised in green production. We also report the coefficient of a regression of green RCA on polluting RCA for each year.

E. Complementary material of Section 5

E.1 Descriptive evidence

We report in Table E.1 and E.2 descriptive statistics of the variables we use in our econometric analysis of Section 5. In the former we look at green and non-green RCAs, the PSM of the green RCA, as well as the number of green and non-green products with RCA. For these we report the descriptives for both the log and non-log variables to show how the log-transformation reduces skewedness of the variables. In the latter we report descriptive statistics for the additional controls we include in our empirical framework inspired by Mulatu *et al* (2010).

Table E.1: Descriptive statistics of RCA variables

Variables	Min	1st Qu.	Median	Mean	3rd Qu.	Max	St. Dev.	Average change 05-15
Green RCA	0.000	0.134	0.603	1.006	1.210	28.702	2.031	0.083
Green RCA (log)	-9.210	-2.008	-0.506	-1.877	0.190	3.357	3.388	0.004
Green RCA (PSM)	0.000	0.186	0.654	0.959	1.241	19.490	1.643	.
Green RCA (log PSM)	-9.210	-1.682	-0.424	-1.751	0.216	2.970	3.307	.
Non-green RCA	0.000	0.201	0.645	0.926	1.139	20.324	1.541	-0.037
Non-green RCA (log)	-9.210	-1.603	-0.438	-1.456	0.130	3.012	2.855	0.085
Number of green products with RCA	0.000	0.000	1.000	1.098	1.000	21.000	2.168	0.036
Number of green products with RCA (log)	0.000	0.000	0.693	0.510	0.693	3.091	0.596	0.005
Number of non-green products with RCA	0.000	0.000	2.000	3.324	4.000	33.000	4.424	-0.100
Number of non-green products with RCA (log)	0.000	0.000	1.099	1.101	1.609	3.526	0.836	0.001

Notes: Authors' elaboration on PRODCOM data. The table reports the distribution of the key variables from equation 6, i.e. only for the period 2005-2015 and only high-green potential industries, as defined in Table 3.

Table E.2: Descriptive statistics of specialisation variables.

Variables	Min	1st Qu.	Median	Mean	3rd Qu.	Max	St. Dev.
Market-based environmental policy stringency	0.50	1.00	1.33	1.64	2.17	4.00	0.82
Average share of green production	0.08	0.16	0.32	0.33	0.36	0.75	0.21
Population	1,314,870	5,461,512	10,500,000	25,300,000	46,600,000	82,500,000	26,000,000
Country capital to labour endowment (log)	0.55	1.69	2.01	1.91	2.23	2.52	0.45
Industry capital to labour requirement	3.28	4.03	4.89	5.03	5.17	8.35	1.45
Country share of tertiary educated workers (log)	2.65	3.14	3.41	3.35	3.58	3.86	0.29
Industry share of skilled workers	4.00	12.00	12.04	14.31	14.41	34.00	7.70
Country share of R&D personnel (log)	-5.32	-4.68	-4.39	-4.42	-4.14	-3.72	0.39
Country total manufacturing output (log)	22.58	25.02	25.83	25.77	26.81	28.23	1.33
Industry average employee per plant (log)	2.93	3.35	3.52	3.60	3.65	5.04	0.53

Notes: Authors' elaboration on PRODCOM data. The table reports the distribution of the key variables from equation 6, i.e. for country-level variable only for the period 2005-2015, while industry-level variables are time-invariant and only high-green potential industries, see Table E.4. for variable description and sources.

Table E.3: Data sources for specialisation drivers

Variable	Country-year	Industry
Environmental policies	Market-based environmental policy stringency index. *Source:* OECD.	mean of industry green share, mean by industry over the entire period, 1995-2015. *Source: PRODCOM.*
Capital intensity	Investment in tangible, non-residential, assets as a share of total employment. *Source:* EUKLEMS-INTANProd 2022.	Investment in tangible assets as a share of total employment, mean by industry over the period 1998-2018. *Source:* Eurostat Structure of Business Survey (SBS).
Skills	Share of tertiary education enrolled students. *Source:* Eurostat.	US data on share of employment in high-skill occupations by industry, i.e. share of workers employed in abstract occupations identified with the following SOC: 47, 49, 51, 53. *Source:* US BLS OES data from 2007.
Technology	Share of R&D personnel and researchers in total active population. *Source:* Eurostat.	R&D expenditure dummy taking value if one if the industry is considered high or medium-high tech. *Source:* Eurostat 3-digit industry classification (see table E.4).
Scale	Manufacturing output. *Source:* EUKLEMS-INTANProd 2022.	Average number of employees per plant, mean by industries over the period 1998-2018. *Source:* Eurostat SBS.

Note: variables at the industry level are mean computed across all countries for all years available in each dataset in order to obtain industry-level measures as exogenous as possible from the country-level variables we use in our econometric analysis.

Table E.4: Technological intensity of industries – Eurostat classification.

Technological intensity	NACE	High green potential
High	- Manufacture of basic pharmaceutical products and pharmaceutical preparations (21);	No
	- Manufacture of computer, electronic and optical products (26);	Yes
	- Manufacture of air and spacecraft and related machinery (30.3)	No
Medium-high	- Manufacture of chemicals and chemical products (20);	No
	- Manufacture of weapons and ammunition (25.4);	No
	- Manufacture of electrical equipment (27);	Yes
	- Manufacture of machinery and equipment n.e.c. (28);	Yes
	- Manufacture of motor vehicles, trailers and semi-trailers (29);	Yes
	- Manufacture of other transport equipment (30) excluding Building of ships and boats (30.1) and excluding Manufacture of air and spacecraft and related machinery (30.3);	Yes
	- Manufacture of medical and dental instruments and supplies (32.5)	No
Medium-low	- Reproduction of recorded media (18.2);	No
	- Manufacture of coke and refined petroleum products (19);	No
	- Manufacture of rubber and plastic products (22);	No
	- Manufacture of other non-metallic mineral products (23);	No
	- Manufacture of basic metals (24);	No
	- Manufacture of fabricated metal products, except machinery and equipment (25) excluding Manufacture of weapons and ammunition (25.4);	No
	- Building of ships and boats (30.1);	No
	- Repair and of machinery and equipment (33)	Yes
Low	- Manufacture of food products (10);	No
	- Manufacture of beverages (11);	No
	- Manufacture of tobacco products (12);	No
	- Manufacture of textiles (13);	No
	- Manufacture of wearing apparel (14);	No
	- Manufacture of leather and related products (15);	No
	- Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (16);	No
	- Manufacture of paper and paper products (17);	No
	- Printing and reproduction of recorded media (18) excluding Reproduction of recorded media (18.2);	No
	- Manufacture of furniture (31);	No
	- Other manufacturing (32) excluding Manufacture of medical and dental instruments and supplies (32.5)	No

Note: the table reports Eurostat's taxonomy of technology intensity based on R&D intensity. This taxonomy identifies industries at either 2 or 3 digits of the NACE rev.2 classification. While this is not a one-to-one correspondence with our analysis at 4 digits, the third column identifies industries that are (or contain) high-green potential industries.

Table E.5: Standard deviations and coefficients of variation for all manufacturing and high-green potential industries.

	Standard deviation	Coefficient of variation	Standard deviation	Coefficient of variation
	All manufacturing		High-green potential industries	
Industry capital intensity	6.47	0.82	1.45	0.29
Industry share of skilled workers	11.74	0.89	7.70	0.54
Industry average employees per plant	48.14	1.13	34.93	0.80

Notes: the table reports the standard deviation and variation coefficient for three industry-level variables used in our econometric analysis. The first two columns report values for the entire manufacturing sector, i.e. green and non-green industries. The second two columns report values for high-green potential industries alone.
Industry capital intensity and average number of employees per plant are retrieved from SBS and the industry share of skilled workers from the BEA-LBS OES data, as indicated in Table E.4 We do not report information for the technology industry-level variable as this is a dummy based on high and medium-high tech industries in Table E.4. We also omit information on green share of production because this measure is only available for green industries.

E2. Robustness checks, econometric results

We report in this Appendix a battery of robustness checks that are described in detail in Section 5. For comparison, Table E.6 reports the results of our study of drivers of export specialisation using all green industries, rather than only high-green potential ones. Table E.7 weights our results from Table 4 in the main text on industries' average turnover and Table E.8 reports the results using the CLEG list for green products. Finally, Table E.9 and E.10 report the marginal effects computed for the specifications in column 1 and 5 of Table 4, respectively.

Table E.6: Drivers of green specialisation – all green industries.

	(1)	(2)	(3)	(4)	(5)
Country environmental policies	0.603*	-0.703***	-0.627**	-0.580***	-0.310*
	(0.322)	(0.251)	(0.252)	(0.222)	(0.186)
Industry environmental policies	2.607	-1.551	0.0629	-0.398	-0.757
	(1.903)	(1.181)	(1.194)	(1.072)	(1.022)
Country env. Policies * Industry env. policies	0.676	1.689***	1.208*	0.859	0.906*
	(0.833)	(0.651)	(0.633)	(0.536)	(0.523)
Population (log)	2.040***	1.464***	1.340***	1.366***	3.660
	(0.661)	(0.479)	(0.458)	(0.442)	(4.774)
Country capital intensity	-0.0603	0.918*	0.745	0.670	0.584
	(1.099)	(0.549)	(0.562)	(0.533)	(0.607)
Industry capital intensity	-0.209	0.0826	0.0714	0.0144	0.00257
	(0.213)	(0.119)	(0.123)	(0.115)	(0.105)
Country capital intensity * Industry capital intensity	0.0892	-0.0295	-0.0184	0.000872	0.00129
	(0.106)	(0.0661)	(0.0686)	(0.0627)	(0.0551)
Country skills	0.187	-0.607	-0.472	-0.384	-1.322
	(1.359)	(0.965)	(0.946)	(0.881)	(1.037)
Industry skills	-0.0616	-0.0651	-0.0839	-0.129	-0.113
	(0.292)	(0.178)	(0.179)	(0.169)	(0.164)
Country skills * Industry skills	-0.00610	0.0154	0.0215	0.0289	0.0227
	(0.0855)	(0.0548)	(0.0548)	(0.0513)	(0.0500)
Country technology	0.263	1.109*	1.041*	1.183**	0.580
	(0.981)	(0.648)	(0.630)	(0.568)	(0.659)
Industry technology	5.274	-1.541	-1.389	-3.374	-2.670
	(4.434)	(2.625)	(2.558)	(2.368)	(2.239)
Country technology * Industry technology	1.102	-0.355	-0.310	-0.733	-0.589
	(0.972)	(0.577)	(0.568)	(0.523)	(0.492)
Country scale	-1.717**	-1.670***	-1.445**	-1.589***	-1.027
	(0.824)	(0.620)	(0.593)	(0.561)	(1.064)
Industry scale	-5.638*	-3.415	-2.167	-2.526	-2.986
	(3.113)	(3.444)	(3.361)	(3.073)	(2.887)
Country scale * Industry scale	0.166	0.109	0.0613	0.0788	0.0945
	(0.117)	(0.133)	(0.130)	(0.119)	(0.112)
Non-green RCA (log, t-1)			0.189***	0.129***	0.124***
			(0.0483)	(0.0488)	(0.0457)
Number of green products with RCA (log, t-1)				1.791***	1.705***
				(0.261)	(0.241)
Number of non-green products with RCA (log t-1)				-0.00178	-0.221
				(0.149)	(0.142)
2005 * PSM RGA (ln)		0.909***	0.854***	0.753***	0.746***
		(0.0276)	(0.0335)	(0.0366)	(0.0362)
2006 * PSM RGA (ln)		0.876***	0.821***	0.730***	0.720***
		(0.0319)	(0.0380)	(0.0404)	(0.0401)
2007 * PSM RGA (ln)		0.816***	0.760***	0.672***	0.661***
		(0.0416)	(0.0477)	(0.0506)	(0.0521)
2008 * PSM RGA (ln)		0.778***	0.734***	0.650***	0.637***
		(0.0458)	(0.0499)	(0.0522)	(0.0539)
2009 * PSM RGA (ln)		0.744***	0.703***	0.621***	0.604***

		(0.0484)	(0.0518)	(0.0521)	(0.0539)
2010 * PSM RGA (ln)		0.750***	0.716***	0.630***	0.610***
		(0.0480)	(0.0499)	(0.0507)	(0.0532)
2011 * PSM RGA (ln)		0.732***	0.702***	0.619***	0.594***
		(0.0494)	(0.0508)	(0.0517)	(0.0537)
2012 * PSM RGA (ln)		0.724***	0.692***	0.611***	0.587***
		(0.0510)	(0.0524)	(0.0524)	(0.0542)
2013 * PSM RGA (ln)		0.689***	0.655***	0.577***	0.549***
		(0.0528)	(0.0546)	(0.0544)	(0.0558)
2014 * PSM RGA (ln)		0.607***	0.569***	0.497***	0.457***
		(0.0634)	(0.0640)	(0.0626)	(0.0629)
2015 * PSM RGA (ln)		0.603***	0.557***	0.489***	0.442***
		(0.0608)	(0.0623)	(0.0604)	(0.0609)
Constant	13.15	26.57*	22.05	25.07**	-26.23
	(16.04)	(13.89)	(13.45)	(12.40)	(94.82)
Observations	3,537	3,537	3,537	3,537	3,537
R-squared	0.292	0.642	0.652	0.692	0.709
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	Yes

Notes: Pre-sample mean computed for the years 2001-2004, for Poland only for 2003-2004 due to data constraints. Production values are deflated to have data at constant prices, with 2010 as base year. All RGA explanatory variables, except the pre-sample mean, are lagged by one year. Variable names are simplified for space's sake, Table E.4 reports full details. Estimation time span is 2005-2015. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table E.7: Drivers of green specialisation – weighted results for high-green potential industries.

	(1)	(2)	(3)	(4)	(5)
Country environmental policies	-0.109	-0.750*	-0.660*	-0.602*	-0.385*
	(0.593)	(0.397)	(0.390)	(0.346)	(0.232)
Industry environmental policies	-3.001	-3.553*	-2.486	-1.972	-2.245
	(2.675)	(1.873)	(1.815)	(1.585)	(1.649)
Country env. Policies * Industry env. policies	2.280	2.157**	1.781*	1.367*	1.411*
	(1.472)	(0.988)	(0.943)	(0.783)	(0.848)
Population (log)	1.114	0.875*	0.817*	0.832*	6.056
	(0.708)	(0.497)	(0.480)	(0.472)	(5.785)
Country capital intensity	2.614	2.976**	2.925**	2.468**	2.549*
	(1.940)	(1.268)	(1.260)	(1.213)	(1.303)
Industry capital intensity	-0.0973	0.582	0.625	0.563	0.477
	(0.641)	(0.452)	(0.429)	(0.443)	(0.425)
Country capital intensity * Industry capital intensity	-0.242	-0.424*	-0.439*	-0.343	-0.329
	(0.340)	(0.234)	(0.226)	(0.224)	(0.213)
Country skills	-0.591	-1.336	-1.163	-0.996	-1.155
	(1.319)	(0.968)	(0.927)	(0.851)	(1.197)
Industry skills	-0.250	-0.231	-0.240	-0.263*	-0.250*
	(0.278)	(0.155)	(0.160)	(0.156)	(0.143)
Country skills * Industry skills	0.0603	0.0711	0.0734	0.0720	0.0682
	(0.0819)	(0.0480)	(0.0489)	(0.0466)	(0.0431)
Country technology	-1.427	0.593	0.705	0.571	0.994
	(1.601)	(0.830)	(0.757)	(0.751)	(0.961)
Industry technology	5.947	-2.589	-3.145	-4.074	-3.424
	(6.603)	(2.967)	(2.595)	(2.659)	(2.704)
Country technology * Industry technology	1.309	-0.516	-0.631	-0.836	-0.689
	(1.420)	(0.653)	(0.571)	(0.581)	(0.588)
Country scale	-2.149**	-1.003	-0.841	-1.244*	0.234
	(1.079)	(0.839)	(0.825)	(0.745)	(1.528)
Industry scale	-14.01**	-2.453	-1.366	-3.255	-3.275
	(6.417)	(5.482)	(5.628)	(4.637)	(4.221)
Country scale * Industry scale	0.504**	0.0758	0.0350	0.113	0.111
	(0.243)	(0.209)	(0.214)	(0.176)	(0.160)
Non-green RCA (log, t-1)			0.157**	0.0967	0.116
			(0.0674)	(0.0725)	(0.0707)
Number of green products with RCA (log, t-1)				0.996***	0.969***
				(0.216)	(0.205)
Number of non-green products with RCA (log t-1)				0.254	0.0565
				(0.165)	(0.158)
2005 * PSM RGA (ln)		0.878***	0.812***	0.731***	0.708***
		(0.0530)	(0.0666)	(0.0670)	(0.0660)
2006 * PSM RGA (ln)		0.855***	0.790***	0.711***	0.688***
		(0.0554)	(0.0682)	(0.0675)	(0.0662)
2007 * PSM RGA (ln)		0.756***	0.683***	0.609***	0.588***
		(0.0740)	(0.0921)	(0.0920)	(0.0926)
2008 * PSM RGA (ln)		0.741***	0.680***	0.603***	0.582***
		(0.0777)	(0.0904)	(0.0902)	(0.0917)
2009 * PSM RGA (ln)		0.706***	0.647***	0.570***	0.549***

		(0.0769)	(0.0862)	(0.0831)	(0.0843)
2010 * PSM RGA (ln)		0.692***	0.637***	0.559***	0.532***
		(0.0776)	(0.0851)	(0.0853)	(0.0865)
2011 * PSM RGA (ln)		0.709***	0.662***	0.583***	0.553***
		(0.0775)	(0.0808)	(0.0821)	(0.0847)
2012 * PSM RGA (ln)		0.677***	0.626***	0.557***	0.527***
		(0.0835)	(0.0848)	(0.0821)	(0.0839)
2013 * PSM RGA (ln)		0.650***	0.596***	0.523***	0.492***
		(0.0837)	(0.0848)	(0.0852)	(0.0855)
2014 * PSM RGA (ln)		0.613***	0.557***	0.487***	0.450***
		(0.0874)	(0.0866)	(0.0890)	(0.0869)
2015 * PSM RGA (ln)		0.652***	0.592***	0.526***	0.487***
		(0.0829)	(0.0849)	(0.0848)	(0.0830)
Constant	33.12	16.75	13.20	21.29	-99.74
	(25.51)	(21.84)	(21.94)	(18.58)	(116.6)
Observations					
R-squared	2,444	2,444	2,444	2,444	2,444
Year FE	0.292	0.651	0.658	0.693	0.710
Country FE	Yes	Yes	Yes	Yes	Yes

Notes: Pre-sample mean computed for the years 2001-2004, for Poland only for 2003-2004 due to data constraints. Production values are deflated to have data at constant prices, with 2010 as base year. All RGA explanatory variables, except the pre-sample mean, are lagged by one year. Variable names are simplified for space's sake, Table E.4 reports full details. Estimation time span is 2005-2015. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table E.8: Drivers of green specialisation – CLEG list of green goods.

	(1)	(2)	(3)	(4)	(5)
Country environmental policies	0.267	-0.223*	-0.228*	-0.240**	0.0997
	(0.166)	(0.125)	(0.120)	(0.116)	(0.0972)
Industry environmental policies	-1.569	-0.935	-0.121	-0.175	-0.322
	(1.349)	(0.823)	(0.772)	(0.735)	(0.712)
Country env. Policies * Industry env. policies	1.065*	0.624	0.372	0.269	0.320
	(0.637)	(0.458)	(0.417)	(0.378)	(0.368)
Population (log)	1.502***	1.248***	1.080***	1.015***	1.400
	(0.430)	(0.271)	(0.257)	(0.251)	(3.059)
Country capital intensity	0.803	0.932**	0.774*	0.641	0.161
	(0.654)	(0.420)	(0.415)	(0.400)	(0.433)
Industry capital intensity	-0.380***	-0.145	-0.165*	-0.178**	-0.178**
	(0.135)	(0.0902)	(0.0861)	(0.0840)	(0.0806)
Country capital intensity * Industry capital intensity	0.00782	0.0233	0.0344	0.0422	0.0386
	(0.0683)	(0.0465)	(0.0446)	(0.0433)	(0.0415)
Country skills	-0.530	-0.0117	0.116	-0.0105	0.0189
	(0.958)	(0.579)	(0.571)	(0.549)	(0.674)
Industry skills	-0.209	0.0473	0.0208	-0.0508	-0.0411
	(0.231)	(0.120)	(0.120)	(0.112)	(0.110)
Country skills * Industry skills	0.0333	-0.0196	-0.0140	0.00289	0.000283
	(0.0684)	(0.0373)	(0.0370)	(0.0346)	(0.0338)
Country technology	0.407	0.315	0.222	0.345	-0.554
	(0.689)	(0.439)	(0.428)	(0.417)	(0.448)
Industry technology	1.806	0.369	0.0949	-1.232	-1.021
	(2.854)	(1.683)	(1.645)	(1.614)	(1.588)
Country technology * Industry technology	0.189	0.0253	-0.0487	-0.347	-0.301
	(0.639)	(0.370)	(0.362)	(0.356)	(0.350)
Country scale	-1.779***	-1.521***	-1.285***	-1.263***	-0.771
	(0.591)	(0.400)	(0.385)	(0.378)	(0.642)
Industry scale	-7.655***	-3.439*	-2.394	-1.965	-2.230
	(2.866)	(2.083)	(2.023)	(1.990)	(1.985)
Country scale * Industry scale	0.305***	0.131	0.0915	0.0756	0.0860
	(0.109)	(0.0818)	(0.0793)	(0.0779)	(0.0775)
Non-green RCA (log, t-1)			0.166***	0.0739**	0.0681**
			(0.0331)	(0.0326)	(0.0330)
Number of green products with RCA (log, t-1)				0.732***	0.672***
				(0.151)	(0.146)
Number of non-green products with RCA (log t-1)				0.632***	0.541***
				(0.104)	(0.0964)
2005 * PSM RGA (ln)		0.912***	0.852***	0.804***	0.809***
		(0.0168)	(0.0222)	(0.0237)	(0.0232)
2006 * PSM RGA (ln)		0.872***	0.810***	0.765***	0.768***
		(0.0213)	(0.0261)	(0.0278)	(0.0273)
2007 * PSM RGA (ln)		0.817***	0.753***	0.711***	0.712***
		(0.0281)	(0.0326)	(0.0341)	(0.0338)
2008 * PSM RGA (ln)		0.769***	0.719***	0.674***	0.672***
		(0.0320)	(0.0348)	(0.0364)	(0.0361)
2009 * PSM RGA (ln)		0.728***	0.680***	0.634***	0.633***

		(0.0342)	(0.0368)	(0.0382)	(0.0379)
2010 * PSM RGA (ln)		0.713***	0.666***	0.620***	0.616***
		(0.0354)	(0.0377)	(0.0390)	(0.0391)
2011 * PSM RGA (ln)		0.684***	0.637***	0.596***	0.588***
		(0.0366)	(0.0387)	(0.0396)	(0.0398)
2012 * PSM RGA (ln)		0.667***	0.620***	0.580***	0.574***
		(0.0376)	(0.0396)	(0.0406)	(0.0408)
2013 * PSM RGA (ln)		0.675***	0.630***	0.592***	0.583***
		(0.0373)	(0.0392)	(0.0399)	(0.0402)
2014 * PSM RGA (ln)		0.658***	0.615***	0.576***	0.566***
		(0.0380)	(0.0396)	(0.0406)	(0.0409)
2015 * PSM RGA (ln)		0.661***	0.616***	0.580***	0.564***
		(0.0354)	(0.0374)	(0.0383)	(0.0391)
Constant	22.72*	18.97**	15.20*	15.90*	-6.679
	(12.80)	(8.980)	(8.749)	(8.609)	(58.35)
Observations	8,478	8,478	8,478	8,478	8,478
R-squared	0.231	0.623	0.636	0.653	0.661
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	Yes

Notes: Pre-sample mean computed for the years 2001-2004, for Poland only for 2003-2004 due to data constraints. Production values are deflated to have data at constant prices, with 2010 as base year. All RGA explanatory variables, except the pre-sample mean, are lagged by one year. Variable names are simplified for space's sake, Table E.4 reports full details. Estimation time span is 2005-2015. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table E.9 –Marginal effects of standard specialisation drivers – basic specification column 1 of Table 4

Industry characteristic	(1) p25	(2) p50	(3) p75	(4) p90	(5) High-tech	(6) Not high-tech
Environmental Policy	0.432	0.700**	0.765**	1.368**		
	(1.30)	(2.79)	(3.13)	(3.21)		
Capital Intensity	0.506	0.687	0.746	1.217		
	(0.63)	(0.92)	(0.99)	(1.07)		
Skills	-0.144	-0.143	-0.0825	0.161		
	(-0.16)	(-0.16)	(-0.10)	(0.13)		
Technology					0.607	-0.628
					(0.73)	(-0.49)
Scale	-1.073	-1.010	-0.960	-0.694		
	(-1.64)	(-1.54)	(-1.47)	(-1.01)		
Observations	2444	2444	2444	2444	2444	2444

Note: the table reports marginal effects of interactions for different industry characteristics at different levels of the variables' distribution as in Mulatu et al. (2010), for the technology characteristic we use the two values of the dummy variable. t statistics in parentheses * p<0.05 ** p<0.01 *** p<0.001

Table E.10 –Marginal effects of standard drivers of specialisation– preferred specification column 5 of Table 4

Industry characteristic	(1) p25	(2) p50	(3) p75	(4) p90	(5) High-tech	(6) Not high-tech
Environmental Policy	0.0194	0.131	0.158	0.410		
	(0.14)	(1.13)	(1.31)	(1.52)		
Capital Intensity	0.768	0.682	0.654	0.430		
	(1.27)	(1.22)	(1.18)	(0.58)		
Skills	-0.390	-0.388	-0.302	0.0473		
	(-0.43)	(-0.43)	(-0.33)	(0.04)		
Technology					0.326	0.171
					(0.51)	(0.23)
Scale	-0.614	-0.616	-0.617	-0.625		
	(-0.58)	(-0.59)	(-0.59)	(-0.60)		
Observations	2444	2444	2444	2444	2444	2444

Note: the table reports marginal effects of interactions for different industry characteristics at different levels of the variables' distribution as in Mulatu et al. (2010), for the technology characteristic we use the two values of the dummy variable. t statistics in parentheses * p<0.05 ** p<0.01 *** p<0.001

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