Scientific Research Publishing

Modern Economy, 2024, 15, 753-763
https://www.scirp.org/journal/me
ISSN Online: 2152-7261
ISSN Print: 2152-7245

A Study on the Effects of U.S.-China Trade War on the U.S. Soybean Market

Yun Feng (Benson) Xie

Concord Academy, Concord, MA, USA
Email: ca900071868@concordacademy.org

How to cite this paper: Xie, Y. F. (2024). A Study on the Effects of U.S.-China Trade War on the U.S. Soybean Market. *Modern Economy, 15,* 753-763.
https://doi.org/10.4236/me.2024.158038

Received: May 16, 2024
Accepted: August 25, 2024
Published: August 28, 2024

Abstract

A theoretical framework was set up and utilized charts to analyze the effects of the U.S.-China trade war on the U.S. soybean market. Then, we collected data from the United States Department of Agriculture's (USDA) website and established an ARIMA model to estimate the effects of the trade war on the U.S. soybean prices and calculate the impact on social welfare. Two scenarios are created for analysis: one baseline scenario with the actual U.S. soybean prices after July 2018, which includes the impacts of the trade war, and a counterfactual scenario with the prices forecasted by the ARIMA model using historical prices before July 2018, excluding the impact of the trade war. Our findings indicate that the trade war constrained the U.S. soybean export to China thus lowering U.S. domestic soybean prices. Furthermore, the trade war increased the consumer surplus, however, it reduced the producer surplus in the U.S. soybean market. As a result, a Dead Weight Loss has been incurred.

Keywords

Soybean, US-China Trade War, ARIMA Model, Social Welfare, Dead Weight Loss

1. Introduction

The U.S.-China relationship has long been a trending topic not just politically but also academically. Beginning in 2018, a trade war broke out between the U.S. and China. In March 2018, the Trump administration proposed tariffs on US$50-60 billion worth of Chinese manufactured goods, and China responded by posing a retaliatory tariff on products including aluminum, cars, pork, soybean, etc. imported from the United States. Being the two economic juggernauts, the tension between U.S. and China has a comprehensive effect on the world's economy. Handley and Limão (2017) studied the impact of policy uncertainty

on the U.S.-China relationship and found that China's 2001 accession to WTO reduced the risk of a trade war from the United States, which accounted for over one-third of the increase in exports between 2000 and 2005. Meanwhile, they found that the reduction in policy uncertainty decreased the U.S. price levels and increased the real income of consumers, being equivalent to a 13-percentage-point reduction in tariff. Chen (2014) explored U.S.-China trade relations as well as the economic distrust between the two countries. They found that the distrust reduced cooperation between the United States and China in certain fields such as clean energy, global warming, and U.S. treasury bonds, where the two countries hold similar interests. Hence, such distrust increased competition in intellectual property, currency exchange rates, etc.

Soybean is one of the most abundantly planted crops in both the United States and China, and it plays a vital role in the economies of both countries. The United States is typically a large soybean exporter while China is a large soybean importer. Dhoubhadel, Ridley, and Devadoss (2023) indicated that over 40 years in the past, the United States and Brazil accounted for at least 75% of the world's soybean exports, while China accounted for 63% of the global soybean imports in 2016. Also, they pointed out that soybeans accounted for about 18% of the total U.S. agricultural export value in 2020, which made it the largest U.S. agricultural export. Song, Marchant, and Xu (2006) compared the competitiveness of the three suppliers of China's soybean import: The U.S., Brazil, and Argentina. They found that the three suppliers were all seasonal complementary soybean suppliers, while Brazil had the biggest advantage over the U.S. and Argentina in the Chinese soybean market.

These studies revealed the far-reaching consequences that the U.S.-China relationship might bring to the economies of both countries or to the world's economy, as well as the role that soybean export plays between the two. However, in what way does the trade war between the United States and China affect soybean exports, domestic soybean prices, and the social welfare of the United States? Being widely planted in the United States, soybean is an important crop whose price fluctuates due to the trade war, which might greatly impact the income of U.S. soybean planters and further the social welfare of the country. Thus, studying the economic effects that the U.S.-China trade war might bring to soybeans in the United States is particularly important.

This study will explore the economic effects that the 2018 trade war brought to the U.S. soybeans, both theoretically and empirically. We used supply and demand graphs to illustrate how the trade war will theoretically affect U.S. soybean prices and social welfare. Furthermore, we collected soybean price data from the website of the United States Department of Agriculture (USDA) and established an ARIMA model to predict soybean prices in a scenario assuming the trade war did not occur in 2018. By comparing with the actual soybean prices in the same period, we can see the impact of the trade war on domestic U.S. soybean prices, and estimate the potential social welfare change based on the price effects.

In Section II, we will review the related studies in the literature. Section III will use graphs to interpret how the trade war will theoretically affect the U.S. domestic soybean prices and the settings of the ARIMA model to be used for empirical analysis. Section IV introduces the data we utilized, and Section V presents the results of our empirical analysis. Section VI is a conclusion, which summarizes our findings and provides policy suggestions.

2. Literature Review

In 2018, a trade war broke out between the United States and China, and it has brought comprehensive effects to the two countries as well as to the world's economy. Given the importance of the U.S.-China relationship, many studies literature studies looked into the trade war and the effects that it had brought on the economy. Itakura (2020) evaluated the impact that the U.S.-China trade war brought through a dynamic general equilibrium global trade model. They found through the escalation of the trade war, it caused a reduction in the Gross Domestic Product (GDP) of the United States and China by 1.35% and 1.41% respectively. Chen et al. (2020) discussed the causes leading to the U.S.-China trade war and concluded that the trade war's emphasis was not on trade but more on technological dominance, a typical conflict emerging when a rising power challenges a dominant power.

While research on the general impacts of the trade war existed in the literature, some focused on the effects on agricultural products. Given that soybean plays a crucial role in U.S. exports and China's import of crops, studying what the trade war brings to soybeans is a vital topic in the literature. Adjemian et al. (2021) studied the effects of China's retaliation tariff on U.S. soybean exports. They used the relative price of a substitute methodology for estimating the trade disruption and found that the U.S. soybean prices lowered by $0.74/bushel on average at the Gulf export locations, while the Brazilian prices increased by $0.97/bushel, caused by the tariff. Wang (2019) adopted a dynamic decision-making model to analyze the effects that the U.S.-China trade war brought on the soybean market of the two countries including Brazil through taking China's soybean import market as a duopoly market, and both Brazil and the United States as two monopoly manufacturers of China's soybean imports. The study found and concluded that China's tariff on the soybeans exported from the United States caused the imported soybean price to rise on the Chinese market, while that from Brazil experienced little impact.

There have been plenty of studies addressing the effects of the U.S.-China trade war, however, analyzing impacts of the trade war on the U.S. soybean market welfare has been rarely paid attention to despite that soybean stands as a pivotal role in the U.S. agricultural population. In this paper, we will use charts to qualitatively analyze how the U.S.-China trade war will affect the soybean prices in the U.S. market and social welfare. Then, we will collect data from the website of the United States Department of Agriculture (USDA) and establish an

ARIMA model to estimate the real effects that the trade war brought to soybean prices and the social welfare in the U.S. domestic market. Two scenarios will be set up: 1) we use the ARIMA model and historical U.S. soybean prices to forecast the prices beginning from July 2018, to create counterfactual prices without the effect of the trade war. 2) The actual U.S. soybean prices beginning from July 2018 are the prices already been affected by the trade war. Based on the prices created in these two scenarios, we will calculate the impact that the trade war brought on social welfare.

3. Methodology

Bjørnskov (2005) introduced a framework for tariff analysis on international trade. Based on this framework, we can interpret the qualitative effects that the U.S.-China trade war brings towards the U.S. soybean prices and social welfare using graphs.

From Figure 1, we can see the trade war's impact on both the U.S. and China. The left chart shows the soybean market in the U.S., and the right chart shows that of China. While the U.S. is a major soybean exporter of the world and China is a major soybean importer, the soybean export of the U.S. mainly goes into China's soybean import. If the two countries do not trade soybeans, the soybean equilibrium price should be represented as P_0 on the U.S. market. Then, we assume trade is free for both sides and the U.S. exports soybeans to China, then the world price of soybeans would be represented as P_w. The soybean supply curve of the U.S. would shift from S_0 to S_1, while $Q_0'Q_2$ would be the amount of soybean exported. Correspondingly, $Q_{10}'Q_{13}$ is the amount of soybeans that China imports. When the trade war begins and China imposes a retaliatory tariff on the soybean imported from the U.S., the soybean import will shrink, the total soybean supply curve of China (aggregating the domestic production and the

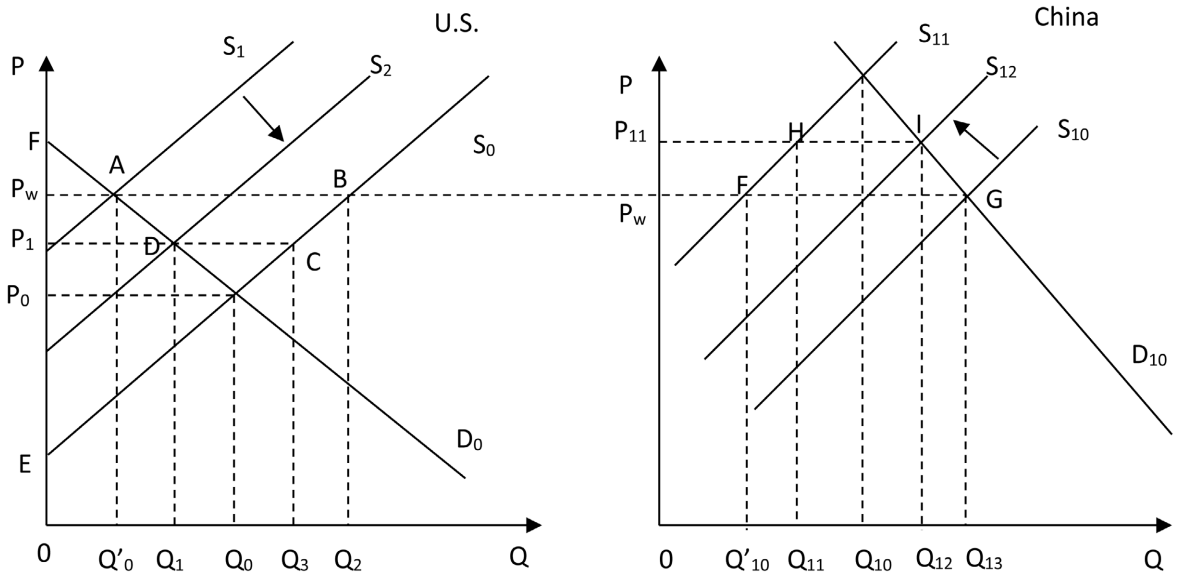


Figure 1. The trade war's impact on the U.S. and China's soybean market.

soybean imported) will shift from S_{10} to S_{12}, and the amount China imports reduces to $Q_{11}Q_{12}$. Just because the main soybean importer, China, reduces its demand for the U.S. soybean, the amount of soybean exported from the U.S. will decrease. This will lead to the shift of the U.S. domestic soybean supply curve from S_1 to S_2, and the amount of soybean exported will change from $Q_0'Q_2$ to Q_1Q_3. From the left chart, we can see the domestic soybean price in the U.S. decreases from P_w to P_1 accordingly.

Concerning the welfare analysis, before China imposed a retaliatory tariff on the U.S. soybean import, the social welfare of the U.S. soybean market is FP_wA (consumer surplus) + P_wBE (producer surplus); after the imposition of the tariff, the welfare of the U.S. soybean market becomes FP_1D (consumer surplus) + P_1CE (producer surplus). When we make the difference between the two cases, we can see that the trade war decreases the social welfare of the U.S. soybean market, and the area ABCD is the dead weight loss.

Besides the theoretical analysis above using charts, we will also collect data and set up a statistical model to empirically analyze what effect the trade war brought to the U.S. soybean market. Box et al. (2015) introduced the ARIMA method, which is an integration of autoregressive and moving averages in time series modeling. The ARIMA model is a very useful tool in forecasting a time series, which can be used in this study to analyze the trade war's effect on the U.S. soybean market. The formula of an ARIMA model is:

$$Y_t = c + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots + \phi_p Y_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \cdots + \theta_q \varepsilon_{t-p} + \varepsilon_t \quad (1)$$

In formula (1), $\{Y_t\}$ is a time series, and ε_t is assumed to identically and independently follow a normal distribution, that is, $\varepsilon_t \overset{iid}{\sim} N\left(0, \sigma_w^2\right)$. If we assume after d order of differencing, the time series $\{Y_t\}$ becomes stationary, then this ARIMA model can be written as the ARIMA(p,d,q) model. When we have the historical values of the time series $\{Y_t\}$, we can run a regression to estimate the coefficients of the model (1) and substitute the values of $Y_{t-1}, Y_{t-2}, \cdots, Y_{t-p}$ to the right-hand-side of the model (1) to forecast the future value Y_t on the left-hand-side.

In the following parts of this study, we will collect the U.S. soybean data like prices, production, export, etc. to establish an ARIMA model and estimate the effects that the trade war brings to the U.S. soybean market. Two scenarios will be set up for the analysis: 1) China's retaliatory tariff took effect in July 2018, thus the historical U.S. soybean prices have already included the impact of the trade war 2) the U.S. soybean historical prices before July 2018 was not impacted by the trade war, thus we can estimate the ARIMA model using this part of data, and use the ARIMA model to forecast the U.S. soybean prices after July 2018. This can be taken as the counterfactual scenario assuming the trade war did not take place. A comparison of the U.S. soybean prices will be made between the two scenarios, to interpret the effects that the trade war brought to the U.S. soybean prices, and then further analysis will be completed on the social welfare impact that the trade war brought to the U.S. soybean market based on these two

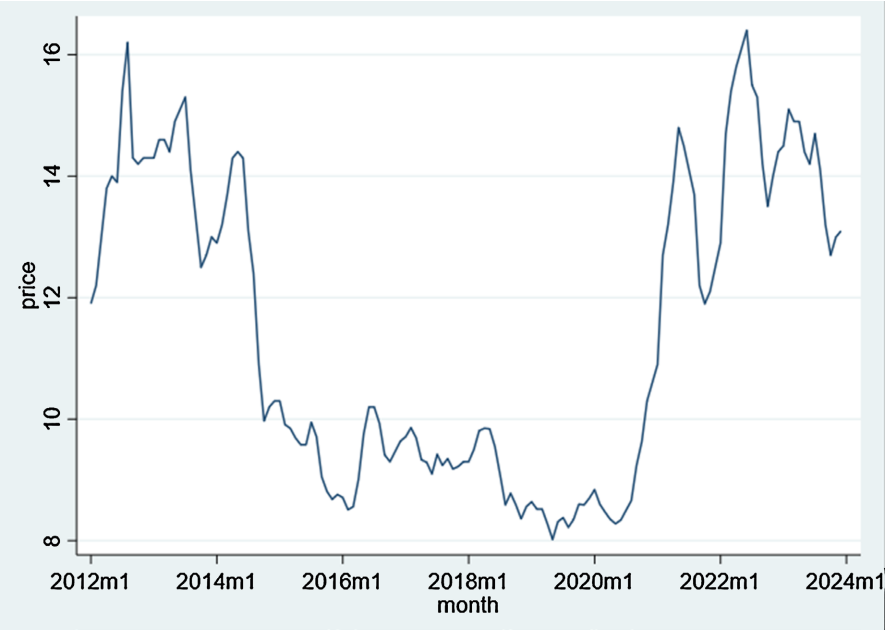
scenarios.

4. Data

The data used for the empirical analysis can be obtained from the website of the United States Department of Agriculture (USDA). We obtain the U.S. soybean monthly prices from the National Agricultural Statistics Service of the USDA website. The soybean prices data cover January 2012 to March 2024. This will be used for estimating an ARIMA model and forecasting the soybean prices beginning from July 2018 for the counterfactual scenario. At the same time, we can use the methods of the relevant computation in Jin (2020) for the welfare analysis. The data collected above are used to calculate the corresponding changes in Producer Surplus and Consumer Surplus brought about by the trade war.

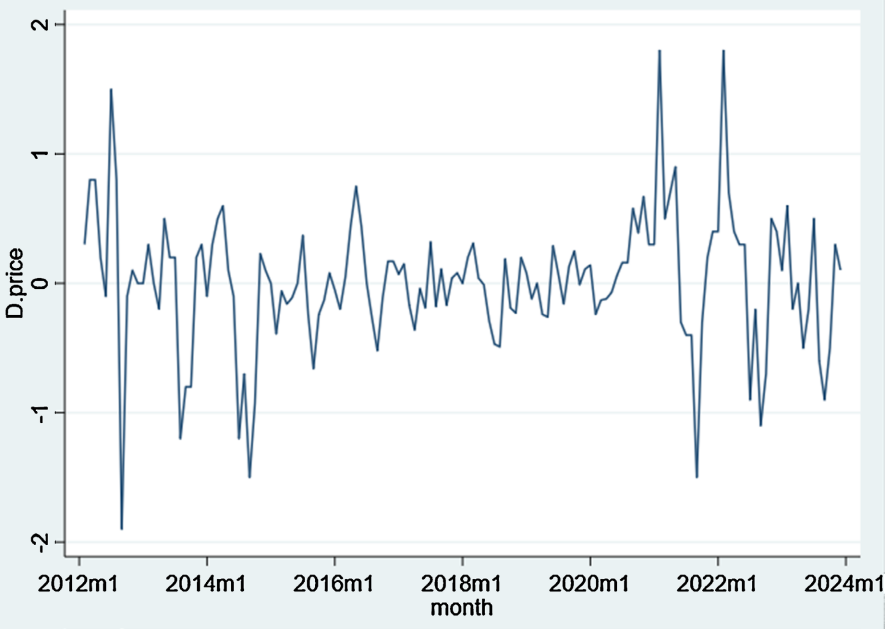
5. Results

We use STATA to deal with the data collected. Since China's tariffs on U.S. soybean imports took place in July 2018, we can use the U.S. soybean price data from January 2015 to June 2018 to estimate the ARIMA model and determine the model's coefficients. By observing the curves of the price data and doing an ADF test on it, we can see the soybean price series is non-stationary, but the first-order difference of the price series is stationary. Figure 2 is a chart of soybean price series, and Figure 3 is the chart of the first-order difference of the soybean prices. Table 1 displays the results of the ADF test on the price series, and Table 2 displays the ADF test on the first-order difference of the price



Source: USDA's website.

Figure 2. U.S. Soybean Prices (January 2012 - March 2024). As could be seen, the trend of soybean price series is unstable and varies, this is why we need to find the first-order-difference to stabilize it (shown in Figure 3).



Source: USDA's website and calculation.

Figure 3. The First-order-difference of the U.S. Soybean Prices (January 2012 - March 2024). After finding the first-order-difference, the soybean prices are relatively more stable where it revolves around a single price and there is no huge variation in slope trends.

Table 1. ADF Test Result for the U.S. Soybean Prices (January 2012 - March 2024).

Test statistic Z(t)	Dickey-Fuller critical value		
	1%	5%	10%
−1.16	−3.50	−2.89	−2.58

MacKinnon's approximate p-value for Z(t) = 0.69.

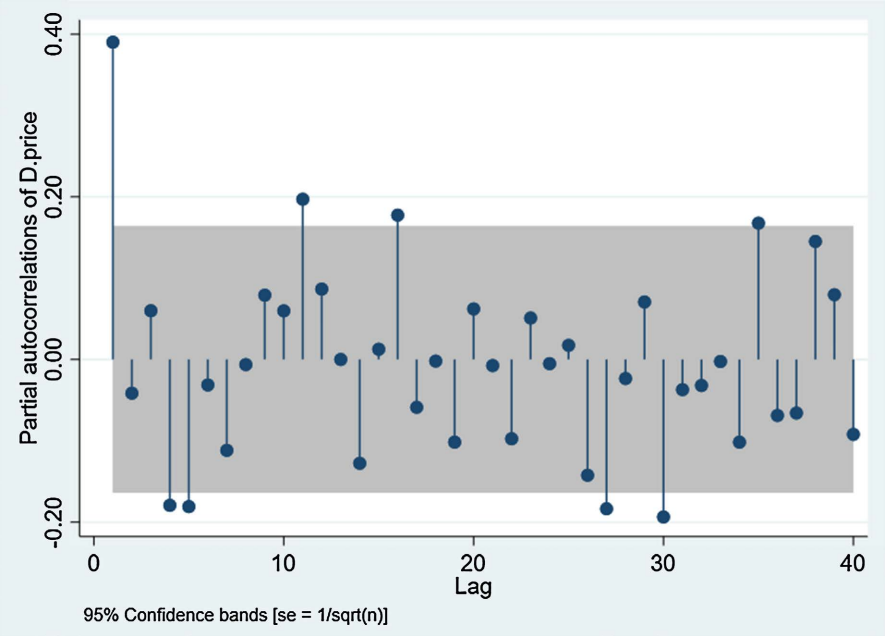
Table 2. ADF test result for the first-order-difference of the U.S. soybean prices (January 2012 - March 2024).

Test statistic Z(t)	Dickey-Fuller critical value		
	1%	5%	10%
−7.85	−3.50	−2.89	−2.58

MacKinnon's approximate p-value for Z(t) = 0.00.

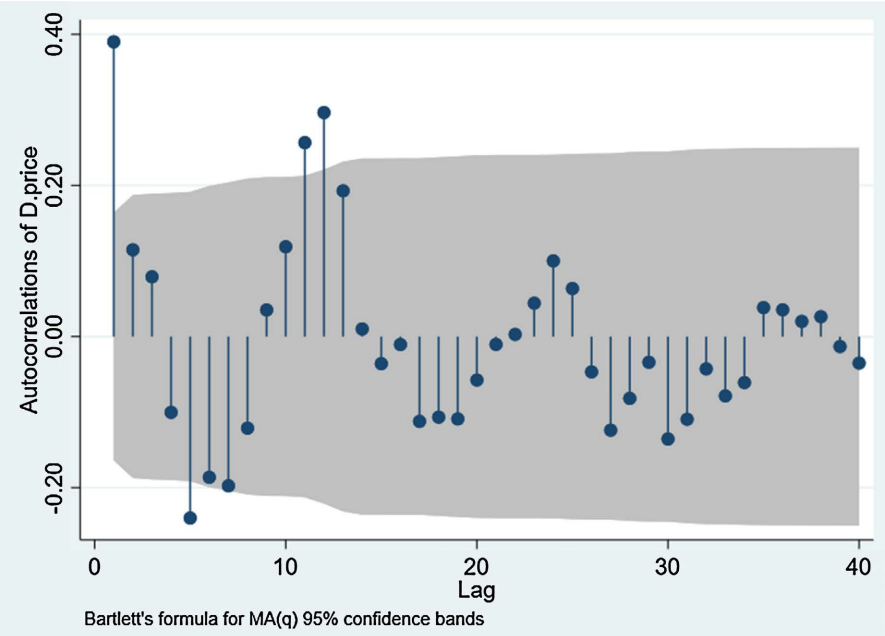
series. Meanwhile, we observe the graphs of **Figure 4** and **Figure 5**, which are the Partial Autocorrelation Function (PACF) and the Autocorrelation Function (ACF) of the first-order-difference of the price series respectively. Based on the above tests and observations, together with trying different parameters of ARIMA models in STATA, we finally decided that ARIMA (1, 1, 1) is the best-fitting model for the data from January 2015 to June 2018. The results of the ARIMA (1, 1, 1) model regression are in **Table 3**.

Based on the result of the ARIMA (1, 1, 1) model estimate, we can forecast the U.S. soybean prices using the historical value from January 2012 up to July 2018,



Source: USDA's website and calculation.

Figure 4. The PACF of the first-order-difference of the U.S. Soybean Prices (January 2012 - March 2024).



Source: USDA's website and calculation.

Figure 5. The ACF of the first-order-difference of the U.S. Soybean Prices (January 2012 - March 2024).

which was before the implementation of China's tariff on the U.S. soybean import. These prices forecasted for one year after July 2018 compared against the actual prices of the same period are presented in **Table 4**. These forecasted prices can be taken as the prices in the counterfactual scenario if we assume the trade

Table 3. The Results of the ARIMA (1, 1, 1) Regression.

ΔPrice	Coefficient	z-statistics
AR (1)	0.01	0.04
MA (1)	0.39	2.32
σ	0.47	19.21
Constant	-0.04	-0.45
Log likelihood	-52.05	
Wald χ^2 (2)	12.10	

Note: ΔPrice is the first-order-difference of the U.S. soybean price series.

Table 4. Forecasted vs actual U.S. soybean prices in dollars per bushel.

Month	Forecasted Prices	Actual Prices
Aug 2018	9.37	8.59
Sep 2018	9.33	8.78
Oct 2018	9.29	8.59
Nov 2018	9.26	8.36
Dec 2018	9.22	8.56
Jan 2019	9.18	8.64
Feb 2019	9.14	8.52
Mar 2019	9.11	8.52
Apr 2019	9.07	8.28
May 2019	9.03	8.02
Jun2019	8.99	8.31
Jul 2019	8.96	8.38

Source: USDA's website and calculation.

war did not occur, while the actual prices are in the baseline scenario where the trade war takes place. From Table 4, we can see the actual prices are lower than the forecasted prices, which means the trade war did lower U.S. soybean prices, which is consistent with what we derived in Figure 1.

We can then estimate the impact of the trade war on the social welfare of the U.S. soybean market using the prices forecasted and the actual prices. We borrow the idea from Alston et al. (1995), and if we define subscript 0 as the baseline scenario, and define subscript 1 as the counterfactual scenario, the change in soybean producer surplus can be calculated by the formula below:

$$\Delta PS = P_0 Q_0 \left(K - Z\right)\left(1 + 0.5 Z \varepsilon_s\right)$$

Here, ΔPS is the change in producer surplus, P_0 is the baseline scenario, K is the coefficient related to the slope of the supply curve, and P_1 is the counterfac-

tual scenario, which is forecasted by the ARIMA (1, 1, 1) model. ε_s is the soybean supply elasticity, Z is defined as: $Z = \frac{P_1 - P_0}{P_0}$.

The change in consumer surplus can be calculated as:

$$\Delta CS = P_0 Q_0 Z\left(1 + 0.5 Z\eta\right)$$

And here, ΔCS is the change in consumer surplus, and η is the absolute value of the soybean demand elasticity.

Jin (2020) estimated the values of the above parameters until 2017. Since 2017 is close to July 2018, we can still use Jin's method to get the 2017 parameter values and our soybean prices P_0 and P_1 in August 2018 to roughly estimate the welfare changes that the U.S.-China trade war brought to the U.S. soybean market immediately after the retaliatory tariff was implemented. P_0 is 8.59 because that is the price when U.S. and China do not trade soybeans, which is the actual price. P_1 is 9.37 because that is the price after China reduced its demands to soybeans, which is the forecasted price. According to Jin (2020)'s method, the values of the parameters are summarized in **Table 5**. From **Table 4**, we know P_0 = 8.59, and P_1 = 9.37, so Z = (9.37 − 8.59)/8.59 = 0.09, ΔPS = 8.59 * 4477.23 * (0 − 0.09) * (1 + 0.5 * 0.09 * 0.04) = -$3467.58 million, and ΔCS = 8.59 * 4477.23 * 0.09 * (1 + 0.5 * 0.09 * (−0.04)) = $3455.12 million. Since the decrease in producer surplus is larger in absolute value than the increase in consumer surplus, thus the Dead Weight Loss (DWL) = −$3467.58 + $3455.12 = −$12.46 million.

Table 5. Latest parameters for welfare estimation.

Parameter	Values
Q_0 (2017)	4477.23 million bushel
K (2017)	$0/bushel
ε_s (2017)	0.04
η (2017)	-0.03

Source: Jin (2020).

6. Conclusion

We set up a theoretical framework to derive the impacts that the U.S.-China trade war brought to the United States soybean market, and also establish an ARIMA model to analyze what the U.S. soybean prices should be without the effect of the trade war, as well as the welfare impact that the trade war brought to the U.S. soybean market.

The theoretical framework of charts and the ARIMA model drew the same conclusion: the trade war constrained the U.S. soybean export to China, and this lowered the U.S. domestic soybean prices. Concerning the welfare effects, the trade war benefited the soybean consumers in the U.S. market, as it lowered the soybean prices, however, at the same time, it harmed the welfare of the soybean producers in the United States, and Dead Weight Loss can be incurred due to

the trade war.

Given the importance of soybean among all the crops in the United States, it is essential to protect the interests of soybean producers, especially those large soybean planters. If needed, the government can enact some policies like subsidies, to protect the large soybean producers from exiting the market.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Adjemian, M. K., Smith, A., & He, W. D. (2021). Estimating the Market Effect of a Trade War: The Case of Soybean Tariffs. *Food Policy, 105,* Article ID: 102152. https://doi.org/10.1016/j.foodpol.2021.102152

Alston, J. M., Norton, G. W., & Pardey, P. G. (1995). *Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting.* Cornell University Press for the International Service for National Agricultural Research.

Bjørnskov, C. (2005). *Basics of International Economics-Compendium*. Christian Bjørnskov & Ventures Publishing ApS.

Box, G. E. P. et al. (2015). *Time Series Analysis: Forecasting and Control*. John Wiley & Sons.

Chen, A. W., Chen, J., & Dondeti, V. R. (2020). The US-China Trade War: Dominance of Trade or Technology? *Applied Economics Letters, 27,* 904-909. https://doi.org/10.1080/13504851.2019.1646860

Chen, E. I. (2014). US-China Trade Relations and Economic Distrust. *Chinese Economy, 47,* 57-69. https://doi.org/10.2753/CES1097-1475470304

Dhoubhadel, S. P., Ridley, W., & Devadoss, S. (2023). Brazilian Soybean Expansion, US-China Trade War, and US Soybean Exports. *Journal of the Agricultural and Applied Economics Association, 2,* 446-460. https://doi.org/10.1002/jaa2.71

Handley, K., & Limão, N. (2017). Policy Uncertainty, Trade, and Welfare: Theory and Evidence for China and the United States. *American Economic Review, 107,* 2731-2783. https://doi.org/10.1257/aer.20141419

Itakura, K. (2020). Evaluating the Impact of the US-China Trade War. *Asian Economic Policy Review, 15,* 77-93. https://doi.org/10.1111/aepr.12286

Jin, M. (2020). *Three Essays on Job Satisfaction, Meat Consumption, and Transgenic Soybean*. Diss., Iowa State University.

Song, B. H., Marchant, M. A., & Xu, S. (2006). *Competitive Analysis of Chinese Soybean Import Suppliers—US, Brazil, and Argentina.*

Wang, H. (2019). Study on Game Model of Soybean Price: A Case Study of China-US Trade War. In *2018 International Symposium on Social Science and Management Innovation (SSMI 2018)* (pp. 445-448). Atlantis Press.