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Time Series Analysis

Measuring the Effect of the US-China Trade Dispute on US Soybean Exports: An Intervention Analysis

This paper adopts an intervention analysis design to measure the price and export quantity effects of a Chinese tariff announcement on American soybeans. The paper finds significant evidence of declines in Chinese imports of US soybeans following the tariff announcement, providing further support for traditional tariff theory. Estimates of the tariff announcement effect on US soybean prices and exports to the world, while negative, were found to be statistically insignificant. This finding suggests reductions in Chinese import demand were covered by increased imports from other countries. However, the limited number of post-intervention observations raise questions regarding the internal validity of the model proposed in this paper.

*Introduction*

On April 4, 2018, the Chinese government announced its intentions to levy a 25% import tariff on American soybeans effective on July 7, 2018. While the Chinese tariff threat does not represent the beginning of trade tensions between the United States and China, its announcement represented a significant escalation in the dispute between the world’s two largest economies. In 2017, China imported 13.9 billion dollars in American soybeans, representing nearly 58% of all American soybean exports.[[1]](#footnote-1) China’s soybean tariff announcement and implementation has become a major topic of discussion in American media.[[2]](#footnote-2) In addition, China’s tariff announcement has raised significant welfare concerns for farmers, whose crop planting decisions were made prior to the Chinese tariff announcement.

In addition to significant social policy implications, the Chinese soybean tariff represents an opportunity to study the effects of a tariff placed by a large importer on a highly fungible, marketized commodity. In this case, tariff theory would suggest that the implementation of a tariff by a large country importer reduces exports and prices of affected products from the exporting country. However, efficient market hypotheses suggest that, in markets with sufficiently low adjustment costs, a large country import tariff has limited effects on trade volumes and prices. In such cases, the implementation of a tariff results in a re-routing of trade rather with zero net effects.

This paper proposes an intervention analysis methodology to measure the effect of China’s tariff on American soybean prices and exports.

*Literature Review*

Mainstream trade theory is clear concerning the effects of an import tariff on import quantitates and prices. Ad valorem tariffs levied on imported goods effectively act as taxes in which a share of the burden falls on importing firms in the form of an import duty.[[3]](#footnote-3) This increase in import prices incentivizes importing firms to find substitutes including similar products or perfect substitutes exporters not subject to tariff treatment. In aggregate, importing firms shift demand away from the tariffed products, resulting in a net decrease in imports of the tariffed commodity. The extent to which imports decline is a function of the price elasticity of demand of the importing firms and the tariff rate. Importers with high price elasticities of demand, such as commodities importers, are more greatly affected by a tariff compared to importers with low price elasticities, such as luxury goods importers.

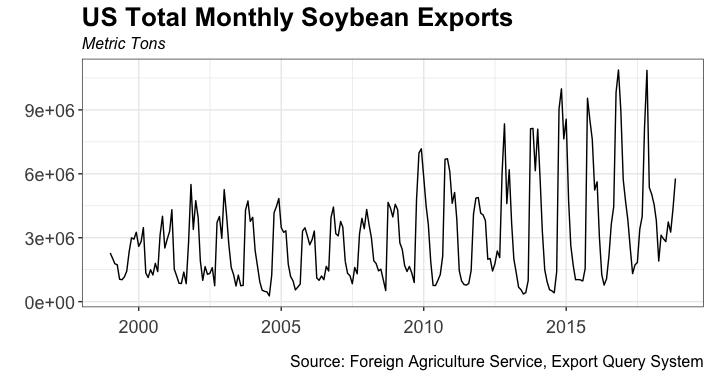
Net export and price effects of a tariff on affected firms are ambiguous. Both are determined by the ability of tariffed exporters to adjust and find trade partners in third country markets. In the case of a fungible commodity like American soybeans, tariff adjustment costs could be negligible and result in a complete reallocation of trade with zero net-export and price effects. In such a case, downward pressure on prices resulting from the decline in demand for imports from the tariff levying country is counteracted by increased import demand from other countries.

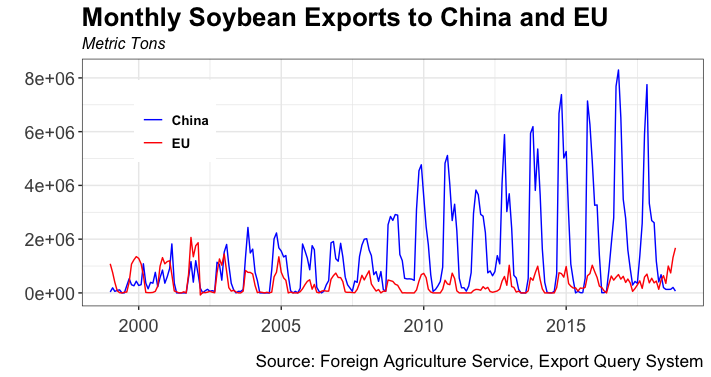
One special trade theory case suggests negative net export and price effects for exporting firms facing a tariff duty. This model, called “optimal tariff theory,” demonstrates that an importing country with a significant world market share and high price elasticity of demand could force exporters to reduce the prices in the fact of a tariff.[[4]](#footnote-4) In this case, third country markets are too small in terms of market power to make up for a decline in import demand from the tariff levying country. As a result, exporters facing a tariff from a large importer must lower their prices to continue exporting to the tariff levying country.[[5]](#footnote-5) While the large country case results in a decline in export firm prices received, the effect of a large country tariff on affected firms’ net export quantities can be ambiguous.

This paper adds to the literature by providing an empirical case study to the above trade theory. The below analysis demonstrates the net export and price effects of a tariff originating from a large country importer.

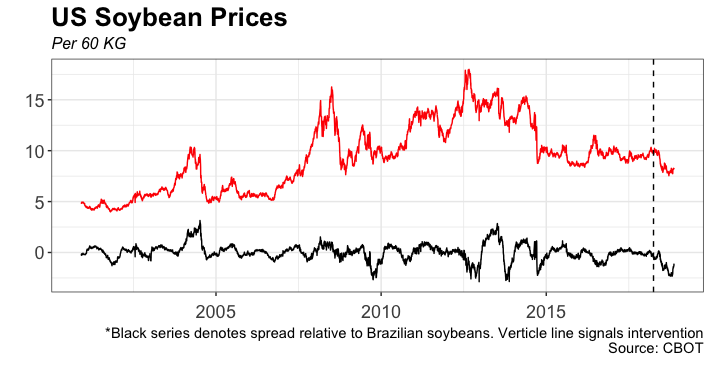
*Data*

US soybean export data were gathered from the Foreign Agricultural Service’s *Export Sales Reporting* database (ESR). ESR contains weekly export volumes of American soybeans to individual partner countries from 1999 through November 2018.[[6]](#footnote-6) Net exports, as well as soybean exports to the United States top two trading partners, China and the European Union, were isolated for analysis. Each series was aggregated to monthly data to better model seasonal trends. Author’s analysis found optimal seasonal model fits with export data aggregated to quarterly. However, doing so would reduce post-intervention observations below the number required for meaningful analysis.





In addition to the above export series, American soybean prices were included for analysis. Continuous one month soybean futures contracts were gathered from the Chicago Board of Trade, the main market for American soybeans.[[7]](#footnote-7)



The below table summarizes the four time series analyzed in this paper. Monthly export time series each contained 239 observations, with results from Augmented Dickey Fuller and Phillips-Perron tests signaling non-stationarity. Daily soybean price data were likewise found to be non-stationarity. This finding is intuitive, as asset prices are typically best fit by non-stationary random walk models.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Series | Observations | Frequency | Stationary | BEST FITTING ARIMA | |
| Total Exports | 239 | Monthly | No | | Yes |
| Exports to EU | 239 | Monthly | No | | Yes |
| Exports to China | 239 | Monthly | No | | Yes |
| Soybean Prices | 4336 | Daily | No | | No |

*Methodology*

This paper relies on an intervention analysis design to demonstrate the effects of China’s tariff on American soybean exports. The analysis features a standard intervention analysis regression specification shown below:

where:

= US soybean prices or exports at time *t*

autoregressive process of lag polynomial A

= coefficient of an intervention dummy term where = 1 post-intervention

= moving average process with a lag polynomial B

In accordance with the intervention analysis procedure put forth by Enders, the author first utilized Box and Jenkins techniques to induce stationarity and determine best fitting ARIMA models for exports and price series.[[8]](#footnote-8) Seasonal ARIMA models were fit to monthly export data to induce a better fit. Best fitting (S)ARIMA specifications for each series were subsequently applied to the entirety of each series, with the addition of intervention dummies as an exogenous regressors. Resulting model coefficients were then used to determine the effect of the Chinese soybean tariff on each series.

*Results*

The below table describes the results of the pre-intervention model fits for each time series.

|  |  |  |  |
| --- | --- | --- | --- |
| Series | ARIMA Model | AIC | Residual Autocorrelation |
| Exports to China | (1,0,0)(0,1,2)[12] | 6469 | Yes- L7; L11; L23 |
| Exports to EU | (2,0,3)(1,1,2)[12] | 5995 | Yes – L22 ; L23 |
| Total Exports | (2,0,3)(1,1,2)[12] | 6614 | Yes - L23 |

1. Author’s calculation from Foreign Agriculture’s Global Agricultural Trade System (GATS) [↑](#footnote-ref-1)
2. For example, Google search data show the highest relative search frequency for the term “soybeans” since 2005 occurred in July 2018, the month in which China’s soybean tariff was implemented. <https://trends.google.com/trends/explore?date=2010-11-10%202018-12-10&geo=US&q=soybean> [↑](#footnote-ref-2)
3. For an introductory analysis on tariff theory, see Krugman, Paul. Obstfeld, Maurice. *International Economics: Theory and Policy.* Pearson. 2009 [↑](#footnote-ref-3)
4. Broda, Christian. Limao, Nuno. Weinstein, David. “Optimal Tariffs and Market Power: The Evidence.” *The American Economic Review.* 2008 [↑](#footnote-ref-4)
5. Humphrey, Thomas. “Classical and Neoclassical Roots of the Theory of Optimum Tariffs.” *Federal Reserve Bank of Chicago.* 1987. [↑](#footnote-ref-5)
6. Measured in metric tons. [↑](#footnote-ref-6)
7. [↑](#footnote-ref-7)
8. Enders, Walter. *Applied Econometric Time Series 4th Edition.* Wiley. 2015. [↑](#footnote-ref-8)