The Incidence of Increased Ocean Freight Rates during the Post-COVID Era

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The Incidence of Increased Ocean Freight Rates during the Post-COVID Era

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The Incidence of Increased Ocean Freight Rates during the Post-COVID Era

Abstract

The lingering effects of COVID-19, including increased freight demand and supply shortages, have led to a historic rise in ocean freight rates spanning from mid-2020 to 2021. The rise in ocean freight rates has raised concerns about its implications for the U.S. agricultural sector. This paper examines the incidence of increased ocean freight rates on the soybean marketing margins between the United States and China. Our findings show that ocean freight rates have a significant positive effect on soybean spreads between the two countries. Furthermore, a one standard deviation rise in ocean freight rates leads to a 0.9 cents per bushel increase in soybean prices in China, while decreasing prices in the United States by approximately 4.3 cents per bushel. These results highlight how higher ocean freight rates widen the marketing margins between the two countries, elevating soybean prices downstream (China) and reducing prices upstream (United States). Moreover, the findings suggest a higher elasticity of Chinese excess demand compared to U.S. excess supply, as reflected by the more pronounced price decrease in the United States.

Introduction

With the rebound of global economic activity and the impact of pandemic-related shortages such as lockdowns, container shortages, and labor constraints, ocean freight rates have experienced an unprecedented surge from mid-2020 to 2021 (UNCTAD, 2021). According to the Freightos Baltic Index (2022), global shipping costs skyrocketed by a staggering sevenfold from $1,461 in January 2020 to $10,525 in November 2021. Figure 1 presents the monthly trend of real ocean shipping rates from 1985 to 2022 using two key indices: the Baltic Dry Index (BDI) and the Freightos Baltic Index, which provide benchmark rates for container shipping. The figure demonstrates that the ocean freight rates began rising in mid-2020 and reached their peak in September 2021. Specifically, the dry bulk freight rates from the Davant port, Louisiana to the port of Dalian, China saw a 73 percent increase from January to November 2021, depicted in Figure 2.[3]

In addition, ocean shipping plays a crucial role in international trade. A vast majority of trade is conducted via maritime transport. Ocean transportation accounts for about 80-90 percent of trade by volume and 60-70 percent of its value (UNCTAD, 2018). Notably, in agricultural trade, Maritime

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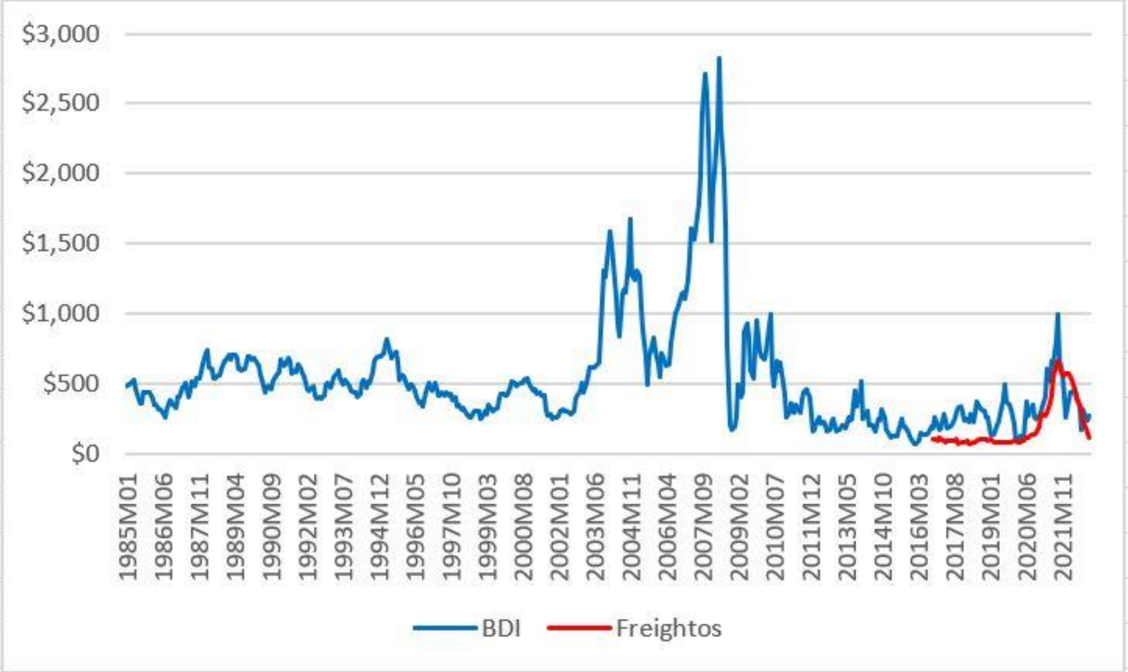
[3] Davant port is a medium-sized port, located at Gulf of Mexico in the United States (Marine Traffic, 2023). Dalian port is one the major seaports in northeastern China, located in Dalian.

transport accounts for over 80 percent of global trade in grains and oilseeds (IGC, 2022).

Figure 1. Trends in Real Ocean Freight Rates Indices, 1985-2022



Sources: Bloomberg terminal and authors' calculations.
Notes: BDI represents Baltic Dry Index and Freightos is the Freightos Baltic Index providing bench rates for container shipping. Ocean freight rates are converted to their equivalent values in U.S. dollars adjusted for inflation as of January 2021, and then adjusted to have a reference value of 100 in January 2020 following Adjemian et al. (2023).

Figure 2. Ocean Freight Rates between the United States and China, 2004-2022

Sources: Bloomberg terminal and authors' calculations.
Notes: The figure depicts monthly Dry Freight Rates Panamax between Davant, Louisiana in the United States and Dalian in China from April 2004 to April 2022. Rates are adjusted to have a reference value of 100 in January 2020.

Understanding how the incidence of transportation costs is shared between suppliers and consumers of commodities becomes crucial when there are changes in transportation costs. Increased transportation costs can affect the marketing margin by passing on the costs to consumers through higher commodity prices and to producers through lower prices, depending on the sensitivity of consumers and producers to the commodity's price (Jayne and Myers, 1994).

Previous research has focused on the relationship between price risk and marketing margins, which refer to the difference between the output price paid by consumers and the farm-level price, in agricultural commodity markets. Brorsen et al. (1985, 1987) conducted studies on the U.S. wheat and rice markets, investigating the effects of changes in output price risk on marketing margins. Their research reveals that an increase in price risk leads to an expansion of expected wheat marketing margins, particularly when marketing firms exhibit decreasing absolute risk aversion.

Jayne and Myers (1994) extended the analysis to the global wheat market by examining the impact of price risk resulting from factors such as production uncertainty, exchange rate fluctuation, and policy intervention. Their study focused on estimating the effects of price risk on equilibrium prices and marketing margins of wheat exports from ports in the Pacific Northwest (PNW) of the United States to Japan. Their findings suggested that price risk leads to an expansion of marketing margins between the two countries in the long run. Haigh and Bryant (2000) investigated the influence of transportation price risk on grain prices and margins in the U.S. inland market, U.S. Gulf, and Rotterdam using a time series model. The research highlighted the significance of considering different types of price risk, specifically barge and ocean freight rates. Their findings indicated that barge rates have a more dominant impact on grain prices and margins compared to ocean freight rates.

In a more recent study, Bushnell et al. (2022) analyzed the impact of an oil boom in North

Dakota on grain spreads, specifically in the U.S. wheat market. Their research specifically investigated how crude oil shipments influenced grain spreads, which represent the differences between grain prices in the spot market and farm prices. The study revealed that grain spreads in the U.S. wheat market increased with crude oil shipments, indicating the presence of transportation capacity constraints caused by the oil boom. Furthermore, the study found that the incidence of increased oil shipments primarily affected consumers in the form of high commodity prices, rather than producers in the U.S. wheat market. This implies that consumers are more sensitive to wheat prices compared to producers.

However, existing studies have overlooked the crucial question of how transportation costs influence both suppliers and consumers of commodities in international trade. The incidence of transportation costs depends on the relative elasticities of excess supply (from the producing and exporting country) and excess demand (from the importing country). For instance, if the soybean excess supply curve in the United States is more elastic than the Chinese excess demand curve, China would bear a greater burden of transportation costs, and vice versa.

In light of this research gap, the primary objective of this paper is to analyze the incidence of transportation costs between the United States and Chinese soybean markets, specifically due to the surge in ocean freight rates during the post-COVID era. By examining the impact of increased transportation costs on the soybean markets of both countries, we aim to shed light on how the burden of these costs is shared between the United States and China.

To investigate the impact of ocean freight rates on soybean marketing margins between the United States and Chinese soybean markets, we first analyze the influence of ocean freight rates on soybean spreads between the two countries. The findings demonstrate a significant positive impact of ocean freight rates on soybean spreads. Subsequently, we employ the cointegrated error correction model utilized by Bushnell et al. (2022) to examine the incidence of increased ocean freight rates on soybean prices in both the United States and China.

The results reveal that a one standard deviation increase in ocean freight rates has two notable effects: it raises the soybean price in China by 0.9 cents per bushel and simultaneously lowers the soybean price in the United States by approximately 4.3 cents per bushel. These findings indicate that the rise in ocean freight rates widens the marketing margins between the U.S. and Chinese soybean prices by elevating soybean prices downstream (in China) and decreasing prices upstream (in the United States). Moreover, the results suggest that the decrease in soybean prices in the United States is more pronounced compared to the increase in soybean prices in China. This implies that the Chinese excess demand for soybeans is more elastic in response to changes in ocean freight rates than the excess supply of soybeans in the United States.

This research provides valuable insights into the importance of transportation costs in shaping the dynamics of the global soybean market by estimating the changes in soybean spreads between the United States and China. By doing so, we aim to contribute to policymakers' understanding of the potential losses incurred by U.S. agricultural commodity producers and their export partners due to supply chain disruptions.

The remainder of this study is organized as follows. First, we provide a brief overview of the U.S. soybean market. Next, we discuss the methods employed, which encompass a theoretical framework, the variables and data used in this study, as well as the empirical model for the estimation. We then present the results of our analysis. Lastly, we conclude this paper with a discussion and final remarks.

Background

The United States has maintained a comparative advantage in the global market for agricultural commodities due to its efficient domestic freight transportation system and well-established agricultural practices. Specifically, the United States is one of the top soybean producers globally and exports approximately half of its soybean output worldwide (Adjemian et al., 2019). In the 2021/2022 marketing year, the United States exported 59 million metric tons (MMT) of soybeans to destinations around the world, equivalent to 51% of the U.S. total production. Among these exports, 30 MMT were transported to China, accounting for 50.5 % of all U.S. soybean exports (USDA, 2022). These figures underscore the vital importance of international trade with China for stakeholders in the U.S. soybean industry, including farmers, shippers, and associated firms, whose incomes are closely tied to the fluctuations of the global market.

Figure 3 depicts the soybean spread between China and the United States from 2015 to 2022. The soybean spread is calculated by subtracting the price of soybeans in China from the price of soybeans in the United States. The spread in Figure 3 mirrors the steep rises in ocean freight rates during the corresponding period, highlighting the strong relationship between transportation costs and the soybean spread between the two countries. Consequently, the significant rise in ocean freight rates holds major implications for the global commodity market.

Figure 3. Soybean Spread between China and the United States, 2016-2021

Source: Bloomberg terminal and authors' calculations

Notes: The figure illustrates monthly the soybean spread between Dalian, China to Davant, Louisiana for the period of 2016-2021.

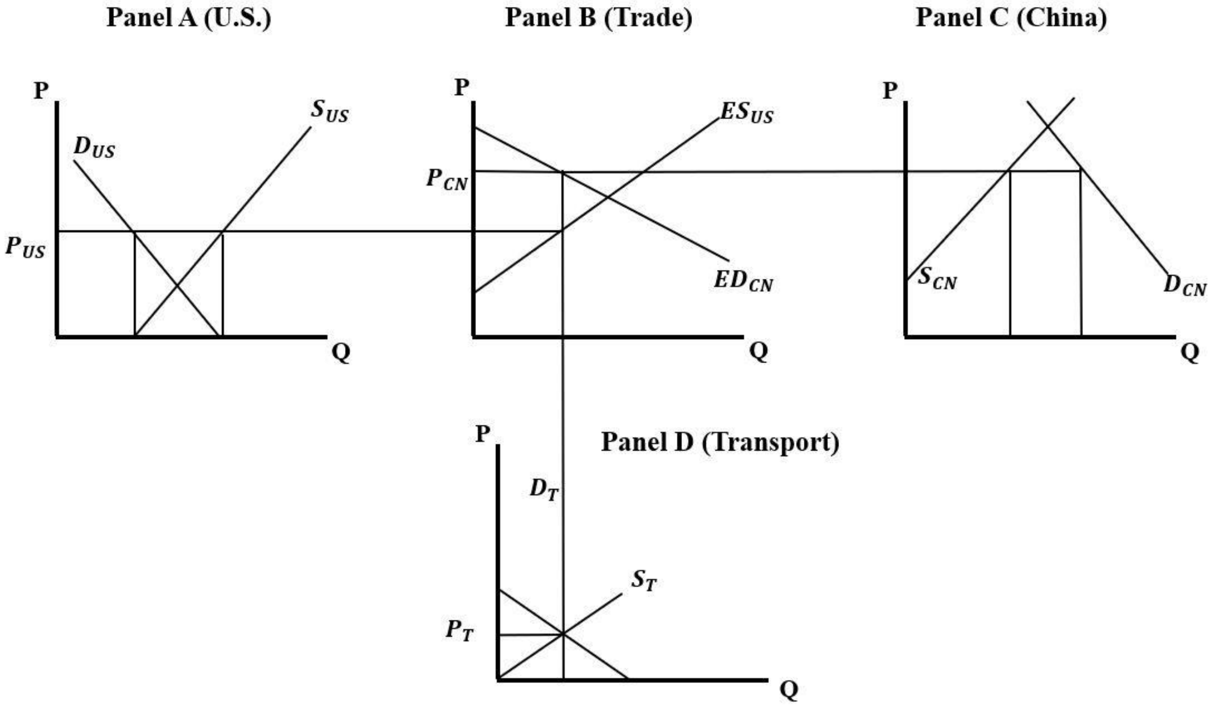
Methodology

This study is founded on a two-region spatial equilibrium model (Yu and Fuller, 2005; Yu et al., 2010;

Babcock and Fuller, 2007; Babcock and Gayle, 2014). This model is designed to illustrate the freight transport demand, which determines the equilibrium transportation rate and grain transported between two regions (Figure 4). We use this model to estimate the impact of ocean freight rates on the soybean spreads, which are the difference in soybean prices between the United States and China.

Because the freight transport demand for soybeans are a derived demand, any forces that shift soybean supply and demand curves in the production region (i.e., the United States) and soybean supply and demand curves in grain demand markets (i.e., China) would influence the transportation demand (Boyer, 1997). In figure 4, we depict a two-region spatial equilibrium model and the corresponding transportation market for the soybean trade between the United States and China. Panel A displays the supply (S_{US}) and demand (D_{US}) of soybeans in production region (i.e., the United States). Panel C presents the soybean demand (D_{CN}) and supply (S_{CN}) in China. Panel B presents the trade panel that includes excess soybean supply which is produced in the United States $(i.e., ES_{US} = S_{US} - D_{US})$, and excess soybean demand created in China $(i.e., ED_{CN} = D_{CN} - S_{CN})$. Absent transportation costs, the intersection of these excess supply and excess demand curves would be the equilibrium soybean trade between the United States and China. However, transportation costs play critical role in grain marketing. Panel D shows the derived demand for grain transportation and the supply of grain transportation services. The derived transportation demand is equivalent to the vertical distance between excess supply (ES_{US}) and excess demand (ED_{CN}) in the trade market. As more than 80 percent of the world trade in grains and oilseeds occurs via maritime transport (IGC, 2022), it is reasonable to make the assumption that the supply of transportation (panel D) is an approximation of maritime transport. Transportation demand intersects with an exogenously set soybean transportation supply curve which provides the equilibrium transportation rate and the quantity of the grain transported between two countries. When the soybean ocean freight supply curve is shifted to the left (S_{T_1}) due to supply chain disruptions, this would change the gap between the United States and China and lead to a reduction in traded soybeans (figure 5). We assume that the ocean freight demand curve remains unchanged.

Figure 4. Two-Region Spatial Equilibrium Model and Derived Transportation Market



The incidence of transportation costs depends on the relative elasticities of excess supply and excess demand. If excess demand of soybeans in China (ED_{CN}) is relatively more elastic than the excess supply of soybeans in the United States. (ES_{US}), higher transportation costs will be passed through more to producers ($P_{US_0} - P_{US_1}$) than consumers ($P_{CN_1} - P_{CN_0}$) presented in figure 6. The opposite is true if the relative elasticities are switched displayed in figure 7.

Figure 5. Impacts of Increased Ocean Freight Rates on the Wedge between the U.S. and Chinese Soybean Markets

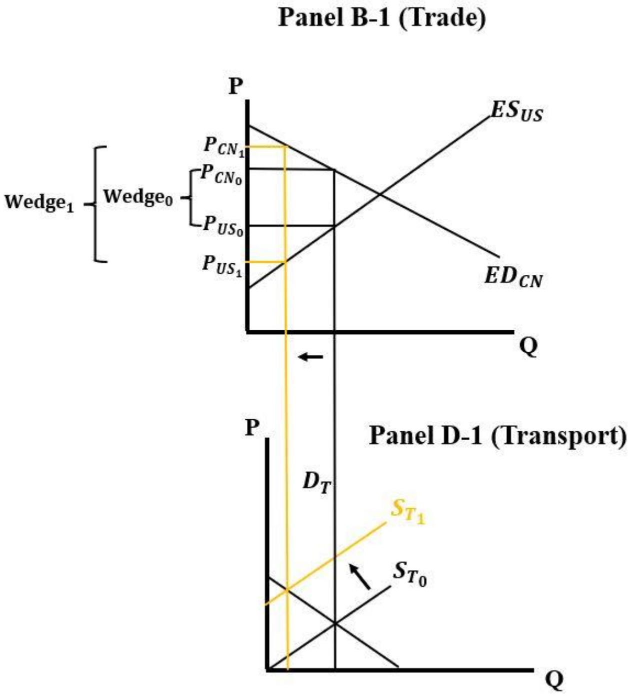


Figure 6. The Incidence of Transportation Costs on Elastic Soybean Excess Demand Relative to Excess Supply

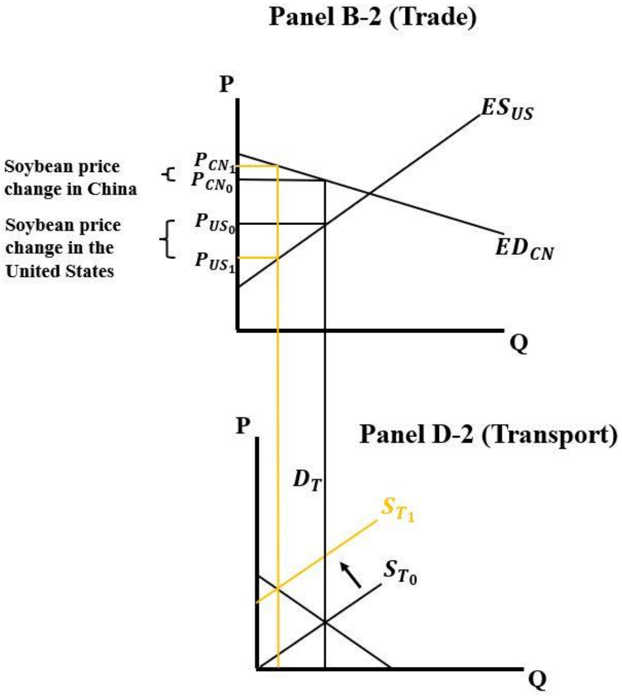
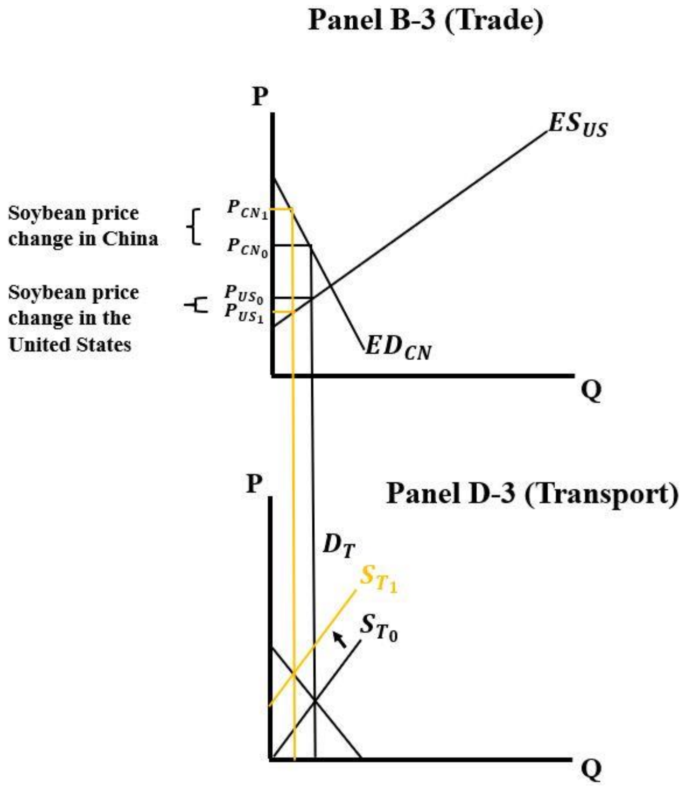


Figure 7. The Incidence of Transportation Costs on Relative Inelastic Soybean Excess Demand Relative to Excess Supply



Econometric approach

We first check to see if the impact of ocean freight rates on soybean spreads between the United States and China. This is done by estimating the following equation via OLS.

$$SoybeanSpreads_t = \beta Rates_t + \delta Exchange_t + \sum_{m=1}^{12}[SoybeanProduction_y \times \theta_m] + \epsilon_t \qquad (1)$$

$SoybeanSpreads_t$ is calculated as the difference between U.S. soybean prices at ports in Dalian, China and the U.S. Gulf at week t (i.e., $P_{CN,t} - P_{US,t}$). $Rates_t$ represents the cost of shipping dry bulk commodities, including grains, from Davant, Louisiana to Dalian, China, using a Panamax-sized vessel. $Exchange_t$ is the Chinese Yuan Renminbi to U.S. Dollar spot exchange rate at week t. Exchange rates are included to examine the impact of exchange rates on the soybean price received for farm products as discussed by Carter et al. (1990). Moreover, $SoybeanProduction_y$ represents U.S. soybean production in a given marketing year. The spreads of field crop commodity prices tend to vary based on the availability of crop stocks, which is influenced by annual variations in harvest size and seasonal changes between harvests. We also control the U.S. soybean harvest size by interacting $SoybeanProduction_y$ with mean effects for a given month, denoted as θ_m.

Next, following the approach employed by Bushnell et al. (2022), we use a cointegrated error correction model to estimate the incidence of ocean freight rates on the soybean prices in United States and China. Furthermore, we aim to decompose the impact of the soybean spread into its impact on the soybean prices in each country. Equations 2-4 contain the estimating equations.

To conduct our analysis, we use weekly data from 2016 to 2021, which includes soybean spot prices at ports in both the United States and China, as well as the corresponding ocean freight rates. As the changes in soybean prices are not expected to have an immediate influence on ocean freight rates within a given week, we employ impulse response functions to estimate the dynamic causal effects using the error correction model (Ghanem and Smith, 2022). The correlation between the error in ocean freight rates and the errors for the two soybean prices provides evidence that changes in ocean freight rates cause soybean price changes in two countries.

In this model, the lagged error correction term, represented by α, captures the response of each price to deviations from the equilibrium price spreads. This term is crucial for determining the long-run incidence. For example, in cases where the price spread exceeds its equilibrium value and the absolute value of α_{CN} is greater than that of α_{US}, the restoration of equilibrium is primarily driven by changes in soybean prices in China rather than by price adjustments in the United States. The β represents the long-run effect of ocean freight rates on the soybean spread. The γ represents short-run revisions.

$$\begin{aligned}\Delta P_{CN,t} = {} & \alpha_{CN}\left(P_{CN,t-1} - P_{US,t-1} - \beta Rates_{t-1} - \delta\right) + \gamma_{11}\Delta P_{CN,t-1} + \gamma_{12}\Delta P_{US,t-1} \\ & + \gamma_{13}\Delta Rates_{t-1} + \varepsilon_{CN,t} \qquad (2)\end{aligned}$$

$$\begin{aligned}\Delta P_{US,t} = {} & \alpha_{US}\left(P_{CN,t-1} - P_{US,t-1} - \beta Rates_{t-1} - \delta\right) + \gamma_{21}\Delta P_{CN,t-1} + \gamma_{22}\Delta P_{US,t-1} \\ & + \gamma_{23}\Delta Rates_{t-1} + \varepsilon_{US,t} \qquad (3)\end{aligned}$$

$$\Delta Rates_t = \alpha_{Rates}\left(P_{CN,t-1} - P_{US,t-1} - \beta Rates_{t-1} - \delta\right) + \gamma_{31}\Delta P_{CN,t-1} + \gamma_{32}\Delta P_{US,t-1}$$

$$+\gamma_{33}\Delta Rates_{t-1}+\varepsilon_{Rates,t} \tag{4}$$

Data

We employ weekly data covering the period from January 2016 to December 2021. Ocean freight rates are measured using the Dry Freight Rates Panamax Grains from the United States Davant to China Dalian. These rates, expressed in U.S. dollars per metric ton, are obtained from the Refinitiv workspace.

For the calculation of the soybean spread, we employ soybean spot prices in the U.S. Gulf and China Dalian. These prices, expressed in U.S. dollars per bushel, are sourced from the Bloomberg terminal. Specifically, we use the U.S. Gulf No.1 Yellow soybean spot price as a representation of soybean prices in the United States, while the U.S. No.2 Yellow soybean spot price in Dalian represents the soybean prices in China. To ensure consistency, we convert the U.S. soybean prices in China, originally expressed in Chinese Yuan, into U.S. dollars.

Exchange rates, expressed as Chinese Yuan Renminbi to One U.S. Dollar, are collected from the Federal Reserve Economic Data (FRED). Additionally, we incorporate annual U.S. soybean production at the national level, obtained from the USDA National Agricultural Statistics Service Information (NASS). Table 1 presents descriptive statistics of the variables used in our model.

Table 1. Descriptive Statistics

	Obs.	Mean	Std. Dev.	Min	Max
Ocean freight rates (USD)	313	38.57	13.30	16.3	79.92
Soybean spread (USD/Ton.)	313	3.52	1.13	0.45	6.95
Exchange rate (CYR to USD)	313	6.71	0.23	6.27	7.15
US soybean production (Million bushels)	313	4185.51	315.65	3551.91	4465.38

Results

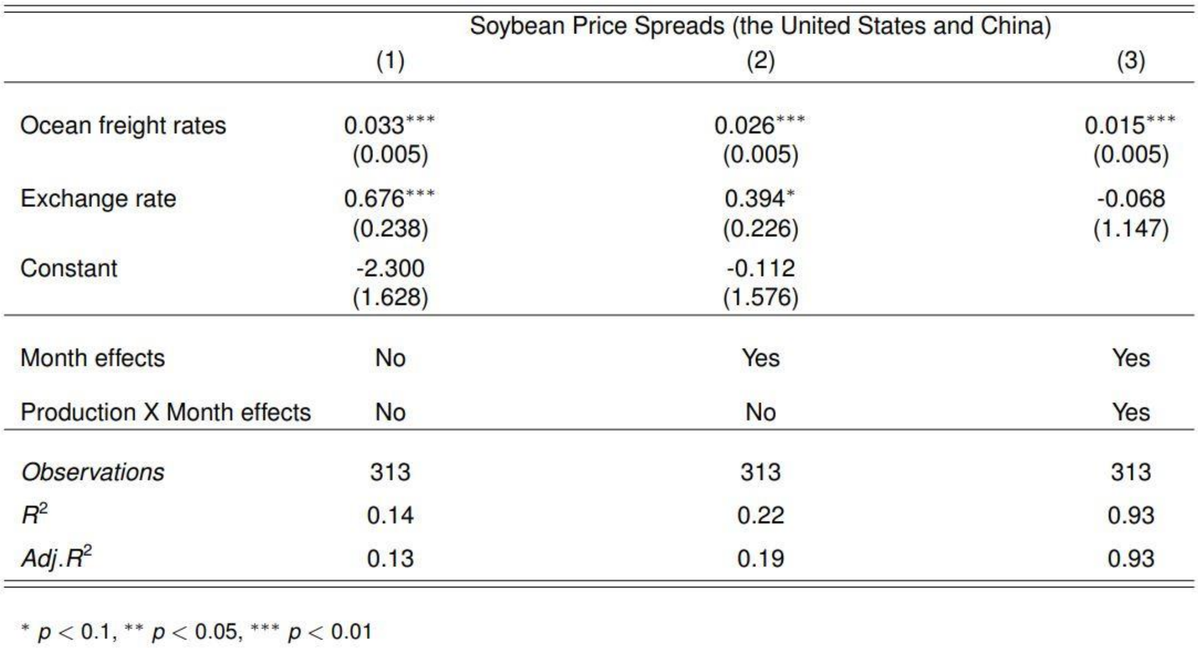
Impacts of ocean freight rates on soybean spreads between the United States and China

Table 2 reports the regression results examining the impact of ocean freight rates on soybean spreads between the United States and China. The table includes three models, each with different control variables. In the first model (column 1), we include exchange rates as the only control variable. Next, we add seasonal effects to the second model (column 2). By incorporating seasonal effects using month dummies, we aim to capture the regular patterns and variations observed across different months, which may influence soybean spreads. Lastly, the third model (column 3) includes the U.S. soybean production, which is interacted with month effects.

As expected, the regression results confirm that ocean freight rates have a positive effect on soybean spreads between the United States and China, with statistical significance at the one percent level. Specifically, in the third model, the estimated coefficient of ocean freight rates is 0.015, indicating that for every one U.S. dollar per ton increase in ocean freight rates, soybean spreads rise by 1.5 cents per bushel. This finding underscores the importance of transportation costs in shaping the dynamics of the soybean market between the two countries.

However, it is important to note that the signs of the estimated coefficient of exchange rates is not significant across all specifications. In the first and second models, the coefficient of exchange rates has positive signs, in line with the expectation that an overvaluation of the U.S. dollar would lead to a decrease in the domestic field crop price (Schuh, 1974). However, in the third model, the sign of the coefficient of exchange rates is close to zero and not statistically significant. The results indicate that the impact of ocean freight rates on soybean spreads tends to decrease with the addition of controls but remains significant at the 1-percent level.

Table 2. The impact of ocean freight rates on soybean spreads



	Soybean Price Spreads (the United States and China)		
	(1)	(2)	(3)
Ocean freight rates	0.033^{***}	0.026^{***}	0.015^{***}
	(0.005)	(0.005)	(0.005)
Exchange rate	0.676^{***}	0.394^{*}	-0.068
	(0.238)	(0.226)	(1.147)
Constant	-2.300	-0.112	
	(1.628)	(1.576)	
Month effects	No	Yes	Yes
Production X Month effects	No	No	Yes
Observations	313	313	313
R^2	0.14	0.22	0.93
$Adj.R^2$	0.13	0.19	0.93

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

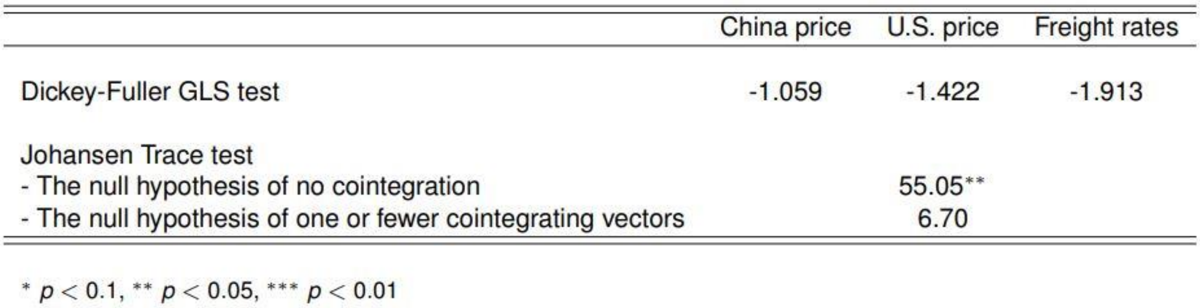
Notes: The numbers in parentheses are the robust standard errors of the coefficient estimates. Standard errors clustered by week of sample, spanning from January 2016 to December 2021.

Diagnostic tests

In this section, we conduct diagnostic tests to assess the validity of our cointegration analysis. Table 3 presents the results of unit root and cointegration tests performed on soybean prices in each country and ocean freight rates.

The outcomes of the Dickey-Fuller GLS test, as shown in the table, indicate that we cannot reject the null hypothesis of a unit root, thus validating cointegration analysis. In the Johansen trace test, while the model can reject the null hypothesis of no cointegration, it cannot reject the null hypothesis of a single cointegration. These findings support the cointegration specification in equations (2)-(4), which involve a single cointegration term. If changes in soybean spot prices in China are highly correlated with those in the United States, isolating individual price responses to shocks would be challenging. We observe a correlation of 0.65 between them, which is comparable to the correlation of 0.59 found in the work of Bushnell et al. (2022) for the wheat market.

Table 3. Unit Root and Cointegration Test Results



	China price	U.S. price	Freight rates
Dickey-Fuller GLS test	-1.059	-1.422	-1.913
Johansen Trace test			
- The null hypothesis of no cointegration		55.05**	
- The null hypothesis of one or fewer cointegrating vectors		6.70	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table includes results of Dickey-Fuller GLS test and Johansen trace tests for soybean prices in the United States and China and ocean freight rates. The critical values at the 5 percent level for the Dickey-Fuller GLS test, null hypothesis of no cointegration in the Johansen trace test, and null hypothesis of one or fewer cointegrating vectors in the corresponding test are -2.891, 29.68, and 15.41, respectively.

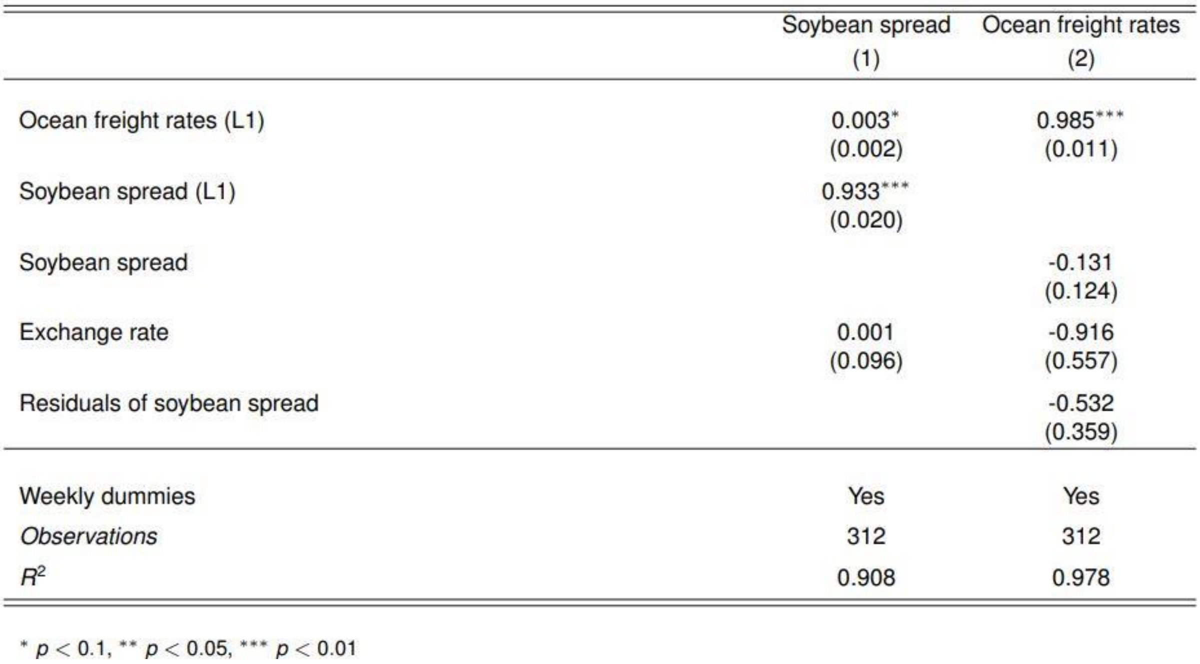
Simultaneity test results between ocean freight rates and soybean spreads

In order to ensure accurate estimation of the impact of ocean freight rates on soybean spreads, it is crucial to verify whether these variables are simultaneously determined, as the presence of simultaneity can lead to unreliable results. To investigate this simultaneity, we perform a Hausman specification error test (see Gujarati and Porter, 2009). The Hausman specification error test examines whether the coefficient of residuals in soybean spreads is statistically significant, which would indicate the presence of simultaneity between ocean freight rates and soybean spreads (Wilson and Lakkakula, 2021). The results of the simultaneity test are presented in Table 4, and they indicate no evidence of simultaneity in our model.

Incidence of increased ocean freight rates on soybean prices in the United States and China

Once again following the empirical approach employed by Bushnell et al. (2022), we estimate the incidence of increased ocean freight rates on soybean prices in the United States and China using the cointegrated error correction model. This model incorporates ocean freight rates between them and the two soybean prices in each country. Table 5 presents results of the cointegrated error correction model for soybean prices in the United States and China. The estimates of the cointegrating vector, 0.025, which represents long-run effect of ocean freight rates is comparable to the estimated coefficients of ocean freight rates in table 4. Specifically, it is very close to the coefficient, 0.026, in the second model.

Table 4. A simultaneity test between ocean freight rates and soybean spreads



	Soybean spread (1)	Ocean freight rates (2)
Ocean freight rates (L1)	0.003* (0.002)	0.985*** (0.011)
Soybean spread (L1)	0.933*** (0.020)	
Soybean spread		-0.131 (0.124)
Exchange rate	0.001 (0.096)	-0.916 (0.557)
Residuals of soybean spread		-0.532 (0.359)
Weekly dummies	Yes	Yes
Observations	312	312
R^2	0.908	0.978

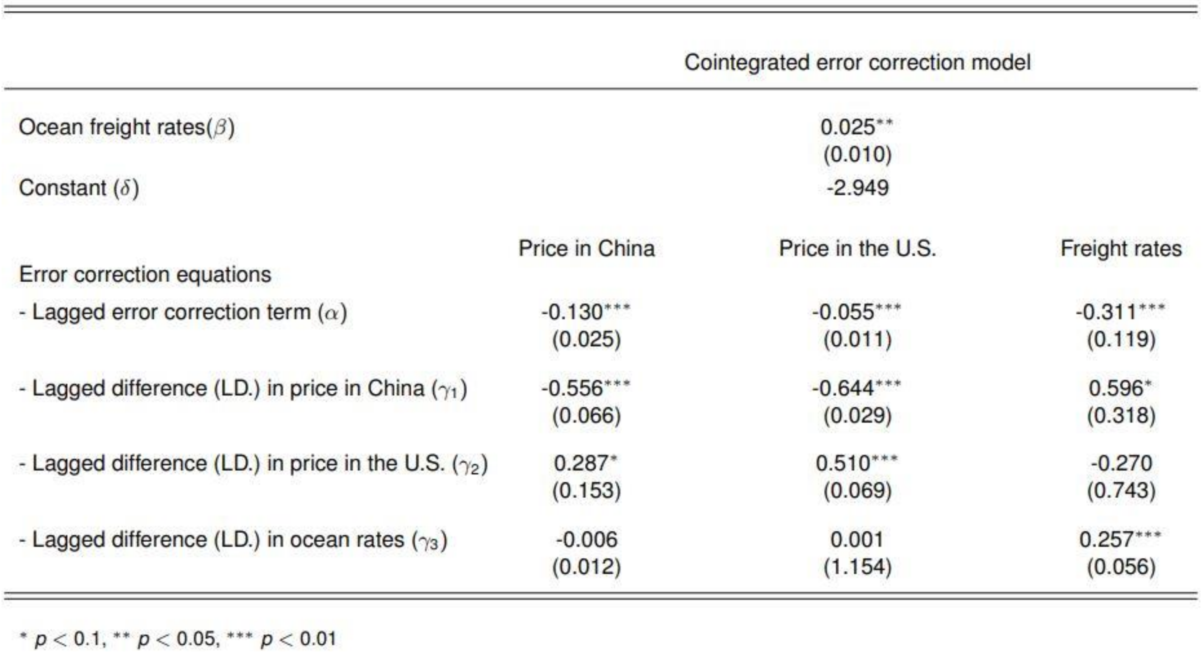
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The numbers in parentheses are the standard errors of the coefficient estimates. The table includes lagged ocean freight rates and lagged soybean spread as dependent variables. This is because the current value at t is closely related to the previous value at $t - 1$.

The error correction term, α, reveals important information about the adjustment process in the soybean market between the United States and China. In the case of a one-unit increase in the soybean spread between the two countries above its equilibrium level, the soybean price in the United States responds by decreasing 0.055 U.S. dollars per bushel in the following week. On the other hand, the soybean price in China decreases by 0.13 U.S. dollars per bushel to restore the equilibrium. These findings indicate that soybean prices in China are more responsive to shocks compared to the prices in the United States.

To decompose the impact of ocean freight rate shocks on soybean prices in each country, we estimate the impulse responses of soybean prices to a shock to ocean freight rates using 1,000 bootstrap replications. Impulse responses quantify the dynamic causal effect of a shock to one variable on the other variables in the model, allowing us to see the long-run impulse responses as long-run causal effects (Ghanem and Smith, 2022). Table 6 presents the impulse response of soybean prices in each country to a shock to ocean freight rates. The results show that a one standard deviation increase in ocean freight rates increases the soybean price in China by 0.9 cents per bushel and decreases the soybean price in the United States by around 4.3 cents per bushel. These results indicate that the rise in ocean freight rates widens the marketing margins between the U.S. and Chinese soybean prices by elevating soybean prices downstream (i.e., in China) and by reducing prices upstream (i.e., in the United States). Furthermore, the results suggest that the decrease in the soybean price in the United States is more significant than the increase in the soybean prices in China. This suggests that Chinese excess demand for U.S. soybeans is more elastic than the excess supply of soybeans in the United States. Consequently, the burden of transportation costs would be born more by soybean producers in the United States rather than by U.S. soybean consumers in China. This result aligns with the case depicted in Figure 6. Moreover, this is consistent with the results presented in Bushnell et al. (2022), which indicate that the demand for corn and soybeans in Upper Great Plains is relatively more elastic than wheat, as the former crops have more substitute producers.

Table 5. Cointegrated error correction model regression results



	Cointegrated error correction model		
Ocean freight rates(β)		0.025**	
		(0.010)	
Constant (δ)		-2.949	
	Price in China	Price in the U.S.	Freight rates
Error correction equations			
- Lagged error correction term (α)	-0.130***	-0.055***	-0.311***
	(0.025)	(0.011)	(0.119)
- Lagged difference (LD.) in price in China (γ_1)	-0.556***	-0.644***	0.596*
	(0.066)	(0.029)	(0.318)
- Lagged difference (LD.) in price in the U.S. (γ_2)	0.287*	0.510***	-0.270
	(0.153)	(0.069)	(0.743)
- Lagged difference (LD.) in ocean rates (γ_3)	-0.006	0.001	0.257***
	(0.012)	(1.154)	(0.056)

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The numbers in parentheses are the standard errors of the coefficient estimates. The cointegrated error correction model is estimated using maximum likelihood estimation. The lag order is set to 3, based on the Akaike Information Criterion (AIC). The analysis utilizes data from January 2016 to December 2021 at a weekly frequency.

Table 6. Long-run impulse responses to ocean freight rates

	Price in China	Price in the U.S.	Freight rates
Long-run impulse response	0.009	-0.043	1

Conclusions

Starting from the middle of 2020, ocean freight rates began a consistent upward trajectory that persisted until 2021. Factors such as the global economic recovery, resumption of operations, and increased demand for transportation services have contributed to this rise. Labor shortages and supply chain challenges stemming from the pandemic have further amplified the increase in ocean freight rates. The United States' dependence on global shipping demand for agricultural commodities raises questions about the impact of increased ocean freight rates on the U.S. agricultural sector. Specifically, the United States holds a prominent position as one of the leading global producers of soybeans, with roughly half of its soybean production being exported to various destinations worldwide.

The objective of this paper is to investigate the incidence of transportation costs on soybean marketing margins between the United States and Chinese soybean markets resulting during the pandemic. Our analysis begins by examining the impact of ocean freight rates on soybean spreads between the two countries. The results reveal a significant positive effect of ocean freight rates on the soybean spreads, indicating that higher freight rates contribute to widen the marketing margins between them.

We also estimate the incidence of increased ocean freight rates on soybean prices in the United States and China using the cointegrated error correction model employed by Bushnell et al. (2022). Our findings demonstrate that a one standard deviation rise in ocean freight rates leads to a 0.9 cent pr bushel increase in soybean prices in China, while simultaneously causing a decline of approximately 4.3 cents per bushel in soybean prices in the United States. These results suggest that rising ocean freight rates have a dual impact, elevating soybean prices downstream (China) and reducing prices upstream (the United States), thereby widening the marketing margins between the two countries. Furthermore, the analysis indicates that the decrease in soybean prices in the United States is more pronounced compared to the increase in soybean prices in China. This implies that the excess demand for U.S. soybeans from China is more elastic than the excess supply of soybeans in the United States.

This research provides valuable insights into the importance of transportation costs in shaping the dynamics of the global soybean market. Specifically, by examining the dynamics between soybean spreads and transportation costs, this study highlights the significance of transportation costs in affecting market outcomes. The findings can serve as a valuable resource for policymakers, offering them insights into the potential losses that may arise from supply chain shocks for U.S. soybean producers, shippers, and their export partners.

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