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Sector relatedness, revealed comparative advantages and production in global value chains

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Abstract

State of the art

A new way of thinking for a new economy is emerging; from a traditional approach based on final goods and services, to a global chain approach based on specific tasks and trade of intermediate goods. Previous research has exploited trade data to identify patterns of product relatedness based on common required capabilities that could guide diversification strategies. In particular (Hidalgo, Klinger et al. 2007) build a product space that relies on the fact that revealed comparative advantages are a reflection of a country pool of capabilities. However, in the 21st century trade, goods and services are the combination of capabilities and resources from different countries; making export data an imperfect measure of country capabilities (Baldwin 2008). Input-Output (I-O) tables are instead, a rich source of information to understand the position of countries on the international supply and value added chain. Measures of vertical specialization (Hummels, Ishii et al. 2001) and value added exports (Johnson and Noguera 2012) can be used to understand specialization patterns and returns appropriation along the global value chain (GVC).

Research gap

In a globalized world, it would be necessary to identify the contribution in value added of countries in the production of specific goods and services to indirectly measure existent capabilities. Taking advantage of linked input- output data, this paper contributes on that direction, exploring structural differences between the network of sectors based on gross exports, and the sector space based on value added exports. Such distinctions are informative about the way that potential patterns of related diversification are understood under diverse production modes at the global level. This paper takes an empirical approach to understand how important is the gap between trade statistics and domestic value added content of exports, and what is the effect of such gap on both, perceived competitiveness of countries; and sector relatedness.

Theoretical arguments

As the position along the GVC has an strategic value, changes from low value added segments to high value added ones characterize growth patterns were returns appropriation are higher. In a world were countries are specialized in particular tasks, the kind of products and the stage in which a country adds value in their production process, are important to identify paths for diversification and growth. Under this perspective, structural change is constrained both by

the kind of capabilities accumulated by a country, and the pattern of linkages among products.
Method
Recently released World Input Output Database (WIOD) covering 40 countries plus an estimation of the rest of the world, and 35 sectors for the period 1995-2009 is used to carry a full decomposition of gross exports in value added components, following (Koopman and Wang 2012) methodology. Balassa Reveal Comparative Advantage (RCA) indexes at sector- country level constitute the basis of sector networks, where sector linkages are cosine similarities based on value added exports. Network structure analysis is implemented, to understand similarities and differences between sector networks based on gross and value added exports. Patterns of connectivity, centrality and assortativity are studied from 1995 to 2009.
Results
Preliminary results reveal an increase in production fragmentation at the country level during 1995 - 2009. The increased specialization of countries in specific segments of the GVC translates into a higher gap between gross and value added exports. The gap is considerably higher in manufacturing activities than in other sectors. However, such gap is not uniformly translated into differences in the distribution of revealed comparative advantages among countries. At the sector level a high degree of heterogeneity among sectors indicate that ordinal differences between both indexes can be quite high at lower levels of disaggregation. The fact that even at the sector level, it is possible to find important differences in the pattern of relatedness among sectors, raises questions about the accuracy of RCA based on gross exports as indirect measure of capabilities in a country.

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SECTOR RELATEDNESS, REVEALED COMPARATIVE ADVANTAGES AND PRODUCTION IN GLOBAL VALUE CHAINS

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1. INTRODUCTION

Nowadays, the existence of a global economy, were production geographical frontiers are difficult to define and interdependence is the rule seems to be a reality. Globalization process has been pushed forward in the last two decades almost everywhere, increasing trade openness and changing the previously existent modes of production. Scholars are aware of these changes and actively seek better ways to address the role of countries in the global production chain, were specialization appear to be the prevalent strategy. Yet, a successful strategy depends on where a country places itself along the global production chain, given that not all the segments provide an equal opportunity to appropriate returns.

The capacity to appropriate returns appears to be strongly related to value added creation. In that sense, global production can be viewed as a global value chain (GVC) were the necessary value to create a final product, is added in a series of linked stages were diverse actors play a distinct role. In a globalized world those actors can be located in different countries, creating diverse patters of rents appropriation and growth. From an empirical point of view this way of production pose some challenges on offices collecting trade data and researchers using that data to understand the role of countries on international trade. In particular, exports statistics can overestimate the value added on an export country, by ignoring all the previous stages and locations were value was added before in the production of a particular good (Johnson and Noguera 2010). Still, trade statistics are a quite complete in coverage and detailed source of information, and are used to carry all kind of empirical studies on diversification and growth. The lack of alternative sources have only recently been addressed by collecting data into harmonized interregional input output databases covering more than one year.

As the position along the GVC has a strategic value, changes from low value added to high value added segments characterize growth patterns were returns appropriation are higher. In a world were countries are specialized in particular products, the *kind* of goods and services produced by a country are important to determine possible paths for diversification and growth. This fact has been highlighted by the *product space* literature, based on the idea of product relatedness. The intuition is that a specific set of capabilities is required to produce a precise good, but commonalities can be found among them; countries can benefit from exploiting those commonalities when choosing higher value added goods. A network perspective is needed to identify opportunity avenues in the space of products that could be availed given the existent capabilities of a country. Under this perspective, structural change is constrained both by the kind of capabilities accumulated, and the pattern of linkages among products. Product relatedness is defined by common required capabilities for production that are in general costly to acquire and cumulative by nature. In consequence, possible paths for related diversification can be understood by the study of the network properties of the product space.

At the empirical level, measuring product relatedness is a sensible task. It involves finding an accurate measure of capabilities to be compared across products. Taking an indirect approach, trade statistics have been used to approximate existent capabilities on countries. The export structure of a country and the level of competitiveness of those exports are used as a proxy of its capabilities; a country able to successfully produce and sell a product in the international market is revealing to have the necessary capabilities to do it. However, this is only true in a world where the exported good is entirely produced and sold by one country. In a globalized world, it would be necessary to identify the contribution in value added of countries in the production of specific goods and services to indirectly measure existent capabilities. A GVC view is needed to isolate the role of individual countries in the global production of goods and services. Taking advantage of linked input- output data, this paper contributes on that direction, exploring structural differences between the network of sectors based on gross exports, and the sector space based on value added exports. Such distinctions are informative about the way that potential patterns of related diversification are understood under diverse production modes at the global level.

In detail, this paper takes an empirical approach to understand how important is the gap between trade statistics and domestic value added content of exports, and what is the effect of such gap on both, perceived competitiveness of countries; and sector relatedness. Recently released World Input Output Database (WIOD) for the period 1995-2009 (Ray, Barney et al. 2004, Timmer 2012) is used to track different stages of value creation taking place in specific countries and build the sector network. After this introduction, a brief description of related literature is done, followed by a methodological note. The second part of the paper presents the results, starting by the observed patterns of production fragmentation from 1995 to 2009, and the comparison of Balassa Reveal Comparative Advantage (RCA) indexes at country – sector level based on gross and value added exports. A characterization of sectors and countries based on ubiquity, diversity and average ubiquity and diversity is the starting point to understand the structure of sector networks build both for gross exports statistics and value added exports data. Finally network structure analysis is implemented, to understand similarities and differences between both sector networks; patterns of connectivity, centrality and assortativity are studied from 1995 to 2009. The final section presents and discusses the main conclusions.

2. Related Literature

A new way of thinking for a new economy. That is what a number of researchers on international and development economics increasingly claim. To go from a traditional approach based on final goods and services to a global chain approach based on specific tasks and trade of intermediate goods. In particular (Kaplinsky 2000) highlights the importance of value chain analysis to understand the determinants of income distribution in a globalized economy. According to Kaplinsky, the value chain approach transcends economic sectors making possible the study of rent dynamics and the appropriation of returns. Consequently, the identification of income generation opportunities is better done by a value chain analysis with a global focus, rather than by national industry studies. This is what (Baldwin 2008) call the perspective of 21st century trade and industry; under this view, international supply chains are key to understand the road of nations to development. Goods and services are the product of combined capabilities and resources from different countries, specialized along the supply chain. The role of countries in the international trade sphere cannot be approximated using only trade data, more detailed information about their specific role along the value chain is necessary.

More accurate measures are needed to analyze international trade. Input-Output (I-O) tables are a rich source of information to understand *how things are done*, *who does what* and *who demands what* especially if they are combined with trade data. In particular they can be used to understand the position of countries on the international supply and value added chain, disentangling its trade pattern (Baldwin 2008). A first measure of *vertical specialization* (VS) is proposed by (Hummels, Ishii et al. 2001)(HIY) at the sector level to quantify the use of imported inputs in a country exports. If a country only exports final goods, but imports intermediate goods for their production, and the use intensity of imported inputs is the same for products sold in the international and national market; the VS index is a measure of the foreign content of exports. Using data for ten OECD and four emerging countries from 1968 to 1990 (Hummels, Ishii et al. 2001) finds VS accounted for 20% of exports in OECD countries, and 40% of exports in smaller countries in 1990.

Using trade data and IO tables for use and destination countries, (Johnson and Noguera 2012) generalize the HIY index allowing by two-way trade in intermediates. Taking a bilateral approach, they calculate value added flows to determine *value added exports,* defined as the total value added (direct and indirect) produced in a sector in a given country that is absorbed in a different country (destination); and *VAX ratio* defned as the bilateral value added to export ratio. The VAX ratio is a measure of the intensity of production sharing in a sector or country. Johnson ad Noguera use the Global Trade Analysis Project (GTAP) database for 2004, and find that value added exports represent 73% of gross exports. Bulding on previous work, (Koopman, Wang et al. 2012) elaborate a formal full decomposition of exports relating domestic value added exports, foreign content of exports and the double – counting portion of value contained on gross exports. Their methodology allows to relate gross exports and value added exports to efectively track value added flows at the country level. In particular they improve the *value added exports* measure by the identification of *domestic content that returs home* included in the VAX ratio proposed by (Johnson and Noguera 2012).

Trade data has been exploited to identify the number of capabilities owned by different countries and to find potential products to guide diversification strategies, based on the similarity among products according to the capabilities that they utilize. In particular (Hidalgo, Klinger et al. 2007) develop a measure of proximity among products based on RCA indexes of countries in each product market. Two products are considered to be close to each other in the *product space,* if the probability of find them together in a country export basket is high. The assumption is that a country revealed comparative advantage in a particular product measured by exports, indicates that such country has *all* the required capabilities for its production. However, as (Baldwin 2008) points out that assumption is no longer true in the 21st century trade.

Relatedness among products is used by (Hidalgo and Hausmann 2009) to quantify the amount of available capabilities in a country and classify products and countries according to their complexity degree. The proposed measure use recursively indicators of *ubiquity* of products, and *diversity* of countries to find out which products require a bigger number of capabilities for their production and which countries are capable of produce them (Hausmann, Hidalgo et al. 2011). A complete map of products and country locations can be developed to understand patterns of development using trade statistics. The existence of new measures to identify *value added exports* at country and sector level open a opportunity window to explore in a more accurate way similarities among sectors under a international value chain view.

3. DATA

A World Input Output Table (WIOT) describes the supply-demand relationships between sectors around the world. It follows the same principle than a traditional IO table, were products can be either used as intermediate inputs or in final consumption, including final domestic use (private and public consumption and investment) and exports. On an industry by industry IO table, the columns contain the value of all intermediate, labor and capital inputs used in the production. A WIOT is then a harmonized construction based on IO national tables were the use and production in each sector is broke down according to their country of origin and destination.

This paper uses the WIOD database, build by a group of researchers at Groningen University. The WIOD has coverage of 40 countries plus an estimation of the rest of the world, and 35 sectors for the period 1995-2009. An interesting feature of the database is the time series availability of WIOT tables; to ensure time consistency the WIOD use country time series on gross output, value added by industry, total imports and total exports and final demand by category from national accounts as benchmark of annual disaggregated data. Basic data on supply and intermediate demand of products by each domestic industry and final use of products comes from national supply and use tables (SUTs). Data on international trade corresponds to import flows at the HS 6 -digit product level coming from the UN COMTRADE database. Bilateral services trade flows have been collected from the UN, Eurostat, and OECD and integrated after consistency checks (Timmer 2012).

To build the WIOD, time series of SUTs were generated based on both publicly available time series on production and final demand, and national SUTs by the SUR-RAS method at basic and purchaser's prices. In a second step the use table is breakdown into domestic and foreign origin, by splitting total imports of products across use categories by share (intermediate, final or investment) for each product as appear in SUTs tables. Within each use category, the allocation of imports is done by the standard proportionality method. Finally the SUTs are combined into an industry to industry WIOT using a fixed product-sales structure, to ensure consistency of data exports are defined as mirror flows of imports (Timmer 2012).

4. METHODOLOGY

To be able to compare the network properties of the sector space under a 20th century trade view, with those of a network of sectors under a 21th century trade perspective, several steps need to be followed. The first step is to distinguish between gross exports and value added exports, it is necessary to decompose gross exports into value added in the exporting country plus value added in other countries; this decomposition should be carried at the country and sector level. The second step is to identify the structure and evolution of comparative advantages of countries in different sectors; computation of indexes of revealed comparative advantage should be carried based both on gross exports and value added exports. Those indexes will be used to study general patterns of diversification and product ubiquity. The fourth step is to build the network of sectors; an indirect approach is taken to quantify sector linkages via gross exports and value added exports, a cosine similarity indicator is used to allow an efficient use of information. A fifth and final step involves the comparison between both networks based on their structural characteristics. Patterns of connectivity, assortativity and centrality are studied.

GROSS EXPORTS DECOMPOSITION AND VALUE ADDED EXPORTS

Gross exports decomposition into value added components follows the method proposed by (Koopman and Wang 2012). The method use a mathematical framework to express gross exports at country level as the sum of vale added exports and various other components that account for value added double counting. Calculations are based on a inter country input output model for G countries, and N differentiated tradable sectors. In each sector, goods can either be consumed or used as intermediate inputs; and each country can export final and intermediate products to all other countries. In block matrix notation the model can be written as:

$$(1)\quad \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_G \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & \dots & A_{1G} \\ A_{21} & A_{12} & \dots & A_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ A_{G1} & A_{G2} & \dots & A_{GG} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_G \end{bmatrix} + \begin{bmatrix} Y_{11} + Y_{12} + \dots + Y_{1G} \\ Y_{21} + Y_{22} + \dots + Y_{2G} \\ \vdots \quad \vdots \quad \ddots \quad \vdots \\ Y_{G1} + Y_{G2} + \dots + Y_{GG} \end{bmatrix}$$

Where X_s is the Nx1 gross output vector of country s, Y_{sr} is the Nx1 vector of demand in country r for final goods produced in s, A_{sr} is the NxN coefficient matrix of intermediate use in country r of goods produced in country r.

Rearranging:

$$(2)\quad \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_G \end{bmatrix} = \begin{bmatrix} 1 - A_{11} & -A_{12} & \dots & -A_{1G} \\ -A_{21} & 1 - A_{12} & \dots & -A_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ -A_{G1} & -A_{G2} & \dots & 1 - A_{GG} \end{bmatrix}^{-1} \begin{bmatrix} \sum_r^G Y_{1r} \\ \sum_r^G Y_{2r} \\ \vdots \\ \sum_r^G Y_{Gr} \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} & \dots & B_{1G} \\ B_{21} & B_{22} & \dots & B_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ B_{G1} & B_{G2} & \dots & B_{GG} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_G \end{bmatrix}$$

Where, B_{sr} is the NxN total requirement matrix, which is the amount of gross output of country s (producer), required to by one-unit increase in final demand in country r (destination). Y_s is the global demand vector of final goods from s. The block matrix inverse is used to decompose gross output by source country and final destination as a first step to track how value added goes from one country to another. This is done pre multiplying the final demand vector by the Leontief matrix:

$$(3)\quad \begin{bmatrix} B_{11} & B_{12} & \dots & B_{1G} \\ B_{21} & B_{22} & \dots & B_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ B_{G1} & B_{G2} & \dots & B_{GG} \end{bmatrix} \begin{bmatrix} Y_{11} + Y_{12} + \dots + Y_{1G} \\ Y_{21} + Y_{22} + \dots + Y_{2G} \\ \vdots \quad \vdots \quad \ddots \quad \vdots \\ Y_{G1} + Y_{G2} + \dots + Y_{GG} \end{bmatrix} = \begin{bmatrix} \sum_r^G B_{1r} Y_{r1} & \sum_r^G B_{1r} Y_{r2} & \dots & \sum_r^G B_{1r} Y_{rG} \\ \sum_r^G B_{2r} Y_{r1} & \sum_r^G B_{2r} Y_{r2} & \dots & \sum_r^G B_{2r} Y_{rG} \\ \vdots & \vdots & \ddots & \vdots \\ \sum_r^G B_{Gr} Y_{r1} & \sum_r^G B_{Gr} Y_{r2} & \dots & \sum_r^G B_{Gr} Y_{rG} \end{bmatrix}$$

$$= \begin{bmatrix} X_{11} & X_{12} & \dots & X_{1G} \\ X_{21} & X_{22} & \dots & X_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ X_{G1} & X_{G2} & \dots & X_{GG} \end{bmatrix}$$

The last matrix at the right of equation 3 is the "gross output decomposition matrix" each element in the matrix X_{sr} is a Nx1 vector of gross output in source country s, necessary to sustain final demand in destination country r. An element in the diagonal X_{ss} is gross output produce and absorbed in country s. Now value added is decomposed by source and destination:

$$(4)\ \hat{V}\mathrm{BY} = \begin{bmatrix} \widehat{V_1} & 0 & \dots & 0 \\ 0 & \widehat{V_2} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \widehat{V_G} \end{bmatrix} \begin{bmatrix} X_{11} & X_{12} & \dots & X_{1G} \\ X_{21} & X_{22} & \dots & X_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ X_{G1} & X_{G2} & \dots & X_{GG} \end{bmatrix}$$

Where $\widehat{V_s}$ is a NxN diagonal matrix of direct value added coefficients. Each element of $\widehat{V_s}$, gives the ratio of domestic value added in total output for country s. Pre multiplying the "gross output decomposition matrix" by $\hat{V}$, we obtain a value added production matrix $\hat{V}$BY. Each element on the $\hat{V}$BY diagonal is the value added produced and absorbed in the same country. Each element outside the diagonal $\widehat{V_s}X_{sr}$ is the value produced in source country s and absorbed in destination country r, the definition of value added exports $\hat{V}T_{sr}$. The total value added exports to the world of country s equal:

$$(5)\ \ \hat{V}T_{s*} = \sum_r^G \hat{V}T_{sr} = V_s \sum_{r \neq s}^{G} \sum_{g=1}^{G} B_{sg}Y_{gr}$$

Notice that:

$$(6)\ \sum_s^G V_s B_{sr} = u$$

Where V_s is the 1xN direct value added coefficient vector of country s; $V_r B_{rr}$ (1xN) is the share of country r value added, needed to produce one unit of product in country r; and $V_s B_{sr}$ is the share of country s value added needed to produce one unit of product in country r.

Total gross exports from country s:

$$(7)\ E_{s*} = \sum_{r \neq s}^G E_{sr} = \sum_{r \neq s}^G (E_{sr}X_r + Y_{sr})$$

Can be expressed as the sum of domestic value added exports and foreign value added exports:

$$(8)\ uE_{s*} = V_{ss}B_{ss}E_{s*} + \sum_{r \neq s}^G V_r B_{rs} E_{s*}$$

(Koopman and Wang 2012) show that this is equivalent to:

$$(9)\quad uE_{s*} = \hat{V}T_{s*} + \{V_s \sum_{r \neq s}^{G} B_{rs}Y_{rs} + V_s \sum_{r \neq s}^{G} B_{sr}A_{rs}X_s\} + \{\sum_{t \neq s}^{G} \sum_{r \neq s}^{G} V_t B_{ts} Y_{sr} + \sum_{t \neq s}^{G} \sum_{r \neq s}^{G} V_t B_{ts} Y A_{sr} X_r\}$$

The first term in equation 9 is value added exports; the second term in brackets is value added in final and intermediate goods that is first exported, but eventually returns and is absorbed at home; the third term is foreign value added in exports both in final and intermediate goods. This last equation relates gross exports and value added exports in a clear way that can be used to calculate each component at the country level.

REVEALED COMPARATIVE ADVANTAGE, AND SECTOR RELATEDNESS

Gross and value added exports at sector- country level are used to calculate Balassa Reveal Comparative Advantage (RCA) indexes:

$$(10)\ RCA^{sp} = \frac{X_{sp}}{\sum_{p=1}^{N} X_{sp}} \Bigg/ \frac{\sum_{s=1}^{G} X_{sp}}{\sum_{s=1}^{G}\sum_{p=1}^{N} X_{sp}}$$

Where X_{sp} denotes country s exports of product p; when gross exports are used the index is denoted as RCAg, if value added exports are used the index is called RCAv. In general, a country is considered to have a comparative advantage in a sector if the RCA index is greater than one, meaning that such sector is relatively more important for that country than for the average country in the world. This basic measure will be used to study both the structure of comparative advantages for countries in the database, and the pattern of relatedness among sectors.

Following (Hidalgo and Hausmann 2009), diversification and average ubiquity of countries, and ubiquity and average diversification of sectors are computed to explore the possible relationship between this two characteristics of countries and sectors. An adjacency matrix M_{sp} summarizes the connections between countries and the sectors in which they export. $M_{sp} = 1$ if country s exports products in sector p with an RCA above one; $M_{sp} = 0$ otherwise. Then, diversification of country s:

$$(11)\ k_{s,o=} \sum_{p=1}^{N} M_{sp}$$

Ubiquity of sector p:

$$(12)\ k_{p,o=} \sum_{s=1}^{N} M_{sp}$$

Average ubiquity of sectors in which country s exports:

$$(13)\ k_{s,1=} \frac{1}{k_{s,o=}} \sum_{p=1}^{N} M_{sp}\, k_{p,o}$$

Average diversification of countries that export in sector p:

(14) $k_{p,1=} \frac{1}{k_{p,o=}} \sum_{s=1}^{G} M_{sp}\, k_{s,o}$

At the product level (Hidalgo and Hausmann 2009) finds a strong negative relation between diversity and average ubiquity of countries, and between ubiquity of products and the average diversification of their exporters. This paper explores this relationship at the sector level for both RCAg and RCAv.

SECTOR RELATEDNESS AND NETWORK STRUCTURE

The structure of possible patterns for related diversification can be understood by approaching relatedness among sectors based on shared required capabilities. Following (Hidalgo, Klinger et al. 2007) idea of product space, this paper takes an indirect approach to quantify such similarities connecting sectors based on revealed comparative advantages. Sector similarity in this context; rely on the assumption that RCA indexes can be interpreted as a measure of existent capabilities required for production in a sector. When relatedness is measured by gross exports, the exporter country is assumed to be the only one responsible for the value added in the production of such good or service. By contrast, relatedness based on value added exports takes into account only the amount of value added supplied by the exporter, subtracting the value directly or indirectly added by other countries in the production of the good or service.

The sector space is an undirected weighted network. Weights of linkages between sectors are calculated by cosine similarity to guarantee the use of all available information concerning revealed comparative advantages (Los 2000). In detail, relatedness between sector a and sector b is defined as:

(15) $$w_{pq} = \sum_{s=1}^{G} RCA^{sp} * RCA^{sq} \Big/ \sqrt{\sum_{i=1}^{G} (RCA^{sp})^2}\ x \sqrt{\sum_{i=1}^{G} (RCA^{sq})^2}$$

Notice that RCA is not used in a binary sense to measure the existence or not of comparative advantages, but as an ordinal indicator of comparative advantages. Sectors p and q are similar if RCA values tend to coincide in several countries. In that sense similarity of two sectors indicates the existence of common required capabilities for their production that are revealed to be present (or absent) in some countries.

Paths of related diversification depend on the structural properties of the sector space. Under both 20th and 21th century trade views, such paths are constrained by the structure of relationships among sectors. For a country specialized in a set of sectors, searching paths for diversification requires to know in first place, which of those sectors are the most intensively connected to others. Rich locally connected sectors offer larger opportunities for diversification than poor connected sectors. For each sector, local connectivity is measured by node strength as:

(16) $s_p = \sum_{q=1}^{N} w_{pq}$

In second place, it would be interesting to know what kind of sectors are similar to well connected ones. If the network exhibits *assortativity mixing*, well connected sectors will be linked to sectors with high similarity intensity, and poor connected sectors will be preferentially attached to sectors with low similarity intensity. If that is the case, diversification paths are divided in *highways* and *country lanes* with *highways* concentrating most of the diversification opportunities in the short and long term. To examine the connectivity of related sectors, the weighted average nearest neighbor degree is used:

(17) $k^{w}{}_{nn,p} = \frac{1}{s_p} \sum_{q=1}^{N} w_{pq}\, k_q$

Where: $k_{p=} \sum_{q=1}^{N} z_{pq}$ is the node degree, and $z_{pq} = 1$ if $w_{pq} > 0$; and $z_{pq} = 0$ if $w_{pq} = 0$. *Assortativity* mixing exists if there is a positive correlation between $k^{w}{}_{nn,p}$ and s_p; if they are negatively correlated, the network exhibit *dissortativity* (Barrat, Barthélemy et al. 2004).

Additionally, a country would be interested in knowing which sectors are more globally connected, because they provide more opportunities for diversification than any other sector in which the country could be specialized. There are many indicators to evaluate global centrality; in this paper *flow betweenness centrality* (Freeman, Borgatti et al. 1991) will be used to identify sectors with high global similarity intensity. The choice of the indicator is done based on the type of flow process that characterize the network, were countries move from one sector to another following trails, and parallel duplication is possible (Borgatti 2005); in this case a centrality measure with a volume property and a medial position is the most appropriated (Borgatti and Everett 2006). Flow betweenness centrality is based on the concept of *maximum flow* or *minimum cut*. A *cut* between two nodes *i* and *q* is a set of edges whose removal from the network disconnects *i* and *q,* its value is the sum of those edge values, and the *minimum cut* is minimum value of all possible cuts between two vertices. Calculations of *flow betweenness* with UCINET software, use the Gomory and Hu algorithm to compute the maximum flow between all pairs of nodes (Borgatti, Everett et al. 2002). In detail, if f_{iq} is the maximum flow from vertex *i* to *q;* and $f^{p}{}_{iq}$ is the maximum flow from *i* to *q* that passes through sector *p*; the degree to which the maximum flow of all possible pairs depends on *p* is:

(18) $\sum_{i}^{n} \sum_{q}^{n} f^{p}{}_{iq \quad for\ (i<q)}$

Flow betweenness is the proportion of maximum flow that depends on the sector *p* (Freeman, Borgatti et al. 1991):

(19) $C_F^p = \frac{\sum_{i}^{n} \sum_{q}^{n} f^{p}{}_{iq}}{\sum_{i}^{n} \sum_{q}^{n} f_{iq}} \quad for\ \ (i < q)$

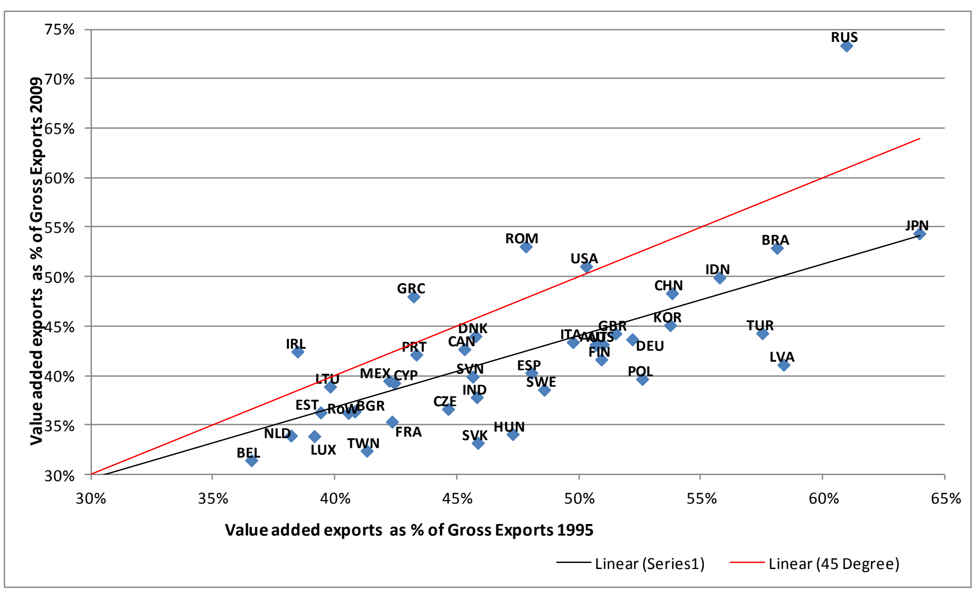
Patterns of connectivity, assortativity and centrality are analyzed in the last section of this paper; covering sector networks from 1995 to 2009, and comparing sector relatedness based on products trade vs. sector similarity based on value added trade.

5. RESULTS

GLOBAL PRODUCTION CHAINS AND GLOBAL VALUE CHAINS, TENDENCIES AND EVOLUTION

On average, value added exports constituted the 76,4% of gross exports in 2008, in 1995 accounted for the 81,8%. For most of the countries in the database, exports decreased their domestic value added content intensity between 1995 and 2009, meanwhile the content of foreign value added of gross exports increased. This finding suggests a more important role of global value chain production in terms of value added for emerging countries via higher vertical specialization. However it is important to notice that changes in the value added content of exports ratio and vertical specialization in this period at country level are in average of two percentage points, which is far from being high enough to conclude that there is a radical change in the way that value added is created in the world. This result is consistent with previous findings using national input-output tables from the OECD Input-Output Database and the IDE-JETRO Asian Input-Output Tables (Johnson and Noguera 2012). On the other hand, the value added content of exports is consistently higher (>80%) in the group of rich countries, including Austria, USA, Japan, France, Germany, Denmark, Finland, Sweden, Australia, Canada and UK. Meanwhile the ratio vertical specialization is always less that 20% for the same countries.

Figure 1 Value added exports as % of Gross exports in manufacturing, by country, 1995 and 2009.



Production fragmentation have had a higher impact on the manufacturing sector, where the production of goods can be easily divided on different stages and those can be developed by independent producers located anywhere. In this sector, the value added content of exports decreased more in countries where it was relatively in 1995. This means that countries were fragmentation was less intense experienced a bigger impact of foreign value added exports, than countries were the process of fragmentation was already advanced in 1995.

In the case of Agriculture, Mining, and Services sector; due to the nature of this activities, it is expected that almost all the content of gross exports is due to domestically created value added. This is true for almost all countries; however, it is possible to find evidence of augmented fragmentation in 2009 with respect to 1995 as well. The role of agriculture in some countries, but especially of services as supporting activity for direct exports of other products is highlighted by value added exports.

COMPETITIVENESS REVISITED: REVEALED COMPARATIVE ADVANTAGE IN GLOBAL VALUE CHAINS.

The use of gross exports or value added exports to study the role of specific sectors in the GVC, provides a different outlook about the role of countries and sectors on the production chain. However, it would be necessary to explore if those differences are reflected in the way that global production is organized by those countries that posses a comparative advantage in specific segments of the chain. In other words, it would be interesting to see if the use of value added exports to measure country performance in the international trade makes a difference to identify the existence of comparative advantages in specific sectors. In this paper, the interest is on the ordinal use of RCA indexes to find out in what sectors a country has a comparative advantage and on which of them the advantage is stronger. Rank correlation between RCAg and RCAv was calculated for every year in the database comparing rankings at the sector level. Both Spearman rho and Kendall Tau correlation methods were used to control for big changes in ranking order, most likely captured by Spearman rho correlation, and small but frequent changes in the ranking, better captured by Kendall Tau correlation.

A positive and high correlation is expected between both RCAg and RCAv, given previous results showing a positive association between gross exports and value added exports, which is confirmed by correlation test for all years and sectors at 2% confidence. Average Spearman rho is around 81% , Kendall Tau average values are around 66%, meaning that small differences in the rank order are frequent comparing RCAg and RCAv, meanwhile big differences on the rank are less frequent, but not completely absent, which explain a smaller value of Kendall Tau correlation compared to Spearman rho. Along the studied period, the average correlation between the two indexes has increased, however the change is rather slow.

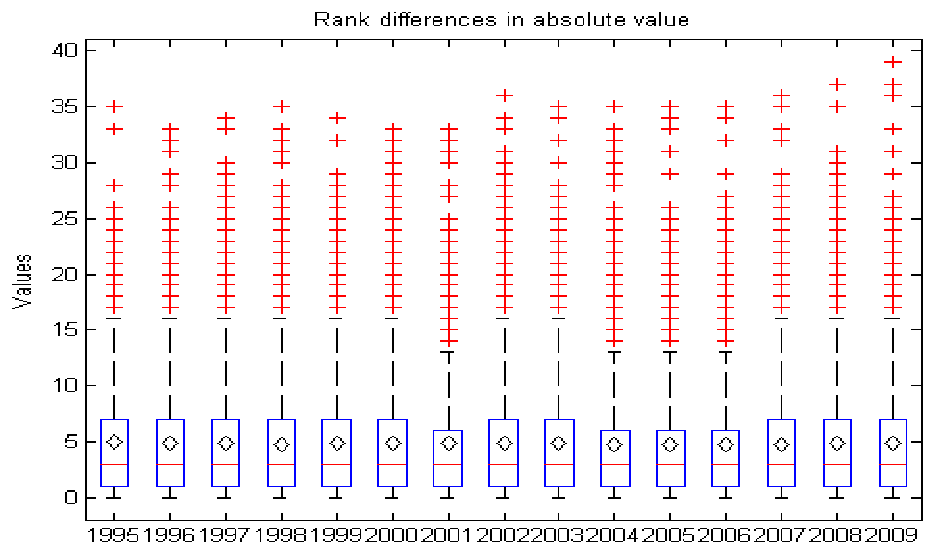
In a binary dimension, the comparison between both indexes is reduced to the rate of agreement classifying countries into the group: "country with RCA in sector i". This is the percentage of countries in each sector, whose RCAg>1 and RCAv>1, relative to the total number of countries whose RCA>1 at least according to one of the indexes. Meaning that, irrespective of the data used to build the RCA index, the country seems to have a revealed comparative advantage in a given sector. Average rate of agreement is around 69% for all sectors (for 1995, 2000, and 2009), which is close Kendall Tau correlation values. The rate of agreement is in general high (above 85%) in Mining and quarrying, Textile, Paper P&P, Machinery Nec., and Transport equipment; whereas in Coke, petroleum and nuclear; Chemicals; Electricity, gas and water; Retail trade; Financial Intermediation; Real state; Education; and Health and social work; register low rates of agreement, always below 65% of the cases.

The average rate of agreement in manufacturing quite differs from the one in services sector. In manufacturing is higher for all years than in Services, where only around 60% - 62% of the cases, both RCAg, and RCAv classify the same country as possessor of a comparative advantage in a given sector. Nevertheless, the average rate of agreement in manufacturing is always smaller than 78%. The same pattern can be observed, using Kendall Tau rank correlation average by sector. Rank correlation between RCAg and RCAv, is the highest in Manufacturing, with values around 78% - 79%, meanwhile in services rank correlation is about 56%-57%. The wider difference between manufacturing and services, according to rank correlation is due to the inclusion of values far from the cut threshold (RCA=1), where values of RCAg, and RCAv are less similar. The magnitude of differences between both measures, and the distribution that followed tell us a lot about the usefulness of gross exports or value added data to measure countries performance and competitive conditions in each sector

At the sector level, is evident a high degree of heterogeneity of ordinal differences inside group sectors; divergence in Kendall Tau correlation values and classification agreement rates support this fact. Agriculture HF&F; coke, petrol & nuclear fuel; chemicals; rubber and plastics; and manufacturing Nec. & recycling, are the most affected sectors by differences between RCAg and RCAv. In those sectors the choice of value added or gross exports can significantly change the perception about the distribution of comparative advantages among countries; not only concerning advantage size, but on its own existence.

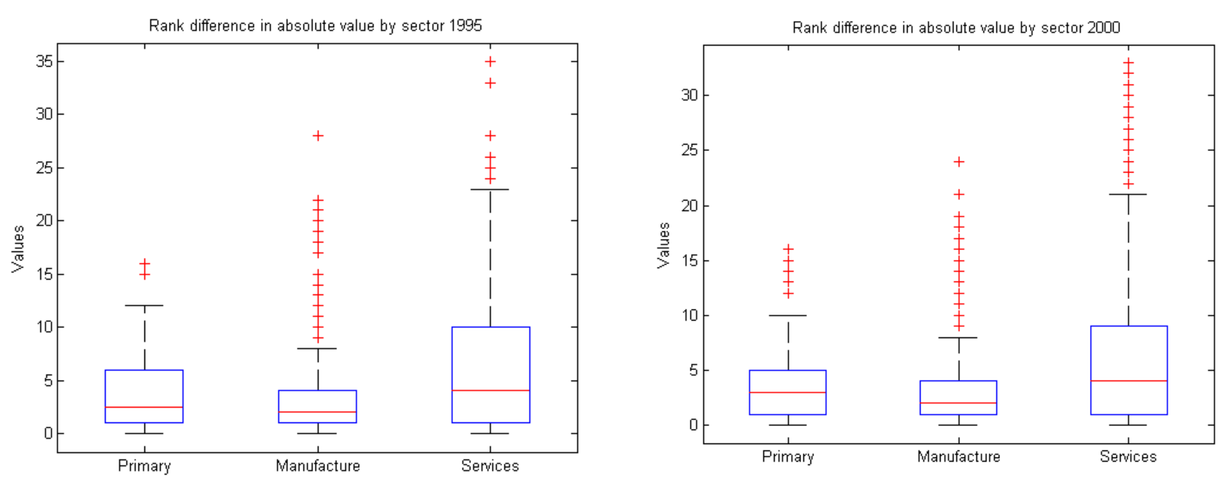
It is natural to think that differences between RCAg and RCAv can be identified by the way they rank countries according to their competitiveness in a given sector. Rank differences were calculated for each sector in all available years in absolute value (RCAg-RCAv) to explore the sources of weak correlation between RCAg and RCAv. As shown in Figure 2 they do not follow a normal distribution, instead is very skewed at the right. Changes on the rank differences distribution over time are driven by a longer tail at the right; it is increasingly possible to find countries in specific sectors for which rank positions according to RCAg and RCAv are really different. Those cases are not the rule, but an increase in number and size difference can be noticed along the period.

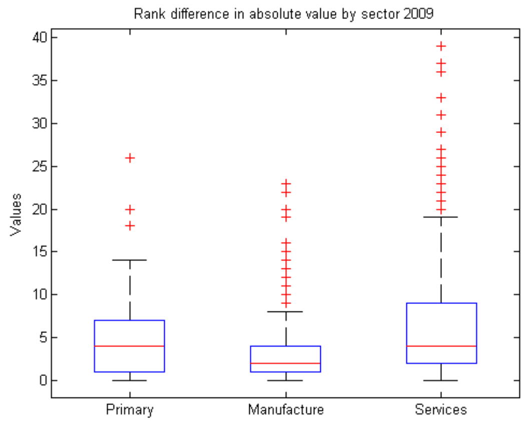
Figure 2. Distribution of absolute rank differences between gross and value added exports RCA indexes, 1995 - 2009



Distribution of rank differences on three groups of sectors; primary, manufacturing and services reveal that higher discrepancies between rankings are present in the services sector, rank differences have a much skewed distribution at the right that has been increasing its tail at right during 1995 - 2009. Manufacture activities by contrast, are less affected by rank differences between RCAg and RCAv. These findings are consistent with results obtained for rank correlation between RCAg and RCAv at the group sector level. On the primary sector, dispersion is higher than in manufacture due to agriculture, hunting, forestry and fishing; in the mining and quarrying sector, rankings by RCAg and RCAv agree in most of the cases.

Figure 3 Distribution of absolute rank differences between gross and value added exports RCA indexes, by group sector, 1995, 2000, and 2009.





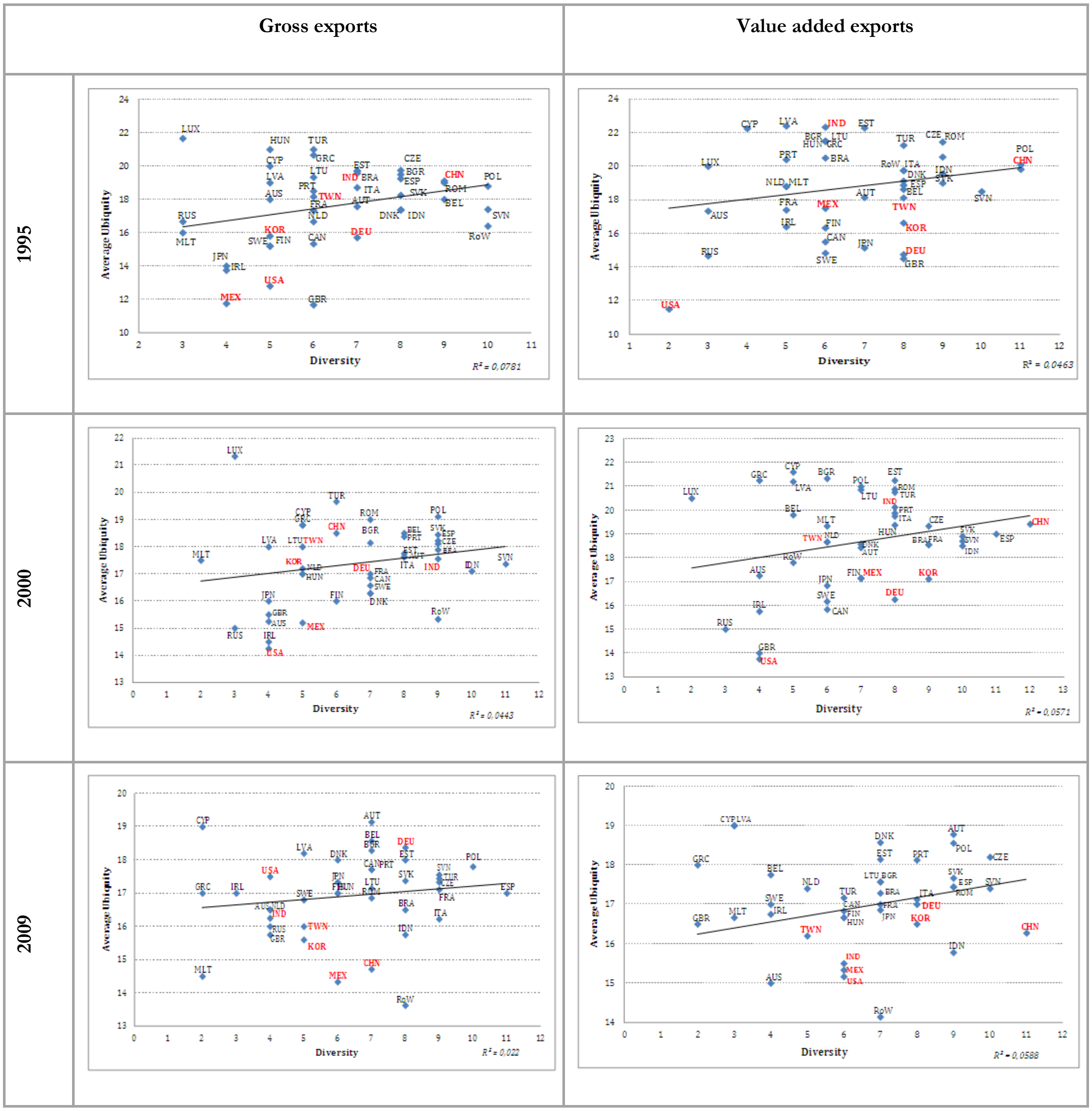
At the sector level, rank differences between RCAg and RCAv behave differently, for some activities the use of one set of data or another represents a real change. Based on the existence of big differences (above average) between both indicators, rank difference values higher than the average for the group sector, and relevance of the activity in the international trade; the six most affected sectors by the indicator choice to analyze competitiveness of countries are: agriculture HF&F; coke, petroleum and nuclear; rubber and plastics; Manufacturig nec. and recycling; electricity, gas and water; and sale, maintenance and repair of motor vehicles and motorcycles & retail sale of fuel.

STRUCTURE OF REVEALED COMPARATIVE ADVANTAGES IN GLOBAL VALUE CHAINS

Following the method of reflections, indicators of diversity, ubiquity, average diversity, average ubiquity, economic complexity, and sectoral complexity were calculated both including all sectors in the database, and excluding services. Only results for primary and manufacturing sectors are presented in here; however, basic results do not change with the inclusion of non tradable sectors.

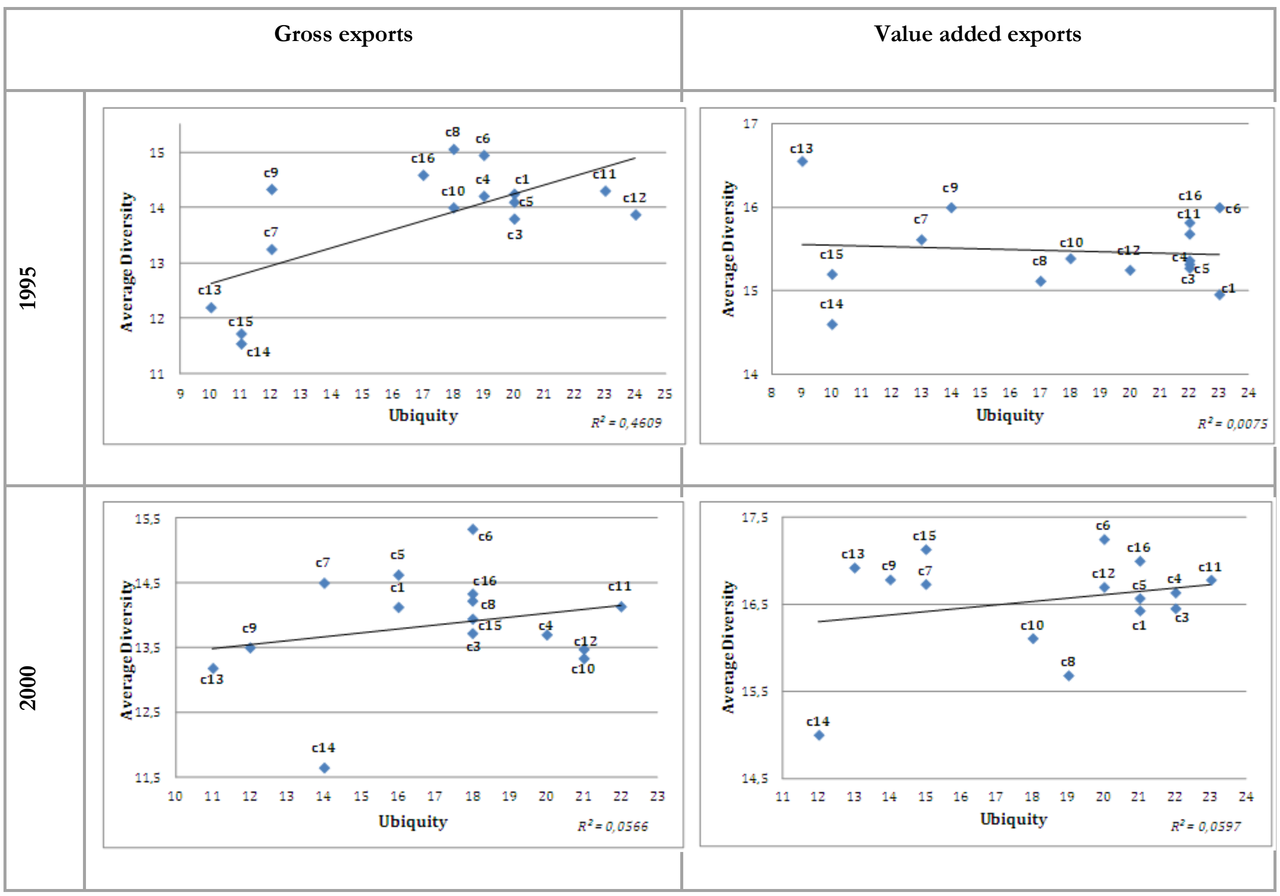
The basic relationship to be studied is between diversity and average ubiquity of products. At the product level, this relationship has been found to be negative and significant. At the sector level, the relationship between diversity and average ubiquity of sectors happen to be weakly positive, both for gross exports and value added exports. Due to a different level of data aggregation, this is not a contradictory result, products with different degrees of ubiquity are aggregated at the sector level, and countries participate with different combinations of products in same or different sectors in trade. Figure 4 presents data for 1995, 2000, and 2009 excluding non tradable sectors from the data, describing the relationship between diversity of exports and the average ubiquity of sectors in which countries have a revealed comparative advantage. It is noticeable that average ubiquity tend to be distributed in a progressively smaller range of values, meaning that countries that in 1995 concentrated their activities in few sectors, in 2009 increased on average the amount of sectors were they have a comparative advantage including more ubiquitous sectors. On the other hand, countries that exported on average products in more ubiquitous sectors, either move to less ubiquitous sectors, or those activities became more ubiquitous.

Figure 4 Diversity and average ubiquity of countries, 1995 and 2009

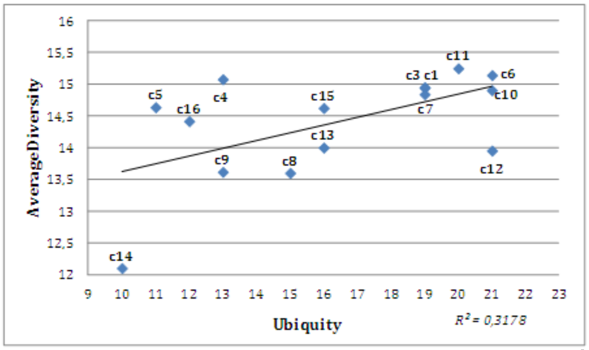


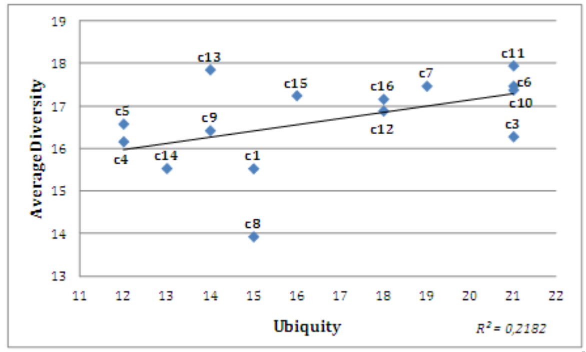
Differences between gross and value added exports translates mostly into different perceptions about degrees of diversification; at the sector level, average ubiquity of export baskets based on gross and value added exports, follow a similar pattern. Spearman correlation in both values and rank order between calculations using RCAg and RCAv is always smaller for diversity than for average ubiquity, correlation decrease over time in the two cases. Korea, appear to be less diversified measured by RCAg than by RCAv in all three years, a sign of existent capabilities to add value in several sectors not reflected in gross exports data; the same for China, where higher differences can be seen in 2000 and 2009; and for Japan in 1995. The opposite case is Belgium; measured by RCAg diversity is higher than by RCAv in all three years, the difference is bigger in 2000 and 2009. The most important divergences in average ubiquity are for Mexico in 1995, Estonia in 2000, and USA in 2009. In the first two cases, average ubiquity is higher measured by its contribution in value added exports than by gross exports data; in the second case, USA revealed comparative advantages based on gross exports exist on average in more ubiquitous sectors than its RCA measured by the contribution in value added to world demand.

Figure 5 Ubiquity and average diversity of sectors, 1995 and 2009



2009





The results are confirmed by the relationship between sector ubiquity and the average diversity of countries with a comparative advantage in the sector. This is slightly positive in some cases, but it is not possible to establish a clear correlation between the two indicators. At the product level the two variables are negatively correlated, meaning that less ubiquitous products are exported by countries with a higher average diversification of exports (Hausmann and Hidalgo, 2010). The use of gross or value added exports do not change in any essential way the classification of sectors according to ubiquity; the main differences can be observed in transport equipment in 2000, manufacturing Nec. and recycling in 2009, and agriculture in 2000 and 2009. The average diversity of countries with comparative advantage in the sector reflects more the existent differences between RCAg and RCAv. The less ubiquitous sectors are especially interesting; machinery Nec. appear to be exported by countries with a higher average diversity if measure by gross exports, than by value added exports. The same is truth for transport equipment, chemicals, and electrical and optimal equipment in 2009.

SECTOR RELATEDNESS, SIMILARITY AND CAPABILITIES

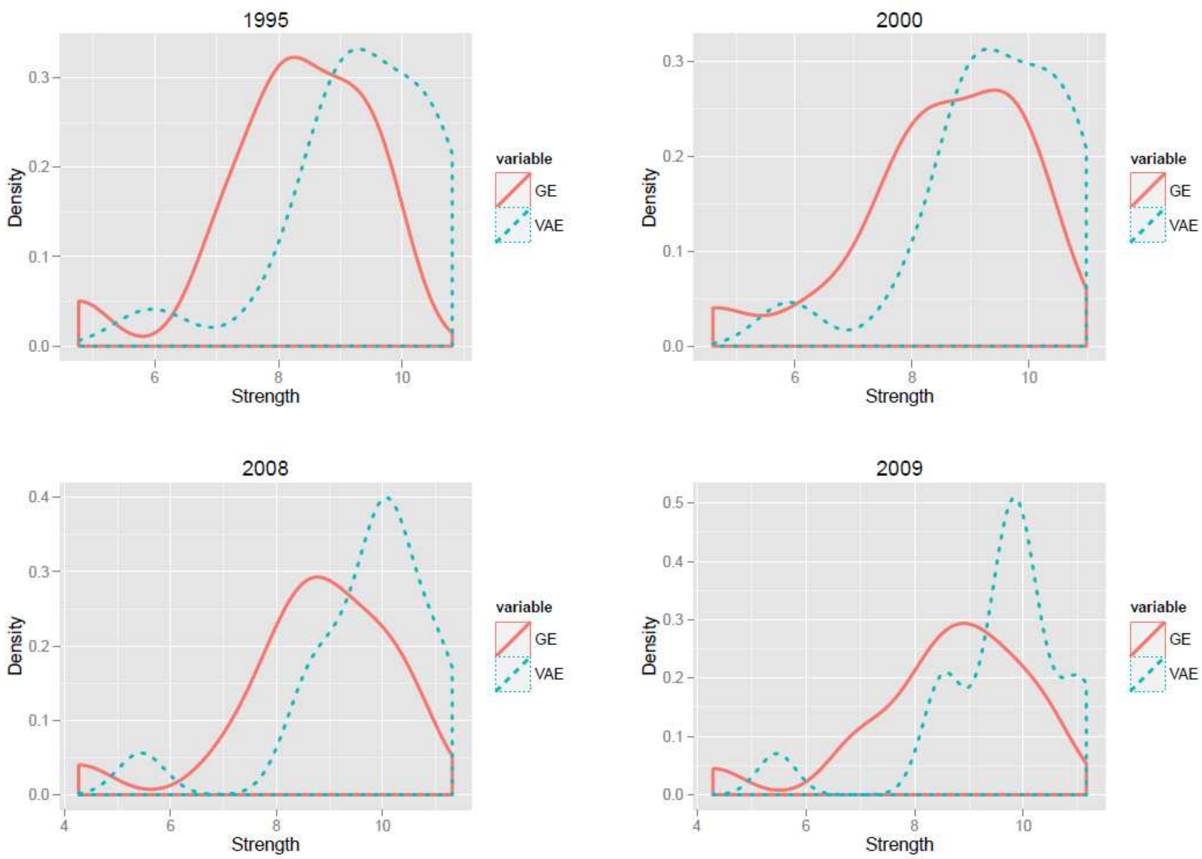
Sector relatedness becomes an interesting concept, when the discussion about competitiveness is given in a prospective framework. Knowledge about the productive structure of countries, the global distribution of comparative advantages, and the role of different countries in the international market; can be useful not only to understand the past or present of international trade, but to foresee possible scenarios at short and medium term. In that direction, a resource based view can be extended to the analysis of potential paths for country diversification, were existent resources and capabilities are the key to identify the next possible step in the route to diversification. In that sense, new potential markets can be spotted by the intersection between, resources and capabilities already available in the country used in the current production of goods and services, and capabilities required to be competitive in new sectors. Following that idea, it could be possible to disentangle the relationship between sectors via the study of required capabilities and resources for their production.

One possible way to approximate such relationship is through the concept of revealed comparative advantages. The approach taken is by definition indirect, and relies on the assumption that revealed comparative advantages reflect the existence of the required capabilities and resources to produce in a given sector at competitive levels. The intuition behind such assumption can be interpreted as a more general application of the Heckscher - Ohlin principle, where a country pattern of specialization not only reflects the relative abundance of productive factors (land and labour), but the abundance of capabilities required for the production of those goods. If this idea is adopted, then sector relatedness can be studied via the structure of revealed comparative advantages; such the approach is taken by (Hausmann and Klinger 2007), to build a network of products or "product space", based on trade data. Location of countries in this "product space" defines their possible diversification paths and can be used to define possible strategies accordingly.

At the sector level, similar networks can be built based both on gross exports and value added exports data. The comparison of these two networks can explain the effect that the chosen measure has on the perception of sector relatedness and the identification of latent comparative advantages. Changes on the network structure over time indicate changes in the sector use of capabilities, or in their relative abundance at country level. Differences in the structure between networks reveal different patterns of capabilities distribution.

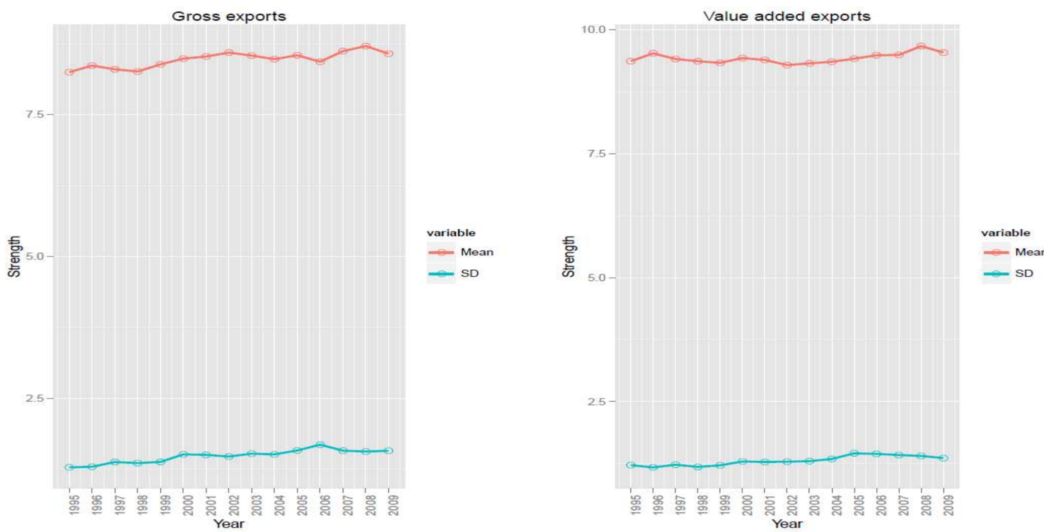
The analysis of sector relatedness is done by adopting an indirect approach. Data of gross and value added exports at the sector and country level is employed to build a network of sectors linked by their similarity in terms of shared capabilities. This can be interpreted as proximity between sectors, where sectors close to each other are those who share a wider set of capabilities. Similarity and proximity will refer in here to the same idea, where the indicator of similarity depends on the pattern of revealed existent capabilities in countries, approximate by the reveal comparative advantage index. Sector networks were built for every year in the period 1995 to 2009 both for gross exports and value added exports data. Services were excluded of the analysis, given the difficulties found for value added exports interpretation due to a price effect. Analysis of network characteristics and comparison in time, follow a similar structure to the one employed by (Fagiolo, Reyes et al. 2008), for binary and weighted trade networks. Network indicators of connectivity, assortativity, and centrality were calculated to analyze the general behaviour and evolution of sector networks. Finally rank differences are used to compare network indicators between gross exports and value added exports networks characterizing individual sectors.

Figure 6. Node strength distribution in gross and value added sector networks; 1995, 2000, 2008 and 2009.



At the sector level, the network is fully connected, both for gross and value added exports. At such level of aggregation is not difficult to find common capabilities required by sectors; however differences are important to understand how countries choose different diversification patterns. The shape of sector strength distribution and its evolution can be appreciated in Figure 6; sector strength measures the similarity intensity of sectors in the range [0, 15]. Strength distribution of gross exports network (GE) is negatively skewed, with a high concentration of value between 8 and 10, reflecting an intense similarity among a big group of sectors, weak similarities are not present in the network, but the left tail have taken smaller values in more recent periods. Strength distribution is quite stable over time, but a increase in the concentration at higher intensities can be observed at the end of the period. Strength distribution of value added exports (VAE) network is more skewed than the GE network, with a higher portion of the distribution concentrated at higher values (between 9 and 11). In that sense sector relatedness is more intense in the value added exports network. Strength distribution have also changed more in time for VAE than for GE, a marked increase in similarity intensity can be observed along the period towards a higher concentration in values around 10. However, similarity intensity is rather stable over time, Figure 7 display the mean and standard deviation of strength distribution along the period, whereas dispersion is quite similar for both GE and VAE networks, mean strength is higher for VAE indicating a higher similarity intensity among sectors when RCAv is used as measure of comparative advantage. The small increase on the GE network average strength in the period, it is not imitated by the evolution of the average strength for VAE network.

Figure 7 Average and standard deviation of node strength in gross and value added sector networks, 1995 – 2009.



The connectivity pattern between the two networks is quite similar. There is a positive strong relationship between node strength in the two networks (Figure 8). The dispersion tends to be higher at middle values of strength and have increased along the period. The biggest differences can be found in AgricultureHF&F (V1), Chemicals (V9), ManufNec&Recyc (V16), CokePetrol&Nuclear (V8) and , PaperP&P (V7). These are sectors where bigger differences between RCAg and RCAv were found before. Interestingly, according to value added exports, sectors with higher similarity intensity are mostly in the category capital intensive manufaturing (B&Fmetal (V12), R&Plastics (V10), OtherNonMet (V11), FoddB&T (V3)); meanwhile sectors with the lowest similarity intensity (except Mining&Q(V2)) belong mostly to the labor intensive manufacturing (Wood (V6), Leather (V5), Textile (V4)). It is difficult then at this level of aggregation to establish a clear relationship between similarity and complexity as was showed by previous analysis of ubiquity and diversity indicators. This result is consistent with the intuition behind sector complexity, more locally connected sectors happen to be those capital intensive that offer more opportunities for diversification than labor intensive sectors.

Figure 8 Gross vs. value added exports node strength; 1995, 2000 and 2009.

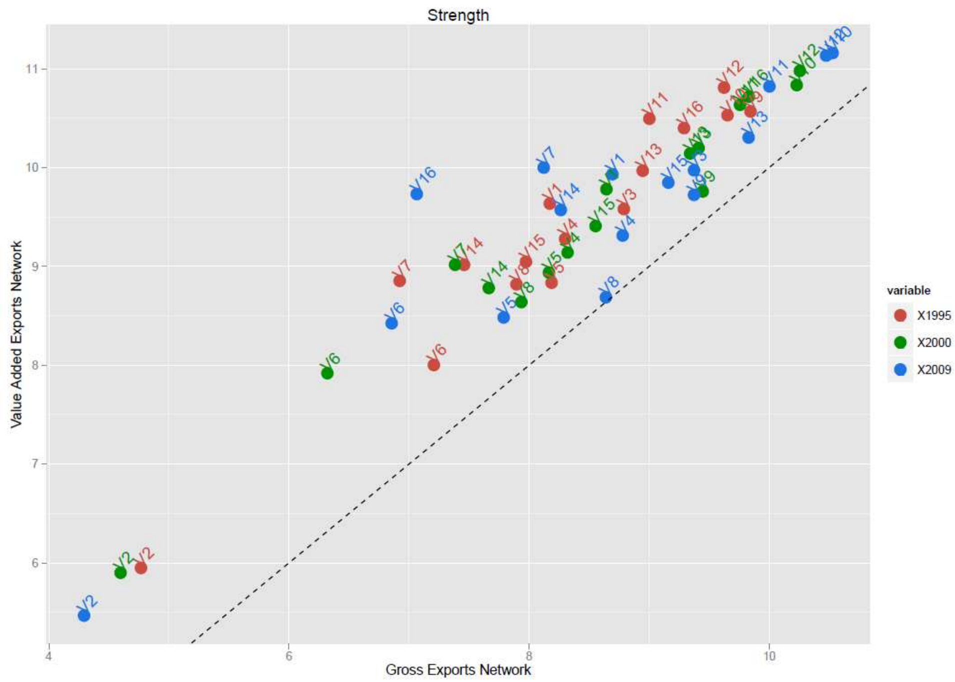
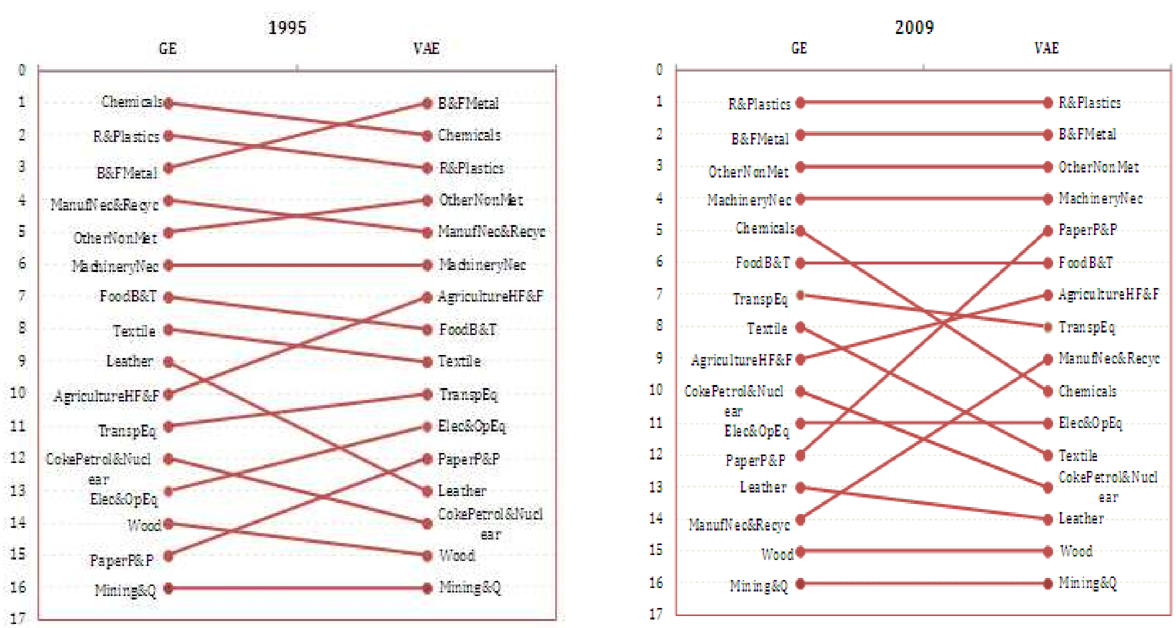


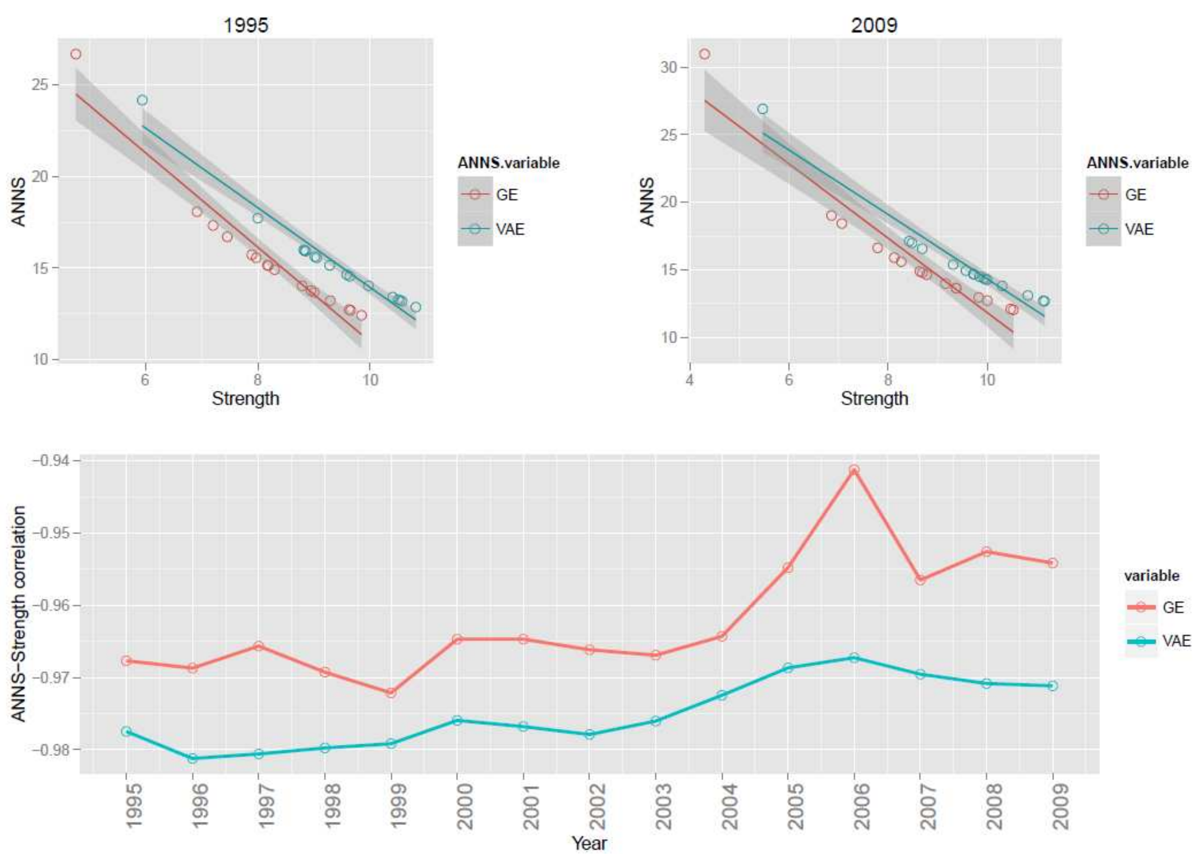
Figure 9 Sector rank order by node strength, gross and value added exports network; 1995 and 2009



Second level indicators are informative about characteristics of sectors similar to a specific node. Average nearest neighbour strength (ANNS) indicates how connected are sectors linked to a specific sector i. Both gross and value added networks exhibit a dissortative structure, meaning that sectors with high similarity intensity are connected to sectors with low similarity intensity and vice versa. As a description of the export basket, countries combine capital intensive with labour intensive manufacturing activities both in sales and in value added contribution to global demand, in this sense specialization it is not unavoidably concentrated following a factor intensity pattern. On the other hand, if similarity is interpreted as shared capabilities, countries posses comparative advantages in different kind of sectors, combining capital intensive with low intensive sectors; however due to a high level of aggregation, specific activities and products inside those sectors, can obey to different use intensities of factors. In that sense, a country can for example own capabilities and resources mostly related to labour intensity products that belong to different sector classifications.

Correlation between ANNS and strength of sectors is negative and close to one during the whole period for both networks. Moreover, an increase in the correlation value can be observed over time; which indicates a higher affinity in similarity intensity between linked sectors. This can be due to a changing composition of export baskets, caused by countries increasing their specialization in capital or labour intensive industries. The higher assortativity can be explained as well by capabilities accumulated in medium and high technology sectors by countries that at the beginning of the period were specialized mostly in low and medium technology intensive sectors. (Rahman and Zhao 2013Rahman and Zhao 2013) highlight the experience of central European countries increasing competitiveness in medium and high technology intensive industries during this period.

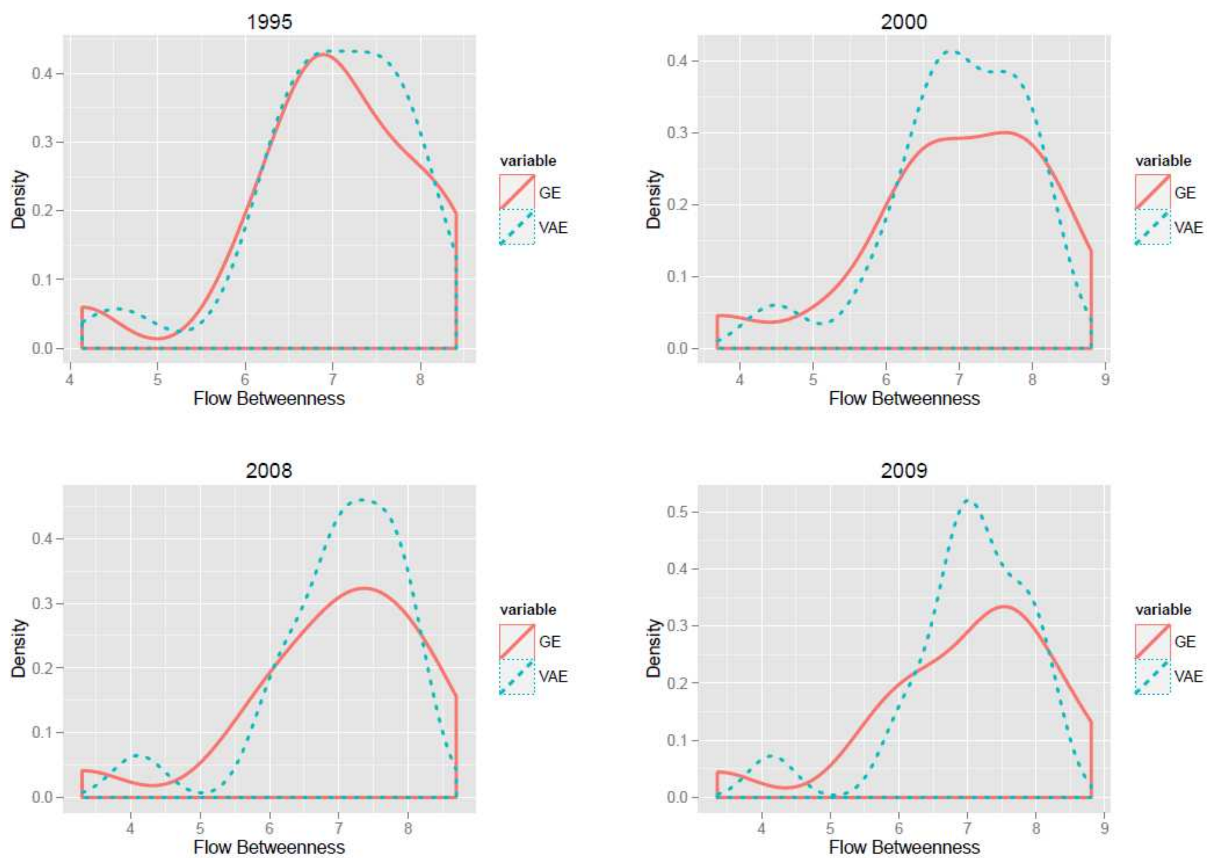
Figure 10 Network assortativity, gross and value added sector network, 1995 – 2009.



Flow betweenness as a measure of global centrality, indicates which sectors are those who share more capabilities with all other sectors in the network. If a country has a revealed comparative advantage in a sector with high FB, the country has a set of capabilities that are required in the production of many other sectors in the economy. In that sense, it would be easier for that country to diversify its export basket than for any other country, just because it has more potential paths to choose from. In the group of most globally central sectors R&Plastics (10), B&Fmetal (12), and FoodB&F (3) are found; OtherNonMet (11) appear as well in this group with an increasing importance along the period.

The shape of FB distribution is quite similar to the strength distribution; being almost identical for GE and VAE network at the beginning of the period, differences started to appear at the end. Flow betweenness distribution of VAE network increased its concentration in values around 7, showing a higher kurtosis than GE. This change in the distribution of FB in the VAE network is an indicator of a higher global centrality of sectors, meaning a higher degree of similarity with respect to all other sectors. As this change is not reflected by the GE network, seem like the increasing global importance of central sectors in the sample is related to production in intermediate stages of the GVC, where the value added in the sector is absorbed by other final sectors. The most notable rank differences between GE and VAE networks in FB are present in AgricultureHF&F (V1), Chemicals (V9), ManufNec&Recyc (V16), and , PaperP&P (V7).

Figure 11 Flow betweenness distribution in gross and value added sector networks; 1995, 2000, 2008 and 2009



The network of sectors is fully connected; all the sectors share a group of required capabilities that happen to be quite large due to the aggregation level. An important group of sectors share common required capabilities with many others, this is satisfied at the local and global level, and can be observed via strength and flow betweenness distributions. This group of highly connected sectors tend to be similar to less connected ones; the first group is composed mostly by capital intensive manufacturing sectors, meanwhile the second one comprises labour intensive sectors. Similarities between this two apparently different group of sectors can be explain by the diversity of products aggregated in each sector, in every category different combinations of labour intensive and capital intensive activities are group together, and countries can be specialized only in one kind of activities belonging to different sectors. Moreover, assortativity have slowly increased along the period, as a response to capability building in new activities. The most local and global connected sectors are B&Fmetal (V12), R&Plastics (V10), OtherNonMet (V11), and FoddB&T (V3), countries wth a comparative advantage in these sectors have more potential paths for diversification due to a higher number of sectors that require similar capabilities for their production.

Differences between gross and value added exports metrics do not change radically the perception of relatedness between sectors. As in the case of RCA indexes, it is important for values at the middle, meaning those sectors that are not the most central ones either locally or globally. Those sectors happened to be the same where biggest differences in RCA indexes were found, like AgricultureHF&F (V1), Chemicals (V9), ManufNec&Recyc (V16), CokePetrol&Nuclear (V8) and , PaperP&P (V7).

6. Conclusions

This paper has explored the differences between gross exports and domestic value added exports at different levels of aggregation. At the country level, an increase in production fragmentation is evident during 1995 - 2009, a higher content of foreign value added on exports is observed at the end of the period in almost all countries in the WIOD database. The increased specialization of countries in specific segments of the GVC translates into a higher gap between gross and value added exports. The gap is considerably higher in manufacturing activities than in other sectors. Major increases in the period studied took place in countries where fragmentation was less intense in 1995. In agriculture and services there is a tendency towards higher fragmentation along the period. Data of value added exports reveal the key role that services, agriculture and mining have supporting other sectors directly involved in exports.

However, such gap is not uniformly translated into differences in the distribution of revealed comparative advantages among countries. At the global level ordinal differences are small between RCAg and RCAv; along the period, changes have slowly increased due to a higher presence of big rank differences between both measures. By group of sectors (primary, manufacturing and services) is on manufacturing where both RCAg and RCAv agree the most, ranking countries according to their comparative advantages. A bigger gap between gross and value added exports in raw values does not imply higher dissimilarity on the country ranking according to comparative advantages in manufacturing; the opposite is true for agriculture. Yet, at the sector level a high degree of heterogeneity among sectors indicate that ordinal differences between both indexes can be quite high at lower levels of disaggregation.

The level of aggregation is clearly one of the limitations of this paper. The lack of a clear relationship between diversity and complexity indexes for example, cannot be interpreted as the inexistence of it; a sector reunites a set of products with production methods and capabilities requirements that can be quite diverse, such diversity cannot be discern if more disaggregated information is not available. Gross exports decomposition requires a full world input output matrix to track the GVC of products, after the initial step that represents the WIOD a continued effort is required to increase the level of precision and consistence of data.

Despite the aggregation problem there are some sectors were the use of gross or value added exports data makes a difference in the perception of comparative advantages distribution. In those sectors, differences are reflected both on the RCA distribution among countries and the similarity among sectors. In Agriculture HF&F; coke, petrol & nuclear fuel; chemicals; rubber and plastics; and manufacturing Nec. & recycling; it does make a difference for countries if the analysis of RCA is done using gross exports data, or if is done based on the domestic contribution in value added exports; the difference is higher for countries at the middle of the ranking, closer to cut off points of the index to define if it exist or not a comparative advantage in the sector.

From the sector similarity point of view an analogous effect is observed, at the aggregate level, the use of gross or value added sectors do not radically change the pattern of relatedness among sectors. For both RCAg and RCAv the sector network is fully connected with intense linkages among them. Capital intensive manufacturing sectors are highly connected, but tend to share more capabilities with labour intensive sectors, This pattern can be explain either by a level of aggregation that does not let to identify products with different capital and labour intensities inside sectors; or by the use of quite different capabilities among capital intensive manufacturing sectors. In the last case, the relevance of GVC production is enhanced; due to a higher degree of similarity in required capabilities along a GVC than across them it is crucial for countries to understand where they stand along the GVC and in what direction can they exploit their advantages in the future. Nevertheless, from 1995 to 2009 a higher assortativity is observed in the network, meaning that similarity have increase among capital intensive manufacturing sectors, which reflects changes in production patterns in some countries that went from labour intensive manufacturing goods exports in 1995 to capital intensive manufacturing goods in 2009.

Sectors like basic and fabricated metal; rubber and plastics; other non metals; and food beverages and tobacco are the most globally central, meaning that many sectors require similar capabilities to the ones needed for their production. A country that has already a comparative advantage in one or more of these sectors has more space to diversify its production to other sectors. The gap between gross and value added exports happens to be important for some sectors with middle connectivity and centrality values. For agriculture HF&F; chemicals; manufacturing Nec. & recycling; coke, petrol & nuclear fuel; and paper P&P their role in terms of centrality in the network changes if the analysis is based on RCAg or RCAv values.

The fact that even at a highly aggregated level, it is possible to find important differences in the pattern of relatedness among sectors, raises questions about the accuracy of RCAg as indirect measure of capabilities in a country. Moreover, future research on sector relatedness should go deeper on the understanding of capabilities, the process of capability building and its role for export diversification. Increasing fragmentation of production is an undeniable phenomenon that pushes forward the need for better measures of domestic contribution of value added creation in the GVC.

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