Trade analysis in a vertically fragmented production structure: empirical challenges and evidence

Marília Bassetti Marcato
Carolina Troncoso Baltar

Resumo

A fragmentação vertical da produção mudou a capacidade de analisar os padrões de especialização dos países, revelando a necessidade de usar métricas que incorporem o surgimento de cadeias globais e regionais de valor. Este artigo buscou utilizar medidas de comércio em valor adicionado para ilustrar os padrões de especialização dos países nas redes de produção verticalmente integradas. Em particular, o artigo buscou mostrar que as análises baseadas em estatísticas tradicionais, isto é, em fluxos de exportação brutos, podem ser enganosas em um cenário de especialização vertical. A partir dos dados da TiVA (OCDE-OMC), esse problema estatístico é apresentado, primeiramente, pela diferença entre exportações brutas e valor adicionado doméstico para países selecionados no período de 1995-2011. Em seguida, os saldos de comércio bilateral em termos de valor adicionado foram calculados, mostrando que déficits ou superávits comerciais são usualmente mal estimados quando analisados a partir dos dados tradicionais. Por fim, calculou-se o índice de vantagem comparativa revelada (RCA) em termos de valor adicionado, elaborado por Koopman *et al.* (2014), para ilustrar mais precisamente os padrões de especialização de um país e sua competitividade internacional em determinados setores. Ademais, outra contribuição deste artigo é mostrar que os países não necessariamente recorreram a uma maior parcela de valor-adicionado estrangeiro para alavancar sua competitividade internacional, mas essa possibilidade mostrou-se restrita a um seleto grupo de países. Portanto, este artigo reforçou a necessidade de utilizar ferramentas de medição que englobem a realidade econômica cada vez mais complexa das cadeias globais e regionais de valor e possam orientar as discussões políticas.

Palavras-chave: produção verticalmente fragmentada; cadeias globais de valor; padrão de especialização; balança comercial bilateral; competitividade internacional setorial.

Abstract

The vertically fragmentation of production has changed our ability to analyze countries' patterns of specialization, revealing the need for using metrics that incorporate the emergence of global and regional value chains. This paper aims to explore some of the value-added trade measures to provide details about countries specialization patterns in vertically integrated production networks. In particular, this paper aims to show that trade analyses grounded on traditional statistics based on gross export flows can be misleading in a vertical specialization scenario. Based on TiVA (OECD-WTO), this statistical problem is, firstly, presented by the difference between gross exports and domestic value added for selected countries over 1995-2011. Secondly, we calculated bilateral trade (im)balances in value-added terms, showing that bilateral trade deficits or surpluses may not be exactly what it seems. Lastly, we used the revealed comparative advantage (RCA) index based on value-added trade proposed by Koopman *et al.* (2014) to illustrate a more accurate picture of a country´s specialization patterns and its export performance. In addition, we have shown that countries are not doomed to gain international competitiveness from higher foreign value-added, but this may be restricted to a select group of countries. Overall, this paper has argued that traditional indicators exclusively based on gross trade are becoming less and less informative and appropriate to support political discussions.

Keywords: vertically fragmented production; global value chains; pattern of specialization; bilateral trade balance; sectorial international competitiveness.

1. Introduction

The labels of “Made in” have become obsolete symbols of a different era of international trade flows. Over the last decades, countries have specialized in specific stages of production networks rather than in final products. As a result, final products are now considered “packages” of several nations’ productive factors (BALDWIN, 2011), turning the fact of a product being “completed” in a particular country into a narrow story about its specialization patterns. Thus, world production is now vertically fragmented across different countries, with intermediate products and services crossing borders multiple times and exports being produced using foreign inputs from several countries. This new scenario has posed significant challenges to the use of traditional measures based on gross trade and has called for new metrics.

The interdependencies between industries in fragmented and internationally dispersed production networks have become a crucial aspect of nowadays trade analysis. Before the emergence of Global Value Chains (GVCs), it was possible to compare gross-trade data to data on value-added without overstating the amount of domestic value-added in exports. However, the use of traditional global trade statistics may lead to a significant amount of “double counting” in gross exports, since exports increasingly rely on (direct and indirect) intermediate imports. When based on gross concepts, the analyses may present a misleading portrait of which country ultimately benefits from bilateral trade flows by exaggerating the importance of producing countries at the end of value chains, and even more importantly, it may lead to misunderstanding in regard to the relationship between trade and macroeconomic variables. In this sense, most recent analyses are based on “factor content” or “value-added” trade that rely on international (or inter-country) input-output (IIO) data (HUMMELS; ISHII; YI, 2001; JOHNSON, 2014; LOS; TIMMER; DE VRIES, 2015; TIMMER *et al.*, 2014).

Differently from other approaches, such as firm-level analysis that use individual firms’ micro-level data and are limited to the structure of a particular product network, input-output analysis covers all set of industries that compose an economic system. IIO tables turned possible to identify the vertical structure of international production sharing. How each country specializes in specific stages of a production sequence is a particular dimension of inter-country production linkages, which is commonly presented as vertical specialization in trade. This notion emphasizes the sequential, multiple-border crossing and the back-and-forth aspects of production processes that are increasingly fragmented geographically. Several recent studies have expanded the concept of vertical specialization and captured different characteristics of value added embedded in trade (AMADOR; MAURO, 2015; DAUDIN; RIFFLART; SCHWEISGUTH, 2011; DI GIOVANNI; LEVCHENKO, 2010; HUMMELS; ISHII; YI, 2001; JOHNSON; NOGUERA, 2012; LOS; TIMMER; DE VRIES, 2015; STEHRER, 2013).

There are many different ways to capture the degree and nature of trade interactions along GVCs. For instance, the import content of exports (HUMMELS; ISHII; YI, 2001), the method of disaggregation of gross exports (KOOPMAN; WANG, 2012; KOOPMAN; WANG; WEI, 2014), the value added exports (JOHNSON; NOGUERA, 2012), the “import to export” (I2E) and “import to produce” (I2P) (BALDWIN; LOPEZ-GONZALEZ, 2013), and the vertical specialization of (value-added) trade (DAUDIN; RIFFLART; SCHWEISGUTH, 2011). The recursive concepts used in this paper are strongly based on the macro level of this literature, which is set apart from case studies for single products or specific firms, and it is concerned with a broad view of countries engagement in GVCs.

This paper aims to provide for more and better evidence regarding the degree and nature of countries’ interaction within global value chains in a vertically fragmented production structure. For that purpose, it uses OECD-WTO TiVA database for measuring flows related to the value that is added by a country in the production of any good or service that is exported. As discussed, trade in value-added allows distinguishing between foreign and domestic value-added exports, addressing the multiple counting implicit in current gross flows of trade. Because a country’s exports tend to embody a large share of other countries’ value added, measures consistent with the fragmentation of production processes and increasing vertical specialization in trade provide more meaningful information about countries' specialization patterns.

In particular, a contribution of this paper is to show that trade analyses grounded on traditional statistics based on gross export flows can be misleading in a vertical specialization scenario. Firstly, this statistical problem is presented by the difference between gross exports and domestic value added for selected countries over 1995-2011. Secondly, we calculated bilateral trade (im)balances in value-added terms, showing that bilateral trade deficits or surpluses may not be exactly what it seems. Lastly, we used the revealed comparative advantage (RCA) index based on value-added trade proposed by Koopman *et al.* (2014) to illustrate a more accurate picture of a country´s specialization patterns and its export performance. Further on, we investigated whether the countries that most added domestic value to their exports are the ones that have made the most gains in sector competitiveness. Based on an analysis in value-added terms, another contribution of this paper is to show that not all countries that have deepen their domestic value-added to their exports have gained competitiveness but at least they remained competitive overtime.

This paper is organized as follows. Section 2 discusses the main changes in the recent production-trade paradigm and its main facilitators. Section 3 provides some empirical evidence about the changing nature of trade analyses and the distorted outcomes of studies based on traditional measures in a vertically fragmented production structure. Section 4 concludes.

2. The new production-trade paradigm

One of the most striking features of the recent wave of globalization is the surge of production fragmentation into various stages internationally dispersed. The phenomenon of breaking the production process into parts, which will be performed domestically or abroad with increasing interaction among economic and non-economic agents, has variously been called by several terms, each one with a partial perspective of this multifaceted research object. *Fragmentation*, *offshoring*, *outsourcing*, *disintegration of production*, *intra-product specialization*, *vertical specialization*, *second unbundling*[1] and *slicing up the value chain*[2] are some of the concepts or "language" used to explain the new global economy in the context of GVCs (BALDWIN, 2006; MENG; FANG; YAMANO, 2012). Whilst the fragmentation of production and the outsourcing of activities across countries are not new phenomena[3], the importance of internationally fragmented production has undoubtedly been growing over time.

This vertically fragmented production structure is commonly associated with global value chains (GVCs). This means that GVCs are an expression of an unprecedented fragmentation of production processes in an increasingly interconnected global economy, where the production of most goods relies on several stages located in different countries and intermediate inputs are crossing borders multiple times. The pace, scale and scope of GVCs have raised a number of questions about the factors that are influencing the decision by firms to internationally fragment their production.

One of the main factors discussed in the literature is the lowering of trade costs. Trade costs include the whole range of costs between suppliers and final consumer, e.g. in the case of goods, would be the sum of land transport, port costs, freight and insurance costs, tariffs and duties, non-tariff costs, mark-ups from importers, wholesalers and retailers; and in the case of services, include communication costs, and trade barriers as non-tariff measures (BACKER; MIROUDOT, 2013). Lower trade costs are primarily a result of technological advances, especially in transportation and communication. The information and communication technology (ICT) advances made it possible to coordinate this new complex paradigm of production at distance. Whilst several costs have to be considered with the international spatial dispersion of production stages, cheaper and more reliable

[1] From a historical perspective, Baldwin (2006, 2013) studies some of the main transformations of international trade over the last centuries, understanding globalization as two great unbundlings. The first unbundling was mostly about the geographical separation of consumption and production that was made possible by the steam revolution, especially railroads and steamships, leading to lower transportation costs and turning profitable to produce at vast scales. This first paradigm is still characterized by locally clustered production, although dispersed internationally, once the proximity reduces the costs of coordinating the complexity of production. More recently, lower transmission and coordination costs turned possible to geographically separate the production stages without losing efficiency or timeliness, giving place to a new paradigm, the second unbundling.

[2] Originally used by Krugman (1995).

[3] For decades, factories in developing nations have imported parts and components from countries with more advanced technology, though generally these imports were only for the assembly of local sales (TAGLIONI; WINKLER, 2016).

ICT tools have increased the tradability of goods and services (OECD, 2013). Other important costs related to GVCs are coordination costs. Some studies observed that the level of fragmentation will be determined by technical characteristics of products and the costs incurred when the stages of production are placed in different locations, specifically a *trade-off* between lower production costs and higher coordination costs (BACKER; MIROUDOT, 2013; JONES; KIERZKOWSKI, 2001).

As it is discussed in Baldwin (2013), before the ICT revolution, a great part of international sourcing was done among mature economies. The new feature is that developing nations become part of international production networks, importing inputs for processing them and export in the form of goods, parts, components, and services (TAGLIONI; WINKLER, 2016). Technological innovations turned possible to coordinate all stages of production at distance without increasing the coordination costs. But most importantly, the vast wage differences between developed and developing countries is what turned this globally dispersed production profitable (BALDWIN, 2013). Thereby, according to the author, was possible to combine developed-economy technology with developing-nation labor.

The fragmentation of production beyond national borders was also facilitated by trade liberalization policy reforms in both home and host countries. This process has resulted in falling trade barriers, first in advanced economies and more recently in many developing countries (RIAD; ERRICO; HENN; SABOROWSKI; SAITO; TURUNEN, 2011). A worldwide process of trade liberalization was in progress since World War II, with notable reduction of global tariffs as the result of multilateral and bilateral free trade negotiations under the GATT (KRUGMAN, 1995), and leaping into the 1980s and early 1990s, trade was facilitated beyond arm's-length operations through FDI and trade in services, as most of the countries liberalized their capital accounts (AL-HASCHIMI *et al.*, 2015). Miroudot, Lanz and Ragoussis (2009) argue that trade tariffs on intermediate goods has been lower than those on final goods during the last 20 years, what partially explains this new dynamic of trade in intermediate goods as the main driver of global trade. From a political perspective, GVCs have raised in a period of trade and investment liberalization and deregulation (FEENSTRA, 1998). Thereby, regulatory reforms, especially in transport and infrastructure sectors, have also contributed to lower trade costs.

These technological and political developments have enabled firms to look at relative costs and factor endowments, building more efficient value chains (OECD, 2013). Hence, apart from lowering international trade costs, other important motivations are *cost efficiency* and *market access* (UNESCAP, 2015). This means that spreading production stages internationally may allow firms to achieve cheaper inputs and large economies of scale (which is desirable for certain tasks of GVCs involving high fixed costs) and can be related to institutional factors or the availability of infrastructure and related costs. One may say that the fundamental rationale of GVCs is economic efficiency and competitive advantage, which are based on transaction cost minimizing behavior of firms (BHATIA, 2013). Following, another important motivation is access to foreign markets, both to strategic inputs (intermediate-import and -export markets) and the entry into new markets (with the proximity to final demand as a key-factor) (UNESCAP, 2015). This last motivation is in accordance with the greater participation of emerging market economies, which has experienced a rapid integration into the world economy (AL-HASCHIMI *et al.*, 2015). Furthermore, the emergence of Asia, especially China, has not only boosted international trade but radically increased the size of world demand (BACKER; MIROUDOT, 2013). In a GVC context, it is important to highlight that the benefits from local agglomerations are commonly related to social-, environmental factors and trade agreements. To sum up, the report considers that "for GVCs to emerge, trade costs must be low enough to enable firms utilizing country-specific advantages related to cost efficiency and/or market access" (UNESCAP, 2015, p. 107).

The nowadays global economy is clearly not about a mere quantitative geographical spread. But it is about "the qualitative transformation of economic relationships across geographical space", involving a set of distinct driving forces (DICKEN, 2011, p. 7). In that sense, the signs that the interconnections between countries through trade have deeply changed are posed both in theoretical and methodological domains. Thus, the central assumption of this paper is that the vertically fragmentation of production has changed our ability to analyze countries' patterns of specialization from traditional trade measures based on gross data, revealing the need for using metrics that incorporate the emergence of global and regional value chains.

3. Empirical analysis

This section presents some empirical evidence about the changing nature of trade analyses and the distorted outcomes of studies based on traditional measures in a vertically fragmented production structure. The empirical exercise that follows is based on the OECD-WTO Trade in Value-Added (TiVA) database. The TiVA database was jointly developed by the OECD and WTO with the aim to better address the global production networks than is possible with conventional measures of international trade. Derived from the 2016 version of OECD's Inter-Country Input-Output (ICIO) database, the latest version was released in December 2016 and includes two more countries (Morocco and Peru) compared to the previous version, covering a total of 63 economies and 34 industrial sectors (16 manufacturing and 14 services industries), for all years from 1995 to 2011. The TiVA database contains a list of indicators measuring the value-added content of international trade and final demand, which are derived from the 2016 version of OECD's Inter-Country Input-Output (ICIO) Database.

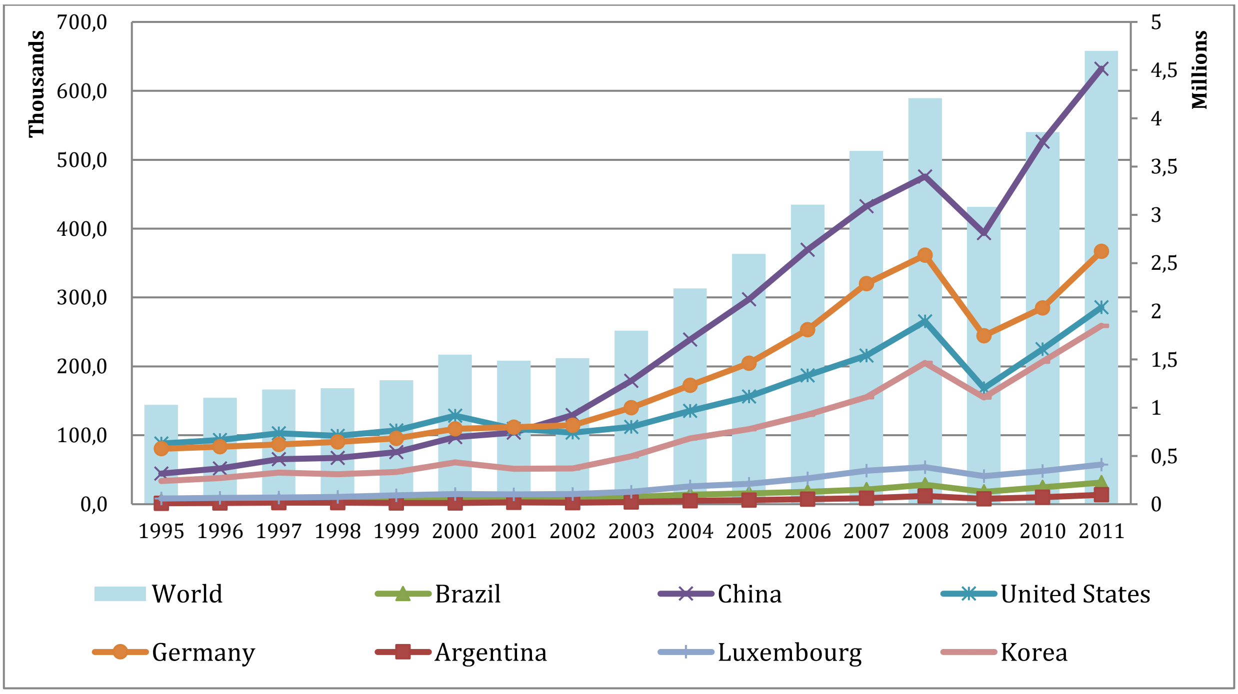
3.1. Gross exports *versus* value-added exports

Traditional statistics based on gross exports tend to "double count" trade flows, as gross exports include the value of imported intermediates that are used in production, blurring the real distribution of value created within countries. In the absence of trade in intermediate inputs, this difference between gross and value added analyses would not be that relevant. However, analysis of gross export flows can be misleading in a vertical specialization scenario.

This statistical problem is represented in Figure 1, which shows the extent of the difference between gross exports and domestic value added for selected countries and the world[4] over 1995-2011.

The gap between measuring in gross terms and value-added trade continually increased over the period for all countries from the sample, with the exception of 2009, when the worldwide trade collapsed at the height of the recent global recession, as well as the import content of exports. However, this increase was more significant for China, Germany, United States, and Korea, respectively. This overall picture is a reflection of vertically fragmented production into international dispersed networks with countries focusing on specific activities and tasks, but the extent of the difference varies across countries depending on the extent of a country's involvement in GVCs.

Figure 0 - Difference between Gross Exports and Domestic Value Added, selected countries (thousands US$) and world (millions US$), 1995-2011

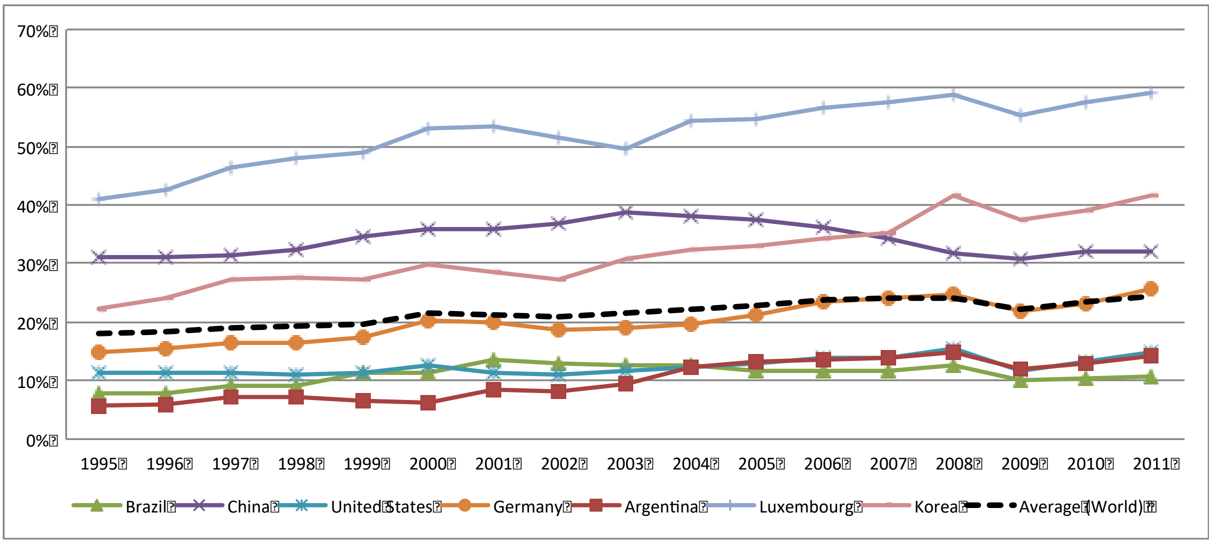


Source: Own elaboration based on OECD-WTO TiVA database (December 2016).

[4] The average of the sum of all TiVA countries, including the proxy "ROW: rest of the World".

Related to gross exports, the average difference was around 20% and it has increased over 1995 to 2011 (Figure 2). In that sense, Germany has a relative amount and behavior very similar to the world average. Luxembourg illustrated that this difference as a share of gross exports is more important the more integrated the country in GVCs. Although this difference was small in nominal terms, in proportion to the total value exported it is not negligible. In contrast, this gap was lower for those countries that are more intensive in commodities, such as Brazil and Argentina. In addition to the United States, these three countries showed that the extent of their differences related to gross exports are less prominent than the world average.

Figure 2 - Difference between Gross Exports and Domestic Value Added (% of gross exports), selected countries and world, 1995-2011



Source: Own elaboration based on OECD-WTO TiVA database (December 2016).

It is worth noting how the Chinese contribution to international trade flows is heavily overestimated when analyzed in gross terms. However, this difference as a share of gross exports has narrowed since 2003 (Figure 2). While most countries are relying less on domestic inputs for production, China is against this trend and is rising its ratio of domestic value added in exports to gross exports (DVAR). This intriguing exception has been showed by other studies (KEE; TANG, 2015; KOOPMAN; WANG; WEI, 2012). Investigating its potential causes, Kee and Tang (2015) [5] found that the rising in Chinese DVAR is due to individual processing exporters substituting domestic

[5] The authors did not use IIO tables in their analysis but customs transaction-level data and firm survey data, measuring DVARs as the weighted averages of the firms' DVARs. This empirical strategy allowed them to embrace firm heterogeneity and overcome significant aggregation biases.

for imported materials in terms of volume and varieties[6], and this would mean that China became more competitive, especially in the intermediate input sectors.

3.2. Bilateral trade (im)balances in value-added terms

The balance of trade in value-added terms is calculated by taking the values that are *consumed* in the two countries, while the gross version depends on values that are *shipped* between the two countries (JONES; POWERS; UBEE, 2013). Thus, bilateral trade balances between countries may considerably change whether measured in value-added terms. That is because it considers the actual origin of the intermediate inputs, re-allocating the value-added of imports and exports. This means that the surpluses and deficits with trade partners are redistributed, while the total trade balance with the world does not change rather based on value-added or gross terms. Value-added trade balance captures the difference between any two countries' domestic value added in foreign final demand and foreign value added in domestic final demand, discounting the double-counted part of trade flows. This stylized fact was already pronounced in earlier studies (JOHNSON; NOGUERA, 2012; KOOPMAN; WANG; WEI, 2008; NAGENGAST; STEHRER, 2013; WTO, 2013).

Figure 3 shows eight countries' bilateral trade balances, measured in gross and in value-added terms. Both goods and services are considered, and the trade balances are shown with respect to the five main trading partners in gross terms for the year of 2011. For example, Mexico's trade surplus with the United States is reduced by almost half if measured in value added terms, while its trade deficit with China is reduced to one third. China's trade rebalance reinforces its importance as a processing hub of imported intermediates from other countries. Considering the sum of Brazil's five main export-markets, the Brazilian trade deficit is reduced by almost 30 per cent in value-added terms. A similar change is felt by the US economy, considering its five main export markets but mostly driven by the trade rebalance with China. Further on, there is a considerable decrease in the trade surplus of East and Southeast Asian countries with China in value-added terms. Some countries showed higher balances with their trading partners if analyzed in value added terms, as is the case of Germany's surplus with the US and with the UK, as well as Korea and Japan's surplus with the US.

The different outcomes of bilateral trade balance in value added and gross terms are a reflection of the relative position of countries in GVCs (ANTRÀS *et al.*, 2012). Those countries that are most at the final stages of the GVC have their trade balances reshaped by the incorporation of foreign inputs, i.e. trade imbalances are created with the countries that act as suppliers of intermediate inputs to the final producer.

[6] According to Kee and Tang (2015), other potential causes are: i) a changing composition of Chinese exports, which would indicate that the Chinese comparative advantage is moving towards industries with high domestic content; and ii) an upsurge of Chinese domestic production costs. But following their model, both causes cannot explain this rising trend.

Moreover, bilateral trade imbalances illustrate how difficult is to analyze the real impact of currency devaluation or appreciation within GVCs[7]. According to Koopman *et al.* (2008), the lower the domestic value-added share in a country's gross exports, the smaller the effect of that country's currency appreciation on trade volume, other things being equal. Put it simply, having a high foreign value-added share in exports, currency depreciation turns exports of final goods cheaper at the same time it makes imported inputs more expensive for domestic producers (OECD, 2013). Overall, it is important to highlight that these results have serious policy implications, such as the potentially distorted effects that protectionist measures may have in the context of complex interactions between foreign and domestic value added.

[7] Riad *et al.* (2011) shows that trade balance adjustment in response to exchange rate changes is weaker within the supply chain than outside it.

Figure 3 - Bilateral trade balances measured in value-added and gross terms, 2011 (US$ millions)

Source: Own elaboration based on OECD-WTO TiVA database (December 2016).

3.3. The Revealed Comparative Advantage (RCA) index: traditional *versus* value-added version

The revealed comparative advantage (RCA) index is a widely used measure of sector competitiveness and a country´s specialization patterns. Primarily based on the Ricardian comparative advantage theory, the traditional RCA index in gross terms (RCA_{ij}) is based on Balassa's (1965) measure, and it is calculated as:

$$RCA_{sj} = (E_{sj}/E_s)/(E_{wj}/E_w)$$

Where E_{sj} is exports of country *s* of sector *j*, E_s is total exports of country *s*, E_{wj} is world exports of sector *j*, and E_w is total world exports.

In contrast, the RCA index in value-added terms nets out foreign value added imported into the economy. Originally proposed by Koopman *et al.* (2014), this indicator is based on domestic value added embodied in gross exports, considering the international production sharing and avoiding the problems of multiple counting. In that sense, as one of the key features behind GVC trade is that it allows the denationalizing of comparative advantage, since countries could join GVCs rather than building the whole value chain (BALDWIN; LOPEZ-GONZALEZ, 2015), the RCA in value-added terms gives a more accurate picture of the patterns of comparative advantage. The RCA index in value-added terms (RCA_{VA}) is calculated as:

$$RCA_{VA} = \left(\frac{DVA_{sj}}{DVA_s}\right) \Bigg/ \left(\frac{DVA_{wj}}{DVA_w}\right)$$

Where DVA_{sj} is the domestic value-added of country *s* of sector *j*; DVA_s is the total domestic value-added of country *s;* DVA_{wj} is the domestic value-added of all countries of sector *j*; and DVA_w is the total domestic value-added of all countries in total gross exports. When the RCA index is greater than 1, it indicates a revealed advantage for that sector.

Figure 4 computes the RCA index in gross and value-added terms at the country-sector level for all TiVA countries and four selected sectors (*machinery and equipment, nec*[8]*; electrical and optical equipment; transport equipment; and total business sector services*).

Comparing on a 45-degree diagram gross and value-added RCA indexes for the selected sectors, in which each dot represents a country-year combination, the considerable difference between such measures becomes perfectly clear. This difference varies according to the analyzed sector, being more significant in the sectors most influenced by GVCs, such as transport equipment and electrical and optical equipment. It is also true that such difference varies according to the country's position in

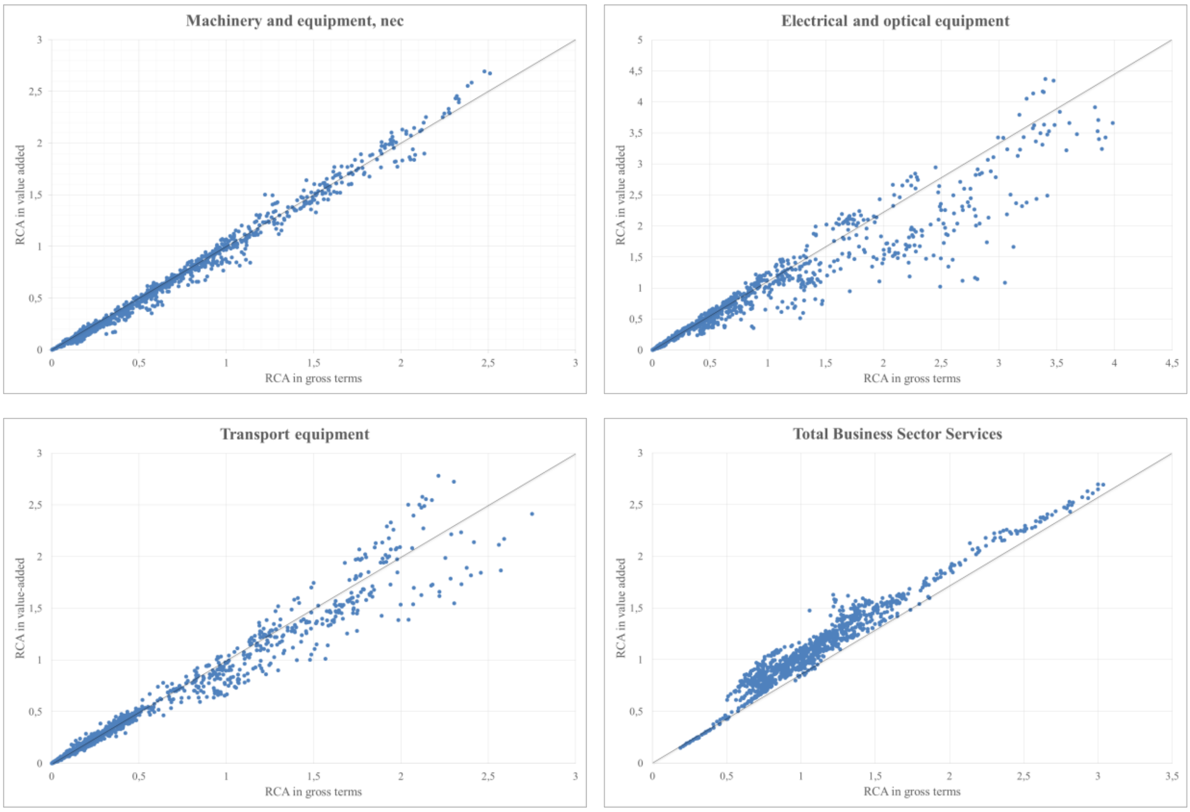
[8] Nec = not elsewhere classified.

the value chain. Countries located more in the downstream part of the value chain (i.e. closest to final demand) show higher values of RCA in gross terms than in value-added terms, falling to the bottom of the 45-degree line (ESCAITH, 2014).

This reflects the problem of multiple counting of intermediate inputs, i.e. countries may incorporate in their apparent comparative advantage the re-exported value added of upstream suppliers (WTO, 2014). This is the case of the United States and Mexico in machinery and equipment, and transport equipment and electrical and optical equipment sectors for the latter country, and Japan in the total business sector services. On the other hand, countries show higher values of RCA in value-added terms whether located more upstream in the value chain (R&D; production of components). For instance, Germany and Japan in all selected sectors, except for business services for the latter, and Brazil in transport equipment and electrical and optical equipment.

Given such relationship with a country's position in the GVCs, and considering the discussion on section 3.1, one may say that China has become more competitive in the production of components, since the country had higher RCA indexes in gross terms until 2001 (year that marked its entry into the WTO), and since then has had higher RCA indexes in value-added terms in all manufactured sectors.

Figure 4 - RCA in gross and value-added terms, selected industries, 1995-2011



Source: Own elaboration based on OECD-WTO TiVA database (December 2016).
Note: RCA indices are calculated for all TiVA countries, each dot represents a country-year combination.

By comparing the share of a given industry in a country´s export to the world share of the industry in world exports, a country is considered to have comparative advantage in a sector if its RCA is greater than one. Table 1 illustrates all TiVA countries that showed revealed comparative advantage in each analyzed sector in the year 2011. Among the largest countries, Germany, Japan, Korea, and Mexico reveal comparative advantage in all three manufacturing sectors. As it was expected, Asian countries stand out among those with comparative advantage in electrical and optical equipment. Based on gross exports[9], Germany, Sweden, Romania and Finland´s RCA index is lower than 1, but when domestic value-added is used it becomes greater than 1 in electrical and optical equipment, while Vietnam has comparative advantage in gross but not in value-added terms, reflecting the importance of intermediate imports.

In the case of transport equipment, when the foreign content of exports is disregarded, Italy has comparative advantage; and on the contrary, Slovenia and Portugal no longer have RCA larger than 1. In the business sector services, Japan and Norway lost their comparative advantage whether it is calculated in value-added, while Bulgaria and Thailand show signs of becoming more specialized in that sector, and this latter country has also lost its fallacious comparative advantage in machinery and equipment. Further on, Table 2 reveals a considerably higher number of countries with comparative advantage in the case of total business services (34 of 63 countries in the sample).

Table 0 - Countries with RCA in value-added terms, 2011

Industry	**Countries with RCA in value-added terms (RCA>1)**
C29: Machinery and equipment, nec	Austria, Czeck Republic, Denmark, Finland, Germany, Hungary, Italy, Japan, Korea, Mexico, Slovakia, Slovenia, Sweeden, Switzerland, United States, China, Romania
C30T33: Electrical and optical equipment	Czech Republic, Estonia, Finland, Germany, Hungary, Israel, Japan, Korea, Mexico, Slovakia, Sweeden, Switzerland, China, Costa Rica, Malaysia, Philippines, Romania, Singapore, Taiwan, Thailand, Tunisia
C34T35: Transport equipment	Canada, Czeck Republic, France, Germany, Hungary, Italy, Japan, Korea, Mexico, Poland, Slovakia, Spain, Sweeden, Turkey, United Kingdom, United States, Argentina, Romania
C50T74: Total Business Sector Services	Austria, Belgium, Denmark, Estonia, France, Greece, Iceland, Ireland, Israel, Latvia, Luxembourg, Netherlands, New Zealand, Portugal, Spain, Sweeden, Switzerland, Turkey, United Kingdom, United States,Bulgaria, Cambodia, Costa Rica, Croatia, Cyprus, Hong Kong, India, Lithuania, Malta, Morocco, Philippines, Singapore, Thailand, Tunisia

[9] To synthesize the results found, table 1 presents only the results in value-added.

Source: Own elaboration based on OECD-WTO TiVA database (December 2016).

The findings outlined in Table 2 show that comparative advantages change over time. It shows the difference between the RCA (traditional and value-added) in 2011 and 1995. Considering both gross and value-added RCA, countries such as Mexico, Indonesia, Germany, and India have become more specialized in all manufactured sectors analyzed, with the latter two also gaining in the business services sector. On the contrary, Belgium and Hong Kong have lost comparative advantage in manufacturing and gained in services sector. More importantly, Table 2 shows substantial changes in the distribution of RCA across countries and industries over time whether calculated based on gross or value-added terms (countries in bold indicate variations between gains and losses). For example, according to the traditional measure, France lost RCA, however it has gained in value-added terms in machinery and equipment, as well as Demark, Finland, and Philippines in the case of electrical and optical equipment.

Table 2 - RCA gains and losses in gross and value-added terms, 1995-2011

Industry	Countries that gain RCA (in gross terms)	Countries that gain RCA (in value-added terms)	Countries that lose RCA (in gross terms)	Countries that lose RCA (in value-added terms)
C29: Machinery and equipment, nec	Austria, Canada, Chile, Czech Republic, Finland, Germany, Hungary, Iceland, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Turkey, Brazil, Bulgaria, China , Croatia, India, Indonesia, Peru, Philippines, Romania, Saudi Arabia, Singapore, South Africa, Thailand, Tunisia, Viet Nam	Austria, Canada, Chile, Czech Republic, Finland, **France,** Germany, Hungary, Iceland, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, **Spain, Sweden,** Turkey, Brazil, Bulgaria, China , Croatia, India, Indonesia, **Malta,** Peru, Philippines, Romania, Saudi Arabia, Singapore, South Africa, Thailand, Tunisia, Viet Nam	Australia, Belgium, Denmark, **France,** Greece, Ireland, Israel, Italy, Latvia, Luxembourg, **Spain, Sweden,** Switzerland, United Kingdom, United States, Argentina, Brunei Darussalam, Cambodia, Colombia, Costa Rica, Cyprus, Hong Kong, Lithuania, Malaysia, **Malta,** Morocco, Russia, Taiwan	Australia, Belgium, Denmark, Greece, Ireland, Israel, Italy, Latvia, , Lithuania, Luxembourg, Switzerland, United Kingdom, United States, Argentina, Brunei Darussalam, Cambodia, Colombia, Costa Rica, Cyprus, Hong Kong, Lithuania, Malaysia, Morocco, Russia, Taiwan
C30T33: Electrical and optical equipment	Austria, **Canada,** Chile, Czech Republic, Estonia, Germany, Greece, Hungary, Iceland, Israel, Italy, Korea, Latvia, Luxembourg, Mexico, New Zealand, Norway, Poland, Slovak Republic, Slovenia, Switzerland, Turkey, Bulgaria, Costa Rica, Croatia, Cyprus, India, Indonesia, **Malaysia**, Morocco, Romania, Saudi Arabia, Taiwan, Tunisia, Viet Nam	Austria, Chile, Czech Republic, **Denmark,** Estonia, **Finland,** Germany, Greece, Hungary, Iceland, Israel, Italy, Korea, Latvia, Luxembourg, Mexico, New Zealand, Norway, Poland, Slovak Republic, Slovenia, **Sweden**, Switzerland, Turkey, Bulgaria, Costa Rica, Croatia, Cyprus, India, Indonesia, Morocco, Romania, Saudi Arabia, **Philippines**, Taiwan, Tunisia, Viet Nam	Australia, Belgium, **Denmark, Finland,** France, Ireland, Japan, Netherlands, New Zealand, Portugal, Spain, **Sweden**, United Kingdom, United States, Argentina, Brazil, Brunei Darussalam, Cambodia, Colombia, Hong Kong, Lithuania, Malta, Peru, **Philippines,** Singapore, Russia South Africa, Thailand	Australia, Belgium, **Canada,** France, Ireland, Japan, Netherlands, New Zealand, Portugal, Spain, United Kingdom, United States, Argentina, Brazil, Brunei Darussalam, Cambodia, Colombia, Hong Kong, Lithuania, Malta, Peru, **Malaysia**, Russia, Singapore, South Africa, Thailand,
C34T35: Transport equipment	Austria, Chile, Czech Republic, Estonia, France, Germany, Hungary, Israel, Italy, Japan, Korea, Luxembourg, Mexico, New Zealand, Poland, Slovakia, Slovenia, Switzerland, Turkey, United Kingdom, United States, Argentina, Bulgaria, Cambodia, China, Colombia, Costa Rica, Croatia, India, Indonesia, Morocco, Philippinnes, Romania, Saudi Arabia, Singapore, South Africa, Thailand, Tunisia, Viet Nam	Austria, Chile, Czech Republic, Estonia, France, Germany, Hungary, Israel, Italy, Japan, Korea, Luxembourg, Mexico, New Zealand, Poland, Slovakia, Slovenia, Switzerland, Turkey, United Kingdom, United States, Argentina, Bulgaria, Cambodia, China, Colombia, Costa Rica, Croatia, India, Indonesia, Morocco, Philippinnes, Romania, Saudi Arabia, Singapore, South Africa, Thailand, Tunisia, Viet Nam	Austria, Belgium, Canada, Denmark, Finland, Greece, Iceland, Ireland, Latvia, Netherlands, Norway, Portugal, Spain, Sweeden, Brazil, Brunei Darussalam, Cyprus, Hong Kong, Lithuania, Malaysia, Malta, Peru, Russia, Taiwan	Austria, Belgium, Canada, Denmark, Finland, Greece, Iceland, Ireland, Latvia, Netherlands, Norway, Portugal, Spain, Sweeden, Brazil, Brunei Darussalam, Cyprus, Hong Kong, Lithuania, Malaysia, Malta, Peru, Russia, Taiwan
C50T74: Total Business Sector Services	Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Israel, Luxembourg, Netherlands, Portugal, Slovenia, Sweeden, Switzerland, United Kingdom, United States, Bulgaria, Cambodia, Costa Rica, Croatia, Cyprus, Hong Kong, India, Malta, Morroco, Philippines, Romania, Singapore, Taiwan,	Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Israel, Luxembourg, Netherlands, **Poland**, Portugal, Slovenia, Sweeden, Switzerland, United Kingdom, United States, Bulgaria, Cambodia, Costa Rica, Croatia, Cyprus, Hong Kong, India, Malta, Morroco, Philippines, Romania, Singapore, Taiwan,	Australia, Austria, Chile, Hungary, Italy, Japan, Korea, Latvia, Mexico, New Zealand, Norway, **Poland,** Slokavia, Turkey, Argentina, Brazil, Brunei, China, Colombia, Indonesia, Lithuania, Malaysia, Peru, Russia, Saudi Arabia, South Africa, Thailand, Tunisia, Viet Nam	Australia, Austria, Chile, Hungary, Italy, Japan, Korea, Latvia, Mexico, New Zealand, Norway, Slokavia, Turkey, Argentina, Brazil, Brunei, China, Colombia, Indonesia, Lithuania, Malaysia, Peru, Russia, Saudi Arabia, South Africa, Thailand, Tunisia, Viet Nam

Source: Own elaboration based on OECD-WTO TiVA database (December 2016).
Note: (1) countries highlighted in bold indicate alternation of gain or loss depending on whether the RCA measure is in gross or value-added terms.

Further on, one of the questions that arise is whether higher levels of domestic value-added in gross exports are positively associated with higher levels of RCA. More specifically, are the countries that most added domestic value to their exports the ones that have made the most gains in sector competitiveness? Or would countries be doomed to gain competitiveness from higher imported content?

Figure 5 shows RCA indexes in value-added terms for all TiVA countries and the four selected industries, with the year 1995 on the x-axis and 2011 on the y-axis, and the size of the bubble as the difference between domestic value-added content of sector's gross exports in 2011 and 1995.

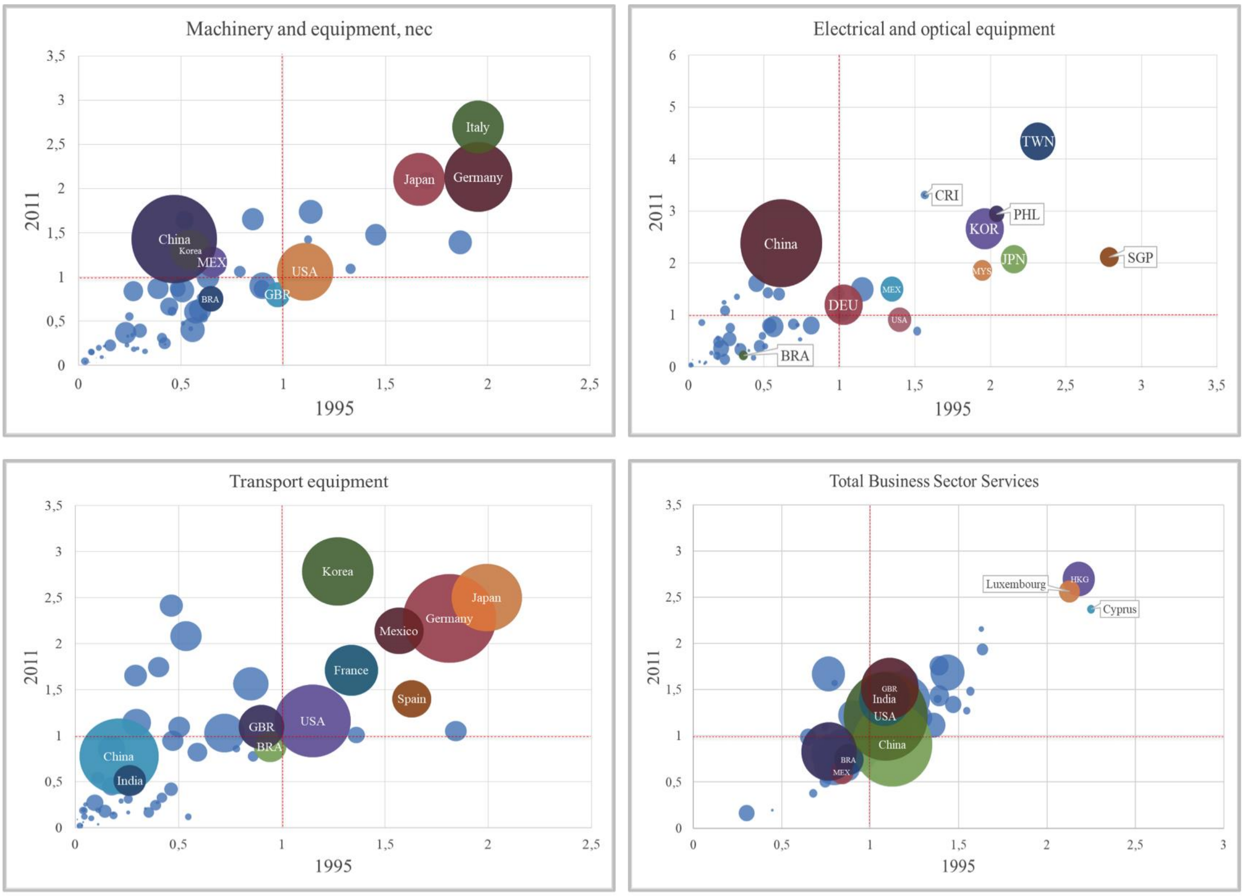
The first countries in the RCA ranking for 2011, respectively, in the case of machinery and equipment, are Italy, Germany, and Japan. These countries are among those that added the highest domestic value in the period analyzed, although they already played a prominent role in the 1995 ranking. In addition, China has boosted its sector competitiveness, showing a considerable RCA gain (0.46 for 1.42) at the same time that it was the country that most added domestic value from the sample. It is interesting to note that other countries also added a substantial amount of domestic value in their exports, but failed to advance in the gains of specialization such as the Chinese example, as is the case of the US economy that remained practically with the same RCA index. Despite higher sums of DVA in 2011, most countries remained with low RCA indexes.

In the case of electrical and optical equipment, the countries of Southeast Asia occupy the first places of the ranking 1995 (Singapore, Taiwan, Japan, Philippines, Korea, and Malaysia). In 2011, Taiwan becomes the first in the ranking, followed by the one Latin American exception, Costa Rica, and other Asian countries - Philippines, Korea, China, Singapore, Japan, and Malaysia, respectively. Ireland and the United States are the only two countries that have lost RCA between 1995 and 2011. Once again, China becomes internationally competitive while adding enormous amounts of domestic value. Different from what happens in the sector of transport equipment, in which although the Chinese economy has a greater RCA index in 2011 when compared to 1995, it does not yet have an RCA greater than one. The United States, while considerably increasing its domestic value-added in exports, failed to translate this increase into competitiveness in the case of transport equipment. In that sector, Japan, Germany and Mexico are among the top five countries in the ranking of 1995 and 2011, and the countries with the highest increases in domestic value-added remained at RCA levels above one.

In total business sector services, the top three places are between Hong Kong, Luxembourg, and Cyprus, while most Latin American countries are lagging behind in terms of competitiveness gains. It also worth noting that this was the only sector in which China has dropped its RCA bellow one in 2011. In general, most countries were unable to move towards higher levels of RCA, even though there were considerable sums of domestic value being added.

Overall, the countries with the highest domestic value-added increases already had comparative advantages in the manufacturing sectors in 1995 and continued to have it in 2011, China aside. Therefore, countries are not doomed to resort to greater imported content to leverage their international competitiveness, but the positive relationship between higher levels of domestic value-added and higher levels of RCA is a possibility restricted to a select group of countries.

Figure 5 - RCA in value-added terms and domestic value-added content of gross exports, selected industries, 1995 and 2011



Source: Own elaboration based on OECD-WTO TiVA database (December 2016).
Notes: (1) the size of the bubble is the difference between domestic value-added content of sector's gross exports in 2011 and 1995.

4. Concluding remarks

This paper has explored some of the value-added trade measures to provide details about countries specialization patterns in vertically integrated production networks. In that sense, we have illustrated the importance of the value-added framework to our understanding of international trade flows, showing the changing nature of international trade within GVC and some of the problems associated with analyzes based on traditional trade statistics. Because a country's exports tend to embody a large share of other countries' value added, measures consistent with the fragmentation of production processes and increasing vertical specialization in trade provide more meaningful information about countries' specialization patterns.

Until recently, evidence on countries specialization patterns has been based on gross trade data. As the last decades have witnessed significant changes on how the world production and international trade are organized, with countries becoming specialized in specific parts and tasks within GVCs, more empirical work is needed to present a comprehensive picture of these integrated global production systems. Thus, without being restricted to case-studies, several international organizations have developed new empirical evidence along GVCs primarily based on IIO tables.

We have argued that the contribution of a specific country to international trade flows proved to be heavily overestimated when analyzed in gross terms. That is because parts and components are crossing borders several times until they compose final goods, causing a multiple-counting effect, which clearly will blur the real picture of world trade and production to a greater or lesser extent depending on the participation and position of a country within GVCs. Traditionally, bilateral trade balances and the RCA index have been calculated in terms of final goods. But this has led to distorted results. When analyzed in value-added terms, the new outcomes are considered a reflection of both countries' relative position in GVCs and how the analyzed sector is influenced by GVC trade.

However, our analysis clearly has a number of limitations. To name a few, first, the country-level analysis imposes a number of limitations, since many characteristics are sector-specific. Therefore, in order to minimize this problem, we opted to analyze four selected sectors to measure the gains in competitiveness and specialization patterns. Second, although the convenience of operating with the ready-to-use TiVA indicators, the ability to develop a more detailed analysis is more limited precisely because they are pre-defined indicators. Lastly, the value-added measures are less up-to-date and require simplifying assumptions in their construction if compared to gross trade.

With this in mind, one can affirm that traditional indicators exclusively based on gross trade are becoming less and less informative and appropriate to support political discussions. Overall, value-added analyses provide a more revealing perspective on how countries are integrated into GVCs and how they are interacting with its trade partners. This is crucial for building development strategies consistent with the current global trade dynamics, allowing the identification of sources of competitiveness and the challenges regarding developing new competitive areas. Besides that, it also adds new perspectives on complex issues with political consequences, such as the discussions about environmental protection and "job content" of trade. Thus, it is not possible to assume which are the potential trajectories to follow without having a reliable map in hands, which clearly could not be build based on traditional gross trade in the current phase of globalization.

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