“Impacto del Comercio Agrícola con el MERCOSUR en el Estado de Seguridad Alimentaria de China”

“Impact of Agricultural Trade with MERCOSUR on the State of Food Security in China”

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Abstract

This paper aims to show that the exports of agricultural commodities from MERCOSUR countries to China has a significant effect in the state of food security in China. MERCOSUR countries have become key suppliers of several agricultural commodities for China, especially soybeans and beef. This suggests that MERCOSUR countries may have an important role in

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the provision of proteins to the Chinese population. We focus on two dimensions of food security in China: availability and access. We use lineal regression to show that the trade with MERCOSUR countries accounted for 8.2% of the total protein supply, or 10.42 grams per person per day, in mainland China, mainly due to trade in soybeans with Brazil. Then we use a cointegration model to prove that the international prices of soybeans are integrated across its main importers, China and the EU, and its main exporters, Brazil, the USA, and Argentina. This shows that there is stable connection between the international prices of this commodity, which has an effect on costs associated with food price stability policies in China. Finally, we use an IRF to find that Brazilian export prices of soybeans have a delayed and permanent effect on Chinese import prices of that commodity. A 1% increase in the soybeans exports price in Brazil can be expected to produce a 0.32% increase in the import price in China after one month and a 2.8% permanent rise after approximately 8 months. This findings will help inform policymakers and scholars in the field of food security and international trade in China and MERCOSUR.

Keywords: agricultural trade, food security, soybeans, horizontal price transmission, international passthrough

Resumen

Este artículo tiene como objetivo demostrar que las exportaciones de productos agrícolas desde los países del MERCOSUR hacia China tienen un efecto significativo en el estado de la seguridad alimentaria en China. Los países del MERCOSUR se han convertido en proveedores clave de varios productos agrícolas para China, especialmente soja y carne vacuna. Esto sugiere que los países del MERCOSUR podrían desempeñar un papel importante en el suministro de proteínas para la población china. Nos enfocamos en dos dimensiones de la seguridad alimentaria en China: disponibilidad y acceso. Utilizamos un modelo basado en regresión lineal para demostrar que el comercio con los países del MERCOSUR explica el 8,29% del suministro total de proteínas, o 10,42 gramos por persona al día, en China continental, explicado principalmente por el comercio de soja con Brasil. Luego, utilizamos un modelo de cointegración para demostrar que los precios internacionales de la soja están integrados entre sus principales importadores, China y la UE, y sus principales exportadores, Brasil, Estados Unidos y Argentina. Esto muestra que existe una conexión estable entre los precios internacionales de este producto, lo cual tiene un efecto en los costos asociados con las políticas de estabilidad de precios de los alimentos en China. Finalmente, utilizamos IRF para encontrar que los precios de exportación de soja de Brasil tienen un efecto retardado y permanente en los precios de importación de ese producto en China. Un aumento del 1% en el precio de exportación de soja en Brasil puede esperarse que produzca un aumento del 0,32% en el precio de importación en China después de un mes y un aumento permanente del 2,8% después de aproximadamente 8 meses.

Estos resultados ayudan a informar a las políticas y los estudios sobre seguridad alimentaria y comercio internacional en China y el MERCOSUR.

Palabras clave: comercio agrícola, seguridad alimentaria, soja, transmisión horizontal de precios, traspaso internacional de precios

1. Introduction

This paper seeks to explain the impact that trade with MERCOSUR countries has on the state of food security in the People's Republic of China, henceforth China. We will use descriptive statistics and analysis based on linear regression and cointegration in order to quantify the precise effect that trading agricultural commodities with MERCOSUR countries has had on food security in China. Our hypothesis is that agricultural trade between MERCOSUR and China has reached such volume that it has gained a significant role in the state of food security in China, that we seek to identify and measure. We expect to help inform policymakers and scholars in the fields of food security and international trade in both MERCOSUR countries and China.

China is one of the world's largest grain producers and is nearly self-sufficient in grain production. According to the OECD-FAO Agricultural Outlook report (2018), corn is the fastest-growing and most important cereal produced in China, followed by rice and wheat. However, the production of rice and wheat has shown slow growth in recent decades and is expected to remain relatively stable in the coming decade due to a variety of factors, while demand for animal feed is expected to continue growing. Thus, the proportion of cereals used in animal feed will decrease as more soybean meal is used, which relies on imports of raw soybeans. Between 2001 and 2018, soybeans accounted for 75.4% of China's total annual agricultural commodity imports, while rice and wheat together made up less than 6%.

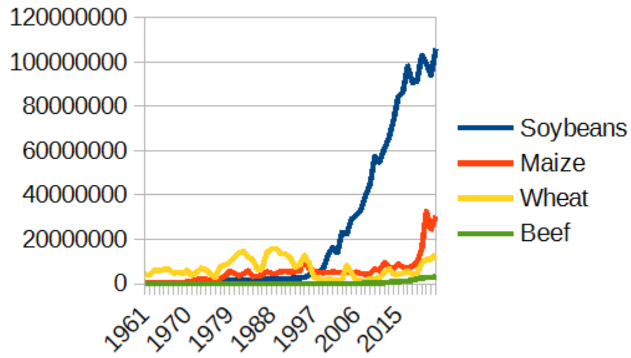
China faces significant challenges to its food security due to limited arable land and freshwater resources. Urbanization and industrialization have contributed to a steady decline in arable land, with China's per capita arable land in 2020 measured at just 0.09 hectares per person–0.17 hectares below the global average of 0.26 hectares. Similarly, China's per capita freshwater availability in 2020 was only 2,239.8 m^3, about one-fourth of the world average. Despite these challenges, the country has managed to keep a high level of food security and grain-sufficiency. Monitoring data from the National Health Commission in China show that the average daily energy intake per person in China has reached 2,172 kilocalories, comprising 65 grams of protein, 80 grams of fat, and 301 grams of carbohydrates. The 2021 China Agricultural Outlook Report (2022–2031) indicates that grain consumption was 31.617 million tons, while actual grain production reached 66.234 million tons, with a ration self-sufficiency rate of 197%. However, structural imbalances persist. While staples like rice, wheat, and corn are often oversupplied, high-quality wheat, specialty grains, and premium rice are undersupplied and require imports.

Also, in the last decades, urbanization has shifted dietary preferences from staple grains to protein-rich foods like meat, eggs, and dairy, creating a significant gap in the supply of protein feed grains. These imbalances between production, supply, and consumer demand present risks to future food security.

Over the past several years, maize and soybeans have played a crucial role in China's animal feed industry. Maize has been the dominant energy source for feed due to its high carbohydrate content, while soybeans have provided the essential protein necessary for poultry, pork, and dairy production. However, the balance between these two crops in feed formulation has been shifting due to changes in domestic supply, global trade relations, and government policies.

Maize has remained the backbone of China's feed sector. Historically, maize demand outpaced production, leading to substantial imports, particularly from the United States and Ukraine. However, since 2021, China has implemented policies to increase domestic maize cultivation and reduce dependency on foreign supply, leading to fluctuating import volumes. Soybeans have been heavily reliant on imports, such that the country has consistently accounted for over 60% of global soybean imports. The following graph 1 shows the trends in agricultural imports in China:

Graph 1: *Agricultural imports in China, in tonnes, from 1961 to 2023*



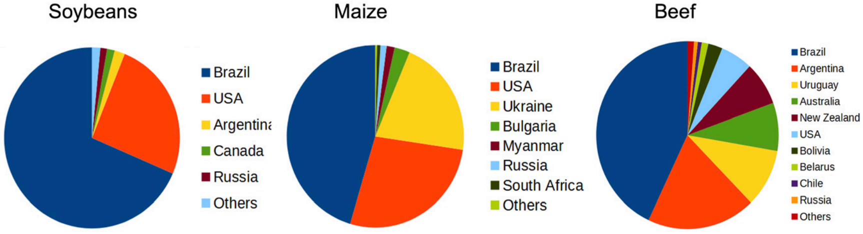
Source: FAOSTAT

We find that soybeans, and to a much lesser extent maize, have come to dominate Chinese imports of agricultural commodities. Because of competition over limited land, increasing demand for animal feed, and policies connected to food security, China has come to depend on foreign markets for their supply of soybeans. Furthermore, since 2018, trade tensions with the USA and concerns about food security have driven China to diversify its suppliers, relying more on Brazil while reducing purchases from the USA.

As mentioned, driven by rising consumption of meat, soybeans and maize are experiencing continuing growth. Per USDA, in 2023, China produced approximately 277.2 million metric tons (MMT) of maize. To meet its growing domestic demand, particularly for animal feed, China imported about 27.14 MMT of maize in 2023, an increase of over 30% from 2022. Notably, in 2023, China accounted for 18.2% of global maize imports, with significant purchases from Brazil and the United States.

Regarding soybeans, in 2023, China imported approximately 99.41 MMT, marking a 9% increase from 2022. Domestic production also increased moderately, up to 19.7 MMT. That year, Brazil was China's leading soybean supplier, accounting for an estimated 77.3 MMT, which represents 74% of China's total soybean imports. The United States follows, supplying 21 MMT and holding a 21% market share. The following graph 2 show the national sources for the main agricultural commodities imported in China:

Graph 2: *Agricultural imports of soybeans, maize, and beef in China by origin country, in 2023.*



Source: FAOSTAT

We can see that Brazil has become the biggest source of soybeans, maize, and beef in China. Other significant agricultural suppliers are the USA and Argentina, while others still are significant in individual items, like Ukraine in maize, and Uruguay, Australia, and New Zealand in beef.

To ensure food security, Chinese policies aim to maintain absolute grain self-sufficiency while expanding trade channels with diverse import sources. This strategy is particularly critical for soybeans and coarse grains, where domestic production lacks comparative advantages.

We find that today China has ensured its self-sufficiency in cereals such as wheat and rice. On the other hand, with respect to corn, it is beginning to have certain difficulties, which is why it is seeking to ensure supplies from foreign markets, as is the case of the Argentine market, which in 2024 China enabled imports from. A different case is in soybeans, a grain that is essential for the supply of protein, not only directly for human consumption (through industrial processes) but also increasingly essential for use as animal feed that is then consumed by Chinese consumers. For this particular case, China is heavily dependent on imports, especially from the United States, Brazil and Argentina. Initially, the United States was the main supplier of soybeans, however this changed radically, being surpassed by Brazil from the year 2013, a difference that was amplified after the so-called trade war between the USA and China.

The MERCOSUR countries, with Brazil at its head, strongly increased exports of other agricultural commodities to China. Currently, China is the main destination for exports of soybeans, beef, pork and other smaller agricultural commodities from MERCOSUR countries. The following table 1 shows recent volumes in agricultural trade between MERCOSUR and China:

Table 1. *MERCOSUR countries' agricultural exports to China*

Country	Soybeans (MMT)	Maize (MMT)	Beef (Metric Tons)	Other Key Commodities
Brazil	60-70	4-5	1,000,000+	Poultry, sugar, cotton
Argentina	6-8	1-2	500,000+	Soybean meal, soybean oil
Paraguay	5-6	0.5-1	100,000+	Wheat
Uruguay	2-3	<0.5	300,000+	Dairy, wool

Note: USDA estimates for the year 2021.

The trade volume of Brazilian exports to China is significantly larger than the other MERCOSUR countries. Their soybean exports to China have grown from approximately 5-10 MMT annually in the early 2000s to over 60 MMT in recent years, accounting for more than 70% of Brazil's total soybean exports; whereas their maize exports to China have surged in recent years, reaching over 4 MMT annually by 2022, as China diversified its import sources amid trade tensions with the United States. Brazil also exports significant quantities of beef, poultry, sugar, and cotton to China, with beef exports exceeding 1 million metric tons annually in recent years.

On the other hand, Argentina is also a major exporter of soybean products and maize, with a stronger focus on value-added products. Argentina is the world's largest exporter of soybean meal and oil, with China importing approximately 10-15 MMT of soybean meal annually. Raw soybean exports to China average 6-8 MMT per year; in addition, their maize exports to China have grown steadily, reaching 1-2 MMT annually in recent years; and it also exports beef, pork, and dairy products to China, though in smaller volumes compared to Brazil.

Next, Uruguayan soybean exports to China have grown significantly, reaching 2-3 MMT annually in recent years. China is Uruguay's largest beef market, with exports growing from around 50,000 metric tons annually in the early 2000s to over 300,000 metric tons in recent years. The country also exports dairy products and wool to China.

Finally, Paraguayan exports to China are routed through other countries, mainly Argentina, so there are no official precise numbers on them, however we may find approximate estimates in USDA and other sources. They estimate that Paraguay's soybean exports to China have grown from less than

1 MMT annually in the early 2000s to over 5 MMT in recent years; while their maize exports to China have increased to 0.5-1 MMT annually; and that Paraguay also exports beef and wheat to China, in modest volumes.

These increasing volumes of agricultural exports, mainly in soybeans, maize, and beef, from MERCOSUR countries to China lend support to our hypothesis that these trade links have a role in determining the state of food security in China, which we will elucidate with adequate empirical research.

2. Literature Review

Food security has had several contrasting definitions over time, but the most widely accepted definition today is the one produced in the 1996 World Food Summit that defined food security as a state "when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." Thus, food insecurity exists when people do not have sufficient physical or economic access to food. In contrast, food self-sufficiency is defined as the ability to meet consumption needs, particularly for staple foods, from a country's own domestic production rather than having to rely on importing or buying from non-domestic sources (minimizing dependence on international trade). Thus, food security exists irrespective of the domestic or international source of the available food, whereas self-sufficiency is centered on a country's ability to provide food security for itself. The definition of food security emphasizes four essential dimensions: availability, access, utilization, and stability, which together form the foundation of food security. Each of these dimensions highlights a critical aspect of what it means for a population to be food secure. In this paper, we will focus on the effect that trade from MERCOSUR has on the availability of food and its access, represented by its price.

Our analysis of the effects of food trade on local prices is grounded in the theoretical principles of the Law of One Price (LOP), first introduced by Marshall (1890), which is a cornerstone of economic theory. The LOP posits that the price of a single product will be identical in two markets that engage in trade, assuming no barriers such as tariffs or trade restrictions. This price alignment occurs because market participants capitalize on any price discrepancies in different markets to generate profit through trade. While local supply and demand conditions may create temporary price differences between regions, these gaps are eventually closed by market participants.

Arbitrageurs purchase goods in lower-priced markets, reducing local supply, and sell them in higher-priced markets, increasing supply there. This adjustment process places upward and downward pressure on prices in the respective markets, ultimately driving them toward equality in the long run. For a comprehensive discussion of the LOP, refer to Fackler and Goodwin (2001).

When prices are internationally transmitted by the effect of the LOP, this is called price passthrough. Kenen and Pack (1980) provide an extensive analysis of the passthrough of global prices to domestic markets, focusing on imports. They attribute incomplete passthrough rates to demand elasticities, suggesting that unitary elasticity results in delayed, but full, price transmission in the long run. In contrast, Kirchgassner and Kubler (1991), also examining imports, argue that incomplete passthrough is influenced by market structure. This aligns with other studies that also link pricing power to incomplete price transmission (Guvheya et al., 1998; Taylor, 2000; Miller and Hayenga, 2001).

Liu et al. (2018) study price passthrough in China and find that China's Eastern regions, characterized by greater integration with international trade, are notably influenced by global market dynamics. The study reveals that price fluctuations in these areas are strongly shaped by trends in international markets. This heightened exposure to global trade contributes to increased price volatility in the Eastern provinces, resulting in less stable price levels and weaker convergence with those of other regions within China.

Focusing on soybeans, Coughlin and Sutton-Vermeulen (2020) use simple correlations to analyze the price passthrough of this commodity in China and other countries. Among other results, for the purpose of our study, they find that there is price transmission between Chinese and Brazilian soybean prices, which strengthens during Brazil's export season. The long-term connection between the Dalian Spot Cash price in China and a combined FOB U.S. Gulf/FOB Brazil price indicates that, under normal market conditions free of trade disruptions or supply/demand shocks, the Chinese benchmark closely tracks prices from the dominant export origins, ie. American and Brazilian prices during each of their harvest seasons. Over the past decade, the correlation between Chinese soybean prices and seasonally-adjusted export prices has averaged around 82%.

Other authors also provide evidence for a strong passthrough effect in soybeans prices in Brazil, the USA, and China. Machado and Margarido (2001) and Mafioletti (2001) provide further evidence of rapid or instantaneous price transmission in the soybean market, indicating high market efficiency.

Finally, focusing on the price transmission dynamics in the global soybean market during the US-China trade war, Barboza Martignone, Behrendt and Paparasthe (2022) examined price relationships across key players in the soybean trade, including China, the USA, the European Union, Brazil, and Argentina. The authors apply various econometric methods, including cointegration analysis, to evaluate how the trade war influenced market integration and efficiency. Their findings reveal that the global soybean market remains highly efficient and cointegrated, with prices across regions moving together over time. Despite disruptions caused by the trade war, such as tariffs and subsidies, the market demonstrated a high degree of integration and price transmission, reaffirming the validity of the LOP in the long term. The study emphasizes the international soybean market's ability to adjust and realign prices and maintain market efficiency, even during periods of geopolitical instability.

We find that the literature lends support to our hypothesis that MERCOSUR countries may hold influence over the price of food commodities in China. We can expect Brazil to have a significant, measurable effect in the prices of soybeans in China.

3. Empirical Models

We will approach the question of the effect of agricultural trade with MERCOSUR on Chinese food security from two different angles. On the one hand, we will attempt to quantify precisely how much of the protein intake of the Chinese population can be attributed to the agricultural trade with MERCOSUR. For this, we will use a linear regression model, which will consider the effect of the total supply of maize and soybeans on the protein supply in order to produce conversion rates of these commodities into the nutrition of the Chinese population. Then we will apply those conversion rates to the maize and soybeans quantities traded from MERCOSUR countries to China, in order to produce the amount of protein that MERCOSUR countries supply to the people of China, by way of trade of soybeans and maize.

Next, we will attempt to identify the influence that the agricultural trade with MERCOSUR countries has had on food prices in China. For this, we will use a cointegration model that puts together the international prices of the major exporters of soybeans, that is Brazil, the USA, and Argentina, with those of the major importers, China and the EU. The purpose of this model is to identify price transmission between Brazil and Argentina on the one side and China on the other. One limitation of this model is that it does not connect the imports price in China to the local domestic price accessible to the Chinese population, which is a better measure to study food security. However, internal prices are heavily regulated in China, so it is likely such a model would yield little useful information. Instead, this model will help elucidate the connection between the international prices of soybeans in MERCOSUR and China, which has a role in the costs associated to Chinese policies on price regulation. This kind of cointegration model could be applied to maize and beef as well, not just soybeans, however these commodities are exported in relatively small quantities by MERCOSUR countries to China, and this precludes the possibility of a significant influence by way of trade.

The linear regression model will be used to quantify the effect that the availability of soybeans and maize in China has on the protein supply in that country. It is grounded on the fact that these two crops constitute the vast majority of animal feed used in China, which in turn is the main source of protein for the Chinese population. Once we quantify the effect of maize and soybeans in terms of protein supply, or the conversion rates for these crops into protein supply, we may estimate the effect of MERCOSUR exports of maize and soybeans to China by way of increased supply.

The first step is thus to outfit a model that may clarify the relation between total availability of these crops and protein supply in China. The dependent variable is protein supply as reported by FAO, available in series of 3-year moving averages centered in the years 2000 to 2022. For the independent variables, total availability of maize and soybeans will be calculated by adding the local Chinese production together with the imports of these crops in China and subtracting that country's exports.

Once the time series for total available maize and soybeans in China are produced, they can be tested for stationarity. We expect these series not to be stationary but to contain unit roots. If they do, the next step is to take the first difference of these series in order to make them suitable for incorporation in models of lineal regression analysis.

The last variable to include will be a control variable for the economic growth of China, which can also have an effect in protein supply by way of other imports and production of minor sources of protein. The control variable chosen for this purpose is GDP per capita of China.

It is important to note that the relatively low amount of observations (23) does not allow for the incorporation of more commodities or control variables that might make for a more refined model. Still, these variables suffice for our purpose. The model produced then takes the form:

$$\Delta\textbf{Protein Supply} = \beta_0 + \beta_1\Delta\textbf{Soybeans} + \beta_2\Delta\textbf{Maize} + \beta_3\Delta\textbf{GDP per capita} + \varepsilon$$

The model will then tell us the effect that total available maize and soybeans in China have on the supply of proteins, measured in grams per person per day, in that country. β_1 and β_2 are thus the conversion rates between maize and soybeans to protein uptake in China. Once they have been calculated we may multiply β_1 by the amount of soybeans exported from MERCOSUR countries to China in order to calculate the exact amount of protein supply in China that can be explained by the trade of soybeans with MERCOSUR. We may do similarly with β_2 to calculate the same for maize. We may then add the results together to find the total amount of protein supply in China that is generated from trade in agricultural commodities with MERCOSUR countries. This is valuable input to inform our understanding of the effect of agricultural trade with MERCOSUR in the food security in China.

The results are likely to underestimate the true value, because they do not include the direct trade of beef and soybean meal from MERCOSUR countries to China, which are other, more direct, sources of protein. We will assume that this underestimation is not significant, owing to their low ratio to local production. We did not run this model on soybeans meal or beef because their traded amounts are not as significant, and because the effect of soybeans and maize into protein supply occurs partly through these other variables, such that their inclusion would yield misleading results for soybeans and maize. Furthermore the data set is relatively short, so it is preferable not to include too many variables.

The data set was obtained from FAOSTAT and it describes the production, imports and exports of soybeans and maize, in tonnes, in China from 1961 to 2023, as well as additional data for protein supply and GDP per capita.

The other model included in our empirical research is a cointegration model. The purpose of the cointegration model is to test the effect of the exports of agricultural goods from MERCOSUR countries into China in terms of the international price of soybeans in China. We will analyze the transmission of price information in soybeans from the MERCOSUR countries into China, which will reveal whether there is an influence of Brazilian and/or Argentinian on Chinese soybeans prices. Per the LOP, we should expect this effect to be statistically significant and measurable.

For this purpose, we will fit a Vector Error Correction Model (VECM) model including the FOB prices of the major exporters of soybeans, Brazil, Argentina, and the USA, and the CFR prices of the major importers, China and the EU. Models of cointegration, like VECM, are extensions of VAR models that attempt to identify a long-run equilibrium connecting the variables under study, as well as short-term correlations between them. The long-run trend is represented by one or more cointegrating vectors, that are produced as the residuals of a lineal regression of the level form of the variables. Despite the variables being non-stationary in level form, the residual does not carry a unit root as long as the variables are cointegrated, or follow a similar long-term trend. The vector of residuals is then included into a VAR together with the variables in first difference form. By taking the first difference, the unit roots are removed from them. Thus, the cointegrating vectors and the variables in difference form are all made stationary, and they may be analyzed with standard lineal regression techniques. In this VAR model, the cointegrating vector informs about long-run connections while the differenced variables inform about short-run correlations among the variables included in the model.

Thus, for our purposes, the VECM would take the form:

$$\Delta PRICE_t = \Pi \cdot ECT_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta PRICE_{t-i} + \epsilon_t$$

Since this is a VAR configuration, the variables in the formula are actually vectors of variables and the Greek letters stand for vectors or matrices of coefficients:

- PRICE is a vector of the five time-series of prices of soybeans employed: Chinese CFR prices, European CFR prices, Brazilian FOB prices, American FOB prices, and Argentinian FOB prices.
- ECT is the error correction term, or the cointegrating vector that captures the long-run equilibrium among the prices.
- Π is a 5×1 vector of coefficients of long-run adjustment, indicating how each price responds to deviations from equilibrium.
- Γ is the matrix of short-run coefficients, measuring correlations between differenced price variables for a set number of lags.
- ε is the vector of error terms.

For the VECM model to be stable, or to represent a long-run relationship in equilibrium, the coefficients in the Π vector must be significant and have a negative sign, which represents that variables in the long-run tend to fall back into each other, or that they do not diverge permanently. This is because the ECT represents a fraction of their difference, thus the variables must behave in the opposite direction that the ECT is taking, in order for them to sustain a long-term equilibrium.

For this model, we will use the log form of the price variables. This is because it will allow us to read the resulting coefficients as elasticities. We must consider this when interpreting the results. The short-run coefficients in the Γ matrix will represent percentage changes, or the way price changes correlate with each other within the specified lag length.

The VECM will allow us to prove that there is price transmission in the long run, if all the prices included in the model have significant, negative Π coefficients; and furthermore, it will reveal whether there is any short-term transmission occurring between Brazil and Argentina on the one side and China on the other. The USA and EU prices have to be included in the model or we would incur a high chance of missing-variable bias. On the other hand, Uruguay and Paraguay were not included in the model because their relatively small traded quantities preclude the possibility of a price transmission effect.

One following step can be undertaken to further clarify the relation between the variables under study. An Impulse Response Function (IRF) can follow a VECM. It is a tool used to analyze how a shock to one variable affects the other variables over time. When a change, or shock, occurs in one variable, the IRF traces the impact of that shock on all other variables in the system across multiple time periods. This allows us to understand the transmission of shocks and how long it takes for variables to stabilize.

The IRF is calculated by recursive substitution of a reduced-VAR form of the VECM equation to produce an MA representation:

$$PRICE_t = \sum_{j=0}^{\infty} \Psi_j \epsilon_{t-j}$$

Where Ψ_j is a matrix representing the effect of a shock in one price at time t into all other prices at an arbitrarily selected number of lags, represented by j. The width of this matrix is given by the length of the vectors of variables, in this case 5, and its length is given by j. From this Ψ_j matrix we may obtain the response of one price variable to a shock originating in another price, called the impulse.

The interpretation of an IRF depends on both the magnitude and the direction of the response. If a shock in one variable leads to a temporary change in another that gradually fades, this suggests a short-term effect without long-term consequences. Conversely, if the response persists, it may indicate a more fundamental relationship between the variables. In a VECM framework, this distinction is particularly important because the model accounts for long-run equilibrium relationships, meaning that some shocks may cause permanent shifts, while others may be corrected over time. Finally, we may produce an IRF graph which visually represents this dynamic adjustment process, showing how the variables react period by period until stability is restored.

For the cointegration and IRF, we used international prices obtained from USDA publications. All the models described will be resolved by use of STATA 11.

4. Results

The ADF test for stationarity results show that all the variables to be used in both models contain a unit root. We considered this when fitting the models for empirical analysis.

The results of the linear regression model are summarized in the following table 2:

Table 2. *Linear regression results*

	Coef.	Std. Error	t	P>z	95% Confidence Interval	
ΔMaize	0.00000 00740	0.00000 00353	2.09	0.050*	0.00000000 00650	0.000000 148
ΔSoy-beans	0.00000 0142	0.00000 00676	2.10	0.050*	0.00000000 0143	0.000000 284
ΔGDP_ per_cap	0.00347 66	0.00113 75	3.06	0.007***	0.0010868	0.0058664
P>F	0.0001					
Adj. R2	0.6162					

Note: The dependent variable is ΔProtein_Supply. Stars for level of significance.

The results tell us that for every tonne of available maize in mainland China during the period 2000 to 2022, protein supply increased by 0.0000000740 grams per person per day, whereas soybeans available in mainland China in this period increased protein supply by 0.000000142 g/cap/d.

We may use these numbers multiplied by the quantities of imported soybeans from MERCOSUR to obtain the amount of protein supply in mainland China that can be attributed to the trade of maize and soybeans with these countries. These results are summarized in the following table 3:

Table 3. *Protein supply*

Source Country	**Crop**	**Imports Quantity (tonnes)**	**Protein Supply (g/cap/d)**
Brazil	Soybeans	64277600	9.127
	Maize	71.98	0.000005
Brazil total			**9.127**
Argentina	Soybeans	7455650	1.058
	Maize	0.3	0.00000002
Argentina total			1.058
Uruguay	Soybeans	1656570	0.235
	Maize	-	-
Uruguay total			0.235
Soybeans total		73389820.08	10.421
Maize total		72.28	0.000005
MERCOSUR total			10.421

Note: Maize and soybeans imports quantities, protein supply levels, and percentage over total protein supply. Year 2020.

We may additionally use those results to consequently calculate the percentage over total protein supply that these amounts represented for the year 2020. The results show that:

- The trade of soybeans and maize with MERCOSUR countries explains 8.29% of the total protein supply, or 10.42 grams per person per day, in mainland China in the year 2020.
- These results are almost exclusively in the trade of soybeans, whereas the trade of maize has a negligible effect.
- The main contributor is Brazil, with 9.12 g/cap/d or 7.26% of total protein supply; followed by Argentina with 1.05 g/cap/d or 0.84% of the total; and finally Uruguay with 0.23 g/cap/d or 0.18% of the total.
- Paraguay does not officially trade with China directly, its harvest is routed mainly through Argentina, so some of the results attributed to Argentina in the model must actually come from Paraguay, but there is no reliable way to make that distinction.

The following model, a VECM, connects the exports prices of Brazil, Argentina, and the USA to the imports prices of China and the EU. It was ran at 4 lags as per the results of an AIC test. The results for China are in the following table 4:

Table 4. *VECM results for China.*

	Coef.	St. Err.	z	P>z	95% Confidence Interval	
Coint. vector	-0.025	0.015	-1.70	0.088*	-0.055	0.003
ΔUSA - lag 1	0.204	0.038	5.30	0.000***	0.128	0.28
ΔUSA - lag 2	0.058	0.041	1.39	0.165	-0.023	0.14
ΔUSA - lag 3	-0.085	0.040	-2.10	0.036**	-0.166	-0.005
ΔBrazil - lag 1	0.048	0.044	1.09	0.274	-0.038	0.134
ΔBrazil - lag 2	0.066	0.042	1.57	0.116	-0.016	0.15
ΔBrazil - lag 3	0.136	0.043	3.15	0.002***	0.051	0.221
ΔArgentina - l1	-0.006	0.049	-0.13	0.893	-0.104	0.091
ΔArgentina - l2	-0.034	0.049	-0.70	0.484	-0.13	0.061
ΔArgentina - l3	-0.073	0.051	-1.44	0.151	-0.174	0.026

ΔEU - lag 1	0.04	0.043	0.94	0.347	-0.044	0.125
ΔEU - lag 2	0.193	0.042	4.50	0.000***	0.109	0.277
ΔEU - lag 3	0.073	0.044	1.66	0.097*	-0.013	0.16
ΔChina - lag 1	0.166	0.059	2.78	0.005***	0.049	0.283
ΔChina - lag 2	0.172	0.055	3.13	0.002***	0.064	0.28
ΔChina - lag 3	-0.013	0.042	-0.32	0.747	-0.097	0.069

Note: Dependent variable is difference in logs of Chinese CIF price of soybeans. Stars for level of significance.

The results show that:

- Chinese prices are integrated with those of the rest of the world, specifically the USA, the EU, Brazil, and Argentina, which means that there is a long-run balance that keeps these prices close to each other without major permanent deviations. This is shown by the statistical significance and negative sign of the coefficient for the cointegrating vector for Chinese prices as well as for the other prices in the model, not shown here.
- We find that the influence of Brazilian prices is not as strong as that of American and European prices. Whereas these two regions are significant in two out of the three lags considered, Brazil is only significant in one, and further their coefficients are higher than the Brazilian one. This is surprising given the fact Brazil has become the largest exporter of soybeans to China since 2013. It shows that American prices are still used as reference prices by Brazilian and Chinese traders. On the other hand, the connection with European prices makes sense, since the EU and China compete directly for imports of soybeans, so the LOP is in full effect between them.
- Furthermore, Argentinian export prices do not directly affect Chinese prices. This can be explained by the relatively low quantities of Argentinian exports of this product compared to Brazil and the USA. It could also be explained by the high degree of collinearity between Argentina and Brazil, since their seasonal patterns are closely aligned, however removing Brazil from the model does not affect these results.

Since we have established that Brazilian exports prices of soybeans do have an effect over Chinese imports prices of this commodity, we may outfit an

Impulse Response Function (IRF) to gauge this influence over time. Doing so yields the results summarized in the following table 5:

Table 5. *IRF results.*

lags	IRF	Lower	Upper
0	0.00161	-0.000349	0.00357
1	0.00329	0.000469	0.00612
2	0.00765	0.00366	0.0116
3	0.0147	0.00862	0.0207
4	0.0222	0.0137	0.0307
5	0.025	0.0143	0.0358
6	0.0265	0.0135	0.0394
7	0.0271	0.0123	0.0419
8	0.0279	0.0114	0.0443
9	0.0284	0.0104	0.0463
10	0.0286	0.0095	0.0478

Note: Impulse is changes to Brazilian FOB prices of soybeans, response is Chinese imports prices.

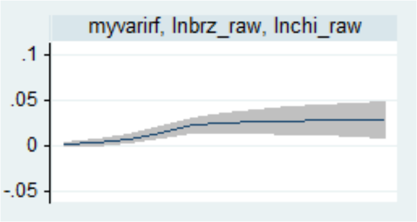
The results show that:

- The immediate effect of changes in Brazilian prices is not significant. We see this because lag 0, representing immediate transmission, is not statistically significant since its 95% confidence interval includes the value 0.
- The effect is significant starting with one lag, that is a one month difference, where a 1% increase in Brazilian prices can be expected to produce a 0.32% rise in Chinese imports prices.
- The effect grows exponentially through lags 2 and 3, then begins to taper off and stabilizes after approximately 8 lags at a 2.8% rise in Chinese prices. This tells us that a 1% increase in Brazilian exports prices of soybeans can be expected to produce a permanent increase in Chinese imports prices of this commodity of approximately 2.8% after 8 months.

This suggests a strong and persistent price transmission effect from Brazil to China.

These results are visible in the following IRF plot:

Graph 3. *IRF graph. Impulse is Brazilian prices and response is Chinese prices*



5. Conclusions

We have shown that Brazil has become a key supplier of every major agricultural commodity imported by China. This includes soybeans, maize, and beef. Argentina is also an important supplier of soybeans and beef, and Uruguay is significant in beef.

Furthermore, by use of descriptive statistics and empirical research based on lineal regression and cointegration, we find support for our hypothesis that trade with MERCOSUR countries has a significant role in the state of food security in China. To be precise, our research shows that by the year 2020, the trade with MERCOSUR countries explained 8.29% of the total protein supply, or 10.42 grams per person per day, in mainland China, explained mostly by the trade of soybeans. Trade with Brazil explains the majority of this effect, or around 87% of the available proteins in China that can be attributed to agricultural trade with MERCOSUR countries.

Finally, Brazilian exports prices of soybeans have a direct impact on Chinese imports prices of that commodity. This impact on prices is delayed, not immediate, but it is permanent, starting at one month with a 0.32% rise in Chinese imports prices after a 1% change in Brazil, and growing exponentially until it stabilizes after approximately 8 months at a 2.8% rise in Chinese prices for a 1% change in Brazil.

Our research is based on official data and robust econometric techniques. It is possible though that it underestimates the true amounts of protein available in China owing to trade with MERCOSUR because it does not consider direct imports of beef and soybeans meal. Also, it does not consider the domestic passthrough on food prices, but rather imports prices which only have an effect on the costs associated with price stabilization policies, but not on food security per se. These are limitations owing to the structure and size of the data employed for the research. As agricultural trade continues and the data set expands, we may address some of these limitations. Others will require an expanded set of variables and a different approach to answer the question.

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