

Potential Economic Impacts of African Swine Fever in Brazil

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Abstract: African Swine Fever (ASF) is a highly contagious disease that can devastate hog herds and disrupt global pork markets. As a top-five pork exporter, Brazil plays a significant role in world pork supply. This paper investigates the potential economic impacts of a hypothetical ASF outbreak in Brazil using a computable general equilibrium modeling framework. Two scenarios are considered: a 4% production decrease with a 20% export reduction (Scenario I), and an 8% production decrease with a 40% export reduction (Scenario II). Results indicate that an outbreak would substantially reduce Brazilian hog and pork production, raise domestic pork prices, and increase global pork prices. While some countries like the U.S. and Europe could see increased pork exports, many regions would experience welfare losses due to factors such as reduced savings and investment or allocative inefficiency. Brazil would suffer welfare losses from deteriorating terms of trade. Understanding the potential economic consequences can help stakeholders prepare for the possibility of an ASF outbreak in Brazil.

1. Introduction

African Swine Fever (ASF) is a disease that affects hogs and results in extremely high mortality rates, which could devastate a herd. Not only does ASF have high mortality rates but also high rates of contagiousness. A highly contagious disease will result in loss for a producer and trigger trade restrictions for biosecurity purposes. A disturbance in trade among countries can have significant effects on a country's economy as well as other trading partners.

ASF has been an issue in recent years and many countries that are top pork exporters are concerned about how an outbreak could potentially affect export potential and the world market overall. China experienced an ASF outbreak in 2018 that led to 1.2 million head of hogs culled which was valued at over \$200 billion in economic losses (You et al., 2021). Following the significant outbreak in China, ASF spread to Southeast Asia and then later moved into some European countries. The Americas had not witnessed any causes of ASF since the 1980s until a case was found in the Dominican Republic in 2021 and then Haiti later in the same year (Ruiz-Saenz et al., 2022). The appearance of ASF in Latin America has created a sense of panic in neighboring countries due to the looming threat of the potential spread and possible ASF outbreaks.

Brazil is a top-five pork exporter in the world and with the close proximity to the recent outbreaks in the Caribbean, it is reasonable for Brazil to be concerned about the potential for ASF introduction and to prepare for possible scenarios of an ASF outbreak. This research will investigate the effects of a hypothetical ASF outbreak in Brazil on the world pork market and national welfare across regions. An outbreak in Brazil would not only have domestic effects but

also an effect on the world market and other importing and exporting countries. Other top pork exporting countries such as the United States (U.S.) and the European Union (EU) would likely experience an increase in demand for their pork products if Brazil is unable to export pork in the case of an ASF outbreak (Shahbandeh, 2023). Importing countries may experience an increase in pork prices because of decrease global supply in the absence of Brazilian pork compounded by the fact that Brazil is typically a relatively affordable export source.

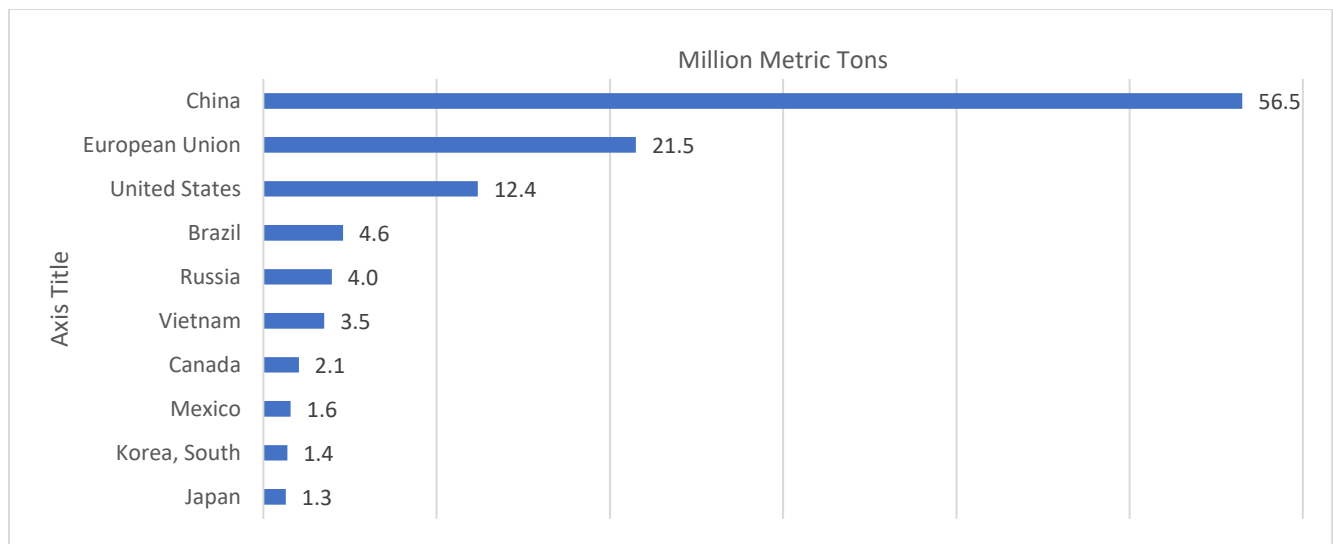
Due to ASF outbreaks all over the world there have been multiple research papers analyzing the impacts on the economies of countries like Uganda (Chenais et al., 2017), China (Mason-D'Croz, 2020), and Vietnam (Nquyen-Thi, 2021). The study for Vietnam used the CIEM-WIDER SAM to run supply decreasing scenarios. While the paper analyzing Uganda used a face-to-face survey method for data collection and then a linear model in R was used to assess the ASF outbreak impacts (Chenais et al., 2017). The study analyzing the ASF outbreaks in China used IMPACT and GLOBE which are linked global models (Mason-D'Croz, 2020).

This research employs a computable general equilibrium modeling framework to investigate the effects of a hypothetical ASF outbreak in Brazil. Results from this work will provide insights into how the world pork supply may change if there were an outbreak of ASF in Brazil that negatively impacts domestic supply in tandem with international trade restrictions on Brazilian hogs and pork products. This potential change in world markets would affect production and welfare across countries, and this work will shed light on global market effects of a potential ASF outbreak in Brazil. By understanding the potential global, economy-wide effects of a potential ASF outbreak in Brazil, policymakers, producers, and other stakeholders can better understand the economic consequences of an ASF outbreak.

2. Background

Brazil has solidified its position as a key player in the global pork industry, securing the fourth spot among the largest pork producers worldwide. As seen in Figure 1, the primary contenders ahead of Brazil in pork production include China, the European Union (EU), and the United States (U.S.). Although China stands out as the leading pork producer on a massive scale, producing 56.5 million metric tons (MMT) in 2023, its domestic demand and import requirements also make it the largest consumer and importer of pork globally. Brazil exhibited a significant capacity in pork production in 2023, contributing a substantial 4.6 MMT to the global market (USDA, 2023).

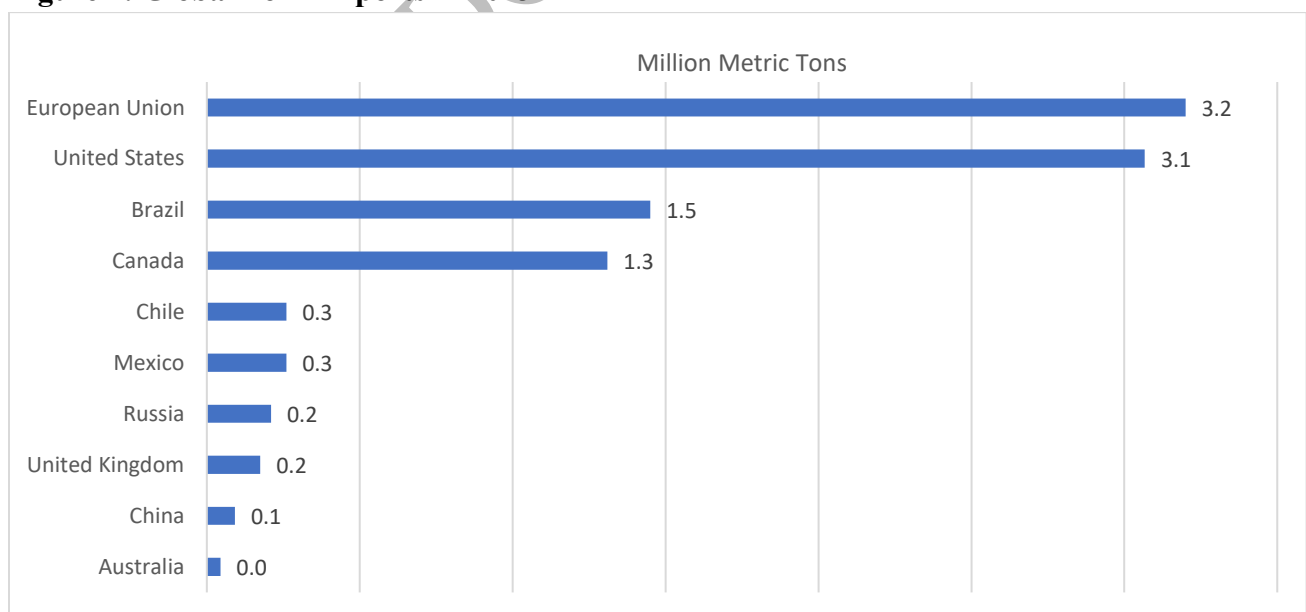
Figure 1: Global Pork Production in 2023



Source: Authors' design from USDA data (USDA, 2023)

Figure 2 shows Brazil's impact on the global market extends beyond its production capabilities, as it emerged as the third-largest exporter of pork, exporting 1.5 MMT (USDA, 2023). Brazil's producing and exporting numbers has placed them among the world's leading pork exporting nations. It is noteworthy that the competition for the top spot in pork exports is fierce, the EU secured its position as the leading exporter with 3.2 MMT exported in 2023. The U.S. closely follows, with a marginal difference of less than 0.2 MMT separating the two regions (USDA, 2023). This intricate global landscape highlights Brazil's pivotal role, not only as a significant producer but also as a major contributor to the international pork trade.

Figure 2: Global Pork Exports in 2023

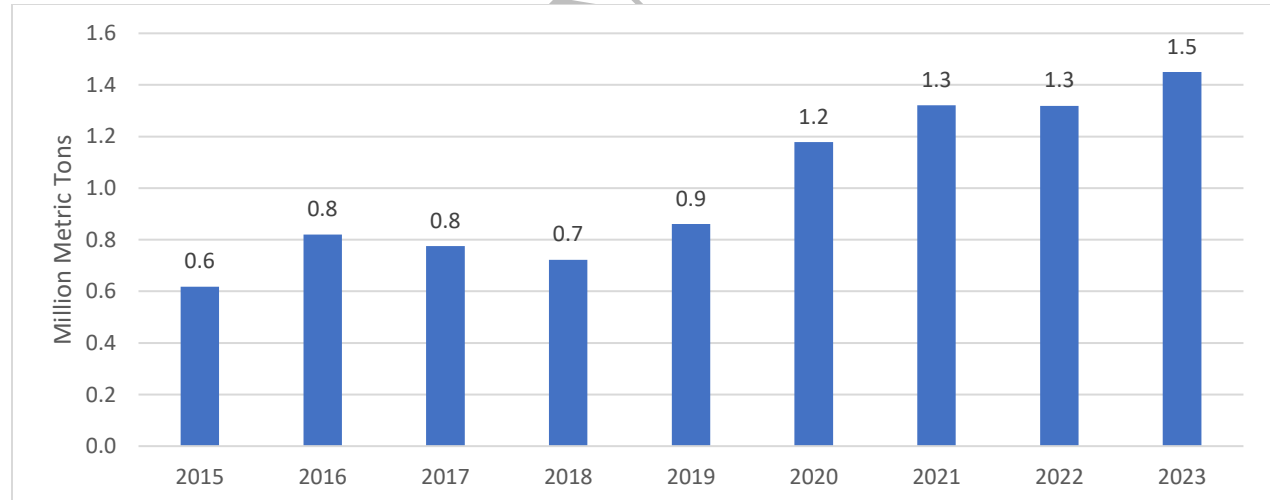


Source: Authors' design from USDA data (USDA, 2023)

The landscape of global pork exports underwent a significant shift in the aftermath of the 2018 ASF outbreak in China. Brazil, responding to the increased demand arising from China's production challenges, experienced a surge in pork exports. From 2018 to 2019 Brazilian pork exports increased 19.25% (USDA, 2023). Brazil continued to solidify its position as a crucial contributor to the international pork trade. The year 2020 witnessed an even more pronounced upswing, with Brazilian pork exports soaring by an impressive 36.81% compared to the previous year (USDA, 2023). Figure 3 illustrates the upward trajectory, showcasing the sustained growth in Brazil's pork exports, a trend that has persisted nearly every year since the initial surge.

The resilience and expanding role of Brazil in the global pork market highlight the interconnected nature of the industry. The 2018 ASF outbreak in China not only disrupted the country's pork production but also created a ripple effect necessitating assistance from other major pork-producing nations. In the face of a disease outbreak in key player it becomes imperative for other countries to step in and help fill the production gap. Brazil's substantial increase in pork exports following the ASF outbreak exemplifies its ability to adapt and respond to shifts in the global pork market dynamics, underscoring its importance as a reliable source for meeting international pork demands. However, in the event that Brazil experienced a disease outbreak the world pork market would change drastically trying to try to recover temporarily losing a major pork exporter.

Figure 3: Brazilian Pork Exports from 2015 to 2023



Source: Authors' design from USDA data (USDA, 2023)

3. Method and Data

The Global Trade Analysis Project (GTAP) model is a computable general equilibrium (CGE) framework known for its ability to provide a more comprehensive and realistic view of the global economy compared to partial equilibrium models. This is primarily because GTAP

encompasses a larger array of sectors, regions, and interdependencies. GTAP's robustness and utility are exemplified in its extensive database, which includes data from 160 regions spanning 65 sectors of the global economy (Aguiar et al., 2022). This dataset allows researchers to conduct a wide range of simulations, making it an invaluable tool for studying various global economic phenomena.

One notable application of the GTAP model is in assessing the economic consequences of a disease outbreak which is the goal of this paper. The intricate regional and sectoral breakdowns within GTAP enable researchers to examine how a disease's impact ripples through the world economy, affecting production, consumption, trade, and overall economic well-being. By considering the global economy, we can gauge the implications of an ASF disease outbreak in Brazil on a scale that reflects the complexity of our global market. The GTAP framework is used to quantify these effects on various economic variables, providing critical insights for policymakers, businesses, and analysts. The

Within the GTAP model, researchers can observe and analyze a wide array of economic variables, including but not limited to production, consumption, exports, imports, trade balances, and gross domestic product (GDP). These economic variables are pivotal in understanding and quantifying the potential consequences of different economic events on the global and regional scales. By providing a holistic view of the world economy, GTAP serves as a vital tool for informed decision-making and in-depth economic analysis when it comes to analyzing the potential impacts of an ASF outbreak in Brazil. The suitability of the GTAP model for assessing the economic impacts of ASF in Brazil is underscored by its previous application in evaluating the effects of other animal diseases in the country, particularly concerning their potential adverse impacts on the international meat market. For instance, Menezes et al. (2022) applied this framework to evaluate the economic impacts of foot-and-mouth disease outbreaks, while Menezes et al. (2024) examined the effects of bovine spongiform encephalopathy with the GTAP model. In their respective studies, Menezes et al. (2022) primarily focused on the consequences for international trade of beef and pork, whereas Menezes et al. (2024) concentrated on the effects on beef exports and imports.

The original GTAP database has pork included in the meat products sector and hogs included in the animal products sector. This paper aims to analyze the effects on pork trade flows if an ASF outbreak occurred in Brazil, which requires the original database to be disaggregated. The animal products sector was disaggregated into hogs and animal products. The meat products sector was disaggregated into pork and meat products. Through this disaggregation, the 65 sectors of the GTAP database turned into 67 sectors. These 67 sectors were then aggregated into 9 sectors including, hogs, pork products, feed, other livestock and meat, other crops, processed food, mining and extraction, manufacturing, and services. The original database consisted of 160 regions that were aggregated into 11 regions. These regions separated out individual key players such as the USA, Canada, Mexico, Brazil, and China and Hong Kong. The rest of the regions were aggregated into larger regions including, rest of Asia and Oceania, South and Southeast Asia, Central and South America, Europe, Middle East and North Africa, and Central and Southern Africa.

In summary, the approach taken in this paper underscores the flexibility and specificity of the GTAP model. The research can provide detailed insights into the global pork market and national welfare, considering the unique roles and interactions of major players while observing the effects of supply changes and trade diversions in a targeted manner. This allows for a more comprehensive analysis of the world pork market and national welfare within the broader context of global trade.

3.1 Scenarios

This study examines two hypothetical scenarios of an ASF outbreak in Brazil, each consisting of exogenous shocks to Brazilian hog and pork production, domestic demand, and exports (Table 1). Scenario I considers a smaller outbreak, with a hog and pork production and export decrease of 4% and 20%, respectively, based on Niemi (2020) estimates for Europe. Domestic pork demand drops by 5%, which matches the impact seen in Vietnam during a small ASF outbreak according to Nguyen-Thi et al. (2021). On the other hand, Scenario II considers a more severe ASF outbreak, doubling the negative shocks to production, domestic demand, and exports in Brazil. Drawing from Carriquiry et al. (2021) and Halasa et al. (2016), who simulated complete bans on pork exports from the U.S. and Denmark during ASF outbreaks, this scenario involves a 40% export ban on Brazilian hogs and pork. The two scenarios provide a range of potential impacts on the Brazilian hog and pork industry, depending on the severity of the hypothetical ASF outbreak.

Table 1. Changes in Brazilian Domestic Production, Demand, and Exports

Variable	Sector	Scenario I	Scenario II
Production	Hogs	-4%	-8%
	Pork	-4%	-8%
Domestic demand	Pork	-5%	-10%
Exports	Hogs	-20%	-40%
	Pork	-20%	-40%

Source: Authors' design

Note: Scenarios formulated to simulate the economic implications of an ASF outbreak in Brazil.

4. Preliminary Results

The occurrence of an ASF outbreak in Brazil leads to negative impacts concentrated in the hog and pork sectors, as expected. In Scenario I, production of hogs drops by 10.52% and pork by 23.25%, driven by decreases in domestic demand and exports (Table 2). In Scenario II, the impact worsens, with hog production down 22% and pork down 46.5%. The other livestock and meat sector is also negatively affected, with a decrease in production of 0.72% and 1.38% in Scenarios

I and II, respectively. Conversely, the other crops sector presents a slight production increase in both scenarios.

Table 2. Percentage Changes in Brazilian Output

Sectors	Scenario I	Scenario II
Hogs	-10.52	-21.96
Pork products	-23.25	-46.53
Feed	0.16	0.34
Other livestock and meat	-0.72	-1.38
Other crops	0.46	0.97
Processed food	0.35	0.80
Mining and extraction	0.01	0.01
Manufacturing	0.31	0.64
Services	-0.01	-0.02

Source: Authors' simulations

The substantial reductions in Brazilian hog and pork production lead to domestic price hikes, particularly for pork. Hog prices rise by 0.6% on average in both scenarios, while pork prices increase by 4.6% and 9.4% in Scenarios I and II, respectively (Table 3). Prices in most other sectors of the Brazilian economy present a slight decline, except for mining and extraction.

Table 3. Percentage Changes in Brazilian Producer Prices

Sectors	Scenario I	Scenario II
Hogs	0.65	0.57
Pork products	4.56	9.38
Feed	-0.17	-0.35
Other livestock and meat	-0.17	-0.39
Other crops	-0.13	-0.26
Processed food	-0.09	-0.20
Mining and extraction	0.03	0.06
Manufacturing	-0.03	-0.06
Services	-0.04	-0.08

Source: Authors' simulations

As the world's fourth-largest pork producer, Brazil plays a substantial role in the global pork supply. When Brazilian exports face restrictions due to an ASF outbreak, global pork export prices rise. Specifically, pork export prices increase by 1.4% in Scenario I and 2.5% in Scenario II (Table 4). However, other sectors experience minimal price fluctuations.

Table 4. Percentage Changes in Average Export Prices in the Global Market

Sectors	Scenario I	Scenario II
Hogs	0.02	0.04
Pork products	1.35	2.50
Feed	-0.11	-0.23
Other livestock and meat	-0.09	-0.20
Other crops	-0.02	-0.03
Processed food	-0.01	-0.03
Mining and extraction	0.01	0.01
Manufacturing	0.00	0.00
Services	0.00	0.00

Source: Authors' simulations

In both scenarios, Europe, the U.S., and China and Hong Kong present an increase in pork exports (Table 5). Europe gains over US\$1 billion in pork exports in Scenario I and US\$2.2 billion in Scenario II. However, Canada experiences a decline of US\$126 million and US\$389 million in pork exports in Scenarios I and II, respectively. Brazil's pork exports decrease by 20% in Scenario I, which is equivalent to US\$324 million, and 40% in Scenario II, corresponding to US\$647 million, due to the exogenous shock. An ASF outbreak in Brazil leads to a global decrease in pork exports, with average global pork exports dropping by 3.33% in Scenario I and 6.64% in Scenario II.

Table 5. Changes in Exports by Country/Region (in US\$ millions)

Country/Region	Scenario I	Scenario II
USA	488.6	1,041.0
Canada	-125.8	-388.5
Mexico	15.6	33.2
Brazil	-323.6	-647.2
China and Hong Kong	84.0	175.2
Rest of Asia and Oceania	15.4	32.0
South and Southeast Asia	21.2	43.7
Central and South America	17.8	41.0
Europe	1,069.5	2,225.7
Middle East and North Africa	-0.6	-1.1
Central and Southern Africa	16.3	35.3

Source: Authors' simulations

Although most countries and regions have an increase in pork exports, many experience welfare losses (Table 6). Despite Europe enjoying the highest pork export gains, the region's welfare declines between US\$108 million and US\$209 million. Conversely, the Middle East and North Africa have the greatest welfare gains, ranging from US\$211 million and nearly US\$580 million. Central and South America, along with the U.S., also present modest welfare gains.

However, the remaining countries and regions suffer welfare losses due to an ASF outbreak in Brazil.

The U.S. and Central and South America's welfare gains are primarily driven by improved terms of trade. Canada, China and Hong Kong, the Rest of Asia and Oceania, and South and Southeast Asia face welfare losses due to reduced savings and investment. Mexico, Europe, and Central and South Africa lose welfare mostly because of allocative inefficiency. The Middle East and North Africa suffer welfare declines due to worsened terms of trade and reduced savings and investment. Lastly, Brazil's welfare decreases due to deteriorating terms of trade, as expected following substantial negative shocks to Brazilian exports.

Table 6. Changes in Welfare (Equivalent Variation, US\$ Million)

Country/Region	Scenario I	Scenario II
USA	19.3	46.2
Canada	-11.3	-34.9
Mexico	-39.1	-80.7
Brazil	-65.4	-160.7
China and Hong Kong	-230.0	-459.0
Rest of Asia and Oceania	-101.0	-203.1
South and Southeast Asia	-28.4	-50.5
Central and South America	38.6	79.8
Europe	-108.0	-209.0
Middle East and North Africa	211.0	578.5
Central and Southern Africa	-32.8	-59.6

Source: Authors' simulations

5. Final Comments

An outbreak of ASF in Brazil could result in substantial repercussions, primarily concentrated in the hog and pork sectors. In both Scenario I and Scenario II, hog and pork production experience substantial declines, with Scenario II exacerbating the impact. This decline leads to domestic price increases, particularly notable in the pork market, while other sectors in the Brazilian economy generally experience slight price decreases. As Brazil is a major player in global pork supply, restrictions on its exports due to ASF cause global pork export prices to rise. However, while some regions such as Europe, the U.S., and China and Hong Kong could present an increase in pork exports, many countries and regions would potentially face welfare losses. The U.S. and Central and South America have modest welfare gains, primarily attributed to improved terms of trade, while others, like Canada and various Asian regions, experience losses due to reduced savings and investment, according to the simulations performed in the GTAP model. Europe, Central and South Africa, and Brazil present welfare declines due to factors such as

allocative inefficiency and deteriorating terms of trade, emphasizing the far-reaching and varied impacts of an ASF outbreak on both domestic and global economic contexts.

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