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Revealed comparative advantages and the role of price in soybean trade relation with China

Ventajas comparativas reveladas y la relevancia del precio en las relaciones comerciales con China

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Abstract

This article aims to identify the relationship between the price of soybeans exported to China and the competitive advantage of the main suppliers of this commodity to the Chinese market. To this end, data on soybean exports from Argentina, Brazil, Canada, the United States, Uruguay, and Russia were analyzed between 2011 and 2021. In addition to obtaining the RCA Index, a panel data model was estimated. The results show that Brazil and the USA are the world's largest soybean exporters, and that Argentina, Russia, and Brazil are China's largest trading partners in soybean transactions, directing more than 70% of their exports, on average in the period, to the Asian country. Concerning the RCA, the South American countries stand out with the highest values for the historical series, and among the analyzed countries, only Russia presented a Revealed Comparative disadvantage. The estimated econometric model showed that the prices of soybeans exported to China are relevant to the behavior of the RCA Index of China's trading partners, positively impacting the competitiveness of their trade relations.

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Resumen

Este artículo propone un análisis de la competitividad en las relaciones comerciales entre los principales países que suministran soja para China, mayor importador mundial de esa commodity. Para eso, fueron analizados datos de las exportaciones de soja de Argentina, Brasil, Canadá, Estados Unidos, Uruguay y Rusia, entre el período de 2011 y 2021. Además de la obtención del IVCR, se estimó un modelo de datos en panel visando identificar la relación entre el precio de la soja exportada para China y la ventaja competitiva de sus principales socios comerciales. Los resultados ponen de manifiesto que Brasil y EEUU son los más grandes exportadores mundiales de soja, y Argentina, Rusia y Brasil son los más grandes socios comerciales de China en las transacciones hechas con soja, destinando más de 70% de las exportaciones, promedio en el período, para el gigante asiático. Ya en relación al IVCR, los países de América del Sur se destacan con los más grandes valores para la serie histórica, y en relación a los países analizados, solamente Rusia presentó desventaja comparativa revelada. El modelo econométrico estimado puso en evidencia que el precio de la soja exportada para China es relevante para el comportamiento del IVCR de los países analizados, impactando positivamente la competitividad en sus relaciones comerciales.

Código JEL: F14; Q17; Q19
Palabras clave: exportaciones; soja; comercio internacional; competitividad

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Introduction

The increasing global demand for food and the significant expansion of the agro-industrial market have been arousing a worldwide interest in agricultural commodities, among which the soybean complex stands out as one of the main protagonists. In this context, China, which is the most populous nation and one of the most dynamic economies in the world, plays a crucial role in the demand for this product.

Historically, Brazil, the United States, Argentina, Uruguay, Canada, and Russia are the main soybean exporting countries to China, and all of them are among the 12 largest global producers of this oilseed (Alves, 2022). Brazil, with its vast territorial extension and well-developed agroindustry, has stood out as the world's largest exporter of soybeans, and it has become a strategic partner for supplying China's increasing needs. On the other hand, the United States, with its highly mechanized and technological agricultural production, as well as Argentina, which is one of the main soybean producers in Latin America, have also been crucial players in supplying the Chinese market. Together, these countries account for two-thirds of global soybean production (Gazzoni & Dall'agnol, 2018).

In contrast, Uruguay, Canada, and Russia are emerging actors in this scenario, each with its particularities. Uruguay, despite having a modest share of the soybean export market, has the potential to expand its operations, with China as a promising market (Rocher, 2015). Canada, in turn, has a developed

logistics infrastructure, and the country has been increasing its production capacity, as well as its trade relations with the Asian market (Junior, 2023). As for Russia, its vast agricultural areas are still little explored, but investments in the sector have contributed to consolidating it as an emerging force in the production and export of soybeans to China (Medetsky, 2020).

The relevance of these countries in the soybean supply chain to China is influenced by several factors, such as the availability of agricultural land, the use of technology in the production process, government policies related to the agricultural sector, and diplomatic and trade relations established between the nations involved. These conditions, in addition to the behavior of supply and demand, also influence the price of this commodity, which, in turn, can impact competitiveness in this market (Maluf & Flexor, 2017).

Given these dynamics, the present study aims to identify the relationship between the price of soybeans exported to China and the competitive advantages of the main suppliers of this commodity to the Chinese market. Through an analytical approach, based mainly on competitiveness indicators, and through an econometric model for panel data, we seek to understand the role of price in the competitiveness of soybean exports to the world's largest importer.

This discussion intends to deepen the knowledge about the dynamics of this important commercial relationship, and it can also contribute to the understanding of the current global scenario and the prospects for soybean exports to China, as well as identifying challenges and opportunities faced by its main trading partners. Studying the competitiveness of soybean exports to China can also provide valuable insights for formulating more solid commercial strategies among the countries involved (Gaia, 2021).

To accomplish this objective, this paper is structured into four other sections besides the introduction. In the theoretical framework, we discuss the importance of comparative advantages, in line with classical and neoclassical theories of international trade. Next, we present the methodological approach, which includes the empirical model for evaluating the commercial relationships investigated. The fourth and the last sections present the results and the discussion, as well as the concluding remarks.

Theoretical framework

Classical and neoclassical theories of international trade

The history of trade can be easily confused with the evolution of humanity, given that this activity, even if in a primitive form, is present in all human relationships; however, international trade as we know it today was only regulated in the 20th century, after the end of the Second World War (Barral, 2007).

According to Guimarães (2005), the study of international trade began around the 17th and 18th centuries with mercantilist studies, as, in that time, the mercantilist policies integrated economics and politics to guarantee a positive balance of trade. In other words, "Mercantilist prescriptions regarding trade aimed to provide the country with greater power, this being an intrinsic element of commercial policies." (Guimarães, 2005, p. 13, our translation). The belief at that time was that for a mercantilist nation to become rich, it would need to sell more products than it would buy from a foreign country (Blinder, 2009).

Nevertheless, this idea was challenged by the classical authors. Classical economists, such as Smith and Ricardo, also relate economics to politics, as the mercantilists, but the classical theory of international trade emphasizes the economic processes (Guimarães, 2005). In The Wealth of Nations (1776), Adam Smith defends the importance and the advantages of free trade, to the detriment of policies to protect industries:

"…If the produce of domestic can be brought there as cheap as that of foreign industry, the regulation is evidently useless. If it cannot, it must generally be hurtful. It is the maxim of every prudent master of a family, never to attempt to make at home what it will cost him more to make than to buy. The tailor does not attempt to make his own shoes, but buys them of the shoemaker. The shoemaker does not attempt to make his own clothes, but employs a tailor. The farmer attempts to make neither the one nor the other, but employs those different artificers. All of them find it for their interest to employ their whole industry in a way in which they have some advantage over their neighbours, and to purchase with a part of its produce, or, what is the same thing, with the price of a part of it, whatever else they have occasion for." (Smith, 2005, p. 364)

High taxes or bans on imports gives an illusion of bringing great benefits to the domestic economic activity. However, the monopoly that is created in the domestic market does not always result in welfare for the nation. Free trade, in the other hand, can increase activities in both foreign and domestic countries, which can be beneficial for both, in some cases. This is evident in this passage from Smith's work:

"…To prohibit, by a perpetual law, the importation of foreign corn and cattle, is in reality to enact, that the population and industry of the country shall, at no time, exceed what the rude produce of its own soil can maintain… The interest of a nation, in its commercial relations to foreign nations, is, like that of a merchant with regard to the different people with whom he deals, to buy as cheap, and to sell as dear as possible. But it will be most likely to buy cheap, when, by the most perfect freedom of trade, it encourages all nations to bring to it the goods which it has occasion to purchase; and, for the same reason, it will be most likely to sell dear, when its markets are thus filled with the greatest number of buyers…" (Smith. 2005, p. 369-370).

From this understating, Smith developed the theory of absolute advantages as the basis of international trade, in opposition to the mercantilist vision of trade surplus (Coutinho et al., 2005). In Smith's view, it is not always necessary to have a trade surplus for trade to be advantageous. According to his concept of absolute advantage, countries that specialize in the production of goods for which they have absolute advantages would benefit from greater productivity (Coutinho et al., 2005). Thus, each country should specialize and focus on the production of those goods that would result in absolute advantage, that is, "What exceeds the internal consumption of the produced good should be exported, and the equivalent revenue should be used to import the goods produced in another country" (Coutinho et al., 2005, p. 102, our translation)."

The existence of absolute advantages, however, does not necessarily mean that there will always be international trade between countries. Krugman, Obstfeld & Melitz (2022) clarify that if a country has absolute advantages in the production of all goods, it will not need to trade with a foreign nation. Meoqui (2023) argues that this issue is due to the way in which absolute advantages are calculated: because it identifies the efficiency in the production of a good according to a production factor (example: the amount of work dedicated to production) between at least two countries and focused on one product only, it fails to explain the formation of an international trade pattern. Despite this failure, Smith still insisted on the importance of nations not banning imports, buying products where they are cheapest and specializing in the most advantageous industrial production (Bernhofen & Brown, 2018).

In 1817, David Ricardo published his work The Principles of Political Economy and Taxation, "improving" Smith's theory. Ricardo's Theory of Comparative Advantages evidence that those countries that do not have absolute advantages can also have gains in trade relations. According to Kurz (2022), Ricardo considered Smith's explanation incomplete: in light of Hume's monetary flow mechanism, if a country specializes in what it has an absolute advantage in terms of production costs, in a situation in which this country has lower production costs than a foreign country, it would export everything to the foreign country, and it would experience an increase in its gold currency reserves; as an effect, local prices would increase in relation to foreign prices, and the foreign country would now have an absolute advantage because, in terms of costs, its prices would be lower than in the local country, causing the absolute advantage to reverse. In response to this failure, Ricardo developed the principle of comparative advantage, based on negotiations between Portugal and England, in terms of hours of work and quantity of production, using the following example: Portugal needs 90 hours of work to produce cloth and 80 hours of work to produce wine; while England needs 100 hours of work to produce cloth and 120 hours of work to produce wine:

"…To produce the wine in Portugal, might require only the labour of 80 men for one year, and to produce the cloth in the same country, might require the labour of 90 men for the same time. It would

therefore be advantageous for her to export wine in exchange for cloth. This exchange might even take place, notwithstanding that the commodity imported by Portugal could be produced ther with less labour thant in England. Though she could make the cloth with the labour of 90 men, she would import it from a country where it required the labour of 100 men to produce it, because it would be advantageous to her rather to employ her capital in the production of wine, for which she would obtain more cloth from England, than she could produce by diverting a portion of her capital from the cultivation of vines to the manufacture of cloth…(Ricardo, 2001, p. 91)"

The example shows that Portugal has an absolute advantage in the production of both goods, but it only has a comparative advantage in the production of wine, as the cost difference for wine (80 – 120 = -40) is greater than that of fabric (90 – 100 = -10). As a result, Portugal must specialize in the production and export of wine, since, in relative terms, the English absolute disadvantage is smaller.

This understating differs from the theory of absolute advantages, as it evidences that there will always be international trade between two countries, because one country will never have a comparative advantage in all goods or services produced (Bernhofen & Brown, 2018). Furthermore, David Ricardo's arguments indicate that a country can benefit even when it decides to import products that could be produced locally at a lower production cost. This counterintuitive idea refutes Smith's proposal based on production costs to justify international trade (Meoqui, 2023).

In Ricardo's view, trade gains occur because countries specialize in what they are most productive, and this increases the global supply of products and lowers prices, benefiting nations that participate in international trade (Blinder, 2019). Furthermore, international trade decentralizes production, generating a greater variety of goods for those who can buy them, with little or no effect on jobs, because they are compensated in specialized sectors.

Shaikh (2022) brought to light an interesting criticism of the model proposed by Ricardo: assuming, for example, an economy with real competitiveness, the Ricardian model to explain the international trade pattern may be flawed when considering the real exchange rate, trade balance, capital balance, free trade, and free capital mobility. It is possible that in situations where the absolute advantage, in terms of costs, is remarkably high, the real exchange rate will not be able to reverse the absolute advantage in the production of wine and cloth from the domestic country (Portugal) to the foreign country (England), as the exampled showed. Therefore, trade imbalances would not always be compensated by the real exchange rate. Relative wages, relative productivity of capital and the effect of the ratio of tradable and non-tradable goods can determine the advantage or disadvantage of absolute production costs – meaning that only Portugal would produce and export wine and cloth.

The author also argues that the international trade pattern identified by Ricardo should be based on comparative production costs and not on absolute production costs, given that in a competitive

capitalist economy "private profits are the only motive", as Smith argues, so companies constantly seek to reduce costs to lower prices, and they do that locally and abroad. Thus, companies with lower costs tend to continue to exist over time, while companies with higher costs tend to disappear (Shaikh, 2022).

Following the evolution of international trade theory, another major contribution to its development was the model proposed by Heckscher (1919 [1991]) and Ohlin (1933), in which comparative costs not only explain the pattern of international trade specialization, but they are also the key variable for this to occur. Based on this understanding, the authors identified that the endowment of factors, their abundance or scarcity, explains the formation of advantages in terms of costs – they are the minimum differences between countries that would be sufficient to explain the existence of trade (Lancaster, 1957).

The Heckscher-Ohlin model considers a group of countries with identical factors to produce identical goods using an identical production function, assuming constant returns to scale. These factors help to explain the factor price equalization theorem and the lack of incentives towards uniformity in the allocation of factors, which would allow commerce to continue to exist even with perfect transmission of knowledge, techniques, and free mobility of the labor factor. According to Lancaster (1957), these assumptions simplify the model to explain international trade, but they are also the reason for criticism, as it strays from reality. Despite its simplicity and unreality, the theory still helps to explain the pattern of international trade.

Rahman (2022) argues that the Heckscher-Ohlin model evidence that the comparative advantage of nations is based not only on international differences in labor productivity but also on countries' abundant resources such as land, capital, and labor. Thus, if a country is abundant in capital, it should export capital-intensive products. If it is abundant in natural resources, it should export natural resource-intensive products, and if it is labor-intensive, it should export labor-intensive products. Hence, the level of abundant resources would be sufficient to determine the comparative advantage all nations gain from international trade. Based on this, firms can expand their borders and achieve economies of scale.

Another more recent approach to international trade is Samuelson's factor-price equalization (FPE) theorem, which addresses the distribution of income and gains from international trade by including the concept of specific factors in the Heckscher-Ohlin model (Boianovsky, 2020). Unlike Heckscher-Ohlin who defend the mobility of factors of production, Samuelson believes that some factors of production are immobile in the short term and mobile in the long term. Thus, in the short term, international trade can result in winning and losing nations until equilibrium in relative wages is reached. That is, only in the long run a country that is abundant in capital would export capital-intensive products and this would increase the relative wage of capital-intensive products. On the other hand, a labor-abundant country would export labor-intensive products, which would increase the relative wage of labor-

intensive products. Furthermore, the FPE theorem suggests that free trade would lead to world Pareto optimality and maximization of production.

Also following the logic of David Ricardo's comparative advantages, Bela Balassa proposed in 1965, in his work entitled Trade Liberalization and Revealed Comparative Advantage, a theoretical model whose central objective is to analyze the performance of a nation on the export of a determined good and, based on this, check whether the country has a comparative advantage over this export product (Batistella et al., 2015). The index is based on data collected after the commercial transaction has been conducted so that distortions, such as subsidies, tariffs, and changes in the exchange rate, do not affect the results (Moreno, Casarotto & Schlindwein, 2021). Since then, the Revealed Comparative Advantage Index proposed by Balassa has been widely used in studies on competitiveness.

In contrast to the classics, Porter's theory argues that the nation's level of well-being depends on its ability to increase productivity Over time (Farinha et. al., 2018). Thus, differentiation is an important determinant of each country's competitive advantage in international trade. Porter also defines the level of competitiveness that nations can assume in three stages of development: stage 1, factor-driven, which includes the least developed countries that compete through efficiency gains in the productivity of raw materials or low added value products; stage 2, efficiency-driven, which include the developing economies that compete through increasing productive efficiency, economies of scale and educating the workforce to reach the next stage; and stage 3, innovation-driven, that encompass the developed countries, which compete through the most sophisticated level of productivity, high-technology industries, high investment and research and development aiming to create new levels of well-being.

As the theories evolved, international trade today appears to be quite different from the economic order of the 17th and 18th centuries studied by classical economic theorists, especially since the turn of the 21st century, in which society went through a period of great transformation. In this sense, it is also important to discuss these changes including the redefinition of a unipolar world to a multipolar one, the repositioning of countries and regions, the crisis of the Washington Consensus, and the rise of China in the international system (Hugueney Filho, 2015).

Changes in trade and international relations

According to Hugueney Filho (2015, p. 122, our translation), "the current period can be characterized as a period of transition in the sense that the power relations that prevailed internally and externally are undergoing important changes". This transition can be analyzed in different ways, but one of the central issues, for example, is the emergence of new actors in the international trade system, such as developing countries, countries from the Global South, and the rise of China, which seems to have established a

multipolar order, instead of the unipolar order imagined at the end of the Cold War and with the Washington Consensus (Cunha, 2011).

From this perspective, society is experiencing a period of global rebalancing with multiple dimensions - political, economic, and military - based on the crisis of the hegemonic power of the United States and the rise of China as a great international power and other emerging groups, such as the BRICS and the G20 (Hugueney Filho, 2015). With the collapse of the Washington Consensus, the possibility of a "Beijing Consensus' arises based on China's extraordinary growth in recent decades and on the country's effective entry into the World Trade Organization (Cunha, 2011).

Regarding the regional level, it is possible to perceive a shift in globalization and trade networks from the Atlantic to the PacIc, due to "[...] production and commercialization chains, especially in East Asia, which are changing trade patterns and investment flows" (Hugueney Filho, 2015, p. 123, our translation). The author also highlights that at the beginning of this new century, there was a significant increase in the participation of developing countries in world GDP and world trade, sustained by the "China effect".

This context shows that significant transformations have occurred in the order of the international system, resulting in changes in trade relations and in the structure of world trade itself, and recognizing this process is essential for analyzing issues related to exports, imports, and competitiveness between different countries. China's growing relevance in trade and international relations imposes the need for a reorganization in countries' commercial relations, thus, those that can benefit from complementarity in their export and import patterns with the Asian country tend to strengthen their international ties; on the other hand, countries that compete with Chinese products face difficulties in the domestic and international markets (Biato Junior, 2010).

Soybean exports to China and the competitiveness of its main trading partners

As emphasized in the previous section, China is currently the world's largest importer of soybeans, and Brazil, the United States, Argentina, Uruguay, Canada, and Russia are extremely important in the production and supply chain of this commodity to the Asian market. In recent decades, the growth and transition of China into a world power indicates the need and urgency to conduct studies that focus on China's economic and commercial international relations. Therefore, this section aims to analyze and discuss the studies that concentrate on these topics, which are summarized in Table 1.

Regarding the export of Brazilian soybeans to China, Coronel, Machado, and Carvalho (2009) applied the Constant Market Share methodology, from data between 1995 and 2006, and identified that competitiveness and the increase in world trade furthered the production of soybean complex products in

Brazil. The results obtained evidence that "Brazil has a significant importance in the global soybean trade and presents edaphoclimatic conditions favorable to increase production" (Coronel, Machado & Carvalho, 2009, p. 281, our translation).

Similarly, Amaral et al. (2013) analyzed the behavior of soybean exports from Mercosur countries using the Constant Market Share model, as well as the Regional Orientation and the Coverage Index, for the period from 1991 to 2009. The study indicated that exports of soybeans by the Bloc are more oriented towards the European Union and China, however, Japan and the European Union were the countries that issued the most notifications of soybeans from Mercosur countries in the analyzed period (Amaral et al., 2013).

Lopes et al. (2014) proposed measuring Sino-Brazilian trade relations using the Regional Orientation and the Revealed Comparative Advantage indexes for iron ore and soybean exports, from 1999 to 2012. Once again it was concluded that China is the main importer of Brazil's soybeans and an important consumer market for the country's products (Lopes et al., 2014).

To test a possible long-term relationship between the exchange rate and world income variables on the performance of Brazilian soybean exports, Braga and Oliveira (2018) applied an econometric model (Vector Error Correction model, Johansen cointegration test, and unit root tests), and the results evidenced that the exchange rate and the world income variables were significant in explaining the fluctuations over time in Brazilian soybean exports (Braga & Oliveira, 2018). In addition to the exchange rate, price is also a factor that can influence the competitiveness of soybean exports. Although soy is a commodity, whose price is defined internationally as a result of several external factors, other internal variables such as costs and tariff barriers also influence price dynamics, and consequently, competitiveness.

Regarding the price of soybean exports, Sampaio, Sampaio and Bertrand (2012) argue that the USA is traditionally the price-setter for soybeans on the international market, but some factors related to costs have favored Brazilian and Argentine producers over the years, guaranteeing these countries greater competitiveness. More specifically on price, the study by Silva et al. (2017) aimed to analyze the determinants of the competitiveness of Brazilian soybean exports, and it identified that both the exchange rate and prices (external and internal) have a positive impact on future soybean exports.

In the study by Figueira and Galache (2023), whose objective was to analyze soybean exports from Brazil, Argentina and the United States during the period between 2002 and 2017, using the Constant Market Share model, the authors found that China drove the global growth in soybeans imports, favoring the exporting countries mentioned above and, in addition, the competitiveness effect was positive for Brazil - due to the participation of Chinese imports - and negative for the others countries (Figueira &

Galache, 2023). The authors also observed that the USA and Argentina lost their share in the Chinese market.

Table 1
Literature review on the competitiveness of China's main trading partners in the soybean market

Authors	Period	Objective and method	Main results
Coronel, Machado e Carvalho (2009)	1995-2006	To analyze the behavior and the competitiveness of Brazilian soybean exports. Constant Market Share.	Brazil has significant importance in the global soybean trade, and it presents favorable soil and climate conditions for increasing its production.
Amaral *et al.* (2013)	1991-2009	To analyze the behavior of soybean exports from Mercosur. Constant Market Share, and Regional Orientation and Coverage Index	Mercosur's soybean exports are more oriented towards the European Union and China. Japan and the European Union were the countries that issued the most notifications of soybeans from Mercosur countries.
Lopes *et al.* (2014)	1999-2012	To measure soybean and iron ore trade relations between Brazil and China. Regional Orientation and Revealed Comparative Advantage Indexes.	China is the main importer of Brazilian soybeans and iron ore and an important consumer market for the country's products.
Silva *et al.* (2017)	1999-2011	To analyze the relationship between the exchange rate, the external and internal prices, and the exports of soybean complex products in Brazil. Vector Autoregression Model.	The exchange rate, prices (external and internal), and past exports have positive impacts on future exports.
Braga e Oliveira (2018)	2000-2015	To test the existence of a long-term relationship between the exchange rate, world income, and the performance of Brazilian soybean exports. Vector Error Correction model, Johansen cointegration test, and unit root tests.	The exchange rate and the world income variables were significant in explaining the fluctuations over time in Brazilian soybean exports.
Figueira e Galache (2023)	2002-2017	To compare the performance of soybean exports from Brazil, Argentina, and the USA. Constant Market Shar.	The effect of competitiveness was positive for Brazil and negative for Argentina and the USA.

Source: Elaborated by the authors.

Although the literature review demonstrates that discussions on the topic have been evolving, it also shows that the present research differs from the existing studies, as it focuses on analyzing China's main trading partners in the soybean market, aiming to present a general overview on the countries' competitiveness, as well as to understand the role of price these commercial relations.

Methodological approach

Revealed comparative advantage index

The indicator proposed by Balassa (1965) and referred to in the literature as the Revealed Comparative Advantage Index (RCA) is based on the understanding that commerce reveals the comparative advantages in its transactions (Soares & Silva, 2013). In this sense, a country's relative performance in the export of a determined good reflects its revealed comparative advantages in that sector (Maia & Oliveira, 2001; Soares & Silva, 2013).

It is worth mentioning that the RCA Index is not a measure of competitiveness, nor a reference related to performance, as it measures the level of international specialization in terms of relative strength (Laursen, 2015). The results obtained through the index indicate if a given country is specialized in the production of a determined good and, consequently, the analyzed country can present high values for the RCA Index in some economic sectors and low in others (Laursen, 2015). The indicator can be described algebraically as follows:

$$\mathrm{RCA}_{it}^{j} = \frac{X_{it}^{j}}{X_{t}^{j}} \Big/ \frac{X_{it}^{w}}{X_{t}^{w}} \tag{1}$$

Where: i is the commodity, that is, soybeans; j represents the exporting countries; w represents total world exports; X_it^j represents exports of commodity i from country j in period t; X_t^j are the total exports from country j in period t; X_it^w are total global exports of commodity i in period t; X_t^w represents total world exports in period t.

Panel data regression

To identify the relationship between the price of soybeans exported to China and the competitive advantage of China's main trading partners - that is, to understand the role of price in the competitiveness

of soybean exports to the world's largest importer, the methodology of this study was inspired by the approach adopted in the work of Topcu (2022) on the effect of price on the competitiveness of the furniture industry.

In this sense, we apply a panel data regression, which, according to Greene (2008), combines time series with cross-sections, providing a suitable environment for the development of theory and estimation techniques. Wooldridge (2016) highlights that the reason for carrying out independent cross-sectional groupings is to increase the sample size, considering that by stacking randomly distributed samples collected from the same population, but in different periods, it is possible to have estimators with a higher level of accuracy. However, this grouping is only appropriate if the association between the dependent variable and at least one of the independent variables remains constant over time.

The panel data model adopted here combines data relating to the competitiveness and the price of exported soybeans in a given period (time series) for each analyzed country (cross-sections). Specific tests for estimating panel data are necessary to evaluate which of the available models best fits the data: the F-test (1960) verifies whether the most appropriate model is the Pooled or the Fixed Effects. On the other hand, the Breusch-Pagan Lagrange Multiplier (LM) test (1980) is applied to check between the Pooled or the Random Effects model and, finally, the Hausman test (1978) examines the Random Effects model against the Fixed Effects model.

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After the selection tests, it is important to run diagnostics tests to identify violations in the chosen model, such as, for example, non-normality and cross-section dependence. For this purpose, the Jarque-Bera and the Pesaran test can be applied, to detect such problems and correct them so that the model does not lead to misinterpretations. Table 2 summarizes the main tests conducted in this study.

Table 2
Selection and diagnostic tests

Tests	Null hypothesis: H_0	Alternative hypothesis: H_1
F-Test	Pooled	Fixed Effect (FE)
Breusch-Pagan (LM)	Pooled	Random Effect (RE)
Hausman	Random Effect (RE)	Fixed Effect (FE)
Jarque-Bera	Data is normally distributed	Data is not normally distributed
Pesaran	No cross-section dependence	There is cross-section dependence

Source: Elaborated by the authors.

Regarding the issue of stationarity, although there are specific tests for panel data, Baltagi (2005) clarifies that such resources require panels of moderate size, with N between 10 and 250, and T between 25 and 250 periods. According to Mesquita, Fernandes, and Figueiredo Filho (2021), stationarity tests for panels are not usually efficient for short panels. Other authors also state that the unit root test is not relevant or necessary for panel models with T and N less than 25 (Sohag, Bamanga & Alam, 2018; Topcu, 2022).

Data analysis and empirical model

In addition to the variables of interest (Revealed Comparative Advantage Index and price), control variables (GDP and taxes on international trade) were applied in the model (Table 3).

Table 3
Data and expected results

Variables	Description	Expected relationship	Data Source
RCA_{it}	Revealed Comparative Advantage Index of countries i.	Dependent variable*	UN Comtrade database
$PRICE_{it}$	Price of soybeans exported by each country (i) to China[1].	(+)	UN Comtrade database
$TAXES_{it}$	Taxes on international trade for each country i.	(–)	World Bank Open Data
GDP_{it}	GDP of each country i.	(+)	World Bank Open Data

[1] Prices were obtained by dividing the total trade value by the total net weight.

Note: *Calculated by the authors following Equation (1), using data obtained from the UN Comtrade database.
Source: Elaborated by the authors

The period of analysis, from 2011 to 2021, was based on the availability of data. This eleven-year time frame allows us to achieve the proposed objectives and to analyze the relationships of interest over the last decade, a period marked by the expansion of the demand for soybeans by China, which increased 142% over the last thirteen harvests, according to Faverin (2024). This interval also includes relevant and recent global events, such as the Covid-19 pandemic. The empirical model is described as follows:

$$RCA_{it} = \beta_0 + \beta_1 PRICE_{it} + \beta_2 TAXES_{it} + \beta_3 GDP_{it} \quad (2)$$

Where: t represents time; i represents each of the six analyzed countries; 〖RCA〗_it is the Revealed Comparative Advantage Index of country i; 〖PRICE〗_it is the price of soybeans exported from each country i to China; 〖TAXES〗_it refers to taxes In exports for each country i; 〖GDP〗_it is the Gross Domestic Product of each country i; β_0 is the intercept; β_1,…,β_3 represent the parameters, and ε_ijt is the error term.

As for the expected relationships between variables, it is well known that price formation is established by the Law of supply and demand, which are the economic actors that play a leading role in price theory. According to Andrade e Palludeto (2019), the balance between supply and demand is obtained as prices adjust, so rising prices indicate a superior demand in relation to supply. The authors also explain that through the demand curve, it is possible to see the demand at each price, and the supply curve demonstrates how much agents are willing to offer at each price. Considering these dynamics, the relationship between competitiveness and price is expected to be positive.

Regarding the relationship between GDP and the RCA Index, it is assumed that the bilateral trade relationship between two economies is directly proportional to the GDP of both (Reis & Azevedo, 2008; Cordeiro, 2016). Therefore, we expect to find a positive sign for this relationship. Regarding the behavior of taxes on trade, which, according to the International Monetary Fund (IMF, 2014), encompasses obligations arising when goods cross the national borders (or customs) of any country, we expect a negative sign, as it usually represents a barrier to competitiveness.

Results and discussion

Revealed comparative advantages of China's main trading partners in the soybean market

The Revealed Comparative Advantage Index indicates that most of China's main trading partners in soybean transactions have comparative advantages in this market (RCA > 1). Among the six analyzed countries, only Russia presented an RCA < 1, that is, the country has a revealed comparative disadvantage for soybean exports. The evolution of the RCA Index over the analyzed period is illustrated in Figure 1.

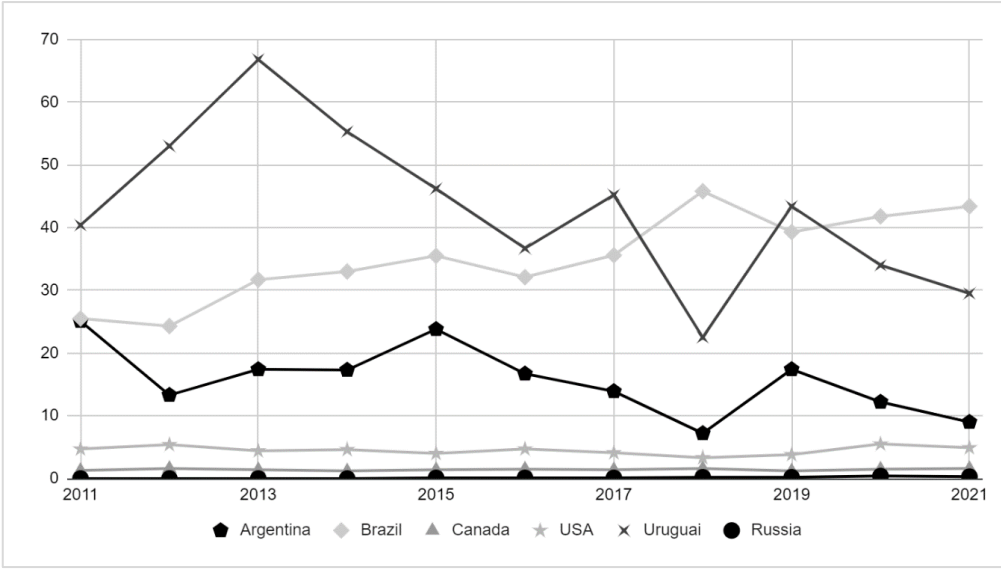

Figure 1. Evolution of the RCA Index of China's main trading partners in the soybean market (2011-2021).
Source: Elaborated by the authors.

It is evident that Uruguay, Brazil, and Argentina stand out in comparison to the other countries in terms of Revealed Comparative Advantages. The descriptive statistics on exports (Table 4) reinforce these results, as they evidence that these same countries have the highest proportions of soybean exports in relation to the total of goods exported in the analyzed period (14.1%, 10.5%, and 5.2%, respectively), which corroborates that soybeans have greater relevance in their export basket, compared to other countries. Another relevant finding from Figure 1 is that the RCA Index remained relatively stable for the

USA, Canada, and Russia, while for Brazil there is a positive trend over the years, which apparently was not affected by the pandemic, while the Mercosur neighbors showed a reduction during the same period. According to Mota (2021), Brazil did not feel the impacts of the pandemic as much as other global economies, in terms of its exports, especially of soybeans, which even increased between 2019 and 2020, due to the Chinese demand, that remained strong during this period.

Trade relations between Latin American countries and China have intensified in recent years, especially in the food sector, as shown by the Economic Commission for Latin America and the Caribbean (ECLAC, 2023). The "International Trade Outlook for Latin America and the Caribbean 2023" report also evidences that the partnership between Brazil and China stands out, as the country is the one that exports the most to China, in comparison to the others in the region, and it is also one of the few to present a trade surplus in exchanges with the Asian giant.

Table 4
Descriptive statistics on exports from the analyzed countries

Country	Country's soybean exports (US$) in relation to global soybean exports (US$)	Country's soybean exports (US$) in relation to its total export of goods (US$)	Country's soybean exports to China (US$) in relation to its total soybean exports (US$)	Price of soybeans exported to China by each country (US$/kg)
Argentina	5,9%	4.8%	84.5%	0.43
Brazil	42.5%	11.0%	74.1%	0.43
Canada	3.4%	0.4%	23.1%	0.47
USA	38.2%	1.4%	53.0%	0.46
Russia	0.3%	0.0%	78.1%	0.29
Uruguay	1.9%	13.4%	30.2%	0.43

Note: Data refers to the mean values for the period (2011-2021).
Source: Elaborated by the authors.

Data also shows that Brazil and the United States were the world's largest soybean exporters (responsible for 42.5 and 38.2% of total soybean exports, on average) in the analyzed period. Another relevant fact concerns the countries' trade relations with China. Of the total value of soybeans exported by Argentina, Russia, and Brazil, more than ¾ were directed to the Asian country (84.5, 78.1, and 74.7%, respectively, on average, in the period). The United States also directed most of its soybean exports to China (53.0%, on average), but in recent years this proportion has suffered reductions, possibly because of the trade war between the countries since the beginning of 2017.

Concerning the prices of soybeans exported to China, the results evidence that Argentina, Brazil, and Uruguay practiced similar prices during the period, as did the USA and Canada, something that can be explained by the geographical proximity between the countries, as well as the commercial blocs and

the relationships between them. Russia was the only country whose price differed from the others, with a significantly lower average value.

The role of price on the competitiveness of soybean exports to China

Following the proposed methodology, the first stage of the econometric exercise consisted of conducting tests to determine the most appropriate model. The results of the Breusch-Pagan and the Hausman tests indicate that the random effects model is recommended, while the F-test indicated the fixed effects model (Table 5).

Table 5
Test results for model selection

Test	p-value	Recommendation
Breusch-Pagan LM	0.0000	Rejects the null hypothesis indicating RE
Chow (F test)	0.0000	Rejects the null hypothesis, indicating FE
Hausman	0.7597	Do not reject the null hypothesis, indicating RE

Source: Elaborated by the authors.

Given the divergence, it was decided to estimate a random effects model, following the results of the Breusch-Pagan LM and the Hausman tests. Considering that the analysis was focused on eleven periods (2011-2021) and six countries and that it was possible to collect all the data, the estimated panel was balanced, with a total of 66 observations. Results are shown in Table 6.

Table 6
Summary of panel data regression results

Variable	Coefficient	p-value
Price	2.179578	0.0103
GDP	-1.693969	0.0344
Taxes	-0.143559	0.0000
Constant	23.66513	0.0156
	R^2: 0.654453	
	Adjusted R^2: 0.637459	
	Prob. (F-stat): 0.000000	
	Durbin-Watson stat: 1.653684	
	Jarque-Bera: 0.117702	
	Cross-section dependence test (Pesaran CD test): 0.9298	

Source: Elaborated by the authors.

The coefficient of 2.179578 indicates a positive and statistically significant relationship at the 5% level (p-value < 0.05) between the price of soybeans exported to China and the RCA Index of the analyzed countries, in accordance with the expected results. This means that the price charged for soybeans exported to China is relevant in determining the Revealed Comparative Advantage in the investigated commercial relations. This result is coherent, since, as mentioned previously, the price of commodities such as soybeans is determined internationally, mainly by the law of supply and demand; therefore, a rise in prices is often a consequence of increased global demand for the product in question, which, in turn, encourages the producing countries to further concentrate their productive efforts in this market, resulting in greater specialization. When analyzing the descriptive statistics of the time series (Table 4), this relationship also makes sense, given that the soybeans exported by Russia to China, for example, were the lowest priced, and even so, the country did not present Revealed Comparative Advantages, which suggests that competition through prices is not a sufficient factor to guarantee competitiveness in this case.

The negative relationship between taxes on international trade and the RCA also proved to be statistically significant at the 5% level and it is in line with the expected behavior. A negative relationship was naturally anticipated as the literature indicates that tax increases are a barrier to international trade. Regarding this issue of taxes, Ponciano and Campos (2003) explain that countries like Brazil, for example, are price takers in the international soybean market, therefore, internal factors, such as taxes, influence profitability and competitiveness. When analyzing the trajectory of the soybean market in Brazil and the United States, Proque (2019) attributes to the Kandir Law, which exempted export taxes on products such as soybeans in Brazil, the fact that the country has become one of the largest exporters of this commodity, which reinforces the role of taxes for competitiveness in this scenario.

As for the relationship between GDP and the RCA Index, it contradicts the expected result. A possible explanation for this lies in the fact that developing countries are highly dependent on the production and export of commodities. According to the United Nations Conference on Trade and Development (UNCTAD, 2019), South American countries such as Brazil, Argentina, and Uruguay are dependent on the export of agricultural products, and their economies are more susceptible to negative price shocks and market volatility. Regarding the GDP growth of developing countries that are commodity-dependent, the entity's report highlights that the majority have shown a slowdown in recent years or even recessions. When analyzing the time series used in the model, it is observed that the negative relationship between GDP and the RCA Index is coherent, although it was not expected, since Uruguay, for example, has the lowest GDP among the six analyzed economies, but it presented the highest RCA Index.

Regarding the adjustment of the estimated model, the coefficient of determination (R2) indicates that the independent variables explain 65.45% of the variations in the dependent variable, which can be considered satisfactory. The Jarque-Bera and the Pesaran CD tests confirm that there are no normality problems, nor correlation in errors between the cross-section units. With respect to autocorrelation, the Durdin-Watson statistic obtained (1.65) is in the test's indeterminacy zone , disallowing any conclusion in relation to the presence of serial autocorrelation of the error term. However, considering that the value is close to 2, the estimated model meets all the basic assumptions, and that the results are consisted, it suggests that autocorrelation is not an issue.

Conclusions

The present study sought to contribute to the literature on competitiveness in commercial relations between the main soybean suppliers to China, the world's largest importer of this important commodity. To this end, data on soybean exports from Argentina, Brazil, Canada, the United States, Uruguay, and Russia were analyzed between 2011 and 2019.

The results indicate that Brazil and the United States are the world's largest exporters of soybeans. Furthermore, it was observed that Argentina' Russia, and Brazil are China's largest trading partners in soybean transactions, directing more than 70% of their soybean exports, on average over the period, to the Asian country. Regarding the Revealed Comparative Advantage Index, the South American countries – Uruguay, Brazil, and Argentina stand out with the highest values for the historical series, and among the analyzed countries, only Russia presented a Revealed Comparative disadvantage.

The estimated econometric model showed that the price of soybeans exported to China is relevant to the behavior of the RCA Index of its trading partners, positively impacting their competitiveness. This finding suggests that countries with comparative advantages should pay greater attention to other factors that affect the competitiveness of their exports, rather than focusing only on price strategies and cost reductions, in line with results obtained by Topcu (2022), whose study analyzed the effect of price on the competitiveness of the furniture industry.

The results also indicate that the world's largest soybean exporters can benefit even more from the specialization in the production of this commodity, as they can obtain advantages from the capital generated through soy exports to invest in sustainable technologies in the soy production chain to increase their productivity and global socio-environmental responsibility, for example. Furthermore, this could generate income and several jobs downstream and upstream of the production chain, benefiting different regions. As argued by Ricardo more than 200 years ago, comparative advantages encourage people to work on what they are most productive at, which result in higher wages.

Although the results obtained here have been consistent, the estimated model is only an econometric exercise to identify possible relationships, and there are, therefore, some limitations that could be better explored in future studies. Other variables, in addition to price, could be included in the model, since competitiveness is a complex issue, which depends on different factors. It would also be interesting to conduct future analysis, when more data is available, to better understand the role of relevant, recent global events, such as the pandemic. Although our analyses included this period in the model, and demonstrated, for example, that Brazil increased its RCA during the pandemic, a more in-depth look is necessary for a better understanding of this incident. Furthermore, comparative studies looking at other agricultural commodities could provide more support to the results obtained by this research.

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