Comparative Advantages and Productive Integration: The case of Agribusiness Global Value Chains

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Área Temática: 6. Globalização e competitividade regional.

Abstract
This article had two main objectives. The first was to analyze the longitudinal comparison of productive integration, comparative advantages and their degree of inequality between countries. The second objective was to verify how productive integration and comparative advantages are related to productivity and per capita income. The first objective was achieved through the global input-output model and traditional measures of productive integration (VAX indices) and comparative advantages (VARCA). The second objective was achieved through a correspondence analysis between measures of comparative advantage and productive integration. The results indicated that: i) comparative advantages and productive integration are inversely related; ii) there was a longitudinal reduction of comparative advantages and equitable among countries; iii) a longitudinal increase in productive integration and very low levels of inequality; iv) countries with low productivity have low per capita income and participate in agribusiness global value chains (AGVC) through comparative advantages and; v) high productivity countries have high per capita income and participate in AGVC through productive integration.

KEYWORDS
Global Value Chains; Comparative Advantages; Productive Integration.

JEL Classification: F1, C7, Q17.

Resumo
Este artigo teve dois objetivos principais. O primeiro foi analisar a comparação longitudinal da integração produtiva, vantagens comparativas e seu grau de desigualdade entre os países. O segundo objetivo foi verificar como a integração produtiva e as vantagens comparativas estão relacionadas à produtividade e à renda per capita. O primeiro objetivo foi alcançado através do modelo global de entrada e saída e medidas tradicionais de integração produtiva (índices VAX) e vantagens comparativas (VARCA). O segundo objetivo foi alcançado através de uma análise de correspondência entre medidas de vantagem comparativa e integração produtiva. Os resultados indicaram que: i) vantagens comparativas e integração produtiva estão inversamente relacionadas; ii) houve uma redução longitudinal das vantagens comparativas e equitativas entre os países; iii) um aumento longitudinal da integração produtiva e níveis muito baixos de desigualdade; iv) países com baixa produtividade têm baixa renda per capita e participam da cadeia de valor global do agronegócio (AGVC) por meio de vantagens comparativas; v) os países de alta produtividade possuem alta renda per capita e participam da AGVC por meio da integração produtiva.

PALAVRAS-CHAVE
Cadeias globais de valor; Vantagens comparativas; Integração Produtiva.

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1. Introduction

In recent years, and specifically after the global economic crisis of 2008, we have seen an increase in tariff and non-tariff barriers around the world. The escalation of trade barriers is accompanied by a resurgence of right-wing and extreme right-wing social movements, with protectionist and even separatist ideas.

Tensions in international trade gained momentum after the heyday of economic liberalization as a result of the intensification of global value chains. The biggest trade disputes are associated with the manufacturing and agribusiness sectors. The latter is the object of analysis of this paper.

Nevertheless, why is there such a trade dispute? The III Industrial Revolution, responsible for the remarkable advances of telecommunications and transport technologies, has provided the process of productive fragmentation where the links of productive chains move around the world in pursuit of strategic elements in maximizing profits and minimizing costs, such as economic stability, productivity gains, skilled labor, and comparative advantages. This new configuration of the production structure is called Global Value Chains (GVC) (Meng, Wang, & Koopman, 2013). The GVC are the cross-border flows of goods, investments, services, knowledge and people associated with international production networks and have transformed the world and is probably the most striking feature of globalization (R. Baldwin, 2012).

In essence, this international fragmentation of production means greater productive integration and amplifies the opportunity for countries to specialize in accordance with their comparative advantages and, consequently, to enjoy trade gains. However, while trade gains represent a gain in average welfare, it is not necessarily good for all capital owners involved (R. Baldwin, 2006; Feenstra, 1998; Timmer, Erumban, Los, Stehrer, & de Vries, 2014).

Some countries have high productivity, low labor costs, abundant labor, or high skilled labor, which stimulates the productive integration of these countries in the productive fragmentation process associated to the GVC. Other countries, however, have low productivity, low skilled labor, and high production and trade costs in parallel with comparative advantages in particular sectors or abundance of natural resources. In this context, how do different types of countries behave in the context of GVC? What is the relationship between comparative advantages and productive integration? Is there a relationship between productive integration, comparative advantages and productivity?

EEconomic literature is hardly suggestive in this respect. The implications of the comparative advantages on international trade are clear, with countries specializing according to the allocation of resources (Heckscher, 1919), the technological level (Ricardo, 1891), characteristics of the labor market (Cuñat & Melitz, 2007), quality of institutions (Costinot, 2009; Levchenko, 2007; Nunn, 2007) and local culture (Belloc, 2006; Belloc & Bowles, 2013). The determinants of productive integration on international trade are also precise, with the market structure (Annicchiarico, Orioli, & Trionfetti, 2012; Combes, 1997; Combes & Lafourcade, 2011; Neary, 2001), the market potential and the multiplicity of equilibria (Crozet, 2004; Davis & Weinstein, 2002, 2008) and transport and agglomerative costs (Behrens & Robert-Nicoud, 2010; Brülhart, Jametti, & Schmidheiny, 2012; Redding, 2010; Redding & Sturm, 2008) influencing the level of productive integration. However, there are no papers in the economic literature that discuss the relationship between comparative advantages and productive integration.

The agribusiness sectors are characterized by heavy dependence on natural resources

and are directly associated with the use of comparative advantages, and often receive subsidies and commercial protection from local governments. In addition, the agribusiness sectors are connected to the whole economy and have also benefited from the possibility of fragmentation brought by global value chains. According to van Arendonk (2015), in 2014, world agribusiness accounted for more than 50% of people employed worldwide and approximately 25% of all global GDP. In the new organization of production, the agribusiness sectors are a strategic element of the modern economy, with a network of activities, upstream and downstream of the farm, geared towards the production of goods and services of agricultural origin (Guilhoto, Assumpção, Modolo, & Imori, 2007). The agribusiness sectors are strong, dynamic, connected with the whole economy and with relevant performance in the process of economic development (Furtuoso & Guilhoto, 2003).

Global trade in the agribusiness sector brings together very diversified and heterogeneous production systems in terms of characteristics, regulatory frameworks, environmental conditions, specialization and consumer preferences. The products are increasingly differentiated and of high added value and the agribusiness sectors are characterized by being located according to their comparative advantages due to the dependence of natural resources. At the same time, increasing productive integration in global value chains brings together buyers and suppliers and offers the perspective of knowledge transfer (Humphrey, 2006).

In order to fill this gap, the objective of this paper is to analyze the relation between comparative advantages and productive integration longitudinally in the agribusiness global value chains (AGVC). That is, how are the comparative advantages in the AGVC used? What is the choice of more or less productive integration with the AGVC?

The results indicated that there was a longitudinal increase in productive integration and, conversely, a reduction of the comparative advantages and in an equitable way between the countries. There is also a dichotomy between productive integration and comparative advantages. That is, countries participate in AGVC through productive integration or locational advantages, and that determines this choice is the total factor productivity level (TFP). Countries with low TFP participate in AGVC taking advantage of comparative advantages, while countries with high TFP participate in AGVC with high productive integration. In addition, we also found a positive relationship between PFF and GDP per capita. Countries with higher per capita GDP have higher productivity, while countries with lower per capita GDP have lower productivity.

In addition to this brief introduction, the work is divided into three more sessions. The second session presents the method used to map the AGVC and correlate the comparative advantages with the productive integration. The third section presents and discusses results for the sectors of the AGVC, comparative advantages, productive integration, the relationship between them and the importance of productivity. Finally, in the fourth section are the conclusions, with implications of the results and suggestions of policies beneficial to international trade.

2. Methodology

2.1. Identifying the Global Agribusiness Value Chains

One way to assess the impact of productive fragmentation is through the global input-output tables, with the largest period and level of disaggregation of sectors and countries possible (R. E. Baldwin, 2012; Feenstra, 1998; Feenstra & Hanson, 1999;

Hummels, Ishii, & Yi, 2001; R. C. Johnson & Noguera, 2012; Koopman, Wang, & Wei, 2012; Meng et al., 2013; Timmer et al., 2014). In this sense, the data provided by WIOD[1] (*World Input-Output Databases*) matching the needs of this article, with a longitudinal coverage from 2000 to 2014, covering the process of productive fragmentation of global value chains

The data provided by WIOD are a time series of input-output tables multilaterally connected among all 43 countries and opening 56 sectors for each country. There is also an adjustment account called "Rest of World", which contemplates all trade flows between nations not directly expressed among the 43 countries (Dietzenbacher et al., 2013).

TTo capture the increasing fragmentation of the productive structure, with the shifting of links from production chains around the world, methods needed to move forward. The challenge was to be able to express the greater productive interdependence and sectoral specialization through the added value (Hummels et al., 2001). Thus, it is an interregional input-output model with n regions, as expressed by Koopman et al. (2012):

$$A^D X + F^D = X \tag{1}$$

$$A^M X + F^M = M \tag{2}$$

$$\mu A^D + \mu A^M + A_v = \mu \tag{3}$$

where A is the matrix of technical coefficients of dimension production $n \times n$. F is a final demand vector that includes public and private consumption, gross fixed capital formation, inventory and export variation, with dimension $n \times 1$. M is an import vector of dimension $n \times 1$. A_v is a vector with the ratio of the value added on the gross exports of dimension $1 \times n$ and μ is a unit vector of dimension $1 \times n$. In addition, every overwritten D indicates that the variables are domestic, every overwritten M makes references to imported variables.

The equations 1 and 2 are the equilibrium condition in the production of domestic and imported goods. The equation 3 is the restriction to the input-output coefficients, imply that the total output, X, in each sector i must be equal to the sum of the value added directly in sector i and equal to the cost of intermediate inputs for all domestic and imported production.

To identify the AGVC it was made the hypothetical extraction of Crop and animal production, hunting and related service activities sector (S1) of the global input-output matrix with the opening of 56 sectors and 43 countries between the years 2000 and 2014 [2]. The sectors with a variation in total production were classified as belonging to the AGVC, both from the perspective of the purchases and from the perspective of sales, above the median in all periods.

[1] For more details on WIOD see Dietzenbacher, Los, Stehrer, Timmer, and De Vries (2013).

[2] About the Hypothetical Extraction method see Dietzenbacher, Linden, and Steenge (1993); Haddad, Perobelli, and dos Santos (2009); Perobelli, Haddad, Domingues, et al. (2006).

2.2. Measuring Productive Integration and Comparative Advantages

Based in the equations 1 to 3, it is possible to obtain the level of productive integration (VAX ratios) and comparative advantages (VARCA) for the AGVC sectors between the years 2000 and 2014.

The rate of value added to export (VAX ratios) is a traditional measure of productive integration to the GVC (Hummels et al., 2001) and was also used by R. C. Johnson and Noguera (2012); Koopman et al. (2012); Timmer et al. (2014) and R. Baldwin and Lopez-Gonzalez (2015). The VAX ratios can be obtained by:

$$VAX = \hat{A}_v(I - A)^{-1}F^{D+M} \tag{4}$$

where VAX is a column vector of dimension $n \times 1$. $\hat{A}_v$ is the diagonal vector of value added on gross exports. $(I - A)^{-1}$ is the inverse matrix of Leontief and F^{D+M} is the final demand column vector of domestic and imported products with dimension $n \times 1$. Each element of 4 indicates the participation of the value-added content of trade. The lower the VAX ratios less the value-added content of trade and more integrated is the sectoral production of each country to the AGVC (R. Baldwin & Lopez-Gonzalez, 2015; R. C. Johnson & Noguera, 2012; Timmer et al., 2014).

To measure the comparative advantages associated with AGVC we suggest a modification in Balassa (1965). In order for the indicator to be able to capture the revealed comparative advantages in terms of added value. The VARCA coefficient (*Value Added of Revealed Comparative Advantages*) can be obtained by:

$$VARCA = \frac{X_{ij}^{Mv}}{X_{wj}^{v}} \frac{X_{i}^{Mv}}{X_{j}^{Mv}} \tag{5}$$

where X_{ij}^{Mv} represents the country's exports i industry j measured in value added. X_{wj}^{v} is the global value added production j industry. X_{i}^{Mv} is the total export of the country i in value added and X_{w}^{Mv} is total global export in value added. Intuitively, the greater the VARCA coefficient, of the sector i in the country j, the greater the revealed comparative advantage of this j country in sector i. The equation 5 indicates the sectors of each country with higher levels of comparative advantage from the perspective of AGVC between the years 2000 and 2014.

2.3. Measuring the Total Factor Productivity (TFP)

The rate of productivity growth has been the source of growth for many economies for decades. Now, in the context of the AGVC, productivity is one of the strongest determinants for the localization or relocation decision (Bhagwati, Panagariya, & Srinivasan, 1998; Meng et al., 2013). According to Miller and Blair (2009), the Total Productivity of Factors, TFP, is defined as the level of production of an industry or economy by input units, and can be obtained from:

$$x_j = \Sigma_{i=1}^{n} a_{ij}x_j + v_j x_j = (\Sigma_{i=1}^{n} a_{ij} + v_j)x_j \tag{6}$$

where x_j is the total output of the sector j, a_{ij} are are the technical coefficients of output and v_j is the value added in sector j. Differentiating Equation 6 in relation to the total output of sector j, we have:

$$dx_j = d[(\Sigma_{i=1}^{n} a_{ij} + v_j)x_j] = (\Sigma_{i=1}^{n} a_{ij} + v_j)dx_j + (\Sigma_{i=1}^{n} da_{ij} + dv_j)x_j \tag{7}$$

where the last term of Equation 7 indicates the growth rate of TFP (Miller & Blair, 2009) and can also be expressed by τ_j. Differentiating finitely and rewriting the equation 7 can be obtained the expression for Total Factor Productivity for each industry j:

$$\tau_j = -(\Sigma_{i=1}^{n} \Delta a_{ij} + \Delta v_j) \tag{8}$$

$$\Delta x_j = \Delta[(\Sigma_{i=1}^{n} a_{ij} + v_j)x_j] = (\Sigma_{i=1}^{n} a_{ij} + v_j)\Delta x_j - \tau_j x_j^o \tag{9}$$

From the equations 8 and 9 we have the TFP for the sector j between the years 2000 and 2014.

2.4. Relating comparative advantages, productive integration and TFP

To analyze the measures of productive integration, comparative advantage and TFP together and between the years 2000 and 2014, a multidimensional Cartesian plan would be necessary, making it difficult to interpret the results. To face this problem, it is possible to synthesize the results and present them efficiently, resizing the variables to only two dimensions, according to the multidimensional scaling method.

The multidimensional scaling method, proposed by Young (2013), is a grouping technique to graph the data matrix $A_{n\times n}$ in a space smaller than the original space $q \leq A_{n\times n}$, considering the similarity between the variables. For the matrix of variables $A_{n\times n}$ exist $M = (N-1)/2$ similarities or distance between the pairs of variables (R. A. Johnson & Wichern, 2002). However, it is necessary to assume that it is possible to organize distances in descending order, one can find a dimension q to matrix $A_{n\times n}$ such that as long as the ordering is valid the magnitude of the distances will not be important.

Applying the spectral decomposition and considering the non-zero eigenvalues it is possible to define the new dimension of the matrix of variables $Y_{n\times q}$ by

$$Y = V\Lambda^{1/2} \tag{10}$$

that $\Lambda_{q\ timesq}$ is a diagonal matrix with the corresponding eigenvalues of $A_{n\times n}$, $V_{n\times q}$ is an orthogonal matrix with eigenvectors corresponding to the spectral decomposition of the original matrix $A_{n\times n}$ and $Y_{n\times q}$ is the new dimension of the data matrix, with Euclidean distances between variables being preserved (R. A. Johnson & Wichern, 2002; Mingoti, 2005).

In some cases, however, the distances between the pairs of variables can be small and for this we use the correspondence analysis (CA) for to relate comparative advantages,

productive integration and TFP between the years 2000 and 2014. For this we use the correspondence analysis (CA). The variables were reorganized in percentiles (ρ) and categorized as low ($\rho \leq 25\%$), medium-low ($25\% \leq 50\%$), medium-high ($50\% \leq 75\%$) and high ($\rho \geq 75\%$) before applied to CA.

Developed by Fisher (1940) and Benzécri (1969), the CA is aimed at identifying associations between categorical variables, offering a relation of similarities between the occurrences and allowing to reduce the original dimension of the data in categories. Be a matching matrix $P_{n\times n}$ e os totais marginais relativo as colunas e linhas, $c_{n\times 1}$ and $r_{n\times 1}$, respectively. CA can be expressed as a generalized least squares problem (GLS), whose purpose is to select an matrix $\hat{P} = \hat{p_{ij}}$ reduced rank that minimizes:

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\left(\frac{p_{ij}-\hat{p_{ij}}}{\sqrt{r_i c_j}}\right) = tr[(D_r^{-1/2}(P-\hat{P})D_c^{-1/2})(D_r^{-1/2}(P-\hat{P})D_c^{-1/2})] \tag{11}$$

where $(D_r^{-1/2}) = diag(\frac{1}{\sqrt{r}})$ and $(D_c^{-1/2}) = diag(\frac{1}{\sqrt{c}})$ are the marginal totals relative to the rows and columns, respectively (R. A. Johnson & Wichern, 2002). The result of the reduced rank matrix is expressed as:

$$P \cong \sum_{k=1}^{S}\widetilde{\lambda_k}(D_r^{-1/2}\widetilde{u_k})(D_c^{1/2}\widetilde{V_k})' = rc' + \sum_{k=2}^{S}\widetilde{\lambda_k}(D_r^{1/2}\widetilde{u_k})(D_c^{1/2}\widetilde{V_k})' \tag{12}$$

where $\widetilde{\lambda_k}$ are the singular eigenvalues. $\widetilde{u_k}$ and $\widetilde{V_k}$ are the singular vectors of $D_r^{-1/2}PD_c^{-1/2}$. The joint plot of the coordinates associated with the rows and columns is called a symmetric map (R. A. Johnson & Wichern, 2002). Another relevant aspect of CA is the total inertia, which measures the dispersion of values relative to the rows and columns of the matching matrix P, expressed by:

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\left(\frac{p_{ij}-\hat{p_{ij}}}{\sqrt{r_i c_j}}\right) = \sum_{i=1}^{I}\sum_{j=1}^{J}t_{ij}^2 = \sum_{k=1}^{min(I-1)(J-1)}\widetilde{\lambda_k^2} = \frac{\chi^1}{n} \tag{13}$$

where $\frac{\chi^2}{n}$ is the Pearson statistic for a chi-square distribution. Their significance indicates that the deviations associated with the rows and columns are significant (R. A. Johnson & Wichern, 2002).

3. Results and discussion

3.1. The Sectors of Agribusiness Global Value Chains

The results of the hypothetical extraction of the sector of Crop and animal production, hunting and related service activities (S1) for purchases and sales indicated that seventeen sectors belong to the AGVC. The sectors classified as belonging to AGVC are expressed in Table 1.

The results indicate that the AGVC are composed of a network of activities, upstream and downstream of the farm, focused on the production of goods and services

Table 1. AGVC Sectors and Sector Aggregation

S1	Crop and animal production, hunting and related service activities	
S2	Forestry and logging	
S3	Fishing and aquaculture	Sectors of Agriculture (SA)
S4	Mining and quarrying	
S5	Manufacture of food products, beverages and tobacco products	
S10	Manufacture of coke and refined petroleum products	
S11	Manufacture of chemicals and chemical products	Sectors of Industry (SI)
S12	Manufacture of basic pharmaceutical products and pharmaceutical preparations	
S23	Repair and installation of machinery and equipment	
S24	Electricity, gas, steam and air conditioning supply	
S29	Wholesale trade, except of motor vehicles and motorcycles	
S30	Retail trade, except of motor vehicles and motorcycles	
S31	Land transport and transport via pipelines	Sectors of Service (SS)
S32	Water transport	
S34	Warehousing and support activities for transportation	
S41	Financial service activities, except insurance and pension funding	
S49	Other professional, scientific and technical activities; veterinary activities	

Source: Authors' own elaboration based on WIOD

of agricultural origin (Anderson, Hoekman, & Strutt, 2001; Guilhoto et al., 2007; Humphrey, 2006). This structure helps build a strong, dynamic agribusiness, connected with all economy and with relevant performance in the process of economic development (Furtuoso & Guilhoto, 2003; Humphrey, 2006; Sexton, 2012).

The sectors of the AGVC, defined in the table 1, will be aggregated into three macro sectors and denominated Agricultural Sectors (SA), Industry Sectors (SI) and Service Sectors (SS). Starting the aggregation one can analyze the behavior of the comparative advantages (VARCA) and the productive integration (VAX ratios) in the AGVC between the years of 2000 and 2014.

3.2. Comparative Advantages and Productive Integration longitudinally

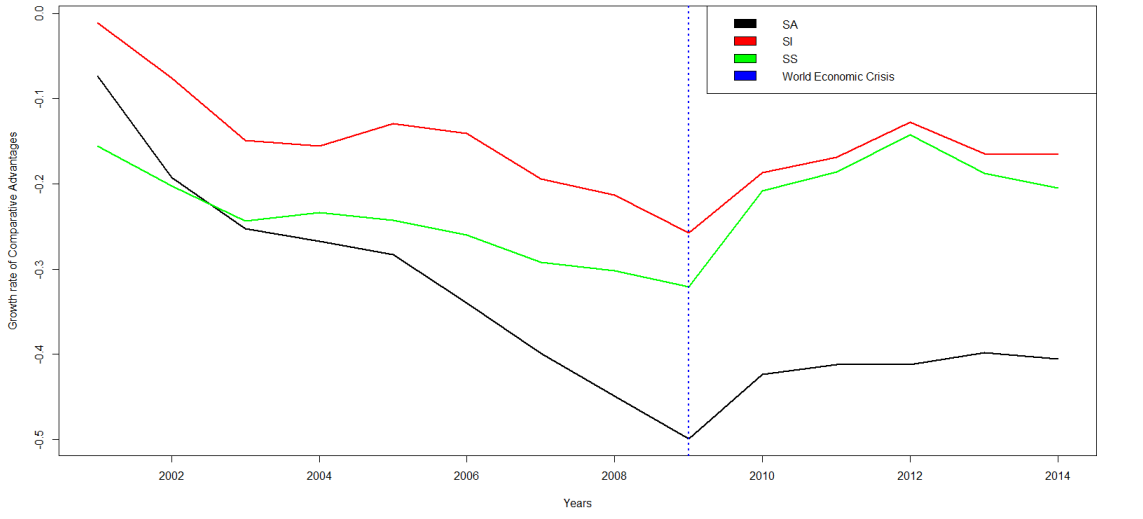
The figures 1a and 1b show the growth rate of the coefficient of comparative advantage revealed in terms of added value (VARCA) for the agricultural (SA), Industry (SI) and Services (SS) macro sectors.

As can be seen in Figure 1a, although with some level of volatility, the comparative advantages were reduced, in average, in all the sectors between the years of 2000 and 2009. On average, the industry sector (SI) was the macro sector with the highest level of comparative advantages and with a smaller longitudinal reduction in the level of comparative advantages. The SI was succeeded by the macro sectors of Services (SS) and Agriculture (SA). Starting of 2009, with the effects of the global crisis, there was a reversal of the trend of reducing the comparative advantages. However, despite this inflection in the trajectory, the level of comparative advantage ended the period in 2014 at a lower level than the initial level in 2000.

The reduction of the comparative advantages together with the rise of the AGVC indicate that the process of productive fragmentation generates sectoral specializations more subdivided by the world. That is, by dividing parts of the production process around the globe according to the comparative advantages of each locality the comparative advantages are distributed throughout the AGVC.

However, the reduction of the comparative advantages may have occurred by some specific countries or, the opposite, the reduction of the comparative advantages can be due to the new productive paradigm of the AGVC. To verify if the occurrence is, in fact, an overall trend associated with CGVA the Gini[3] coefficient was calculated for

[3]For more details on the Gini coefficient see Gini (1921)



(a) Growth rate of VARCA

(b) Gini Coefficient of VARCA

Figure 1. Growth rate of Comparative Advantages and Gini Coefficient

each macro sector between the years of 2000 and 2014.The main idea is that, if it is a trend associated with AGVC, the inequality coefficient will be reduced to the period and will end the period with a lower value than in the initial period. This typology will reveal whether comparative advantages have declined for all countries equitably or if there have been only a few outliers.

The figure 1b shows the growth rate of the Gini coefficient for the comparative advantages (VARCA) in the agricultural (SA), Industry (SI) and Services (SS) macro sectors. We can note that the growth rate Gini coefficient for the comparative advantages showed trajectory of fall for the three-macro sectors longitudinally. These results show that the reduction of comparative advantages are associated with all countries

and are a characteristic of AGVC.

The level of inequality between comparative advantages is high. The macro sector of agriculture was the sector with the lowest inequality of comparative advantages in 2000, with a Gini coefficient of 0.85. Even with the reduction in the level of inequalities in the macro sector of agricultural, in 2014 its Gini coefficient of 0.81, and the minimum reached in the period was 0.80 in 2012. The macro sector of service, which is a sector characteristic of global value chains, (R. Baldwin, 2011; Sturgeon, Gereffi, Guinn, & Zylberberg, 2013), had the greatest inequality in comparative advantages and the lowest rate of growth of the Gini coefficient.

In summary, the results for the comparative advantages reveal that the intensification of the productive fragmentation process meant a redistribution of the sectoral specializations (comparative advantages). This redistribution was relatively equitable and systematic across countries over the period. This revealing characteristic has no evidence in the economic literature.

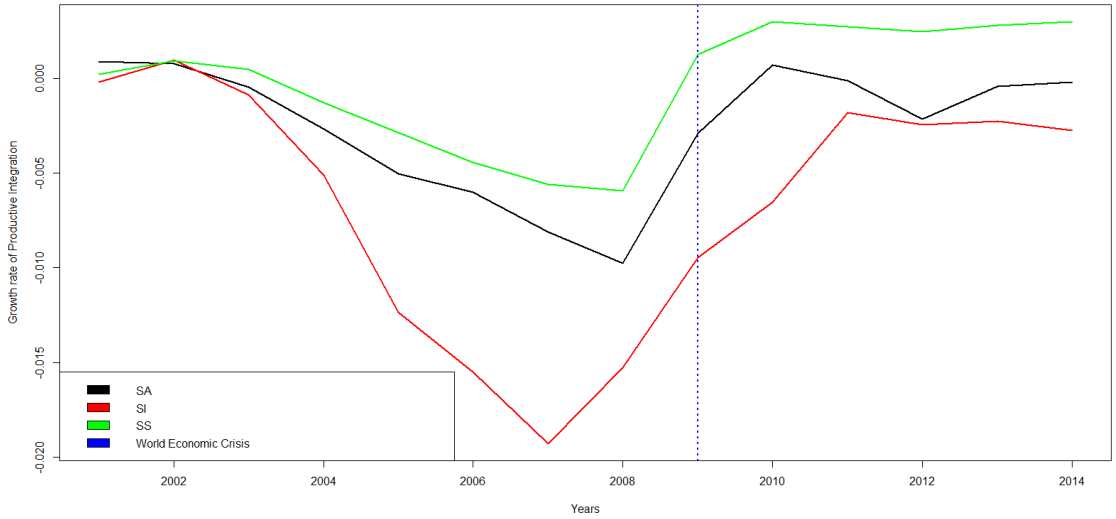
Figures 2a and 2b shows the growth rate of the participation of the value-added content of trade (VAX ratios) and the growth rate of the Gini coefficient between 2000 and 2014 for Agriculture (SA), Industry (SI) and Services (SS). In Figure 2a it is possible to observe a tendency to reduce the VAX ratios in all sectors up to the year 2007 (SA) or 2008 (SI and SS). This trend of reduction in the VAX ratios represents an increase of the productive integration between the years 2000 and 2007/2008. After this period, which coincides with the arrival of the global economic crisis, there was a reversal in the level of productive integration of the countries. The effect of this was that, in 2014, the services sector had a productive integration coefficient higher than that of 2000, which indicates productive disintegration to the period. Analogous behavior was observed in agricultural and industrial macro sectors, which presented a reduction of only 0.27% and 0.03% to the period.

TThe results on the level of productive integration are in agreement with the literature associated with the Global Value Chains. R. E. Baldwin (2012) found similar results for global supplement chains, by Timmer et al. (2014) for automotive value chains, by Costinot, Vogel, and Wang (2012a) for the wages level and by Meng et al. (2013) to China's global value chains, suggesting that there has been an increase in productive integration along the global value chains. Timmer et al. (2014) affirms that the global economic crisis has also influenced global value chains in terms of the automotive chain. However, such evidence is unprecedented for the AGVC and for this period.

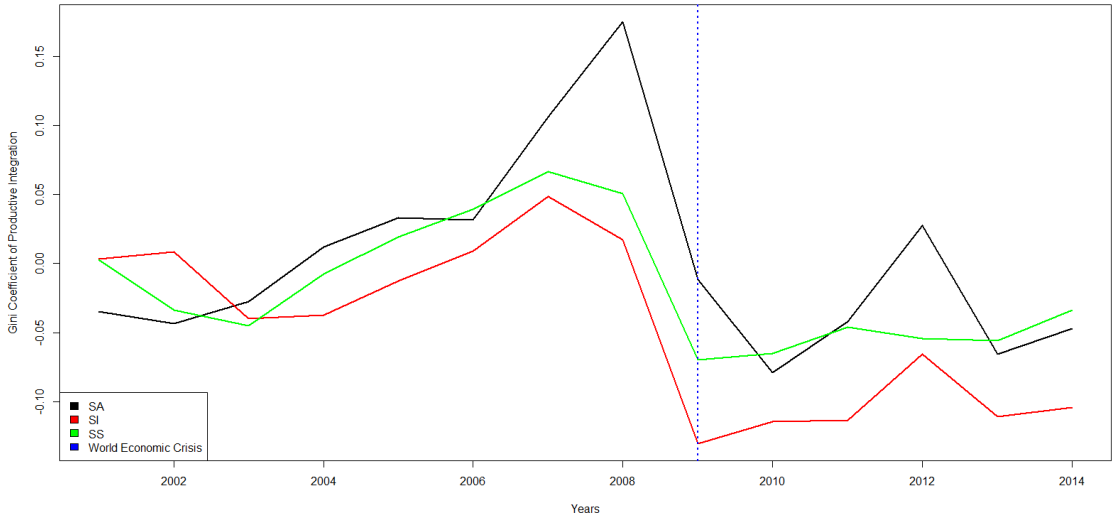
In general terms, what can be observed by Figure 2a is an increase in productive integration (reduction of the VAX ratios) between the years of 2000 and 2014 in all macro sectors. However, this trend is caused by greater integration of only a few countries or is it a global trend, followed by all these countries? In order to verify if the greatest trend towards productive integration is a trend adopted by all countries, the Gini coefficient for the sectors was calculated.

The figure 2b presents the growth rate for the Gini coefficient between the years 2000 and 2014 in the macro sector of Agriculture (SA), Industry (SI) and Services (SS). The results for the growth rate of the Gini coefficient did not present a clear tendency to the period. However, between 2000 and 2008 it is possible to verify an increase in the Gini coefficient for productive integration in all sectors. This result suggests that, although there was an increase in productive integration during the period, it was unevenly and was motivated by some countries.

On the other hand, during the global economic crisis (2007-2009) it was possible to observe a reduction of inequalities in terms of productive integration. A new peak



(a) Growth rate of VAX



(b) Gini Coefficient of VAX

Figure 2. Growth rate of Productive Integration and Gini Coefficient

of inequality growth in terms of productive integration occurred between the years 2011 and 2013, as well. It is important to note that, although productive integration occurs unevenly and has increased over the period, the level of inequality is low in absolute numbers. The macro sector with the greatest inequality differential in 2000 was that of industry, which had a Gini coefficient of 0.020 in 2000, peaked at 0.021 in 2007 and finished the historical series at 0.018. Even the macro sector of agricultural, with greater inequality to the period, presented 0.019 as the highest coefficient of Gini (2008) and lower coefficient of 0.015 (2010).

The growth of productive integration is in line with that observed in the economic literature on global value chains (R. Baldwin, 2012; Costinot, Vogel, & Wang, 2012b;

Meng et al., 2013; Timmer et al., 2014). Equity in productive integration is not clear, although there is evidence that all countries have a similar degree of productive integration. These results on equity are unprecedented in the literature and are important for the determination of trade policies associated with AGVC.

3.3. Measuring the relationship between Comparative Advantages and Productive Integration

In order to evaluate the relationship between the comparative advantages and the productive integration, the correspondence analysis was used. For correspondence analysis the indicators were divided into four percentiles, with 25% of observations in each. Each percentile was classified by intensity of comparative advantages and productive integration as low (1), medium-low (2), medium-high (3) and high (4).

The figures 3a to 3f presents the correspondence analysis between the comparative advantages and productive integration for the macro sectors of Agriculture (SA), Industry (SI) and Services (SS). Correspondence analysis was also subdivided into between (2014-2014) and within (2014-2000) analyzes.

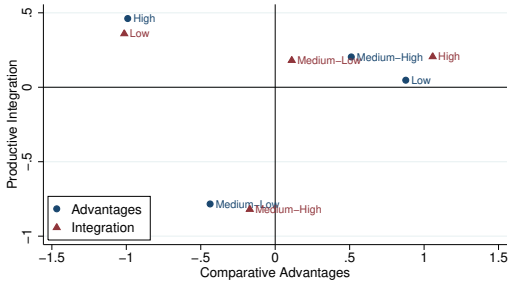
The Correspondence Analysis for the macro sector of Agriculture in 2014 (3a) reveals a dichotomy between productive integration and comparative advantages. Countries with low comparative advantages have high productive integration and, conversely, countries with high comparative advantages have low productive integration. The same dichotomy is found in the average levels of comparative advantage and productive integration. Thus, countries of medium-low comparative advantages present medium-high productive integration and, countries with medium-high comparative advantages present medium-low productive integration. The same pattern remains for the macro sectors of industries (3b) and services (3c).

Longitudinally (between) the pattern is also maintained for the three macrosetors, as expressed in the Figures 3d, 3e and 3f. These results indicate that countries with high comparative advantages in 2000 had low production integration in 2014. Conversely, countries with low comparative advantages in 2000 had high productive integration in 2014.

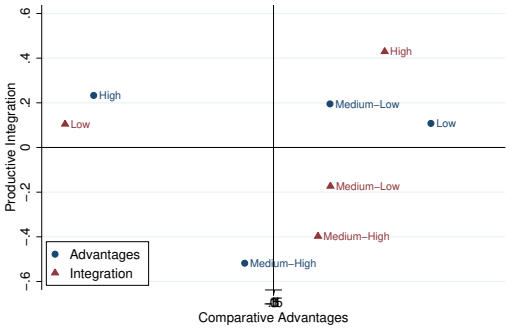
The economic intuition is that the dichotomy between comparative advantages and productive integration may reflect the trade-off faced by countries. On the one hand, countries can take advantage of high productive integration, such as trade agreements and reduction of transport costs (R. E. Baldwin, 2012; Hirth, 2014). While, on the other hand, it is also desirable that countries use their comparative advantages, such as the availability of natural resources, capacity for investment in R&D, and higher levels of productivity (Heckscher, 1919; Ricardo, 1891; Rybczynski, 1955; Samuelson, 1953; Stolper & Samuelson, 1941).

The longitudinal separation, by country, of productive integration and comparative advantage is relevant to the precise categorization of duality for each group of countries and allows for more precise conclusions. In this sense, Figures 4a to 4d shows the multidimensional scaling for SA, SI, SS and AS.

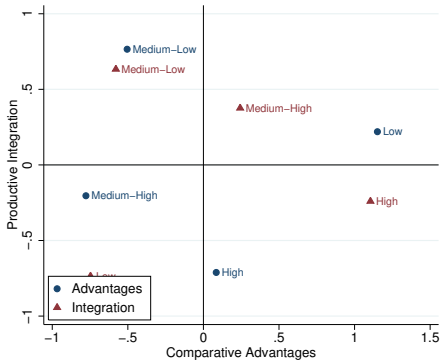
The lower the coefficient for the VAX ratios, the greater the productive integration and, conversely, the higher the VARCA coefficient, the greater the comparative advantage. Thus, in the fourth quadrant of the Figures 4a to 4d we have the countries with the highest degree of productive integration and the greatest comparative advantage to AGVC between the years 2000 and 2014. In the second quadrant is the worst case, in which there is low productive integration and low comparative advantage between



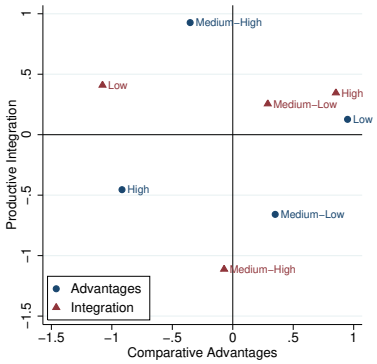
(a) Comparative Advantages × Productive Integration in SA in 2014



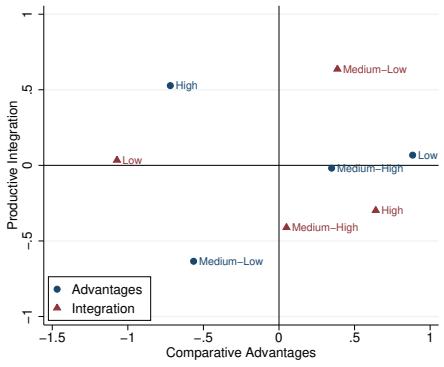
(b) Comparative Advantages × Productive Integration in SI in 2014



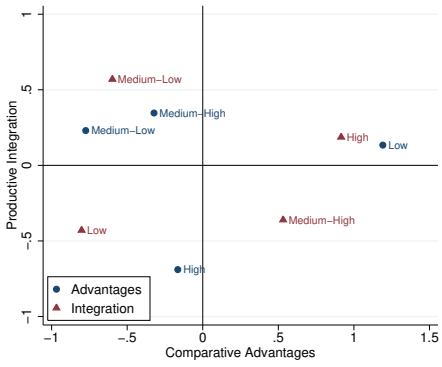
(c) Comparative Advantages × Productive Integration in SS in 2014



(d) Comparative Advantages × Productive Integration in SA between 2000 and 2014



(e) Comparative Advantages × Productive Integration in SI between 2000 and 2014

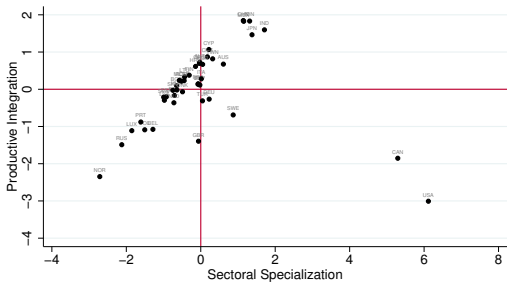


(f) Comparative Advantages × Productive Integration in SS between 2000 and 2014

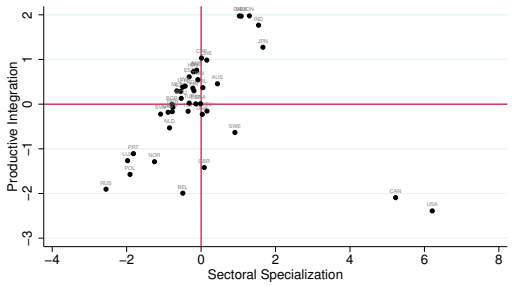
Figure 3. Comparative Advantages and Productive Integration in the macro sectors of Agriculture (SA), Industry (SI) and Services (SS) in 2000 and 2014.

the years 2000 and 2014.In the third and fourth quadrant are the intermediate scenarios, with countries with high productive integration and low comparative advantage between the years 2000 and 2014 and the opposite, with low productive integration and high comparative advantage between the years 2000 and 2014, respectively.

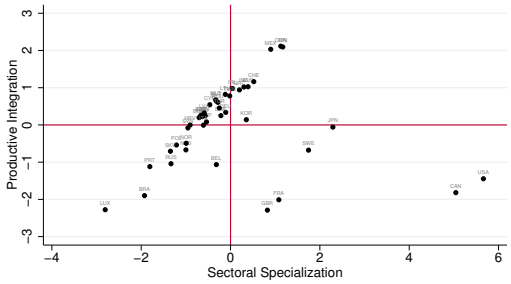
In the SA (4a) we note that the countries with high comparative advantage and high productive integration with the AGVC were the United States, Canada, Sweden, Ger-



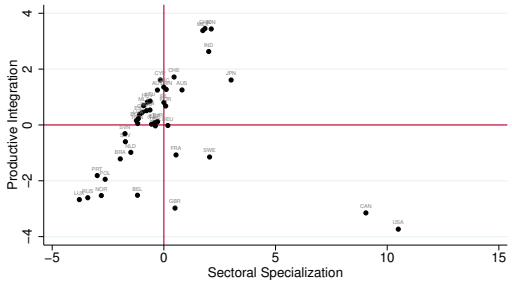
(a) Productive integration × Comparative Advantages in SA



(b) Productive integration × Comparative Advantages in SI



(c) Productive integration × Comparative Advantages in SS



(d) Productive integration × Comparative Advantages in AS

Figure 4. Multidimensional scaling for the macro sectors of Agriculture (SA), Industry (SI), Services (SS) and Sectoral Average (AS)

many and Turkey. The countries with low comparative advantage and high productive integration, in the third quadrant, were the United Kingdom, Latvia, Denmark, the Netherlands, Portugal, Belgium, Luxembourg, Portugal, Poland, Russia and Norway. The countries with high comparative advantage and low productive integration, in the first quadrant, were China, Hungary, Mexico, Indonesia, Japan, Australia, Taiwan, Cyprus, Switzerland and Austria. The results for SA can be explained by the economic literature. According to FAO (2012), Germany, Australia, Canada, China, United States, Indonesia, Japan, Mexico, Russia and Turkey are among the largest agricultural producers and exporters in the world, with an emphasis on the production and trade of milk, chicken, beef, pork and rice.

In the SI (4b) the countries that showed high productive integration and comparative advantage were the United States, Canada, Sweden, Germany, Denmark and the United Kingdom. The countries with high productive integration and low comparative advantage were Slovakia, Slovenia, the Netherlands, Norway, Portugal, Luxembourg, Poland and Russia. The countries with high comparative advantage and low productive integration were China, Hungary, Mexico, Japan, Australia, Switzerland, Australia, Ireland and Cyprus. Again, the results for the SI can be explained by the fact that countries are the largest food processors (Germany, Australia, Canada, China, United States, Japan, and Russia) and the largest producers of oil and coke (Canada,

China, United States, Mexico, Norway and Russia), which are products included in the SI (FAO, 2012).

In the SS (4c) the countries with the greatest comparative advantage and high productive integration were the United States, Canada, Japan, Sweden, France and the United Kingdom. The countries with high productive integration and low comparative advantage were Norway, Poland, the Netherlands, Slovakia, Russia, Portugal, Belgium, Brazil and Luxembourg, and the countries with high comparative advantage and low productive integration were South Korea, Switzerland, Greece, Taiwan, Ireland, Indonesia, Mexico, China and Hungary.

For the sector average (4d) we observed that the countries with the greatest productive integration comparative advantage between the years 2000 and 2014, in the fourth quadrant, were the United States, Canada, Sweden, France, the United Kingdom and Germany. The countries with high productive integration and comparative advantage to AGVC, in the third quadrant, were Belgium, Holland, Slovakia, Slovenia, Brazil, Portugal, Poland, Norway, Russia and Luxembourg. With high comparative advantage and low productive integration, in the first quadrant, were Mexico, China, Indonesia, Japan, Switzerland, Australia, Hungary and South Korea. The other countries showed low productive integration and low comparative advantage, without great variability between indicators, clustering in the second quadrant.

These results, disaggregated for a set of countries and covering the entire longitudinal extent, reinforce the existence of contradiction between productive integration and comparative advantages. But why does this duality exist? Why do countries choose by productive integration or comparative advantages? In order to answer these questions, the figures 4a to 4f present the correspondence analysis between productive integration and comparative advantages with respect to productivity (TFP).

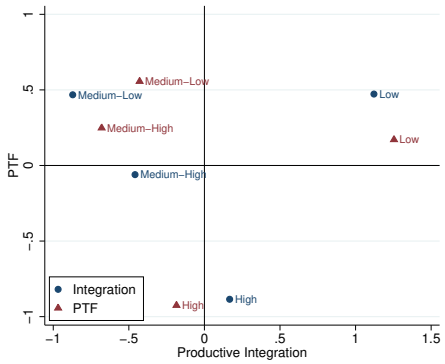
In the figures 5a to 5c analyzes of the correspondence between productive integration and TFP are presented for the SA, SI and SS. The results showed a positive relation between the variables. This means that countries with high productivity have high productive integration to the AGVC, while countries with low productivity have low productive integration to the AGVC. These results are valid for the three sectors (SA, SI and SS).

On the other hand, in the figures 6a to 6c the correspondence analysis between local advantages and TFP are expressed for the SA, SI and SS. The results show a direct relationship between the variables. The economic intuition of this result is that countries with high local advantages to AGVC have low productivity, while countries with few comparative advantages to AGVC have high productivity.

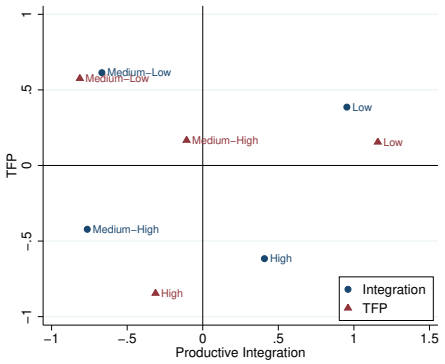
This means that the duality between comparative advantages and productive integration is driven by low productivity. Countries with low productivity choose to participate in the AGVC by taking advantage of their comparative advantages, while high-productivity countries choose to be more integrated into AGVC.

However, as shown throughout this paper, the comparative advantages are diminishing with the intensification of AGVC, which can bring distributive issues to the discussion. How will low-income countries, which also have low productivity, participate in the game of international trade? Are they going to seek productivity increases through more productive integration? Or will they increase tariff barriers and try to protect their comparative advantages?

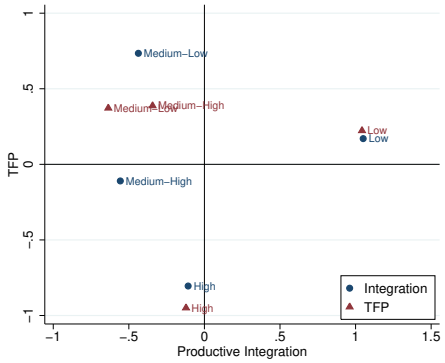
These results partly explain the tension in international trade in the post-crisis of 2008. While high-productivity countries with higher per capita incomes have gained a foothold in international trade through AGVC, the countries with low productivity and low per capita income have ceased to gain from their comparative advantages.



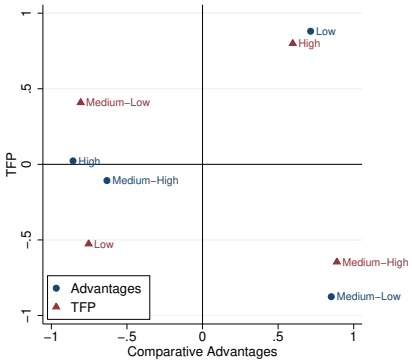
(a) Productive Integration × TFP in SA in 2014



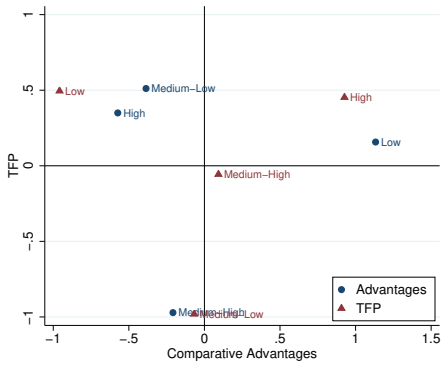
(b) Productive Integration × TFP in SI in 2014



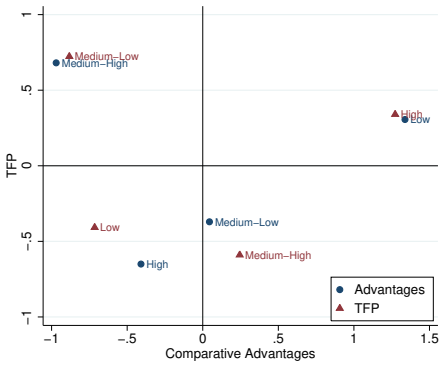
(c) Productive Integration × TFP in SS in 2014



(d) Comparative Advantages × TFP in SA between 2000 and 2014



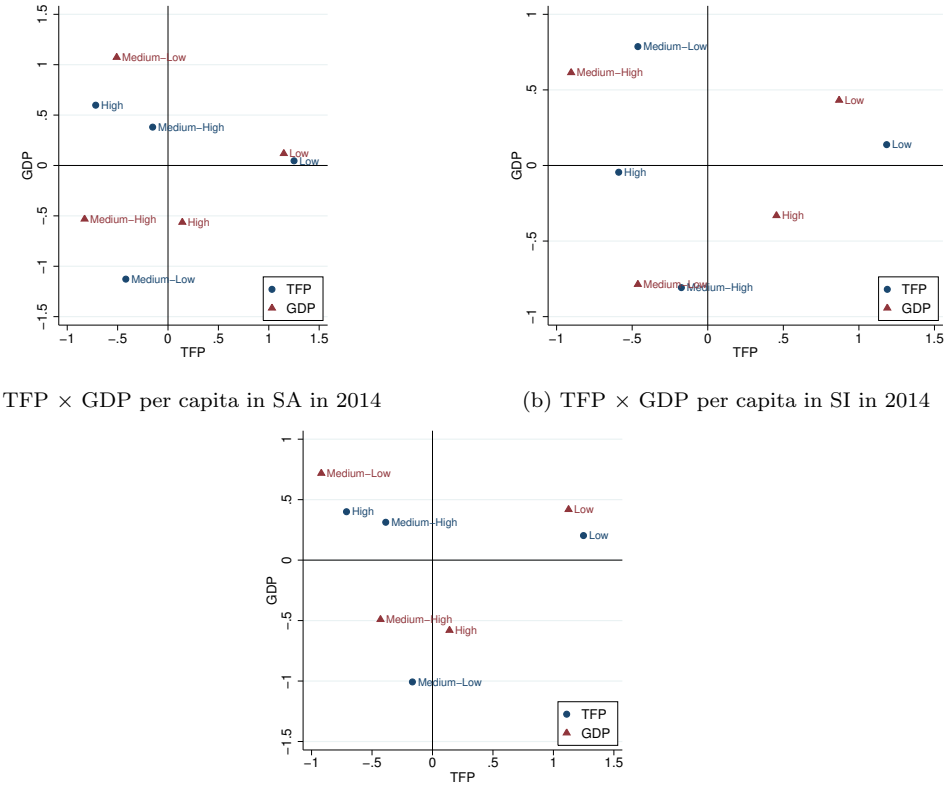
(e) Comparative Advantages × TFP in SI between 2000 and 2014



(f) Comparative Advantages × TFP in SS between 2000 and 2014

Figure 5. Productive Integration, Comparative Advantages and TFP in the macro sectors of Agriculture (SA), Industry (SI) and Services (SS) in 2014

Judging from recent events, with the surge in protectionism and increased right-wing movements, such as the USA-China trade war and Brexit, the second option seems more realistic. The question is how the global economy and the AGVC will organize themselves in this global winners and losers dispute.



(a) TFP × GDP per capita in SA in 2014

(b) TFP × GDP per capita in SI in 2014

(c) TFP × GDP per capita in SS in 2014

Figure 6. TFP × GDP per capita in the macro sectors of Agriculture (SA), Industry (SI) and Services (SS) in 2014.

4. Conclusion

The new productive paradigm of global value chains changed the world. Each country's opportunities to specialize in accordance with its comparative advantages and to maximize its trade gains have been amplified. However, this new form of production organization brings with it a trade-off between between taking advantage of comparative advantages or productive integration.

In this context, the objective of this article was to verify the relation between productive integration and comparative advantages in the sectors of the Agribusiness Global Value Chains. It is also important to answer how such variables behaved longitudinally.

The results for productive integration revealed a longitudinal reduction in domestic content in trade and low levels of inequality. This confirms the hypothesis of greater productive integration between countries, as also suggests recent literature. However, the results also indicate that greater productive integration was brought about by a small number of countries until the global crisis of 2008. Since the crisis of 2008 there has been greater equity in productive integration between countries and in all macro-sectors.

In terms of comparative advantages, the results point to a longitudinal reduction in the level of comparative advantages. The reduction in the level of comparative advantages, as opposed to productive integration, was an equitable movement among

countries.

The results presented a duality between productive integration and comparative advantages, either between or within. This result reveals that the higher the level of comparative advantage, the lower the level of productive integration and *vice-versa*. The economic intuition is that countries with greater comparative advantages are less integrated, while more productively integrated countries are less specialized.

What this duality between comparative advantages and productive integration represents is the total factor productivity (TFP) and, ultimately, the per capita income of the countries. That is, countries with low productivity (low income) participate in AGVC through their comparative advantages, while high productivity countries (high income) participate in AGVC through productive integration.

However, the longitudinal fall in comparative advantage brings to the discussion the distributive issues of international trade. How will countries with low productivity and low per capita income, which are losing their comparative advantages, behave in the face of international trade and AGCV?

Recent events, such as the US-China trade war and Brexit, suggest a process of self-defense of the comparative advantages vis-a-vis the AGVC. It is now up to international trade theory to find a way to accommodate the relationship between winners and losers in the context of global value chains with the aim of avoiding the rise of protectionism on a global scale.

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5. Appendix

Table 2.: Sectors of Input-Output Matrix

Number	Sectors
1	Crop and animal production, hunting and related service activities
2	Forestry and logging
3	Fishing and aquaculture
4	Mining and quarrying
5	Manufacture of food products, beverages and tobacco products
6	Manufacture of textiles, wearing apparel and leather products
7	Manufacture of wood and of products of wood and cork;
8	Manufacture of paper and paper products
9	Printing and reproduction of recorded media
10	Manufacture of coke and refined petroleum products
11	Manufacture of chemicals and chemical products
12	Manufacture of basic pharmaceutical products and pharmaceutical preparations
13	Manufacture of rubber and plastic products
14	Manufacture of other non-metallic mineral products
15	Manufacture of basic metals
16	Manufacture of fabricated metal products, except machinery and equipment
17	Manufacture of computer, electronic and optical products
18	Manufacture of electrical equipment
19	Manufacture of machinery and equipment n.e.c.
20	Manufacture of motor vehicles, trailers and semi-trailers
21	Manufacture of other transport equipment
22	Manufacture of furniture; other manufacturing
23	Repair and installation of machinery and equipment
24	Electricity, gas, steam and air conditioning supply
25	Water collection, treatment and supply
26	Sewerage; waste collection, treatment and disposal activities; materials recovery;
27	Construction
28	Wholesale and retail trade and repair of motor vehicles and motorcycles
29	Wholesale trade, except of motor vehicles and motorcycles
30	Retail trade, except of motor vehicles and motorcycles
31	Land transport and transport via pipelines
32	Water transport
33	Air transport
34	Warehousing and support activities for transportation
35	Postal and courier activities
36	Accommodation and food service activities
37	Publishing activities
38	Motion picture, video and television programme production
39	Telecommunications
40	Computer programming, consultancy and related activities

Continued on next page

Table 2 – continued from previous page

Number	Sectors
41	Financial service activities, except insurance and pension funding
42	Insurance, reinsurance and pension funding, except compulsory social security
43	Activities auxiliary to financial services and insurance activities
44	Real estate activities
45	Legal and accounting activities; activities of head offices
46	Architectural and engineering activities; technical testing and analysis
47	Scientific research and development
48	Advertising and market research
49	Other professional, scientific and technical activities; veterinary activities
50	Administrative and support service activities
51	Public administration and defence; compulsory social security
52	Education
53	Human health and social work activities
54	Other service activities
55	Activities of households as employers;
56	Activities of extraterritorial organizations and bodies