Agris on-line Papers in Economics and Informatics

Volume XVII Number 4, 2025

Comparative Advantages and Specialization Dynamics in Agri-food Trade of Argentina, Paraguay and Uruguay

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Abstract

The article interrogates the shape, dynamic, and fragility of revealed comparative advantages of 46 agri-food products traded by Argentina, Paraguay, and Uruguay in the period 1995-2020 using normalized revealed comparative index and summary statistics, stochastic kernels, Galtonian regression, Markov chains, and Kaplan-Meier survival analysis. The analysis reveals the agri-food flagship products and the agri-food trade of these countries has formed mainly around these flagship products. The results support the argument that changes in distribution of comparative advantages in agri-food trade underwent an increase in specialization in these countries, especially in the period from the beginning of millennia until about period slightly after the Great Recession. The results also indicate slight convergence in the change in agri-food comparative advantages in these three countries, as well as the increased complexity of agri-food comparative advantages in Argentina and Paraguay at the end of the period under scrutiny. Despite these variations and differences among countries under scrutiny the distribution of comparative advantages remains stable and persistent. Given this evidence, we conclude that these countries will continue to develop their agriculture-led growth economic model and these flagship products will play an important role in the overall agri-food export structures of these countries in the future.

Keywords

Liberalization, Markov chain model, regression analysis, revealed comparative advantage, RCA, agri-food trade.

Zdráhal, I., Hrabálek, M., Kadlec, P. and Krpec, O. (2025) "Comparative Advantages and Specialization Dynamics in Agri-food Trade of Argentina, Paraguay and Uruguay", *AGRIS on-line Papers in Economics and Informatics*, Vol. 17, No. 4, pp. 137-155. ISSN 1804-1930. DOI 10.7160/aol.2025.170410.

Introduction

Trade liberalization has been recognized as a vital engine of economic growth, with substantial contributions to rising living standards worldwide (Wacziarg and Welch, 2008; Gnangnon, 2018). Yet, despite these strides, numerous barriers still hinder the full realization of trade's potential benefits, both locally and globally, due to persisting trade distortions and policy constraints (WTO, 2024). The international performance of agri-food trade has significant implications for the entire external economic balance of member countries of Mercado Común del Sur (The Southern Common Market), also known as MERCOSUR, as could be seen, for example, in UNCTAD data (UNCTAD, 2023). On average, the importance of agri-food trade (SITC 0+1+22+4) in the structure of total exports is 31.0%, 51.7%, 56.6% and 55.5% in the case of Brazil, Argentina, Uruguay, and Paraguay between 1995 and 2020. Contrary to the developed countries, the share of agri-food exports in total exports increased in these countries in the past decades. MERCOSUR represents 9.5% of global agri-food exports in 2022 (UNCTAD, 2024) and is a serious competitor to the global market dominance of the world's leading agri-food exporters, the EU and the United States (Hopewell, 2016). This also puts the MERCOSUR countries in an important position with regard to the provision of food security at the global level.

In this article, we would like to examine comparative advantages and specialization dynamics in the agri-food trade of three out of four

MERCOSUR countries – Argentina, Paraguay and Uruguay. The reason behind it is that those countries, and Latin America in general, have enormous potential to increase their competitiveness in agri-food production and trade and become a global leader, as pointed for example by Borges Aguiar and Balogh (2022).

We are aware of the fact that Brazil is by far the most important agricultural producer out of the MERCOSUR countries, but given that its position in international agri-food trade was addressed several times (see Hubbart et al., 2017; Jank et al., 2019; Zdráhal et al., 2021), we focus on the other three members of MERCOSUR. The idea is that these countries have not been adequately covered so far by academic literature, although the agri-food sector is a crucial part of their economies, even more so when we speak about exports. The analysis covers a long period of years 1995-2020. This approach gives the authors the possibility to cover different stages in the period before COVID-19 and to concentrate on the trade dynamics in a larger period than in other studies.

Against this background, the aim of the article is to evaluate evolution of the overall degree of specialization (the external shape of the distribution) and the degree and the pattern of intra-distributional mobility (changes in the intra-distributional dynamics) within the agri-food trade of smaller MERCOSUR countries as Argentina, Uruguay, and Paraguay in the last almost three decades before COVID-19.

Literature review

Dynamic of trade patterns and comparative advantages

The pattern of trade refers to the nature of trade between countries and how this changes over time. The evolution of trade patterns often reflects deep structural changes in the whole economies of countries, and such patterns usually emerge over long periods, and comparative advantages may not change in the short run (Bojnec and Ferto, 2018). The theory of comparative advantage indicates that specialization according to comparative advantage is a prerequisite for reaping gains from trade (Kowalski, 2011). Generally, trade theories give different predictions regarding the specialization dynamics of a country. According to the Heckscher-Ohlin model, the specialization pattern is formed based on the relative endowment of the countries (and its change) in the production factors. A certain limiting feature of this framework is that assumptions of the model do not have to be met by the economic realities. Other streams of theoretical literature emphasize the endogeneity of technological change (Grossman and Helpman, 1991; Krugman, 1987; Lucas, 1988; Redding, 1999) or economic geography that underlines the importance of agglomeration economies (Krugman, 1991; Fujita et al., 1999). Removing tariffs, product standards and simplifying government formalities reduces the transaction costs of trade, which should lead to an increase in the degree of specialization (Aiginger, 2001). Higher specialization can lead to higher productivity and competitiveness (and vice versa). Each of these streams of theoretical research identifies some forces that lead to persistence in trade patterns and others that stimulate mobility.

However, since comparative advantage is dynamic and develops endogenously over the years, changes in trade patterns often reveal structural changes that occurred in certain countries and regions. Liberalization and integration are channels for improving productivity, scale, and export expansion and a way to improve comparative advantage. The specialization pattern of a country also develops around the comparative advantage of each product. Because of the influence of factor endowment as well as endogenous and exogenous factors on the formation of specialization shape of trade, the shape of specialization is the matter of empirical testing (its evolution over time and the intra-distributional dynamics).

Agri-food trade dynamics of Argentina, Uruguay and Paraguay

Even though the most important economy of the MERCOSUR group is Brazil, the smaller countries – Argentina, Uruguay, and Paraguay – have also a significant influence on the direction of MERCOSUR. Agri-food production and trade are important for these smaller MERCOSUR economies due to their economic development context. It is also important to mention that these countries are important regarding providing food security on the global level.

From the beginning of the new millennium, the intensive growth of agri-food trade followed the implementation of the commitments of the Uruguay Round Agreement on Agriculture. It led to a mandatory 36% cut in average bound tariffs at the end of 2000 for developed countries and 2004 for developing ones (Bureau et al., 2017). Together with the decrease in unilaterally applied tariff levels and preferential applied tariff levels, it improved market access of these countries and increased integration into the global.

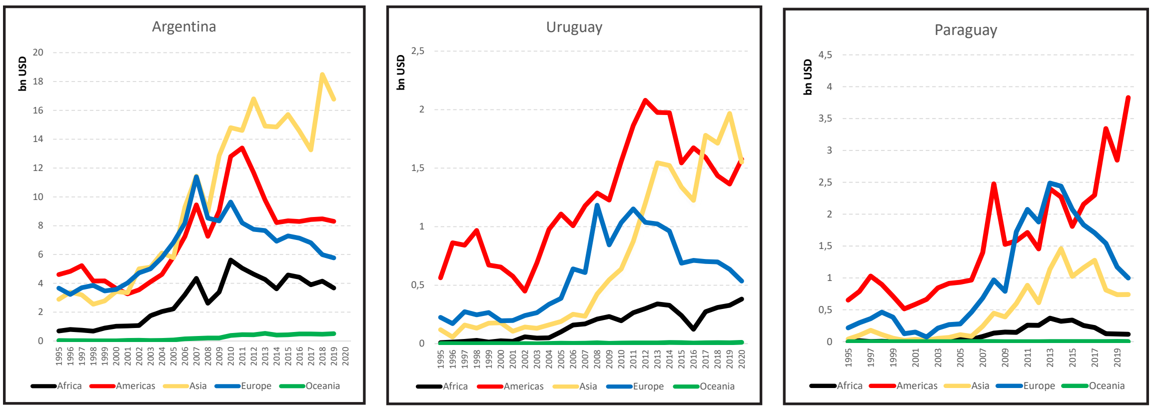
There were also economic and political structural changes in these countries that could affect the comparative advantages and specialization dynamics in the agri-food sectors in Argentina, Uruguay, and Paraguay in the last decades. The whole Latin American region has witnessed rapid increase in agro- and pastoral areas in the last two decades. More specifically, as regards the growth of fields and pastures, the region grew faster than any other region in the world, with the Southern Cone being particularly dynamic in that respect. Most of this growth was an answer to the increasing foreign demand for agri-food products (Norberg, 2020). Agricultural production rose to the forefront of national economic growth, and the agroexport model became rather typical in these countries. The changes in the total agri-food trade of Argentina, Uruguay and Paraguay are presented in the following figure (Figure 1).

The dimension of Argentina's agri-food trade is significantly higher compared to Uruguay and Paraguay. The balance of agri-food trade with its turnover shows, in general, that all three countries are net exporters of agri-food products. Especially Argentina shows a high balance of agri-foods with a high turnover ratio. All three countries have experienced rapid growth in agri-food trade since the start of the new millennium up to about 2014. Liberalization led to a significant increase in the balance-to-turnover ratio, especially in the case of Paraguay. Since 2014, growth trends have changed to slight drop and stagnation.

Comparing the change in agri-food exports of countries under review with the FAO Food price index (see Figure A1 in Appendix), it is evident that the change in agri-food exports was also influenced by the dynamics of prices on the world market.

During the period under scrutiny the territorial shape of agri-food trade has changed (see Figure A2 in the Appendix). The share of traditional export markets of the European Union and to some extent also of the United States has decreased. On the other hand, the rise of Asian (mainly Chinese) demand for many of the typical agri-food products in the production structure of Argentina, Uruguay, and Paraguay caused the change in the territorial shape of agri-food trade and served as an additional impulse forming agri-food trade of these countries. Despite the slowdown in total agri-food exports in the second half of the period under scrutiny, exports to Asia are still growing in Argentina and Uruguay. The change in territorial shape is caused also by intraregional agri-food trade. However, our data indicate a mixed intensity with respect to which each country trades agri-food products regionally. Such a dynamic suggests that there is a common group of factors that form the agri-food trade of Argentina, Uruguay, and Paraguay, and there are probably factors specifically affecting the agri-food trade of each country.

Despite the fact that most of the agri-food production is exported, the MERCOSUR countries face severe constraints as regards their integration into the world agri-food trade, as they were so far not able to successfully conclude negotiations on free trade with their largest external partners,



Note: 1) Trade balance index (TBI) compares the balance of trade (X-M) to its turnover (X+M); the value close to 1 would mean that the country only exports (is a purely net exporter). 2) Note the different scale of the y-axis when comparing Argentina to Uruguay and Paraguay.
Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Figure 1: Change in total agri-food trade of Argentina, Uruguay, and Paraguay; 1995-2020.

namely United States, European Union, and China. This causes certain frustrations between the MERCOSUR countries and could undermine the unity of the countries, as Uruguay was considering bilateral trade cooperation with China in the past (Urdinez et al., 2016), something that is clearly against the rules of the integrational project. However, China presents the largest export market for agricultural products from MERCOSUR countries: Two-thirds of Argentina and more than half of Uruguayan bovine meat exports end up there (Nolte, 2021).

In the case of the negotiations with the European Union, the progress is very slow. After almost 25 years, the countries have not sealed a final deal, mostly due to the resistance from the European side in the agricultural chapter, mostly about the beef quotas. This resistance is based both on the agricultural interests of particular European countries (Luciano and Borges, 2022), given by the high level of competitiveness of MERCOSUR countries and concerns about environmental impacts of the agreement (Monnerat, 2023).

Material and methods

Revealed comparative advantage

To assess the shape of trade specialization and its stability, it is critical to define the distribution of the country's comparative advantage (CA) in the products trade. The traditional approach is based on the concept of 'revealed' comparative advantage (RCA). Balassa (1965; 1977) developed the empirical method and it is widely used to identify a nation's most robust and weakest export sectors. The theoretical foundation and empirical distribution characteristics of the Balassa index have long been debated and criticized in the literature (Bowen, 1983; Vollrath, 1991; Hinloopen and Van Marrewijk, 2001; Sanidas and Sin, 2010; De Benedictis and Tamberi, 2004; Gnidchenko and Salnikov, 2015). Due to the shortcomings of the Balassa index, other indices have been proposed (i.e., Bowen, 1983; Vollrath, 1991; Lafay, 1992; Dalum et al., 1998; Proudman and Redding, 2000; Hoen and Oosterhaven, 2006; Yu et al., 2009; Leromain and Orefice, 2014; Gnidchenko and Salnikov, 2015; Stellian and Danna-Buitrago, 2022).

The normalized revealed comparative advantage index (NI) was proposed by Yu et al. (2008) as another alternative measure of RCA. Due to the fact that it is comparable across products, countries, and time, the index should more precisely and consistently reveal the extent of CA that a country has in a certain product, making it robust quantitative tool.

$$\mathbf{NI} = \frac{x_{ij}}{x_w} - \frac{x_j \times x_{wj}}{x_w \times x_w} \qquad (1)$$

where *x* indicates exports, *i* represents a nation, *j* signifies a product and *w* represents a set of countries (world). The *NI* index ranges from -0.25 to 0.25 and the comparative neutral point is zero. The sum (and the mean value) of the *NI* scores is constant and equals zero, and a sum of positive scores equals the sum of negative scores. If *NI* is higher (lower) than 0, the country reveals comparative advantage (disadvantage) in product *j*. The higher the value, the stronger the CA and vice versa.

Statistical data were obtained from databases of the UNCTAD for the period between 1995 and 2020. The commodity structure of individual sectors (product groups) in the agri-food trade is defined according to the SITC (revision 3). The analysis is carried out at the level of a 3-digit code for 46 various agri-food products traded (SITC 0 + 1 + 22 + 4). The values of NI have been calculated for each agri-food product group (Table A1 in the Appendix) traded between analysed countries (Argentina, Uruguay, and Paraguay) and the World market for the period 1995-2020.

Scores of NI scores were examined on how weak or strong the comparative advantage of each product is. There is no general guidance in the literature for classifying NI values into classes. Following current empirical studies (eg, Kostoska and Hristoski, 2018), the data were grouped based on quartiles (relative thresholds) from positive values of RCA scores calculated for all MERCOSUR countries. Positive NI values are grouped as: revealed comparative disadvantage (CdisA) if $NI \leq 0$, weak comparative advantage (CA) if $NI > 0$ and $NI \leq 2.877$ (first and second quartile), medium CA if $NI > 2.877$ and $NI \leq 16.352$ (third quartile), and strong CA if $NI > 16.352$ (fourth quartile).

First, a static view of the comparative advantage of individual products is applied using mean values (1995-2020) of NI to assess and identify agri-food products revealing CA or CdisA and so the potential capacity to cope with competitive pressures (and to identify agri-food flagship products). Following recent empirical studies in agri-food trade (Hinloopen and Van Marrewijk, 2001; Ferto and Hubbard, 2003; Ban, 2017; Smutka et al., 2018; Kostoska and Hristoski, 2018; Hoang, 2019; Vondráček et al., 2022), a battery of empirical approaches is employed to analyse structural stability of the comparative advantage of agri-food of Argentina, Uruguay, and Paraguay. According to Hinloopen and Van Marrewijk (2001), one can distinguish at least two types of stability; first, the stability of the distribution of the indices from one period to the next (Stability I); second, the stability of the value of the indices for particular product groups from one period to the next (Stability II). The stability of the distribution of 4 product groups (CdisA, weak, medium, and strong CA) was evaluated, according to the strength of Cdis/CA. In addition, an alternative approach is the duration analysis based on the survival function methodology.

Stability I

Based on procedures suggested by Hinloopen and van Marrewijk (2001), summary statistics was employed to investigate the external shape of the distribution of RCA indices.

Next, following Ban (2017) the intra-distributional dynamic was analysed applying stochastic kernels. It is a non-parametric approach useful to estimate the density function. Because the empirical distributions are highly leptokurtic, in order to minimize the impact of extreme values, the NI scores were transformed:

$$\mathbf{TNI} = \frac{\mathbf{NI}}{\mathbf{abs(NI)+1}} \quad (2)$$

An accurate estimation depends on the bandwidth (h) correctly determined. The rule suggested by Silverman (1986) was applied:

$$\mathbf{h = 0.9 \times A \times N^{-1/5}}, \text{ where}$$

$$\mathbf{A = min(\sigma, IQR/1.349)}, \quad (3)$$

N is the number of observations, and IQR represents the interquartile range and is calculated as the difference between the third and first quartile. Estimated probability densities are presented for two-year averages identified by summery statistics as time points when there could be potential change in dynamic in the distribution of CA.

Next, Galtonian regression (Galton, 1889) was calculated and applied as a quantitative technique. This methodology was successfully deployed in previous studies (e.g., Hart, 1995; Cantwell, 1989; Dalum et al., 1998; Laursen, 1998; Ban, 2016). The regression is used as an indicator of structural stability that indicates changes in trade specialization patterns. The Galtonian method is linear simple regression with respect to the two cross sections of two different time periods of RCA indices scores (Sanidas and Shin, 2010). The corresponding regression equation for a given country to test the changes in the trade specialization pattern is as follows.

$$\mathbf{RCA_{ij}^{t2} = \alpha_i + \beta_i \times RCA_{ij}^{t1} + e_{ij}} \quad (4)$$

where $t1$ indicates the initial point in time and $t2$ the last point in time, ai and βi, are standard regression coefficients and eij is an error term.

The fundamental concept of the Galtonian regression is basically to assess the similarity or dissimilarity between the distributions of revealed comparative advantages for two different points in time. This provides an indication of the stability, or convergence/divergence of the trade specialization patterns. To interpret the corresponding results, the overall changes can be expressed in terms of the regression effect, indicated by β, and the mobility effect, indicated by R, where:

- If $\beta > 1$, there is a divergence of trade specialization.
- If $R < \beta < 1$ divergence of trade specialization
- If $\beta < R < 1$ convergence of trade specialization
- If $\beta = R$ there was no convergence or divergence, the trade specialization pattern remained more or less stable then there are no changes in the hierarchy of the industries (the ones that are competitive remain competitive and the ones that are non-competitive remain non-competitive) or in the relative position versus the other industries (the products that have an advantage do not have an advantage).

Divergence means that the pattern of trade specialization has strengthened due to industries with an initial revealed comparative advantage that exhibit an increase in this score, while the score for those exhibiting an initial revealed comparative disadvantage decreased. Convergence means that the opposite dynamics is taking place. That means that the pattern of trade specialization can be considered to have weakened.

Another indicator of stability is the relative importance (in the export structure) of product groups that reveal CA in the period t, but reveal CdisA in the period $t + 1$ or vice versa (Kostoska and Hristoski, 2018). Because of the year-by-year fluctuation, the comparison is made between average value of indices at the beginning (avg. 1995-1996) and at the end (2019-2020) of the observed period.

Stability II

To assess structural changes in the overall structure, as well as at the sectoral level, stability is analysed in terms of the distribution of NI scores of specific products in 4 groups (CdisA, weak, medium, and strong CA) from period to period. Following Quah (1996), Proudman and Redding (2000), Brasili et al. (2000), Hinloopen and Van Marrewijk (2001) and Zaghini (2005), the changes in distribution of product groups among the particular classes were analysed using the Markov chain model. The evolution of the NI distribution over time may be modelled formally to measure the probability that a product group moves from one class to another. Thus, represent the NI by the measure x and its distribution across sectors at time t by $Ft(x)$. Similarly to Ft, it can be define a probability measure λt, where $\lambda t((\lambda(t - 1), x)) = Ft\ (x)$. The evolution of the distribution of RCA over time is then modelled in terms of a stochastic difference equation:

$$\lambda_t = P(\lambda(t - 1), u_t) \qquad (5)$$

where u_t is the error term and P is an operator that measures if an element, initially part of the $Ft - 1$ distribution, will end in Ft. If the operator P is time invariant and the disturbances are equal to zero, by iterating the relation above, we could obtain:

$$\lambda(t + s) = P \times \lambda(t + s - 1) = ... = \mathrm{P}^s \times \lambda_t \qquad (6)$$

Allocating the NI into the classes, the operator P becomes a transition matrix. An element of i_t, p_{ij}, represents the probability that a value that at the beginning of the period was in the state i, will be, after s years, in the state j. If the large values are situated on the main diagonal of the transition matrix, then the mobility inside the distribution is rather small and vice versa. The general degree of mobility can be assessed using the trace and the determinant of transition matrix, as follows:

$$M1 = (n - tr(P))/(n - 1), \text{ respectively}$$

$$M2 = 1 - |det(P)| \qquad (7)$$

where n is the number of classes used in the product mapping; $tr(P)$ is the trace of matrix P; $det(P)$ is the determinant of matrix P. $M1$ captures the importance of diagonal and off-diagonal terms. In the case of total persistence, the value of $M1$ would be zero. In the case of total mobility, $M1$ would be 1. The $M2$ gives a similar explanation. When the values on the main diagonal are close to 1 and those on the off-diagonal small (high persistence), the matrix determinant takes a value close to 1 and the mobility indicator is 0. The assessment of persistence, resp. mobility was done throughout the reporting period. Furthermore, the year-on-year $M1$ and $M2$ indices were calculated to assess their changes from 1995 to 2020. This allows one to assess whether the distribution of product groups among product mapping classes is already formed or is still undergoing changes.

Fragility / duration analysis

Following the latest empirical trade literature (Besedeš and Prusa, 2006; Bojnec and Fertö, 2016; Kostoska and Hristoski, 2018) we employ the duration analysis to interrogate the fragility defined as the length of duration of the revealed comparative advantage at product level. Duration is defined as the time (measured in years) that a product maintained CA without any interruption. The duration can be modelled as a sequence of conditional probabilities that the comparative advantage revealed by the product continues after t periods, as it has already survived for t periods. Specifically, let T be a random variable that denotes the length of a spell with uninterrupted $NI > 1$. In discrete time, the survival function $S(T)$ is defined as:

$$S(T) = Pr(T \geq t) \qquad (8)$$

Specifically, the duration of CAs of products consisting agri-food trade of Argentina, Uruguay, and Paraguay is estimated by the Kaplan-Meier product limit estimator. The Kaplan-Meier survival analysis (Kaplan and Meier, 1958) is non-parametric statistics used to estimate the probability of survival past given time points (describes and quantifies time-to-event data). The event is defined as failure ($NI > 0$ resp. $LFI > 0$ shifts to $NI \leq 0$ resp. $LFI \leq 0$). Survival time specifies the time-to-event duration. (Time for an event to occur). The longer $NI > 0$ (resp. $LFI > 0$) a product has, the longer its survival time and the higher the survival rate. We applied the Kaplan-Meier method to estimate the cumulative survival function for the product groups as a single unit. The survivor function is the share of spells that survive at time t, but this time is cumulative of all preceding time intervals. That is, if all spells survive and the ratio is one, the survivor function is flat at this interval; otherwise, the function is gradually declining. Formally, the Kaplan-Meier estimator of the survival function is as follows:

$$S(t) = \prod_{t(i)} \frac{n_j - d_j}{n_j} \quad (9)$$

where *NI* denotes the number of subjects at risk of failure in $t(i)$ and d_j denotes the number of observed failures. Estimated survival functions were analysed using the traditional logarithmic rank test to assess their statistical similarity.

Results and discussion

Measurement revealed comparative advantages in agri-food production

The comparative advantages revealed of 46 products (see Table A1 in the appendix) of the agri-food trade of Argentina, Paraguay, and Uruguay were evaluated using the NI index (Table 1).

On average, from 1995 to 2020, Argentina revealed CA for 9 products, Uruguay 11 products, and Paraguay 7 products. The flagship products (revealing medium or strong CA) are colored blue and green in the table. Argentina reveals six flagship products (S011, S041, S044, S081, S222, S421) and both Uruguay (S011, S042) and Paraguay (S011, S222) only two.

There is a link between NI scores and the shares of specific products in export and import structures. Products revealing CA are export sectors and account, on average 1995-2020, for 71.9% (flagship products account for 70.1%) of agri-food exports in Argentina, 81.8% (flagship products: 42.8%) of agri-food exports in Uruguay, and 91.2% (flagship products: 62.8%) of agri-food exports in Paraguay. The products revealing CdisA are the import sectors and account, on average, for 76.8% of the agri-food imports in Argentina, 87.3% of the agri-food imports in Uruguay and 86.1% of the agri-food imports in Paraguay. These results suggest that the specialization patterns of the agri-food trade of Argentina, Paraguay, and Uruguay develop around comparative advantage of each agri-food sector.

S	Argentina		Uruguay		Paraguay		S	Argentina		Uruguay		Paraguay	
	avg.	rank	avg.	rank	avg.	rank.		avg.	rank	avg.	rank	avg.	rank
001	-4.47	34.	0.28	7.	-0.36	25.	057	-8,75	43.	-1.15	42.	-1.98	46.
011	2.91	6.	7.94	1.	3.80	2.	058	-1.32	22.	-0.42	31.	-0.40	28.
012	-10.26	44.	-0.39	29.	-1.32	41.	059	-0.19	13.	-0.31	27.	-0.33	24.
016	-1.00	19.	-0.09	18.	-0.11	12.	061	-4.21	33.	-0.56	35.	-0.38	27.
017	-1.25	21.	-0.04	13.	-0.38	26.	062	-1.45	25.	-0.25	25.	-0.26	22.
022	-3.28	28.	1.33	4.	-0.90	39.	071	-6.93	40.	-0.78	41.	-0.76	37.
023	-1.34	23.	0.22	8.	-0.18	21.	072	-3.67	31.	-0.38	28.	-0.41	29.
024	-4.80	35.	0.43	5.	-0.68	36.	073	-3.61	29.	-0.51	34.	-0:54	31.
025	-0.90	18.	-0.11	19.	-0.12	13.	074	-0.44	15.	-0.18	23.	-0.15	17.
034	-6.00	37.	0.02	11.	-1.33	42.	075	-1.46	26.	-0.17	22.	-0.17	20.
035	-1.11	20.	-0.13	21.	-0.14	16.	081	50.29	1.	-1.29	44.	2.55	3.
036	-0.12	11.	-0.64	37.	-0.80	38.	091	0.00	10.	0.12	10.	-0.12	14.
037	-5.20	36.	-0.50	33.	-0.61	32.	098	-10.41	45.	-1.26	43.	-1.35	43.
041	9.57	5.	-0.11	20.	-0.16	18.	111	-3.62	30.	-0.44	32.	-0.44	30.
042	-2.33	27.	3.06	2.	0.04	7.	112	-11.31	46.	-1.65	46.	-1.74	45.
043	0.50	8.	-0.07	16.	-0.16	19.	121	-0.15	12.	-0.25	24.	-0.12	15.
044	20.06	3.	-0.58	36.	1.14	5.	122	-7.47	41.	-0.40	30.	-0.62	33.
045	0.70	7.	-0.07	17.	-0.08	10.	222	16.19	4.	2.71	3.	12.34	1.
046	0.47	9.	-0.05	14.	-0.09	11.	223	-0.48	16.	-0.06	15.	0.07	6.
047	-0.22	14.	-0.03	12.	-0.03	8.	411	-0.87	17.	0.20	9.	-0.05	9.
048	-6.23	38.	0.34	6.	-1.01	40.	421	33.74	2.	-0.75	40.	1.29	4.
054	-7.88	42.	-1.37	45.	-1.37	44.	422	-6.38	30.	-0.74	39.	-0.66	34.
056	-3.96	32.	-0.67	38.	-0.67	35.	431	-1.36	24.	-0.26	26.	-0.26	23.

Note: Green - strong CA, blue - medium CA, yellow - weak CA
Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 1: Mean (1995-2020) and ranking of specific sectors according to NI values.

The year-over-year change indicates fluctuation in NI scores. Products such as S036, S043 (Argentina), S091 (Uruguay) and S042, S223 (Paraguay) gained CA and products as S017 (Argentina), S017, S34 (Uruguay) lost CA compared to the beginning and the end of the period under scrutiny.

Stability I (external shape of the distribution of RCA)

The number of products that reveal CA has changed slightly and the high coefficients of variation of some agri-food products (not presented here) indicate dispersion in the variables between 1995 and 2020. This could signal a relative instability of some products revealing comparative (dis) advantages and a possible ongoing structural change of the agri-food trade pattern. The summary statistics (mean, median, range, skewness, i.e.; see Table A2 in the Appendix), the regression analysis (Table 2), and kernel density estimation (Figure A3 in the Appendix) of NI were investigated to assess the evolution of the external shape of the distribution of RCA and thus the overall change in the degree of specialization.

In the case of Argentina, the summary statistics of the NI scores show an increasing range of quartiles and of standard deviation from 1995 to about the Great recession. The number of products that reveal CA decreased slightly during this period. This is in line with the results of the regression analysis. The regression analysis indicates divergence from the beginning of the millennia until the Great Recession. This means that products that reveal CA increased the strength of CA and the products that reveal comparative disadvantage have weakened their position compared to the previous period of time. This suggests that the liberalization and commodity boom in the first decade of the century enhanced the specialization pattern of Argentina's agri-food trade. After the Great recession, results suggest convergence (also, range and standard deviation started to decrease), and thus changes were leading to slightly (the pattern diverge again from about 2013) new specialization pattern.

Similarly to Argentina, regression analysis of NI scores for Uruguay and Paraguay indicates divergence from the beginning of the millennium until the Great Recession. Summary statistics suggest (e.g., stagnation of standard deviation, decrease in range) that since about 2013, the strengthening of specialization of agrarian trade has stopped in Uruguay and Paraguay. Regression analysis between 2013-2014 and 2021-2022 indicates convergence. In other words, it means that the pattern of trade specialization can be considered to have weakened. There is a question whether this convergence will lead to a new specialization pattern or its only fluctuation (e.g., linked to the impact of the COVID pandemic on international trade). Median values of the indices fluctuate, but there is a visible tendency to decrease. Overall, these trends in both countries led to a change in the number of products that revealed comparative advantage. The number of products revealing CA has slightly decreased in Uruguay and slightly increased in Paraguay.

The evolution of the external shape of the distribution of RCA and thus the overall change in the degree of specialization was interrogated using kernel density estimation (Figure A3 in the Appendix) of the NI. A result of kernel density estimation confirms conclusions based on summary statistics and regression analysis. Visualization

Country	period	1999-2000				2007-2008				2013-2014			
		β	R	β/R		β	R	β/R		β	R	β/R	
Argentina	07-08	0.984	0.948	1.038	DIV								
	13-14	0.683	0.726	0.940	CON	0.703	0.777	0.906	CON				
	21-22	0.917	0.867	1.057	DIV	0.910	0.894	1.018	DIV	0.900	0.800	1.125	DIV
Uruguay	07-08	0.920	0.848	1.085	DIV								
	13-14	0.874	0.683	1.280	DIV	1.067	0.904	1.180	DIV				
	21-22	0.841	0.734	1.146	DIV	0.972	0.920	1.056	DIV	0.835	0.933	0.895	CON
Paraguay	07-08	1.161	0.964	1.204	DIV								
	13-14	1.283	0.941	1.363	DIV	1.104	0.976	1.132	DIV				
	21-22	1.187	0.916	1.295	DIV	1.021	0.950	1.076	DIV	0.941	0.990	0.950	CON

Note: DIV – divergence, CON - convergence
Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)
Table 2: Regression analysis of NI scores (selected years).

of the distribution of comparative advantages in agri-food highlights the important position of flagship products in the distribution structure.

Another indicator of (un)stability and of an increased specialization pattern in agri-food trade is the relative importance of products (in the export and import flows) that reveal a CA in the period *t*, but a CdisA in the period *t* + 1 (Table 3) or vice versa (Ballance et al., 1987).

In the case of Argentina, the product groups that revealed CA in 1995-1996 but CdisA in 2019-2020 represented 3.65% of total agri-food export at the beginning of the period and 0.27% at the end. In the case of Uruguay, these product groups represented 11.30% of the total agri-food export at the beginning and 2.75% at the end. In the case of Paraguay, these product groups accounted for 2.70% of the total agri-food export at the beginning and 0% at the end.

The products showing opposite (revealing CdisA at the beginning of the period and CA at the end) accounted for 3.10% of total exports at the beginning of the period and 4.76% at the end. In the case of Uruguay, the change was from 1.03% to 18.88% of the total agri-food exports. In the case of Paraguay, these products represented 0.27% to 6.59% of total agri-food export.

Stability II (intra-distributional dynamics)

Using results of the previous analysis of the overall specialization pattern, it is possible to gather only some information about the shape of the overall distribution of the NI indices, but not much can be said as regards the changes in the relative position of any single product. The mobility of products within the distribution was analysed to investigate intra/distributional dynamics and transitions among the subsequent classes: CdisA (class a), weak CA (class b), medium CA (class c), and strong CA (class d). The scores in Markov transition probability matrices are presented in Table 4.

Products revealing CdisA (class a) are highly persistent in time. This means that products without an initial comparative advantage appear to remain uncompetitive in all three countries during the period under scrutiny. Using NI scores, 29 out of 46, 27 out of 46 and 35 out of 46 products analysed consisting of agri-food trade of Argentina, Uruguay, and Uruguay resp. Paraguay never revealed CA from 1995 to 2020.

	CA → CdisA			CdisA → CA		
	No.	RCAt	RCAt+1	No.	RCAt	RCAt+1
		1995-1996	1919-2020		1995-1996	1919-2020
		%	%		%	%
ARG	1	3.65	0.27	2	3.10	4.76
URG	2	11.30	2.75	2	1.03	18.88
PRG	1	2.70	0.00	3	0.27	6.59

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 3: Stability of revealed comparative advantage - relative importance of products.

Argentina (NI)

Pi,j (-)	i (-)	a	b	c	d
j (-)					
a		0.97	0.03	0.00	0.00
b		0.26	0.64	0.11	0.00
c		0.07	0.18	0.56	0.18
d		0.00	0.00	0.11	0.89

Uruguay (NI)

Pi,j (-)	i (-)	a	b	c	d
j (-)					
a		0.98	0.02	0.00	0.00
b		0.09	0.89	0.02	0.00
c		0.00	0.11	0.89	0.02
d		0.00	0.00	0.00	1.00

Paraguay (NI)

Pi,j (-)	i (-)	a	b	c	d
j (-)					
a		0.99	0.01	0.00	0.00
b		0.09	0.88	0.03	0.00
c		0.00	0.05	0.91	0.05
d		0.00	0.00	0.67	0.33

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 4: Markov transition probability matrices for the NI indices.

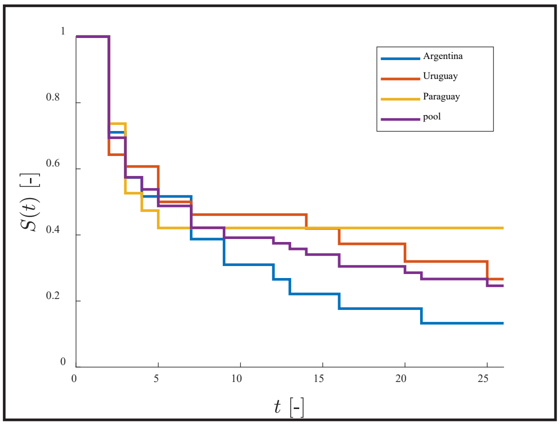
Generally, the products in class a (CdisA) and in class d (flagship products; strong CA) are more persistent than the products revealing weak and medium CA (classes b and c), except of Paraguay. Paraguay revealed a strong CA in export of oil seeds (soya) only in 3 out of 26 years, however, the product revealed most of the time medium CA.

Despite variation when comparing Argentina, Uruguay, and Paraguay among each other, another result indicates that products initially revealing weak CA (class b) rather change its status to CdisA that to change its status to medium or strong CA (groups c and d). Also, the probability of closer shifts is higher than the probabilities of longer moves between classes. The change in the status from weak CA to CdisA can be considered as a channel through which the number of products that reveal CA has decreased and the structure of comparative advantages has weakened in the countries under scrutiny. In the case of Uruguay, another channel through which the structure of comparative advantages has weakened is the relatively low persistent CA in group c (medium CA) because more products have changed its status from medium CA to weak CA that change its status from medium CA to strong CA.

The general degree of mobility was assessed using traces and the determinants of transition matrixes for the whole period, as well as in sub-periods (Table 5). In the case of total persistence, the value of M1 would be zero. In the case of total mobility, M2 would be 1. The M1 and M2 scores indicate high persistence (low mobility), especially in the case of Uruguay, and medium persistence (modest mobility), especially in the case of Argentina. This means that elements on the main diagonal are close to 1. There is no rallying any trend when comparing M1 and M2 scores in sub-periods.

Fragility / duration analysis of the comparative advantage

The Kaplan-Meier survival function was deployed to evaluate the duration of the NI indices during the period under review. We developed a survival function for Argentina, Uruguay, and Paraguay as well as a survival function for pool data. The results of the estimate of survival functions show that survival times are not persistent over the period under scrutiny and there are some differences when comparing Argentina, Uruguay and Paraguay among each other (Figure 2).



Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Figure 2: Plot of survival functions S(t) for Argentina, Uruguay, and Paraguay; 1995-2020.

In the case of pooled NI scores, the chances of comparative advantages of a particular product to survive (revealing CA) at least in four years continuously (not moving from CA to CdisA) are about 50%. Taking into account individual country data, the 50% chance of survival is between 3 to 7 years. The steep slope of the survival function in the first part of the period and then the flat slope over the remaining years indicate that new products turning from CdisA to CA are much more likely to fail than products already revealing CA. The countries under scrutiny differ in this aspect.

NI	Mobility index	Period					
		95-20	95-00	00-05	05-10	10-15	15-20
M1	ARG	0.29	0.34	0.35	0.32	0.26	0.20
	URG	0.07	0.04	0.12	0.07	0.06	0.07
	PRG	0.09	0.20	0.00	0.04	0.18	0.04
M2	ARG	0.67	0.81	0.69	0.65	0.68	0.51
	URG	0.20	0.11	0.32	0.20	0.17	0.19
	PRG	0.25	0.56	0.01	0.11	0.46	0.11

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table 5: Mobility indices of the NI.

In the case of Paraguay, if the product survives (reveals CA) more than 5-6 years, there is fairly small risk of failure. In the case of Uruguay and especially Argentina, the product has to survive more years to create stable CA and to increase the probability of the CA to survive. After 26 years (our analysed period), the probability of CA of a product to survive is 13.3%, 26.6% and 42.1% in the case of Argentina, Uruguay, and Paraguay.

Summary of empirical findings and discussion

We examined comparative advantages, specialization dynamics, and its fragility in the agri-food trade of these three countries. We applied the NI index to ask for the comparative advantage of each agri-food product/sector.

The results suggest that the agri-food trade of Argentina, Paraguay, and Uruguay have developed around comparative advantage of each agri-food sectors. Argentina reveals more flagship products (six products: bovine meat, wheat, maize, animal feed, oil seeds, vegetable oils) compared to Uruguay (two products: bovine meat, rice) and Paraguay (two products: bovine meat, oil seeds). These products revealed a medium or strong comparative advantage in the agri-food trade. The observed persistence and gradual evolution of comparative advantages are consistent with Bojnec and Ferto (2018), who emphasize that structural changes in agricultural competitiveness often unfold slowly over long periods due to entrenched factor endowments and institutional constraints. This finding reinforces the notion that agri-food specialization is not highly volatile but path-dependent.

When comparing the change in the number of products revealing comparative advantage, NI indicates that Argentina has increased the number in the second half of the period under scrutiny. A similar increase is seen in the case of Paraguay. The number of products that reveal comparative advantages remains about the same in the case of Uruguay. This suggests a slight improvement in the complexity and export portfolio of the agri-food trade of Argentina and Paraguay.

We evaluated the overall change in the shape of the specialization pattern. The NI index suggests that competitive products became more competitive and products revealing comparative disadvantage have weakened their position in the period from the beginning of the millennia until about 2013 when the agri-food exports dynamic slowed down /stalled in subsequent period. At the end of the covered period, the results indicate a change in trend and an opposite process in Uruguay and Paraguay.

The divergence of trade specialization in the period from the beginning of the millennia until about 2013 is in line with Aiginger (2001) and his conclusion that removing tariffs product standards and simplifying government formalities reduces the transaction costs of trade, which should lead to an increase in the degree of specialization, and higher specialization can lead to higher productivity and competitiveness. The observed divergence of comparative advantages during the early 2000s also aligns with arguments by Lederman, Olarreaga, and Perry (2009), who emphasized how the commodity boom fostered specialization in primary exports across Latin America. Our results are also in line with Fernandez and Curado (2019) concluding that although historically it has been the developed countries that have been responsible for the dominance of commodities in Argentina's export pattern, in recent decades it has been the developing countries of Asia.

Using results of the previous analysis of the overall specialization pattern, it is possible to gather only some information about the shape of the overall distribution of the NI indices, but not much can be said as regards the changes in the relative position of any single product. The mobility of products within the distribution was analysed applying Markov transition probability matrices to investigate intra-distributional dynamics. Products without an initial comparative advantage remained uncompetitive in all three countries during the period under scrutiny. Similarly, the class of flagship products is also stable and persistent. This suggests that the agri-food trade of these three countries was and probably would also be formed around these flagship products in the future. The analysis of fragility/durability of comparative advantage indicates that the 50% chance of survival (product revealing comparative advantage on year-on-year basis) is between 3 and 7 years. In the case of Paraguay, if the product survives more than 5-6 years, there is fairly little risk of failure and loss of its comparative advantage. In the case of Uruguay and especially Argentina, the product must survive more years to create a stable trade partnership and increase the probability of the comparative advantage to survive. After 26 years (our analysed period), the probability of a product's comparative advantage to survive is 13.3%, 26.6% and 42.1% in the case of Argentina, Uruguay, and Paraguay. However, the steep slope of the survival function in the first part of the period and then the flat slope over the remaining years indicate that new products turning from comparative disadvantage to comparative advantage are much more likely to fail than products already revealing comparative advantage. This result implicates that policy makers must focus on supportive policies and improve the enabling environment to ensure the survival of comparative advantages.

The specialization of exports from the agri-food sectors has created a specific channel that transmits impulses/incentives from the global economy to the national economies of these countries. The agri-food led economic growth has support from the political representation. The impact of it on general economic development and domestic food security should become the subject of further research and policy interventions as the recent study of Carrington et al. (2023) concludes that institutional and structural characteristics can bolster resilience in the face of such shocks.

Conclusion

We ex-post examined comparative advantages, specialization dynamics, and its fragility in the agri-food trade of Argentina, Uruguay and Paraguay. These countries have potential to increase its competitiveness and further enhance its position at the World markets in agri-food production and the agri-food led economic growth has support from the political representation. The results suggest that the agri-food trade of Argentina, Paraguay, and Uruguay have developed around comparative advantage of specific agri-food sectors and similar trend can be probably expected in the future. This study identifies these flagship sectors and shows that Argentina reveals more flagship products (bovine meat, wheat, maize, animal feed, oil seeds, vegetable oils) compared to Uruguay (bovine meat, rice) and Paraguay (bovine meat, oil seeds). Results suggest that the multilateral liberalization and commodity boom in the first decade of the century enhanced the specialization pattern of agri-food trade of countries under scrutiny. However, after the Great recession, results suggest slight convergence in specialization patterns, and thus changes that could lead to slightly new specialization pattern and further research is needed. Our results implicate that policy makers should focus on supportive policies and improve the enabling environment to ensure the survival of comparative advantages in these countries under scrutiny (and especially in Argentina).

Despite these minor variations and differences among countries under scrutiny, the distribution of comparative advantages remains mostly stable and persistent (especially in the case of flagship products and products revealing comparative disadvantage). Potential further liberalization steps (removing tariffs and other transaction costs of trade) with EU and China could lead to the further increase in the degree of specialization in specific agri-food sectors and thus in improvement of productivity and competitiveness (ceteris paribus). These findings are important to inform agriculture policymakers and to improve or design structures and mechanisms to stimulate the international performance of agri-food trade in these countries.

The development of global agricultural markets after 2020 has been marked by several serious shocks, e.g. the COVID-19 pandemic, Russian aggression against Ukraine, or now the escalation of tariffs with the accession of the Trump administration in the USA. The methodology used in this article provides the framework to further analyze the competitive position and its stability of MERCOSUR or other countries.

We conclude the three countries under scrutiny have managed to establish very competitive parts of the agri-food sector within global agricultural markets. This is in line with Norberg (2020) concluding that the whole Latin American region has witnessed rapid increase in agro- and pastoral areas as a consequence of the increasing foreign demand for agri-food products globally in the last two decades. Agriculture will most likely remain an important part of its development in the coming years, and the role of the agri-food sector in the export mix of those countries might still grow as a result of further specialization of the markets.

Policy implication

In the context of the EU-MERCOSUR free trade agreement, our analysis has shown strong competitiveness of the three smaller MERCOSUR countries in bovine meat, a product that has been difficult to negotiate in the EU-MERCOSUR trade deal. The fate of the deal remains uncertain today, but if it is successfully ratified and functioning in the near future, it could have further impact on trade specialization of those countries, even though the agreement includes limits on imports. The role of beef meat within the negotiations with the EU is still significant. It has to be noted though that EU is not the most important market for Argentinian, Uruguayan, and Paraguayan bovine meat exports, as most of those exports end up in China, whose role as a destination was increasing in the last decades. The impact of a potential trade liberalization with EU might be limited by that fact, while to Chinese-MERCOSUR trade deal, that is being talked about in 2023 (with negotiations not being started yet) might in fact be far more significant for all countries involved.

Limitations and perspectives of future research

This study has certain limitations and highlights avenues for future research. First, the study relies on aggregated trade data. Despite providing useful understandings already now, a more detailed product classification beyond the SITC 3-digit level could provide further insights into specific product trade dynamics e.g. value-add variances, product quality differentiation, intra-industry trade or microeconomic firm-level complexity and heterogeneity. Additional research is warranted on the role of intermediaries, value-added flows and complex export arrangements within global agri-food value chains between the MERCOSUR countries and major food markets in the world.

Additionally, the use of Kernel densities, Markov chains, and Kaplan–Meier survival functions provides valuable descriptive insights but does not fully uncover causal mechanisms. This methodology does not fully support robust causal conclusions, as we were unable to fully isolate the specific effects determining agri-food trade dynamic of analysed countries as well to fully isolate the country-specific factors on the observed trade differences. Future research could employ econometric approaches to analyse causal relationships more rigorously, specifically examining how global, regional and national factors influence trade flows over time.

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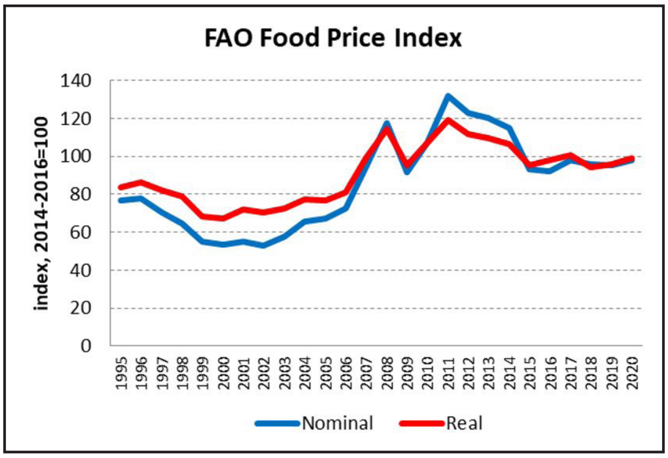
Appendix

001	Live animals	057	Fruit, nuts excl. oil nuts
011	Bovine meat	058	Fruit, preserved, prepared
012	Other meat, other offal	059	Fruit, vegetable juices
016	Meat, ed. offl., dry, slt, smk	061	Sugars, molasses, honey
017	Meat, offl. Prdd, nes	062	Sugar, confectionery
022	Milk and cream	071	Coffee, coffee substitutes
023	Butter, other fat of milk	072	Cocoa
024	Cheese and curd	073	Chocolate, oth. cocoa prep.
025	Eggs, birds, yolks, albumin	074	Tea and mate
034	Fish, fresh, chilled, frozn	075	Spices
035	Fish, dried, salted, smoked	081	Animal feed stuff
036	Crustaceans, Molluscs	091	Margarine and shorten
037	Fish etc. prepd, prsvd. nes	098	Edible prod. prepetns, nes
041	Wheat, Meslin, Unmilled	111	Non-alcohol. beverage
042	Rice	112	Alcoholic Beverages
043	Barley, unmilled	121	Tobacco, unmanufactured
044	Maize unmilled	122	Tobacco, manufactured
045	Other cereals, unmilled	222	Oil seeds and oleaginous fruits (excl. flour)
046	Meal, Flour of wheat, msln	223	Oil seeds, oleaginous fruits (incl. flour, n.e.s.)
047	Other cereal meal, flours	411	Animal oils and fats
048	Cereal preparations	421	Fixed veg. fat, oils, soft
054	Vegetables	422	Fixed veg. fat, oils, other
056	Vegetables, prpd, prsvd, nes	431	Animal, veg. Fats, oils, nes.

Source: SITC rev. 3

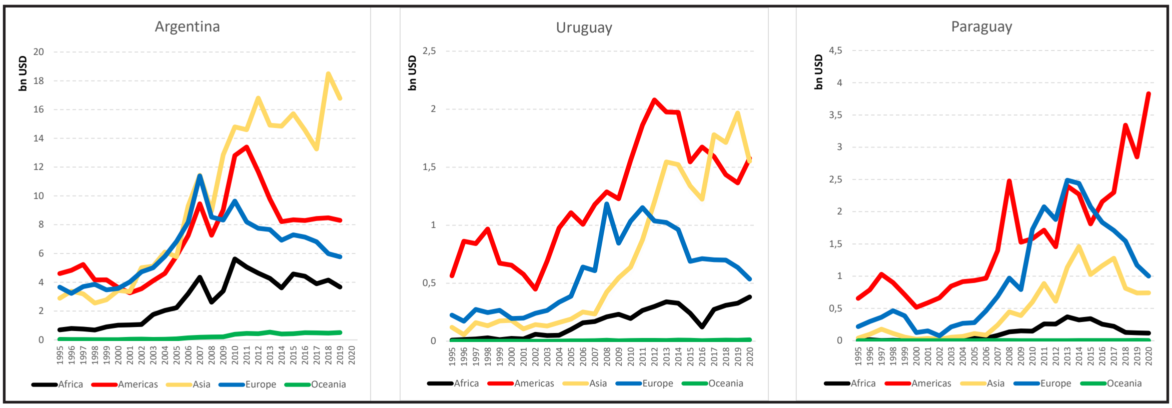
Table A1: Sectors and their numeric designations (SITC rev.3, 3-digit code.



Note: FAO Food price index records the development of world market prices and consists of average of 5 commodity group (meat price index, dairy price index, cereals price index, vegetable oil price index, and sugar price index) price indices weighted with the average export shares of each of the groups for 2014-2016. The base period price consists of the averages for the years 2014-2016.

Source: Authors' calculations based on FAO data (FAO, 2024)

Figure A1: FAO food price index, 2014-2016 = 100, 1995-2020.



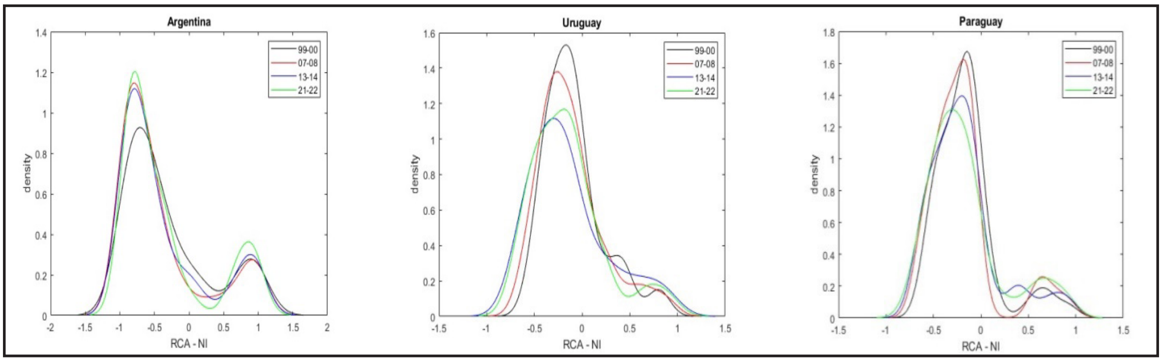
Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Figure A2: Change in total agri-food export of Argentina, Uruguay and Paraguay to particular continents; 1995-2020.

	1995	2000	2005	2010	2015	2020	avg.95-20
	Argentina						
stand dev.	7.85	10.27	11.29	12.91	11.86	9.54	11.14
median	-1.10	-1,55	-1.53	-1.45	-1.78	-1.62	-1.49
kurtosis	11.11	8.20	8.18	12.26	19.00	9.16	12.39
skewness	2.80	2.63	2,72	3.31	3.97	2.78	3.19
min.	-11.72	-14.48	-13.55	-11.34	-12.00	-13.12	-12.91
max.	37.79	44.06	46.52	61.97	64.39	40.87	52.25
range	49.51	58.55	60.07	73.32	76.39	53.99	65.15
	Uruguay						
stand dev.	0.898	1.329	1.614	1.688	1.872	1.599	1.53
median	-0.189	-0.172	-0.252	-0.253	-0.263	-0.220	-0.23
kurtosis	10.286	23.167	31.621	14.867	15.480	20.365	19.05
skewness	2.975	4.424	5.241	3.404	3.675	4.028	3.96
min.	-1.069	-1.518	-1.772	-1.969	-1.896	-1.893	-1.73
max.	3.945	7.535	9.917	8.620	9.329	8.850	8.07
range	5.014	9.053	11.690	10.589	11.225	10.743	9.80
	Paraguay						
stand dev.	1.549	1.268	1.660	2.510	2.216	2.330	2.12
median	-0.188	-0.156	-0.197	-0.374	-0.335	-0.373	-0.30
kurtosis	31.292	32.883	32.809	23.507	10.905	21.301	27.08
skewness	5.234	5.407	5.403	4.545	3.083	4.211	4.81
min.	-1.200	-1.069	-1.424	-2.315	-2.788	-2.771	-2.00
max.	9.497	7.863	10.282	14.233	10.154	12.954	12.34
range	10.697	8.932	11.706	16.549	12.942	15.726	14.34

Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Table A2: Summary statistics of NI scores (selected years).



Source: Authors' calculations based on UNCTAD data (SITC, 3-digit level)

Figure A3: Estimated Kernel densities of transformed scores of RCA indices (avg. 1999-2000, avg. 2007-2008, avg. 2013-2014, avg. 2021-2022).