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INDUSTRY-LEVEL COMPETITIVENESS AND INEFFICIENCY SPILLOVERS IN GLOBAL VALUE CHAINS

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Abstract: *Global production, the servicification of manufacturing and global value chains (GVCs) have changed the way trade and international economics are understood today. The present essay revisits comparative advantage and builds on recent statistical advances to suggest new ways of looking at industry-level competitiveness and comparative advantage. The empirics focus on the 61 countries that are included in the OECD-WTO Trade in Value Added database (TiVA), covering OECD, EU28, G20, most East and South East Asian economies and a selection of South American countries. The paper looks at the implications of global manufacturing for our understanding of trade and growth from an international supply chain perspective, through a comparative advantage approach and the redefinition of domestic value chain upgrading as the deepening of efficient inter-industrial linkages.*

Keywords: Global value chains, trade and development, revealed comparative advantage, competitiveness benchmarking.

JEL: C18, C67, F14, F19, F43, F63, O11, O19, O41, O47, O57

[1] **Disclaimer**: This is a draft for discussion only and represents research in progress. The opinions expressed in this paper are those of its authors. They are not intended to represent the positions or opinions of the OECD or WTO, or their Members.

1 INTRODUCTION

The emergence of global production, the servicification of manufacturing and the expansion of international supply chains have changed the way we understand trade and international economics today. For Grossman and Rossi-Hansberg (2006), this is a change of paradigm and requires new theoretical modelling. Without entering into this debate (see Park, Nayyar and Low [2013] for a literature review), the present essay builds on recent statistical advances to suggest new ways of looking at the demand and supply side of trade when global value chains are taken into consideration.

Theory cannot advance without data and statistics need to be guided by theory. Thanks to the recent efforts of national and international organisations in improving our knowledge of global trade and production, we can now build on evidence that allows us to test the relevance of old theories and, if proven false, can suggest paths to new ones. This paper –which is still work-in-progress– builds on the results of the 2015 release of the OECD-WTO Trade in Value Added database (TiVA). It aims at investigating the statistical feasibility and the analytical usefulness of developing a series of new indicators on the trade and growth nexus. Covering 61 countries, the TiVA database offers a good opportunity to analyse these indicators in a reasonable number of developed and developing economies.

The paper looks at some of the implications of the global value chain (GVC) model for our understanding of supply-side dynamics. Because GVCs are primarily conceived for optimising the efficiency of each of the various steps involved in manufacturing, the paper concentrates on two approaches for measuring efficiency. The first approach in Section 2 revisits revealed comparative advantage (RCA) through the lens of trade in value-added. The second approach in Section 3 benchmarks industrial sectors based on the information provided by the input-output accounting framework underpinning the measure of trade in value-added. Section 4 summarises the main results.

2 COMPARATIVE ADVANTAGE AND COMPETITIVENESS: LOOKING FOR CONCEPTUAL FOUNDATIONS

This section first spends some time on the underlying models that can guide our interpretation of comparative advantage, before revisiting the different competitiveness indicators suggested by the new body of trade statistics known as "trade in value-added". As Koopmans (1947) once commented: "(…) the rejection of the help that economic theorizing might give leaves a void. (…) Without resort to theory, in the sense indicated, conclusions relevant to the guidance of economic policies cannot be drawn." Accordingly, the measure of international competitiveness and comparative advantage based on trade in value-added needs to be guided by theory.

While trade theory textbooks traditionally start with a short presentation of the Ricardian comparative advantage, they generally focus on the Heckscher-Ohlin-Samuelson framework which is unable to explain patterns of bilateral trade in tasks or any type of intra-industry (or business to business) trade. The New Trade Theory and the New "New" Trade Theory, associated with respectively Krugman and Melitz, provide theoretical elements that are closer to the reality of economies. Yet, these approaches remain focused on trade in final goods and do not deal adequately with the B2B dimension of trade in value-added. Theories introducing imperfect competition increase the relevance of trade theory in a world were markets are not so competitive and start to take into consideration differences among businesses. But at the end, they do not question either the nature of international trade and still assume that imperfect competition takes place between producers of final goods.

It is only in the management and business school approach, pioneered by Porter (1985, 1990), that the concept of competitiveness of nations is introduced and that the success of some countries in international trade is explained by the capacity of their firms to outperform foreign competitors. For the economic school, this approach is taking us back to the absolute advantage of Smith, made obsolete by Ricardo's comparative advantage. While firms can be more or less competitive, this is not the case of nations (Krugman, 1994).

Yet, if B2B trade at the micro-level is driven by competitiveness and absolute advantage considerations, countries do trade according to Ricardo's comparative advantage. There is no contradiction between Porter and Ricardo (Smit, 2010). The fusion of both firm-level competitiveness and comparative advantage theories remains an unfinished project. Grossman and Rossi-Hansberg (2006) predict that this would require new theoretical modelling. Instead, we propose here to revisit Ricardo's comparative advantage under the lights of (i) the micro and macro perspectives of the neo-Ricardian theory of value (Fujimoto and Shiozawa, 2012) and (ii) the data provided by the OECD-WTO Trade in Value-Added database.

2.1 A neo-Ricardian lecture of international-input output tables

The micro-economic definition of competitiveness is closely related to A. Smith's understanding of absolute advantage. Ricardo's law of comparative advantage is often presented as based on a totally different logic, driving a wedge between these two classical authors and –more importantly for our purpose—complicating the fusion between the business and economic approaches to competitive advantage. As Morales-Meoqui (2014) shows, this theoretical wedge is a misperception and Ricardo concurred with Smith proposition that market extension leads to dynamic productivity gains (a proposition modelled through increasing returns by the proponents of the New Trade Theory). This new lecture of Ricardo has also the merit of debunking the credo that his comparative advantage theory is static by nature.[2] According to Morales-Meoqui (2014), reconciling Smith with Ricardo brings also a richer treatment of the natural and acquired sources of comparative advantage to explain the optimal pattern of trade specialisation, in a way that is superior to the HOS model.

From our particular perspective of GVC trade, it also has the advantage of providing a joint micro and macro theoretical referent to the new division of labour observed in trade in value-added. Comparative natural advantage and production costs are the drivers of the series of "make or buy" decisions that aim at optimising the various segments of Porter's value chain in an international perspective. As we shall see, the neo-Ricardian approach also has the great advantage of being well matched with the accounting framework defined by the international input-output tables (IIOT) that underpin the measure of trade in value-added. Indeed, classical economists look at value through the "cost of production" approach, something inherent to the IIOT where all the products consumed are decomposed into a series of value-added associated to different production functions in each country and industry. In other words, any product consumed as final demand can be seen as the total sum of the tasks (value-added) embodied along an international supply chain.

The neo-Ricardian model and is cost of production based theory of value, such as in Fujimoto and Shiozawa (2012), has an almost one-for-one counterpart in the IIOT. Using the notation of Shiozawa (2012), the basic relation is based on Sraffa (1960) system linking prices to production costs and value-added (wages and profit):

$$\mathbf{p} = (1+r)\,[(w.\mathbf{a}0) + \mathbf{A}\,\mathbf{p}] \qquad \textbf{[1]}$$

With
p: the price vector (of dimension N, N being the number of goods)
r: rate of profit
w: wage rate
a0 : column vector of labour input coefficients
A: the matrix of intermediate input coefficients

Under the usual conditions of $(\mathbf{I}-\mathbf{A})^{-1}$ existence [1] can be written:

$$\mathbf{p} = \boldsymbol{w}\,(\mathbf{1}+\boldsymbol{r})\,\mathrm{a}\mathbf{0}\,[\mathrm{I} - (\mathbf{1}+\boldsymbol{r})\mathbf{A}]^{-1} \qquad \textbf{[2]}$$

[2] A perception based on Ricardo's famous wine and cloth example used to explain trade between England and Portugal.

The cone of sustainable production is given (discarding the possibility of financing consumption and investment through financial debts) by:

$$\langle \mathbf{x}, \mathbf{p} \rangle \leq \mathbf{w} \qquad \textbf{[3]}$$

x being the set of possible consumption for a typical worker. Equation [3] relates the real rates of profit and wage in a long-term situation where the economy is at full capacity and budgetary constraints are binding (consumption must be paid out of wages and gross investment out of savings).

At the difference of neoclassic economists who rely on supply and demand to determine market prices, the Neo-Ricardian school follows the tradition of mark-up pricing. In this case, the production sale price is fixed by multiplying the full production cost (including wages)[3] by a pre-determined rate, or mark-up. Because part of the gross profit is used to replace the consumption of productive capital and remunerate investors, the mark-up rate between industries will depend on the capital intensity of production. Equation [1] becomes:

$$(1+\mathbf{M})[\boldsymbol{w}.\mathbf{a}0 + \mathbf{A}\,\mathbf{p}] = \mathbf{p} \qquad \textbf{[4]}$$

With **M** a diagonal square matrix of mark-up rates.[4]

Shiozawa (2012) formulates the Neo-Ricardian model from an international perspective. There are K countries and N traded goods; in a situation of frictionless trade, the price of a traded product is equal across countries. Labour within each country is assumed homogeneous, but may differ across countries; there is no international movement of labour forces. The wage rate for country "k" is uniform across industries and denoted w_k.

There are H different possible techniques. Each country has at least one production technique for any good and two countries cannot compete in production using the same technique; in other term, a production technique is operated in one country at most. A good can nevertheless be produced by different processes/countries (for simplicity, the author assumes that a single industry "*j*" in a country "*k*" will use only one technique for producing "*j*"). The set of all production techniques applied to all (traded) goods is H x N. The productive capacity of any country is determined by the quantity of labour set of feasible production techniques.

In the Leontief-like case of unused productive capacity (including labour), the set of international values **v** = (**w**, **p**) linking wages and prices satisfies the system:

(i) $\mathbf{y}\,\mathbf{A} = \alpha\,\mathbf{d}$, for at least one $\alpha>0$.
(ii) $\mathbf{y}\,\mathbf{I} = \mathbf{t} \leq \mathbf{q}$
(iii) $\mathbf{I}\,\mathbf{w} \geq \mathbf{A}\,\mathbf{p}$
(iv) $\langle \mathbf{t}, \mathbf{w} \rangle = \langle \mathbf{y}, \mathbf{p} \rangle$ **[5]**

with
y: world production activity vector **;** α **d** world consumption
A: HxN matrix of production techniques
I : HxN input Boolean matrix; each row vector of **I** contains only one value 1 which indicates in which country the production is made according to a given technology.

Condition (i) indicates that the net production for consumption is a proportion of demand vector; (ii) becomes an equality at full employment; the left-hand side of (iii) is labour costs while the right-hand side is net value for the corresponding production technique (no positive profit); conversely, (iv) excludes the possibility of negative profit.

[3] Here, we find a first divergence between Neo-Ricardian accounting and I-O analysis, because part of the value-added is now considered as a cost, and not a margin as in national account.

[4] It is not the purpose of this paper to enter into the debate on prices and value. Full cost pricing suits well our purpose of looking at the world trade economy from the sole angle of production, discarding the demand side. As in the Leontief model, one may settle for a short-term scenario where prices are fixed (the economy operates below full capacity) and production adjusts to demand.

2.2 Global value chains, production techniques, international value and trade costs

Shiozawa (2012) extends the model to the case where trade suffers from transport costs. In this case, the products are also distinguished by their localisation, and there are now KxN different commodities.[5] It is intuitive that by increasing the number of product categories, trade costs multiply the possibility of feasible productive techniques. The higher the trade costs, the easier it is for a production technique to remain competitive in its home market. When trade costs decrease uniformly, "*each product will be produced in a smaller number of countries and in the extreme case specializations of many products will be complete*" (op. cit, page 13)

The main interest of this model for our purpose is twofold: (i) it sets the wage rate of a given country within certain proportion in order to maintain production under a prescribed technique. In order to increase the relative wage rate of a country, its production technique should also improve. (ii) the cone of feasible production techniques for each country depends on trade costs. As a consequence, we can state that there is a close relationship between technology, wage rate and trade costs.

This relationship is particularly important in the case of trade along global value chains, considering the key importance of trade costs. But, as we shall see, the effect of trade costs on the range of possible productive activities may be quite different in the case of B2B trade in tasks as opposed to the classical B2C trade in final goods.

When the production of the final good is segmented into different "tasks", the value-added (wages and profit) created by each country is embodied in the goods for processing that are crossing several borders before reaching the final consumer. Trade costs such as applied tariffs, transportation and insurance costs or other border taxes and fees are amplified while they cascade down the supply chains. This "cascading effect" arises since trade costs accumulate as intermediate goods are imported and then re-exported further downstream, going into different processing nodes before reaching the final consumer. Moreover, the financial impact of these trade costs on profitability is magnified in the "trade in tasks" framework that governs GVCs. At the difference of a large integrated firm concentrating most of the production processes under the same roof, specialised processing firms need to recoup the trade cost applying to the full value of the good from the smaller fraction of value-added created at each consecutive production stage. This larger relative weight of transaction expenses on the profitability of individual business operations explains why trade along GVCs is particularly exposed to trade costs (Yi, 2003).

Yet, an important difference with trade in final goods is that the "acc*umulation and magnification"* effects of cascading trade costs tend to reduce, and not increase, the range of production technologies available to countries, especially developing countries. When trade costs are low, the production of a single commodity can be split --unbundled, using Baldwin (2006) terminology-- into several "tasks", each one requiring different sets of production technologies. A country with limited technological capabilities that had been priced out of the full production of a final commodity may become internationally competitive for the production of one or several of the "tasks" embodied in the final product.

In a situation where all trade partners can be ranked by their material productivity, the high ranking country can in theory deploy all the possible technologies while the lowest ranking countries will be restricted to the least productive ones. According to the neo-Ricardian model, the distribution of production will be subject to the international theory of value $\mathbf{v} = (\mathbf{w}, \mathbf{p})$: irrespective of comparative advantages, the wage rate for least-developed economies needs to be lower than in more developed countries.[6] Similarly, value chain (social) upgrading implies improving labour productivity, wages and material productivity. When trade costs are high, the cone of feasible production is larger for both developed and developing countries. Because the demand for final goods (consumption and investment) is higher in developed market due to higher wage rates and a higher capitalistic intensity of production, the protectionist impact of high trade costs is more effective in sustaining production (as in the Keynesian "effective" demand") in the

[5] If exporting costs are an ad-valorem addition to production costs, irrespective of the country of final destination, and each country has a different "transportation technique" (id est, trade costs differ from country to country), each product is referenced not only in the product space N but also in the country list K.

[6] Implicitly, comparative advantages have to translate into production costs and market prices for trade to take place. This conclusion differs from the usual text book interpretation of Ricardo (Morales-Meoqui, 2014).

case of developed economies. When trade costs decrease, the set of feasible production will drop in each group of countries, but new activities, linked to outsourcing and trade in tasks, will become feasible.

To look at the implications of GVC trade for the neo-Ricardian model, we use Shiozawa's model with trade costs and extend it to the case of trade in tasks.[7] Let assume the world economy to be made of two traded goods, produced with a different mix of low and high technology, and two countries. One country is developed and at the technological frontier (A) the other is a developing economy below the technological frontier (B). Technologies available to B (defined as the subset $\mathbf{k}^B$) are also feasible for A ($\mathbf{k}^A$), but the reverse is not true if the particular technology mix is above B's capacity (not included in $\mathbf{k}^B$).

If trade takes place without any cost, the price of the two traded goods is the same in both countries. For one unit of output for product 1, the material input coefficients for country A are $\mathbf{a}_+(\mathbf{k}^A)$ and the labour inputs $\mathbf{a}_0(\mathbf{k}^A)$. If $\mathbf{k}^A$ is superior to $\mathbf{k}^B$ for a given international value vector $\mathbf{v} = (\mathbf{w}, \mathbf{p})$, the following inequality holds:

$$\mathbf{a_0}(\mathbf{k}^A)\ \boldsymbol{w}(A) + (\mathbf{a}_+(\mathbf{k}^A)\ ,\ \mathbf{p}) < \mathbf{a_0}(\mathbf{k}^B)\ \boldsymbol{w}(B) + (\mathbf{a}_+(\mathbf{k}^B)\ ,\ \mathbf{p}) \qquad \textbf{[6]}$$

If the techniques for product 1 are similar in A and B and process are equalised between countries, the difference in competitiveness arises because of higher workers' productivity in A at the existing wage structure.

$$\mathbf{a_0}(\mathbf{k}^A)\ \boldsymbol{w}(A) < \mathbf{a_0}(\mathbf{k}^B)\ \boldsymbol{w}(B) \qquad \textbf{[7]}$$

$$\boldsymbol{w}(A)\ /\ \boldsymbol{w}(B) < \mathbf{a_0}(\mathbf{k}^B)\ /\ \mathbf{a_0}(\mathbf{k}^A) \qquad \textbf{[8]}$$

Now, let us include in this neo-Ricardian model of trade in final goods the possibility of splitting production of good 1 into two production steps. Each of these two steps is operated a level y(**k'**) and y(**k"**) and are part of the subsets $\mathbf{k}^A$ and $\mathbf{k}^B$. **k'** and **k"** are complementary and not substitutes (as in a Leontief model).

k' is labour intensive, **k"** is technology intensive and:

(i) $\mathbf{a_0}(\mathbf{k'}^A)\ \boldsymbol{w}(A) > \mathbf{a_0}(\mathbf{k'}^B)\ \boldsymbol{w}(B)$

(ii) $\mathbf{a_0}(\mathbf{k''}^A)\ \boldsymbol{w}(A) < \mathbf{a_0}(\mathbf{k''}^B)\ \boldsymbol{w}(B)$ **[9]**

Even when equation [6] holds and the production of the entire good is more competitive in A, the existence of trade in tasks and possibility of unbundling the production in two separate steps [9] means that part of the production corresponding to **k'** will be outsourced to B. If the labour intensive tasks belonging to **k'** are performed after the high technology ones **k''** (for example, the assembly of a car or an electronic product), then country B will import intermediate goods from A and export the final good. This is a situation commonly found in modern days trade statistics and will be analysed more in details at a later stage when we discuss revealed comparative advantages.

What happens in the presence of trade costs?

In this case, the price of goods **p**(A) and **p**(B) is not identical anymore in the two countries. Moreover, dealing with trade costs includes additional labour requirements $\mathbf{t_0}$ on the part of the exporting country (e.g., time to process export customs and shipment procedures, to be similar in both countries).

Even when equation [6] holds at international free prices, the production of final good 1 in country B for sale in its home domestic market becomes competitive when:

$$[\mathbf{t_0} + \mathbf{a0}(\mathbf{k}^A)]\ \boldsymbol{w}(A) + (\mathbf{a}_+(\mathbf{k}^A)\ ,\ \mathbf{p}(A)) > \mathbf{a_0}(\mathbf{k}^B)\ \boldsymbol{w}(B) + (\mathbf{a}_+(\mathbf{k}^B)\ ,\ \mathbf{p}(B)) \qquad \textbf{[10]}$$

[7] Shiozawa, Y. (2014) 'The Revival of Classical Theory of Values', draft, mimeo.

However, nominal competitiveness in the home market is due only to trade frictions and B would not be able to export to A, as its exports would have to support trade costs and, if equation [6] holds at international free prices:

$$\mathbf{a0}(\mathbf{k}^A)\ \boldsymbol{w}(A) + (\mathbf{a}_+(\mathbf{k}^A)\ ,\ \mathbf{p}(A)) < [\mathbf{t_0} + \mathbf{a_0}(\mathbf{k}^B)]\ \boldsymbol{w}(B) + (\mathbf{a}_+(\mathbf{k}^B)\ ,\ \mathbf{p}(B)) \qquad \textbf{[11]}$$

This is the most probable outcome, unless **p**(B) is sufficiently lower than **p**(A) to compensate for the gap in real productivity and the transportation costs. This may occur following a very competitive devaluation (over-shooting), but may not result sustainable in the long run (regression to mean). Thus, trade costs in a neo-Ricardian model reduce trade, a standard result of gravity models (Escaith and Miroudot, 2015) but offer protection to uncompetitive home firms against international competition, another standard result of the effective protection rate theory (Diakantoni and Escaith, 2014).

What happens to trade in tasks in the presence of trade costs? If [9] holds at frictionless market prices, B's competitiveness in the subset of tasks k' is no more granted, and:

$$\mathbf{a_0}(\mathbf{k'}^A)\ \boldsymbol{w}(A) + (\mathbf{a}_+(\mathbf{k'}^A)\ ,\ \mathbf{p}(A))\ \mathbf{<?>}\ [\mathbf{t_0} + \mathbf{a_0}(\mathbf{k'}^B)]\ \boldsymbol{w}(B) + (\mathbf{a}_+(\mathbf{k'}^B)\ ,\ \mathbf{p}(B)) \qquad \textbf{[12]}$$

If trade costs are large enough and the price level in B on intermediate goods is not too inferior to those in A, then trade in tasks is not possible: countries A and B do not specialize in the activities where they have real competitive advantages.

Therefore, the end effect of trade costs and its inter-relation with real wage rates and productive feasibility remains so far an empirical debate. The rest of the paper deals therefore with the empirical side of the investigation.

3 COMPARATIVE ADVANTAGE AND INDUSTRY-LEVEL COMPETITIVENESS: EMPIRICAL FINDINGS

The previous theoretical discussion can be translated to the domain of statistics thanks to the close relationship between the neo-Ricardian approach and the accounting framework used to measure trade in value-added. The next section will explore some of the new information brought by the OECD-WTO TiVA database that could help understanding competitiveness in GVCs and the capacity of countries below the technology frontier to develop a competitive domestic value chain.

3.1 Trade in value added and revealed comparative advantage

When looking at international competitiveness, trade analysts –true to the Ricardian tradition– focus on the export specialisation of each country as an ex-post indicator. Specialisation is usually measured through Revealed Comparative Advantage (RCA). RCAs estimate the (unobserved) competitiveness position of an exporting country in producing a subset of products by comparing its export structure with the overall trade composition. As countries are expected to specialise in products where they have comparative advantage, this comparison reflects their RCA. The calculation of RCAs is associated to Balassa (1965) while Shift-Share Analysis (known as "Constant Market Share Analysis" by trade analysts) can be traced back to Tyszynski (1951).

Before the rise of GVCs, RCAs were expected to show a distribution of comparative advantage closely related to the degree of industrialisation, with developed countries specialising in complex manufacturing and least-advanced countries exporting commodities. More recently, RCAs were also seen as *predictors* of the development potential. In particular, export specialisation as observed through trade flows was seen as a reliable indicator of a country's underlying technological competencies, conveying important information on countries' latent capabilities (Hausmann, Hwang and Rodrik, 2007).

This approach of dynamic comparative advantage "revealed" by export flows in the product-space is valid when trade is composed of commodities and final goods but much less when trade is in value-added. GVCs allowed less advanced countries to leapfrog the industrialisation ladder by specialising in some of the tasks required for the manufacturing of the final products. As a result, the gross export structure (as measured through traditional customs data) may not reflect anymore the relative situation of the exporting country with respect to the technology frontier. We formally analysed this situation in the previous section (equation [9]).

As mentioned by Ferrarini and Scaramozzino (2011), today, a measure of comparative advantage that actually looks at supply capabilities should be based on net trade flows at the sectoral level. The analysis of RCAs on the basis of net trade flows is particularly relevant in the presence of global production sharing and vertical specialisation. Understanding the reality of today's trade in global manufacturing networks provides important information regarding the capacity for any given country to use international trade for deepening domestic intra-industry linkages in order to generate a larger share of the value-added created in the international supply chain. Trade in value added data present the opportunity to move the analysis one step further and include domestic inter-industrial relationships in the analysis of comparative advantage and competitiveness at the industry level.

The purpose of this section is to look at the changes in comparative advantage that occurred during the 1995-2011 period, providing a few stylised facts and exploring the role of global value chains from a trade in value-added perspective.

The TiVA database is particularly well suited for analysing RCAs as it is organised not according to products, like most trade databases, but according to industries. Moreover, building on the suggestion of Ferrarini and Scaramozzino (2011) by using an industry perspective rather than a product-by-product approach, it is possible to subtract imports of intermediate inputs from exports. This is easily done in the OECD-WTO TiVA database by taking into consideration the value of the vertical specialisation (VS) index.

The calculation of RCAs is based on the comparison of export structures relative to the world. In Table 1, RCAs are obtained by comparing individual export structures with the TiVA countries average. The calculation was done for all industries (goods and services) for years 1995 and 2011. We also differentiated exports according to their use (final demand or intermediate use). This may provide interesting information on the comparative advantage relative to an upstream or downstream position in the GVC. Depending on the industry, it may be more or less interesting to be upstream or downstream. For example, being downstream is a sign of market power in agriculture (brand reputation associated to geographical appellations) while being upstream in electronics or the motor vehicles industry indicates a strong position in R&D.

Our first interest is to observe the change in RCAs and to check whether the initial situation in 1995 is a good predictor of achieving similar results in 2011.

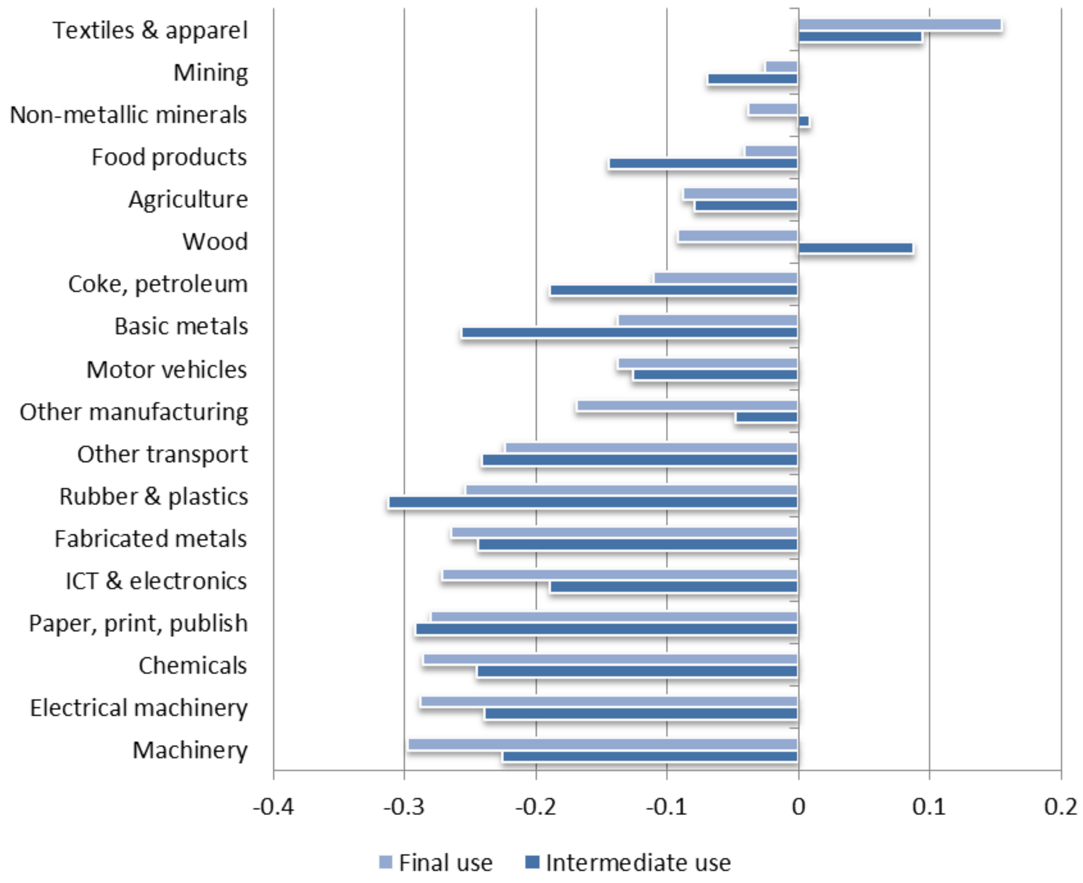
Table 1 Correlation between sectorial comparative advantage in 1995 and in 2011

All Sectors	**RCA Final Goods and Services 2011**	**RCA Intermediate Products 2011**
RCA Final Goods and Services 1995	0.5	0.3
RCA Intermediate Products 1995	0.5	0.6

Source: Based on OECD-WTO TiVA database 2015.

The results in Table 1 can be read as a kind of transition matrix, indicating the probability of maintaining the initial status over the 1995-2011 period. Overall, the odds are rather in favour of a conservative situation, especially if we take into account the nature of the sample with a fair number of emerging and developing economies that have been through important structural changes during the period. We would find higher correlations by restricting the sample for example to OECD economies. Most exporters retain their relative strengths and weaknesses, but the results vary from sector to sector.

Figure 1 Correlation between 1995 shares in exports and export growth from 1995 to 2011, by industry



Source: Based on OECD-WTO TiVA database.

Figure 1 shows the results obtained for all goods-producing sectors, some identified as low technology, others more in the high-tech segment. The figure compares the initial strength in the base year with the subsequent growth of exports. With the exception of textiles and apparel, all other manufacturing sectors recorded a reversion to the mean: the dominant countries in 1995 recorded, on average, lower export growth. However, in the case of textile and apparel, we observe a consolidation of dominant positions (with China being a clear outlier, as shown in the next section, in Figure 8). This may indicate that this sector, which was among the first ones to be internationalised, had achieved its structural mutation in 1995, while new players in the other industries arrived after this date. For commodities (agriculture, mining and wood products as intermediates), resource rich countries are in a better position to maintain their advantage. But even in these industries (with the exception of intermediate wood products) we see some reshuffling, although not as important as for manufacturing products.

3.2 Global value chains, domestic value added and upgrading

For many developing countries, particularly in East Asia, incorporation into GVCs has been a great opportunity for export diversification (WTO and IDE-JETRO, 2011). By creating much needed low-skilled employment opportunities required to absorb the excess labour resulting from rural-urban migration, GVCs contributed in lowering the incidence of poverty and are credited for making possible the achievement of the related Millennium Development Goals. But joining GVCs at the low-skill entry level is only a first step, and the objective of many firms and policy makers is to upgrade by performing increasingly complex tasks and functions. This type of upgrading is in line with the export diversification policy understood in Hausmann, Hwang and Rodrik (2007).

Table 2 Revealed comparative advantage: Difference between gross and value-added exports, 2011 (in %)

Country	Average	Food products	Textiles & apparel	Wood	Paper, print, publish	Coke, petroleum	Chemicals	Rubber & plastics	Non-metallic minerals	Basic metals	Fabricated metals	Machinery	ICT & electronics	Electrical machinery	Motor vehicles	Other transport	Other manufacturing
Argentina	-3.6%	-7.3%	-1.2%	0.1%	-11.9%	6.6%	-4.7%	-7.3%	-3.7%	0.8%	1.3%	-6.2%	-4.5%	3.7%	-12.7%	-6.5%	-3.4%
Australia	-0.4%	-3.2%	-2.2%	2.2%	-7.2%	13.8%	5.8%	-0.1%	-3.7%	-8.8%	-1.3%	-6.3%	14.9%	-1.6%	4.2%	-8.9%	-7.3%
Austria	-4.9%	-4.4%	-3.9%	1.5%	-4.9%	-58.3%	6.0%	8.3%	-1.0%	-11.3%	4.8%	-1.9%	34.2%	7.6%	-13.7%	-13.9%	-8.9%
Belgium	8.4%	-3.0%	13.1%	5.2%	9.3%	-50.0%	13.4%	22.8%	6.3%	-1.6%	12.6%	15.6%	42.8%	34.3%	-11.0%	5.4%	0.9%
Brazil	-3.1%	-10.6%	-2.8%	-6.2%	-11.0%	15.5%	-4.9%	-5.2%	-7.8%	1.7%	-1.0%	-8.6%	1.0%	3.6%	-1.6%	-8.3%	-2.9%
Bulgaria	5.3%	7.8%	15.6%	8.4%	10.6%	-31.5%	-1.9%	-3.2%	0.0%	-15.5%	25.0%	8.2%	29.9%	17.6%	18.7%	8.1%	11.5%
Cambodia	14.5%	55.5%	-12.6%	46.2%	4.7%	95.3%	-13.5%	-17.7%	5.2%	6.4%	1.4%	-4.0%	17.1%	15.5%	11.3%	-1.1%	18.4%
Canada	5.4%	4.2%	-2.7%	9.3%	9.4%	39.3%	4.4%	-0.6%	15.6%	0.6%	5.7%	-5.2%	13.5%	0.3%	-33.8%	-3.7%	8.5%
Chile	-7.6%	-11.2%	-20.5%	-7.3%	-13.3%	-20.5%	-12.7%	-15.1%	-16.9%	4.1%	3.5%	-4.2%	13.9%	-4.1%	4.0%	-2.9%	-7.8%
China	5.1%	5.9%	12.2%	-10.5%	-20.9%	9.3%	-10.3%	0.9%	5.4%	27.4%	-2.6%	8.6%	-14.4%	-9.2%	17.6%	16.5%	18.0%
Chinese Taipei	-3.3%	12.5%	6.3%	0.2%	1.5%	-42.8%	-18.0%	0.6%	-13.7%	-23.2%	1.5%	-11.2%	29.0%	8.0%	12.4%	4.2%	9.4%
Colombia	-9.9%	-13.2%	-7.7%	-8.8%	-15.9%	44.0%	-12.4%	-16.0%	-2.6%	6.5%	-14.1%	-21.3%	-1.3%	-18.6%	-27.8%	-46.2%	-11.8%
Costa Rica	9.3%	11.0%	16.3%	16.6%	1.7%	-24.0%	16.5%	19.9%	8.3%	-12.3%	18.7%	-4.5%	2.6%	1.2%	40.5%	20.6%	5.4%
Croatia	-1.8%	1.0%	2.3%	6.2%	-10.5%	-23.5%	-12.1%	-13.6%	-4.4%	-13.6%	7.8%	0.8%	36.2%	12.3%	10.4%	-5.2%	-5.4%
Czech Republic	3.0%	6.9%	-4.6%	14.2%	7.7%	-38.6%	5.5%	3.9%	21.0%	-8.0%	17.3%	4.5%	-21.7%	4.0%	2.1%	9.1%	8.2%
Denmark	-0.3%	-20.3%	0.0%	-8.0%	-5.0%	-4.8%	3.8%	13.5%	-0.4%	5.3%	-1.2%	-9.0%	26.2%	1.1%	16.1%	-15.9%	-0.5%
Estonia	1.0%	-1.7%	-6.7%	5.5%	1.9%	36.0%	-14.2%	-6.7%	0.5%	18.7%	-4.7%	-3.2%	-11.2%	-6.8%	0.8%	-0.6%	2.8%
Finland	1.1%	3.6%	3.3%	11.9%	4.6%	-49.0%	1.7%	10.0%	5.4%	-20.0%	8.4%	0.2%	16.7%	11.8%	-4.6%	8.4%	2.3%
France	-0.3%	-1.5%	-6.0%	3.6%	-0.6%	-31.3%	-1.4%	2.9%	4.4%	10.1%	7.8%	0.5%	21.1%	7.7%	-1.5%	-18.0%	-3.1%
Germany	-4.1%	-12.1%	-9.6%	-4.4%	-3.9%	-34.7%	-2.7%	-1.2%	-2.0%	-19.1%	4.7%	-2.2%	22.9%	12.1%	3.1%	-11.2%	-4.3%
Greece	12.4%	12.5%	17.1%	9.8%	13.0%	-39.5%	2.7%	-1.8%	7.9%	1.5%	4.3%	14.6%	49.0%	20.5%	29.3%	41.3%	10.2%
Hong Kong, China	0.7%	-0.7%	3.1%	5.0%	2.4%	24.1%	-9.1%	9.4%	-12.8%	-29.8%	-23.1%	-0.1%	9.3%	6.4%	17.6%	5.3%	-11.5%
Hungary	11.2%	26.2%	-2.7%	21.5%	18.4%	1.2%	16.3%	15.7%	17.6%	0.5%	23.0%	18.8%	-30.2%	-4.2%	-3.9%	37.0%	20.5%
India	4.7%	16.8%	14.7%	11.6%	-1.3%	-14.4%	8.3%	12.2%	6.5%	-6.3%	-0.2%	-1.5%	22.8%	9.4%	11.3%	3.3%	-18.0%
Indonesia	-5.4%	-4.7%	-8.2%	-4.2%	-17.6%	38.1%	-4.6%	-2.8%	-5.5%	-2.6%	-12.4%	-28.8%	2.1%	-3.5%	-3.5%	-7.9%	-7.5%
Ireland	-8.3%	-5.1%	-7.3%	-13.5%	-20.4%	-24.8%	-1.2%	-4.9%	-14.5%	-19.9%	-6.1%	-1.9%	0.9%	19.3%	-5.2%	-6.6%	-28.5%
Israel	-2.2%	-9.9%	-7.4%	-5.0%	0.1%	-1.0%	-3.5%	4.7%	-44.8%	-21.7%	4.6%	-4.7%	28.7%	27.4%	19.0%	-0.4%	-20.0%
Italy	-3.8%	-4.0%	-2.5%	1.4%	-3.8%	-52.4%	-6.8%	-1.5%	-2.9%	-20.1%	7.5%	2.0%	23.4%	8.7%	2.5%	-0.1%	1.5%
Japan	-4.6%	-9.6%	-15.2%	-13.1%	-7.9%	-33.6%	-10.0%	-1.9%	-5.5%	-2.0%	2.4%	-2.3%	15.2%	9.1%	10.6%	-0.5%	-9.7%
Korea	3.2%	3.0%	11.4%	8.3%	13.5%	-54.5%	-14.4%	8.9%	3.2%	-9.5%	11.8%	4.2%	24.2%	23.1%	23.7%	12.0%	9.2%
Latvia	-2.8%	-7.5%	-12.6%	0.3%	-9.0%	69.1%	34.1%	-33.1%	-13.4%	-14.6%	-12.9%	-9.1%	5.2%	-9.6%	-12.0%	-19.0%	-7.3%
Lithuania	-8.7%	-24.3%	-8.3%	-15.7%	-15.8%	47.4%	-21.6%	-1.5%	-25.7%	-5.1%	-10.2%	-14.9%	4.6%	-13.1%	-16.0%	3.6%	-8.5%
Luxembourg	11.6%	2.8%	2.7%	-18.9%	0.1%	49.2%	-15.5%	2.2%	0.2%	-38.0%	24.7%	16.8%	48.3%	41.8%	26.7%	49.6%	0.3%
Malaysia	8.7%	20.2%	-2.5%	39.5%	16.4%	51.0%	18.6%	27.0%	14.2%	-4.0%	-8.8%	-5.6%	-20.6%	-16.0%	-9.5%	2.6%	-4.2%
Mexico	13.0%	24.8%	0.9%	28.0%	2.1%	65.6%	26.1%	4.2%	29.6%	52.3%	-6.4%	3.6%	-27.7%	-2.3%	-6.3%	13.8%	-17.3%
Netherlands	-0.2%	-11.7%	-3.3%	-1.4%	-5.0%	10.0%	-3.8%	2.8%	-1.3%	-4.2%	1.2%	1.7%	7.8%	1.3%	3.2%	-0.6%	5.4%
New Zealand	-6.0%	-11.9%	-13.1%	-4.2%	-15.9%	8.1%	-20.2%	-4.5%	-15.3%	-10.4%	-2.3%	-6.8%	13.2%	2.4%	-3.7%	-1.2%	-4.4%
Norway	-0.2%	-9.4%	-7.5%	-7.8%	-6.5%	51.0%	1.0%	-10.0%	5.4%	-14.1%	-3.9%	-7.0%	9.7%	0.1%	-11.0%	-3.8%	-4.4%
Philippines	-5.5%	4.5%	8.7%	0.1%	-8.9%	-25.1%	-7.7%	-5.6%	-19.3%	-16.1%	-15.0%	-5.8%	14.8%	7.8%	-11.4%	-15.8%	0.3%
Poland	0.1%	7.2%	0.9%	9.4%	-2.6%	6.8%	-1.2%	-0.5%	5.6%	-11.6%	4.0%	-1.7%	-12.0%	2.3%	-11.0%	-0.5%	-3.7%
Portugal	-1.5%	4.0%	8.8%	9.6%	10.8%	-74.2%	-0.8%	2.7%	1.7%	15.8%	11.6%	3.4%	-4.5%	-5.1%	-22.7%	7.0%	4.2%
Romania	-2.1%	0.6%	0.2%	2.6%	-6.3%	13.6%	-14.2%	-22.8%	-12.1%	-3.3%	-17.2%	-13.8%	29.7%	9.4%	7.0%	-1.5%	1.6%
Russian Federation	-6.8%	-12.0%	-16.0%	-10.8%	-15.6%	38.4%	-8.7%	-11.2%	-7.9%	-0.2%	-4.8%	-16.4%	4.7%	-8.9%	-17.9%	-14.7%	-9.0%
Saudi Arabia	-17.3%	-24.0%	-24.7%	-25.4%	-27.2%	37.4%	-3.2%	-21.6%	-8.7%	-5.8%	-36.9%	-28.2%	4.4%	-16.1%	-32.6%	-46.2%	-31.9%
Singapore	-4.6%	-17.2%	-20.7%	-2.5%	4.2%	-52.2%	4.9%	19.9%	-23.2%	-41.1%	-0.2%	-1.3%	33.9%	-1.5%	6.8%	15.5%	7.4%
Slovak Republic	11.0%	23.9%	27.1%	49.6%	20.2%	-62.8%	12.5%	13.7%	20.4%	-19.4%	38.8%	11.9%	-1.5%	22.1%	-8.9%	22.9%	20.0%
Slovenia	1.0%	-2.1%	-18.7%	0.4%	-7.2%	53.2%	7.6%	3.5%	-4.1%	-6.5%	1.4%	-8.9%	17.4%	3.6%	-20.3%	-3.5%	-3.7%
South Africa	0.0%	0.1%	-1.1%	1.8%	-6.1%	18.2%	2.1%	7.0%	-4.7%	-3.0%	1.2%	-4.7%	3.8%	-0.1%	7.3%	-22.6%	-1.2%
Spain	1.6%	-1.5%	-2.6%	4.8%	7.2%	-53.4%	1.4%	8.5%	6.3%	9.0%	8.9%	8.4%	29.1%	8.5%	-9.3%	2.7%	5.1%
Sweden	0.9%	-1.7%	-0.5%	2.4%	0.9%	-36.4%	11.2%	7.7%	0.3%	-11.8%	10.4%	2.3%	18.9%	1.2%	-9.4%	5.9%	-5.2%
Switzerland	-9.3%	-10.9%	-23.3%	-8.4%	-12.7%	11.1%	4.4%	-15.7%	-13.2%	-22.4%	-2.8%	-8.7%	14.6%	-15.9%	-18.5%	-8.9%	-21.7%
Thailand	-0.5%	26.6%	31.1%	31.3%	-6.4%	-1.2%	9.8%	19.2%	4.5%	-27.1%	-26.4%	-19.7%	-23.3%	-4.6%	-11.2%	-3.8%	-13.5%
Tunisia	3.9%	9.2%	-4.3%	19.4%	-25.2%	65.4%	-6.8%	4.0%	24.1%	-4.4%	-13.6%	-12.7%	5.2%	-7.7%	1.6%	13.2%	-4.4%
Turkey	0.7%	8.7%	9.1%	0.7%	1.5%	24.4%	3.3%	2.5%	5.4%	-20.6%	-14.3%	-11.1%	7.5%	4.0%	-9.3%	0.4%	-14.7%
United Kingdom	-0.9%	-2.6%	4.1%	-2.6%	6.3%	-14.0%	2.1%	4.3%	-0.4%	-22.3%	9.0%	-2.6%	22.8%	6.5%	-8.9%	-3.0%	1.8%
United States	-1.3%	-6.5%	-4.8%	-4.1%	-5.0%	7.5%	1.2%	2.0%	-5.7%	-11.3%	-1.7%	-9.4%	26.5%	4.7%	-13.3%	-4.3%	-1.4%
Viet Nam	-9.0%	24.8%	11.7%	-1.8%	-3.2%	2.8%	-32.0%	-24.0%	8.4%	-36.2%	-21.3%	-47.2%	-34.1%	-30.5%	-7.5%	-24.2%	10.6%

Note: a: simple average of manufacturing industries. All sectorial results are in percentage of the RCA calculated for Gross Exports of goods producing sectors.
Source: Based on OECD-WTO TiVA database 2015

Looking at export diversification from a GVC perspective opens also new options: upgrading can be achieved by including more and more domestic value added in the final export through deeper inter-industrial linkages. What the TiVA data tell us is that an industry exports not only directly (either final or intermediate products), but also by supplying other exporting industries with inputs (indirect VA exports). This role of second-tier supplier is particularly important for services, and half of service exports are indirect exports through service inputs embodied in merchandise goods. It is also often the best avenue for increasing small and medium firms' contribution to national exports. Upgrading through deepening ties with GVCs is closely related to Hirschman's views of economic development. [8]

For illustrative purpose, the Table 2 above goes beyond the G-20 group and includes a larger set of countries. It shows the difference between manufacturing sectors' RCAs calculated using gross export statistics (direct exports from the industrial sector, including domestic and foreign contents), and RCAs calculated based on the value-added, directly and indirectly, exported by the same industry (domestic content of the direct export plus sectoral value-added embodied in exports from other national industries). A positive value indicates that the sector is indirectly exporting by supplying inputs to exporting firms; a negative value indicates that the sector is relying on imported inputs for its exports. This, using Hirschman's view, would signal potential for encouraging more backward linkages to domestic suppliers, provided that domestic suppliers are sufficiently close to the international efficiency frontier (see page 15).

For some sectors, the difference can be quite important. In the case of ICT & electronics, for example, Singapore and Viet Nam present a very contrasting situation. Measured in value added, the comparative advantage of Singapore is almost 34% higher than what would imply its gross exports. At the opposite side, Viet Nam drops by a bit more than 34% due to its high reliance on imported inputs.

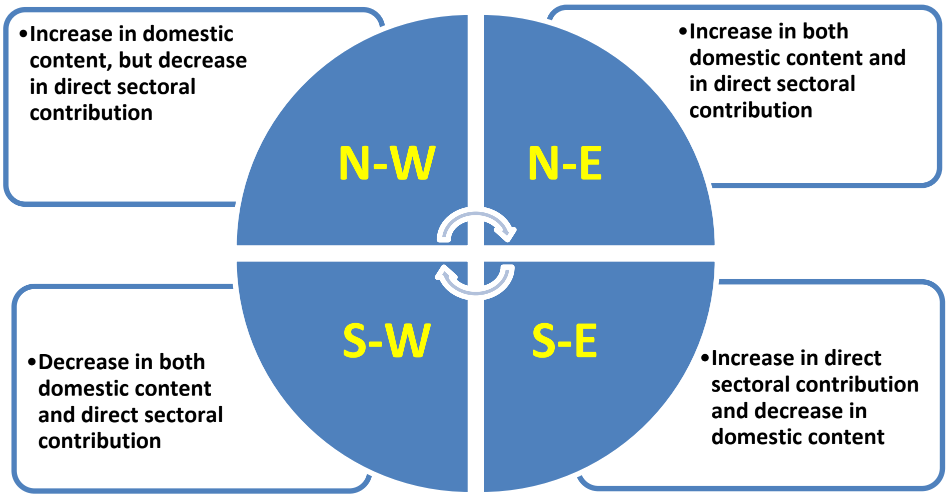
This said, a higher domestic value-added content might not be the sole objective from an upgrading perspective. In the case of the motor vehicles industry, Canada also has a large negative difference between its RCA in gross and value added terms (-33%). Its gross exports rely more on imported inputs not because the country is not able to produce these inputs domestically, but because it focuses on the segment where it has the highest competitive advantage. Thus, for more advanced economies, upgrading may also mean gaining overall competitiveness by shortening the upstream domestic linkages and outsourcing non-core inputs (similar to the "make or buy" decision at the firm level). Escaith and Miroudot (2015) mention the non-homothetic relationship between income levels and product diversification; Cadot, Carrère and Strauss-Khan (2011) point out that when GDP per capita increases, there is first a diversification in exports up to some threshold of USD 25,000 PPP; above this income, concentration takes place again.

Figure 2 helps illustrate some of the hypothetical upgrading trajectories that will be analysed in Figure 3. The graph is based on changes over a given period affecting three components: (i) gross exports, as the sum of domestic value-added plus the value of imported intermediate inputs required for the production of the products (foreign value-added); (ii) domestic value-added generated by the exporting industry (value of export minus purchase of imported and domestic inputs); (iii) domestic value-added generated by the various national sectors that supply inputs to the exporting industry. It presents on the vertical axis the change in the domestic content of exports (Δ Domestic VA / Gross Exports); the horizontal axis presents the change in the contribution of direct value-added created by the exporting sector in relation to the total (direct and indirect) domestic content (Δ Sectoral VA/Domestic VA).

A first phase in upgrading would be to increase the domestic content of exports (upper-right *North-East quadrant*) by increasing the direct contribution of the exporting sector (intensive upgrading) and by increasing the indirect contribution of other sectors (horizontal upgrading à la Hirschman). This corresponds to a reduction in vertical specialisation in concordance with traditional import-substitution industrialisation policies, albeit in practice modalities are very different as we shall see later.

[8] Hirschman (1958) was not much optimistic about spontaneous and autonomous outcomes and favoured the role of "binding agents" and "inducement mechanisms" in economic development. Actually, GVC trade is a kind of "inducement mechanism" which makes decisions "induced" by lead firms and first-tier suppliers.

Figure 2 Upgrading and stylised patterns of changes in the domestic value-added content of exports



Note: The matrix crosses, on the vertical axis the change in the domestic content of exports and on the horizontal axis the change in the contribution of direct value-added created by the exporting sector in relation to the total (direct and indirect) domestic content

Quadrant North-West corresponds to a situation where the increase in indirect domestic content is at least partially based on some outsourcing by the exporting industry to other domestic sectors.

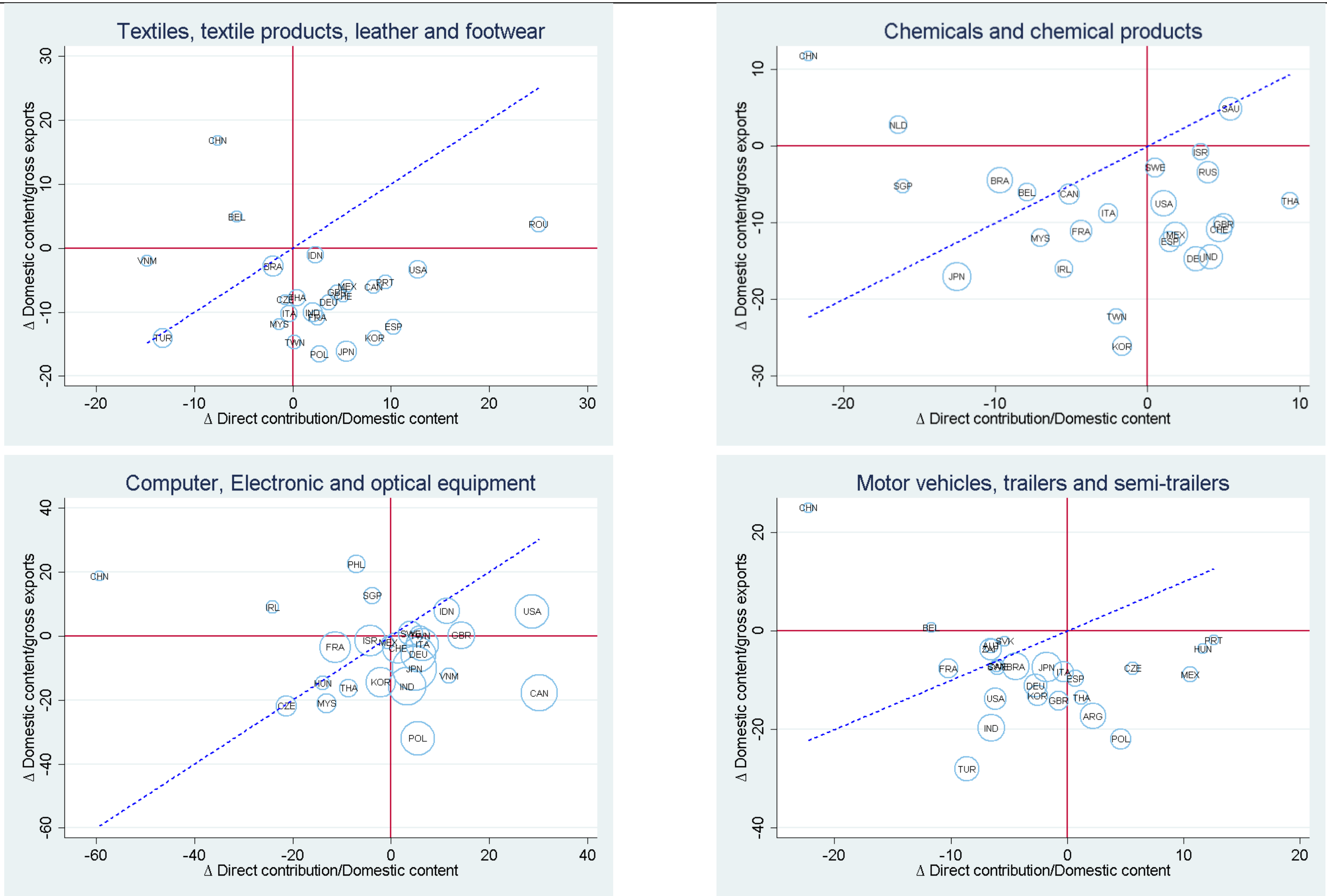
The *South-East quadrant* corresponds to a mature industry which outsources non-core activities and concentrates on the most profitable segment of the value-chain: sectoral contribution increases but the share of other domestic suppliers decreases. This is the typical position of a post-industrial developed economy during the Third Industrial Revolution. Such outsourcing behaviour fuels the upgrading trajectories of less advanced countries in the northern quadrants.

The *South-West* quadrant corresponds to a situation where both direct and indirect domestic contributions are retreating. It may not be seen forcibly as a negative outcome when it is the result of shifting productive resources in order to exploit comparative advantages. Actually, it may characterise a phase of rapid structural transformation in developing countries from a structuralist perspective "*à la Lewis*." For example, resources shifting from agriculture to manufacturing industries. In fact, the sectorial results analysed with the help of matrix in Figure 2 should not be considered in isolation of the behaviour of other sectors. It should also be noted that, in practice, TiVA results analysed through this matrix are affected by changes in exchange rates. So, after devaluating its currency, a country may be located in the S-W quadrant just because the value of foreign inputs increased.

Applying this analytical matrix, Figure 3 shows the results obtained by comparing the 1995-2011 evolution of domestic content (Δ Domestic VA / Gross Exports) and the direct sectoral content of exports (Δ Sectoral VA/Domestic VA) for four products: i) Textiles, textile products, leather and footwear; (ii) Chemicals and chemical products; (iii) Computer, Electronic and optical equipment; (iv) Motor vehicles, trailers and semi-trailers. All results are based on OECD-WTO TiVA database at current prices, converted in USD at market exchange rates.[9] To facilitate the analysis of the charts only countries for which the sector accounts for a significant share of total trade (above 2%) are represented. Calculations are based on the Leontief inverse and include all direct and indirect linkages. The size of the spheres indicates the share of domestic content in the initial year 1995 (percentage of direct and indirect domestic value-added embodied in gross exports). As we shall see below, overall domestic content (contribution of the entire economy through inter-industrial linkages) may vary in a different direction than the sectoral content (contribution of the exporting industry).

[9] Measuring non-tradable intermediate and primary factors in $PPP may alter the results and probably reduce the incidence of commercial exchange rate variations on the results, especially for developing countries where $PPP tend to "anticipate" future exchange rate appreciations due to the Balassa-Samuelson effect.

Figure 3 Foreign and domestic outsourcing: domestic content of exports and direct contribution of the exporting sector, 1995-2011



Notes: Change over 1995-2011 in percentage points; 45° line of balanced variation in dotted red.
Source: OECD-WTO TiVA database 2015.

Before we examine individual sectors, three stylised facts emerge from the four panels. First, most observations are located in the Southern quadrants, indicating an increase in vertical specialisation (*i.e.*, a decrease in the domestic content of exports due to a higher reliance on imported inputs). Secondly, China in the North-West quadrant (increase in domestic content principally due to an increase in the proportion of indirect value-added) is an outlier. It should be kept in mind that the Chinese situation in 1995 was very specific as most export-oriented activities were functioning as industrial enclaves. The domestic content of computer and electronic equipment exports was only 26% (vs. a 64% average for all countries) while direct value-added represented 96% of this domestic value-added (vs. an average of 52%). The third observation is the scarcity of N-E cases (direct and indirect growth of the domestic value-added content based on a drop in vertical specialisation).

In the case of textiles, textile products, leather and footwear, almost all countries are located in the bottom quadrants, indicating decreasing domestic content in gross exports (increased vertical specialisation), except China, Belgium and Romania. As China started with a very low domestic content, the increase in domestic VA may reflect more domestic integration or/and higher prices of non-tradable intermediate and primary inputs, including wages. Primary inputs are also likely to be behind the increase in the domestic content in Romania as it has also increased its direct VA in exports. In the case of Belgium, the higher domestic content could be related to a shift towards higher-end products involving higher wages and more expensive domestic inputs.

Only Viet Nam is above the 45° line in the South-West quadrant, where the decrease in the sectoral share of domestic VA was larger than the decrease in the domestic content of gross exports. The results being in percentage of total value, this result may relect different trends. Either the wages and profits in this sector dropped relative to the rest of the economy, or there was a process of internal outsourcing, with an increase in inter-industrial linkages. All other countries, except Brazil, the Czech Republic, Italy and Malaysia, are in a situation where sectoral content increased in a situation of overall decrease in domestic content. This is possibly a sign of foreign outsourcing and/or increase in sectoral wages and profit (both options being compatible).[10]

In the case of chemicals and chemical products (an industry that includes perfumes and pharmaceuticals), Saudi Arabia is the sole country that increased its share of domestic content and its share of sectoral value-added. Here, the surge of commodity prices after 2003 may have played a role. With regards to countries which increased their domestic content but lowered their sectoral participation, we find China, which started with a very low domestic content, and the Netherlands. An increase in domestic content may reflect more domestic integration or a higher rate of value-added (wages, profits) in domestic suppliers (exchange rate appreciation, due for example to the Belassa-Samuelson effect). Few countries, (Brazil, Belgium and Singapore) are above the 45° line in the South-West quadrant where the decrease in the sectoral share of domestic VA was larger than the decrease in the domestic content of gross exports. All other countries in this quadrant, are in a situation where the domestic content decreased more than than the sectoral content. In the South East quadrant are found the countries that in a situation of overall decrease in domestic content have increased their direct contribution: sign of large foreign outsourcing and/or increase in sectoral wages and profit (both options being compatible)?

Computer, electronic and optical equipment is probably the most illustrative sector when looking at the geographical fragmentation of production. Indonesia and the USA are in the positive North-East quadrant, with Chinese Taipei, Sweden and the UK on the border. The situation of these economies is particularly interesting in view of the current debate on globalisation, outsourcing and deindustrialisation. It appears that the USA (and Sweden and the UK in a lower proportion) were able to specialise in high and dynamic value-added segments of the industry. Few countries (China, Ireland, the Philippines and Singapore) have increased their domestic content while reducing their direct contribution. France and Israel are in a similar situation above the 45° line in the South-West quadrant but their domestic content slightly decreased. Korea, an important exporter in this industry, has both a lower domestic content and lower sectoral contribution, the consequence of offshoring strategies, particularly in China. Germany or Japan have also reduced their domestic content but the higher direct contribution suggests an increase in wages and profits together with foreign outsourcing strategies.

[10] The sectoral analysis presented here is for illustration only. As a first approximation based on macro-estimates, it should be completed by an in-depth sectoral and microanalysis before attempting a more elaborated diagnostic.

With respect to motor vehicles, trailers and semi-trailers, no country has increased both domestic and direct sectoral contents. Leaving aside Belgium at the border of the horizontal axis, China is alone in the N-W quadrant: starting from a very low domestic content in 1995, it increased the contribution of domestic suppliers while lowering, in proportion, the direct contribution of the sectoral value-added. Few countries (Austria, France and South Africa) are above the 45° line in the South-West quadrant where the decrease in the sectoral share of domestic value-added was larger than the decrease in the domestic content of gross exports. Either the wages and profits in this sector dropped relative to the rest of the economy, or there was a double process of international and domestic outsourcing, with an increase in foreign content and in domestic inter-industrial linkages. Most of the main exporters such as Germany, Japan and the United States are in a situation where both direct sectoral content and the domestic content have decreased, in the context of offshoring strategies. Mexico is an interesting country at the other end with an increase in the direct sectoral content in a situation of overall decrease in domestic content. It could be related to the specialisation of the country in parts and components with higher wages and profit.

As mentioned, most observations are located in the Southern quadrants, indicating an increase in vertical specialisation over the period 1995-2011 for all sectors. To confirm this stylised fact, Table 3 presents the result of a correlation analysis.

Table 3 Correlation between initial trade in value-added indicators and 1995-2011 changes (*all TiVA economies*)

	Domestic VA / Gross Exports	Sectoral VA/Domestic VA	Domestic VA / Gross Exports	Sectoral VA/Domestic VA
	Textile		Chemical	
Domestic VA/Gross Exports (1995)	**1**	**-0.3**	**1**	**-0.3**
Sectoral VA/Domestic VA (1995)	**-0.3**	**1**	**-0.3**	**1**
∆Domestic VA / Gross Exports	**-0.4**	-0.0	**-0.3**	0.1
∆Sectoral VA/Domestic VA	0.0	-0.1	-0.1	-0.2
	Computers		Vehicles	
Domestic VA/Gross Exports (1995)	**1**	**-0.4**	**1**	-0.0
Sectoral VA/Domestic VA (1995)	**-0.4**	**1**	-0.0	**1**
∆Domestic VA / Gross Exports	**-0.5**	**0.3**	**-0.5**	0.1
∆Sectoral VA/Domestic VA	**0.3**	**-0.5**	-0.1	**-0.4**

Note: 62 observations. Values in bold are different from 0 with a significance level alpha=0.05
Source: OECD-WTO TiVA database 2015.

For all sectors, the correlation is negative and significant between (i) the value of domestic content and the share of direct value added in 1995; and (ii) the value of domestic content in 1995 and the change between 1995-2001. The countries that sourced most of their inputs domestically in 1995 were those that also outsourced more actively to other domestic suppliers in 1995 (large domestic content positively associated with strong inter-industry linkages); the same industries outsourced more to international suppliers over the 1995-2011 period. The trend is particularly strong for 'computers and electronics': because of this international outsourcing substituting domestic inputs for foreign ones, the direct sectoral content increased (the correlation coefficient of 0.3 is positive and significant).

3.3 Deepening domestic value chains: Sectoral efficiency and inefficiency spillovers

We see that the possibility of unbundling production in separate steps, as in equation [9] allows less advanced developing countries to join global value chains by undertaking labour intensive tasks (the productive tasks corresponding to **k'**). Gains in sectoral efficiency when using intermediate inputs translate into higher value-added, and therefore support GDP growth. Public policies have increasingly adopted a GVC approach to economic development, in particular for the manufacturing sector. Indeed, many low-income developing countries join global value chains by performing only the most labour-intensive tasks, such as assembly. The objective of most trade and development agencies is to incorporate more domestic value-added by performing more of the tasks belonging to the higher-technology subset **k''** of equation [9]. This implies promoting domestic inter-industrial linkages in a context of international competitiveness. This approach is sometimes called "smart industrial policy" to differentiate it from previous import substitution strategies which aimed at increasing domestic value added by offering effective protection to some sectors (Diakantoni and Escaith, 2014).

Efficiency from an export-oriented viewpoint is best benchmarked by the "competitiveness" of domestic industries both in terms of process and price. For reasons that will be discussed later, competitiveness in technology intensive activities for less advanced countries cannot be sustained in the long term on the basis of low wages or competitive exchange rate (nominal competitiveness) but needs also to be anchored in real technological capabilities. Returning to equation [6], the less advanced country B should, for a subset of tasks $\mathbf{k'''}^{B}$ at a given international value vector **v** = (**w**, **p**), verify the following inequality:

$$\mathbf{a_0}(\mathbf{k'''}^{A})\ \boldsymbol{w}(A) + (\mathbf{a_+}(\mathbf{k'''}^{A})\ ,\ \mathbf{p}) > \mathbf{a_0}(\mathbf{k'''}^{B})\ \boldsymbol{w}(B) + (\mathbf{a_+}(\mathbf{k'''}^{B})\ ,\ \mathbf{p}) \qquad \textbf{[13]}$$

With **k'''** standing in-between **k'** subset of labour intensive tasks and **k"** subset of highly technology intensive activities.

The TiVA data help us to understand the relationship between nominal (price) competitiveness and productive efficiency, but with some caveats. Actually, the technical coefficients of the IO matrix reflect the industry's production function under the domestic price structure and not at the international value vector **v** = (**w**, **p**).

Domestic prices differ from country to country: the domestic price of internationally tradable inputs is affected by a series of costs (freight costs, tariffs and other trade hurdles) while wages and the price of non-tradable inputs reflect (more or less) the level of development of a country and its per capita income due to the Balassa-Samuelson effect (Feenstra, Inklaar and Timmer, 2015). Moreover, when trade is not frictionless and some inputs are not tradable, the inefficiency of some domestic sectors may in turn affect the international competitiveness of the industries that depend from them for their inputs.

This section reviews how the information derived from TiVA can help establish a diagnostic relative to sectoral efficiency and its down-stream spillovers. The following examples are based on the results obtained for two industries where GVCs are prevalent: textiles and apparel, a buyer-driven GVC, and motor vehicles, an industry-driven GVC.

3.3.1 Nominal efficiency at domestic and international prices

There are many definitions of productivity and efficiency, most performance indicators taking the form of a ratio between an output and an input (Bogetoft and Otto, 2011). If we have input-output data for all industries, we can use this information to determine which is doing best according to a specific dimension of efficiency. In a first approach, we approximate productive efficiency by the ratio, sectoral value-added per unit of output. The ratio derives directly from the national input-output data, setting aside for the time being turnover and scale effects. [11]

Comparing sectoral ratios with other foreign producers, nevertheless, does not reflect just differences in gross return per unit due to technology as reflected by the (IO matrix) technical coefficients, but also the difference in the purchase price of inputs and output. Even under the assumption of a unique international price for tradable goods, domestic prices are affected by trade costs, while the price of non-tradable inputs (services and primary inputs) is affected –inter alia– by differences in nominal wages and exchange rate considerations.

[11] This is a clear restriction on the use of this indicator for inter-enterprise comparison, as a small-sized industry may generate high value added per unit, but be less profitable (e.g., in terms of return to investment or total wages per worker) than a high-volume/low-margin industry.

Diakantoni and Escaith (2014) explore the impact of tariff policies on the domestic price of inputs and their cascading effect on costs of production, calculating effective protection rates (EPR):

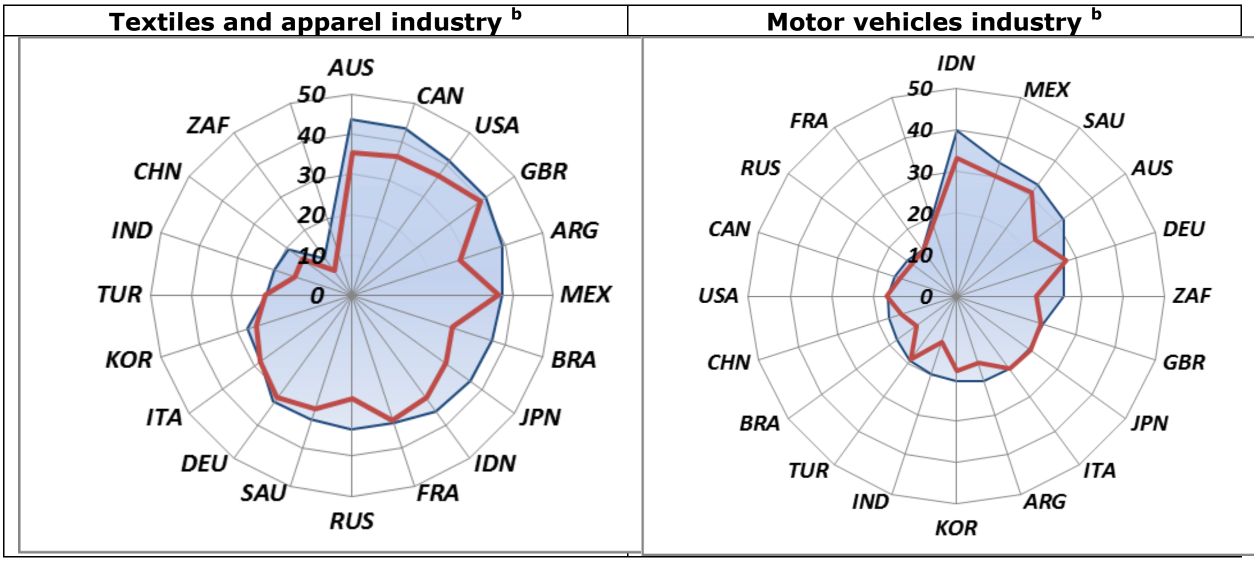
$$EPR_j = \frac{t_j-(\sum_i t_i \cdot a_{ij})}{1-\sum_i a_{ij}} \qquad [14]$$

With $[1-\sum_i a_{ij}]>0$

EPR for sector "*j*" is the difference between the nominal protection enjoyed on the output (t_j) minus the "weighted average" of tariff paid on the required inputs ($\Sigma t_i . a_{ij}$). [12] The measure is divided by what would have been value-added in a frictionless economy (if all domestic prices had been equal to the international ones). [13]

A high sectoral VA ratio may reflect a situation where the industry benefits from a high nominal protection on its output, while the intermediate goods required by the production process are subject to lower tariffs.[14] Correcting for the artificial bias induced by tariff escalation allows for a more transparent international comparison of sectoral efficiency.

Figure 4 Textiles & apparel and motor vehicles: Sectoral value-added at current domestic prices and correcting for tariffs, 2011[a]



Notes: a/ Effective Protection Rates are calculated on 2008 tariff data, including preferences and ad-valorem equivalents.

b/ The blue area shows the sectoral value-added in per cent of total production; the red line indicates the unit value-added after adjusting for effective protection due to tariff policy.

Source: OECD-WTO TiVA database 2015 and Diakantoni and Escaith (2014).

Developed G-20 countries top the ranks of gross return per unit in the textile industry while developing G-20 members do so for the automotive industry. France, Canada and the USA have very low gross rate of return per dollar of motor vehicles produced; as for textiles, the lowest returns are found for South Africa, China Indonesia or Turkey. But a low rate of return per unit may actually show competitiveness in the high-volume segments, while high rates of value-added may be the characteristics of niche markets (luxury or specialised products). This indicates that the indicator is probably not a good one for international comparison.

[12] It is not strictly a weighted average, as by EPR definition, the weights cannot sum up to 1 (services and primary inputs are excluded from the formulation).

[13] Because the international prices are not observable directly, EPR is often approximated by using observed prices at the denominator, then adding tariffs to calculate the numerator.

[14] In the following section, we will not consider differences in transportation costs, which may also play the role of differentiated trade barriers and affect the degree of sectoral effective protection. Shiozawa (2012) presents a neo-Ricardian model accounting for differences in production techniques and labour costs that provides further insights on the issue.

Correcting for effective tariff protection provides, nevertheless, an indication on the extent of genuine vs. policy-induced competitiveness. The red line in Figure 4 corrects the rate of value added for the bias introduced by the differences in nominal tariff protection between output in a two-sector example (textiles and apparel and motor vehicles) and the various inputs required for their production.

The automotive industry in developed countries (barring Australia) does not benefit from a significant effective protection, and its gross profitability (per unit) is genuine; this is also the case for Turkey. In many developing G-20 countries, part of the profitability of the automotive industry relies on the difference between the nominal protection received and the additional cost paid on inputs due to tariffs. EPR in [5.1] is the ratio of value-added generated dues to this difference in nominal protection relative to the VA that would have been generated in a situation without tariff duties. The difference is particularly high for Indonesia (41%) and Brazil (32%). Australia and South Africa provide 25% effective protection to their automotive industry, inflating by a similar margin its profitability.

When it comes to textiles and apparel, a more labour-intensive industry, many developed countries also provide effective protection, even if in a lower proportion than developing countries. 21% of value-added generated by textiles and apparel activities in Japan, 19% in Australia and 17% in Canada can be attributed to the tariff structure. The profitability of these industries would therefore be affected by a flattening and reduction of the tariff schedules. It would also be the case in South Africa (32%), Brazil (29%), Argentina (28%), China, Indonesia and Russia (between 21 and 25% of additional return due to trade policy).Some developing countries do not provide much protection to their domestic industry, relying on their own capacity for international competitiveness as is the case for Mexico (3%) and especially Turkey, where the protection is negative (its textiles and apparel industry would generate more value-added in the absence of effective protection).

3.3.2 Nominal efficiency and exchange rates

The input-output coefficients sustaining the calculation of TiVA indicators are measured in domestic prices before being translated in US dollar using market exchange rates. Those market rates may differ from their long-term value, for a number of reasons. Without entering into a complex debate about the determinants of long term parities, we will use here the common practice of correcting market exchange rate by the purchasing power of the currency on its domestic market. Purchasing Power Parity equilibrium is attained when the equivalent in domestic currency of one UD dollar will buy in the domestic market the same bundle of goods and services than in the US economy. [15] Our data are based on the Penn Tables.

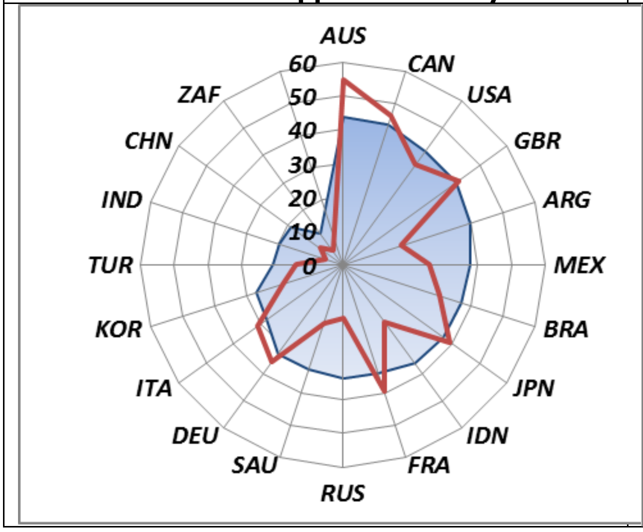
A Purchasing Power Parities ($PPP) of 1 means that the commercial exchange rate is aligned with the cost of living (one USD will buy the same amount of goods and services in both countries); a value above/below one indicate that the country is more/less expensive than in the US (overvalued/undervalued). Developing countries tend to have $PPP lower than one, due to the low production cost of most non-tradable (services). Nevertheless, when countries develop, wages and cost of living increase, due to the Belassa-Samuelson effect and the gap tends to decline.

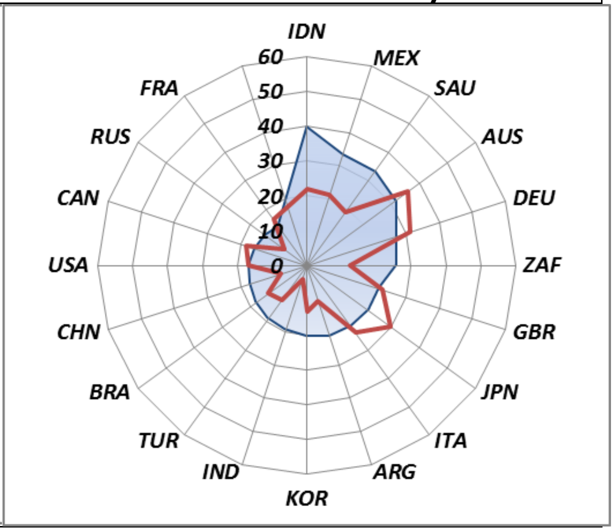
Figure 5 shows the change of competitiveness per unit of output if, in addition to correcting for the nominal bias created by effective protection, the remuneration of primary factors (value-added) adjusts to a purchasing power situation where $PPP=1. Australia, Brazil or Canada (commodity exporters that suffered from an episode of "Dutch Disease" during the commodity super-cycle of 2003-2011) would benefit from a devaluation of their currency; it would also be the case for Europe and Japan, albeit for different reasons. Most of the other countries, at the contrary, would have to appreciate their commercial exchange rate increase in order to align purchasing power parities with the USD. Were it the case, Indonesia, China, Saudi Arabia or Russia would see their competitiveness eroded.

[15] Such international comparison, based on the demand side of the GDP identity, is conducted on a regular basis by the International Comparison Program, a partnership of various statistical administrations of up to 199 countries coordinated by the World Bank. PPP exchange rates are also available in the Penn Tables for a wider coverage, using imputations to supplement official sources.

Figure 5 Textiles & apparel and motor vehicles: Sectoral Value-Added at current domestic prices, and correcting for tariffs and purchasing power parities, 2011[a]

Textiles and apparel industry [b]	Motor vehicles industry [b]





Notes: a/ Effective Protection Rates are calculated on 2008 tariff data, including preferences and ad-valorem equivalents. Purchasing power parity US-PPP =1 in 2011. b/ The blue area shows the sectoral value-added in per cent of total production; the red line indicates the unit value-added after adjusting for tariff policy and exchange rate misalignments.
Source: OECD-WTO TiVA database (June 2015), PWT8 and Diakantoni and Escaith (2014).

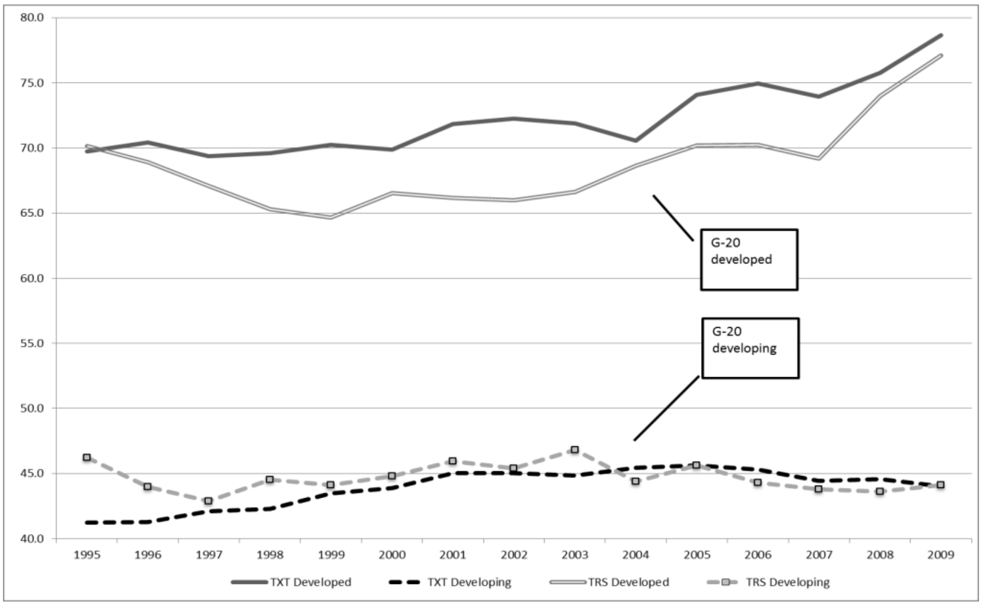
Extreme caution needs to be applied here, as this simulation is done under the "*ceteris paribus*" hypothesis, something highly unlikely were the relative prices to change so drastically. [16] Figure 5 shows the results of this (very hypothetical) simulation, after considering both the EPR and the exchange rate adjustments. The competitiveness gap would be much higher in developing countries, which usually have a more protectionist policy and benefit from lower costs of living than the US. The size of the gap provides some indication of the productive shift that the sector would require to maintain its profitability if domestic prices were to align with international ones. On the contrary, most developed economies would benefit from a price situation (including exchange rate) closer to its "pure free market" ideal (e.g., Australia in the case of textiles and Japan for motor vehicles).

Moreover, the PPP hypothesis applies mainly to wages and employees compensation, rather than to the full value-added remunerating primary factors. The share of workers' compensation varies greatly between developed and developing economies (Figure 6). While the average is relatively representative of the individual situation of developed G-20 countries, the developing countries in the G-20 group reflect a large heterogeneity.

Higher levels of development through GVC upgrading would therefore not only translate into higher wages, but also in a higher proportion of the value-added being dedicated to workers' remuneration. The contradiction between higher technological intensity and lower remuneration for capital is only apparent, as the main criteria for investor's remuneration is the net rate of return on investment rather than the mark-up rate on production cost. This rate of return on capital depends also on the turnover (production scale) and the efficiency of the production technologies beside wages.

[16] The analysis of large shocks in relative prices through general or partial equilibrium approaches would be much more appropriate for large permanent shocks.

Figure 6 Compensation of employees relative to value-added, 1995-2009



Note: Compensation of employees in percentage of gross value-added at current basic prices.
Source: Based on WIOD socio-economic accounts.

To conclude this section, let us return now to the equation that conditioned upgrading to the competitiveness condition:

$\mathbf{a_0}(\mathbf{k'''}^A)\ \boldsymbol{w}(A) + (\mathbf{a_+}(\mathbf{k'''}^A)\ ,\ \mathbf{p}) > \mathbf{a_0}(\mathbf{k'''}^B)\ \boldsymbol{w}(B) + (\mathbf{a_+}(\mathbf{k'''}^B)\ ,\ \mathbf{p})$ **[13]**

When by upgrading from **K**' to **K**''', the less developed country B increases GPD and per capita income (social upgrading). Economic and social development will translate in a relatively large increase in ***w***(B) at international prices under the double effect of higher wages in domestic currency and revaluation of the PPP exchange rate. The competitiveness condition [13] can hold only if technological efficiency increases more than proportionally to compensate for the higher cost of production at international prices, so that $(\mathbf{a_+}(\mathbf{k'''}^B)\ ,\ \mathbf{p})$ becomes small enough.

3.3.3 Benchmarking inefficiencies

Social upgrading and international competitiveness can be achieved through an increase in technological content but also by reducing existing inefficiencies. When a developing country adopts more efficient technologies, it is probable that not all of its industrial sectors will move in parallel towards the technological frontier. A productive chain is as strong as its weakest link, and the competitiveness of an industry may be lowered if it relies on inputs from less competitive suppliers. One solution, if the inputs are tradable, is to substitute the inefficient suppliers with imports. Actually, the TiVA results indicate that the most dynamic exporters were also those who had increased their reliance on imported inputs, deepening their vertical specialisation (as illustrated with Figure 3). This option may not always be policy makers' objectives in developing countries that may prefer to deepening backward and forward domestic linkages. For domestic suppliers to substitute efficiently imported inputs, domestic value chains must look –inter alia– at value creation by identifying and reducing industrial inefficiencies. Because (international) efficiency is only relative to (international) industrial standards, this implies comparing national industries against international benchmarks.

As in the work of Cella and Pica (2001) on 5 OECD countries, International Input-Output matrices offer a novel source of data for a worldwide efficiency benchmarking analysis, comparing domestic inter-industrial linkages for a given country against its main trade partners.[17] Accounting for inter-industry linkages via the IO relationship allows tracking sectoral inefficiency spillovers over the upstream and downstream domestic and international segments of the value-chain.

This section applies frontier analysis to identify those sectors that effectively convert intermediate inputs into maximum achievements from an economic growth perspective (production and domestic value-added). To this purpose, we use the benchmarking technique of data envelopment analysis (DEA), which has been used extensively in the last 30 years in the estimation of production frontiers for private and public entities, and even development programs.[18] Efficiency, in a multiple input-output setting is measured as the maximum Output/Input ratio, obtained either by minimizing inputs for a given level of output (primal) or maximizing output for a given level of inputs (dual). DEA uses the input-output data of a sample of industries to identify a production frontier and determine the location of each observation. A DMU is a frontier point in an input-oriented optimization (primal) if its current input levels cannot be reduced (proportionally) to obtain the same value of outputs. On-frontier industries are ascribed an "efficiency rating" of 100%; less efficient "off-frontier" observations are characterised by a "distance" from the frontier which measures a potential for enhanced performance.

Applying DEA to input-output data in order to benchmark industries against their international competitors is not without difficulties. On the analytical side, the main issue is the international comparability of highly aggregated sectors as those presented in the TiVA database. Because DEA is best applied as a benchmarking device when the units are homogeneous (in their inputs, outputs and operating environment), the aggregation biases present in national accounts is a tangible issue. Comparing the agricultural sector of India and of Japan on the implicit assumption that the "representative" Indian and Japanese farmer face the same environment and can use the same productive technologies is at best heroic.[19] There exist several options for controlling heterogeneity and calculate meta-frontiers that consider the different environmental constraints in which the industries operate, but these techniques demand a large number of observations.

In a small sample such as the G-20, DEA loses discriminatory power and may flag too many observations as "efficient". There are in practice several rules of thumb for adapting the sample size to the depth of the optimization problem (Avkiran, 2006): sample size must be larger than the product of number of inputs and number of outputs or larger than three times the sum of the number on inputs and outputs. In the case of the G-20, the sample size is fixed (19 countries), so we reduced the number of sectoral inputs (domestic and imported) in order to reduce them to five: three domestic inputs, sourced from the primary, secondary and tertiary sectors of the economy, and two imported ones (intermediate goods imported from primary and secondary foreign sectors).[20]

We consider two outputs: production and value-added. Including the latter as an output of the optimisation system is not straightforward and requires some attention. Indeed, from a public industrial policy perspective, the objective is to create as much value-added as possible as it is the source of factorial income (wages, profits, indirect net taxes on production) and economic growth (a country's GDP is equal to the sum of its sectorial value-added). Yet, from a value-chain perspective, high value-added in an upstream industry also reflects higher prices for its output and inflated production costs for the other down-stream industries. So, from an efficiency spill-over perspective, value-added should be treated as a primary input, as it is the case in standard production function. Koopmans mentions when reviewing earlier research that Leontief and von Neumann treat labour as an output, even if himself prefers integrating it as a fixed primary input

[17] Cella and Pica (2001) use also the "price" dimension, which allows refining the analysis and examine allocative efficiency. In our case, TiVA data come from accounting sources and are "values" (cost and revenues); therefore, separate data on quantity and prices are missing.

[18] Thore and Taverdyan (2015) explore this technique of providing diagnostics to support policymaking aimed at achieving sustainable development goals (SDGs).

[19] Not to mention the "representativeness" of the input-output sectoral average, when firms are highly heterogeneous, which is one of the limitation of the present TiVA estimates. In the 2015 version of TiVA, this aggregation bias is reduced in the case of China and Mexico, by separating export-oriented from domestic oriented firms. Future work, differentiating firms by size and ownership based on the compilation of Extended Supply Use Tables should reduce the TiVA aggregation biases.

[20] Food was considered as "primary" in our aggregation, even if it includes agro-industrial products.

(Koopmans, 1951).[21] The results presented here adopt the policy-makers perspective by considering value-added as part of the objective function.

All calculations were made using the "Benchmarking" package implemented in "R" (Bogetoft and Otto, 2015). Following Avkiran (2006), the data were normalised by dividing all inputs and outputs by their sample mean; this does not affect the results but facilitates calculations. This transversal normalization across countries breaks down the accounting identity linking the sum of inputs and the sum of production and value-added, and avoid strong collinearity issues. The results presented here are for illustration only as they only rasp the surface of the analytical power of modern DEA analysis and, more importantly, were not submitted to robustness tests (the results are based on a relatively small sample).

- **A simple benchmarking of the motor vehicles industry**

The data in Table 4 correspond to TiVA sector "Motor vehicles, trailers and semi-trailers" collected for the nineteen G-20 countries in 2011. The analysis considers two outputs (production and value-added) and 5 aggregated inputs (three domestic, two imported). A first exploration of the data set relies on simple correlation coefficients between inputs (three classes of domestic inputs and two imported ones). With the exception of primary domestic inputs, all correlations are significant. Interestingly, and in accordance to the GVC axiom that "Imports make exports", value-added and production are highly correlated with the use of imported industrial inputs (6th column of Table 4).

Table 4 Motor vehicles industry: Correlation coefficients between inputs, output and value-added, 2011

Variables	Primary_D	Secondary_D	Tertiary_D	Primary_I	Secondary_I
Primary_D	**1.0**	**0.6**	**0.7**	**0.9**	**0.8**
Secondary_D	**0.6**	**1.0**	**0.9**	0.4	**0.6**
Tertiary_D	**0.7**	**0.9**	**1.0**	0.4	**0.7**
Primary_I	**0.9**	0.4	0.4	**1.0**	**0.8**
Secondary_I	**0.8**	**0.6**	**0.7**	**0.8**	**1.0**
Value_Added	**0.8**	**0.7**	**0.8**	**0.6**	**0.9**
Production	**0.8**	**0.7**	**0.8**	**0.7**	**1.0**

Note: Pearson coefficients calculated on 19 observations, values in bold are different from 0 with a significance level alpha=0.05. Input suffixes "_D" and "_I" stand, respectively, for "domestically sourced" and "imported".
Source: Authors' calculations, based on TiVA data.

The DEA benchmarking is based on the optimal use of inputs (the primal model). Table 5 presents the results obtained under two alternative technologies: variable and constant return to scale. More countries are classified as efficient under the variable returns hypothesis, and many countries are very close to the efficiency frontier (id est, a more flexible approach integrating random measurement errors would have probably classified them as efficient). Following Avkiran (2006), we can conclude from the high number of efficient DMUs that the sample size is probably too small to discriminate correctly between them.[22]

As mentioned previously, the results may not represent international competitiveness because the value of inputs and outputs used in the benchmarking exercise are based on domestic prices. A more thorough analysis should correct for the biases introduced by trade and tariff policy, as was done in the previous section in Figure 4.

[21] The treatment of non-discretionary inputs such as "labour" in Koopmans' case falls beyond the scope of this essay. In our cases, all inputs are deemed to be flexible and can be discretionarily adjusted (within limits set by production technologies) by the industry managers.

[22] Under standard DEA, a DMU may be classified as efficient only for the use of one particular input, even if it is inefficient for all others. Other benchmarking methods (e.g., Stochastic Frontier Analysis) may correct for this bias, but at the cost of introducing assumptions that are more demanding.

Table 5 Motor vehicles industry: Frontier efficiency scores under variable (VRS) and constant (CRS) returns to scale, 2011.

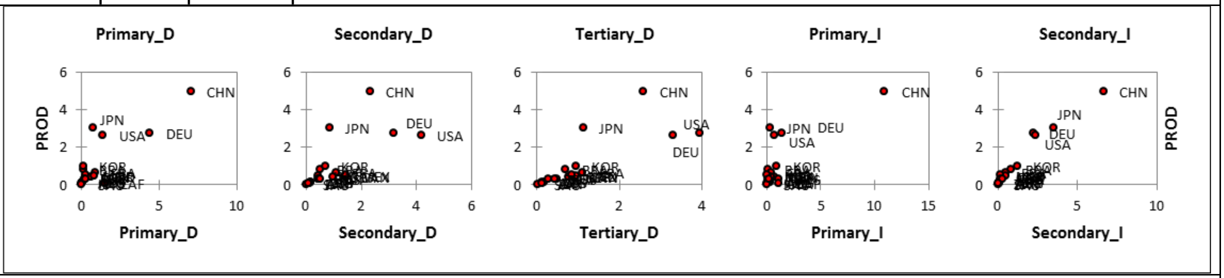
ISO3	ARG	AUS	BRA	CAN	CHN	DEU	FRA	GBR	IDN	IND
VRS	0.89	1.00	1.00	0.87	1.00	1.00	0.96	0.96	1.00	0.93
CRS	0.88	1.00	1.00	0.83	0.82	0.85	0.82	0.83	1.00	0.91
ISO3	ITA	JPN	KOR	MEX	RUS	SAU	TUR	USA	ZAF	
VRS	1.00	1.00	1.00	1.00	0.95	1.00	0.87	1.00	0.94	
CRS	0.91	1.00	0.99	1.00	0.85	0.96	0.86	0.82	0.91	

Source: Authors' calculations, based on TiVA data and 'Benchmarking' R package.

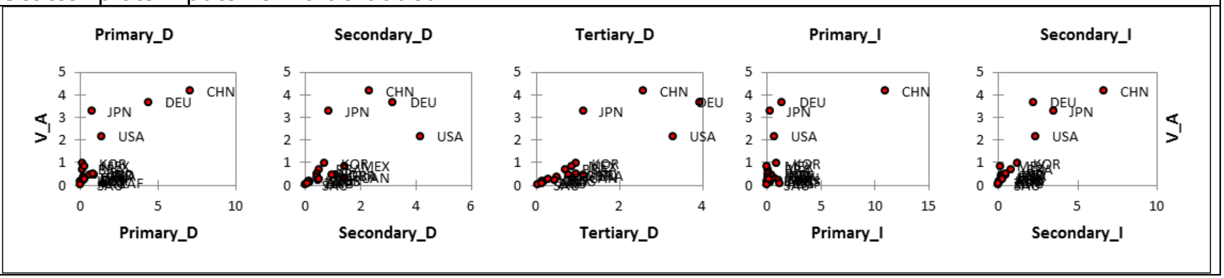
One may gain additional information by considering inputs or outputs separately (Figure 7). The four leaders (China, Germany, Japan and USA) differ in their use of inputs. For example, China's automotive industry is particularly intensive in the use of primary inputs, especially imported ones.

Figure 7 Motor vehicles industry: Input use vs production and value-added

Scatter plots inputs vs. production



Scatter plots inputs vs. value-added



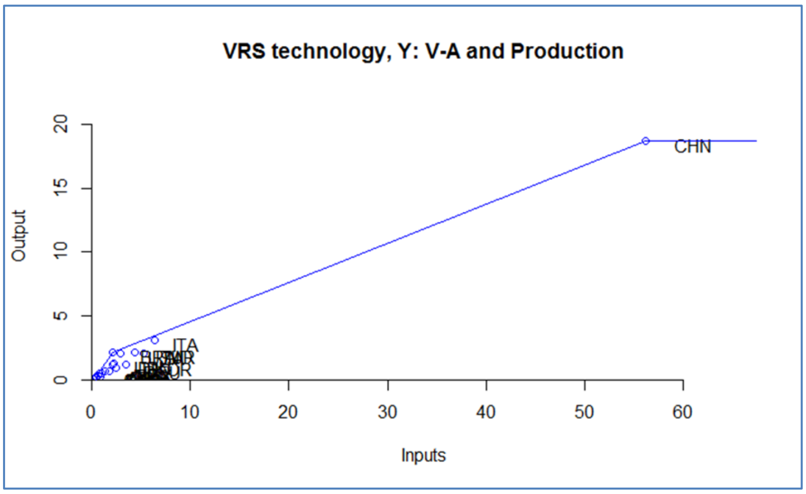
Note: Input suffixes "_D" and "_I" stand, respectively, for "domestically sourced" and "imported".
Source: Authors' calculations, based on TiVA data.

Some industries are also clear outliers and weigh too much on the sample, distorting the analysis. Ideally, outliers should be excluded within the sample size limitations discussed before. An example is provided in the following section on textiles and apparel.

➢ Benchmarking various dimensions of the textiles and apparel industry

When looking at textiles and apparel industry (Figure 8), China is clearly an outlier. The large scale of its production overshadows the results obtained for other G-20 countries. In order to gain analytical insights for the other G-20 economies, we drop the Chinese textiles and apparel industry from the sample.

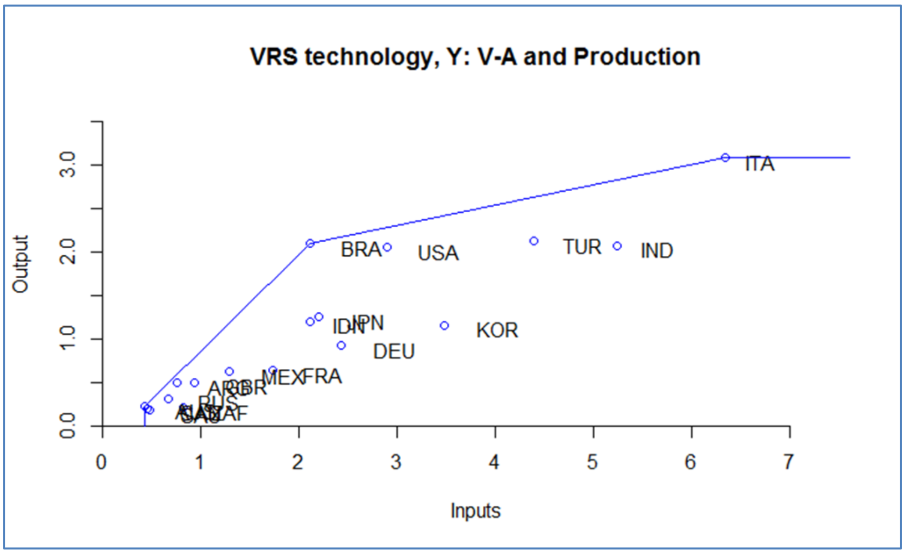
Figure 8 Textiles and apparel industry: Frontier efficiency graph under variable returns to scale, G-20 (2011)



Note: Due to the projection of 5 inputs and 2 outputs on a 2 x 2 graph, the position of each point relative to the frontier is approximated.
Source: Authors' calculations, based on TiVA data and 'Benchmarking' R package.

Taking China out of the sample provides a clearer view of the relative efficiency of other G-20 textiles and apparel industries (Figure 9).

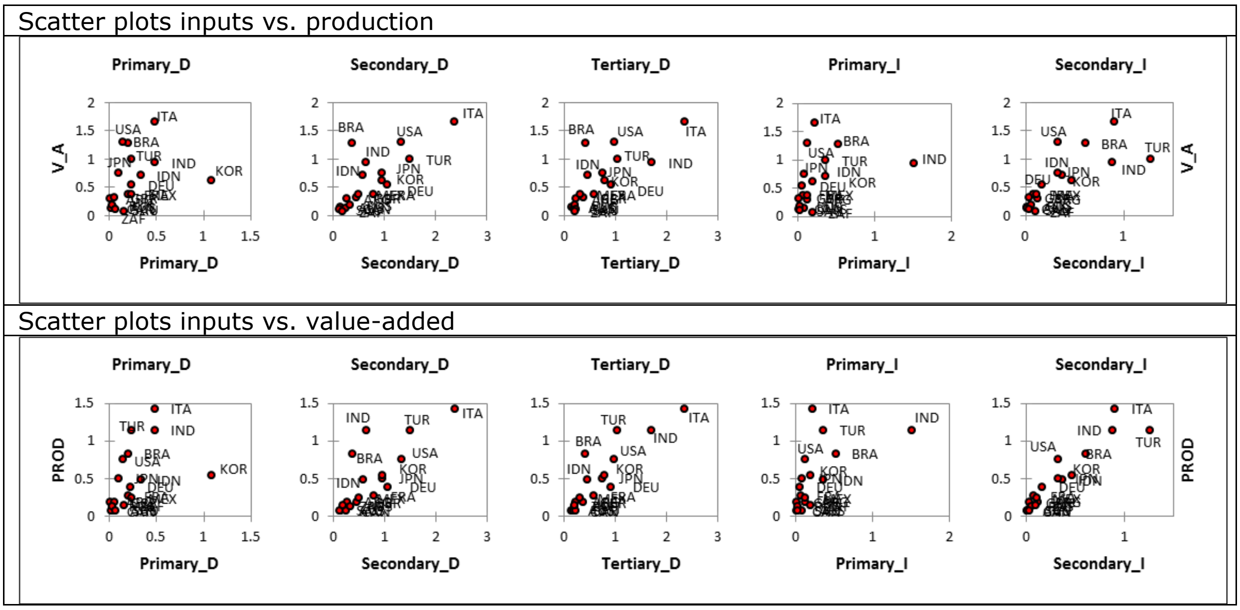
Figure 9 Textiles and apparel industry: Frontier efficiency graph under variable returns to scale, G-20 less China (2011)



Note: Due to the projection of 5 inputs and 2 outputs on a 2 x 2 graph, the position of each point relative to the frontier is approximated and some efficient DMUs may be plotted inside the frontier.
Source: Authors' calculations, based on TiVA data and 'Benchmarking' R package.

The frontier analysis considers a weighted sum of all inputs on the one hand, and all outputs on the other. As Figure 10 shows, countries differ widely in the mix of domestic and imported inputs used in the production process. Table 10 tells us also that primary inputs (domestic or imported) may play a lesser role in "producing" value-added than in determining turnovers.

Figure 10 Textiles and apparel industry: Input use vs production and value-added



Note: G-20 countries, excluding China. Input suffixes "_D" and "_I" stand, respectively, for "domestically sourced" and "imported".
Source: Authors' calculations, based on TiVA data.

Table 6 Textiles and apparel industry: Correlation coefficients between inputs, output and value-added, 2011

Variables	Primary_D	Secondary_D	Tertiary_D	Primary_I	Secondary_I
Primary_D	**1.0**	0.4	**0.5**	0.4	**0.5**
Secondary_D	0.4	**1.0**	**0.9**	0.1	**0.7**
Tertiary_D	**0.5**	**0.9**	**1.0**	**0.5**	**0.7**
Primary_I	0.4	0.1	**0.5**	**1.0**	**0.6**
Secondary_I	**0.5**	**0.7**	**0.7**	**0.6**	**1.0**
V_A	0.4	**0.8**	**0.8**	0.4	**0.8**
PROD	**0.5**	**0.8**	**0.9**	**0.6**	**0.9**

Note: Excluding China. Pearson coefficients calculated on 18 observations, values in bold are different from 0 with a significance level alpha=0.05. Input suffixes "_D" and "_I" stand, respectively, for "domestically sourced" and "imported".
Source: Authors' calculations, based on TiVA data.

In order to analyse more precisely the efficient use of some factor of particular interest, DEA analysis can focus on particular inputs or outputs. Figure 11 provides an example of the differences in efficiency observed in the G-20 textiles and apparel industries (minus China) for their use of domestic and foreign intermediate goods. For example, the graphs show that the use of imported inputs is in general more efficient (more countries are on the frontier or close to it).

Some countries in Figure 11 are always on the efficiency frontier for each individual category of inputs (Italy, for example), others may be in some cases (e.g., Japan), others are always inside the efficiency frontier (Korea). Once again, we should keep in mind that this comparison is based on domestic prices for outputs and inputs, and an industry benefitting from a high effective protection may be efficient due to inflated output or value-added prices but may not be competitive at international prices (see section 5.1 for a discussion).

A full DEA analysis would deliver additional information on how the actual performance of sub-optimal industries could be improved, for example by comparing them to their peers located at the frontier.[23] Korea, for example, lies relatively far from the frontier in Figure 9 and has up to five peers (one for each of the inputs). Among the textiles and apparel industries, five of them could improve the efficiency of one or several inputs. Slacks (i.e., the possibility of reducing the use of some input without increasing the need for other inputs or reducing the production of outputs) are more frequent in the use of domestic primary inputs and non-existent in the use of imported secondary inputs (Table 7).

Table 7 Textiles and apparel industry: DEA "VRS-efficient" industries with slack in inputs

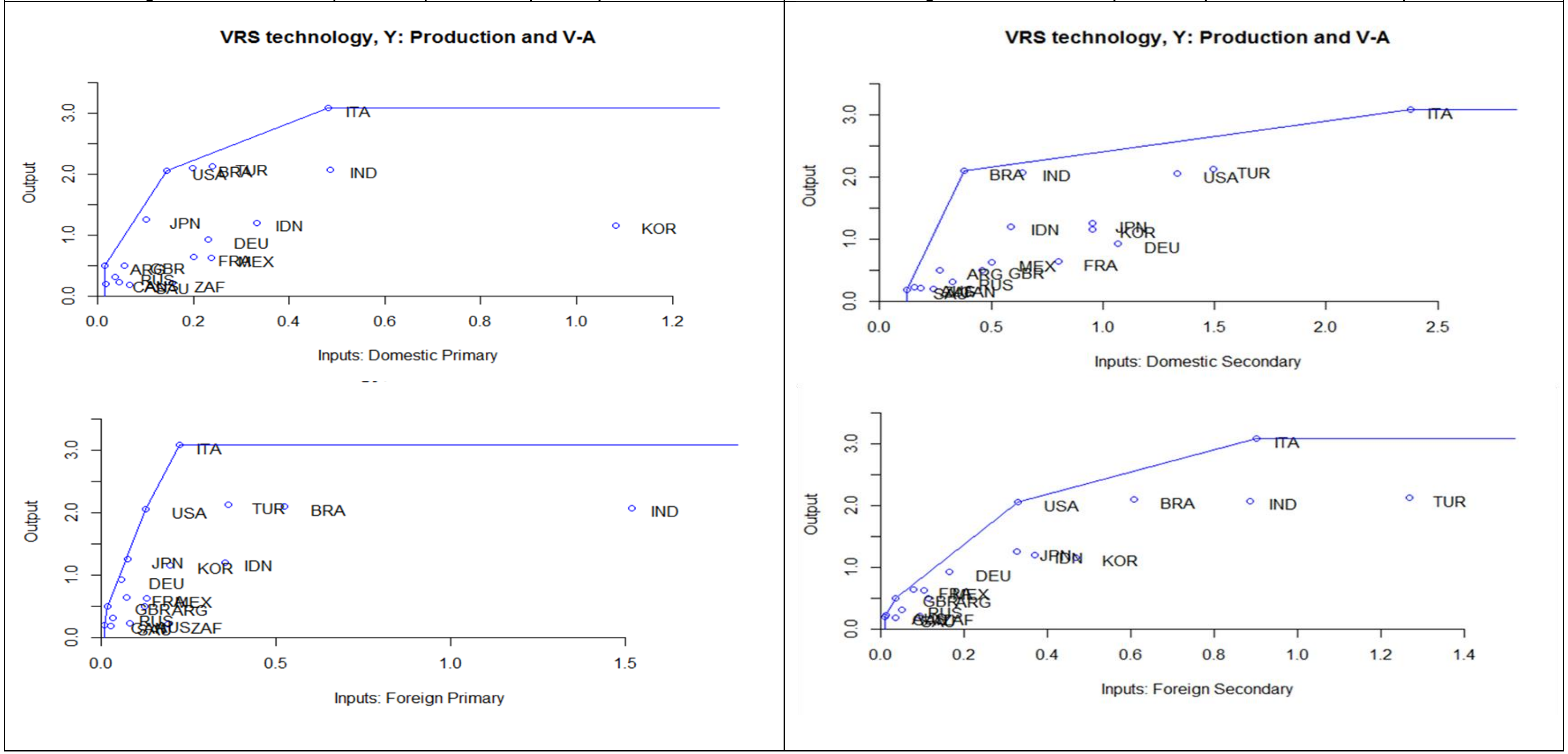
	Primary_D	Secondary_D	Tertiary_D	Primary_I	Secondary_I
DEU	0.12	0.27	0.27	0.00	0.00
IDN	0.19	0.05	0.00	0.05	0.00
KOR	0.92	0.00	0.00	0.00	0.00
MEX	0.16	0.11	0.00	0.02	0.00
ZAF	0.09	0.00	0.02	0.05	0.00

Note: Input suffixes "_D" and "_I" stand, respectively, for "domestically sourced" and "imported".
Source: Authors' calculations, based on TiVA data and 'Benchmarking' R package.

[23] Because efficient firms according to DEA may still be Koopmans inefficient, some inputs can still be reduced by efficient DMUs without affecting the need for other inputs (Bogetoft and Otto, 2011).

Figure 11 Textiles and apparel: Frontier efficiency for different domestic and imported inputs, G-20 less China (2011)

Frontier using domestic and imported inputs from primary sectors	Frontier using domestic and imported inputs from secondary sectors



Source: Authors' calculations, based on TiVA data and 'Benchmarking' R package.

4 CONCLUSIONS

Including the possibility of fragmenting the production process of a complex final good into tasks of different technological and labour content creates new trade opportunities for developing countries. By allowing countries to specialise along their comparative advantages, it offers also the possibility of maximizing value, moving M. Porter's business approach to the global economy. Comparative advantages need not being static and revisiting them through a neo-Ricardian perspective provides a way of analysing competitiveness and comparative advantages through a dynamic perspective.

On the empirical side, the paper uses the TiVA data to offer new perspectives for analysing the international competitiveness of domestic industries. Revealed Comparative Advantages are revisited through the Trade in Value-Added angle. Because international competitiveness in trade in task relates to the cost of primary factors (value-added), we adjust industrial competitiveness and correct the nominal bias on profitability induced, for example, by tariff policies.

GVC upgrading strategies imply often increasing domestic inter-industrial linkages. This strategy is sustainable in the long term only if the new domestic suppliers can efficiently substitute foreign ones. If not, an inefficient upstream provider will increase the production costs of the rest of the domestic chain; inefficiency spillovers reduce the competitiveness of the entire domestic cluster. The paper shows how benchmarking techniques applied to international input-output data could help identifying industrial inefficiencies.

The results presented in this essay are only illustrative of the new dimensions of growth accounting that can be derived from the trade in value-added data. If the G-20 example offered a balanced group of developed and developing countries, the small size of the sample limits the robustness of our results. But this should not limit the researchers' ambition: the present version of TiVA includes already more than 60 economies and its coverage is expected to increase in the future.

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