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ECONOMIC COMPLEXITY AND THE GREEN ECONOMY

Penny Mealy & Alexander Teytelboym

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Economic Complexity and the Green Economy*

Penny Mealy[†] Alexander Teytelboym[‡]

Abstract

Which countries currently have the productive capabilities to thrive in the green economy? How might countries reorient their existing industrial structures to be more competitive in an environmentally friendly world? To investigate these questions, this paper develops a novel methodology for measuring productive capabilities to the green economy. By constructing a new and comprehensive dataset of traded green products and drawing on economic complexity methods, we rank countries in terms of their ability to export complex green products competitively. We show that higher ranked countries are more likely to have higher environmental patenting rates, lower CO_2 emissions, and more stringent environmental policies even after controlling for per capita GDP. We then examine countries' potential to transition into green products in the future and find strong path dependence in the accumulation of green capabilities. Our results shed new light on green industrialisation and have a number of implications for green industrial policy.

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[†]Email: penny.mealy@inet.ox.ac.uk. Institute for New Economic Thinking at the Oxford Martin School, and the Smith School for Enterprise and the Environment, University of Oxford.

[‡]Email: alexander.teytelboym@economics.ox.ac.uk. Department of Economics, St. Catherine's College, Institute for New Economic Thinking at the Oxford Martin School, and the Smith School for Enterprise and the Environment, University of Oxford.

1 Introduction

The transition to the green economy is high on policymakers' agendas and is likely to involve a transformation of economic activities around the world (World Bank, 2012; AfDB, 2013; ADB, 2013; EBRD, 2017). With greater emphasis placed on clean technologies and environmentally friendly goods and services, the shift to a greener growth model has the potential to alter the global competitive landscape (Fankhauser et al., 2013). Such structural changes are likely to have important implications for the economic fortunes of nations.

Research in economic complexity has shown that the mix of products in countries' export baskets influences their future economic diversification possibilities and growth outcomes (Hidalgo et al., 2007; Hausmann et al., 2007; Hidalgo and Hausmann, 2009; Hausmann et al., 2014). However, relatively little work has studied the relevance of countries' productive structures for their success in the green economy. A key barrier has been a lack of a universally accepted definition of environmental goods and services. In 2001, the World Trade Organisation (WTO) instigated a mandate to reduce or eliminate tariffs on environmental goods and services and numerous lists of green products have since been proposed by various international organisations (WTO, 2001). However, largely due to the conceptual and practical challenges of identifying and classifying products with environmental benefits, a global consensus on green goods and services has not yet been reached (Bucher et al., 2014).[1]

This paper first addresses the empirical gap by pooling together all existing environmental goods classifications from the WTO, the Organisation for Economic Cooperation and Development (OECD), and the Asia-Pacific Economic Cooperation (APEC) into a comprehensive dataset of green products traded between 1995 and 2014. We then extend methodologies from the economic complexity literature to examine: (i) which countries are currently best placed to benefit from the transition to the green economy, and (ii) how countries might reorient their industrial structure to become more competitive in green (or environmentally friendly)

[1]The latest round of talks on WTO Environmental Goods Agreement which promised to deliver a list of green products stalled in December 2016.

products in the future.

We start by showing that compared to all traded products, green products have, on average, higher *Product Complexity Index* (PCI) values (Hidalgo and Hausmann, 2009). The PCI has often been used as a proxy for the technological sophistication of products (Felipe et al., 2012; Poncet and de Waldemar, 2013; Javorcik et al., 2018). Our finding suggests that green products, on average, require more technologically advanced know-how than non-green products (see also Dechezleprêtre et al. (2014)).

In order to understand which countries are more likely to thrive in the green economy, we develop a new measure called the *Green Complexity Index* (GCI). The GCI aims to estimate a country's green production capabilities. A country's GCI is increasing in the number and the PCI of green products can export competitively.[2] Top ranked countries in 2014 include Germany, Italy, the United States, Austria, and Denmark, while countries such as Turkmenistan, Mauritania, and Angola occupy the bottom ranks.

While the GCI is correlated with per capita GDP, it also captures a lot of variation in different environmentally relevant variables. For example, controlling for countries' per capita GDP, countries with higher GCI tend to have significantly higher environmental patenting rates, lower CO_2 emissions, and more stringent environmental policies. We also investigate the evolution of countries' GCI rankings between 1995 and 2014. We find relatively little variation in the highest rankings (Germany has remained in the top position over the 20 year period). However, other countries, such as China, Vietnam, and Uganda have made significant gains in their GCI scores, while other countries such as Australia show notable declines.

To understand how countries may reorient their industrial structure to become more competitive in green products, we draw on the "principle of relatedness" from economic geography and economic complexity literatures (Hidalgo et al., 2018). There is substantial evidence that countries are more likely to diversify into products or industries that require related (or similar) production capabilities

[2] We say that a country is *competitive* in a product if its revealed comparative advantage (RCA) for this product is greater than 1 (Balassa, 1965). See Equation 1 below.

to those they currently possess (Patel and Pavitt, 1997; Weitzman, 1998; Hidalgo et al., 2007; Neffke et al., 2011; Boschma et al., 2013). By assuming that the transition to green or environmentally friendly products should follow the same pattern, we apply relatedness measures developed in Hidalgo et al. (2007) to construct each country's *Green Adjacent Possible* (GAP). The GAP identifies the set of green products that are most related (or similar) to a country's current production capabilities – i.e. the new green industrial opportunities that a country is most likely to transition to given the country's current technological capabilities.

We also develop the *Green Complexity Potential* (GCP) measure, which aggregates the information contained in each country's GAP into a single, comparable metric. The GCP measures each country's average relatedness to complex green products that the country is not yet competitive in. We show that the GCP is able to significantly predict future increases in a country's GCI, green export share, and the number of green products that a country is competitive in, even after controlling for each country's GDP per capita. We also find a strong positive correlation between the GCP and GCI suggesting that countries that currently export a significant number of green complex products are generally well placed to diversify into other green complex products in the future.

Our results contribute to a number of policy discussions. First, we establish an extensive set of products relevant to the green economy and identify which countries currently have the capabilities to produce them competitively. Our findings complement Fankhauser et al.'s (2013) related efforts to analyse "who will win the green race", but provides a broader coverage of countries and an alternative analytical lens based on the economic complexity methodology. Second, our GCI measure allows policymakers to assess a country's green production capabilities relative to other countries and also consider how its green competitiveness has been changing over time. The path dependence in green diversification suggests that earlier and more aggressive action to establish green production capabilities is required in order to succeed in the future green economy (Aghion et al., 2014, 2016). Third, by identifying the GAPs we provide a data-driven indication of which products countries are best placed to gain a competitive edge in, informing policymakers about the likely directions of green diversification and as well as the appropriate levers for green industrial policy (Aghion et al., 2011; Huberty and Zachmann, 2011; Hallegatte et al., 2012, 2013; Rodrik, 2014). We also present some preliminary results on the effect of recent green stimulus policies on green exports and the GCI for a selection of countries.

This paper is organized as follows. Section 2 reviews background literature on capabilities, diversification, and existing efforts to apply economic complexity approaches to study the green economy. Section 3 gives an overview of the data and methods used in this paper. Section 4 presents our results and Section 5 discusses key policy implications and avenues for future work. The Appendix contains more information about the data (A.1 and A.2), green products and their relatedness (A.4 and A.6), countries and green exports (A.3 and A.5) and also gives further regression robustness checks (A.7).

2 Related literature

2.1 Capabilities and complexity

The notion of "production capabilities" has strong ties to the growth and development literature. In the development context, capabilities are often discussed with reference to the technologies, productive know-how, infrastructure, and institutions that enable a country to improve its productivity and achieve higher growth rates (Lall, 1992; Bell and Pavitt, 1995; Sutton and Trefler, 2016). In this paper, we consider production capabilities in a similar spirit, but with a distinct focus on the set of capabilities that are relevant to the green economy.

However, precisely defining and measuring "productive capabilities" is challenging. A number of efforts have tried to infer information about countries' productive capabilities using trade data, with the key assumption that if a country has revealed comparative advantage in a product, then it must have the capabilities to produce it competitively (Lall, 2000; Lall et al., 2006; Hausmann et al., 2007; Hidalgo and Hausmann, 2009; Hausmann et al., 2014). Trade data is also advantageous in offering a rich source of detailed information on tradable goods comparable across time and space.

Strategies to measure capabilities relevant for growth and development have taken various forms (see Verspagen et al. (2015) for a review). Here we focus on the country-based Economic Complexity Index (ECI) and product-based Product Complexity Index (PCI), which were originally introduced in Hidalgo and Hausmann (2009) in order to infer the "complexity" (or technological sophistication) of countries' production capabilities. The ECI and PCI have a number of different economically relevant mathematical interpretations including spectral clustering, diffusion maps, and correspondence analysis (Mealy et al., 2019).

The ECI has attracted significant attention from researchers and policymakers because it can explain more variation in country income per capita and economic growth than other variables commonly employed in growth regressions such as governance, institutional quality, education, and competitiveness (Hidalgo and Hausmann, 2009; Hausmann et al., 2014). As we will discuss further in section 3.2, when applied to trade data, the ECI provides a ranking of countries by exploiting the pattern of similarities in their export portfolios. Countries with a high ECI have export baskets that are similar to other countries with a high ECI, and these countries tend to be advanced economies that are able to export technologically sophisticated products competitively. In contrast, countries with low ECI have export baskets that tend to be characterized by less technologically sophisticated products (Mealy et al., 2019). The PCI, on the other hand, provides a similarity ordering over products. High-PCI products, which are exported by high-ECI countries, tend to reflect more technologically sophisticated products, and vice versa for low-PCI products.

Although this paper primarily focuses on the measures proposed by Hausmann et al. (2014), we note that alternative measures for capturing the "complexity" or "fitness" of countries' productive capabilities have also been proposed by Tacchella et al. (2012). These measures are calculated as the fixed-point solution of a non-linear mapping function, which instead exploits the pattern of export diversity (the number of products a country is able to export competitively). Tacchella et al.'s (2012) Country Fitness measure (an alternative to the ECI) can be thought of as a weighted-diversity measure, where each product that a country exports competitively is weighted by its estimated "complexity". Tacchella et al.'s (2012) corresponding Product Complexity measure is a non-linear function that is inversely related to the number of countries that can export a given product competitively.

2.2 Relatedness and diversification

The tendency for countries and regions to diversify into economic activities that involve related production capabilities to activities they already specialize in has received significant attention in the economic geography literature (see Hidalgo et al. (2018) for an overview). The underlying intuition is that if a country or region has the capabilities to produce shirts, it is relatively easy for it to diversify into the production of trousers because many of the requisite production capabilities (such as sewing techniques, factory layout, textile supply chains, clothing designs) are similar. However, it is more difficult for that country or region to diversify directly from producing shirts to trucks because it would need to acquire a large amount of new production know-how and invest in completely new factors of production (Hausmann et al., 2014).

Evidence to support this "stickiness" in the knowledge accumulation process has been documented using a range of different data sources for a variety of activities. For example, Hidalgo et al. (2007) measured the relatedness between exported products by examining their probability of being co-exported and found this measure to be significantly predictive of future export diversification. Boschma et al. (2013) applied a similar approach to investigate regional diversification in Spain. Alternative strategies have measured relatedness by studying the flow of workers between industries (Neffke and Henning, 2013; O'Clery et al., 2016; Neffke et al., 2017) and firms (Guerrero and Axtell, 2013), or by looking at the strength of input-output linkages across industries (Essletzbichler, 2015). Research has also investigated relatedness underpinning different technologies by investigating patent citations (Leten et al., 2007; Rigby, 2015) and the co-classification of patents across technology classes (Kogler et al., 2013, 2017).

In addition to complementing the broader literature on the path-dependent nature of economic development (David, 1985; Arthur, 1989; Krugman, 1991a,b,c; Matsuyama, 1991; Arthur, 1994; David, 1994; Aghion et al., 2014, 2016), efforts to measure and understand related diversification has also provided policymakers with new frameworks to analyze industrial development policies (Boschma and Gianelle, 2014; Thissen et al., 2013; Balland et al., 2018). But despite calls from policymakers and development agencies to find greener development strategies (e.g. Lin and Xu (2014); Hamdok (2015); Brahmbhatt et al. (2017); Newfarmer et al. (2018)), there has been relatively limited efforts to apply notions of relatedness to better navigate the transition to the green economy.

2.3 Applications of economic complexity to the green economy

Although limited data and the lack of a universally accepted definition of environmental goods and services has hampered efforts to study the transition to the green economy from an economic complexity perspective, some recent work has made fruitful progress in this direction. In particular, Fankhauser et al. (2013) investigated countries' "green competitiveness" by drawing on data on sectoral patenting rates, exports, and industry output. However, due to data limitations, this work only examined 8 countries in 110 manufacturing sectors. Inspired by the methodological approaches underpinning the Product Space (Hidalgo et al., 2007), Hamwey et al. (2013) identified 11 green products in the Product Space focusing on the case of Brazil. Huberty and Zachmann (2011) looked at the position of 6 green products in the Product Space (relating to electric meters, solar cells, wind turbines, and nuclear reactors) to analyze the effectiveness of green industrial policies in the context of European countries. Fraccascia et al. (2018) analysed 41 green products in 141 countries and showed that green products with the highest growth potential tend to be products that are the most related to countries' existing export structures.

3 Data and Methods

3.1 Green trade data

To construct the dataset of green products used in this paper, we draw on existing lists and classifications developed by the World Trade Organization (WTO, 2010, 2011), the Organisation for Economic Cooperation and Development (OECD, 1999; Sauvage, 2014), and the Asia-Pacific Economic Cooperation (APEC, 2012) (see Table 7 in Appendix A.1). We combine all available lists to construct a dataset totalling 543 products classified at the 6-digit level in HS1992. We then combine this dataset with COMTRADE data to analyse environmental trade across countries for the period 1995-2014.

While our dataset of 543 products represents a useful benchmark of *potentially* green products, the environmental status of a number of products included the broad-reaching WTO Reference List may be questionable.[3] In order to arrive at a robust set of green products that share wide expert endorsement—and are useful to policymakers—we develop two main product lists. The first is a list of 293 green products, which we obtain by taking the union of the WTO Core list, OECD list, and the APEC list.[4] This refined list of green products has the advantage that each product has either been endorsed by a large number of WTO or APEC member countries, or its environmental benefits have been determined by the (rather selective) OECD. This list represents a range of environmental categories, such as air pollution, waste water management, and recycling. We use this green product list for our empirical analysis throughout the paper.

We also develop a smaller list of 57 renewable energy products (a subset of the products on the green product list). This list includes all products falling under the WTO Renewable Energy Products category, under the OECD's Renewable Energy Plant categories, as well as two additional APEC renewable energy products (solar heliostats and parts for solar heliostats) that were not included on either the

[3] For example 848210 (ball bearings) submitted by Saudi Arabia with the rationale that they are used in carbon capture and storage applications.

[4] While the original set of green products included 295 goods, we had to remove Profile Projectors (903110) and Exposure meters (902740) due to data quality issues.

WTO or OECD lists. The renewable energy product list focuses on low-carbon technologies that are key for addressing climate change. More information about the green product data can be found in Appendix A.1 and A.2. All our data are available upon request.

3.2 Economic Complexity Index and Product Complexity Index

We first calculate the ECI and PCI for COMTRADE export data. Here, we follow the approach set out in Hausmann et al. (2014) and define a binary country-product matrix M, with elements M_{cp} indexed by country c and product p. $M_{cp} = 1$ if country c has a *'revealed comparative advantage'* (RCA) > 1 in product p and 0 otherwise. RCA is calculated using the Balassa (1965) index

$$RCA_{cp} = \frac{x_{cp}/\sum_p x_{cp}}{\sum_c x_{cp}/\sum_c \sum_p x_{cp}}, \tag{1}$$

where x_{cp} is country c's exports of product p.

We can calculate how many products a country has RCA in (its *diversity*) by summing across the rows of the M matrix (denoted d_c). Similarly, we can count how many countries have RCA in a given product (its *ubiquity*) by summing aross the columns of the M matrix (denoted u_p). That is,

$$d_c = \sum_p M_{cp} \tag{2}$$

and

$$u_p = \sum_c M_{cp}. \tag{3}$$

The ECI is defined as the eigenvector associated with the second largest eigenvalue of the matrix

$$\widetilde{M} = D^{-1}S, \tag{4}$$

where D is the diagonal matrix formed from the diversity vector, and S is a matrix whose rows and columns correspond to countries and whose entries are given by

$$S_{cc'} = \sum_{p} \frac{M_{cp} M_{c'p}}{u_p}. \tag{5}$$

S is a symmetric similarity matrix, which corresponds to how similar two countries' exports baskets are.

The associated PCI measure is symmetrically defined as the eigenvector associated with the second largest eigenvalue of the transpose of the $\widetilde{M}$ matrix.

3.3 Green Complexity Index

Our *Green Complexity Index* (GCI) draws on the PCI measure described above. It aims to capture the extent to which countries can competitively export a diverse range of technologically sophisticated green products and is given by

$$GCI_c = \sum_{g} \rho_g \widetilde{PCI_g}. \tag{6}$$

Here ρ_g is a binary vector in which a 1 corresponds to a country having $RCA > 1$ in green product g and 0 otherwise, and $\widetilde{PCI_g}$ is the Product Complexity Index of g normalized to take a value between 0 and 1.

It is important to emphasize how a country's GCI differs from its ECI. While the ECI represents the average PCI of all products a country is competitive in, the GCI sums up the PCI of green products a country is competitive in. Note that while we have applied the GCI to a specific subset of green traded products, the measure is completely general and can be applied to any subset of products (such as biotech).

3.4 Product proximity and Product density

In order to estimate how related two products are in terms of their underpinning production capabilities, we draw on Hidalgo et al.'s (2007) measure of product *proximity* (denoted ϕ_{ij}), which is increasing in the likelihood that two products i and j are exported by the same country.

$$\phi_{ij} = \min(\mathbb{P}(RCA_i > 1|RCA_j > 1), \mathbb{P}(RCA_j > 1|RCA_i > 1)). \tag{7}$$

Here, $\mathbb{P}(RCA_i > 1|RCA_j > 1)$ is the conditional probability that a country is competitive in product i given that it is competitive in product j. Following Hidalgo et al. (2007), we take the minimum to ensure that $\phi_{ij} = \phi_{ji}$.

To estimate how related a given product is to a country's current set of production capabilities, we employ a second measure introduced in Hidalgo et al. (2007) known as *density*. This measure (denoted ω_j^c) calculates the average proximity between a given product j and all the products country c can currently export competitively and is given by

$$\omega_j^c = \frac{\sum_i \rho_i \phi_{ij}}{\sum_i \phi_{ij}}, \tag{8}$$

where ρ_i is a vector of i products for which country c has $RCA > 1$.

3.5 Green Complexity Potential

Finally, we introduce a measure we call *Green Complexity Potential* (GCP). This measure operates on green products that countries are *not* presently competitive in, and, as the name suggests, aims to estimate how much "potential" countries have to diversify into green, technologically sophisticated products in the future. The GCP for country c is given by

$$GCP_c = \frac{1}{|1-\rho_g|} \sum (1-\rho_g)\omega_g^c \widetilde{PCI}_g, \tag{9}$$

where $1 - \rho_g$ is the vector of green products a country currently does not have RCA > 1 in, ω_g^c is the proximity of product g to country c, and $\widetilde{PCI}_g$ is the PCI of product g, normalized to take a value between 0 and 1. GCP is similar to the *Complexity Outlook Index* (Hausmann et al., 2014) and the *Complexity Potential* measure (O'Clery et al., 2016). However, while these measures are applied to the entire set of traded products (Hausmann et al., 2014) or industries (O'Clery et al., 2016), the GCP is specific to the subset of green products.

4 Results

4.1 Trade in green and renewable products

Before turning to our results on green production capabilities, we first look at the total volume of trade green and renewable products represent and how this has changed over time. As shown in Panel A of Figure 1, green and renewable energy products have exhibited steady growth in trade volumes, particularly over the 2000—2011 period, with a levelling off in later years. As of 2014, total trade in green products was around \$1.5 trillion, while trade in renewable products was around \$0.5 trillion.

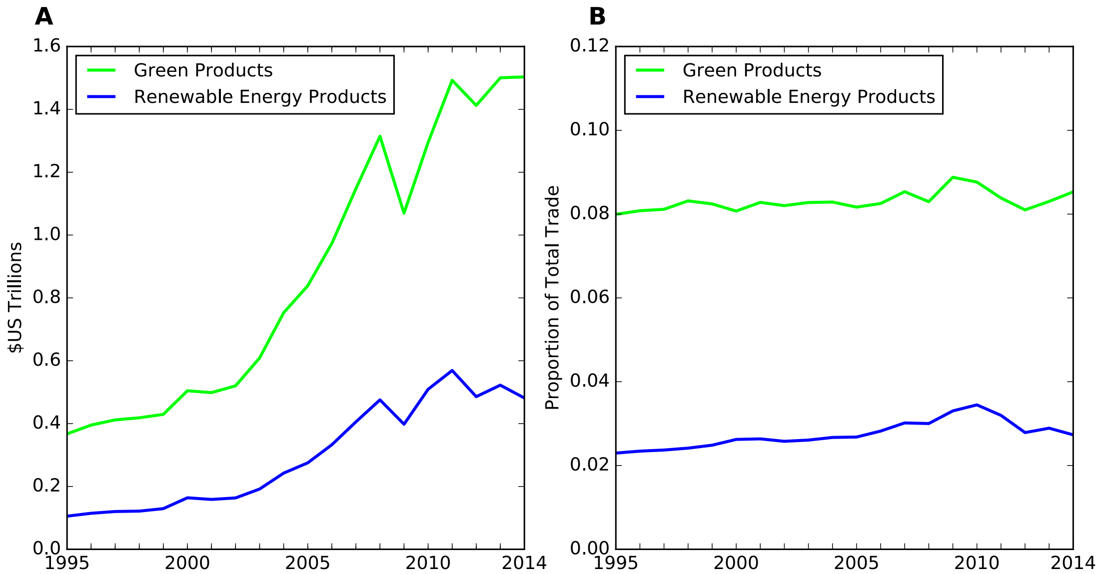

Figure 1: Growth in Green and Renewable Energy Products

Interestingly, Panel B shows that when we examine the evolution of trade in green and renewable products as a proportion of total trade, the trajectory has been relatively flat. Over the 20 year period, green products has accounted for around 8.5% of global trade, while renewable energy products has fluctuated around 3%. In Appendix A.3, we present some further results showing the top exporters of green and renewable products (in terms of trade volumes).

4.2 PCI of green and renewable products

In Table 1 and 2 we present the top 10 and bottom 10 green products ranked according to their PCI values for the year 2014. We also include the environmental benefit or category associated with each product. Similar tables for renewable energy products in are presented in Appendix A.4. Green products with the highest PCI values relate to devices used for environmental monitoring and analysis, and concentrated solar technologies, green products with the lowest PCI values tend to relate to environmentally friendly products – many of which are made from vegetable material.

Table 1: Top 10 Green Products by PCI

Rank	PCI	HS6 Code	Product Description	Environmental Benefits
1	2.5073	901380	Optical devices, appliances and instruments, nes	Solar Heliostats (Heliostats orient mirrors in concentrated solar power systems to reflect sunlight on to a CSP receiver)
2	2.0716	902790	Microtomes, parts of scientific analysis equipment	Microtomes are devices that prepare slices of samples for analysis - used in environmental monitoring
3	2.0134	847989	Machines and mechanical appliances, nes	Machines and appliances designed for a wide range of areas of environmental management including waste, waste water, drinking water production and soil remediation
4	1.8805	902730	Spectrometers, spectrophotometers, etc using light	Used in a wide range of environmental applications, including identification of unknown chemicals, toxins and trace contaminants, environmental control, water management, food processing, agriculture and weather monitoring
5	1.8625	902780	Equipment for physical or chemical analysis, nes	Used to measure, record, analyse and assess environmental samples or environmental influences
6	1.8291	680690	Mineral heat or sound insulating materials and articles	Used for heat and energy management
7	1.8119	902720	Chromatographs, electrophoresis instruments	Used to monitor and analyse air pollution emissions, ambient air quality, water quality, etc.
8	1.8077	902710	Gas/smoke analysis apparatus	Used for monitoring and analysing environmental pollution.
9	1.7945	847990	Parts of machines and mechanical appliances nes	Parts for environmental management devices (Machines and appliances designed for a wide range of areas of environmental management including waste, waste water, drinking water production and soil remediation)
10	1.7795	848360	Clutches, shaft couplings, universal joints	Used for initial assembly, repair, and maintenance of wind energy systems

Table 2: Bottom 10 Green Products by PCI

Rank	PCI	HS6 Code	Product Description	Environmental Benefits
284	−1.2445	871200	Bicycles, other cycles, not motorized	Cleaner or more resource efficient technology or product
285	−1.2826	871411	Motorcycle Saddles	Cleaner or more resource efficient technology or product
286	−1.2935	220710	Undenatured ethyl alcohol > 80% by volume	Renewable Energy Plant
287	−1.4189	560790	Twine, cordage, ropes and cables, of other materials	Environmentally preferrable product
288	−1.5074	960310	Brooms/brushes of vegetable material	Waste collection equipment (solid waste management)
289	−1.6088	560721	Binder or baler twine, of sisal or agave	Environmentally preferrable product
290	−1.864	460120	Mats, matting and screens, vegetable plaiting material	Environmentally preferrable product
291	−2.1905	530599	Vegetable fibre nes, processed not spun, tow and waste	Environmentally preferrable product
292	−2.2365	630510	Sacks and bags, packing, of jute or other bast fibres	Environmentally preferrable product
293	−2.9908	530310	Jute and other textile bast fibres, raw or processed but not spun	Environmentally preferrable product

In Table 3, we show key descriptive statistics for the PCI of all HS6 products, green products, and renewable energy products. Following Hausmann et al. (2014), we have normalized the PCI values so that that the set of all HS1992 6 digit products have a mean of 0 and standard deviation of 1.

Table 3: Product PCI distribution descriptive statistics

Product Set	Number of Products	Mean PCI	Std PCI
All HS6 Products	4857	0	1
Green Products	293	0.48	0.79
Renewable Energy Products	57	0.49	0.72

We find that green and renewable energy products have higher PCI values than average. Green products have a mean PCI of 0.48, while renewable energy products have a mean PCI of 0.49. In Figure 2, we also show the distribution of PCI values of green and renewable energy products and compare them to the distribution of all traded products. To the extent that the PCI is an appropriate proxy for measuring the technological sophistication of products, our results suggest that green and renewable energy products, on average require more technologically advanced know-how than typical products.[5]

[5] The Kolmogorov-Smirnov 2-sample tests reject the null hypothesis that green product PCI distributions are different from all product PCI distributions (KS-Statistic for green products vs all products = 0.242, p-value = 1.11×10^{-14}). The Kolmogorov-Smirnov 2-sample test fails to reject the null hypothesis that the green and renewable energy products are drawn from the same distribution (KS-Statistic = 0.096, p-value = 0.747)

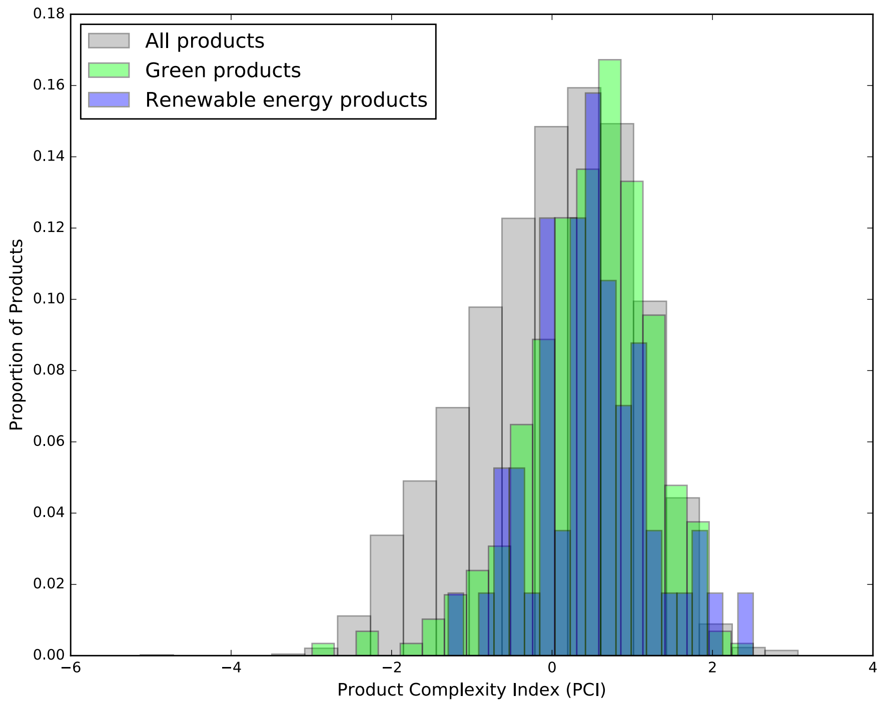

Figure 2: PCI distribution for all HS6 products, green products and renewable energy products

4.3 Green Complexity Index across countries and time

We now turn to the question of which countries have the most technologically advanced, green production capabilities. Figure 3 presents the GCI ranks across countries over the period 1995 (left axis) and 2014 (right axis). In 2014, Germany held the top rank, followed by Italy, the United States, Austria, and Denmark. The bottom ranks included countries such as Turkmenistan, Mauritania, Angola, and Azerbaijan. Looking at how ranks have changed over the 20 year period, Germany has impressively maintained its top position throughout. Some countries, such as China, Vietnam and Uganda have made significant gains in their green production capabilities, while other countries, such as Australia, have seen a substantial decline in their GCI rankings.

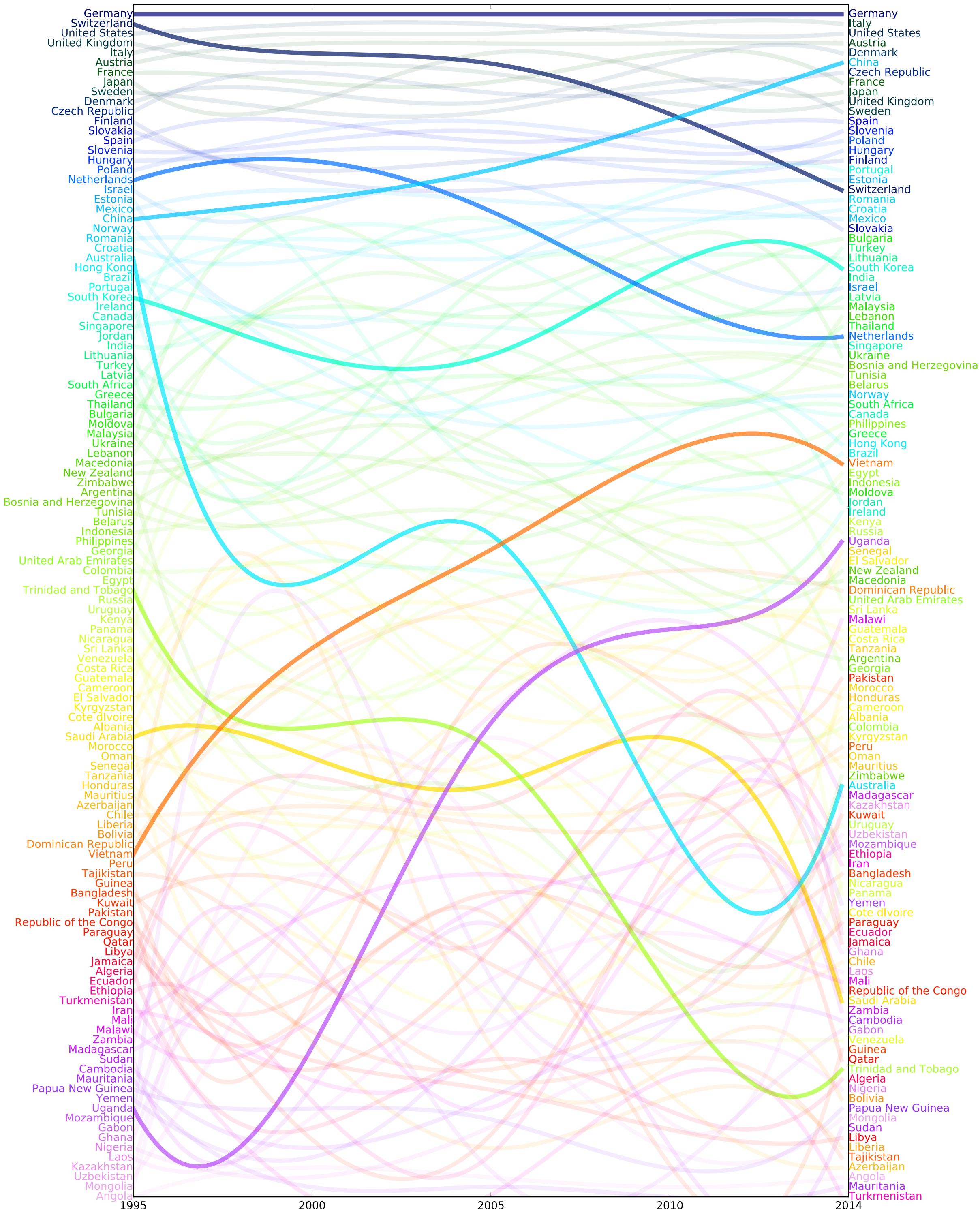

Figure 3: Green Complexity Index rankings over time

In Figure 4, we compare countries' GCI to their ECI. Panel A shows a positive correlation between the GCI and ECI values[6], while Panel B shows the relationship between country rankings.[7] The positive correlations are unsurprising given that richer countries tend to have higher ECI scores and green products tend to have higher PCI on average.[8] However, the deviations in the ranks and values of the ECI and GCI are informative about the differences in the orientation of countries' export baskets. For example, countries that are heavily focused on exporting oil and petroleum products, such as Saudi Arabia, Trinidad and Tobago, and Qatar, have lower GCI compared to their ECI. In contrast, Tunisia, China, and Italy have much higher GCI scores relative to their ECI, suggesting that their production capabilities may be more aligned to green products. It may also suggest that if a green transition substantially increased demand for green goods, these countries could stand to benefit, relative to other countries having similar ECI values.

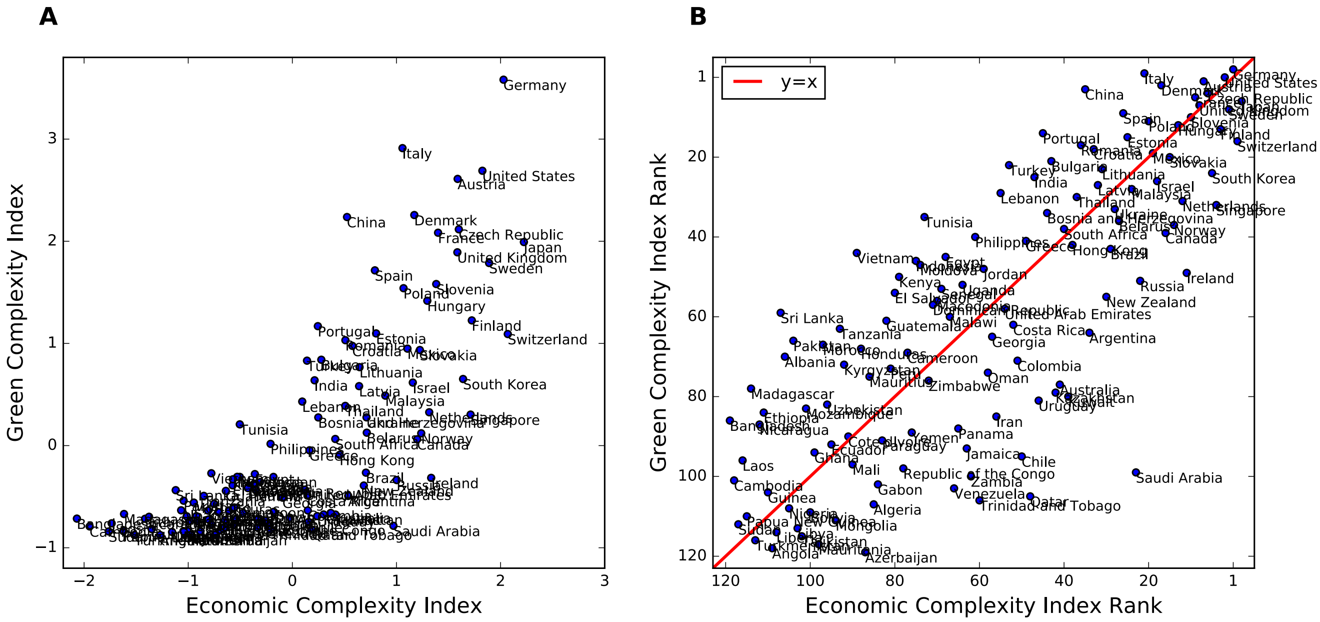

Figure 4: GCI and ECI comparisons for 2014

[6]Pearson correlation coefficient $= 0.766$, p-value$= 0.5 \times 10^{-25}$.

[7]Spearman's rank correlation coefficient $= 0.79$, p-value$= 5.2 \times 10^{-27}$.

[8]The correlation between the ECI and GCI has remained relatively stable over the 1995-2014 period. These results are available upon request.

In Figure 5, we show the relationship between the GCI and log GDP/capita for 2014. Again, the positive relationship is not surprising[9], but the variance in the relationship provides additional insights into the current orientation of countries' economies. Consistent with Figure 4, a number of resource-rich countries have low GCI scores given their income. Germany, Italy, China, and India stand out as having much higher GCI scores given their income per capita, suggesting that their production capabilities are more oriented to the green economy than other countries with a similar standard of living.

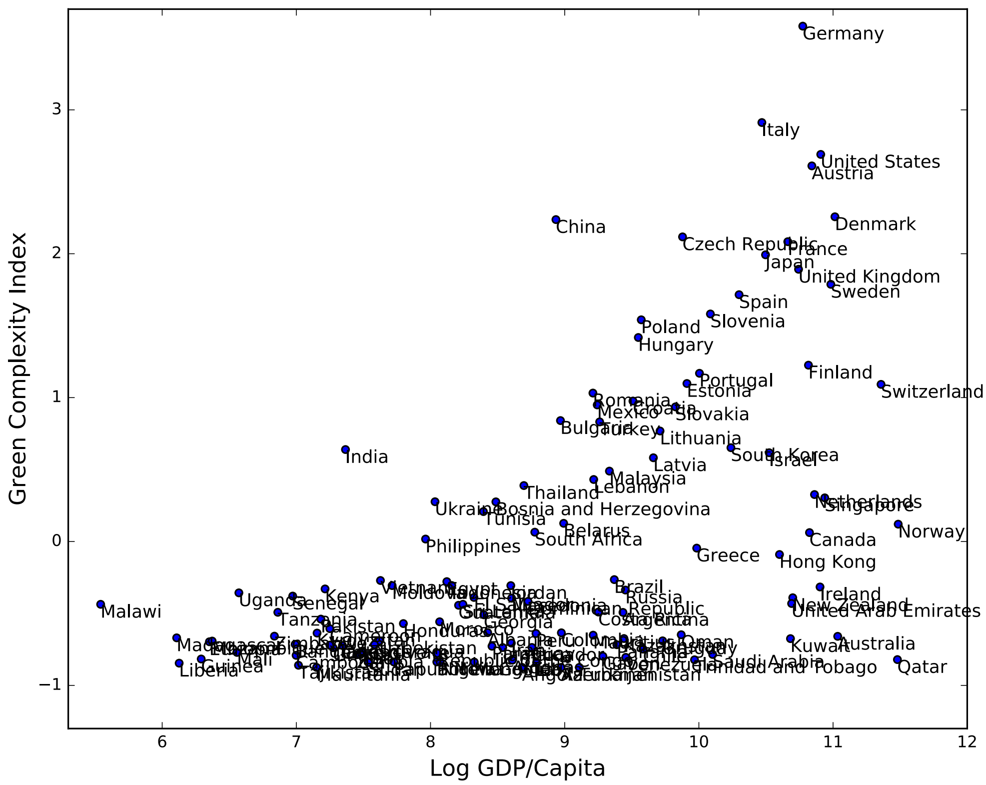

Figure 5: GCI vs log GDP per capita for 2014

Finally, to provide some validation that the GCI is a useful estimate of green production capabilities, we also examine the extent to which it can explain variation in environmentally relevant country characteristics. Specifically, we look at the relationship between the GCI and countries' environmental patenting rates,

[9] Pearson's correlation coefficient $= 0.55$, p-value $= 7.52 \times 10^{-11}$.

CO_2/capita emissions, and the OECD's measure of environmental policy stringency (EPS).

Since the GCI and ECI can fluctuate year on year due to variability in trade data, we use simple regressions on time-averaged explanatory variables as follows:

$$\bar{y}_i = \bar{x}_i \beta + \epsilon_i$$

where $y_i \in$ {Log Env. Patents, CO_2/capita, Log EPS}, $\bar{y}_i = \frac{1}{N}\sum_{t=t_0}^{t=t_N} y_{it}$, $\bar{x}_i = \frac{1}{N}\sum_{t=t_0}^{t=T_N} x_{it}$ are time-averaged explanatory variables for N available periods, and ϵ_i is the error term.

Table 4 shows the GCI's ability to explain variation in environmentally relevant variables over the twenty year period covered by our data. We find that the GCI is strongly positively correlated with the number of environmental patents across countries, even after controlling for their GDP/capita and ECI. We also find that countries with higher GCI tend to have lower CO_2 emissions. This relationship is particularly interesting, given our dataset does not account for the emissions intensity of each product's production process. Additionally, we find a positive relationship between the GCI and the OECD's Environmental Policy Stringency Index, suggesting there is some association between the environmental policies in place in a country and its green production capabilities. While the results in Table 4 reflect GCI's explanatory power over the long run, we also run regressions for different years in Appendix A.7 and find consistent results.[10]

[10] We have also compared the GCI calculated using the Hausmann et al. (2014) PCI and Tacchella et al. (2012)'s Product Complexity measure. As shown in Appendix A.8, both formulations give very similar results, suggesting that the GCI is robust to the choice of product complexity measure. It is also important to note that for this particular set of traded products, the complexity scores are fairly homogenous (see Figure 2), particularly when normalized to take a value between 0 and 1. As such, the GCI score is very strongly correlated to a country's green diversity (the number of green products it is competitive in). However, this will not necessarily be the case for different product subsets, where there is greater variation in product complexity.

Table 4: Green Complexity Index

	Log Env. Patents	Log CO_2/cap	Log EPS
GCI	1.009***	−0.307***	0.100***
	(0.215)	(0.102)	(0.029)
ECI	1.158***	0.290*	−0.115**
	(0.286)	(0.157)	(0.053)
Log GDP/Cap	0.116	0.850***	0.213***
	(0.128)	(0.086)	(0.034)
Intercept	1.593	−6.196***	−1.093***
	(1.125)	(0.734)	(0.315)
Observations	1220	2318	558
Adjusted R^2	0.766	0.765	0.7532

Robust standard errors in parenthesis.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Environmental patents data covers 2000 and 2005-2013, available from http://stats.oecd.org/. CO_2 (metric tons per capita) data covers 1995-2013, available from https://data.worldbank.org/indicator/EN.ATM.CO2E.PC. Environmental Policy Stringency (EPS) data covers 1995-2012, available from http://stats.oecd.org/. For all regressions, we take country averages over all available time periods.

4.4 Green Adjacent Possible

While the GCI gives us an idea of which countries are currently competitive in green products and technologies, successfully transitioning to the green economy will no doubt require many countries to reorientate their existing productive structure and cultivate new green industries. Naturally, it would be helpful if countries could identify green diversification opportunities that were relatively proximate to their existing production capabilities, as this would allow them to take advantage of skills, infrastructure and know-how that they already possess. To this end, we introduce the *Green Adjacent Possible* (GAP), which aims to identify the most proximate green diversification opportunities for each country.

In Figure 6, we illustrate the GAP for four countries with contrasting production structures. In each panel, dots represent green products that countries do not currently export competitively. The x-axis plots the density value for each green product, which estimates how related that product is to the country's current capabilities. The y-axis measures each product's PCI. We also label some of the most proximate diversification opportunities for each country.

A number of things are interesting to note. As we would expect, Saudi Arabia is much less proximate to the set of green products because its productive know-how is more closely focused on extracting fossil fuel resources. Uganda is less proximate to green products with higher PCI because it is a developing country with less advanced technological capabilities. However, Uganda could potentially build on its agricultural base to diversify into green products made from vegetable materials, such as screens and matting materials, which are used to prevent soil erosion. In contrast, Germany's advanced manufacturing base and significant existing expertise in green products is reflected in its greater positive slope and high proximity to high-PCI green products, such as optical devices (used in concentrated solar). South Korea also has a slight positive slope, suggesting that its productive capabilities are more oriented towards higher PCI green products such as transmission shafts and static converters. In Appendix A.6, we construct the Green Product Space (a network where green product nodes are linked to each other on the basis of their relatedness) to provide further visualisations of the same four countries' green production capabilities.

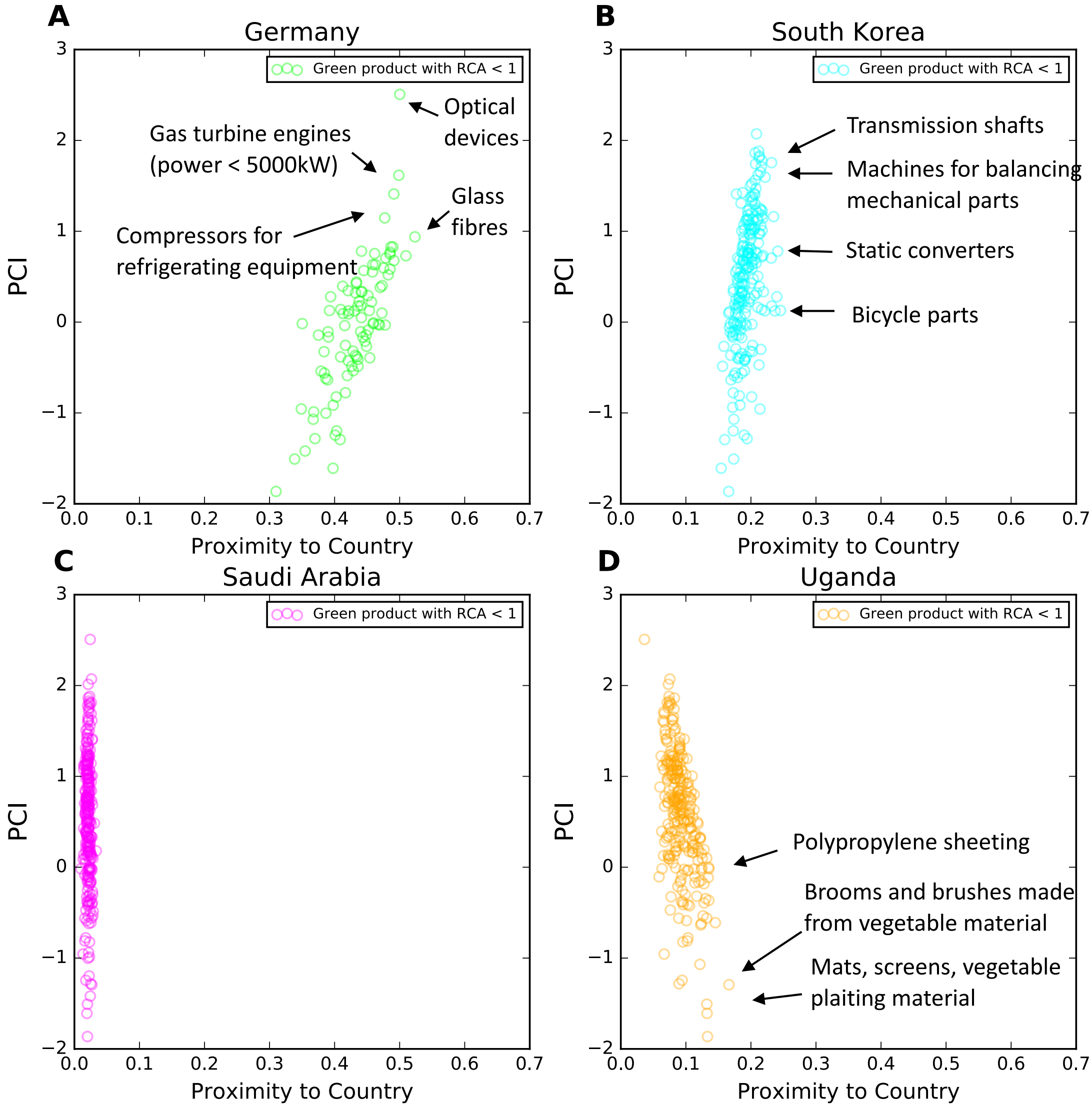

Figure 6: Illustrating the Green Adjacent Possible for different countries.
In each plot, the circles represent green products that the denoted country is not competitive in. The y-axis plots the PCI of each product and the x-axis plots that product's density to a country.

4.5 Green Complexity Potential

Recall that the Green Complexity Potential (GCP) measures each country's average relatedness to green complex products it is not currently competitive in. Hence, the GCP summarizes each country's GAP into a single number and allows us to compare countries in terms of their overall potential to diversify into green, technologically sophisticated products.

In Table 5, we explore how predictive a country's GCP is for future increases in its green capabilities (as measured by the GCI), the number of green products it is able to export competitively, and the share of green exports in its total export basket. Specifically, we regress the countries' GCP at the beginning of the period (averaged over 1995—2000) on the change in countries' GCI, number of competitively exported green products and green export trade ratio at the end of the period (averaged over 2009—2014) i.e.

$$\Delta \bar{y}_i = \bar{x}_i \beta + \epsilon_i$$

where $y_i \in \{\text{GCI, \#Green exported products, Green exports}\}$, $\Delta \bar{y}_i = \frac{1}{5}\sum_{t=2009}^{t=2014} y_{it} - \frac{1}{5}\sum_{t=1995}^{t=2000} y_{it}$, $\bar{x}_i = \frac{1}{5}\sum_{t=1995}^{t=2000} x_{it}$ are explanatory variables averaged at the beginning of the sample, and ϵ_i is the error term. This specification is similar to the approach taken by O'Clery et al. (2016). However, to ensure our results are robust to year-on-year trade data fluctuations, we take 5-year averages.

Controlling for countries' current incomes and ECI, we find that countries with higher GCP scores are more likely to have greater future increases in their GCI, green export trade ratio, and number of green products they are able to export competitively. In Appendix A.7, we show that the predictive power of the GCP is robust to different time-averaging specifications.

Table 5: Green Complexity Potential

	Δ GCI $(t+\delta)$	Δ #Green exported products $(t+\delta)$	Δ Green export trade ratio $(t+\delta)$
Log GCP(t)	0.172***	7.118***	0.012***
	(0.038)	(1.678)	(0.003)
Log GDP/Cap(t)	−0.005	−0.448	0.001
	(0.024)	(1.135)	(0.002)
ECI(t)	−0.143**	−7.450***	−0.006*
	(0.043)	(2.112)	(0.004)
GCI(t)	−0.060		
	(0.051)		
Green exported products(t)		0.084	
		(0.057)	
Green export trade ratio(t)			−0.075
			(0.158)
Intercept	0.577**	29.715***	0.039**
	(0.245)	(11.110)	(0.016)
Observations	1220	1220	1220
Adjusted R^2	0.203	0.212	0.169

Robust standard errors in parenthesis.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
t relates to country averaged values over years 1995-2000 and $t + \delta$ relates to country averaged values over years 2009-2014. #Green exported products refers to the number of green exports in which the country has $RCA > 1$ (i.e. diversity).

Figure 7 shows the relationship between the GCP and GCI for 2014. Panel A shows the relationship between the GCP and GCI values, while Panel B shows the relationship between the GCP and GCI ranks. In both cases, we find a strong correlation which indicates that the more green production capabilities a country has, the easier it is to diversify into additional new green products.[11]

[11] Panel A: Pearson correlation coefficient = 0.921, p-value= 3.49×10^{-51}, Panel B: Spearman correlation coefficient = 0.951, p-value= 2.11×10^{-63}.

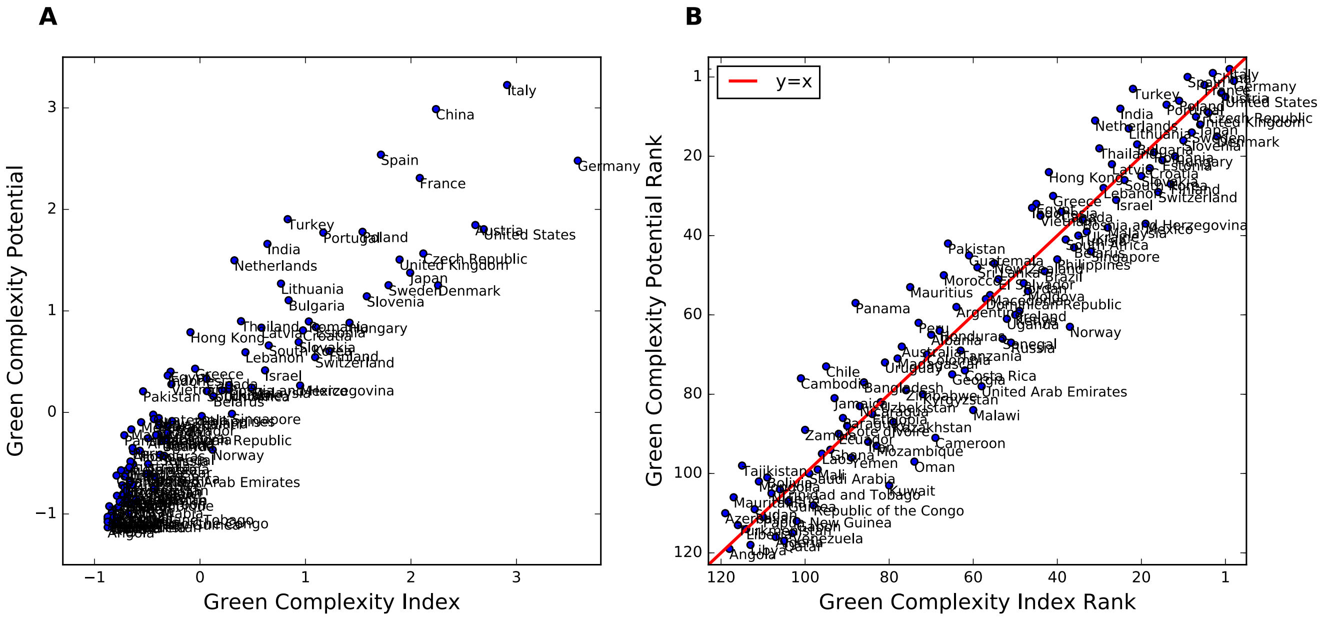

Figure 7: GCP and GCI comparison for 2014

However, the differences between the GCI and GCP provide additional information about future growth: countries including China, Spain, Turkey, India and the Netherlands have significantly higher GCP than GCI, suggesting that these countries may be particularly well-positioned for fast development of future green capabilities. In contrast, while countries such as the US, Japan, and Denmark currently have very strong green production capabilities, their lower GCP scores indicate that future expansion into new green product markets could be relatively slower.

4.6 Green stimulus packages and green production capabilities

Finally we turn to the question of whether direct government intervention can influence green production capabilities. Here, we present some preliminary evidence to suggest that policy can make a difference. We analyse data on green stimulus packages in 19 countries over the early years of the global financial crisis (Barbier et al., 2010). Many countries embarked on stimulus programmes to boost their weak economies and green spending formed a significant part of the stimulus. As shown in Table 6, even after controlling for GDP per capita, the size of the stimulus packages is positively associated with increases in (i) the GCI, (ii) the number of green exports that the country is competitive in, and (iii) the ratio of green exports to total exports between 2008 and 2011 (this holds both for stimulus and stimulus per capita, see Appendix A.7).

Table 6: Green Stimulus Analysis

	Δ GCI $(t+\delta)$	Δ #Green exported products $(t+\delta)$	Δ Green export trade ratio $(t+\delta)$
Green Stimulus	0.970***	41.565***	0.027*
	(0.205)	(9.699)	(0.015)
Log GDP/Cap(t)	0.000**	0.000**	0.0000
	(0.000)	(0.000)	(0.0000)
GCI(t)	0.054*		
	(0.027)		
#Green exported products(t)		0.076**	
		(0.029)	
Green export trade ratio(t)			0.082*
			(0.043)
Intercept	0.056	−0.337	−0.007*
	(0.047)	(2.204)	(0.003)
Observations	19	19	19
Adjusted R^2	0.495	0.495	0.265

Robust standard errors in parenthesis.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
t relates to the year 2008 and $(t + \delta)$ relates to the year 2011.
Green Stimulus units are US '000 per capita. Green Stimulus data are from Table 1 of Barbier et al. (2010), and relates to low carbon support for renewable energy, carbon capture and sequestration, energy efficiency, public transport and rail, and improving electrical grid transmission. #Green exported products refers to the number of green exports in which the country has $RCA > 1$ (i.e. diversity).

5 Discussion and conclusion

This paper has advanced a novel, data-driven approach to analyse green production capabilities across countries. Our results have a number of policy implications.

First, we are able to identify and measure trade in a much more extensive set of green products by drawing on a number of international agreements and independent policy sources. Our dataset is therefore a robust, consensus-driven definition of green products that can be used in research and policy. Our results in section 4.1 highlight that green and renewable products have not grown as a fraction of total trade in the last twenty years. Given the urgency of the transition towards a green economy, agreements to advantage trade in these products might play an important role. The reason is that, as we show in this paper, many green and renewable energy products have high PCI values and could consequently be difficult—at least in the short run—for less technologically advanced countries to export competitively.

Second, we estimate which countries are currently best positioned to thrive in the green economy thereby shedding light on an increasingly important question for policymakers. We also show how our estimates of countries' green capabilities have evolved over time. A country that finds itself sliding down the GCI or GCP ranking may want to strengthen policies aimed at increasing its green capabilities. Our work not only complements many recent papers on this topic (Huberty and Zachmann, 2011; Hamwey et al., 2013; Fankhauser et al., 2013; Fraccascia et al., 2018), but also provides a more extensive coverage of countries and green products. Moreover, our novel GCI and GCP measures demonstrate how analytical methods from economic complexity can be gainfully employed to understand possible pathways towards a green economy.

Third, our results show that green diversification is path-dependent. The strong positive correlation between the GCI and GCP suggests that early success in gaining green capabilities better enables countries to develop more green capabilities in the future. Additionally, countries with production capabilities too narrowly focused on resource extraction activities may find that their green production capabilities are underdeveloped and their competitive advantage is less aligned with the direction of the future green economy.

The path dependence in green capability accumulation tentatively indicates a role for industrial policy (see, for example, Aghion et al., 2011; Hallegatte et al., 2013; Rodrik, 2014). Our results do not pin down a specific and advantageous green industrial policy. However, by identifying the GAP, we can provide concrete indications of where the next competitive green opportunities for each country are likely to be. But whether a transition to these technologies requires interventionist industrial policy or regulatory reform needs to be decided on a case-by-case basis. Our green stimulus results only provide some indication that government policy can have an effect on green capabilities. It is also important to stress that the GCI, GCP, and GAP only reflect the particular orientation of countries' current export baskets and do not account for domestic or service-based green production capabilities that may exist within these countries. Green industrial policy should ideally take all green capabilities and all relevant domestic policy objectives and constraints into account.

There are plenty of fruitful areas for further work. First, we have only considered capabilities based on export data. While the GCI and GCP explain variation in environmentally relevant measures across countries, we do not account for capabilities embodied only in services (Stojkoski et al., 2016; OECD, 2017) or in goods sold only domestically. Second, we do not account for occupation-specific skills relevant for new green economy products (Neffke and Henning, 2013). Third, we do not look at regional or city-level variation (Boschma et al., 2013; O'Clery et al., 2016). Fourth, we have not considered channels for green technology diffusion across neighbouring countries (Bahar et al., 2014). Fifth, we have not explored regional green industrial policy or regional specialisation (e.g. Pearl River Delta, Silicon Valley); government policy and research might want to focus directly on the competitiveness of regional production clusters (Delgado et al., 2014). Finally, it would be worth understanding what roles services, skills, and regional specialisation play in a more expanded definition of the green economy by looking closely at green patents, green research and development, carbon emissions, and environmental protection.

A Appendix

A.1 Description of the data sources

Table 7: Green Product Data Sources

List	Description	Source
WTO Reference Universe	408 products that represent a universe of potentially green products proposed by different WTO Member States	• WTO Report by the Chairman to the Trade Negotiations Committee on the Committee and Trade and Environment in Special Session TN/TE/19 (22 March 2010) • WTO Report by the Chairman to the Trade Negotiations Committee on the Committee and Trade and Environment in Special Session TN/TE/20 (21 April 2011)
WTO Sample Core List	26 products with wide endorsement from WTO Member States	• WTO Report by the Chairman to the Trade Negotiations Committee on the Committee and Trade and Environment in Special Session TN/TE/20 (21 April 2011)
APEC List of Environmental Goods	54 green products for which APEC Member states agreed to reduce applied tariff rates to 5% or less by the end of 2015	• 2012 APEC Leaders Declaration Annex C
OECD (1999) Illustrative Product List of Environmental Goods	List of 121 illustrative environmental products developed by the OECD/Eurostat Informal Working Group	• OECD (1999), "Future Liberalisation of Trade in Environmental Goods and Services: Ensuring Environmental Protection as well as Economic Benefits" • A Comparison of the APEC and OECD Lists", *OECD Trade and Environment Working Paper No. 2005-04* Table A1.
List of 257 customized products developed by the OECD	List of 257 customized products developed by the OECD	• Sauvage (2014), "The Stringency of Environmental Regulations and Trade in Environmental Goods", *OECD Trade and Environment Working Papers*, 2014/03

A.2 Data advantages and limitations

The green product classifications we use to construct our two product lists offer a number of advantages. First, for each proposed product in the WTO and OECD lists, it is possible to identify one (or more) environmental category that the product falls under. Although the WTO and OECD differ in the structure of their environmental categories, they are still broadly consistent and helpful for identifying a product's environmental purpose (such as renewable energy, waste water management, energy efficiency etc.) Second, the APEC and WTO lists also include specific information about each product's environmental benefits. This information was provided by member countries of the respective organisations as rationale for a proposed product's environmental endorsement. Thirdly, the APEC and WTO lists also indicate the set of member countries endorsing a given product as green. This information is useful for helping gauge the level of consensus associated with each product's environmental status.

A number of limitations are also important to keep in mind. First, the HS system (which classifies products for the purpose of trade and tariffs) was not set up to account for the environmental benefits of products. This can sometime result in poor alignment between a recognized environmental product (such as a wind turbine) and its most relevant HS code.[12] Second, many products are dual use, which means they can have both environmental and non-environmental purposes. Although WTO and APEC classifications provide "ex-outs" (a further description to identify relevant environmental products classified under the HS code), it can be very challenging to identify the precise environmental trade flow associated with a particular ex-out for a given HS category. As such, our analysis (which is based trade volumes for entire HS-6 commodity codes) will tend to somewhat over-estimate environmental trade volumes. Finally, our dataset does not provide information about the production process of a given product, only its use-oriented benefits. Consequently, our data do not allow us to examine the environmental impact of product production and use (e.g. lifecycle emissions of a product).

A.3 Top exporters of green and renewable products (by trade volume)

Figure 8 shows the top exporters of all green products (by trade volume). Panel A presents leaders in absolute terms. While the US was the largest green exporter from 1995-2003, Germany took over in 2004 but was in turn displaced by China in 2010. Panel B shows the green exports of these same countries, but instead as a proportion of each country's total exports. Denmark has had the highest relative share of green exports – peaking over the financial crisis period at around 14 per cent. Of all these countries, South Korea has seen the largest "greening" of its export basket – its green exports increased as a percentage of total exports from around 6 percent in 2002 to around 12 percent in 2010.

[12] For example, a key relevant HS code for identifying wind turbine towers is a very broad HS category - 730820 - which relates to "Towers and lattice masts, iron or steel".

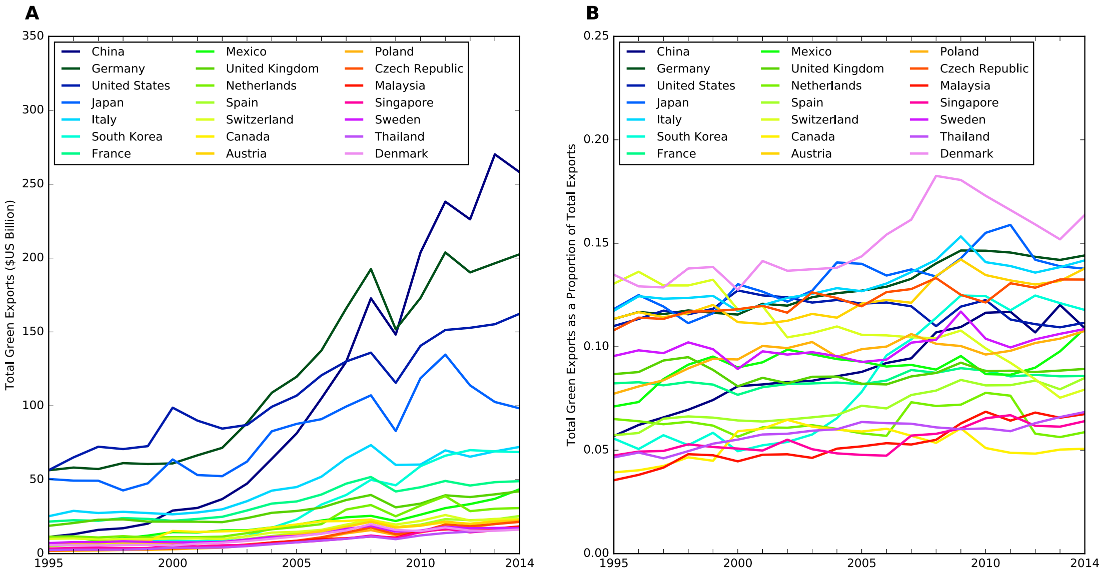

Figure 8: Top 20 Exporters of Green Products

Figure 9 shows the top exporters of renewable energy products. Again, Panel A presents the leading countries in absolute terms. As before, China has become the largest exporter of renewable energy products and its export dominance in renewable energy products (in some years exceeding $20 billion) is even greater than its dominance in all green products. In Panel B, we show the same countries' renewable energy exports relative to each nation's total exports. Here, South Korea's and Denmark's rapid patterns of green export growth become even more prominent.

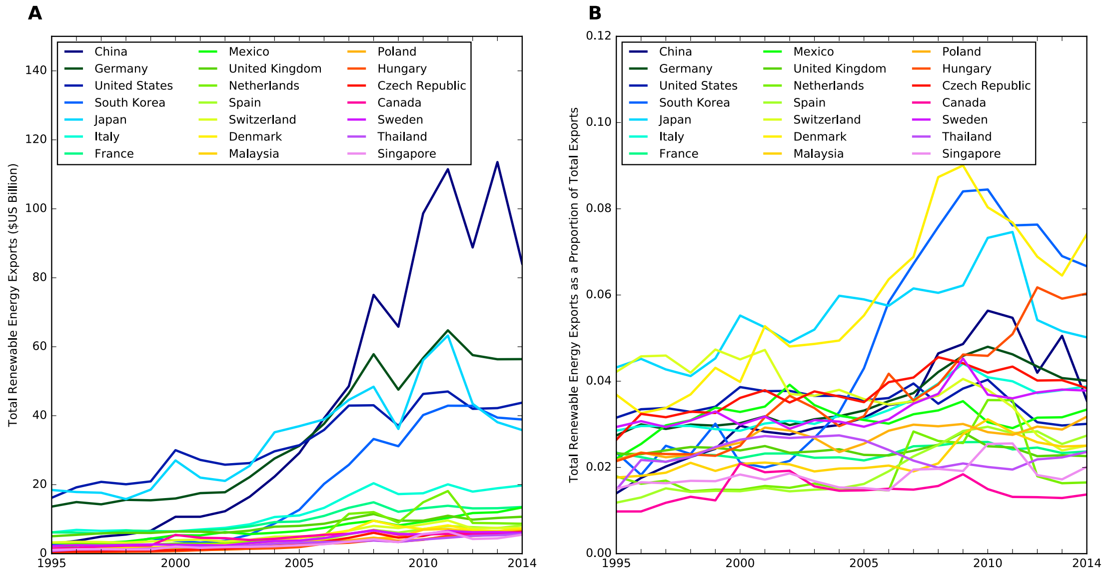

Figure 9: Top 20 Exporters of Renewable Energy Products

A.4 Products

Table 8: Top 10 Green Products by PCI

Rank	PCI	HS6 Code	Product Description	Environmental Benefits	Environmental Lists
1	2.5073	901380	Optical devices, appliances and instruments, nes	Solar Heliostats (Heliostats orient mirrors in concentrated solar power systems to reflect sunlight on to a CSP receiver)	APEC, OECD (2014)
2	2.0716	902790	Microtomes, parts of scientific analysis equipment	Microtomes are devices that prepare slices of samples for analysis - used in environmental monitoring	APEC, OECD (1999), OECD (2014)
3	2.0134	847989	Machines and mechanical appliances, nes	Machines and appliances designed for a wide range of areas of environmental management including waste, waste water, drinking water production and soil remediation	WTO Sample, APEC, OECD (1999), OECD (2014)
4	1.8805	902730	Spectrometers, spectrophotometers, etc using light	Used in a wide range of environmental applications, including identification of unknown chemicals, toxins and trace contaminants, environmental control, water management, food processing, agriculture and weather monitoring	WTO Sample, APEC, OECD (1999), OECD (2014)
5	1.8625	902780	Equipment for physical or chemical analysis, nes	Used to measure, record, analyse and assess environmental samples or environmental influences	APEC, OECD (1999), OECD (2014)
6	1.8291	680690	Mineral heat or sound insulating materials and articles	Used for heat and energy management	OECD (2014)
7	1.8119	902720	Chromatographs, electrophoresis instruments	Used to monitor and analyse air pollution emissions, ambient air quality, water quality, etc.	APEC, OECD (1999), OECD (2014)
8	1.8077	902710	Gas/smoke analysis apparatus	Used for monitoring and analysing environmental pollution.	APEC, OECD (1999), OECD (2014)
9	1.7945	847990	Parts of machines and mechanical appliances nes	Parts for environmental management devices (Machines and appliances designed for a wide range of areas of environmental management including waste, waste water, drinking water production and soil remediation)	APEC, OECD (2014)
10	1.7795	848360	Clutches, shaft couplings, universal joints	Used for initial assembly, repair, and maintenance of wind energy systems	OECD (2014)

Table 9: Bottom 10 Green Products by PCI

Rank	PCI	HS6 Code	Product Description	Environmental Benefits	Environmental Lists
284	−1.2445	871200	Bicycles, other cycles, not motorized	Cleaner or more resource efficient technology or product	OECD (2014)
285	−1.2826	871411	Motorcycle Saddles	Cleaner or more resource efficient technology or product	OECD (2014)
286	−1.2935	220710	Undenatured ethyl alcohol > 80% by volume	Renewable Energy Plant	OECD (1999)
287	−1.4189	560790	Twine, cordage, ropes and cables, of other materials	Environmentally preferrable product	OECD (2014)
288	−1.5074	960310	Brooms/brushes of vegetable material	Waste collection equipment (solid waste management)	OECD (1999)
289	−1.6088	560721	Binder or baler twine, of sisal or agave	Environmentally preferrable product	OECD (2014)
290	−1.864	460120	Mats, matting and screens, vegetable plaiting material	Environmentally preferrable product	WTO Sample
291	−2.1905	530599	Vegetable fibre nes, processed not spun, tow and waste	Environmentally preferrable product	OECD (2014)
292	−2.2365	630510	Sacks and bags, packing, of jute or other bast fibres	Environmentally preferrable product	OECD (2014)
293	−2.9908	530310	Jute and other textile bast fibres, raw or processed but not spun	Environmentally preferrable product	OECD (2014)

Table 10: Top 10 Renewable Energy Products by PCI

Rank	PCI	HS6 Code	Product Description	Environmental Benefits	Environmental Lists
1	2.5073	901380	Optical devices, appliances and instruments, nes	Solar Heliostats (Heliostats orient mirrors in concentrated solar power systems to reflect sunlight on to a CSP receiver)	APEC, OECD (2014)
2	2.0134	847989	Machines and mechanical appliances nes	Machines and appliances designed for a wide range of areas of environmental management including waste, waste water, drinking water production and soil remediation	WTO Sample, APEC, OECD (1999), OECD (2014)
3	1.7795	848360	Clutches, shaft couplings, universal joints	Used for initial assembly, repair, and maintenance of wind energy systems	OECD (2014)
4	1.7554	848340	Gearing, ball screws, speed changers, torque converte	Gearboxes transform the rotation of the blades of wind turbines into the speed required to produce renewable electricity	OECD (2014)
5	1.7419	841199	Parts of gas turbine engines except turbo-jet/prop	Parts for gas turbines, which generate electrical power from recovered landfill gas, coal mine vent gas, or biogas	APEC, OECD (2014)
6	1.4104	841181	Gas turbine engines nes of a power $<$ 5000 kW	Gas turbines for electrical power generation from recovered landfill gas, coal mine vent gas, or biogas (clean energy system)	WTO Sample, OECD (2014)
7	1.2239	840619	Steam and vapour turbines nes	Turbines designed for the production of geothermal energy (renewable energy) and co-generation ((CHP) which allows for a more effective use of energy than conventional generation)	WTO Sample, OECD (2014)
8	1.216	903289	Automatic regulating/controlling equipment nes	Used in renewable energy and smart grid applications, as well as other process control instruments and apparatus for temperature, pressure, flow and level, and humidity	APEC, OECD (1999), OECD (2014)
9	1.1399	841950	Heat exchange units, non-domestic, non-electric	Provide cooling effect to heat exchangers in solar collector or solar system controllers to avoid overheating. Heat exchangers are also used in geothermal energy systems.	WTO Sample, OECD (1999), OECD (2014)
10	1.1216	840690	Parts of steam and vapour turbines	Parts for turbines designed for production of geothermal energy (renewable energy) and co- generation ((CHP) which allows for a more effective use of energy than conventional generation	APEC, OECD (2014)

Table 11: Bottom 10 Renewable Energy Products by PCI

Rank	PCI	HS6 Code	Product Description	Environmental Benefits	Environmental Lists
48	−0.14782	761100	Aluminium reservoirs,vats, tanks, etc, volume >300l	Containers for the production of biogas, waste water management, drinking water production and solar thermal energy purposes.	OECD (2014)
49	−0.31929	850432	Transformers electric, power capacity 1-16 KVA, nes	Renewable Energy Plant	OECD (2014)
50	−0.36528	850421	Liquid dielectric transformers $<$ 650 KVA	Used for initial assembly, repair, and maintenance of wind energy systems	OECD (2014)
51	−0.38168	850161	AC generators, of an output $<$ 75 kVA	Used in conjunction with boiler and turbines to generate electricity in renewable energy plants	OECD (2014)
52	−0.41086	850720	Lead-acid electric accumulators except for vehicles	Provides for energy storage in off-grid PV system	OECD (2014)
53	−0.56155	700992	Glass mirrors, framed	Renewable Energy Plant	OECD (2014)
54	−0.61976	730820	Towers and lattice masts, iron or steel	Used to elevate and support a wind turbine for the generation of renewable energy	WTO Sample, OECD (2014)
55	−0.63559	290511	Methyl alcohol	Renewable Energy Plant	OECD (1999)
56	−0.81094	850431	Transformers electric, power capacity $<$ 1 KVA, nes	Renewable Energy Plant	OECD (2014)
57	−1.2935	220710	Undenatured ethyl alcohol $>$ 80		

A.5 Countries

In Table 12, we present each country's GCI, GCP and ECI ranks for 2014. We also identify each country's most proximate green product that they are not yet competitive in and show the density of that product to the given country.

Table 12: Country Rankings and most proximate green product for 2014

Country	GCI Rank	GCP Rank	ECI Rank	Most proximate green product	Proximity Density
Germany	1	4	3	Webs, mattresses, other nonwoven fibreglass products	0.523527
Italy	2	1	24	Multiple-walled insulating units of glass	0.551191
United States	3	8	5	Vacuum pumps	0.393836
Austria	4	7	10	Manostats	0.407972
Denmark	5	18	20	Mineral and aerated waters not sweetened or flavoured	0.338434
China	6	2	38	Jute and other textile bast fibres, raw or retted	0.547997
Czech Republic	7	12	9	Parts of wash, filling, closing, aerating machinery	0.357498
France	8	5	12	Valves, pressure reducing	0.4277
Japan	9	15	1	Railway maintenance-of-way service vehicles	0.355749
United Kingdom	10	13	11	Compression refrigeration equipment with heat exchange	0.335603
Sweden	11	17	4	Gas/smoke analysis apparatus	0.316329
Spain	12	3	29	Mineral and aerated waters not sweetened or flavoured	0.486129
Slovenia	13	19	13	Domestic iron/steel solid fuel appliances, not cooker	0.299162
Poland	14	9	23	Mineral and aerated waters not sweetened or flavoured	0.398532
Hungary	15	23	16	Manostats	0.267572
Finland	16	30	6	Mufflers and exhaust pipes for motor vehicles	0.228582
Portugal	17	10	48	Brooms/brushes of vegetable material	0.422045
Estonia	18	24	28	Mineral and aerated waters not sweetened or flavoured	0.284672
Switzerland	19	32	2	Clutches, shaft couplings, universal joints	0.230932
Romania	20	22	39	Liquid dielectric transformers < 650 KVA	0.282028
Croatia	21	26	36	Building blocks, bricks of cement, or artificial ston	0.307701
Mexico	22	40	22	Gas supply/production/calibration meters	0.170645
Slovakia	23	28	18	Prefabricated structural items of cement or concrete	0.241184
Bulgaria	24	20	46	Mineral and aerated waters not sweetened or flavoured	0.327624
Turkey	25	6	56	Brooms/brushes of vegetable material	0.462755
Lithuania	26	16	34	Cans, iron/steel, capacity <50l closed by crimp/solde	0.336749
South Korea	27	29	8	Bicycle brakes, parts thereof	0.245542
India	28	11	50	Brooms/brushes of vegetable material	0.388543
Israel	29	34	21	Surveying, etc instruments nes	0.1938
Latvia	30	25	35	Tank, cask or container, iron/steel, capacity 50-300l	0.280853
Malaysia	31	41	27	Parts and accessories of optical appliances nes	0.182011
Lebanon	32	31	58	Building blocks, bricks of cement, or artificial ston	0.262736
Thailand	33	21	40	Mats, matting and screens, vegetable plaiting material	0.268803
Netherlands	34	14	15	Surveying, etc instruments nes	0.344208
Singapore	35	47	7	Optical devices, appliances and instruments, nes	0.183491
Ukraine	36	42	31	Sheet etc, cellular of polymers of styrene	0.189066
Bosnia and Herzegovina	37	39	47	Liquid dielectric transformers < 650 KVA	0.216554
Tunisia	38	43	76	Sacks and bags, packing, of jute or other bast fibres	0.231006
Belarus	39	46	30	Mineral and aerated waters not sweetened or flavoured	0.186029
Norway	40	66	17	Anhydrous ammonia	0.112998
South Africa	41	44	43	Sacks and bags, packing, of jute or other bast fibres	0.205328
Canada	42	37	19	Railway cars nes, closed and covered	0.204049
Philippines	43	49	64	Brooms/brushes of vegetable material	0.167938
Greece	44	33	52	Sacks and bags, packing, of jute or other bast fibres	0.24185
Hong Kong	45	27	41	Bicycle hubs, free-wheel sprocket wheels	0.264135
Brazil	46	52	32	Railway cars nes, closed and covered	0.139184
Vietnam	47	38	92	Jute and other textile bast fibres, raw or retted	0.282421
Egypt	48	35	71	Sacks and bags, packing, of jute or other bast fibres	0.278484
Indonesia	49	36	78	Jute and other textile bast fibres, raw or retted	0.273387
Moldova	50	57	77	Mineral and aerated waters not sweetened or flavoured	0.159036
Jordan	51	55	62	Sacks and bags, packing, of jute or other bast fibres	0.181749
Ireland	52	62	14	Surveying, etc instruments nes	0.125117
Kenya	53	63	82	Sacks and bags, packing, of jute or other bast fibres	0.195668
Russia	54	70	25	Gas turbine engines nes of a power < 5000 kW	0.10655
Uganda	55	64	67	Undenatured ethyl alcohol > 80% by volume	0.166241
Senegal	56	69	72	Surveying, etc instruments nes	0.134271
El Salvador	57	54	83	Brooms/brushes of vegetable material	0.183812

Continued on next page

Table 12 – continued from previous page

Country	GCI Rank	GCP Rank	ECI Rank	Most proximate green product	Proximity Density
New Zealand	58	50	33	Surveying, etc instruments nes	0.164334
Macedonia	59	58	73	Brooms/brushes of vegetable material	0.169198
Dominican Republic	60	59	74	Sacks and bags, packing, of jute or other bast fibres	0.179649
United Arab Emirates	61	81	57	Anhydrous ammonia	0.098455
Sri Lanka	62	51	110	Sacks and bags, packing, of jute or other bast fibres	0.24724
Malawi	63	87	70	Surveying, etc instruments nes	0.072619
Guatemala	64	48	85	Sacks and bags, packing, of jute or other bast fibres	0.237824
Costa Rica	65	77	55	Chlorine	0.089105
Tanzania	66	72	96	Sacks and bags, packing, of jute or other bast fibres	0.169185
Argentina	67	61	37	Methyl alcohol	0.133796
Georgia	68	78	60	Undenatured ethyl alcohol > 80% by volume	0.088708
Pakistan	69	45	107	Jute and other textile bast fibres, raw or retted	0.307798
Morocco	70	53	100	Brooms/brushes of vegetable material	0.2086
Honduras	71	67	91	Undenatured ethyl alcohol > 80% by volume	0.14617
Cameroon	72	94	80	Undenatured ethyl alcohol > 80% by volume	0.054028
Albania	73	68	109	Brooms/brushes of vegetable material	0.162402
Colombia	74	73	54	Undenatured ethyl alcohol > 80% by volume	0.101699
Kyrgyzstan	75	83	95	Sacks and bags, packing, of jute or other bast fibres	0.083056
Peru	76	65	84	Sacks and bags, packing, of jute or other bast fibres	0.149909
Oman	77	100	61	Mineral and aerated waters not sweetened or flavoured	0.044163
Mauritius	78	56	89	Brooms/brushes of vegetable material	0.186092
Zimbabwe	79	82	75	Jute and other textile bast fibres, raw or retted	0.088834
Australia	80	71	44	Methyl alcohol	0.112851
Madagascar	81	74	117	Brooms/brushes of vegetable material	0.148984
Kazakhstan	82	90	45	Anhydrous ammonia	0.07086
Kuwait	83	106	42	Methyl alcohol	0.032296
Uruguay	84	75	49	Undenatured ethyl alcohol > 80% by volume	0.0896
Uzbekistan	85	85	99	Sacks and bags, packing, of jute or other bast fibres	0.08202
Mozambique	86	96	104	Jute and other textile bast fibres, raw or retted	0.072479
Ethiopia	87	88	114	Sacks and bags, packing, of jute or other bast fibres	0.10837
Iran	88	95	59	Liquid dielectric transformers < 650 KVA	0.042025
Bangladesh	89	80	122	Brooms/brushes of vegetable material	0.14754
Nicaragua	90	86	115	Sacks and bags, packing, of jute or other bast fibres	0.111789
Panama	91	60	68	Sacks and bags, packing, of jute or other bast fibres	0.169703
Yemen	92	99	79	Sacks and bags, packing, of jute or other bast fibres	0.056184
Cote dIvoire	93	91	94	Surveying, etc instruments nes	0.066838
Paraguay	94	89	86	Sacks and bags, packing, of jute or other bast fibres	0.069216
Ecuador	95	93	98	Sacks and bags, packing, of jute or other bast fibres	0.067348
Jamaica	96	84	66	Mineral and aerated waters not sweetened or flavoured	0.082543
Ghana	97	97	102	Undenatured ethyl alcohol > 80% by volume	0.059005
Chile	98	76	53	Anhydrous ammonia	0.091139
Laos	99	98	119	Sacks and bags, packing, of jute or other bast fibres	0.070638
Mali	100	102	93	Sacks and bags, packing, of jute or other bast fibres	0.056515
Republic of the Congo	101	111	81	Sacks and bags, packing, of jute or other bast fibres	0.023712
Saudi Arabia	102	103	26	Manganese oxides other than manganese dioxide	0.033556
Zambia	103	92	65	Sacks and bags, packing, of jute or other bast fibres	0.066985
Cambodia	104	79	121	Jute and other textile bast fibres, raw or retted	0.153735
Gabon	105	115	87	Surveying, etc instruments nes	0.017623
Venezuela	106	118	69	Surveying, etc instruments nes	0.011949
Guinea	107	110	113	Sacks and bags, packing, of jute or other bast fibres	0.03639
Qatar	108	120	51	Buoys, beacons, coffer-dams, pontoons, floats nes	0.009239
Trinidad and Tobago	109	107	63	Mineral and aerated waters not sweetened or flavoured	0.029218
Algeria	110	119	88	Sodium hydroxide (caustic soda) solid	0.009689
Nigeria	111	108	108	Jute and other textile bast fibres, raw or retted	0.029281
Bolivia	112	104	103	Jute and other textile bast fibres, raw or retted	0.042712
Papua New Guinea	113	114	118	Sacks and bags, packing, of jute or other bast fibres	0.02736
Mongolia	114	105	97	Sacks and bags, packing, of jute or other bast fibres	0.032406
Sudan	115	112	120	Sacks and bags, packing, of jute or other bast fibres	0.033396
Libya	116	121	106	Sacks and bags, packing, of jute or other bast fibres	0.010857
Liberia	117	117	111	Surveying, etc instruments nes	0.016883
Tajikistan	118	101	105	Jute and other textile bast fibres, raw or retted	0.046313
Azerbaijan	119	113	90	Methyl alcohol	0.020978
Angola	120	122	112	Methyl alcohol	0.003356
Mauritania	121	109	101	Sacks and bags, packing, of jute or other bast fibres	0.027647
Turkmenistan	122	116	116	Sacks and bags, packing, of jute or other bast fibres	0.018702

A.6 Green Product Space

To visualize the relatedness in capabilities underpinning green products, we follow Hidalgo et al. (2007) and construct a hierarchically clustered network where green products are linked to other green products if they have a high probability of being co-exported. To create this network, we construct a maximum spanning tree[13] from the weighted matrix ϕ and add additional edges with proximity greater than a given threshold (here we use a proximity threshold $= 0.37$).[14] This ensures we only connect green products that have a high probability of being co-exported. We show the resulting network, the *Green Product Space*, in Figure 10.

Similar to Hidalgo et al.'s (2007) product space for the entire set of traded products, we find green products with lower PCI tend to be located in the periphery of the green product space, while products with higher PCI are located in the core. This is interesting from a green diversification-oriented development perspective: while it may be relatively easy to export green products with lower PCI, the accumulated capabilities may have limited spillover opportunities into other green products. However, as green products with higher PCI tend to be related to many other green products, gaining capabilities to export high-PCI green products could provide greater future green industrial development possibilities.

The Green Product Space also provides a new way to visualize each country's competitive green exports. We show a selection of different countries in Figure 11. Holding the underlying network fixed, we colour (in green) products that a given country exports competitively. While the most striking aspect of Germany's export basket is the sheer abundance of competitive green products, it is interesting to note that the majority of these are located in the core of the Green Product Space. South Korea also competitively exports a number of complex green products located in the Green Product Space core, but specializes in a distinct branch of green products relating to solar photovoltaics and batteries. As a developing country, Uganda currently exports fewer green products - many of which are less complex and tending relate to vegetable materials. Finally and unsurprisingly, Saudi Arabia currently exports very few green products - all located around the periphery of the Green Product Space.

[13] A spanning tree of a given graph is a tree (contains no cycles) that connects all vertices with the minimum possible number of edges. A *maximum* spanning tree is a spanning tree of a weighted graph that has the maximum weight. That is, it connects nodes by adding edges with the largest weight until the graph is fully connected.

[14] Alternative thresholds give similar results.

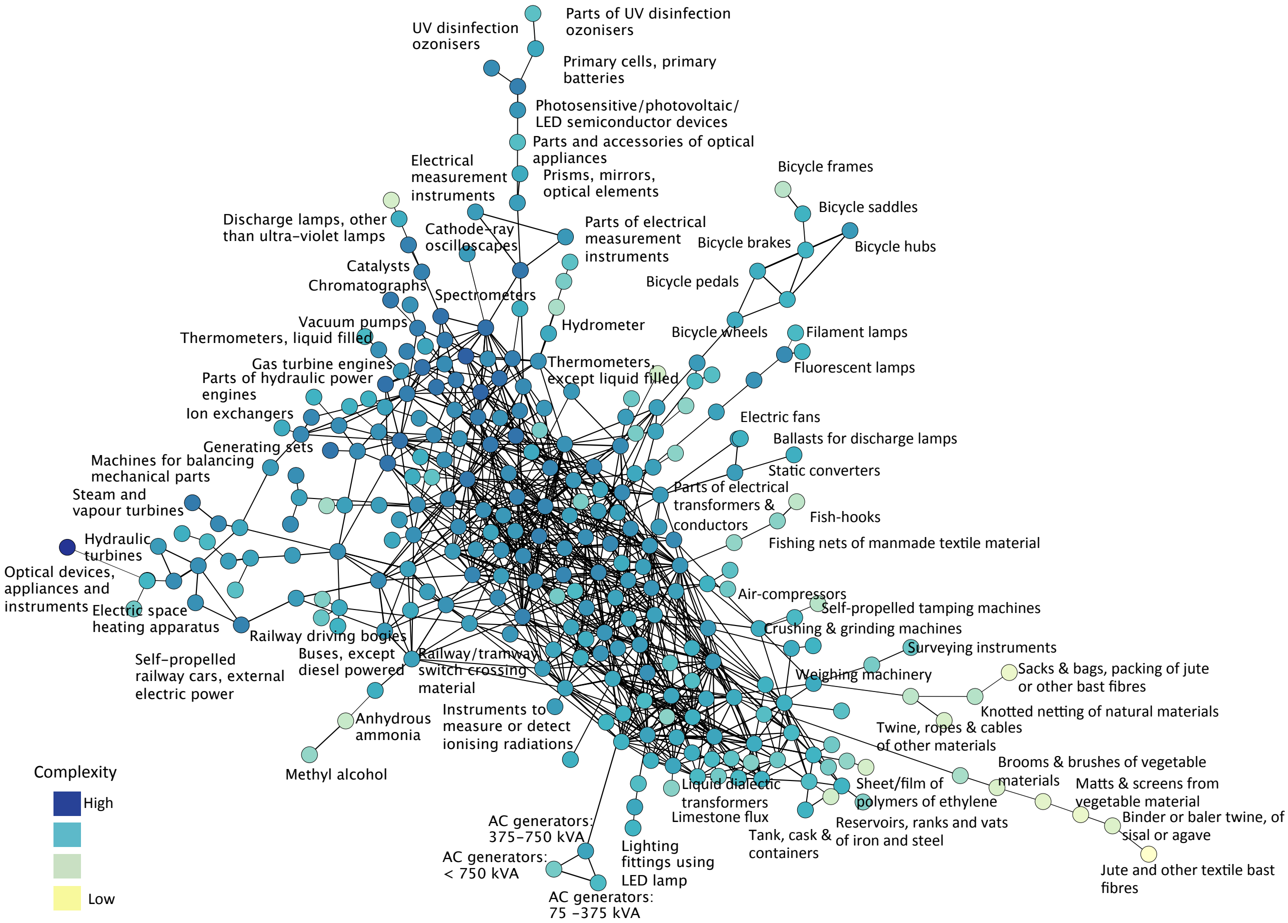

Figure 10: The Green Product Space

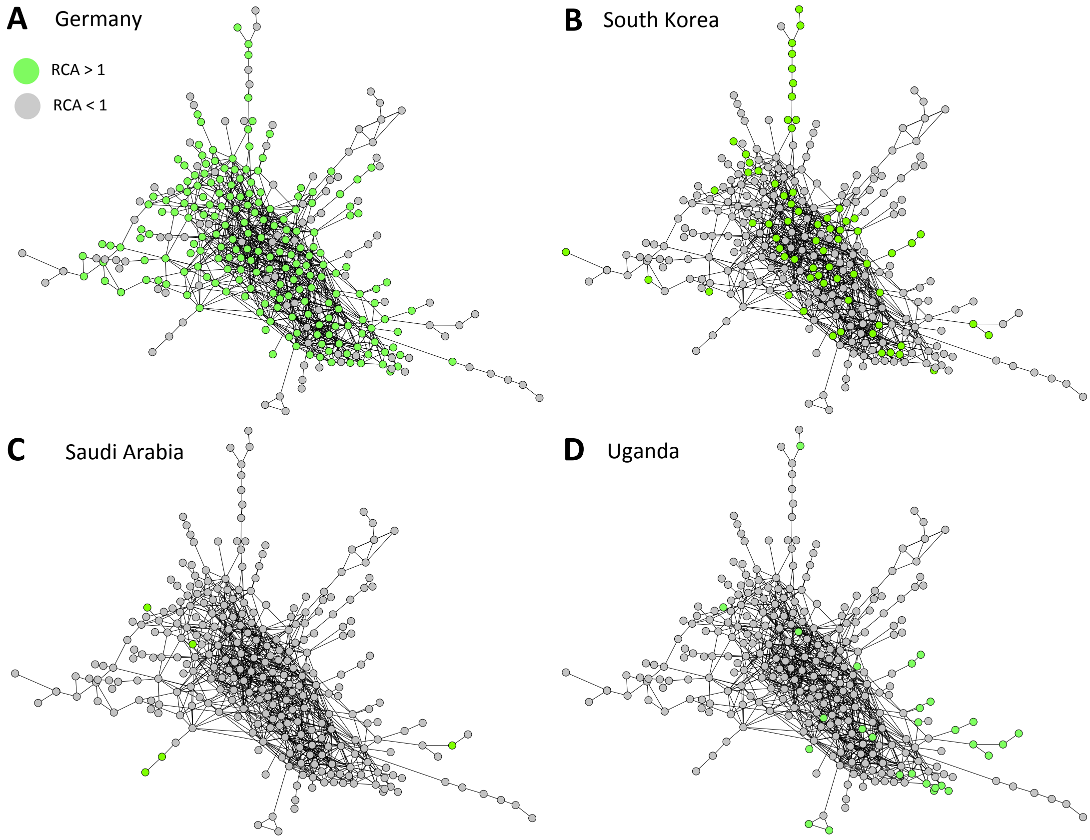

Figure 11: Competitive green product spaces for a selection of countries

A.7 Robustness checks for regression results

There is not enough within country variation in the GCI and GCP for the relatively short period covered by our dataset to run a country-fixed-effect panel regression. Instead, we present additional regression analyses for different years covered by our dataset.

A.7.1 GCI and Environmental Patents

Table 13: Robustness tests for the relationship between GCI and Log Env. Patents over different years

	2010	2005	2000
GCI	1.144***	1.034***	1.205***
	(0.201)	(0.213)	(0.177)
ECI	0.956***	1.147***	0.782***
	(0.307)	(0.273)	(0.189)
Log GDP/Cap	0.208	0.003	0.111
	(0.150)	(0.127)	(0.102)
Intercept	0.632	2.338**	1.089
	(1.237)	(1.067)	(0.798)
Observations	122	122	122
Adjusted R^2	0.752	0.741	0.755

Robust standard errors in parenthesis.
Significance levels: * p<0.1, ** p<0.05, *** p<0.01
The Env. Patent variable can be found in the OECD Statistics database under Environment – Innovation in environment-related tech – Technology Development (Family Size: one or greater; Technology Domain: Selected Environment-Related Technologies). Available at: http://stats.oecd.org/

A.7.2 GCI and CO_2 Emissions

Table 14: Robustness tests for the relationship between GCI and Log CO2/cap emissions over different years

	2010	2005	2000
GCI	−0.171*	−0.333***	−0.2765***
	(0.097)	(0.100)	(0.103)
ECI	0.048	0.377**	0.398**
	(0.158)	(0.152)	(0.153)
Log GDP/Cap	0.923***	0.767***	0.746***
	(0.091)	(0.080)	(0.087)
Intercept	−7.086***	−5.432***	−5.017***
	(0.807)	(0.679)	(0.708)
Observations	122	122	122
Adjusted R^2	0.756	0.755	0.715

Robust standard errors in parenthesis.
Significance levels: * p<0.1, ** p<0.05, *** p<0.01
CO_2/cap (metric tons per capita) is sourced from https://data.worldbank.org/indicator/EN.ATM.CO2E.PC

A.7.3 GCI and Environmental Policy Stringency

Table 15: Robustness tests for the relationship between the GCI and Environmental Policy Stringency over different years

	2010	2005	2000
GCI	0.085*	0.100**	0.099***
	(0.049)	(0.047)	(0.028)
ECI	−0.079	−0.096	−0.091
	(0.085)	(0.083)	(0.057)
Log GDP/Cap	0.236***	0.218***	0.155***
	(0.055)	(0.038)	(0.031)
Intercept	−1.154**	−1.122***	−0.704***
	(0.538)	(0.331)	(0.242)
Observations	31	31	31
Adjusted R^2	0.527	0.556	0.647

Robust standard errors in parenthesis.
Significance levels: * p<0.1, ** p<0.05, *** p<0.01
Environmental Policy Stringency (EPS) data is sourced from http://stats.oecd.org/

A.7.4 GCP - 10 year average predictions

Table 16: Green Complexity Potential Regression Analysis (10 year averages)

	Δ GCI $(t+\delta)$	Δ #Green exported products $(t+\delta)$	Δ Green export trade ratio $(t+\delta)$
Log GCP(t)	0.132***	5.223***	0.009***
	(0.028)	(1.194)	(0.003)
Log GDP/Cap(t)	0.004	0.018	0.001
	(0.017)	(0.757)	(0.001)
ECI(t)	−0.124***	−6.374***	−0.005*
	(0.032)	(1.508)	(0.003)
GCI(t)	−0.032		
	(0.037)		
#Green exported products(t)		0.086**	
		(0.040)	
Green export trade ratio(t)			−0.012
			(0.130)
Intercept	0.381*	17.989**	0.025*
	(0.170)	(7.449)	(0.013)
Observations	2440	2440	2440
Adjusted R^2	0.211	0.251	0.152

Robust standard errors in parenthesis.
Significance levels: * p<0.1, ** p<0.05, *** p<0.01
t relates to country averaged values over years 1995-2004 and $t+\delta$ relates to country averaged values over years 2005-2014.

A.7.5 Green Stimulus - Total Spend

Table 17: Green Stimulus Total Spend

	Δ GCI $(t+\delta)$	Δ #Green exported products $(t+\delta)$	Δ Green export trade ratio $(t+\delta)$
Green Stimulus ($US Bn)	0.0028***	0.1276***	0.0001***
	(0.0004)	(0.0179)	(0.0000)
Log GDP/Cap(t)	0.0000	0.0000	0.0000
	(0.0000)	(0.0001)	(0.0000)
GCI(t)	−0.0042		
	(0.0153)		
Green exported products(t)		0.0171	
		(0.0184)	
Green export trade ratio(t)			0.0605
			(0.0479)
Intercept	−0.0054	−0.3881	−0.0080*
	(0.0368)	(1.7720)	(0.002)
Observations	19	19	19
Adjusted R^2	0.586	0.628	0.236

Robust standard errors in parenthesis.
Significance levels: * p<0.1, ** p<0.05, *** p<0.01
t relates to the year 2008 and $(t+\delta)$ relates to the year 2011.
Green Stimulus Data is from Table 1 in Barbier et al. (2010), and relates to low carbon support for renewable energy, carbon capture and sequestration, energy efficiency, public transport and rail, and improving electrical grid transmission.
#Green exported products refers to the number of green exports in which the country has $RCA > 1$.

A.8 GCI robustness tests using alternative complexity measures

An alternative approach for estimating the complexity of productive capabilities associated with countries and exported products has also being proposed by Tacchella et al. (2012). This methodology uses the same binary M_{cp} matrix constructed on the basis of countries' RCA's, as defined in section 3.2. However, Tacchella et al. (2012) introduce a different formulation for arriving at a country-specific estimate (called *Fitness*) and a product-specific estimate (called *Complexity*).

The measures are calculated as the fixed-point solution of the non-linear iterative mapping given by

$$\begin{cases} \tilde{F}_c^{(N)} = \sum_p M_{cp} Q_p^{(N-1)} \\ \\ \tilde{Q}_p^{(N)} = \dfrac{1}{\sum_c M_{cp} \dfrac{1}{F_c^{(N-1)}}} \end{cases} \rightarrow \begin{cases} F_c^{(N)} = \dfrac{\tilde{F}_c^{(N)}}{\frac{1}{C}\sum_c \tilde{F}_c^{(N)}} \\ \\ Q_p^{(N)} = \dfrac{\tilde{Q}_p^{(N)}}{\frac{1}{P}\sum_p \tilde{Q}_p^{(N)}} \end{cases}, \tag{10}$$

where $\tilde{F}_c^{(N)}$ and $\tilde{Q}_p^{(N)}$ are the N^{th} iterations for the Fitness of country c and Complexity of the product p respectively, and P is the number of products. The initial conditions are given by vectors of 1's (i.e. $\tilde{F}_c^{(0)} = 1 \forall p$ and $\tilde{Q}_p^{(0)} = 1 \forall c$), and at each iteration, the intermediate variables $\tilde{F}_c^{(N)}$ and $\tilde{Q}_p^{(N)}$ are calculated and then normalized by the average values.

As shown in Cristelli et al. (2015, 2017), the Fitness measure appears useful for predicting the growth of countries falling into a particular region in the Fitness × GDP per capita plane.

Here, we compare the GCI regression results using different product complexity formulations. We use *GCI(HH)* to denote the GCI calculated on the basis of the Hausmann et al. (2014) Product Complexity Index (as specified in equation 6) and GCI(Tacch) to denote the GCI calculated on the basis of the alternative Product Complexity measure proposed by Tacchella et al. (2012).

In Table 18 we show that the relationship between environmental patents, carbon emissions and environmental policy stringency are very similar for both GCI(HH) and GCI(Tacch). This suggests that the GCI is robust to the choice of product complexity measure.

Table 18: Comparison of GCI regression results using alternative complexity measures

	Log Env. Patents		Log CO_2/cap		Log EPS	
GCI(HH)	1.551***		−0.168**		0.070***	
	(0.174)		(0.080)		(0.022)	
GCI(Tacch)		1.584***		−0.180**		0.056**
		(0.169)		(0.077)		(0.021)
Log GDP/Cap	0.524***	0.532***	0.946***	0.948***	0.168***	0.175***
	(0.109)	(0.104)	(0.060)	(0.059)	(0.021)	(0.022)
Intercept	−1.913***	−1.975**	−6.990***	−7.010***	−0.757***	−0.805***
	(0.908)	(0.864)	(0.521)	(0.510)	(0.204)	(0.215)
Observations	1220	1220	2318	2318	558	558
Adjusted R^2	0.727	0.747	0.760	0.761	0.726	0.708

Robust standard errors in parenthesis.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
GCI (HH) refers to the GCI calculated using the Hausmann et al. (2014) Product Complexity Index and GCI (Tacch) refers to the GCI calculated using the Tacchella et al. (2012) Product Complexity measure Environmental patents data covers 2000 and 2005-2013, available from http://stats.oecd.org/. CO_2 (metric tons per capita) data covers 1995-2013, available from https://data.worldbank.org/indicator/EN.ATM.CO2E.PC. Environmental Policy Stringency (EPS) data covers 1995-2012, available from http://stats.oecd.org/. For all regressions, we take country averages over all available time periods.

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