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Econ436

Project 3: Commodity Responses to Exchange Rate

Introduction

The goal of this project is to determine the effects of shocks in exchange rate on commodity prices through a Bi-VAR model. The economic thinking is that exchange rates and trade affect each other concurrently; if a country exports more value at a greater rate than it imports, the value of their currency will increase. And if the value of the currency increases, it becomes cheaper to import rather than export commodities. An increase in exchange rate means that the dollar is more valuable, so it becomes less expensive to import commodities because the dollar has increased buying power compared to foreign currencies.

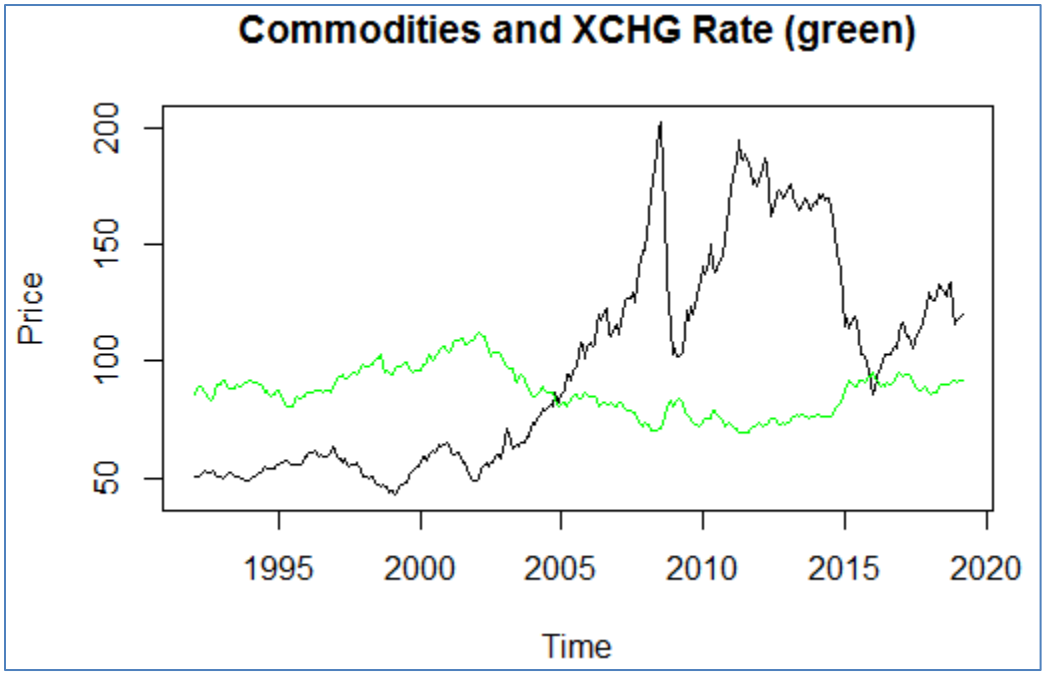
This paper presents a simplified theory explaining differences in the elasticities of commodity prices as dependent on the flexibility of a commodity to be imported or exported. A commodity that the U.S. both exports and imports at similar quantities will be more inelastic towards shocks in exchange rate since the source of the commodity can easily switch from inside the U.S. (domestic) to outside the U.S. (foreign import). In this way, shocks to demand can be absorbed. More specifically, a commodity that the U.S. largely exports rather than imports will be inelastic towards changes in the global value of the dollar, since production is within the U.S. However, if the U.S. imports a large amount of a certain commodity that it is not a large producer of, the price of that commodity will be very susceptible/elastic to shocks in exchange rate (how other countries value the dollar). Finally, a commodity that the U.S. is not an exporter or importer of will have an inelastic price, since the sources of the commodities will be independent of the U.S. dollar.

As a part of the analysis, the Impulse Responses (IRFs) of each commodity to exchange rate increases will be plotted, as well as the impulse responses of the exchange rate itself. Additionally, the average dynamic elasticities of the commodities will be calculated and the commodities will be ranked from most elastic to inelastic. Three categories of commodities, Agricultural goods, Metals, and Fuels, will be examined in detail.

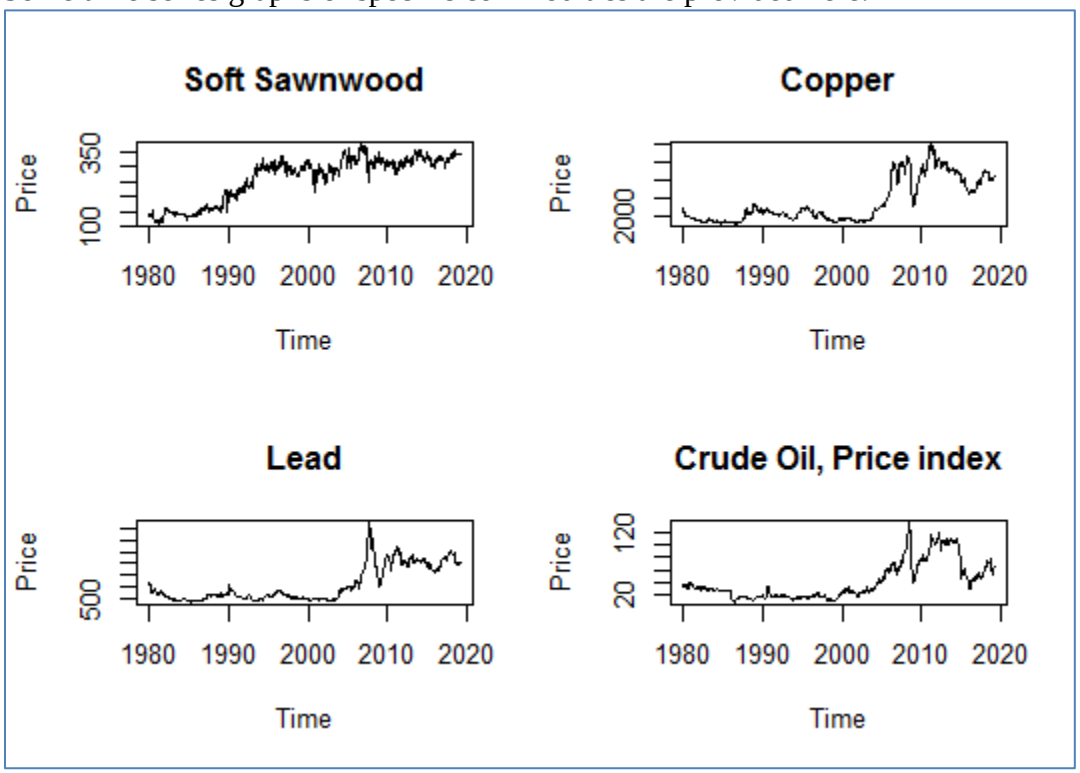
Data Description

The monthly commodity price data is downloaded from the IMF. The time period studied is from January 1980 to March 2019. The price histories of 49 commodities are analyzed, including 23 foods, 4 beverages (Coffee and Tea), 9 agricultural products, 8 metals, and 5 fuels (coal and oil). The exchange rate data is downloaded as "Trade Weighted U.S. Dollar Index: Broad, Goods" from The Federal Reserve Back of St. Louis (FRED).

Here is a time series graph of those data. The commodity price is a weighted average of all commodities. Note that the graphs are the inversely related; as the exchange rate goes up, commodity prices go down.



Some time series graphs of specific commodities are provided here.



Methodology

The log difference of both the commodities and exchange rate is taken in order to have comparable rates of change: $\log(p_i) - \log(p_{i-1})$. The "vars" package in R is used to generate the IRFs for the commodities and exchange rate, modeling the interaction as a Bi-VAR model. The impulse responses of each commodity and the exchange rate from a shock in exchange rate are recorded. A formal expression of the model used is given here:

$$p_t^i = c_i + \lambda_i \Delta e_t + \epsilon_t^i$$

Where "p" is the commodity price, "i" is the commodity, and "e_t" is the nominal exchange rate. Once the Impulse Responses for each commodity to a 1% increase shock in exchange rate were obtained, were graphed along with the 95% CI bounds given by the "vars" package.

The dynamic elasticities (and 95% CI bounds) of each commodity were found by comparing the IRF of the commodity to the IRF of the exchange rate. The equation for dynamic elasticity of a commodity price compared to the exchange rate at time $(t + j)$ is given here:

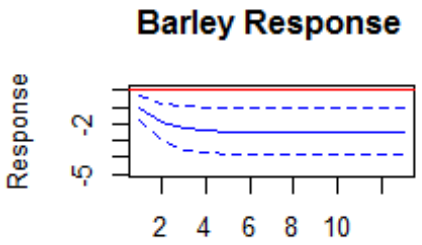
$$\eta_e^p(j) = \frac{\phi_e^P(j)}{\phi_e^e(j)}$$

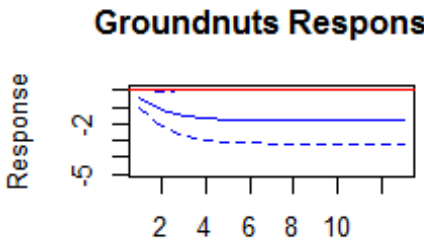
Finally, the average of each commodity's dynamic elasticity (and bounds) over 12 periods is calculated. The commodities are then ranked and classified as "under-reacting," "over-reacting," or "reacting the same" compared to the exchange rate response to a shock in exchange rate, given by the Bi-VAR model.

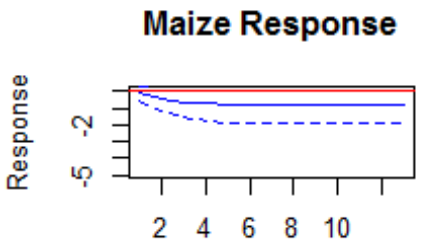
In the analysis, information on the export and import shares of the U.S. on commodities comes from The Observatory of Economic Complexity, which is hosted by MIT.

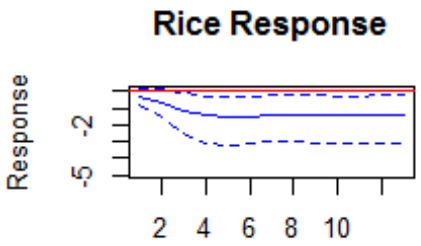
Analysis: IRF Plots of All 49 Commodities

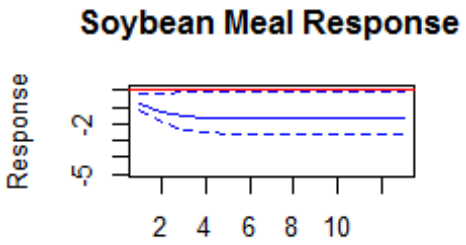
Impulse Responses of Commodity prices to shocks (1% increase) in exchange rate.

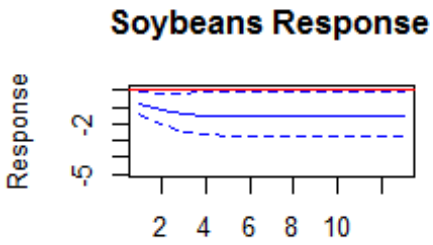


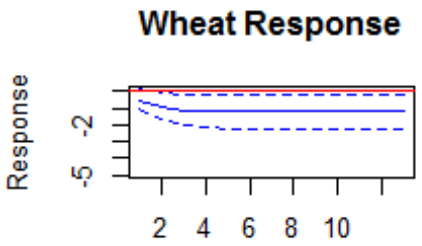


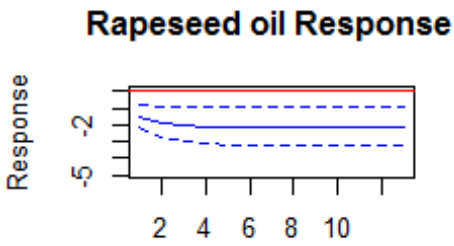


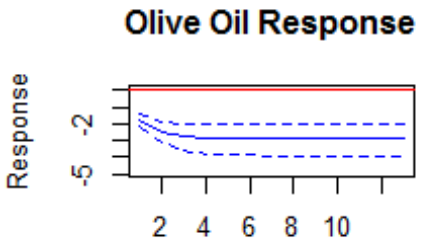


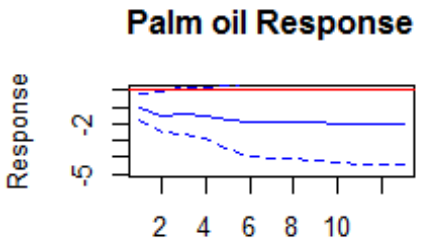









Olive Oil Response
Response
-5
-2
2
4
6
8
10


Palm oil Response
Response
-5
-2
2
4
6
8
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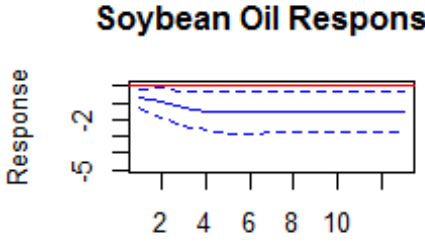
Soybean Oil Response
Response
-5
-2
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4
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8
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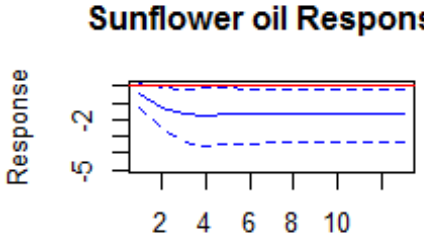
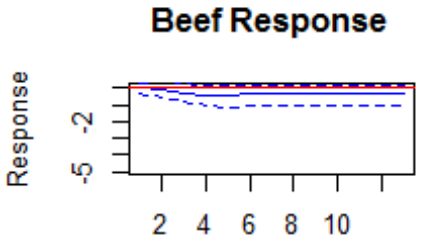

Sunflower oil Response
Response
-5
-2
2
4
6
8
10


Beef Response
Response
-5
-2
2
4
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8
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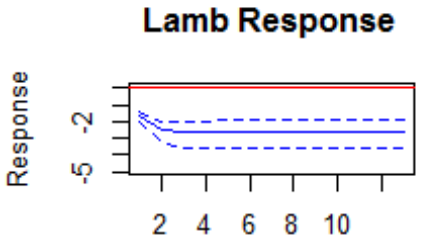
Lamb Response
Response
-5
-2
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4
6
8
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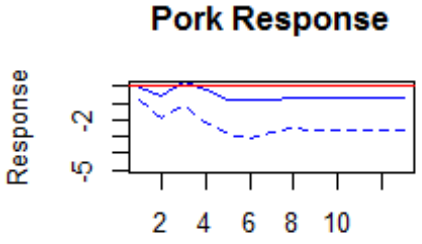
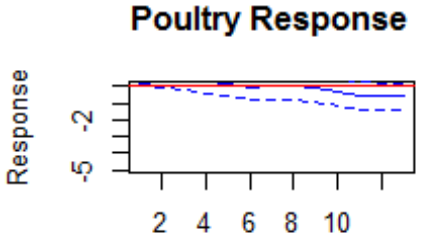

Pork Response
Response
-5
-2
2
4
6
8
10


Poultry Response
Response
-5
-2
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4
6
8
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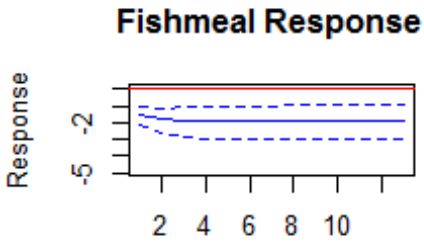
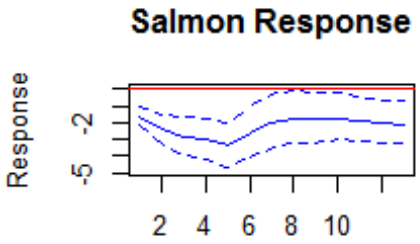
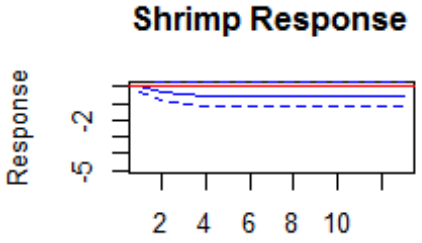
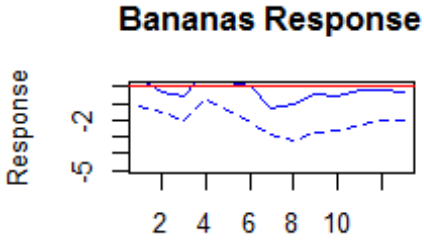
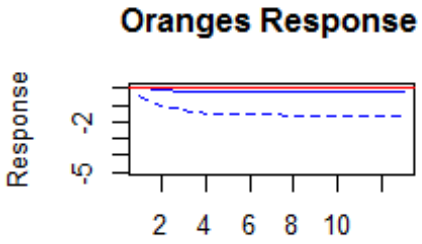

Fishmeal Response
Response
-5
-2
2
4
6
8
10


Salmon Response
Response
-5
-2
2
4
6
8
10


Shrimp Response
Response
-5
-2
2
4
6
8
10


Bananas Response
Response
-5
-2
2
4
6
8
10


Oranges Response
Response
-5
-2
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4
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8
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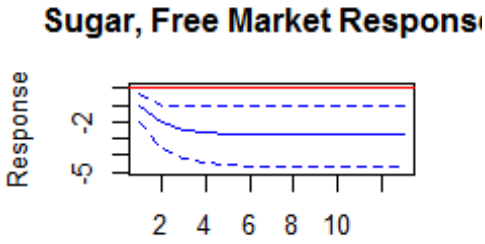
Sugar, Free Market Respons
Response
-5
-2
2
4
6
8
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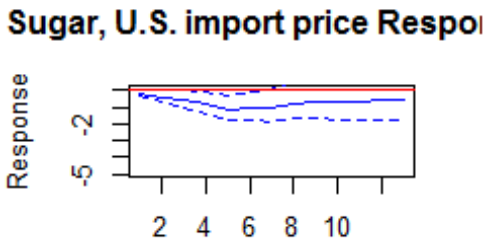
Sugar, U.S. import price Respo
Response
-5
-2
2
4
6
8
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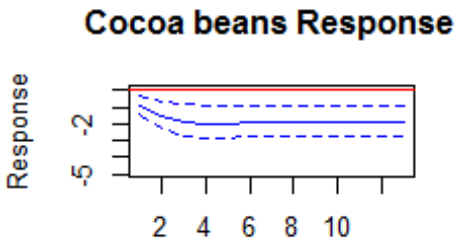
Cocoa beans Response
Response
-5
-2
2
4
6
8
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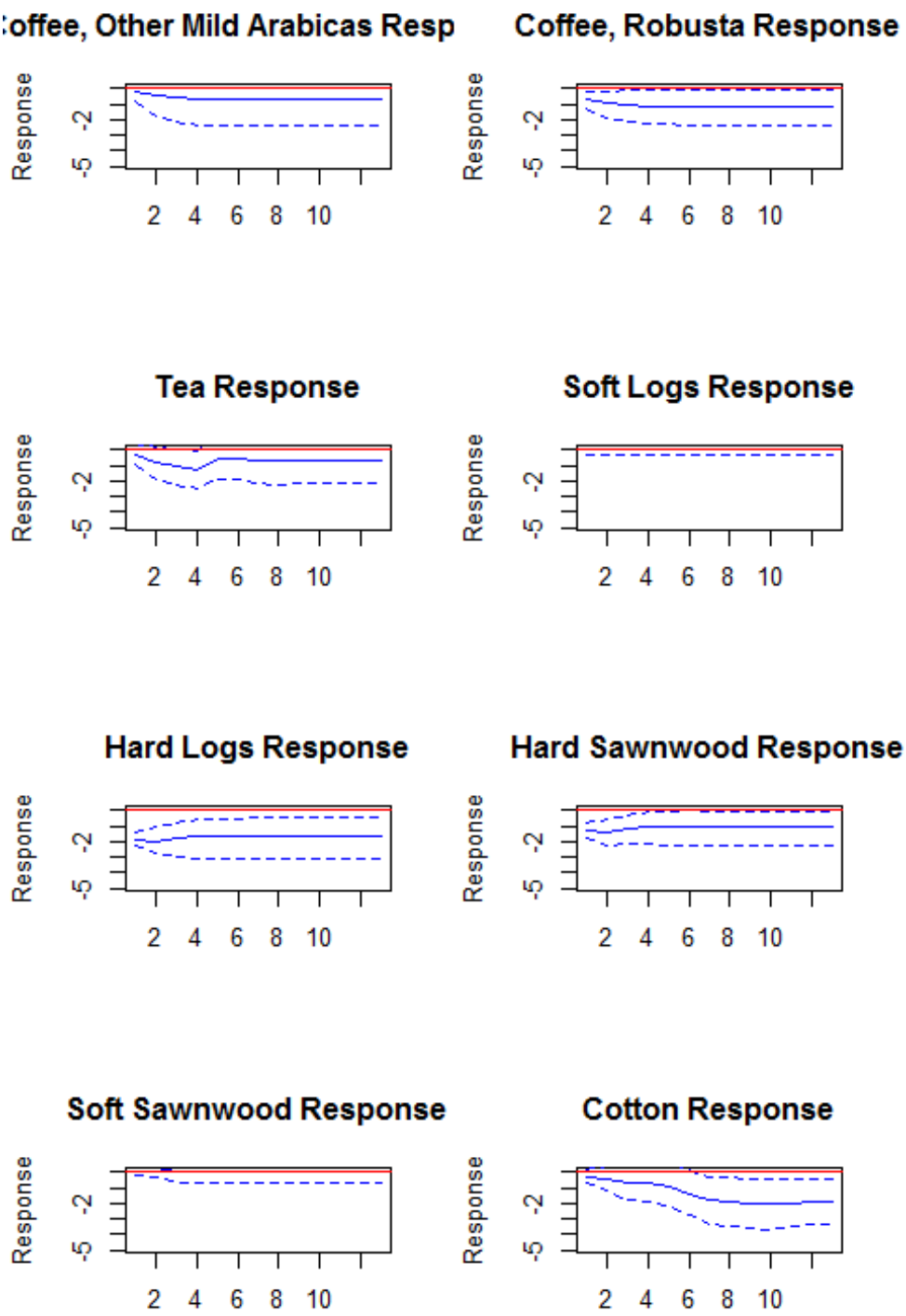
:offee, Other Mild Arabicas Resp
Coffee, Robusta Response
Tea Response
Soft Logs Response
Hard Logs Response
Hard Sawnwood Response
Soft Sawnwood Response
Cotton Response
Response
-5
-2
2
4
6
8
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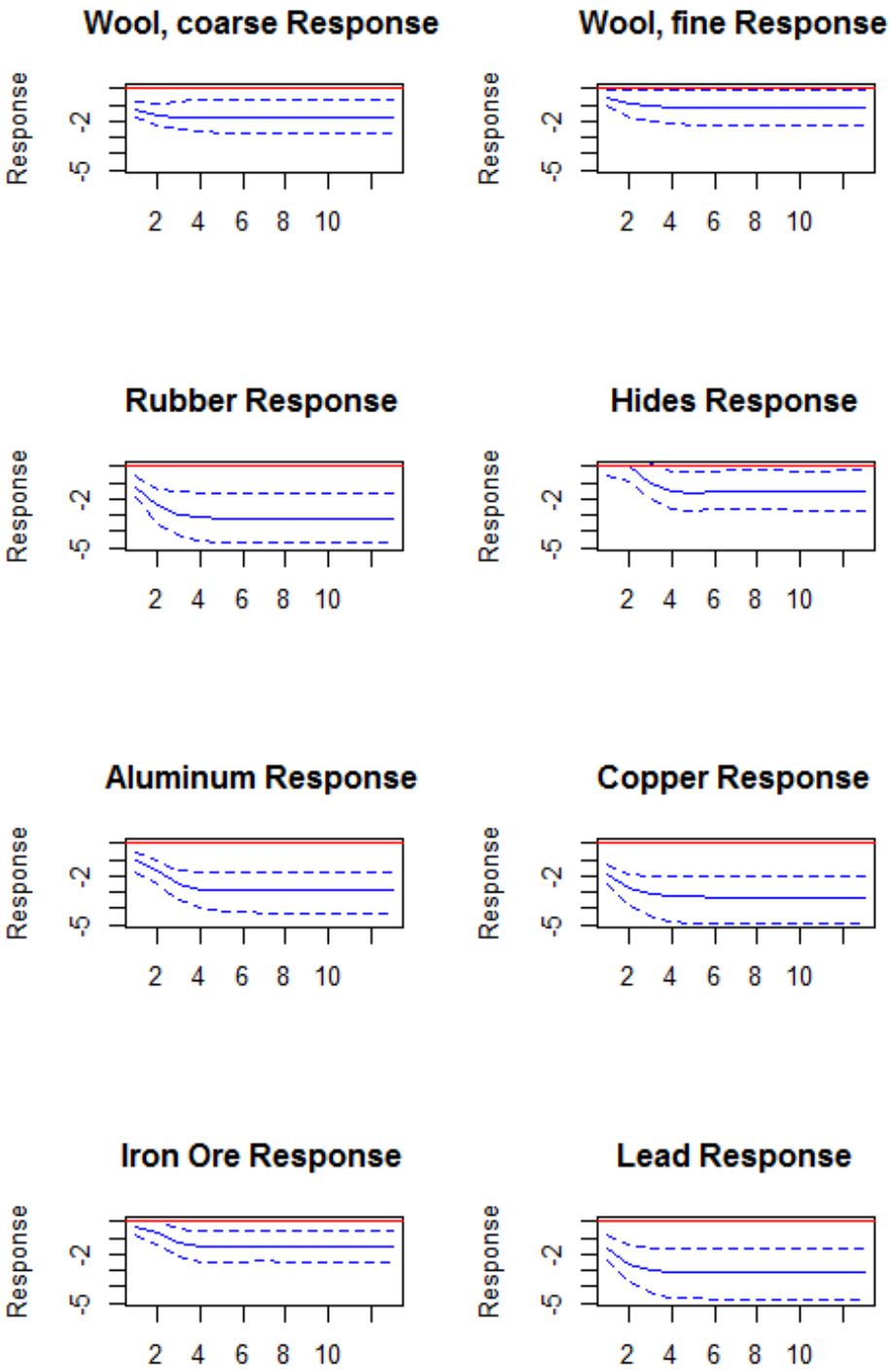
Wool, coarse Response
Wool, fine Response
Rubber Response
Hides Response
Aluminum Response
Copper Response
Iron Ore Response
Lead Response
Response
-5
-2
2
4
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8
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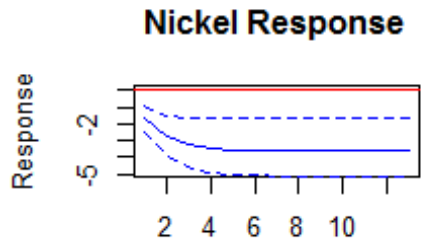
Nickel Response
Response
-5
-2
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8
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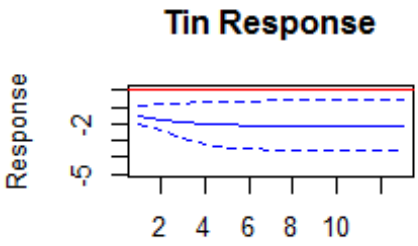
Tin Response
Response
-5
-2
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4
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8
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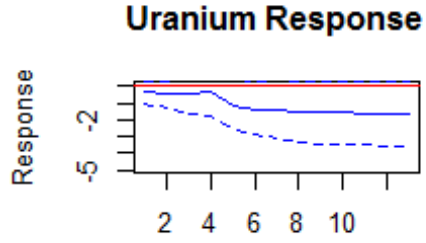
Uranium Response
Response
-5
-2
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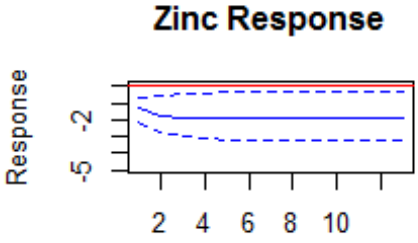
Zinc Response
Response
-5
-2
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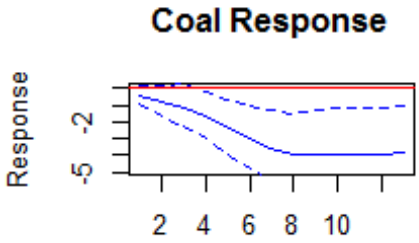
Coal Response
Response
-5
-2
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4
6
8
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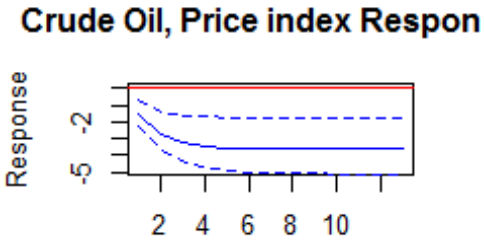
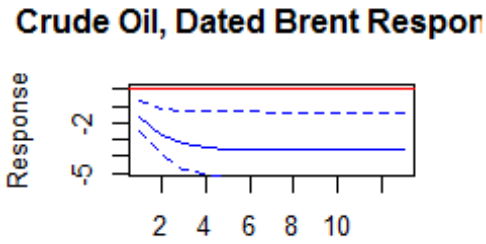

Crude Oil, Price index Respon
Response
-5
-2
2
4
6
8
10


Crude Oil, Dated Brent Respor
Response
-5
-2
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4
6
8
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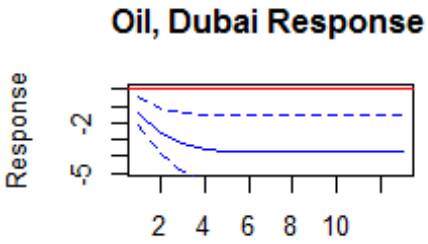
Oil, Dubai Response
Response
-5
-2
2
4
6
8
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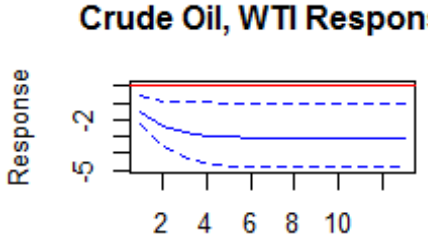
Crude Oil, WTI Response
Response
-5
-2
2
4
6
8
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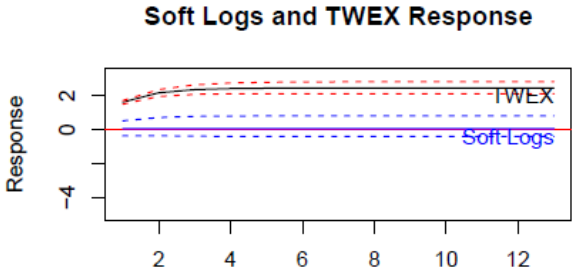
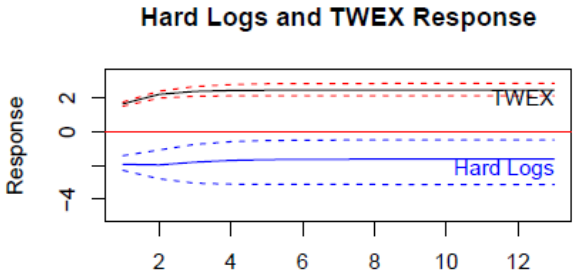
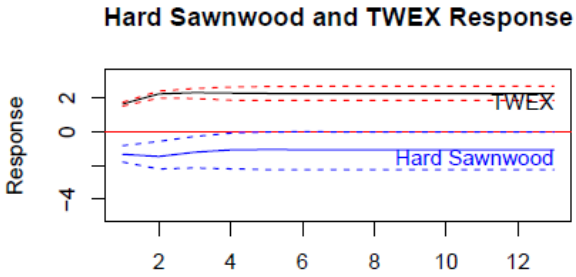
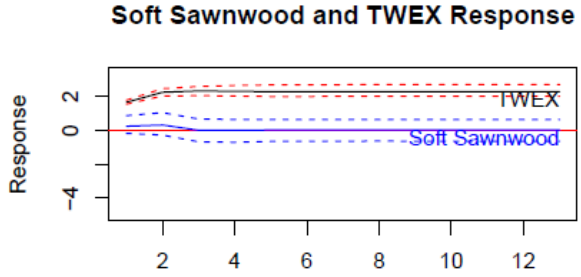
	Avg DE	Avg Lower	Avg Upper	Classify	Test Result
Oil, Dubai	1.428	0.5194	2.494	OVER	---
Nickel	1.415	0.606	2.312	OVER	---
Crude Oil, Price index	1.403	0.5964	2.285	OVER	---
Crude Oil, Dated Brent	1.399	0.4725	2.324	OVER	---
Copper	1.318	0.7301	2.143	OVER	---
Rubber	1.269	0.5712	2.005	OVER	---
Lead	1.256	0.5957	2.182	OVER	---
Coal	1.211	0.261	2.562	OVER	---
Crude Oil, WTI	1.201	0.3513	2.137	OVER	---
Aluminum	1.176	0.6204	2.028	SAME	---
Olive Oil	1.173	0.7201	1.791	SAME	---
Lamb	1.143	0.7435	1.785	SAME	---
Sugar, Free Market	1.053	0.3631	2.083	SAME	---
Salmon	0.9705	0.3574	1.861	SAME	---
Barley	0.9618	0.3464	1.728	SAME	---
Tin	0.9128	0.28	1.764	SAME	---
Rapeseed oil	0.869	0.3506	1.471	SAME	---
Cocoa beans	0.8314	0.3272	1.389	SAME	---
Fishmeal	0.7839	0.3925	1.42	UNDER	---
Zinc	0.7758	0.1569	1.463	UNDER	---
Palm oil	0.7418	-0.1242	1.905	UNDER	---
Hard Logs	0.736	0.2589	1.474	UNDER	---
Wool, coarse	0.7224	0.2744	1.286	UNDER	---
Sunflower oil	0.6978	0.04537	1.658	UNDER	---
Groundnuts	0.6638	-0.004894	1.398	UNDER	---
Soybean Meal	0.6446	0.02289	1.199	UNDER	---
Soybean Oil	0.6299	0.1295	1.329	UNDER	---
Iron Ore	0.6054	0.1809	1.154	UNDER	---
Cotton	0.6034	0.01086	1.437	UNDER	---
Soybeans	0.6012	0.03652	1.193	UNDER	---
Rice	0.5717	0.06655	1.435	UNDER	---
Hides	0.5565	0.02505	1.214	UNDER	---
Hard Sawnwood	0.524	0.07302	1.199	UNDER	---
Uranium	0.5097	-0.1407	1.444	UNDER	---
Wheat	0.4792	0.07056	0.9999	UNDER	UNDER
Coffee, Robusta	0.4688	0.0289	1.057	UNDER	---
Wool, fine	0.4629	0.04377	0.9809	UNDER	UNDER
Tea	0.3255	-0.337	1.065	UNDER	---
Sugar, U.S. import price	0.3005	-0.1459	0.8498	UNDER	UNDER
Maize	0.2885	-0.1796	0.7984	UNDER	UNDER
Coffee, Other Mild Arabicas	0.2496	-0.2717	1.096	UNDER	---
Pork	0.2388	-0.5218	1.163	UNDER	---
Shrimp	0.2013	-0.1089	0.503	UNDER	UNDER
Beef	0.1381	-0.08826	0.5231	UNDER	UNDER
Bananas	0.08774	-0.5775	1.158	UNDER	---
Oranges	0.08168	-0.3336	0.6862	UNDER	UNDER
Poultry	0.0243	-0.2081	0.4126	UNDER	UNDER
Soft Sawnwood	-0.0224	-0.267	0.3015	UNDER	UNDER
Soft Logs	-0.03624	-0.2954	0.1812	UNDER	UNDER

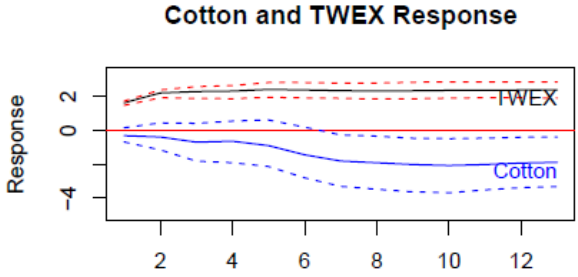
Analysis of Category: Raw Agriculture

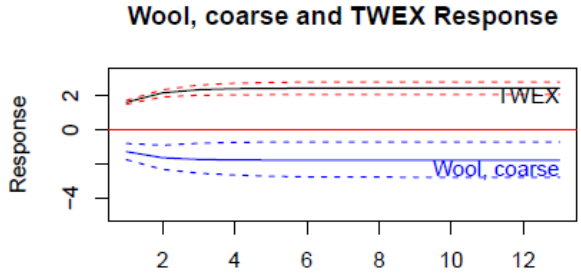


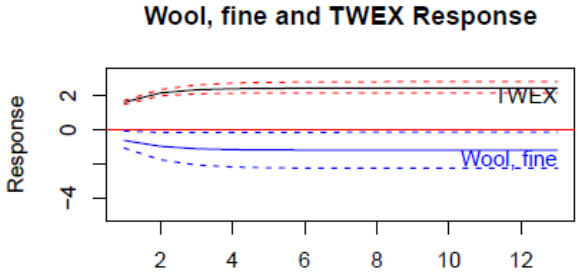


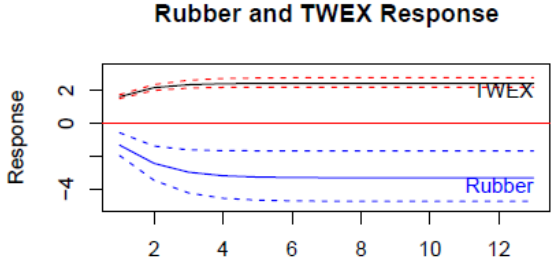


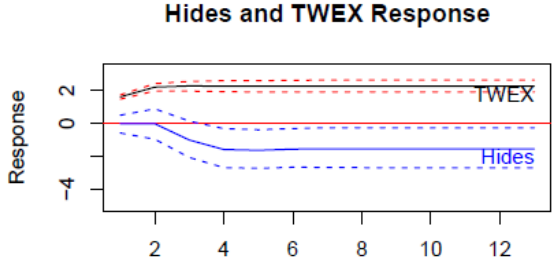












Dynamic Elasticities

	Avg DE	Avg Lower	Avg Upper	Classify	Test Result
Rubber	1.269	0.5712	2.005	OVER	---
Hard Logs	0.736	0.2589	1.474	UNDER	---
Wool, coarse	0.7224	0.2744	1.286	UNDER	---
Cotton	0.6034	0.01086	1.437	UNDER	---
Hides	0.5565	0.02505	1.214	UNDER	---
Hard Sawnwood	0.524	0.07302	1.199	UNDER	---
Wool, fine	0.4629	0.04377	0.9809	UNDER	UNDER
Soft Sawnwood	-0.0224	-0.267	0.3015	UNDER	UNDER
Soft Logs	-0.03624	-0.2954	0.1812	UNDER	UNDER

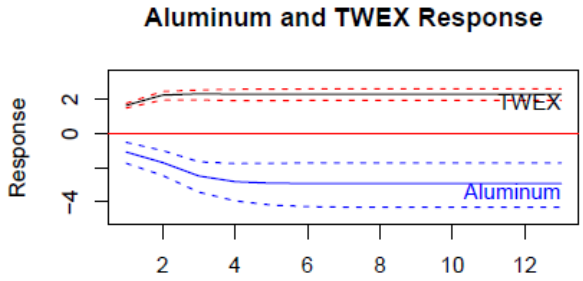
Almost all the Raw Agricultural products studied under-react to shocks in exchange rate compared to the exchange rate impulse. For three agricultural products (fine Wool, Soft Sawnwood, and Soft Logs) the under-reaction is statistically significant at the 5% level; the 95% interval bounds are all below 1. So the majority of agricultural commodities are inelastic to shocks in the exchange rate. The exception is rubber, which slightly over-reacts, so it is the most elastic to changes in exchange rate.

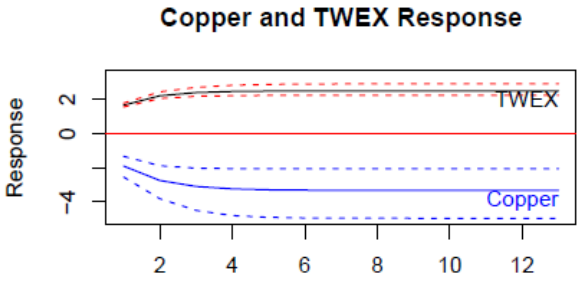
In effect, demand for soft logs, sawnwood, and fine wool is mostly unaffected by changes in exchange rate. Another way of thinking about it is that for these commodities, demand shocks are being absorbed more easily. If the exchange rate increases, the value of the dollar increases, and so importing goods becomes cheaper than exporting goods. A commodity that can be sourced from both inside and outside the U.S. might be inelastic to changes in exchange rate since the shocks are mitigated/absorbed by the amount of domestic production. Elastic commodities might be ones which the U.S. is a major importer of, but not a major producer/exporter, so exchange rate shocks (decreases in dollar value) cannot be absorbed by switching from buying foreign to buying domestic production.

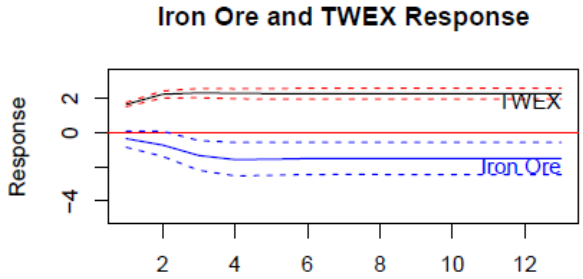
For soft logs, sawnwood, and fine wool, the U.S. both produces and imports a fair amount of each. Thus, the source of these commodities can be easily changed from foreign to domestic purchases, and their prices might be inelastic because of this. The shocks in exchange rate can be absorbed by switching the source the good is bought from. For rubber, the U.S. is mostly an importer (rubber ties, etc.), so demand in the U.S. will be high and prices will always heavily rely on foreign countries. The commodity price will be very dependent on the buying power of the U.S. dollar--specifically compared to the currency of the exporting countries--because it is so exposed to those markets. Finally, the U.S. is neither a major importer nor exporter of wool. This explains the inelasticity of soft logs, sawnwood, and fine wool: the U.S. either does not handle these commodities, or if it does, it is a producer and can easily switch its source (domestic or foreign) for them.

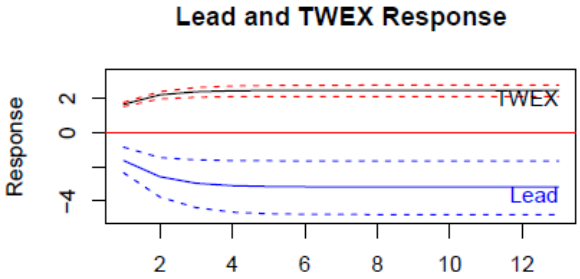
Exceptions to this explanation might include cotton: the U.S. is a gargantuan exporter of cotton, and China is the top importer of raw cotton. Because of this exposure, it would be relevant to research the price of cotton compared to the specific exchange rate of the dollar and the Yuan.

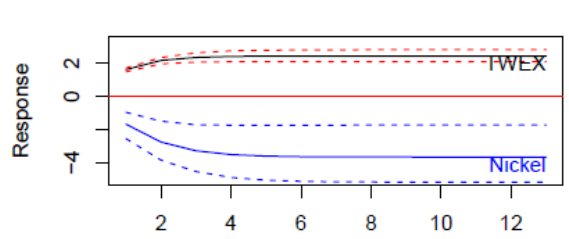
Analysis of Category: Metals

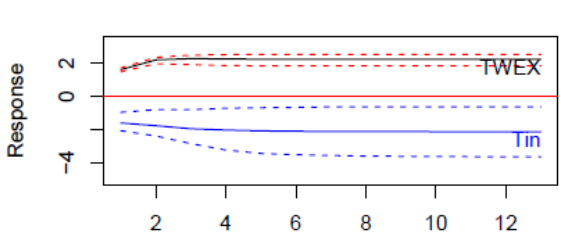


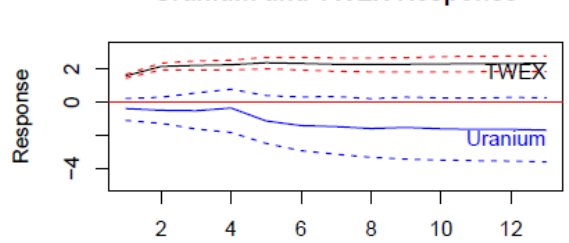


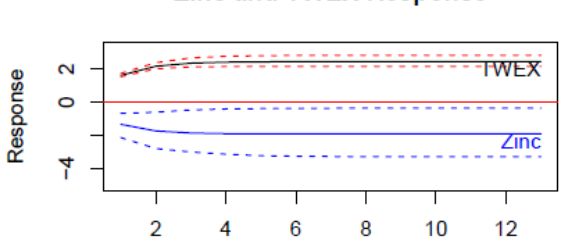












Dynamic Elasticities

	Avg DE	Avg Lower	Avg Upper	Classify	Test Result
Nickel	1.415	0.606	2.312	OVER	---
Copper	1.318	0.7301	2.143	OVER	---
Lead	1.256	0.5957	2.182	OVER	---
Aluminum	1.176	0.6204	2.028	SAME	---
Tin	0.9128	0.28	1.764	SAME	---
Zinc	0.7758	0.1569	1.463	UNDER	---
Iron Ore	0.6054	0.1809	1.154	UNDER	---
Uranium	0.5097	-0.1407	1.444	UNDER	---

Metal commodities have diverse response to shocks in exchange rate, but it seems that mostly they react in parallel to the response of the exchange rate. That is, the metals neither under-reacts nor over-reacts to changes in exchange rate, but reacts similarly.

In effect, demand for Zinc, Iron Ore and Uranium is mostly unaffected by changes in exchange rate, while Nickel, Copper, and Aluminum are affected. The U.S. is a very large importer of raw nickel, but is not a producer of it. The commodity source is inflexible, so the commodity price will be elastic. In fact, the U.S. is a large exporter of refined nickel products, which is something that should be researched in the future. There are some commodities that the U.S. not only imports, but refines and exports to other countries, making the value of the dollar that much more important. Both the raw materials and refined products made from them should be tracked.

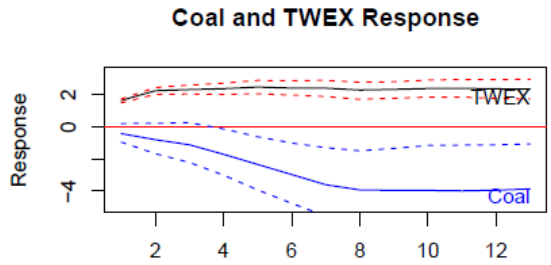
The U.S. both imports and exports Aluminum, but seems to mostly be an importer, so Aluminum demand errs on the elastic side. The U.S. is a large importer and not an exporter of "copper cathode" (as it is described by the IMF) and raw lead.

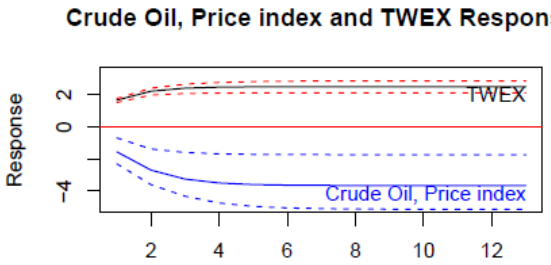
The U.S. exports more than it imports for iron ore ($825 and $550 Million, respectively), and iron ore is relatively inelastic to exchange rate shocks.

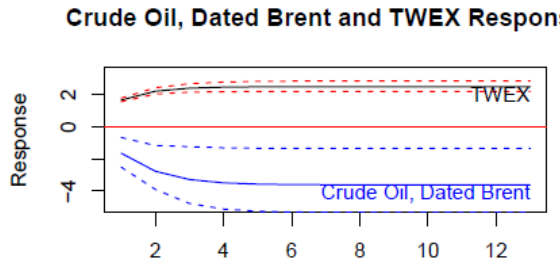
Uranium is an exception where the U.S. is not an exporter at all, but a huge importer, and yet the price is very inelastic. This should be looked into further; perhaps there are regulations or deals specific to Uranium that make it imperceptible to shocks in dollar value. Tin and Zinc could also count as exceptions, since the U.S. is a huge importer of but not a producer of these, yet the prices of tin and zinc aren't as elastic as would be predicted.

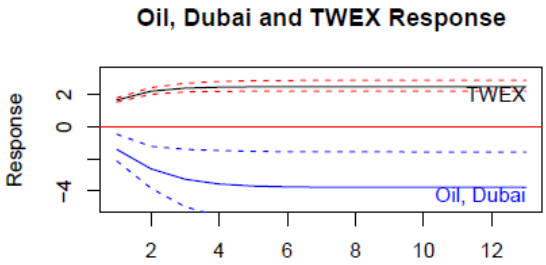
On the whole, the flexibility to choose a domestic source of the commodities may decrease the elasticity of responses to shocks in exchange rate. The U.S. is a larger importer (not producer) of raw nickel, aluminum, copper, lead, tin, and zinc. Despite this, they have varied responses to shocks in exchange rate, and it is unclear where these differences come from. The exportation of refined goods produced from those raw materials might increase elasticity. The U.S. does not seem to export refined zinc products, but does for copper and nickel. Another important factor would be the major country that is exporting the raw materials: what is their specific exchange rate with the U.S. dollar?

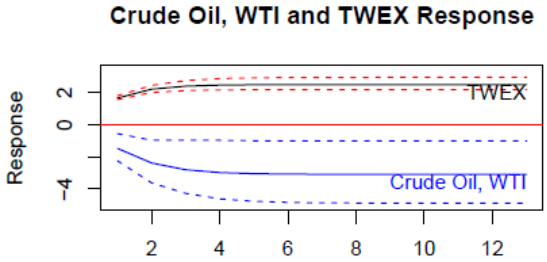
Analysis of Category: Fuel











Dynamic Elasticities

	Avg DE	Avg Lower	Avg Upper	Classify	Test Result
Oil, Dubai	1.428	0.5194	2.494	OVER	---
Crude Oil, Price index	1.403	0.5964	2.285	OVER	---
Crude Oil, Dated Brent	1.399	0.4725	2.324	OVER	---
Coal	1.211	0.261	2.562	OVER	---
Crude Oil, WTI	1.201	0.3513	2.137	OVER	---

All fuel source price responses are very elastic to shocks in exchange rate. This could be because the commodities are traded in a large volume in a very global, competitive market. The source of coal and oil could change very easily, from foreign to domestic sources. Here, foreign sources of fuel (imported into the U.S.) are the most elastic, while crude oil from West Texas Intermediate and coal (both produced domestically) are inelastic compared to the rest of the energy commodities. It seems that wherever the U.S. is a major importer, the commodity will be elastic to exchange rate shocks. If the commodity can be bought from within the U.S., the shock can be absorbed, and so the response will be inelastic.

Conclusions

The response of commodity prices to shocks in exchange rate is dependent on many different things and perhaps the ability of U.S. firms to switch sources for commodities affects the elasticity of that response. Overall, fuels sources are very elastic, agricultural commodities are inelastic, and the response of metals varies on whether the U.S. is a major importer and how much it exports refined products made from the raw metal it imported. Demand plays a large part in the elasticity of the commodities, and thus the ability to switch the source of procurement for those resources can absorb shocks in demand, regardless of the source of those shocks.

More research needs to be done to analyze the comparative volume of imports and exports, as well as the flexibility of U.S. firms to buy commodities within the U.S. or outside the U.S. A major topic that should be addressed is the macroeconomic conditions in the major exporter country of each commodity. Finally, trade deals and regulations for certain commodities, such as oil, Uranium, and other metals, should be investigated and accounted for.

References

Anderson, Nate. (2005). Where did your house grow? SUNY College of Environmental Science and Forestry

Akram, Q. F. (2009). Commodity prices, interest rates and the dollar. Energy economics, 31(6), 838-851.

Cerda, R. (2005). Market power and primary commodity prices: the case of copper.

Frankel, J. A. (2014). Why Are So Many Commodity Prices Down in the US… Yet Up in Europe?. econbrowser. com, December.

Kim, H., & Zhang, Y. (2018). Investigating properties of commodity price responses to real and nominal shocks. The North American Journal of Economics and Finance.

Simoes, A. (2010). The Observatory of Economic Complexity.(2010). URL https://atlas. media. mit. edu/en.

Stuermer, M. (2018). 150 years of boom and bust: what drives mineral commodity prices?. Macroeconomic Dynamics, 22(3), 702-717.