HOW HARMFUL CAN CHINESE EXPORTS BE TO BRAZILIAN EXPORTS TO MERCOSUR?: A SIMILARITY AND QUALITY ANALYSIS REVISITED

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Abstract: We investigate the competitiveness of Brazilian and Chinese exports to MERCOSUR from 2008 to 2017. Following conventional methods, we compute an Export Similarity Index (ESI) for Brazilian and Chinese exports to MERCOSUR. This index is disaggregated according to product similarities. Results show that the similarity between Brazilian and Chinese product exports has increased over time. However, the ESI disaggregation reveals that the similarities largely occur with vertically differentiated goods, where the quality of the goods exported by Brazil are considered superior to those exported by China. Thus, competition between Brazil and China in the MERCOSUR has declined over time since the two countries export to different market segments.

Keywords: International trade, Export Similarity, Competitiveness.
JEL Classification: F1, F11, F14.

Resumo: Este artigo investiga a competitividade das exportações brasileiras e chinesas para o MERCOSUL para o período de 2008 a 2017. Com a utilização de métodos convencionais, o Índice de Similaridade das Exportações (ISE) é calculado entre as exportações brasileiras e chinesas para o MERCOSUL. Este índice é desagregado de acordo com as similaridades dos produtos. Os resultados mostraram que similaridade entre as exportações brasileiras e chinesas vem aumentando com o tempo. No entanto, a desagregação do ISE revelou que as maiores similaridades vêm ocorrendo com produtos diferenciados verticalmente, ou seja, naqueles produtos cuja qualidade se mostra superior para as exportações brasileiras do que as exportações chinesas. Ou seja, a competição entre Brasil e China no MERCOSUL tem declinado ao longo do tempo, pois os dois países exportam bens destinados para diferentes segmentos de mercado.

Palavras-chave: Comércio internacional, Similaridade de exportação, competitividade.
Classificação JEL: F1, F11, F14.

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1. INTRODUCTION

A large portion of China's economic growth can be attributed to increased participation in international markets. The contribution of international trade to China's GDP increased from virtually zero in the sixties to approximately 30 percent in 2006 (Rodrik, 2006). By 2013 China became the world's largest trading nation, outpacing the United States and Germany. The rapid integration of China into world markets has attracted the attention of many economists. Rodrik (2006) notes that, despite the important role of the intensive export sectors, China has increased its exports of more sophisticated products. Paradoxically, despite low per capita income, China has a highly sophisticated and diversified export structure, similar to countries with per capita income many times higher.

The international trade of China and Brazil is closely linked. Increased Chinese participation in international markets has directly impacted Brazilian foreign trade. Between 2000 and 2009, total trade (exports plus imports) between Brazil and China increased from $ 2.3 to $ 56.4 billion, making China the main trading partner of Brazil in 2009 (IPEA, 2011). The pattern of trade between the two countries is clearly inter-industry in nature; Brazil exports primary commodities (iron ore, soybeans and derivatives, leather products, wood pulp) and imports mostly industrialized products (electrical equipment, inorganic chemicals, optical instruments, photographic equipment) (IPEA, 2011). While China constitutes an important target market for Brazilian exports, Chinese products compete with Brazilian products in markets with similar export structures.

Filgueiras and Kume (2010) analyze the degree of similarity of export structures of Brazil and China in North American markets. By applying the Finger and Kreinin (1979)[5] similarity index, the authors found that the similarity of each country's their exports to North American increased from 0.11 to 0.15 between the years 2000 to 2005, but retreated to 0.10 by 2008. Filgueiras and Kume suggest this decrease could be due to the displacement of Brazilian exports by increased Chinese exports.

Carmo et al. (2014) investigate the trade similarities between Brazilian and Chinese exports to MERCOSUR for the period 1995-2009[6], and they conclude that the similarity of exports for MERCOSUR has increasing over time, however, most of it based on vertically differentiated products, which indicates that Chinese exports are not an important threat to the Brazilian exports at the time.

According to Fontagné et al. (2007) trade competition between countries can be reduced if the products exported are vertically differentiated or have distinct qualities and thus targeted for distinct market segments. To illustrate, these authors examined the competition between the European Union (EU) and China in vertically differentiated products during the period 1995-2004. They grouped the products into three categories: low, medium and high quality according to the unit value of the product. They found the EU concentrated its exports on the high-quality segment, while Chinese exports were concentrated on the low-quality segment. They conclude that export competition is lessened when the exported products are directed toward different market segments.

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[5] The Finger and Kreinin index varies in the interval between 0 and 1. See section 3 for more details.

[6] In Carmo et al. (2014), however, it might be possible that the results were mostly influenced by the boom in the commodities' prices in the international markets.

Based on the contributions of Filgueiras and Kume (2010) and Fontagné et al. (2007), our goal here is to analyze the competitiveness of exports from Brazil and China to MERCOSUR[7], in an attempt to revisit Carmo et al. (2014) study, but considering a more recent period, without a possible influence of the commodities higher prices for the most of 2000s. We begin by computing Finger and Kreinin´s index of export similarity. This is followed with a disaggregation of the index to assess whether the quality of Brazilian products is superior or inferior to the quality of Chinese products. We thus gain a more detailed and more comprehensive understanding of the nature of competition between the two countries.

The results of this study suggest that the similarity of exports from Brazil and China in MERCOSUR has increased over time, suggesting that competition between countries has become stronger. However, through the decomposition of the Finger and Kreinin (1979) index, we find that the similarity of exports occurs mostly in vertically differentiated products, where the quality of products exported by Brazil are higher than the quality of products exported by China. These conclusions seem to confirm and stress most of the results showed in Carmo et al. (2014).

We follow with four sections. In Section 2 we present our theoretical framework. In section 3 we describe our empirical strategy and data sources. We present and discuss our results in Section 4. And, in section 5 we offer some concluding remarks.

2. THEORETICAL BACKGROUND: HORIZONTAL AND VERTICAL PRODUCTS DIFFERENTIATION

Products can be differentiated in either horizontal or vertical form. Horizontal differentiation is due to heterogeneous consumer preferences. Even if the differences among products are very subtle there is a consensus about which product is best. Vertically differentiated products have substantial quality differences so that a consensus is reached as to which product is preferred (Church and Ware, 2000).

To better distinguish the concepts of horizontal and vertical differentiation we use an example for the automobile industry where new cars are produced by different firms. These cars can be described as horizontally differentiated, since they have certain characteristics and attributes that distinguish them from each other. These differences are small and specific resulting in a consensus among consumers about which car is better. Here we might compare the products of different luxury car manufacturers.

Vertically differentiated products show substantial quality differences, as when we compare entry-level to luxury cars. Luxury cars have characteristics and attributes that elevate them to a higher level than entry-level cars. Consumers are thus likely to conclude that luxury cars are of higher quality than entry-level cars.

2.1. MAIN THEORETICAL MODELS

The foundation of the neoclassical theory of international trade is the Heckscher-Ohlin (HO hereafter) model. In this model international trade is determined by the comparative advantage of countries, which stems from the relative abundance of capital and labor. The main result is that capital-abundant countries specialize in the production/export of capital-intensive products, while labor-abundant countries specialize in the production/export of labor-intensive products. The resulting pattern depicts inter-industry trade behavior where countries trade products from different industries.

[7] The choice of MERCOSUR was due to the fact that this market is an important export market for the Brazilian manufactured products (Hiratuka and Cunha, 2011). MERCOSUR consists of Argentina, Brazil, Paraguay and Uruguay.

The basic assumptions of the HO model began to be questioned in the literature when Balassa (1967) and Grubel (1967) found that international trade between countries belonging to the newly formed European Economic Community took place in two ways. Although the trade list of countries can be similar, a different pattern of trade can emerge that is of intra-industry in nature.

While empirical evidence appeared in the sixties, not until the late seventies did theoretical models of intra-industry trade emerge, from which we have the seminal work of Krugman (1979, 1980, 1981).

Krugman (1981) starts with a monopolistically competitive structure where economies of scale are internal to the firm, and consumer preference is of the "love for variety" type. Krugman shows that exported goods will be similar for all countries, following an intra-industry pattern of trade. This model suggests that the specialization of countries no longer occurs at the industry level, but at the product level, which is differentiated horizontally (in variety).

The theoretical models of Krugman (1981) and Helpman and Krugman (1985) accommodate inter-and intra-industry trade patterns. Krugman (1981) assumes that inter-industry trade is explained by the comparative advantage of countries, as in the HO model, while intra-industry trade is explained within a monopolistically competitive structure. The conclusion of the Helpman and Krugman (1985) model is that the list of export products of the countries will become more similar the greater the similarity in capital-labor ratios.

It is important to mention that the models of Krugman (1979, 1980, 1981) and Helpman and Krugman (1985) assume the productive specialization of countries might occur at the product level, where it is differentiated horizontally i.e., by variety. However, some theoretical literature finds the intra-product specialization may occur vertically, when it is differentiated by quality as in Falvey (1981), Falvey and Kierzkowski (1987), Flam and Helpman (1987), and Grossman and Helpman (1991).

Falvey (1981) and Falvey and Kierzkowski (1987) demonstrated that vertical product differentiation is a direct consequence of the differences in the production functions of trading partners. The capital-abundant country will specialize in the production of differentiated high quality products, while labor-abundant country will specialize in the production of low quality products. Thus, models of Falvey (1981) and Falvey and Kierzkowski (1987) can be viewed as a variation of the HO model. Instead of production specialization occuring at the industry level, in Falvey (1981) and Falvey and Kierzkowski (1987) it occurs at the level of product specialization, that is, varieties of a product have different qualities.

Thus, while the HO model predicts trade of different goods, models based on Falvey (1981) and Falvey and Kierzkowski (1987) considers trade in different varieties of goods, but with different qualities. According to Greenaway and Milner (1986), "Falvey" type of models can be considered neo-Heckscher-Ohlin model of intra-industry trade. These are based on the assumptions described in Jones (1974) and Deardorff (1979), in which: (i) all countries have access to the same production technology; (ii) the available technology is of constant returns to scale; (iii) countries, on the supply side, differ only in the relative factor endowments; (iv) different varieties of goods have different requirements of production factors, that is, the higher the quality, the higher the relative capital intensity; and (v) factor prices are only partially equalized[8].

Further, the model of Flam and Helpman (1987) considers the differences between the qualities of the products are from technological differences between countries. In this case, the most technologically advanced countries will specialize in exporting the highest quality products, while the less technologically advanced countries will specialize in products of lower quality.

In the same line of Flam and Helpman (1987), Grossman and Helpman (1991) develop a theoretical model of the product cycle, known in the literature as "quality ladder model". In

[8] This assumption avoids the problem of trade pattern indeterminacy, which occurs when having more factors than final goods if factor prices are equalized (Bhagwati, 1972).

this model, the most technologically advanced countries use their comparative advantage in innovation to develop new products of higher quality. After venturing into the market, these new products are then copied by follower countries.

2.2. WHAT DOES THE EMPIRICAL LITERATURE HAVE TO SAY?

With the development and improvement of international trade data at more disaggregated levels, empirical studies have emerged that examine not only the similarity of the exports of the countries but also the intra-product specialization. For example, Hummels and Klenow (2005) used a database composed of 126 exporting countries and 59 importing countries, with trade flows disaggregated at six-digit Harmonized System. They find robust evidence that countries with higher levels of per capita income export to a larger number of products and penetrate their products on a larger number of markets at export prices slightly higher than the competition. They assumed that product price reflects the quality. The authors conclude that international trade specialization exists at the product level with the most developed nations specializing in the production and exporting of the highest quality products, while the less developed nations specializing in the production and exporting of lower quality products.

Using disaggregated U.S. import data at the level of 10-digit Harmonized System, Schott (2006) observes that the U.S. imports the same products from different countries, but product prices vary systematically according to the level of income of trading partners. In this case, the evidence shows that product prices from rich countries are higher than those coming from poor countries. Again it is assumed that the higher product price reflects its higher quality. Schott argues that firms from capital abundant countries use their productivity advantage to specialize in the production of higher quality products and mitigate competition with low quality products from labor abundant countries.

Following this logic, Fontagné et al. (2007) argue that competition between countries can be reduced if exports are differentiated in quality. In examining the competition between the European Union and China, based on the unit value of the products the authors divide the trade flows in low, medium and high quality. In this case, the authors observed that the EU exports are concentrated in the high quality segment, while China had a high share of exports in the low quality market segment[9]. The authors conclude that European Union-China competition is mitigated due to the form of product differentiation.

Faruq (2010) found the quality of exported products to be directly related to research and development activities, supporting the hypothesis of technological leadership models (Flam and Helpman, 1987; Grossman and Helpman, 1991). Faruq also finds evidence that the quality of products is determined by foreign direct investment, confirming the results of Reganati and Pittiglio (2005) and Caetano and Gallego (2007). The foreign firm uses the investment to adopt new technology, thus improving product quality.

Krishna and Maloney (2011) analyzed the imports of the U. S. in the period 1990-2001 using unit values as proxies for product quality. They found that U.S. imports many of the same products from different countries, even though there can be large differences in their unit values (which are interpreted as differences in qualities). These imports are positively correlated with the level of per capita income of the exporting country. They also argue that there is an intra-product specialization in international trade, corroborating the results found in Hummels and Klenow (2005) and Schott (2006). Moreover, Krishna and Maloney (2011) also identified that the growth rate of the quality of products has increased over time, but differ across countries where the highest rates are observed for the richer countries belonging to OECD.

Kang and Lee (2012) study the relative quality of products traded between South Korea and 15 OECD countries plus Taiwan. For the period 1996-2003. The authors used

[9] Paillacar and Zignago (2007) also conclude that the Chinese exports are concentrated on low quality products.

disaggregated bilateral trade flows for high quality and poor quality goods. They observed that the quality of exported products from South Korea is inferior to the quality of the products exported by the 15 OECD countries. Using panel data econometric methods, the authors found that differences in the availability of physical capital tends to increase trade in vertically differentiated products, supporting the central hypothesis of Falvey (1981) and Falvey and Kierzkowski (1987).

3. METHODOLOGY

The above literature shows that export specialization occurs in intra-product form, which can be either either horizontally or vertically differentiated. When differentiated vertically, competition among countries in the international market is reduced, given products are designed for different market segments. Following this idea, this section describes the methodology we use to investigate the competition between China and Brazil in the MERCOSUR market. Following the theoretical models of Falvey (1981) and Falvey and Kierzkowski (1987), does competition occur in differentiated products in variety or quality?

The methods used in this paper are defined two fold. First, using the index of Finger and Kreinin (1979), we identify the similarity of products exported by both Brazil and China to MERCOSUR. Second, we characterize how product differentiation occurs, whether products are differentiated horizontally or vertically.

3.1. MEASURING AND DECOMPOSITION OF THE EXPORT SIMILARITY INDEX

The measurement of product similarity of exports from Brazil and China in the MERCOSUR is performed through the Finger and Kreinin index:

$$\mathrm{ESI}_{\mathrm{ijmt}} = \sum_{\mathrm{k=1}}^{\mathrm{n}} \min\left(\mathrm{C}_{\mathrm{kimt}}; \mathrm{C}_{\mathrm{kjmt}}\right) \qquad [1]$$

where, ESI_{ijmt} denotes export similarity index of country *i* (Brazil) and country *j* (China), in the market *m* (MERCOSUR), at time *t*; C_{kimt} is the share of product *k*, in the list of exports from country *i* (Brazil), in the market *m* (MERCOSUR), at time *t*; C_{kjmt} is the share of product *k*, in the list of exports of country *j* (China), in market *m* (MERCOSUR), at time *t*.

The export similarity index (*ESI*) varies in the interval between 0 and 1. When the exports of country *i* (Brazil) and country *j* (China) have the same distribution, the index is equal to one. When exports have completely different distributions, the index is equal to zero. An *ESI* index close to unity can be an indication that the competition between China and Brazil in MERCOSUR is quite fierce.

In this paper we propose a way to decompose the index of Finger and Kreinin (1979) to identify whether exports from Brazil and China to MERCOSUR occurs in horizontally or vertically differentiated products. This decomposition will be based on the criterion of similarity of products (Crespo and Fontoura, 2004), which is difined as the ratio of unit values of product *k* exported by Brazil ($\mathrm{VU}_{\mathrm{kt}}^{\mathrm{B}}$) and China ($\mathrm{VU}_{\mathrm{kt}}^{\mathrm{C}}$) for MERCOSUR[10]. If the ratio of unit

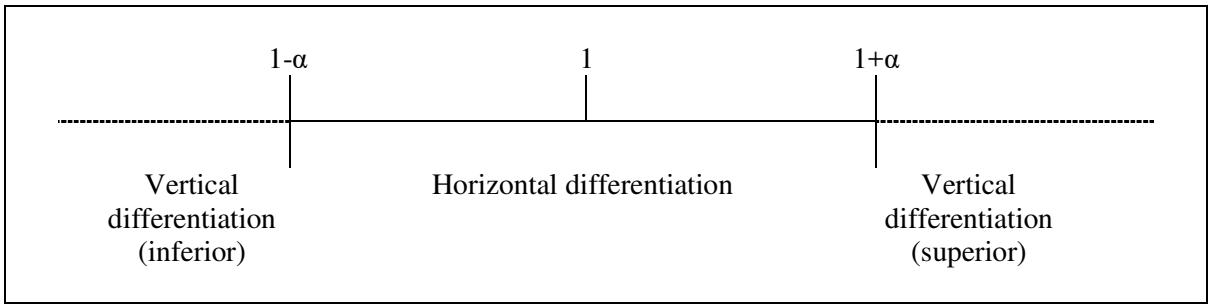
[10] The application of the criterion of similarity of products in the index of Finger and Kreinin (1979) is an innovation of this paper, since most of the studies in the literature (Abd El-Rahman, 1991;. Greenaway et al, 1994; Fontagné and Freudenberg, 1997; Durkin and Krygier, 2000; Nielsen and Lüthje, 2002; Crespo and Fontoura, 2004; Jensen and Lüthje, 2009) employ the criterion of similarity of products to obtain the disaggregated index of Grubel and Lloyd (1975).

values[11] [$\lambda = VU_{kt}^{B}/VU_{kt}^{C}$] is near the one, the products marketed by the countries do not have significant differences and are considered horizontally differentiated. When the ratio of unit values deviates too far from one, the products marketed have significant differences and are considered vertically differentiated. The criteria used to define if λ is close or far from the unit is the dispersion interval: [(1-α); (1 + α)]. Thus, when λ lies within this range the products are horizontally differentiated; otherwise, they are vertically differentiated.

When applying the criterion of product similarity, the the parameter α is very important because it sets the way the products are marketed by different countries. Following Greenaway et al. (1994), Durkin and Krygier (2000), Nielsen and Lüthje (2002), Crespo and Fontoura (2004) and Jensen and Lüthje (2009), we use a dispersion factor (α) equal to 25 percent[12]. Thus, the range for identifying the horizontal product differentiation is defined by: [0.75; 1.25]. If the ratio of the unit values (λ) lies outside this range the products are considered vertically differentiated.

The similarity criterion further allows us to identify if the quality of the products exported by Brazil are superior or inferior to the quality of products exported by China. In this case, from Brazil's perspective, the product quality is considered inferior or superior when $\lambda <$ (1-α) or $\lambda >$ (1 + α), respectively. Figure 1 illustrates the differentiation of products according to similarity.

Figure 1. Product differentiation acording to the criterion of similarity.



Source: Carmo et al. (2014).

It is also important to note that the similarity criterion assumes that the unit value of the product is a proxy for quality. According to Greenaway et al. (1994), the rationale for the use of unit value as a proxy for quality derives from the assumption that consumers have perfect information and are able to distinguish product quality. The good will have a higher quality when the unit value is larger than the good of poorer quality. Stiglitz (1987) sbmits the unit

[11] According to the standard literature (Greenaway et al., 1994; Fontagné and Freudenberg, 1997; Schott, 2004; Crespo and Fountoura, 2004; Fontagné et al., 2007; Jensen and Lüthje, 2009; Hiratuka and Cunha, 2011) the unit value is calculated by the ratio between the trade value (V) and the trade quantity (Q), that is: VU = V/Q.

[12] Abd-el-Rahman (1991), Fontagné et al. (1997), and Jensen and Lüthje (2009) use a dispersion factor (α) equal to 15%. According to Greenaway et al. (1995), the adoption of a dispersion factor equal to 15 percent will result in a range of dispersion equal to 30 percent, which may be considered too narrow, if imperfect information prevails in the market. Thus, the authors advocate the use of a dispersion factor of 25 percent, which provides a range of dispersion equal to 50 percent; with such interval it is expected to cover information gaps that are due to the size and diversity of the country (Zhang et al. 2005). Greenaway et al. (1995), Durkin and Krygier (2000), Crespo and Fontoura (2004), and Jensen and Lüthje (2009) found no statistically significant differences between factors of dispersion of 15 and 25 percent. However, despite all the care in choosing the dispersion factor, its definition still has an arbitrary nature. For a more detailed discussion of this topic, see Davis and Weinstein (2001).

value (price) will have a positive relationship with product quality even when consumers do not have perfect information[13].

Most product quality studies in the international trade literature are based on the assumption that, at high level of disaggregation, relative prices reflect relative quality. Greenaway et al. (1994). Fontagné et al. (1997) recognize that the direct association between the unit price and the quality has limitations, because other factors, such as, market structures, cost differences, differences in technology may affect the unit value of the product and, thus, lead to an erroneous interpretation of quality. Fontagné et al. (2007) also point out that the adoption of the unit value as a proxy for quality uses the restrictive hypothesis that productivity is homogeneous across countries, following the assumptions described in Jones (1974) and Deardorff (1979). Despite these limitations, Fontagné et al. (2007) argue that at the empirical point of view, the quality that distinguishes exported products are present in unit values, supporting the plausibility that the unit value of the product is a reasonable proxy for quality.

After applying the criterion of product similarity, the export similarity index (ESI) described in equation [1] can be decomposed:

$$\mathrm{ESI_{ijmt}} = \mathrm{ESI^{H}_{ijmt}} + \mathrm{ESI^{V}_{ijmt}} \qquad [2]$$

or:

$$\mathrm{ESI_{ijmt}} = \mathrm{ESI^{H}_{ijmt}} + \mathrm{ESI^{V-Inf}_{ijmt}} + \mathrm{ESI^{V-Sup}_{ijmt}} \qquad [3]$$

Thus, the export similarity index (ESI) between countries *i* (Brazil) and *j* (China), in the market *m* (MERCOSUR), at time *t*, is the sum of the similarity index of exports in horizontally differentiated products (ESI^{H}_{ijmt}) and similarity index of exports in vertically differentiated products (ESI^{V}_{ijmt}), where the latter can also be decomposed into vertical inferior (ESI^{V-Inf}_{ijmt}) and vertical superior (ESI^{V-Sup}_{ijmt}). These definitions are elaborated in Table 1.

Table 1. Export similarity index and definitions.

Index	Definition
ESI	Measures the similarity of exports structures of countries *i* and *j* in market *m*, but does not identify if products are differentiated horizontally or vertically
$\mathrm{ESI^{H}}$	Refers to the similarity of exports that occurs in horizontally differentiated products.
$\mathrm{ESI^{V}}$	Refers to the similarity of exports that occurs in vertically differentiated products.
$\mathrm{ESI^{V\text{-}Inf.}}$	When the similarity of exports occurs in vertically differentiated products, the quality of the product originated from country *i* (Brazil) is lower than the quality of the product coming from the country *j* (China).

[13] Stiglitz (1987) describes several models that demonstrate the relationship between quality and price based on incentive effects and selection.

$ESI^{V\text{-}Sup.}$	When the similarity of exports occurs in vertically differentiated products, the quality of the product originated from country *i* (Brazil) is higher than the quality of the product coming from the country *j* (China).

Source: Carmo et al. (2014).

3.2. DATASET

The index of Finger and Kreinin (1979) of equation (1) is sensitive to the level of trade data disaggregation. The index tends to be higher the higher the level of aggregation. Therefore, to enable us to achieve our objectives, we use trade data disaggregated at six-digit level of the Harmonized System, which includes more than 5,000 products. These data come from the *Base pour l'Analyse du Commerce International* (BACI), which is published by *the Centre d'Etudes Prospectives et d'Informations Internationales* (CEPII) and is available for download at: *http://www.cepii. fr / anglaisgraph / bdd / baci.htm.* These data cover the period 2008 to 2017.

The use of the database BACI has an advantage over other databases of international trade, such as COMTRADE. While most databases report exports on FOB value (*free on board*) and imports on CIF value (*Cost, Insurance and Freight*), in BACI, the monetary values of exports and imports are supported on a FOB-FOB base, considering CIF costs were estimated and removed from the values of imports. For details of the BACI dataset, see Gaulier and Zignago (2010).

It is important to recognize that the use of trade data at the six-digit level, while extremely disaggregated, has at least one potential problem. Baldwin (2006) refers to the fact that these data do not measure the total number of products exported by individual countries, given that a large number of products must be comprehended under the same category of the Harmonized System. Thus, it is possible that the values we obtain will overestimate the true degree of export similarity Brazil and China to MERCOSUR. Despite this limitation, we believe that the data used here can provide a good picture of the trade competitiveness of Brazil and China in MERCOSUR.

4. RESULTS AND DISCUSSION

4.1. BRAZILIAN AND CHINESE EXPORTS TO MERCOSUR FROM 2009 TO 2017

Before analyzing export competitiveness, we present an overview Brazil and China exports to MERCOSUR during the period 2008-2017. Throughout the period Brazil's exports are higher than those of China, but their difference is getting smaller over time (see Figure 2). For instance, in 2008, China's exports to MERCOSUR was only 31.5 percent of Brazilian exports to that market, but in 2017 this figure exceeded 56.5 percent, reflecting the rising share of Chinese products in MERCOSUR[14].

[14] A fact which contributed to greater integration of China in MERCOSUR was the entry of China into the World Trade Organization (WTO) in 2001.

Figure 2. Exports of Brazil and China to MERCOSUR from 2008 to 2017 (in US$ Billions).

Source: elaborated by the authors using BACI dataset.
Note: export values are at current prices.

The sectoral composition of exports from Brazil and China in MERCOSUR is shown in Table 2, noting that the numbers are average percentages for the sub-periods of 2008/2010 and 2015/2017. For Brazil in both periods 2008/2010 and 2015/2017, exports were concentrated in the sectors: Transportation, Machines/Electrical, Mineral products and Chemicals, which together accounted for around 69.6 percent and 69.2 percent of Brazilian exports to MERCOSUR in the two periods, respectively. Brazil's exports to MERCOSUR have become more concentrated over time, largely driven by the transportation sector. Similarly, in the first sub-period China's exports to MERCOSUR were concentrated in Machinery/Electric, Textiles, Transoirtation and Chemicals, which collectively represent around 75 percent of exports. However, by the latter sub-period China's exports were focused on the same sectors and, to a lesser extent Miscellaneous Products, accounting for 82.7 percent of China's exports to MERCOSUR. Like Brazil, there was also an increase in the concentration of China's exports in MERCOSUR over time. However, in China's case this increase was largely driven by the transportation and miscellaneous products sectors.

Table 2. Sectoral composition of Brazil and China exports in MERCOSUR (average percentages, 2008/2010 and 2015/2017)

Setor	Brazil		China	
	2008/2010	2015/2017	2008/2010	2015/2017
Animal e animal products	0.75	1.03	0.08	0.06
Vegetable products	1.21	1.58	0.16	0.21
Food products	3.01	3.85	0.34	0.35
Mineral products	10.02	9.00	0.32	0.17
Chemicals	10.89	9.35	16.18	13.08
Plastic/rubbers	6.59	6.11	5.10	4.73
Leather and skins	0.07	0.21	1.89	1.47
Wood	2.80	3.36	0.84	0.89
Textiles	2.75	2.14	10.28	9.97
Shoes	1.22	1.30	2.37	2.08

Stone/glass	1.32	1.56	1.51	2.19
Metals	8.70	7.52	4.20	5.14
Machines/Electric	20.06	13.58	40.02	39.51
Transportation	28.66	37.26	8.79	10.51
Miscellaneous products	1.97	2.16	7.93	9.64
Total	100.0	100.0	100.0	100.0

Source: elaborated by the authors using BACI dataset.

The number of products exported by Brazil and China to MERCOSUR (at six-digit Harmonized System) is reported in Table 3. The number of products exported by Brazil to MERCOUSR dropped from 3,454 in 2008 to 3,417 in 2014. After 2015, a slight recovery in the total number of products exported by Brazil, reaching 3,541 in 2017.

In China's case, the total number of products exported to MERCOSUR showed an increasing trend, from 2,901 products in 2008 to 3,121 products in 2011. After a slight decrease in 2012-13, the total number of products exported reached 3,266 in 2017. While China added 365 products to its MERCOSUR export list, from 2008 to 2017, Brazil saw an increase of only 87 products over the same period.

In Table 3 we also show that the products simultaneously exported (same products) by both countries increased from 2,469 in 2008 to 2,754 in 2017. After a slight decrease in 2009 and 2012, the number of products simultaneously exported increased after 2013. It is interesting to note that in 2017, 77.8 percent of products exported by Brazil were also exported by China, up from 71 percent in 2008. This suggests increasing product competition in MERCOSUR.

Table 3. Number of products exported by Brazil, China, and both to MERCOSUR.

Year	Brazil	China	For both countries
2008	3454	2901	2469
2009	3410	2900	2423
2010	3489	3044	2578
2011	3490	3121	2627
2012	3461	3082	2565
2013	3436	3082	2596
2014	3417	3133	2624
2015	3438	3164	2671
2016	3501	3184	2717
2017	3541	3266	2754

Source: elaborated by the authors using BACI dataset.

In Table 4 we present the average number of products exported to MERCOSUR by Brazil, China, and simultaneously by sector, for the periods 2008-2010 and 2015-2017. Both countries are focusing their exports on the Machinery/Electric, Metals, Textiles and Chemicals sectors. An interesting observation is that, between periods of 2008-2010 and 2015-2017, China increased the number of products exported in all sectors, except for the footwear sector, while Brazil showed small increases in some sectors, mainly for Transportation, Mineral Products and Textiles.

For the Machinery/Electric, Miscellaneous products, Textiles, Footwear and Stone/Glass sectors, the number of products exported by China exceeded the number of products exported by Brazil in 2015-2017. As increasing Chinese penetration in MERCOSUR occurred in virtually every sector, the products simultaneously exported by Brazil and China for MERCOSUR also increased.

Table 4. Number of products exported by Brazil, by China, and simultaneously by both countries to MERCOSUL (average for 2008-2010 and 2015-2017).

Sector	Brazil		China		For both countries	
	2008/2010	2015/2017	2008/2010	2015/2017	2008/2010	2015/2017
Animal and animal products	167	162	36	62	15	10
Vegetable products	492	478	133	175	82	114
Food products	424	411	128	166	116	142
Mineral products	224	242	82	99	71	80
Chemicals	1,587	1,605	1,391	1,500	1,119	1,228
Plastic/Rubber	557	557	469	497	444	468
Leather and skin	110	117	78	79	67	67
Timber	461	458	338	420	286	344
Textiles	1,644	1,706	1,684	1,736	1,357	1,455
Footwear	111	114	130	125	99	103
Stone/Glass	386	387	351	388	291	338
Metals	1,318	1,324	1,043	1,184	948	1,078
Machinery/Eletrical	1,918	1,953	1,918	2,056	1,736	1,850
Transport	246	280	220	274	188	224
Miscellaneous Products	706	686	844	853	651	641

Source: elaborated by the authors using BACI dataset.

Between 2008-2017 China increased its exports to MERCOSUR and this increase has been accompanied by a rise in the total number of products sold. With the increase of the number of products simultaneously exported, the export basket of China in MERCOSUR has become increasingly similar to Brazil. A closer analysis of the extent of the similarity of exports from Brazil and China in MERCOSUR will be performed in the next section by computing the ISE index.

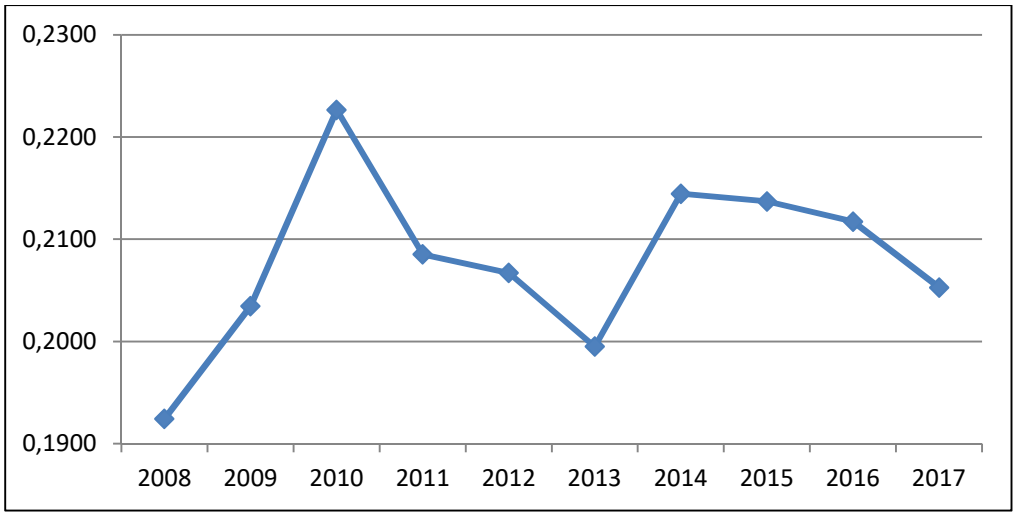
4.2. EXPORT SIMILARITY INDEX (ESI)

We now further quantify the similarities of products exported from Brazil and China in MERCOSUR. This is done in two steps. In the first step we compute product similarity indices at the aggregate level, all trade between Brazil and China with MERCOSUR. In the second, we compute disaggregated indices by sector.

4.2.1. Agregate analysis

The evolution of the export similarity index (ESI) of Brazil and China in MERCOSUR over the period 2008-2017 is shown in Figure 3. It is unmistakable that exports from Brazil and China have become increasingly similar over time, as the ESI index is increasing. From the initial year (2008) to the final year (2017), the index increased from 0.19 to 0.20, or 7.8 percent.

Figure 3. Export Similarity Index (ESI) between Brazil and China Exports to MERCOSUR, 2008 to 2017.



Source: elaborated by the authors using BACI dataset.

The evidence found here is different from that found by Filgueiras and Kume (2010) in the North American market. These authors found the similarity of exports between Brazil and China in the North American market first increased from 0.11 to 0.15, between the years 2000 to 2005, then decreased to 0.10[15] in 2008, virtually no change over the entire period. In Figure 3 we can see a slight increasing trend. This could well indicate that the competition between China and Brazil in MERCOSUR has become stronger over time, but at lower pace than showed in previous studies, such as Carmo et al. (2014).

We argued earlier that the competition between Brazil and China can be smoothed if the traded products are vertically differentiated. This may be the situation here as the same products may be sold in different market segments, according to Fontagné *et al.* (2007). Thus we decompose the ESI into horizontal and vertical differentiated components, ESI^H and ESI^V.

Table 5. Decomposition of ESI into ESI^H and ESI^V (percent).

Year	ESI^H	ESI^V
2008	40.8	59.2
2009	29.9	70.1
2010	29.2	70.8
2011	34.0	66.0
2012	17.2	82.8
2013	28.9	71.1
2014	29.0	71.0
2015	29.4	70.6
2016	32.4	67.6
2017	16.8	83.2

Source: elaborated by the authors using BACI dataset.

[15] The data used by Filgueiras and Kume (2010) to calculate the similarity of exports from Brazil and China in the North American market were more disaggregated from those used in this study. While these authors used data disaggregated at 10-digit level, in the present study the data are disaggregated to six-digit level. Thus, as noted in subsection 3.2, more disaggregated data tend to provide lower values of the ISE index than more aggregated data.

In Table 5 export similarity occurs mainly in vertically differentiated products (products with different qualities), as the ESI^V represents more than 70 percent of the ESI over the entire 2008-2017 period. Thus, product competition between Brazilian and Chinese products in MERCOSUR has been attenuated, since the products simultaneously exported are directed toward different market segments.

Whereas vertically differentiated products possess different qualities, in Table 6 we compute indices to see if the quality of products exported by Brazil are superior or inferior to those exported by China.

Table 6. Decomposition of ESI into $ESI^{V\text{-}Inf.}$ and $ESI^{V\text{-}Sup.}$ (percent).

Year	$ESI^{V\text{-}Inf.}$	$ESI^{V\text{-}Sup.}$
2008	36.1	63.9
2009	29.7	70.3
2010	29.6	70.4
2011	15.9	84.1
2012	12.6	87.4
2013	22.6	77.4
2014	31.6	68.4
2015	35.8	64.2
2016	27.1	72.9
2017	11.6	88.4

Source: elaborated by the authors using BACI dataset.

In Table 6, it is apparent that when products simultaneously exported by Brazil and China possess different qualities, the quality of Brazilian products is larger than the quality of Chinese products. These data are consistent with the results observed in Filgueiras and Kume (2010) in the North American market, and Carmo et al (2014) for Brazilian and Chinese exports to MERCOSUR, where these studies also found the quality of products exported by Brazil to be higher than the quality of products exported by China.

According to the neo-Hecksher-Ohlin (Falvey, 1981; Falvey and Kierzowski, 1987), the quality of exported products is directly linked to the capital-labor ratio of the countries. The country with the larger capital-labor ratio will export a higher quality product to the country with a lower capital/labor ratio. Therefore, the relatively higher quality of Brazilian exports is attributed to the relatively higher capital-labor ratio of Brazil[16]. These results are in consonance with other studies which also found the existence of a intra-product trade specialization (Hummels and Klenow, 2005; Shott, 2006).

In sum, we find that the similarity of exports from Brazil and China in MERCOSUR has increased over time, suggesting that competition between countries in that market is increasingly getting stronger. However, this competition has softened a bit since a high portion of the exported products are vertically differentiated. We further observe product quality differences; the quality of Brazilian products exported to MERCOSUR is higher than those from China.

[16] Based on World Bank data, Filgueira and Kume (2010) report that in 2008 per capita income in Brazil was US$ 10,070 while in China it was US$ 6,020. The rationale for the use of per capita income as a proxy for capital/labor ratio is the following: consider that Y = F (K, L), where Y denotes GDP, K is the amount of physical capital, (.) L denotes the number of workers and F is a smooth function of degree one. Thus, by dividing both sides by the function L, we get: y = f (k); where y = Y/L and k = K/L.

4.2.2. Sectoral analysis

Now we turn to the similarity of exports from Brazil and China to MERCOSUR by specific sector. In order to avoid a large dispersion of information, data in Table 7 are reported as average values for the following subperiods: 2008-2010, 2011-2014, and 2015-2017.

Table 7. Export Similarity Index (ESI) between Brazil and China in MERCOSUR by industrial sectors (average by sub-periods).

Sector	2008/2010	2011/2014	2015/2017
Animal and animal products	0.01	0.00	0.01
Vegetable products	0.02	0.02	0.03
Food products	0.20	0.21	0.24
Mineral products	0.03	0.11	0.05
Chemicals	0.18	0.17	0.19
Plastic/Rubber	0.38	0.42	0.44
Leather and skin	0.12	0.04	0.06
Timber	0.21	0.27	0.31
Textiles	0.30	0.27	0.31
Footwear	0.62	0.65	0.65
Stone/Glass	0.34	0.33	0.26
Metals	0.28	0.31	0.31
Machinery/Eletrical	0.26	0.26	0.27
Transport	0.26	0.30	0.25
Miscellaneous Products	0.30	0.28	0.29

Source: elaborated by the authors using BACI dataset.

In Table 7, we see how export similarity between Brazil and China has changed over time. The highest similarity occurs in the Footwear industry, reaching a magnitude of 0.65 for the period 2011-2014 and 2015-2017[17]. Ranking second in 2008-2010, the Plastic/Rubber industry saw a continuous rise in the ESI reaching 0.44. Other sectors that showed continuous increase in similarity over time were Food products and Timber. All sectors in Table 7 show increases over time, with the exception of Stone/Glass sector. The lowest ESI are for those sectors producing primary goods (Animal and animal products and vegetable products) and sectors that are intensive in natural resources (Mineral products). This is plausible since the list of exports from Brazil and China in MERCOSUR focus mostly on manufactured products, as seen earlier in Table 2.

We now desaggregate the ESI in ESI^H and ESI^V for each of the fifteen sectors. These results are reported in Table 8 as the mean percentages for the sub-periods: 2008-2010, 2011-2014 and 2015-2017. For the majority of sectors, the ESI occurs in vertically differentiated products, given that the ESI^V is larger than the ESI^H. However, the ESI^H increases in the last sub-period for Timber sector. This may suggest that the quality of Brazilian and Chinese products in this sector have recently become more similar. In the case of Animal and animal products, however, the similarity changed over time from vertically to horizontally differentiated products.

[17] Probably most of these changes were due to Brazilian exchange rate policy in each period.

Table 8. ESI decomposition in ESI^H and ESI^V by sectors (mean percentage values by sub-periods).

Sector	2008/2010		2011/2014		2015/2017	
	ESI^H	ESI^V	ESI^H	ESI^V	ESI^H	ESI^V
Animal and animal products	1	99	13	87	96	4
Vegetable products	59	41	54	46	37	63
Food products	19	81	18	82	19	81
Mineral products	61	39	94	6	44	56
Chemicals	28	72	26	74	30	70
Plastic/Rubber	34	66	14	86	21	79
Leather and skin	4	96	7	93	4	96
Timber	53	47	51	49	36	64
Textiles	32	68	20	80	33	67
Footwear	11	89	9	91	10	90
Stone/Glass	32	68	27	73	28	72
Metals	26	74	30	70	28	72
Machinery/Eletrical	36	64	26	74	23	77
Transport	48	52	46	54	39	61
Miscellaneous Products	10	90	14	86	16	84

Source: elaborated by the authors using BACI dataset.

In Table 9 we see if the quality of the Brazilian exports is superior or inferior to the quality of the Chinese exports when they are vertically differentiated. Because $ESI^{V\text{-}Sup.}$ is larger than the $ESI^{V\text{-}Inf.}$ the quality of products exported by Brazil is superior to the quality of Chinese products in most industries. However, in some sectors the $ESI^{V\text{-}Inf.}$ is larger than $ESI^{V\text{-}Sup.}$ such as Animals, Food, and Mineral products. Specifically in the case of Animals and Mineral products, there has been a change in the pattern of product differentiation between the subperiods. Although the export similarity index (ESI) in these sectors are very low (as in Table 7), product quality can be strongly influenced by the behavior of a single product, making the quality measurement less stable.

Table 9. ESI^V decomposition in $ESI^{V\text{-}Inf.}$ and $ESI^{V\text{-}Sup.}$ (mean percentage values by sub-periods).

Sector	2008/2010		2011/2014		2015/2017	
	$ESI^{V\text{-}Inf.}$	$ESI^{V\text{-}Sup.}$	$ESI^{V\text{-}Inf.}$	$ESI^{V\text{-}Sup.}$	$ESI^{V\text{-}Inf.}$	$ESI^{V\text{-}Sup.}$
Animal and animal products	86	14	92	8	46	54
Vegetable products	25	75	22	78	42	58
Food products	62	38	74	26	86	14
Mineral products	82	18	44	56	5	95
Chemicals	15	85	9	91	14	86
Plastic/Rubber	1	99	6	94	7	93
Leather and skin	44	56	7	93	4	96
Timber	25	75	42	58	42	58
Textiles	35	65	9	91	23	77
Footwear	5	95	1	99	2	98
Stone/Glass	35	65	38	62	30	70

Metals	5	95	14	86	5	95
Machinery/Eletrical	54	46	29	71	35	65
Transport	22	78	14	86	30	70
Miscellaneous Products	52	48	38	62	39	61

Source: elaborated by the authors using BACI dataset.

In the sectoral analysis, it was possible to verify that most of the results has the same trend as showed by Carmo et al. (2014) for the period 1995-2009. Therefore, even after the period of the boom in the commodities' prices, there were some changes in the sectors' competitiveness in the Brazilian and Chinese exports to MERCOSUR, which might be a sign of other factors than export prices.

5. FINAL COMMENTS

The rapid growth in China's participation in international product markets over the past couple decades has impacted exporters competing in similar markets. In particular, exports from China to MERCOUSR may threaten Brazilian exports, especially when the exported products are similar. However, Fontagné et al. (2007) finds that competition between countries can be mitigated if the exported products are vertically differentiated.

In this paper we investigate the competitiveness of exports from Brazil and China in MERCOSUR over the period 2008 to 2017. We measure the similarity of their exports to using the index (ESI) proposed by Finger and Kreinin (1979). The further decomposition of the index enables us to identify product quality. Thus we are able to find out if the quality of Brazilian exports is superior or inferior to the quality of Chinese exports to MERCOSUR.

Using disaggregated trade data at the six-digit level of the Harmonized System, our results suggest that the similarity of exports from Brazil and China in MERCOSUR has increased over time, ESI moving from 0.19 (in 2008) to 0.20 (in 2017). Thus, export competition between the two countries has become stronger.

Through ESI decomposition, we found that the similarity of exports occurs mostly in vertically differentiated products, where the quality of the products exported by Brazil is greater than the quality of the products exported by China. Our findings are consistent with trade models of the "Falvey" type, which show countries with a higher relative abundance of capital will produce goods of superior quality to those produced by countries with a higher relative abundance of labor.

Despite increasing exports by both Brazil and China to MERCOSUR, Brazil has increased its relative share of high value added (quality) export products. As Brazil seeks to add value to its MERCOSUR exports, the China's increased presence may not be in direct competiton with Brazil.

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