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Analysis of Non-Tariff Measures Imposed by China and the United States on Brazilian Meat Complex Exports

Análise das medidas não-tarifárias praticadas por China e Estados Unidos sobre as exportações brasileiras do complexo de carnes

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Abstract: This study investigates the extent to which non-tariff measures (NTMs) imposed by China and the United States have affected Brazil's meat complex exports between 2011 and 2022. Using coverage ratio and frequency index, the analysis quantifies the proportion of Brazilian meat exports subject to NTMs and compares the relative incidence across these two major trading partners. The results indicate a high concentration of trade barriers in this segment, with a larger number of notifications originating from China.

Keywords: Non-tariff measures; Brazilian meat complex; Coverage ratio and frequency index; Dispute Settlement Body; China and the United States.
JEL Classification: F13, Q18; H71

Resumo: O objetivo deste trabalho é analisar a incidência de medidas não-tarifárias impostas por China e EUA sobre as exportações brasileiras dos principais produtos do seu complexo de carnes. A partir do cálculo dos índices de cobertura e de frequência para o período que compreende os anos de 2011 a 2022, realiza-se uma verificação da proporção destas medidas não-tarifárias sobre o montante exportado. Os resultados revelam uma quantidade significativa de notificações de barreiras ao comércio praticadas por China e EUA sobre este segmento brasileiro, porém, em maior proporção por parte dos chineses.

Palavras-chave: Medidas não-tarifárias; Complexo de carnes do Brasil; Índices de cobertura e frequência; Órgão de Soluções de Controvérsias; China e EUA.
Classificação JEL: F13, Q18; H71

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1. Introduction

Several specialized bodies under the World Trade Organization (WTO)—including the World Organization for Animal Health, the Codex Alimentarius Commission, and the International Plant Protection Convention—help regulate and facilitate trade among its 164 members. Based on the principle of fostering sound relations among nations, the organization created the Dispute Settlement Body (DSB), whose main purpose is to mediate and resolve trade conflicts between WTO members (Varella, 2009).

The DSB was introduced during the Uruguay Round and allows for the opening of discussions that may or may not result in "sanctions" for countries found in violation of trade agreements. The body also acts in monitoring and supervision, ensuring that its decisions are effectively implemented. The disputes addressed by the DSB generally involve breaches of trade agreements. A typical example includes cases of dumping or other forms of unfair trade practices considered violations of international market rules. Once a case is brought forward, a procedure similar to a trial takes place, in which the parties involved discuss ways to resolve the dispute (Martins, 2002; Varella, 2009).

A case in point involves China, which, according to Ansanelli and Barros (2020), has treated Brazilian products unfavorably by imposing a large number of technical and sanitary notifications on agricultural exports from Brazil. This type of trade dispute falls under the jurisdiction of the DSB. In 2018, for instance, Brazil filed a complaint with the body, arguing that the non-tariff measures (NTMs) imposed by China on Brazilian agricultural products were excessive.

Alongside Brazil and China, the United States is also recognized as a major player in international trade, particularly due to its extensive use of production subsidies. Because of this characteristic, the U.S. is likewise highly active in the DSB's dispute settlement mechanism. As Bruno, Azevedo, and Massuquetti (2012) point out, subsidies represent government interventions in specific economic activities, essentially involving the transfer of funds to producers or consumers. However, these authors warn that excessive use of such policies by developed nations can distort international trade and negatively affect market dynamics.

Agribusiness, in turn, is a sector of great importance to the Brazilian economy. In addition to its strong grain production and exports, Brazil also stands out in livestock production and meat exports. The country ranks among the world's largest producers and consumers of meat, just behind the United States and China. Although both are major global producers, China and the United States also import Brazilian meat. In China's case, this demand reflects rising income levels and population growth, while in the United States, imports are driven mainly by the recognized quality of Brazilian meat, which benefits from favorable climatic and territorial conditions (Embrapa, 2023).

In 2016, Brazil's meat complex accounted for roughly 20% of the global market. Between 1994 and 2016, the country's agricultural sector recorded remarkable expansion, with production rising by 85.2% for beef, 161.7% for pork, and 284.9% for chicken. From 2000 to 2020, Brazil's share in the global meat market averaged 8.8%, reaching 9.2% in

2020 and positioning the country as the world's third-largest producer. In the same year, Brazil accounted for 13.4% of global meat exports, ranking just below the United States (Embrapa, 2023).

According to the Brazilian Association of Meat Exporting Industries (ABIEC – *Associação Brasileira das Indústrias Exportadoras de Carnes*, 2023), from June 2022 to May 2023 China was Brazil's largest importer of beef, representing 58.25% of the total exported by the sector. The United States ranked second, accounting for 5.89%. Regarding chicken exports, Brazil shipped 4.3 million tons in 2020—around 20.9% of total global production—generating US$6.6 billion in revenue. As for pork, Brazil ranked fifth among global producers, also showing consistent growth over the past decades, with revenues of US$1.6 billion in 2020 (Embrapa, 2023).

Given this context, the purpose of this study is to analyze the incidence of non-tariff measures imposed by China and the United States on Brazilian exports of beef, pork, and poultry, considering the intensive use of such trade instruments by these countries. By estimating coverage and frequency indices, the study measures the extent to which these NTMs affect the selected products and identifies the penalties applied by the DSB in each case. The measures considered are those related to food safety, public health, product safety, and environmental protection.

The Brazilian literature includes several studies on the imposition of NTMs on specific items of the country's meat complex, such as Viégas (2003), Bellonia and Silva (2007), Mendes, Coelho, and Campos (2009), Rubin, Ilha, and Lopes (2012), Ansanelli *et al*. (2018), and Ansanelli and Barros (2020), among others. This study advances this discussion by adopting a broader approach that considers the three main products of Brazil's meat complex and examines their trade relations with China and the United States—two major global players and strategic trade partners for Brazil. Furthermore, Ansanelli and Barros (2020) emphasize that developing countries have been facing an excessive number of technical, sanitary, and phytosanitary regulations on their agricultural exports, reinforcing the need for studies that quantify the magnitude of such practices, which undermine the comparative advantages of primarily export-oriented economies such as Brazil's.

Overall, the results show that the NTMs imposed by China cover roughly half of Brazil's meat complex exports to that country—a proportion twice as high as that observed for the United States. The study also reveals the excessive use of NTMs by China, especially concerning beef exports. Despite numerous notifications submitted against China for these practices, only four penalties were recorded during the period under analysis, all related to the poultry sector, raising questions about the effectiveness of the WTO's Dispute Settlement Body in curbing the misuse of trade barriers.

To achieve the proposed objectives, the paper is organized as follows. Section 2 discusses the concept of non-tariff measures and the role of the Dispute Settlement Body. Section 3 examines the structure and relevance of Brazil's meat complex. Section 4 presents the methodological procedures, while Section 5 reports and discusses the results of the coverage and frequency index analysis. Finally, the study offers concluding remarks.

2. Non-Tariff Measures and the Dispute Settlement Body

Non-tariff measures (NTMs) are any public measures other than customs duties, such as phytosanitary measures, voluntary export restraints, import licensing regimes, or export subsidies (Krugman; Obstfeld, 2015). According to Viegas, Jank, and Miranda (2007), they may have either negative or positive effects on the market, as they directly or indirectly influence both the country imposing them and the one subject to their imposition. Consequently, such practices can affect prices and quantities and may generate distortions in trade, production, consumption, income, employment, and welfare.

Sanitary and phytosanitary measures are examples of NTMs that, in principle, aim to preserve and ensure that products do not negatively affect human, plant, or animal health. These measures are essential for maintaining quality control over traded products and are therefore often justifiable and necessary when properly applied (Mendes; Coelho; Campos, 2009).

Although there are valid reasons for the use of NTMs, in some cases these measures are employed for protectionist purposes. To prevent such practices, the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) was established to ensure that the adoption of these measures is scientifically justified. The World Trade Organization allows new measures to be created or maintained, provided that they follow established standards and that the organization is notified to justify their necessity. Nevertheless, these NTMs may still alter market prices and, consequently, harm international trade (Mendes; Coelho; Campos, 2009).

Complaints filed by countries that consider themselves harmed by the commercial practices described are submitted to the World Trade Organization's Dispute Settlement Body (DSB). According to Thorstensen and Oliveira (2014), the dispute settlement system incorporates two legal traditions: Common Law and Civil Law. In Common Law, the guiding principle is that cases should be developed based on the decisions of judges and courts, whereas Civil Law is characterized by a set of codified rules that judges are required to follow. This framework aligns with the General Agreement on Tariffs and Trade (GATT) tradition, under which decisions are made by consensus and can be changed only through a shift from positive to negative consensus, meaning that members must oppose the rule or precedent for it not to take effect.

According to Varella (2009), the Dispute Settlement Body (DSB) carries out its activities in three main stages. The first consists of consultations between the litigating members in an attempt to reach an amicable solution through conciliation and mediation. If no agreement is reached, the complaining country requests the establishment of a panel. The second stage begins once the panel is formed, initiating the procedure within the DSB. At this point, the parties jointly appoint three to five experts, whose work must be completed within a maximum of six months. If one of the parties is dissatisfied or if noncompliance is found, the case may proceed to appeal. In such cases, the third stage involves the Appellate Body, where a final decision is issued. This body is composed of seven judges who must decide whether to modify or reverse the contested practice within

a maximum period of 90 days. Under these conditions, the country still has the right to appeal the ruling; however, it has a maximum of 15 months to comply with the decisions set forth in the report (OMC, 2022).

Da Silva (2006) associates the DSB with the concept of sovereignty, as this is one of the topics that most often generates conflict. According to the author, some researchers argue that Brazil's participation in this type of foreign institutional structure is undesirable, as it may be interpreted as a form of submission that undermines national sovereignty. Others, however, do not regard the body's role as a threat to sovereignty, contending instead that it performs a regulatory function in international relations, adapting to the country's specific needs.

Despite these conflicting views, it is important to recognize that law exists as a means of regulating relations and can be shaped according to the specific needs of each context. In this regard, Rage (2013) highlights the WTO's inability to strictly enforce its decisions, since it cannot impose its directives on member states through direct sanctions. Such interference could infringe upon a nation's sovereignty; however, the organization may authorize retaliatory measures against those that violate its rules.

The use of unfair trade practices is directly related to the DSB. According to Falasque Junior (2018), the use of unfair market mechanisms and the establishment of defense measures are regulated by three agreements: the Anti-Dumping Agreement (ADA), the Agreement on Subsidies and Countervailing Measures (ASCM), and the Agreement on Safeguards. Noncompliance with these agreements may result in disputes brought before the DSB.

According to the WTO (OMC, 2022), as of December 2021 there were 607 cases pending resolution, involving 52 members as complainants, 61 as respondents, and 90 as third parties in proceedings—totaling 111 members participating directly or indirectly in these cases. Given the nature of the DSB, it is evident that several countries have resorted to this body over the years—either as complainants or respondents—in pursuit of favorable outcomes to their trade disputes. Among them, Brazil stands out, along with one of its largest trading partners, China, which plays an active and consistent role within the organization.

Based on WTO (OMC, 2022) data, it is possible to observe that these two countries are occasionally involved in disputes within the organization, being classified both as complainants and respondents, even when they are not directly involved in the cases. The most recent dispute between Brazil and China occurred in 2018 concerning "Certain Measures Concerning Imports of Sugar", in which Brazil requested consultations with China regarding a safeguard measure imposed by the Asian nation on imported Brazilian sugar. At first glance, given that Brazil and China are major trading partners, one might intuitively assume that there are frequent direct conflicts between them. However, considering their long-standing history of cooperation, such disputes are relatively minor when compared with those involving the European Union or the United States.

Due to the United States' extensive involvement in DSB proceedings, the country also represents a relevant object of analysis. According to WTO (OMC, 2022) data, since

the creation of the DSB in 1994, the United States has been involved in 15 disputes with Brazil—11 as complainant and four as respondent—while China has appeared only once, as a respondent. When comparing overall disputes, the proportions between Brazil and China are nearly equivalent, whereas the United States displays a much higher number of cases, particularly as complainant.

Specifically regarding NTMs applied to the meat market, Miranda (2001) highlights that part of the barriers imposed by the United States are protectionist measures that go beyond mere technical practices. In this context, the restrictions imposed by the country on Brazilian meat have harmed the sector's exports, particularly those of fresh meat.

Neto (2018) notes that, in recent years, the United States has imposed import quotas, strict customs inspections, quantitative restrictions, and severe import licensing requirements, all of which have limited the access of Brazilian products to the U.S. market. Additionally, Silva, Triches, and Malafaia (2011) point out that the U.S. market has applied inflexible NTMs related to product quality, exerting a profoundly negative impact on Brazil's meat exports.

Along the same line, Bannwart (2019) points out that China has suspended imports of Brazilian meat on several occasions, citing a wide range of reasons—from Federal Police operations such as "*Operação Carne Fraca*" to strict sanitary and phytosanitary concerns—requiring certifications to ensure the absence of diseases, which made exports to the Chinese market particularly difficult. For instance, Ansanelli and Barros (2020) highlight the Law on the Entry and Exit Animal and Plant Quarantine, which requires that any animal, plant, or by-product transiting through Chinese territory be subjected to quarantine inspection. In addition, the authors note that China has adopted import quotas, strict customs inspections, quantitative restrictions, and severe import licensing requirements, thereby hindering Brazilian products' access to the Chinese market. The country ranks sixth among those imposing the greatest number of restrictions on this category of Brazilian meat. However, the measures adopted by the Chinese government are often regarded as unreliable, as they lack relevant scientific evidence.

3. The Brazilian Meat Market

Brazil is one of the world's largest exporters of animal protein. According to data from Embrapa (2023), in 2016, 14% of total Brazilian exports consisted of beef, 10.5% of chicken, and 2.7% of pork. Brazilian meat products reach more than 150 countries and are recognized globally for their quality and safety standards.

Currently, Brazil's meat complex is a benchmark in the global market. The country's low labor costs and extensive pastureland make it a highly efficient producer of beef, pork, and chicken (Stal; Sereia; Da Silva, 2010). According to the Brazilian Association of Animal Protein (ABPA – *Associação Brasileira de Proteína Animal*, 2023), in the first four months of 2023, pork exports totaled 379.4 thousand tons, while chicken exports reached 1.314 million tons in the first quarter of the year.

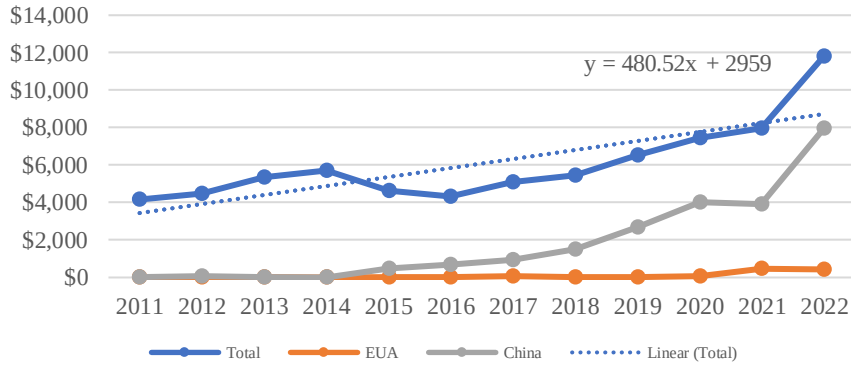
The beef market, according to information from the Comex Stat portal (2023), generated US$867.9 million in 2022 and US$343.4 million in the first months of 2023. Investment in technology in this production area has placed Brazil in a prominent position worldwide, recording a significant trade surplus in 2016 despite the existence of trade barriers that continue to hinder the commercialization of this Brazilian product (Neto, 2018).

Another important aspect of Brazil's livestock sector is its ability to serve two highly profitable markets: meat and dairy. This dual production is economically and socially significant, as it enables the country to meet the needs of a wide range of international markets—from high-end segments to mass consumption. Currently, Brazilian beef is considered healthier and leaner than that of other countries, a distinction largely attributed to the environmental conditions in which the cattle are raised and to the rigorous sanitary controls implemented nationwide (Pereira; Almeida; Oliveira, 2020).

A key competitor of Brazil in the beef market is the United States, the world's largest cattle producer, which is also internationally recognized for its extensive government subsidies that favor domestic production. Nevertheless, even in the face of such advantages, Brazil continues to export part of its beef production to the United States, a trade flow that has expanded in recent years (Dill *et al*., 2013).

Figure 1 shows the total value of Brazilian beef exports, as well as exports to China and the United States, in millions of U.S. dollars, from 2011 to 2022, based on data from Comex Stat (2023). The figure reveals that, after a period of relative stability during the first five years under review, exports grew gradually, showing a notable increase between 2021 and 2022. On average, Brazil's beef export revenues rise by approximately US$480.52 million each year.

Figure 1 – Total Brazilian Beef Exports, and Exports to the United States and China, 2011–2022 (in millions of US$)



Source: Authors' elaboration based on data from Comex Stat (2023).

This change in the pace of exports after 2014 can be explained by several factors. According to Pereira, Almeida, and Gonçalves (2020), beginning in 2012 China imposed restrictions on imports of fresh Brazilian beef, while negotiations with the United States for the export of processed beef products had been underway since 1999, accompanied by strict non-tariff measures imposed by the U.S. on these Brazilian products. However, in 2015 Brazil and China resumed negotiations and established sanitary rules that resulted in a new trade agreement for the sector, leading to a 52.24% increase in Brazilian beef exports to China as early as 2016. Similarly, in 2016 Brazil and the United States reopened negotiations to promote reciprocal exchanges of processed beef, and this agreement led to an increase of more than 1,500% in Brazilian exports of this product to the U.S. market.

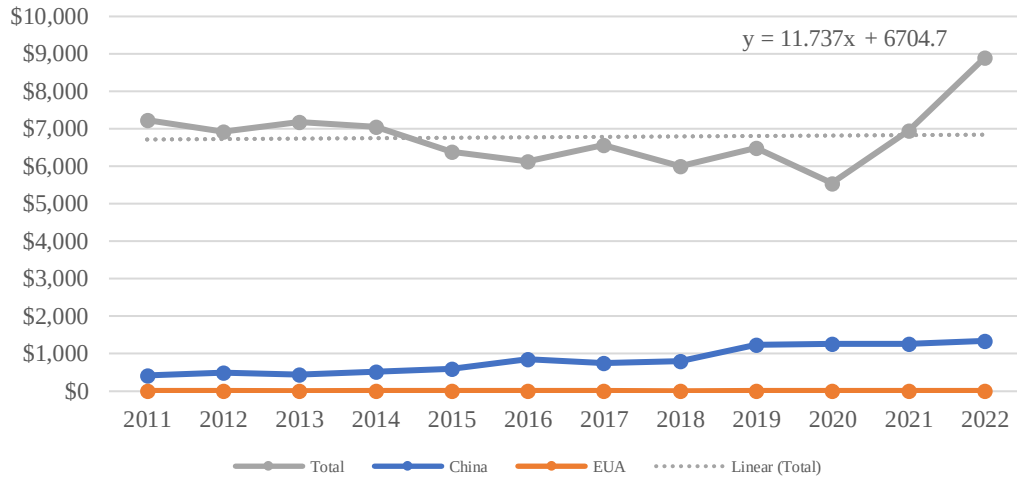
Also worth noting is China's significant share of exports in this sector, as the country accounted for 67.35% of Brazil's beef sales in 2022. The United States, in turn, represented only 3.77% of consumption in the same year, a considerably more modest figure compared with that of China. Clearly, as the world's largest beef producer, the United States imports Brazilian beef only marginally. Moreover, Pereira, Almeida, and Gonçalves (2020) emphasize that exports of fresh beef represent, on average, 90% of Brazil's total beef export volume. Since China's demand is primarily concentrated in this product category, its participation naturally stands out compared with that of the United States, which mainly imports processed Brazilian beef.

Beyond beef, Brazil also has a promising market outlook for both chicken and pork production. The chicken market has grown exponentially in recent years, largely driven by genetic improvements within this production segment. As the sector grew in the global market, Brazil has emerged as one of the leading producers and exporters, competing with China and the United States, which together account for 47% of world production (Favro *et al*., 2021).

Figure 2 displays total Brazilian poultry exports, as well as exports to China and the United States, in millions of dollars from 2011 to 2022, according to data from Comex Stat (2023). A relatively stable pattern is observed over the years, particularly between 2011 and 2019. Afterward, exports declined slightly in 2020, followed by a relatively strong increase from 2021 to 2022. Throughout the analyzed period, Brazil's poultry export revenues rose by an average of US$11.737 million per year.

Because China and the United States are also major producers in the poultry sector, their shares in Brazil's export destinations for this segment remain modest. During 2022, for example, China accounted for 15.11% of Brazil's poultry exports, while the United States received only 0.0005% of the sector's shipments. However, the 54.94% jump in Brazilian poultry exports to China in 2019 relative to the previous year, establishing a new level of Chinese imports that persisted through 2022. Additionally, according to ABPA's 2023 annual report, China imported 640,470 tons of Brazilian poultry in 2021 and 540,555 tons in 2022.

Figure 2 – Total Brazilian Poultry Exports, and Exports to China and the United States, 2011–2022 (in millions of US$)

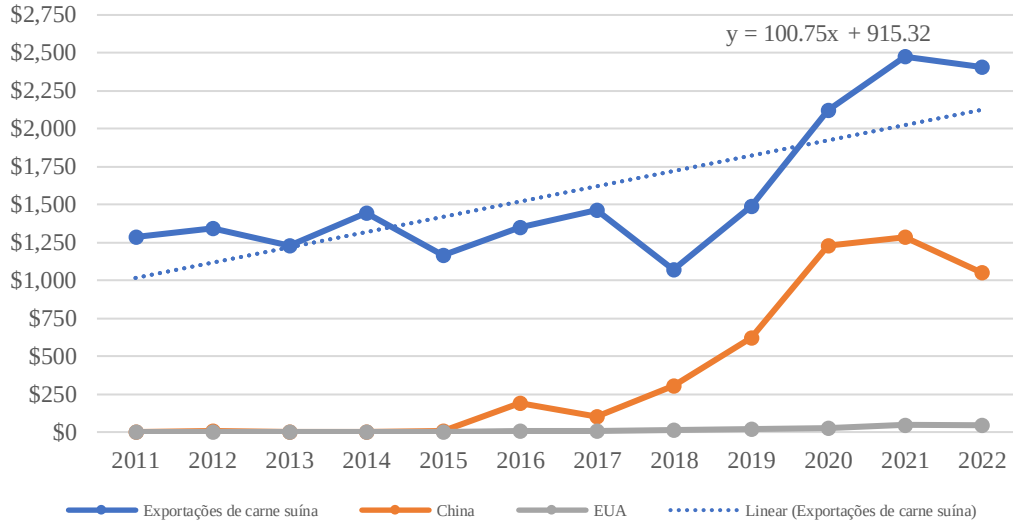


Source: Authors' elaboration based on data from Comex Stat (2023).

In pork production, according to Embrapa (2023), Brazil ranked fifth among the largest consumers and fourth among the leading exporters in 2022, showing a 4.59% increase in exports compared with 2021. Figure 3 shows the total value of Brazilian pork exports, as well as exports to China and the United States, in millions of U.S. dollars, from 2011 to 2022, based on data from Comex Stat (2023).

A relatively stable trend was observed in exports between 2011 and 2019. In 2020, however, exports rose by 42.5%, remaining at a higher level in the following years. Rubin, Ilha, and Lopes (2012) highlight that Brazilian pork has a medium level of competitiveness in the international market, with growth prospects over time, provided that tariff and non-tariff barriers are eliminated or reduced, which would consequently lead to an increase in exports from this sector.

Figure 3 – Total Brazilian Pork Exports to the United States and China, 2011–2022 (in millions of US$)



Source: Authors' elaboration based on data from Comex Stat (2023).

Overall, Brazil's revenues from pork exports have increased by an average of US$100.75 million per year. It is also important to highlight the shift in China's share of Brazil's pork export portfolio beginning in 2016, when the country's external sales to the Asian market rose by approximately 1,700% compared with the previous year, and again in 2018, when exports to China reached US$304 million—an increase of 201% over 2017. In this context, Escher and Wilkinson (2019) emphasize the importance of the Chinese market, which accounts for 50% of global pork consumption. Specifically for Brazil, since 2020, China has absorbed roughly 50% of the country's pork exports.

Although at a substantially lower level, the United States has also significantly increased its consumption of Brazilian pork, particularly since 2020, when imports grew by 55% relative to the previous year. Likewise, from 2020 to 2021, Brazilian pork exports to the United States increased by 71.43%, a level that remained steady through 2022. However, it is worth noting that the United States accounted for only 1.87% of Brazil's total pork exports in that same year.

4. Methodology

Between 2011 and 2022, a detailed search was conducted in the TRAINS[1] database (UNCTAD, 2023) to identify 12 non-tariff measures imposed by China and the United

[1] The TRAINS database provides access to information on countries that apply NTMs, the affected products, the types of measures imposed, and the selected time period, among other functionalities.

States on five Harmonized System (4-digit HS code) codes related to Brazil's meat complex, which are listed in Table 1. These items were selected due to their relevance in Brazil's export portfolio and the significant trade volumes directed to the Chinese and U.S. markets during the analyzed period, as highlighted in the previous section.

Table 1 – Description of the Items Comprising Chapter 02 – Meat and Edible Meat Offal under the Harmonized System (HS-4)

HS-4	Description
0201	Meat of bovine animals, fresh or chilled;
0202	Meat of bovine animals, frozen;
0203	Meat of swine, fresh, chilled or frozen;
0206	Edible offal of bovine animals, swine, sheep, goats, horses, asses, mules or hinnies, fresh, chilled or frozen;
0207	Meat and edible offal, of the poultry of heading 01.05 (fowls, ducks, geese, turkeys and guinea fowls), fresh, chilled or frozen.

Source: Authors' elaboration.

The sanitary and phytosanitary (non-tariff) measures analyzed in this study are described in Table 2. In general, most of the trade barriers examined are related to food safety, public health, product safety, and environmental protection.

Table 2 – Analyzed Non-Tariff Measures

Protection of biodiversity;
Protection of animal and plant life;
Protection of human and animal health;
Protection of human health;
Ensuring product safety;
Protection of the legal rights and interests of consumers, producers, and sellers;
Ensuring food safety, public health, and life security;
Automatic licensing requirements for certain products;
Guarantee of food security;
Environmental protection;
Prevention of the spread of animal diseases;
Unspecified purpose.

Source: Authors' elaboration.

To analyze the incidence of NTMs imposed by China and the United States on Brazilian exports of the main products within its meat complex, coverage and frequency indices developed by Laird (1996) will be calculated. In addition to data from the UNCTAD TRAINS database (2023) and from the Ministry of Development, Industry, Trade, and Services (MDIC – *Ministério do Desenvolvimento, Indústria, Comércio e Serviços*, 2023), export data from the Comex Stat portal (2023) will also be used to assess the NTMs applied by these countries to Brazil's beef, poultry, and pork exports during the 2011–2022 period.

According to Ansanelli and Barros (2020) and Viegas, Jank, and Miranda (2007), the coverage ratio (CR) indicates the share of trade subject to NTMs across specific sectors or countries. Thus, the CR is calculated as follows:

$$\mathrm{C}_{ij} = \left[\frac{\sum_{i=1}^{m} (M_{jm} * \mathrm{N}_{jm})}{\sum_{i=1}^{m} M_{jm}}\right] * 100 \quad (1)$$

where:
C_{ij} = coverage ratio of NTMs applied to the selected Brazilian meat complex products, composed of m non-tariff lines imposed by China or the United States;
M_{jm} = value of Brazil's exports to China and the United States;
$\mathrm{N}_{jm} = 1$ if there is incidence of a notification affecting product m (at least one notification) between 2011 and 2022;
$= 0$ if there are no notifications.

The frequency index (FI) represents the ratio between the number of products registered in the Dispute Settlement Body that have at least one NTM notification issued by the importing country (Ansanelli; Barros, 2020; Viegas; Jank; Miranda, 2007). Thus, the FI is calculated as follows:

$$\mathrm{F}_{ij} = \left[\frac{\sum_{i=1}^{m} (L_{jm} * \mathrm{N}_{jm})}{\sum_{i=1}^{m} L_{jm}}\right] * 100 \quad (2)$$

where:
F_{ij} = frequency index of NTMs applied to the selected Brazilian meat complex products, composed of m non-tariff lines imposed by China or the United States;
$\mathrm{L}_{jm} = 1$ product m is exported by Brazil to China or the United States;
$= 0$ if product m is not exported by Brazil to China or the United States;
$\mathrm{N}_{jm} = 1$ m if there is an NTM notification affecting product m (at least one notification);
$= 0$ if there is no NTM notification affecting product m (no notification);
$\sum_{i=1}^{m} \mathrm{L}_{jm}$ for all $i = 1, \ldots, m$ represents the number of goods comprising group i.

According to Ansanelli and Barros (2020), the index values range from 0 to 100%, representing the percentage of a country's exports of a given product that are subject to NTMs. Additionally, to classify and better interpret these results, Viegas, Jank, and Miranda (2007) explain how the indices relate to each other and which interpretations can be drawn from the observed outcomes. These relationships are presented in Table 3.

Table 3 – Relationship Between the Coverage Ratio (CR) and the Frequency Index (FI)

	Item	Low CR	High FI
Low CR	Non-tariff lines	Few	Many
	Export value	Low	Low
	Irrelevance of products in the export portfolio or impediment to exports	Yes	Yes
	Degree of protection	Low	Medium
High CR	Non-tariff lines	Few	Many
	Export value	High	High
	Irrelevance of products in the export portfolio or impediment to exports	No	No
	Degree of protection	Medium	High

Source: Adapted from Viegas, Jank, and Miranda (2007).

In the literature, there is a substantial body of research applying this methodology. Viégas (2003), for instance, used these methods to estimate the impact of trade barriers imposed by the United States and the European Union on Brazilian agricultural exports. Ansanelli *et al*. (2018) applied the frequency and coverage indicators to estimate the incidence of Chinese environmental non-tariff barriers on Brazilian exports between 2001 and 2014. Bellonia and Silva (2007) analyzed these indices in relation to Brazilian meat exports (beef, pork, and chicken) to the country's main trading partners in 2000.

Mendes, Coelho, and Campos (2009) used coverage ratio and frequency index to assess the incidence of non-tariff measures on Brazilian exports of four fruits—banana, mango, pineapple, and orange—between 2003 and 2008. Similarly, Rubin, Ilha, and Lopes (2012) applied these indicators to examine the non-tariff measures imposed on the world's main pork exporters from 1995 to 2010.

Building on this evidence, the present study seeks to contribute new findings through the application of these indices to the selected products of Brazil's meat complex. The following section presents the results of this analysis.

5. Results

Table 4 presents the total number of notifications applied, according to the NTMs listed in Table 2, by China and the United States for each 4-digit HS code between 2011 and 2022. Each code represents a specific category within Brazil's meat production destined for export, as well as the penalties imposed by the DSB in response to each notification. As shown in Table 4, both countries were involved in a large number of notifications, indicating close monitoring and strict regulation of the Brazilian meat products analyzed. However, in terms of recorded penalties, these were found only for item 0207—applied to China—which refers to poultry meat and offal.

Table 4 – Notifications and Penalties Related to NTMs Imposed by China and the United States on Brazil's Meat and Edible Meat Offal Exports (HS-4), 2011–2022

HS-4	Notifications		Penalties	
	China	United States	China	United States
0201	601	238	0	0
0202	479	251	0	0
0203	482	241	0	0
0206	472	292	0	0
0207	476	201	4	0

Source: Authors' elaboration based on data from Unctad (2023).

The coverage ratios and frequency indices calculated for the United States are presented in Table 5. Overall, the CR results reveal a modest number of notifications applied by the U.S. during the analyzed period, with the coverage of NTMs on Brazil's meat complex exports ranging between 14.56% and 28.33%. On average, the coverage ratio reached 23.36%, meaning that less than one-quarter of these exports were subject to potential trade barriers imposed by the United States. It is also noteworthy that the lowest magnitude of the indicator corresponds to HS 0207 (poultry meat), which recorded the smallest number of U.S. notifications.

Table 5 – Coverage Ratio and Frequency Index for Non-Tariff Measures on Selected Items of Brazil's Meat Complex Exported to the United States, 2011–2022

HS-4	CR	FI
0201	22.16	24.00
0202	24.21	20.92
0203	27.53	21.82
0206	28.33	24.33
0207	14.56	16.75

Source: Research results.

Similarly, the FI indicates that the frequency of NTMs applied to the analyzed Brazilian meat exports ranges between 16.75% and 24.33%, with an average of 21.56%. In other words, the results suggest that the frequency of NTMs imposed by the United States on these products is relatively low.

According to the relationships presented in Table 3, the combination of low CR and low FI values indicates a low degree of protection exercised by the United States over the Brazilian segments analyzed. Moreover, the results point to a probable irrelevance of these products in the export portfolio or a restriction on exports, few non-tariff lines, and a low export value. To some extent, these findings are consistent with the magnitudes of exported values for these products to the United States, as illustrated in Figures 1, 2, and 3, which show the modest U.S. consumption of the Brazilian meats under analysis.

Table 6 presents the coverage ratios and frequency indices calculated for China. Overall, the CR results show that, on average, 52.02% of Brazil's meat complex exports to China are covered by NTMs. Unlike the pattern observed for the United States, these findings suggest that such NTMs cover more than half of the exported values, implying that a significant portion of these trade flows are affected by restrictions imposed by China, which may create distortions that hinder the entry of Brazilian meat products into the Chinese market.

Table 6 – Coverage Ratio and Frequency Index for Non-Tariff Measures on Selected Items of Brazil's Meat Complex Exported to China, 2011–2022

HS-4	CR	FI
0201	55.82	57.00
0202	53.39	39.92
0203	53.71	40.17
0206	52.67	39.33
0207	44.51	39.67

Source: Research results.

Similarly, the FI values indicate a moderate frequency of NTMs imposed by China on the Brazilian meat products under analysis. On average, the FI reaches 43.22%, suggesting a mid-range level of regulatory intervention affecting Brazil's meat exports. A particularly high FI value is observed for HS 0201 – Meat of bovine animals, fresh or chilled (57%), which points to the existence of considerable trade barriers imposed by China on these products. This elevated figure is likely related to China's substantial demand for beef, as illustrated in Figure 1, reflecting the country's growing dependence on imported animal protein.

According to the framework presented in Table 3, the combination of a high CR and a low FI corresponds to a medium degree of protection applied by China to Brazil's meat complex. This configuration suggests that, while Brazilian exports in these segments are not explicitly restricted, they face significant procedural and regulatory barriers that

complicate market access. Moreover, the results are consistent with the high export values reported in Figures 1, 2, and 3, confirming China's central role as Brazil's leading destination for meat complex exports.

Overall, the analysis of Tables 5 and 6 reveals a marked variation in the coverage ratio (CR) and frequency index (FI) for each country examined. This pattern reflects the direct relationship between the extent and frequency of NTMs and the export volume to each destination. The results show that both indicators are significantly higher for China—approximately more than twice the average values estimated for the United States—since China is Brazil's largest importer of beef and pork, whereas the U.S. accounts for only a small share of the country's meat complex consumption.

Notably, that Brazil's meat products with the greatest market potential include beef, pork, and chicken, according to Embrapa (2023). Consequently, in exports to the United States, there is a stronger tendency toward purchases of frozen beef (HS 0202), which naturally results in a greater number of notifications concerning frozen meat. By contrast, in the Chinese market, the incidence of notifications for both fresh and frozen meat is relatively high, reflecting the large volume of exports of these products to that destination.

In the case of pork production, there is a similar scenario: the smaller export volume to the United States results in a lower number of notifications, whereas China, which imports a much larger quantity of this product, registers an increase in notifications. Regarding the HS-4 codes related to bovine and poultry offal (0206), which are consumed in slightly higher volumes in the United States, there is a modest relative increase in notifications.

Another plausible explanation for these variations lies in the fact that both the United States and China are major meat exporters, particularly of beef. According to Silva, Triches, and Malafaia (2011), countries that are global benchmarks for exports of a given product tend to apply a greater number of non-tariff measures on such items at their customs borders. Therefore, it can be inferred that the beef sectors—specifically those corresponding to HS codes 0202 for the United States and 0201 and 0202 for China—are among the most affected by trade barriers. This leads to more pronounced variations in the coverage ratio compared with other sectors. Across all HS-4 codes analyzed, but especially in the case of beef, the most frequently applied NTMs are those related to human health protection and to ensuring food safety, public health, and life security.

Silva, Triches, and Malafaia (2011) also highlight the restrictions imposed by the United States on Brazilian beef, a pattern clearly reflected in the coverage and frequency indices estimated in this study, given the high magnitudes recorded for this segment. Such behavior confirms the use of NTMs by the United States as a mechanism to protect its domestic market. In particular, a large number of restrictions have been observed on frozen beef exports to that destination.

According to Neto (2018), although the United States is a major importer of processed beef, it prohibited the entry of fresh Brazilian beef until 2016. Similarly, despite being one of the world's largest beef importers, China maintained a highly restrictive stance

toward the sector, reducing the competitiveness and profitability of Brazilian production as a result of protectionist policies (Junqueira; Lírio; Gomes, 2007).

In addition, Jank *et al*. (2020) warn that Brazil's high-volume export products face considerable impact from production subsidies granted to U.S. producers. Consequently, Brazilian meat—especially beef—is affected both by subsidies and by NTMs. This situation is illustrated in Table 5, which shows fewer notifications for HS 0201 (fresh beef) than for HS 0202 (frozen beef). This difference can be explained by the smaller volume of fresh beef exported to the United States, mainly due to the production subsidies maintained in the U.S. market.

Regarding pork, Silva *et al*. (2011) found that between 1995 and 2010 the coverage and frequency indices were undetermined due to null export flows, which could indicate the existence of barriers preventing the entry of Brazilian pork into the Chinese market. However, the data presented in this study reveal the presence of notifications concerning Brazilian pork in China, suggesting a greater degree of market openness to this product in recent years.

In the context of the U.S. pork market, it is common to observe the application of non-tariff barriers, particularly those related to sanitary and phytosanitary issues. The United States imposes strict standards for the importation of this product, which discourages Brazilian pork exports to that destination (Jank *et al*., 2020).

In a simulated scenario of a potential tariff elimination agreement between Brazil and China, Buchmann, Massuquetti, and Azevedo (2021) found that the meat trade could expand by 0.4% if tariffs were abolished. Under this scenario, for example, Brazilian chicken exports to China could increase by as much as 49.6%. This finding suggests that China currently applies several trade barriers that, if removed, could substantially boost Brazilian exports. This pattern can be clearly observed in Table 6, which shows a high number of NTM notifications across most of the products analyzed.

Table 4 also shows that the poultry sector was the only one to face penalties due to the significant number of barriers imposed in the Chinese market. According to Bauermann *et al*. (2023), chicken meat has been highly demanded and subject to strict sanitary and phytosanitary barriers. The authors further point out that Brazil is a powerhouse in this market, as their findings show that the country holds substantial competitive advantages in the chicken industry compared with the United States. This may help explain the high frequency of non-tariff barriers imposed on Brazilian chicken exports to China, as well as the penalty applied to the Chinese government for excessive use of such measures.

Aranda *et al*. (2017) emphasize that Brazil's poultry production sector has undergone a continuous process of technological advancement over the years, leading to a significant increase in productivity. The country's poultry industry is widely recognized for its efficiency and production quality, making it a strong competitor for both the United States and China. Nevertheless, it is worth noting that Brazilian chicken production is distinguished by its high animal health standards, which underscores a certain inconsistency in the barriers applied to this segment.

In summary, the results highlight the importance of a thorough and effective assessment of the non-tariff measures implemented by a given country. Such evaluation ensures that these NTMs are applied appropriately and with proper justification, while also reinforcing the need for the Dispute Settlement Body to act more effectively in ensuring that the excessive or improper use of these measures is duly addressed or sanctioned when necessary.

Final Considerations

This study aimed to analyze the incidence of non-tariff measures (NTMs) imposed by China and the United States, as well as the penalties applied to these countries by the Dispute Settlement Body (DSB), on Brazilian exports of beef, pork, and poultry to those destinations. By calculating the coverage ratios and frequency indices, this study identifies the share of Brazilian products subject to NTMs imposed by the countries under review.

Overall, in the period from 2011 to 2022, several sanitary and phytosanitary measures were identified as being applied by these countries, significantly affecting Brazil's beef, pork, and poultry sectors. In addition, considerable variations were observed in the volume of notifications, reflecting the dynamics of trade relations among Brazil, China, and the United States throughout the analyzed period.

The coverage ratio calculations showed that the NTMs imposed by China affected a proportion of Brazil's meat complex exports roughly twice as large as those imposed by the United States. Likewise, the frequency index magnitudes indicated that the incidence of NTMs applied by China to these products was approximately double that of the measures imposed by the United States.

The findings also revealed China's excessive use of non-tariff measures, particularly on the beef sector, in which Brazil has established itself as a strong competitor in the international market. Moreover, despite the high number of NTM notifications, only four penalties were recorded during the analyzed period in the poultry segment, which raises concerns about the effectiveness of the WTO's dispute settlement mechanisms in curbing the misuse of trade barriers.

Even amid intense competition in the global meat market—affected not only by trade policy but also by domestic policy and product quality—Brazil has maintained its position as a major producer and exporter in the sector. Nonetheless, the country continues to face significant challenges due to trade barriers imposed by other nations, particularly China and the United States, which have negatively affected its export performance.

Therefore, the study underscores the need for the effective operation of the Dispute Settlement Body as an essential mechanism for resolving trade disputes and ensuring fair and equitable international trade practices. The excessive number of NTMs applied by China and the United States to Brazil's meat complex products highlights the importance of the DSB in addressing unfair practices that generate significant distortions in global trade.

Finally, this study acknowledges several limitations. First, the focus on only two countries may have excluded other relevant trading partners, thereby restricting a broader understanding of global trade dynamics. Future studies could extend the time frame and/or apply a more disaggregated analysis of the meat complex. Additionally, adopting probabilistic or deterministic approaches could yield more robust evidence regarding the actual effects of NTMs on Brazil's selected meat complex exports.

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