Using product space to identify 'green' export strengths

A note by the UNCTAD Secretariat*

Introduction

Policymakers face a number of challenges when designing government initiatives that aim to foster the development of new green sectors. The first and most critical challenge they encounter concerns selecting which, among many, green sectors to promote. The literature on industrial policy shows that this selection process, often referred to as 'picking winners', has more often been a failure than it has been a success. Importantly, however, it also indicates that when governments have designed policy packages to support those sectors in which their country has a demonstrated comparative advantage, industrial policy is most likely to succeed. Following their areas of natural and comparative advantage has produced clear successes for some developing countries. For example, in recent years government initiatives helped to successfully spawn IT services in India and Mauritius; the salmon and wine industries in Chile; and the cut flowers sector in Kenya, among others.

As the global economy increasingly orients itself towards a green economy, many policymakers would like to know which green sectors offer the greatest potential for diversification and growth of their economies. Based upon the 'Product Space' model pioneered by Hidalgo and Hausmann,[1] UNCTAD has developed a data-based analytical approach to help policymakers identify green sectors and green products which a country is best positioned to produce and export.

Within product space, product groups are classified according to SITC-4 at the 4-digit level.[2] For any given country, product space can be visualized in a two dimensional network representation wherein each product occupies a node (shown as a filled-circle) of size proportional to the product's share of the country's total exports (or alternatively by the product's share of world exports), and color corresponding to the category of the product (e.g., textile, machinery, chemicals, electronics, etc.). However, when a country has a revealed comparative advantage for exporting a given product, the product node is depicted as a black square. Also, when a country does not export a particular product it is depicted by an unfilled circle.

Revealed comparative advantage

A country A is said to have a revealed comparative advantage in a product i when its ratio of exports of product i (X_{Ai}) to its total exports of all goods ($\Sigma_j X_{Aj}$) exceeds the ratio of world exports of product i (X_{Wi}) to total world exports of all goods ($\Sigma_j X_{Wj}$). Mathematically, this condition is met when:[3]

$$RCA = \frac{X_{Ai} \Big/ \sum_j X_{Aj}}{X_{Wi} \Big/ \sum_j X_{Wj}} \geq 1$$

When a country has a revealed comparative advantage for a given product (RCA ≥1), statistically, it is identified to be a competitive producer and exporter of that product relative to a country producing and exporting that good at or below world average efficiency. We consider a country with a revealed comparative advantage in product i to have an export strength in that product. The higher the value of a country's RCA for product i, the higher its export strength in product i.

* This note has been prepared to support discussions at UNCTAD's Ad Hoc Expert Meeting on The Green Economy: Trade and Sustainable Development Implications, 8–10 November 2011, Geneva, Switzerland.

[1] Hidalgo, C., and R. Hausmann, 2009, "The Building Blocks of Economic Complexity", Proceeding of the National Academy of Science, 106(26), pp.10570-10575.

[2] This nomenclature and level of disaggregation was used by Hidalgo and Hausmann. In principle, however, product groups can be plotted in product space using any nomenclature (i.e., HS) and at the 6-digit level of disaggregation.

[3] Balassa, B., 1986, "Comparative Advantage in Manufactured Goods: A Reappraisal", The Review of Economics and Statistics, 68, pp. 315-319.

Within the two dimensional network representation that characterizes product space, products that are situated close to each other, and connected by a link, are known to be strongly correlated in countries' export profiles based on historical world trade data. When one product is produced and exported there is a high propensity for the other nearby product to be produced and exported as well (see Hidalgo and Hausmann for further details). Product space maps thus show that countries tend to diversify through closely related products: as a country diversifies its export base it often tends to increase exports in similar products which are in close proximity in product space to products which it already produces and exports. Much more rarely it diversifies from already exported products into dissimilar products that are located far from the former in product space. If it is to diversify into dissimilar products, it will need to make a big leap across product space, and observations of empirical data show this is uncommon.

There could be many reasons for the close proximity of products in product space. For example, among other reasons, nearby products may require the same inputs, share the same or similar production processes, or in the case of agricultural goods and minerals, they may share common geographical, climatic or geological factors related to their natural occurrence or production. Factors influencing the proximity of products in product space may also be related to downstream marketing and distribution channels. For example, exporters linked to distribution networks for oranges may also respond to demand in their distribution channels for grapefruits by introducing and increasing the production and export of the latter over time.

UNCTAD's approach to analyzing countries' export potential for green products

The analytical approach being used at UNCTAD to identify green products of export interest to individual developing countries is based on delineating green products in product space and assessing their proximity to products in which a country has export strengths. Of the many and varied green products that can be identified in a country's product space, UNCTAD's analysis can help policymakers and other stakeholders to identify which ones the country may best be placed to export, and in this way help policymakers select winners rather than losers when formulating green economy development strategies and industrial policy to support green growth.

To introduce the concepts described above and introduced UNCTAD's approach to analyzing countries' export potential for green products, we examine the simplified product space of a hypothetical country 'Terra' as shown in Figure 1. This allows us to illustrate the basic features of product space.

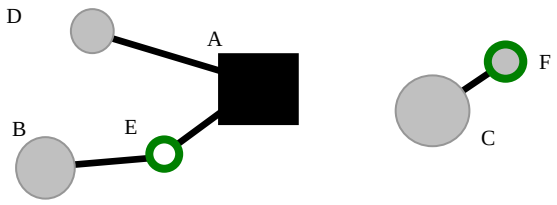


Figure 1. Simplified product space of Terra, see text.

The product space map of Terra shows that Terra exports all of the products A-F except E (unfilled circle) which is not exported by Terra. Green goods are depicted in the figure as product nodes (i.e., circles) with a green colored outline; namely products E and F. It can be seen from Figure 1 that Terra's largest exports are product A and C and its smallest exports are E and F. Terra has a revealed comparative advantage in the production and export of product A (black square which denotes an RCA ≥ 1), but none of the other products. Noticing the close proximity of products A and E, and recalling that Terra has a comparative advantage in exporting product A, strongly suggests that Terra may be well positioned to build productive capacity in, and competitively export the green product E. Terra policymakers and other national stakeholders could take a closer look at prospects for supporting national firms to produce and export product E. On the other hand, the green product F, which is already exported by Terra in relatively small quantities, is not an export for which Terra has an RCA ≥ 1. Policymakers and other national stakeholders could take a closer look at whether in recent years Terra's RCA for product F has increased and whether it is close to or approaching a value of 1.

The product space map

A product space map for the world is shown in Figure 2. From an examination of the product space map several observations can be made. First, the size of a product node is proportional to its share of world exports. Second, products are classified by color, using a different color for each product class, according to the product class they belong to. Products in the same classes lie close to each other and often form clusters. Third, links between products in different classes are always weaker than links between products in the same class. Lastly, none of the nodes in Figure 2 are shown as black squares (denoting and RCA ≥ 1) since the world itself does not have revealed comparative advantages in particular products, only individual countries do. It is also important to keep in mind that product space maps describe the situation of product exports at a given instant in time, and that from one year to another, the size of product nodes, as well as their RCA values will change. Keeping in mind these general features of product space, one can examine and interpret the product space map of individual countries.

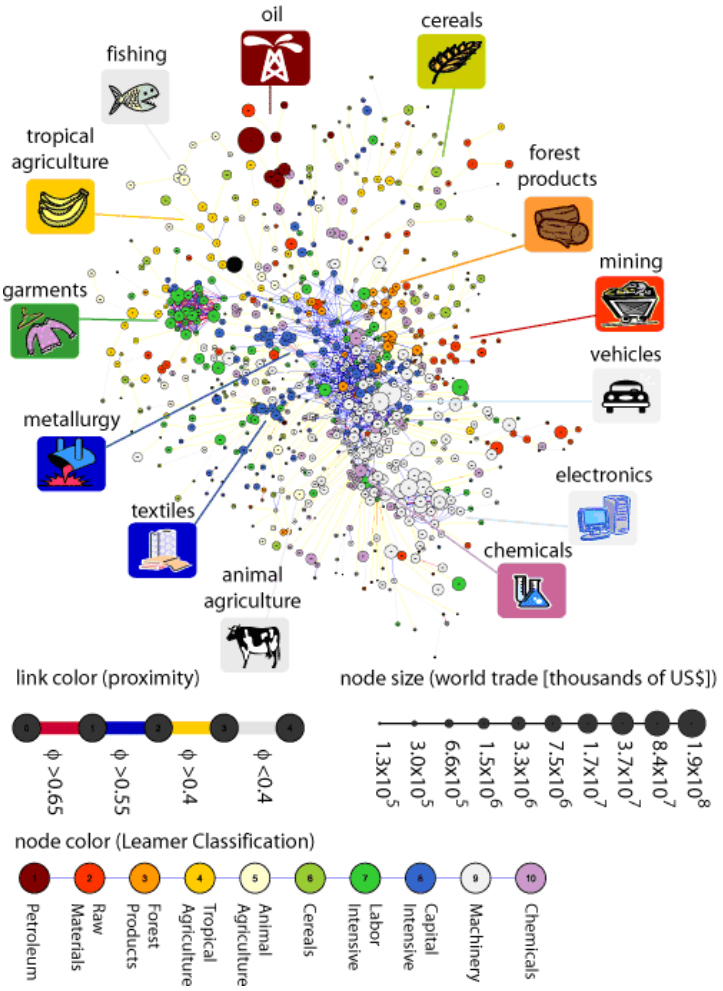
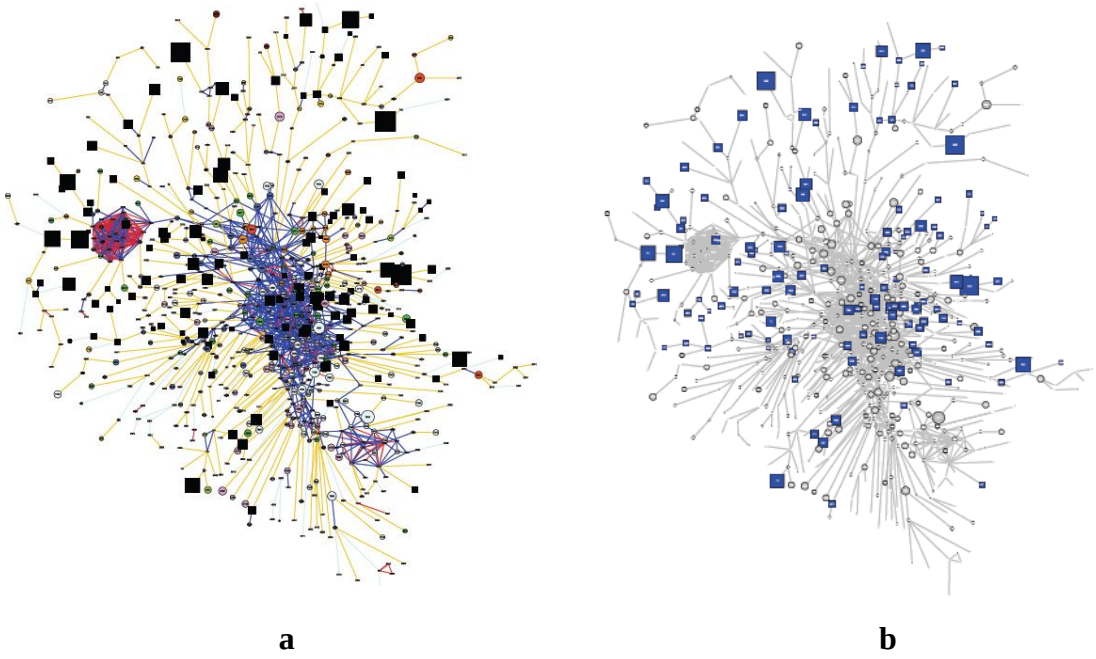


Figure 2. Product space map of the world in 2000. Source: Hidalgo and Hausmann (2009).

Examining the product space map of individual countries

A product space map can be produced for any country, but simply for the purposes of demonstration, we present the product space map of one country, Brazil, the host of the Rio+20 UNCSD. The product space map of Brazil is presented in Figure 3 using 2009 trade data. The product space map is shown in color in Figure 3a. For ease of viewing, in Figure 3b the colors of all product nodes for which Brazil does not have a revealed comparative advantage have been greyed-out, and all black squares representing product nodes in which Brazil is a competitive producer (i.e., RCA ≥ 1) have been changed to blue. Each product node is labelled by its 4-digit SITC 4 code (only visible when zooming in on product space map at higher magnification). Product node sizes are proportional to Brazil's export volumes.



a **b**

Figure 3. Product space map of Brazil in 2009 (see text).

Brazil's product space map clearly shows that Brazil has a very diversified export base with a revealed comparative advantage in the products in many different classes across product space. It is important to note that most of these products are also in close proximity to each other, and many are linked, although there some of these products seem to be isolated. It also shows that Brazil is an efficient trader because such products account for a predominant share of its total exports, which is expected according to the Ricardian theory of comparative advantage.

In order to see a country's export profile for environmental goods it is first necessary to define a set of environmental goods. To date there is no internationally agreed definition or list of environmental goods. Interest in international agreement on a definition and list of environmental goods emerged in the WTO Doha Round of negotiations with a view of reducing trade barriers, including applied tariffs, for environmental goods at the global level. Despite nearly 10 years of effort by the WTO Committee on Trade and Environment (CTE) a list of environmental goods for trade purposes remains elusive. However, recently in April 2011, the CTE presented, on an illustrative and starting-point basis, without prejudice to the final outcome of negotiations, a core set of environmental goods identified by group of WTO members.[4] This core set of environmental goods contains 26 tariff lines drawn from the reference universe of over 400 tariff lines proposed by Members to the CTE.

Features of Brazil's export profile as it relates to environmental goods, i.e. green products, is not immediately apparent from Figure 3. However, these features can be highlighted by depicting product nodes which contain environmental goods as large green circles in the product space map. Here, for the purposes of illustration, the 4-digit SITC-4 product groups containing 9 of the 26 goods included in the CTE core list of environmental goods, along with two other product groups (containing biofuels, i.e., ethanol, and energy efficient lighting products) are used to define 11 'green' product nodes. In Figure 4 these 11 product groups are depicted as large green circles in the product space map. This figure can be referred to as a 'green product space map'. It must be recognized, however, that the green product groups in Figure 4 are only a selected subset of a larger group that could be defined.

[4] WTO, 2011, Committee on Trade and Environment in Special Session, Document TN/TE/20, 21 April 2011.

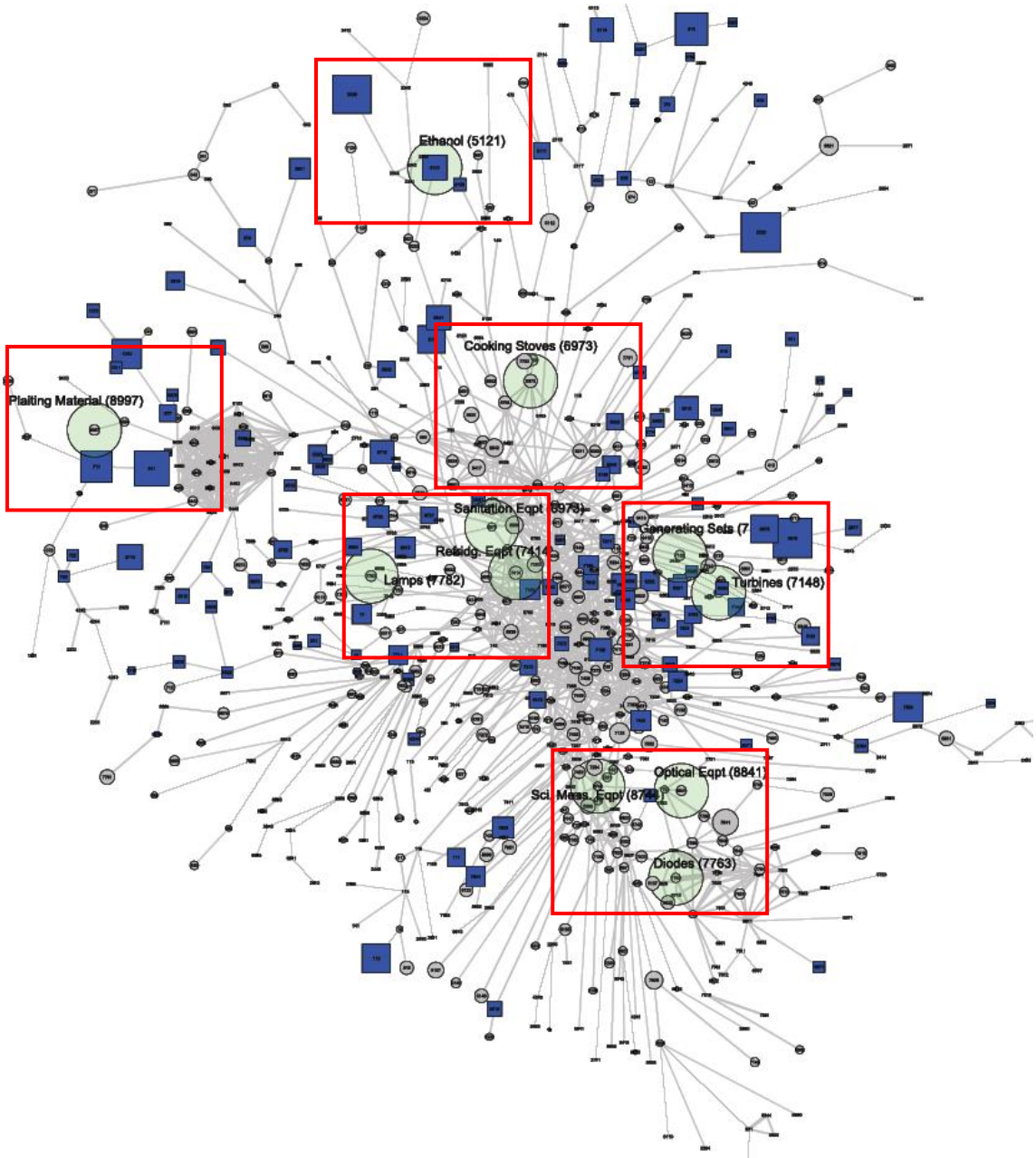


Figure 4. Green product space map of Brazil in 2009. Zoom images of the areas in the red squares are presented in Figure 5. The 11 green product groups depicted in the green product space map are listed in Table 1.

SITC4	HS2002	SITC4	Category
8997	4601	Basketware, wickerwork and other articles of plaiting materials…	Waste management
6973	7321	Cooking or heating apparatus of a kind used for domestic purposes…	Energy efficiency
6975	7324	Sanitary ware, and parts thereof, … of iron, steel, copper or aluminum	Waste management
7148	8410/11	Turbines	Energy efficiency
7414	8418	Refrigerating equipment (electric or other), other than household-type…	Renewable energy
7162	8502	Electric generating sets	Renewable energy
7763	8541	Diodes… and semiconductor devices (including photovoltaic cells…	Renewable energy
8841	9001	Optical fibres... prisms, mirrors and other optical elements…	Renewable energy
8744	9027	Instruments and apparatus for physical or chemical analysis …	Environmental analysis
5121	2207	Acyclic alcohols & their halogenated derivatives	Renewable energy
7782	8539	Electric filament lamps and discharge lamps	Energy efficiency

Table 1: Selected green product groups (see text)

Figures 4 and 5 allow a visual scoping analysis to be done to identify green product groups with promising export potential. The configuration of Brazil's product exports, relative volume as a share of

Brazil's total exports (size of product node), the similarity of products exported (proximity), and the likelihood of exporting two products in proximity (links between the two products) are shown in Figures 4 and 5. The zoom views of Brazil's product space map provide sufficient detail for a visual analysis of Brazil's potential to enhance export capacity in the green products listed in Table 1.

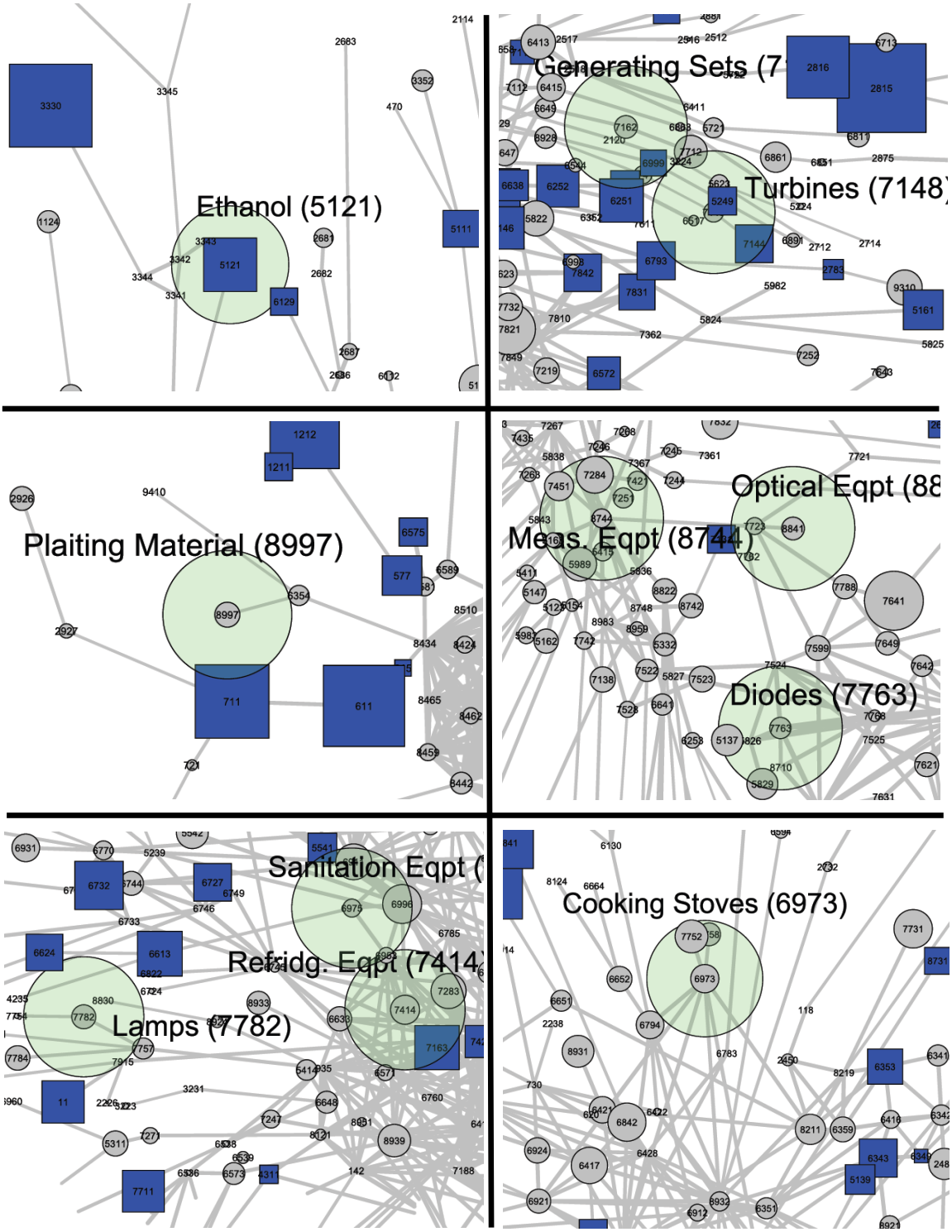


Figure 5. Zoom views of green product space map of Brazil in 2009.

The zoom views of Figure 5 show that Brazil exports in all of the green product groups listed in Table 1, but that Brazil only has a revealed comparative advantage in the export of ethanol. Several product groups (turbines, optical equipment, plaiting materials and refrigeration equipment) are located in close

proximity to other product groups for which Brazil has a revealed comparative advantage. The green products in the former product groups (turbines, optical equipment, plaiting materials and refrigeration equipment) could be examined more closely through additional analyses and investigation as potential candidates for enhancing competitiveness and further development of production and export. National firm level analysis and focussed discussions between firms and national policymakers would be needed to validate and extend the scoping analysis provided through the product space mapping exercise presented here.

Limitations of green product space maps

The analysis of product spaces to identify green export strengths has limitations which should be clear to policymakers. Product space maps exports of goods only and does not include services. Additionally, the scope of the analysis limits itself to exported goods: it provides no information on the domestic production and consumption of these goods. This implies that there may be products for which a country is an efficient and internationally competitive producer, however, the country may not be exporting these goods in quantities large enough for a revealed comparative advantage to be indicated (i.e., the product is 'under-exported').

Another caveat is intrinsic to the classification systems used for product groups and products. Product space maps are created using 4-digit classification code resolution, and many different subtypes of products exist for each 4-digit code. Even while featuring in the WTO EGS list, many of 4-digit categories encompass products with multiple possible usages (not necessarily only in green sectors).

In both in SITC-4 and in the HS product classification systems there is no differentiation of products based on how they are produced – i.e., by environmentally and socially sustainable methods or not. In reality, however, products can be produced in different ways (e.g., conventional vs. organic apples or conventional vs. certified sustainable ethanol). The current classification systems cannot therefore distinguish between, for example, organic and non-organic agricultural products in international trade.

There is also an issue of static and dynamic perspectives. International trade is highly competitive and shares of countries' exports in different markets often vary considerably over time, including from one year to another for some products and countries. However, product space maps for individual years are static and do not capture intertemporal changes in RCAs. For a product or product group within a country the RCA might be greater than one but steadily decreasing over time (the country is losing its competitive edge to other world producers) or less than one but steadily increasing over time (the country is gaining a competitive edge over other world producers). In the latter case, the RCA on a product space map may be lower than one but hide the fact that the index is rising throughout the years, meaning a country is becoming more competitive in the production and export of a certain product category. The magnitude of RCA also matters - while a square is plotted for any RCA above one, a value of three would mean a much stronger competitive position in a certain sector, while no sign of this information would be apparent in the map itself. It is therefore important to compare maps in perspective, keeping all of these considerations in mind.

Product space analysis is scoping tool. It is in no way a substitute for conventional tools guiding industrial policy, but instead a complementary lens through which countries can better and quickly identify green product sectors where they appear to have a high chance of developing sustainable and profitable engagement.