Green Exports and the Global Product Space: Prospects for EU Industrial Policy

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1 Introduction

The European Union has set ambitious targets for emissions reduction and renewable energy penetration by the year 2020. As part of the policy framework to achieve these goals, it has emphasized the development of European industrial competitiveness in global markets for "green" technologies, such as wind and solar electricity generation. If these goals prove achieveable, they would suggest that industrial policy could offset the constraints on growth thought to accompany emissions reduction. This achievement would suggest the potential for reconciling climate change mitigation and economic activity, potentially resolving one of the great challenges of both domestic and international emissions reduction policy.

This paper argues that the emphasis on "green" export competitiveness is alone unlikely to deliver broad-based growth across the EU member states. Green energy, like other sophisticated technologies, develops on the basis of complex networks of financial, human, and physical capital. In several major categories of green technologies, we demonstrate strong correlations between longstanding patterns of industrial competitiveness and successful green technology export. As such, "green growth" is merely growth. Countries which succeed do so on the basis of drawing on existing advantages in closely related sectors. Countries which have not succeeded have much weaker supporting sectoral networks, and are unlikely to develop competitiveness in "green" technology without very expensive industrial policy interventions. As such, renewable energy policy alone is unlikely to generate broad European competitiveness

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in renewable energy technologies. Instead, it will likely reinforce existing patterns of competitive advantage.

2 Green Growth and Export Competitiveness

Green growth is often used but rarely defined. Both the Danish government (Danish Ministry of the Environment, 2009) and the Organization for Economic Cooperation and Development (OECD, 2010) treat green growth as the decoupling of economic growth from environmental damage. In contrast, the European Green Party (European Greens Party, 2009; Schepelmann et al., 2009) views green investment as Keynesian demand stimulus, designed to mobilize idle resources during the present economic recession to improve energy efficiency and repair environmental damage.

The European Commission has adopted a somewhat narrower approach to green growth, emphasizing export competitiveness. The European Energy Strategy (The European Commission, 2007a, p4-5) sets as a goal "[b]oosting investment, in particular in energy efficiency and renewable energy... to lead the rapidly growing global market for renewable energy... [and] creates an opportunity to drive the global research agenda." Such activity, the Commission concludes, should eventually lead to job creation and growth. The Strategic Energy Technology Plan (The European Commission, 2007b, p4) argues that this innovation can "catalyze a new industrial revolution" and argues that "in a carbon constrained world, mastery of technology will increasingly determine prosperity and competitiveness." These policy statements clearly suggest a view that conflates promotion of domestic emissions reduction via renewable energy, and global competitiveness and job growth.

For the purposes of this paper, we adopt the Commission's approach, and "green growth" as the development of new economic sectors in "green goods" that generate returns through improved competitiveness on global markets. Competitiveness comes either through first-mover advantages in some industry or technology (Krugman, 1991); or through superior productivity of labor and capital in the Ricardian terms-of-trade model. The goal of preserving global competitiveness in existing renewable energy industries reflects the former, while the development of innovation and production capabilities across Europe reflects the latter.

We anticipate one conceptual and three operational objections to this definition. First, and most importantly, there is no particularly good reason why export competitiveness should be considered "green growth." Growth as traditionally understood refers to productivity-enhacing investment that leads to the enlargement of national wealth. Export competitiveness may play a role, and certainly has played a role in economic growth in the past. But export competitiveness may also reflect a mis-allocation of resources out driven by mercantilist concerns about global leadership in strategic sectors. Thus export competitivess *per se* does not necessarily imply the connection between environmental sustainability and productivity improvements that would feature in "green growth."

We share this substantive concern. The emphasis of the European Union on preserving and extending export competitiveness via promotion of domestic renewable energy may or may not actually increase the productivity of the European economy. It may also reflect the misallocation of domestic resources relative to other, potentially greener investments. Finally, the emphasis on maintaining a lead in rapidly changing global industries may reflect a mercantilist concern wtih strategic sectors that is misplaced in a global economy.

Nevertheless, we persist with this definition in this instance in order to assess whether the Commission's goals are, on their own terms, reasonable. Should we expect the emphasis on renewable energy–itself laudable and necessary as a means to decarbonize the electricity supply–to drive global economic competitiveness across Europe? Or are there good reasons to expect that the experiences of countries like Denmark and Germany reflect organic growth of renewable energy industries that, when replicated elsewhere, may be distortionary or simply unsuccessful?

We anticipate three narrower objections to this definition. First, it relies on trade data classifications that were never intended to capture products' "greenness", and so may ignore sectors engaged in the production of renewable-energy-related goods. Second, it does not attempt to deal with energy services, which are less likely to be exported but form the bulk of the economic activity in the advanced industrial countries. Finally, we have no way to determine whether changes in competitive advantage occurred through the transfer of resources out of productive sectors based solely on industrial policy subsidies, or reflect more economically sound changes to production patterns based on externality corrections or relative returns to investment.

Objections one and two certainly make this analysis more conservative than others. We are interested in the ability of green products to generate growth on its own terms. Too broad a specification of "green" products leads to uncertain conclusions, as in the OECD studies.[1] The services objection is more salient. Addressing this problem, however, would require the ability to differentiate similar services serving different ends. For instance, water infrastructure engineering might either design and build sewers, or design and build greywater recovery systems for green buildings. The line between generic and green water engineering services is clearly much less bright than that between coal-fired power plants and solar photovoltaics. Thus while our conclusions are necessarily conservative, they are probably more precise for that.

Finally, the inability to capture secondary substitution effects is a concern reflected in the environmental regulation debate. As section 2.1 will show, however, the identification strategy for establishing the antecedents of green growth depends on looking at surrounding networks of export competitiveness. We thus internalize changes to the goods most likely to lose out if green sectors canabalize their resources. This is, of course, not perfect: we do not watch actual resource migration throughout the economy, nor do we have a strong counterfactual for the export behavior of supporting

[1] Vossenaar (2010) has combined trade data sets in an attempt to parse from a broader set of trade categories only the environmental goods. His approach relies on using more detailed data from the US and EU to supplement UN data. However, because we rely on global data to compute the RCA values, correcting only US and EU exporters would bias the results. Hence his approach is not applicable here.

sectors in the absence of green goods.

Whether "green growth" and export competitiveness are equivalent or not is unclear. One may certainly lead to the other; but export competitiveness alone does not necessarily make it either "green" or "growth". But the success of several European Union member states in using renewable energy to support job growth, and the attractiveness of that success to policymakers, merits persisting with export competitiveness to see whether, on its own terms, we should expect success.

2.1 Research design

To move from broad observations on trade patterns to cleanly specified arguments about policy interventin and economic change, we follow Hidalgo et al. (2007) in defining a global product space that captures relationships between trade patterns for different products. The product space allows us to formalize and quantify networks of related products and track the evolution of those networks over time. Since green products like solar cells and wind turbines come into global markets later than hypothesized supporting sectors, we can watch the emergence of global trade in these products and its relationship to pre-existing patterns of industrial competitiveness.

Consistent with Hidalgo et al. (2007), we define the product space as the matrix P, containing the proximities $p_{i,j}$ between goods i and j. The proximity is the conditional probability that a country which exports good i also exports good j. We define exporting to mean a revealed comparative advantage RCA_i of greater than 1.

Formally, we define the revealed comparative advantage for country $c \in C$ in good $i \in I$ as

$$RCA_{c,i} = \frac{\frac{x(c,i)}{\sum_i x(c,i)}}{\frac{\sum_c x(c,i)}{\sum_{c,i} x(c,i)}} \tag{1}$$

Given the RCA values for countries C and goods I, we compute the proximity matrix as

$$prox_{i,j} = min(p(x_j|x_i), p(x_i|x_j)) \tag{2}$$

$$p(x_j|x_i) = \frac{\sum_c RCA_{c,j} > 1 | RCA_{c,i} > 1}{\sum_c RCA_{c,i} > 1} \tag{3}$$

Equation 2 generates a symmetric proximity matrix of dimension $n \times n$, for n globally traded goods. As this indicates, we define a country to have "traded" a good if that country's exports of that good are a larger share of its overall exports than the similar ratio for world exports. The proximity is then the conditional probability of exporting good j given that a country exports good i. Consistent with Hidalgo et al. (2007), we take the minimum of $p_{i,j}$ and $p_{j,i}$ to ensure that countries which are sole global exporters for some good do not dominate the calculation of proximity values.

For the purposes of constructing the green product space, we calculate the proximity matrices for years 2005-2009 and average the results across the common set of product codes. This provides some means to mute short-term fluctuations in trade patterns.

2.2 Data

Hidalgo et al. (2007) use 4-digit trade data to construct their product matrix. However, the 4-digit data do not allow us to identify green products in the global trade space. Instead, we use the HS-6 product data from the United Nations COMTRADE database, for years 1990-2009. At the six-digit level, it becomes possible to identify a range of products usually classified as "green", including solar cells, wind turbines, electric metering equipment, and nuclear power stations and parts therefore.

Unlike the original paper, use of 6-digit data does not permit restriction of the goods that classify the product space. Hidalgo et al. (2007) find that only 775 of the 1006 goods defined in the 4-digit SITC product classification represent the entire product space. But at finer levels of granularity, we cannot observe that behavior. Hierarchical clustering of the proximity matrix does not reveal a set of unrelated goods that can be excluded from the resulting product space.

2.3 The product space

Figure 1 shows the Maximum Spanning Tree of the global product space as defined by $p > 0.5$. Darker links indicate closer proximities between nodes. Clustering of major product categories is clearly visible, particularly for textiles. Consistent with earlier work, the MST shows significant distance between clusters of expertise in industries like textiles and food production on the one hand; and high-value-add manufacturing, transport, and chemicals on the other. As Hidalgo et al. (2007) argued, this suggests the difficulty of moving an economy's comparative advantage from one sector or cluster of sectors to another. The product space provides an abstract representation of the set of characteristics–capital and skill formation, infrastructure, production networks, and retained expertise–that shape what that country can competitively produce and export. The separation of textiles and machine tools in the product space is a projection of their significant separation in a multidimensional space comprised of a range of political and economic variables that determine national comparative advantage.

2.4 Outcomes: the sectoral constraints on green growth

We can learn a great deal about the prospects for green growth by observing the product space and the location of green products inside it. For the green growth question, we want to determine four things:

1. Are green products significantly different from non-green products?

2. Do green products display a consistent pattern of links to the rest of the product space?

3. What do those links imply about the requirements for moving into green products from other parts of the product space?

4. How did domestic industrial capability influence member state commitments to renewable energy targets for 2020?

We define green products in the following categories: solar cells; wind turbines; nuclear power plants and parts therefore; and electric meters.[2]

2.4.1 Green products in the product space

We first present data on the product space as a whole. Figure 2 shows that green products are evenly distributed in their relative proximity to other products in their own 2-digit HS-6 product classification. Figure 3 suggests that green products are in general less proximate to their most similar exports than the product space as a whole; though here the small N complicates inference.

Figure 4 shows the detailed product space surrounding solar photovoltaic cells and nuclear plant parts. The annotations indicate the products represented by nodes proximate to the green products themselves. The results are not surprising: solar cells are proximate to other sophisticated microelectronics and integrated circuit parts; nuclear power plant components are proximate to sophisticated metallurgical technologies and scientific apparatus.

Thus the product space itself suggests that green products are not much different from their non-green counterparts. They show similar proximity to other products in their same product classification; the distribution of proximity values between green products and the rest of the product space is about that of the product space as a whole, with some products being disproportionately more isolated; and the products most proximate to green products in the Maximum Spanning Tree representation display clear sectoral relationships.

2.4.2 The emergence of green products

If green products are no different than their generic counterparts, this raises the question of whether a green development strategy can transcend the normal problems faced in industrial and sectoral transition. Moving into new sectors is made easier by competence in closely related industries, whose solutions to capital formation, skill development, firm relations, and other economic issues can be easily adapted to the new production chain. This observation generates the following hypothesis: *countries with historically strong supporting sectors for green goods will do better in green industries than those without.*

[2]The HS-6 codes are, respectively, 854140; 850231; 840140; 840110; 902830; and 902890.

We test this hypothesis in two ways. First, we identify the top 5% of products by proximity value in the 2005-2009 product space for each of the green products. We then take the mean RCA value for that set of products for each country, weighted by the proximity values. If our hypothesis holds, higher RCA values in 1996 should correlate with higher RCA values for the green product in 2008.[3]

Figure 5 displays the graphical results of this test for solar cells and wind power generation. Visual confirmation of the correlation between historically strong supporting sectors is clear. Local linear regression of the 2008 RCA value on the mean 1996 RCA for the supporting sectors confirms this relationship, but only weakly and only for solar cells.

Second, we take the top 500 products by RCA value for each country in 1996, by country. For each green product, we sum the proximity of these top 500 products in the 2005-2009 product space. Again, we expect that higher total proximity values should correlate with stronger RCA for green products in 2008. But whereas the first test was retrospective, this test looks forward from historic national strengths to later outcomes.

Figure 8 shows that this relationship holds again. States with strong green products sectors in 2008 were strong in closely related sectors in 1996. Those that were not, did not develop strong sectors.

Several outliers deserve mention. First, negative incentives appear to retard the growth of green industry. Poland, for instance, which has historically preferred to develop indigenous coal reserves, has achieved subpar RCA values for both wind and solar technology. The lack of domestic markets may therefore impede the development of these industries.

Second, and more encouraging for the green growth hypothesis, Spain in particular has achieved RCA levels for wind far above those we would expect from its performance in supporting sectors.[4] Both countries aggressively promoted renewable energy as both an environmental initiative and an economic development strategy. For wind turbines in particular, both figures 5 and 8 show that this has pushed their revealed comparative advantage in wind turbines much higher than nations with comparable supporting-sector RCA values. Indeed, both approach the level of international export competitiveness in wind turbines achieved by Denmark and Germany, which appear to have much stronger supporting sectors.

That said, the most successful cases of renewables-driven "green growth" are clearly Denmark and Germany. Both countries benefitted from historically strong supporting sectors in engineering, high-precision machining, and manufacturing. Their aggressive promotion of domestic markets for wind and solar energy built atop these existing foundations.

As we move away from obvious green products like wind and solar power generators, these relationships weaken. Table 1 shows the correlations between both the

[3]Note that the 2008 data were used because they comprise a larger set of countries than the 2009 data, which were still incomplete at the time of this analysis. This should not affect the proximity values, as it would take country trade out of both the numerator and denominator of the RCA values.

[4]Portugal appears as an outlier in the 2008 data, but not in 2005-2007. 2009-2010 data are not yet available.

historically leading sectors and the green energy supporting sectors, and the strength of green energy sectors, for 2008. Nuclear reactor technology development has been heavily concentrated in a few countries–chiefly France and the United Kingdom–and relied on substantial state support. The lack of many significant exporters for the resulting products do not permit strong tests of these relationships for nuclear power. Correlations are also less clear for gas and electrical meters, though here the HS-6 data does not permit us to disentangle next-generation "smart" meters from legacy metering technology that has changed little in a century.

	Product	LS, all	LS, EU	SS
1	Wind turbines	0.37	0.42	0.16
2	Solar cells	0.56	0.49	0.51
3	Nuclear reactors	0.43	0.44	0.31
4	Nuclear reactor parts	0.45	0.46	0.44
10	Electrical meters	0.06	0.34	0.33
11	Electrical meter parts	0.21	0.50	0.48

Table 1: Correlation of 2008 RCA values for green goods with 1996 RCA indicators. SS = Supporting sectors, as defined by proximity to green goods in the 2005-2009 product space; LS = Leading sectors, as defined by the highest RCA values in 1996.

2.4.3 Influence on the 2020 targets

Finally, the 2008 Climate and Energy Package included aggressive renewable energy targets intended to achieve a 20% renewable energy share in final electricity consumption by 2020. Negotiations to set national targets that would guarantee progress toward the overall target reflected several concerns: national GDP; national baseline renewable energy usage; and indigenous endowments of natural energy sources like sun, wind, or tidal energy.

To achieve those targets, each member state had to submit a National Action Plan specifying where the gains would come from, and via what policy mechanisms. Buerskens and Hekkenberg (2010) have catalogued those plans and merged them with the baseline renewable energy production data. The result is a database that breaks down the 2020 targets and the 2005 baselines by renewable energy source. This provides a detailed view of how member states plan to achieve their 2020 targets.

We hypothesize that the 2020 target itself should have been a function of the member states' understanding of their economies' ability to generate the renewable energy infrastructure required to meet the targets. Countries with highly-developed renewable energy industries should, in general, be more willing to pursue aggressive targets than countries that would need to import substantial amounts of technology.

To test this hypothesis, we compare 2005 sectoral data on the wind and solar industries to the net change in renewable energy production from those industries' products.

We test whether more aggressive pursuit of the 2020 targets via wind or solar correlate with more capable domestic wind or solar industries. Consistent with the product space theory used above, we check for correlations with either the 2005 RCA for wind or solar products directly; or for the mean 2005 RCA for their supporting sectors, as defined by proximity in the 2005-2009 product space.

Figures 9 and 10 show the results of these correlations. The plots indicate no clear relationship between strong supporting or primary wind or solar sectors, and ambitious national targets for wind or solar energy penetration. The strongest correlations between sectoral strength and renewable energy targets are seen for the primary solar sector (0.35) and the secondary wind sector (0.21).

It thus remains unclear how the political economy of green growth played out in the final 2008 negotiations on the climate and energy package. State agreements to renewable energy targets, later detailed in their national action plans, have inconsistent relationships to the strength of their domestic renewable energy industries. Whether that is due to the use of cross-subsidization of imports of the necessary technology; or more prospective motivations built around developing otherwise weak renewable energy industries at home; or some other rationale, remains unclear.

3 Path dependency and green growth: implications for European industrial policy

As section 2 noted, the European Union has explicitly invoked economic growth as a justification for pursuing intensified development of renewable energy industries and other "green" technologies. This has included both the protection of existing comparative advantage, and the development of export competitiveness in these industries for all European member states.

Examination of the product space and its historical development suggests that this goal may be difficult to achieve. "Green growth," defined as export competitiveness, turns out to be as problematic and path-dependent as normal growth. Moving into sophisticated engineering and manufacturing industries like photovoltaics or wind turbines requires significant physical and human capital assets, production know-how, and firm expertise. The countries that have most successfully moved into these industries have done so from positions of strength in closely related sectors, which they have supplemented with strong incentives like feed-in tariffs. Countries without these asset bases have had less success.

Thus the promotion of export competitiveness in renewable energy industries may not deliver economic solidarity for EU member states. Indeed, it may even reinforce existing disparities between the member states. Figures 11-12 show the rather substantial differences that exist in the strength of the supporting sectoral networks for wind and solar technology across the EU. If the expenditures required to pursue renewable energy industrial policy yield positive returns in states with strong supporting sectors, and negative returns elsewhere, this will exacerbate the already substantial differences in export competitiveness in green industries observed in Europe today.

Rapidly developing international competition will only make this problem more difficult. To the extent that the new member states achieve comparative advantage through mid-level manufacturing expertise coupled to lower labor costs, they will face intense competition in green industries from China in particular. The Chinese government has moved its own solar and wind industries rapidly up the value chain, in part through the sheer scale of demand for energy in the Chinese economy. So long as Chinese labor costs continue to undercut those of the new member states, while delivering comparable products, green growth will prove very difficult.

4 Conclusions

Green or not, the core problems of growth remain. If the European Union is serious about achieving broad-based growth through promotion of green technology and sustainable development, mere focus on the deployment of green energy is insufficient. Rather, the EU and its member states must continue to drive convergence in the ability to generate technological innovation, train skilled workforces, invest capital strategically, and move into new markets in the presence of intense international competition. Absent convergence in these areas, pursuit of export competitiveness in renewable energy is no more likely to deliver economic solidarity or durable comparative advantage for the EU as a whole, than in any other industry. "Green growth," if it will come, will require a broader emphasis on reconciling the fundamentals of growth with the imperatives of environmental sustainability.

References

Buerskens, L. W. M. and Hekkenberg, M. (2010). Renewable energy projections as published in the national renewable energy action plans of the european member states. ECN Report ECN-E–10-069, European Research Center of the Netherlands, Petten, the Netherlands.

Danish Ministry of the Environment (2009). Agreement on green growth. Report, Danish Government and the Danish People's Party, Copenhagen, Denmark.

European Greens Party (2009). A green new deal for europe: Manifesto for the european election campaign 2009. Press release, The European Greens Party, Brussels, Belgium.

Hidalgo, C., Klinger, B., Barabási, A., and Hausmann, R. (2007). The product space conditions the development of nations. *Science*, 317(5837):482.

Krugman, P. (1991). *Geography and trade*. the MIT Press.

OECD (2010). Interim report of the green growth strategy: Implementing our commitment for a sustainable future. Interim Report C/MIN(2010)5, Organization for Economic Cooperation and Development, Paris.

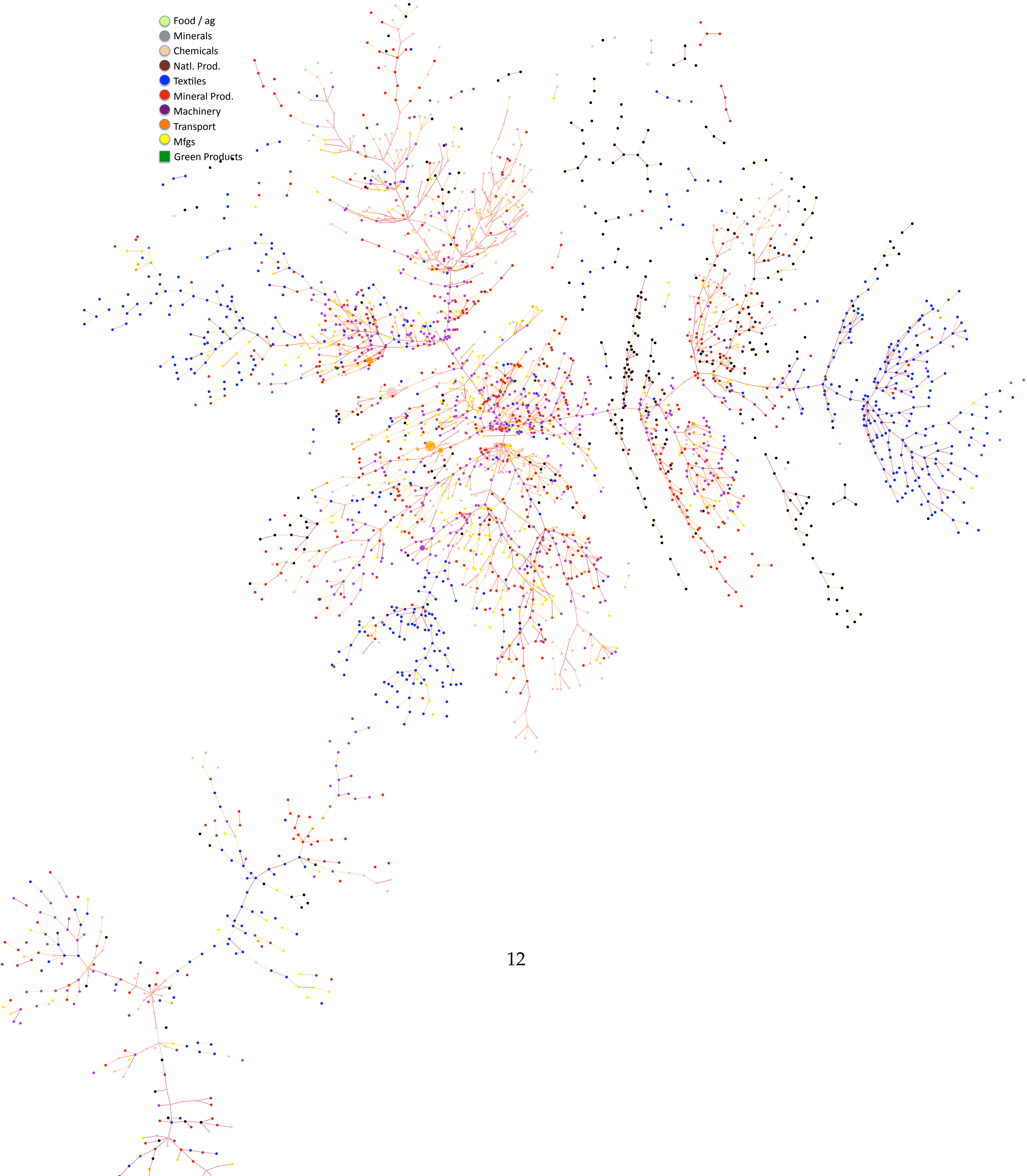
Schepelmann, P., Stock, M., Koska, T., Schüle, R., and Reutter, O. (2009). A green new deal for europe: Towards green modernization in thef ace of crisis. Green New Deal Series 1, Green European Foundation and the Wuppertal Institute for Climate, Energy, and the Environment, Wuppertal, Germany.

The European Commission (2007a). An energy policy for europe. Communication to the European Parliament and European Council SEC(2007) 12, Commission of the European Communities, Brussels, Belgium.

The European Commission (2007b). A european strategy energy technology plan (set-plan). Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions COM(2007) 723, The European Commission, Brussels, Belgium.

Vossenaar, R. (2010). Climate-related single-use environmental goods. Issue Paper 13, ICTSD Programme on Trade and Environment, Geneva, Switzerland.

Figure 1: Maximum Spanning Tree for the product space defined by the HS-6 data in years 2005-2009. The MST was constructed using Kruskal's algorithm. Only links with $p > 0.5$ are shown. Darker links indicate greater proximity.



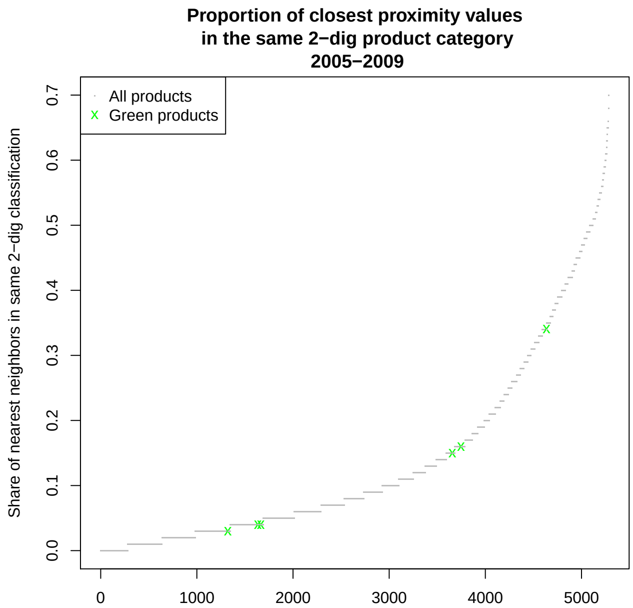


Figure 2: Proximity of green products to other products in the same product class.

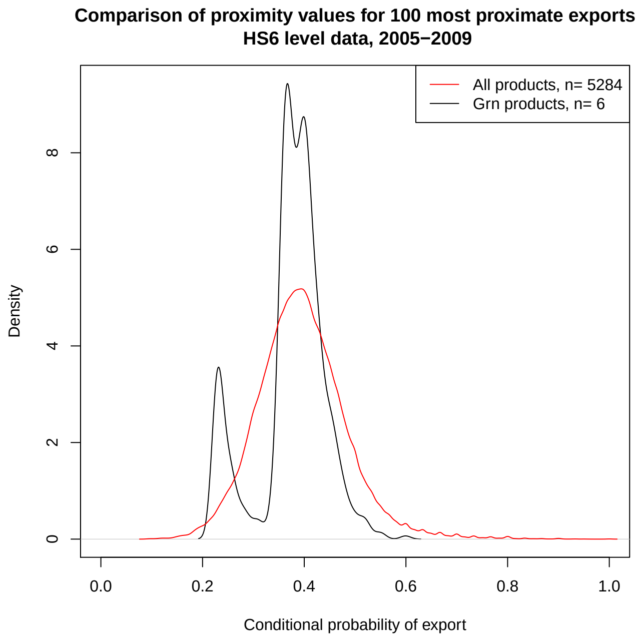
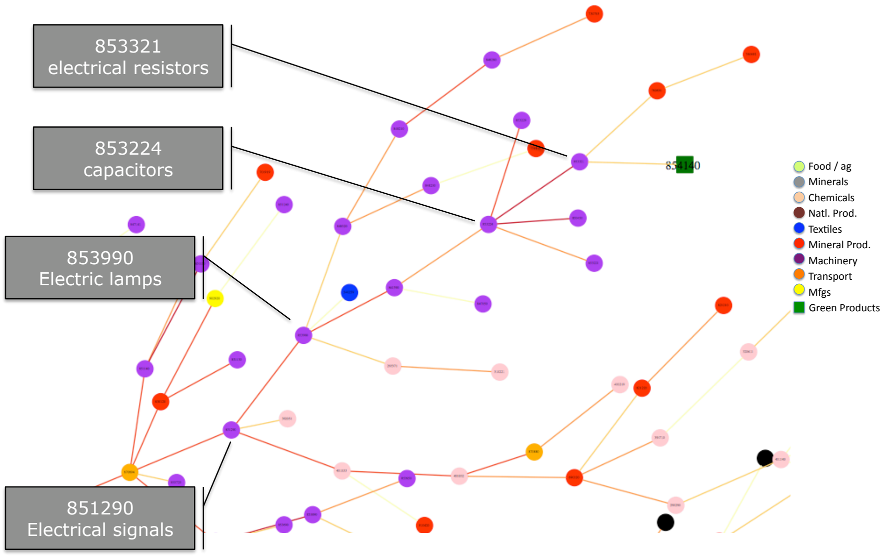
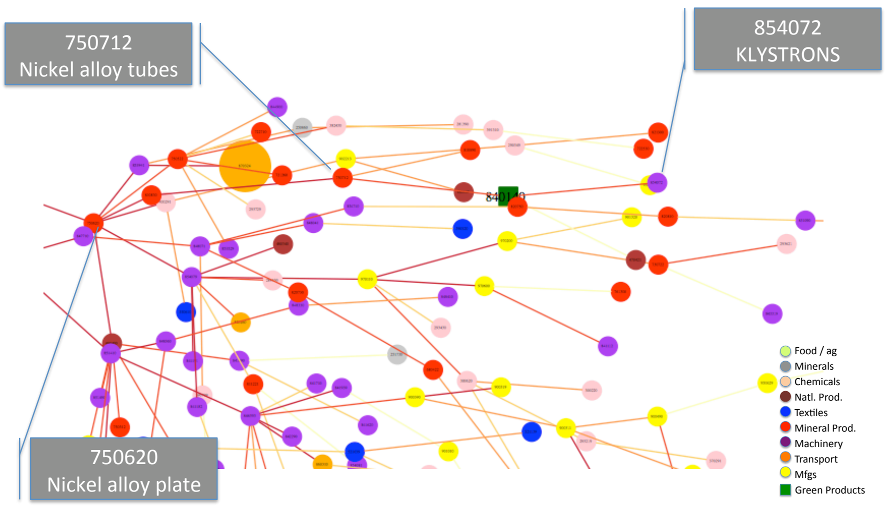


Figure 3: Distribution of proximity values for green products compared to the entire product space



(a) The local solar cell product space



(b) The local nuclear power plant parts product space

Figure 4: The local product space for solar cells and nuclear power plant parts.

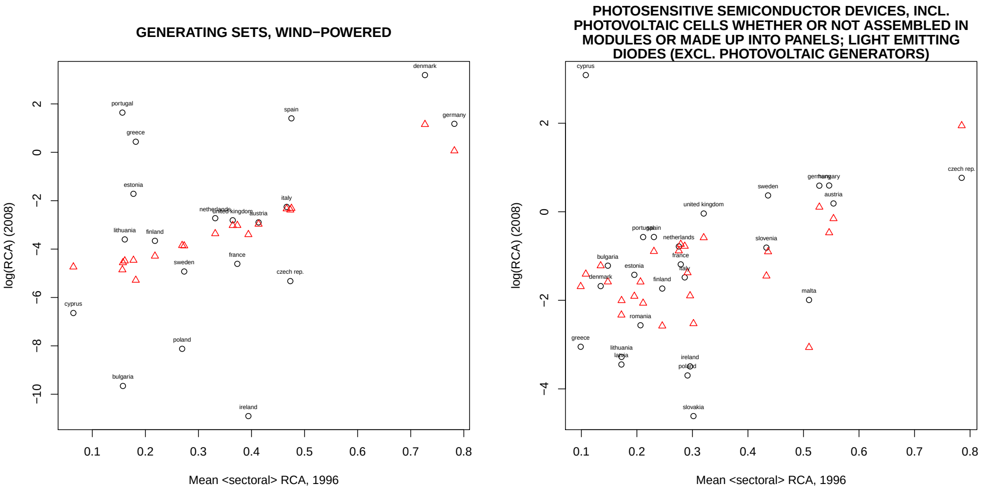


Figure 5: Test 1 (EU countries): Correlation of mean RCA_{1996} values for the most proximate products to green exports in 2008. Reporting EU countries only. Red shows fitted values from linear regression of the form $log(RCA_{2008}) = \beta_1 \overline{RCA_{1996}} + \beta_2 \sigma_{RCA_{1996}} + \beta_3 \overline{RCA_{1996}} \sigma_{RCA_{1996}}$ 1996 RCA value.

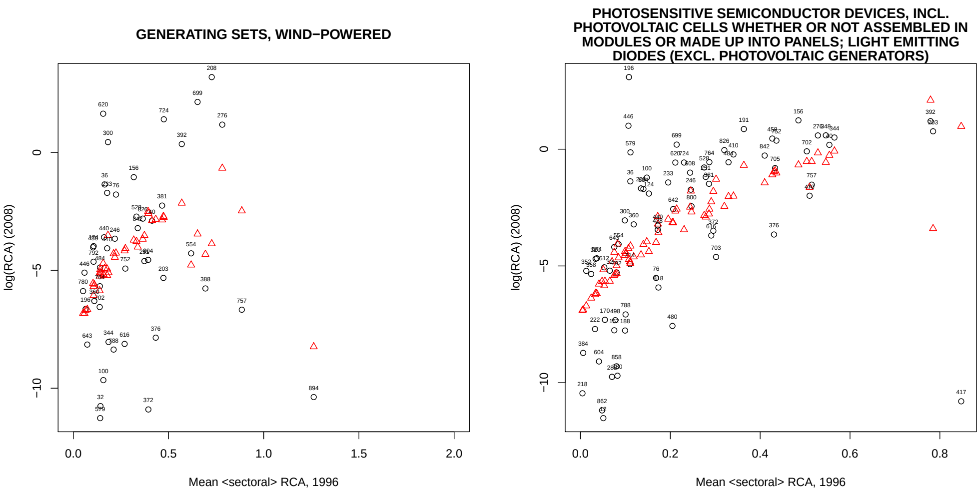


Figure 6: Test 1 (all countries): Correlation of mean RCA_{1996} values for the most proximate products to green exports in 2008. All reporting countries. Red shows fitted values from linear regression of the form $log(RCA_{2008}) = \beta_1 \overline{RCA_{1996}} + \beta_2 \sigma_{RCA_{1996}} + \beta_3 \overline{RCA_{1996}} \sigma_{RCA_{1996}}$ 1996 RCA value.

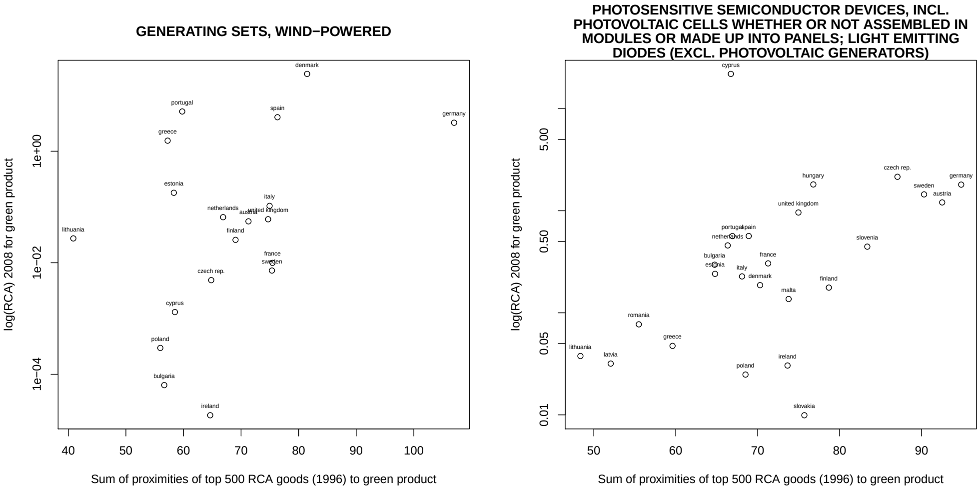


Figure 7: Test 2 (EU Countries): Correlation between the proximity to green products of leading industrial sectors in 1996, and 2008 green product RCA.

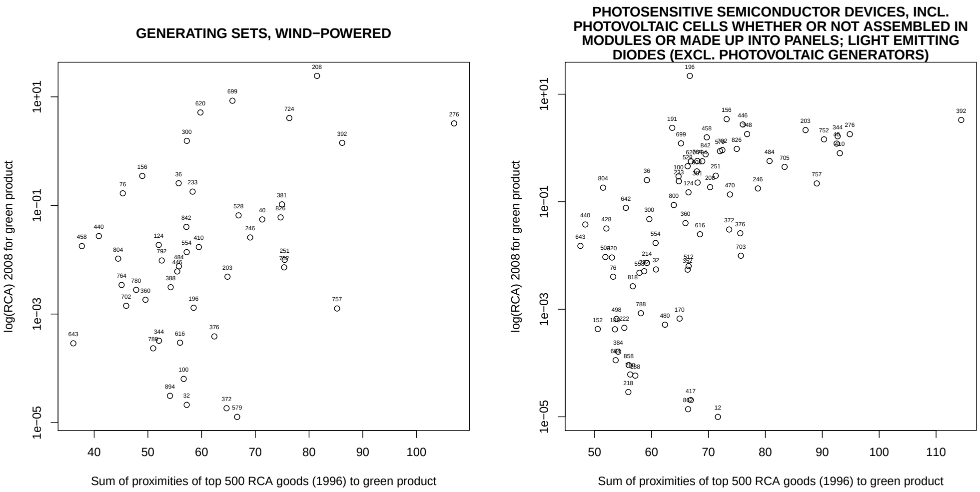


Figure 8: Test 2 (All Countries): Correlation between the proximity to green products of leading industrial sectors in 1996, and 2008 green product RCA.

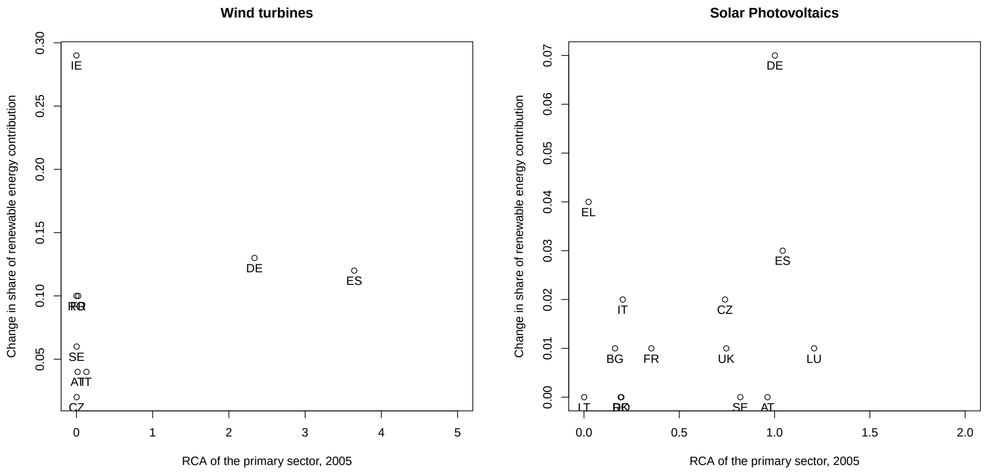


Figure 9: Correlation of net 2020 targets in wind and solar energy with the 2005 RCA for national wind and solar sectors. Denmark is omitted from the Wind Turbine data as an extreme outlier ($RCA \approx 30$)

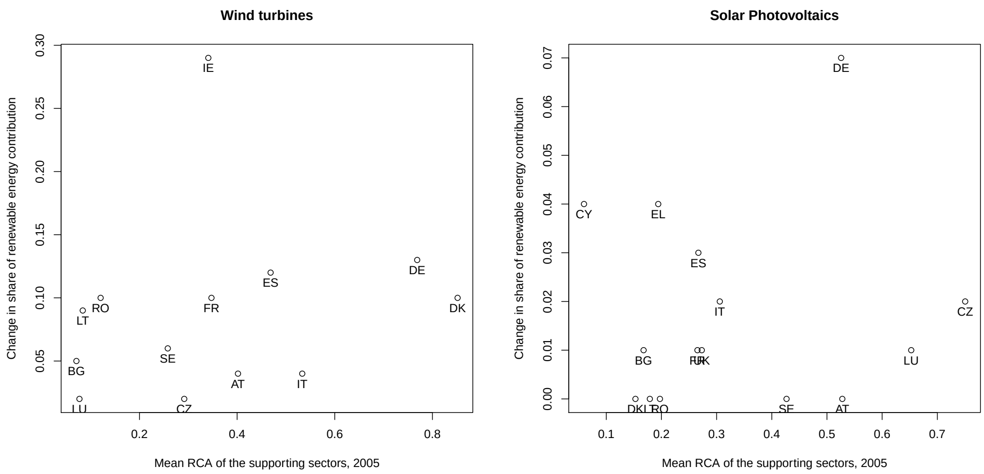


Figure 10: Correlation of net 2020 targets in wind and solar energy with the 2005 RCA for national wind and solar supporting sectors.

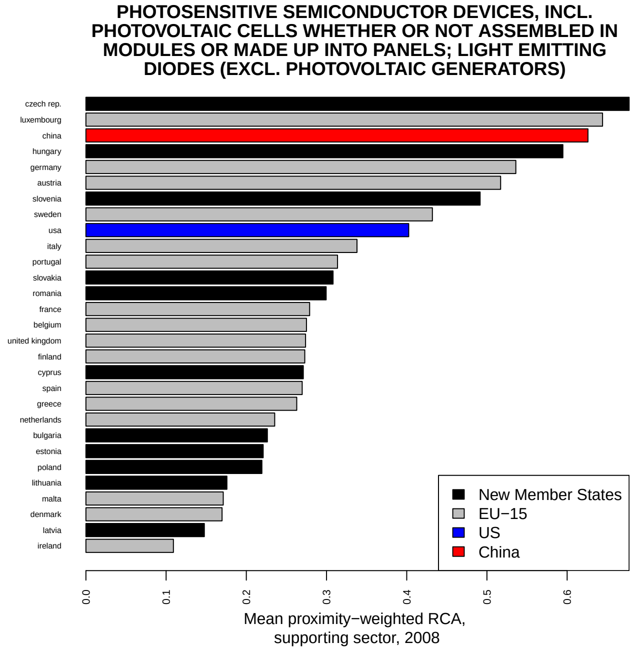


Figure 11: Mean RCA of the supporting sectors for solar cell production by country, 2008.

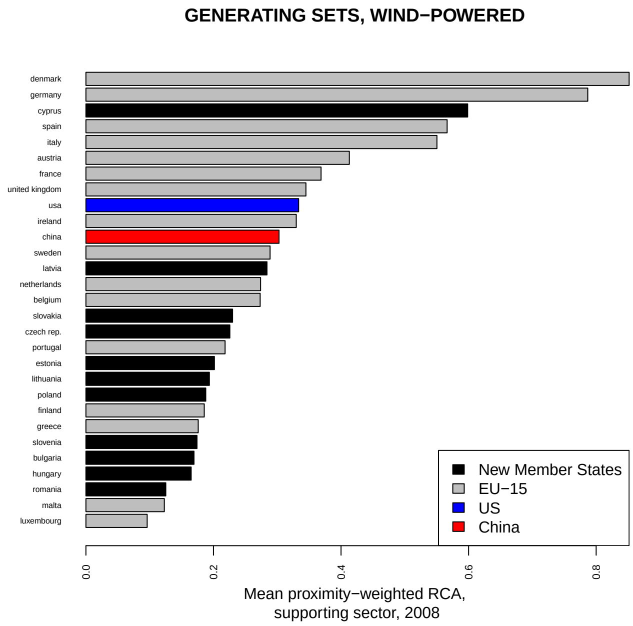


Figure 12: Mean RCA of the supporting sectors for wind turbine production by country, 2008.