Forecasting Agricultural Exchange Rates: Comparing Strength of USD Relative to CAD

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ECON 4395 - Time Series Econometrics

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1 Introduction

Agricultural exchange rates are vital to the economy due to the wide-reaching effect on the health of domestic agricultural trade, international trade, export revenue, input costs, inflation, & monetary policy decisions. Daily exchange rate price fluctuations affect the competitive nature of agricultural products in global markets, influencing earnings and trade balance. Impacts of exchange rates can be felt by the public due to the relationship it shares with the cost of food locally, as well as products we import from other countries that are sold in our grocery stores.

When our exchange rate decreases (relative to other currencies) we can purchase more of their items at a lower price - this is what impacts the affordability of our items in foreign markets. For example, if we share a 1:1 exchange rate ratio with the Canadian dollar and the exchange rate of the USD drops to 0.75, for each CAD, only $0.75 (USD) is needed to buy $1 worth of Canadian products. Exchange rate movements influence input costs, inflation, & food prices - impacting farmers' profitability and consumer purchasing power. Policymakers closely monitor agricultural exchange rates to design effective policies and manage economic challenges. Overall, understanding and analyzing agricultural exchange rates are essential for informed decision-making and risk management in the agricultural sector and broader economy.

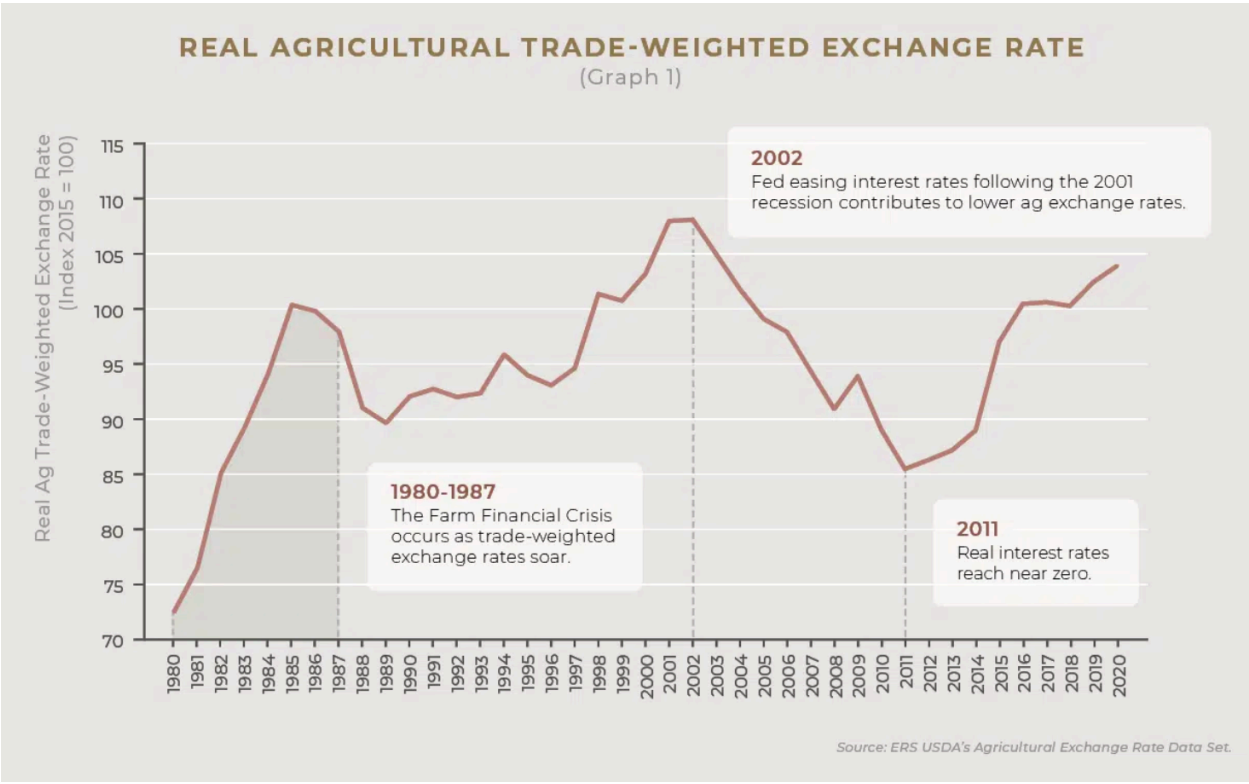
The agricultural exchange rate compares the relative prices of agricultural products between countries. A weak exchange rate leads to a decrease in the value of agricultural products on the international market which then leads to an increase in exports and a decrease in imports. Similarly, a strong exchange rate leads to an increase in the value of agricultural products on the international market which leads to a decrease in exports and an increase in imports.

This analysis examines the agricultural exchange rates, comparing the U.S. Dollar to the Canadian Dollar to look at the historical exchange rates. The data originates from the ERS USDA Agricultural Exchange Rate Data Set from January of 2000 to December 2022, and forecasts for January 2022 - December 2022.

2 Research Overview

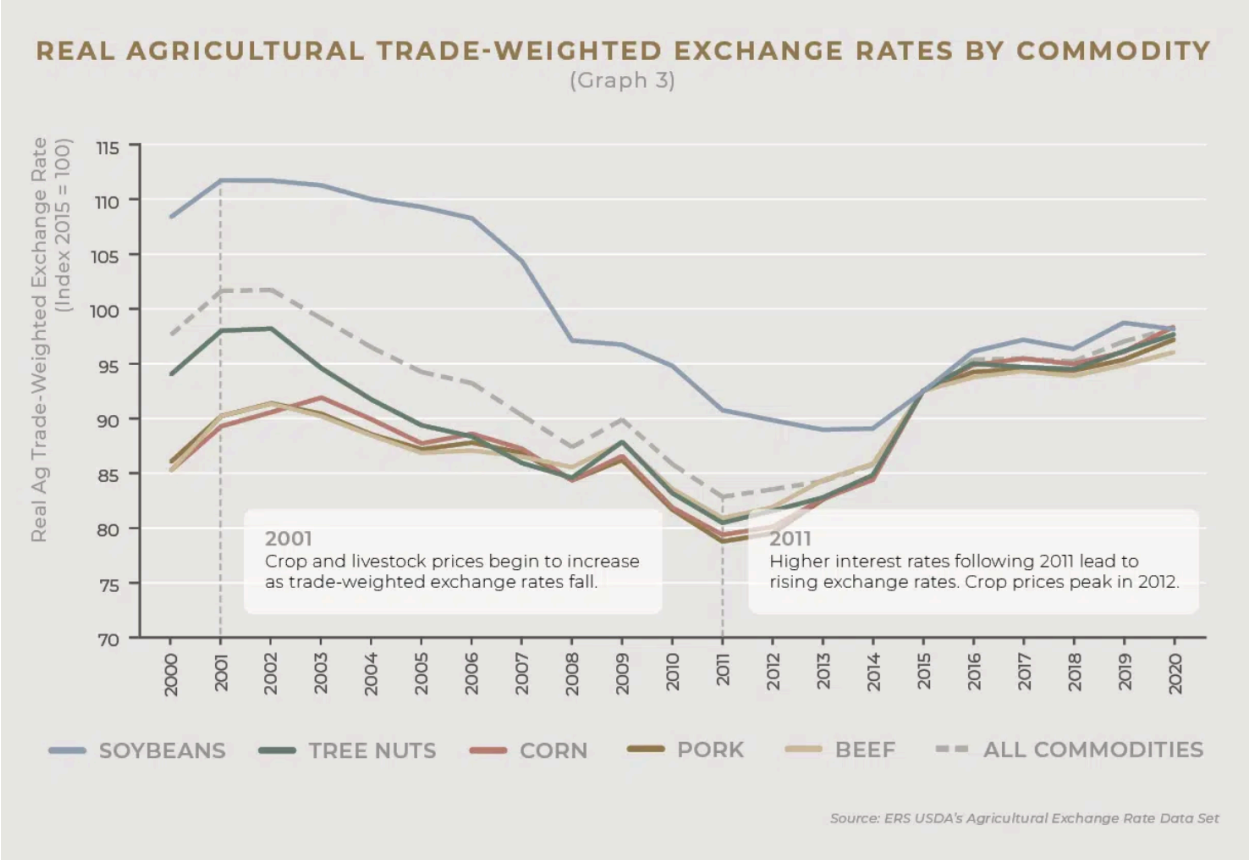
Sharing the world's longest international border, Canada and the US share a strong and influential trading relationship. They are major trading partners in many industries, especially when it comes to agriculture. The US is Canada's largest agricultural export market, with about 15% (67.2 billion CAD) of Canada's total agricultural exports going to the US. Canada's main exports include wheat, canola, soybeans, beef, and others. Changes in the Canadian dollar agricultural exchange rate can significantly impact US imports and exports of agricultural products. Furthermore, since their economies are very inter-connected, the Canadian dollar agricultural exchange rate can also affect the investment decisions of US companies and individuals who conduct business within the agricultural sector of Canada. If the exchange rate strengthens, then companies and individuals in the US might find investments in Canada less attractive. Fluctuations in the Canadian dollar agricultural exchange rate also have domestic effects such as the cost of machinery, fertilizer, fuel, and agricultural inputs. This can influence Canadian policymakers to push export subsidies or import tariffs to promote the competitiveness of Canadian agricultural products in the global market.

Figure 1



As shown in Figure 1, There is an inverse relationship between value of the dollar and price of commodities. When the value of the dollar drops, prices of goods increase locally, exchange rates fall, and as the dollar appreciates, exports decline because the price relative to other currencies changes (costs more for other countries to buy our goods). A weaker dollar points to greater financial strength for agricultural exports. The 1980s farm financial crisis, introduced by low commodity prices and high-interest rates, led to severe financial stress for ranchers because of the increasing value of the dollar. This is due to monetary policy actions taken by the Fed to reduce high inflation, which led to the real value of the US Dollar increasing by 57%. This led to commodity prices declining because the competitiveness of the US agricultural exports was inhibited. In the 2000s, the US dollar depreciated which led to record-level agricultural exports through 2014. However, the US dollar strengthened and starting in 2015, export demand dampened for the rest of the decade.

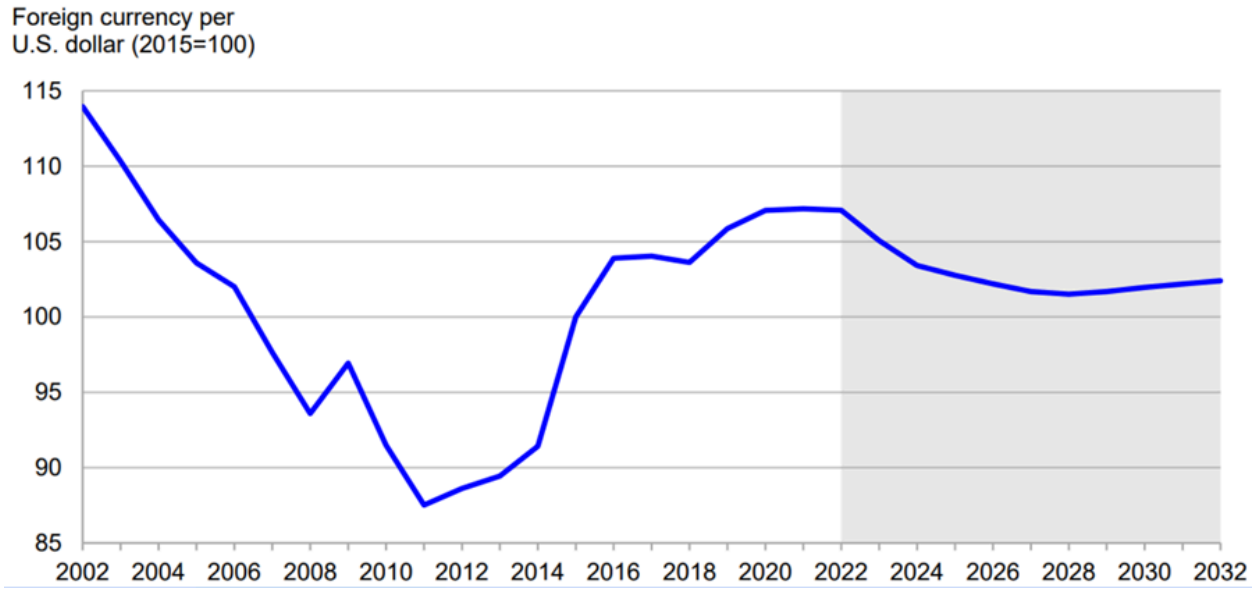
Figure 2



In Figure 2, we can see the USDA reports trends in real trade-weighted exchange rates for 49 specific US agricultural commodities and commodity groupings from 2000 to 2011. The trend is the dotted line. You can see the effect that easing interest rates had in 2002 as the dollar appreciates, and the economic strength that followed the 2011 interest rates reaching near zero. Note - as numbers increase (Figure 2), the value of the dollar increases as well, in addition to inflation rates.

The greatest source of information pertaining to the data was collected through the USDA - in Figure 3 (below), their forecasted trend for 2022-2032 tells a story of a weakening dollar. The methods used in their research used multiple factors tied to the forecasting - inflation, trade policy, war, and other factors were considered for this trend.

Figure 3: Agricultural trade-weighted USD exchange rate '02-'32



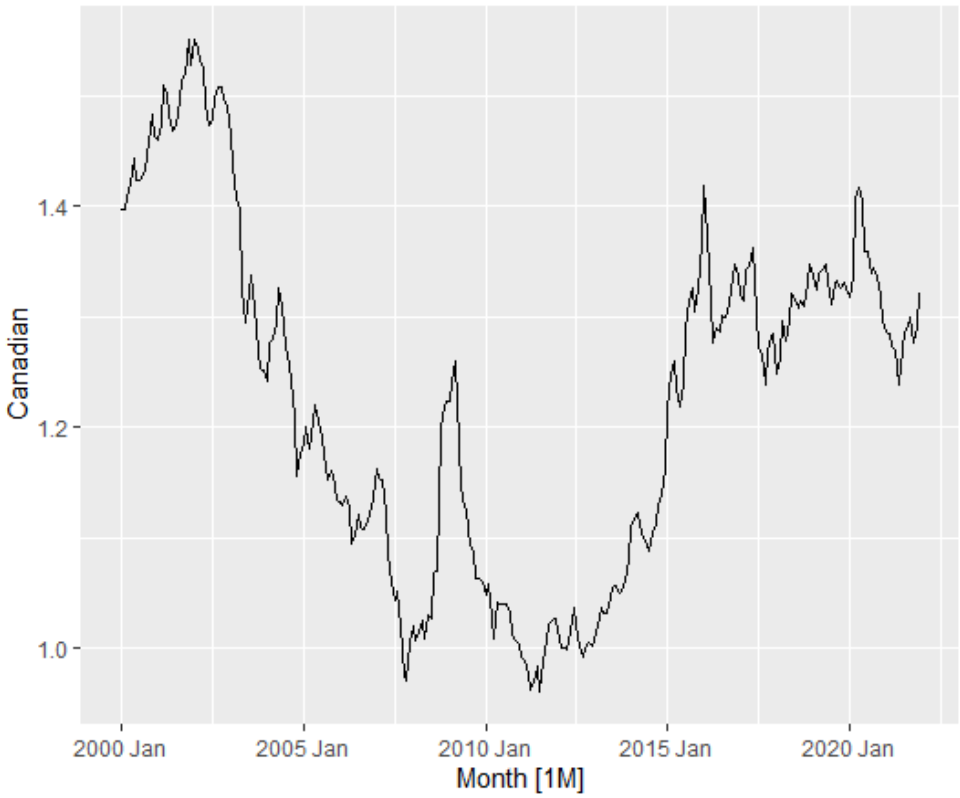
This forecast looks out until 2032, which is interesting when looking at what we forecast with the Canadian Dollar. When compared to many other currencies, the US Dollar is projected to stay strong through 2023-2032, but is projected to decrease gradually over the next 9 years.

3 Forecasting the USD to Canadian Dollar Agricultural Exchange Rate: Empirical Analysis

3.1 Data Description

Our data is from the USDA Economic Research Service and includes monthly agricultural exchange rates comparing the US dollar, Canadian Dollar, and Peso from January 2000 to December 2022. Our "holdout" period for forecasting is for all of 2022. The original data set included 79 countries, but we decided to compare the strength of the dollar to our neighboring countries because they had the highest correlation w/ our currency. Although the data set goes as far back as the 1980s, extracting data for the 21st century (2000-2022) helps with interpretation and relevance.

Figure 4- The Canadian Dollar Exchange Rate



Just by looking at the data, we can see some seasonality and trends. Specifically, we can see historical events in the United States that affected the Canadian Dollar agricultural exchange rate. In the early 2000s, there was a significant spike when dot.com exploded which increased

the value of the US dollar. In 2008, during the recession, the US dollar value decreased significantly and the Canadian dollar was worth more. Since then, there has been a significant increase indicating the US dollar has increased its strength with some ups and downs in the late 010s leading into the 2020s. Overall, we can see the relationship between the US Canadian Dollar and the US dollar as an increasingly strong one.

Figure 5- The Canadian Dollar Exchange Rate Seasonality

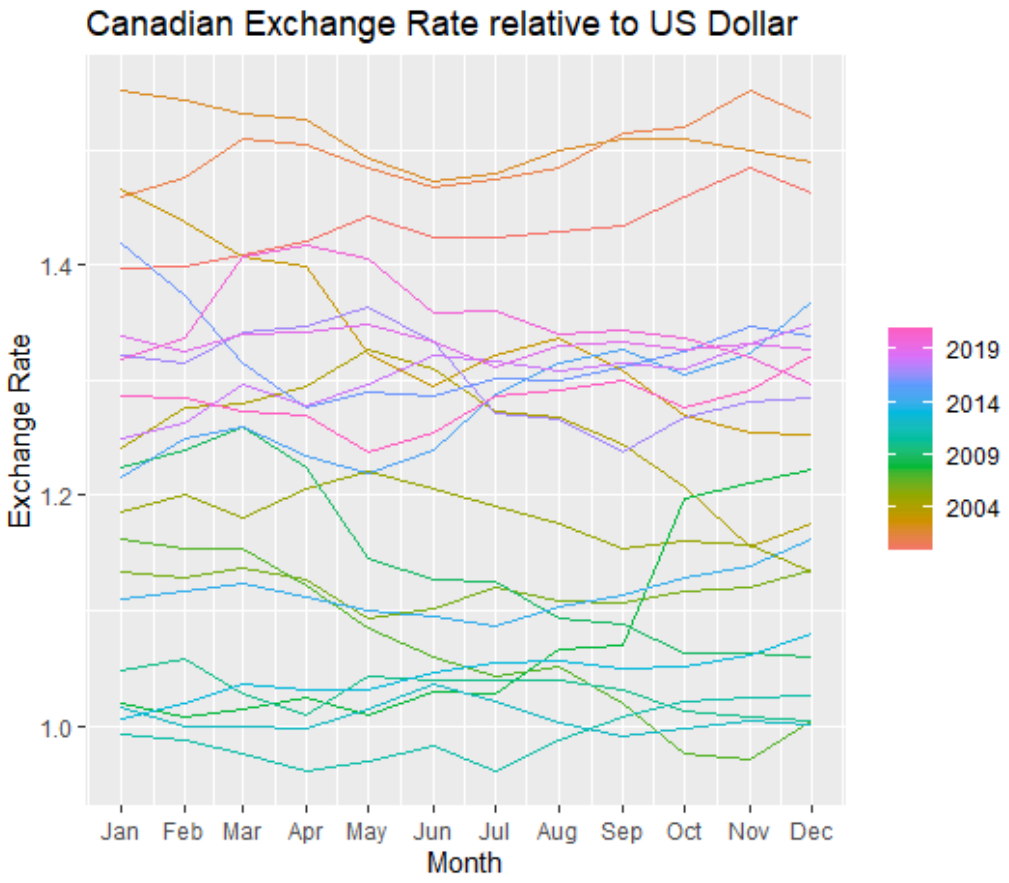
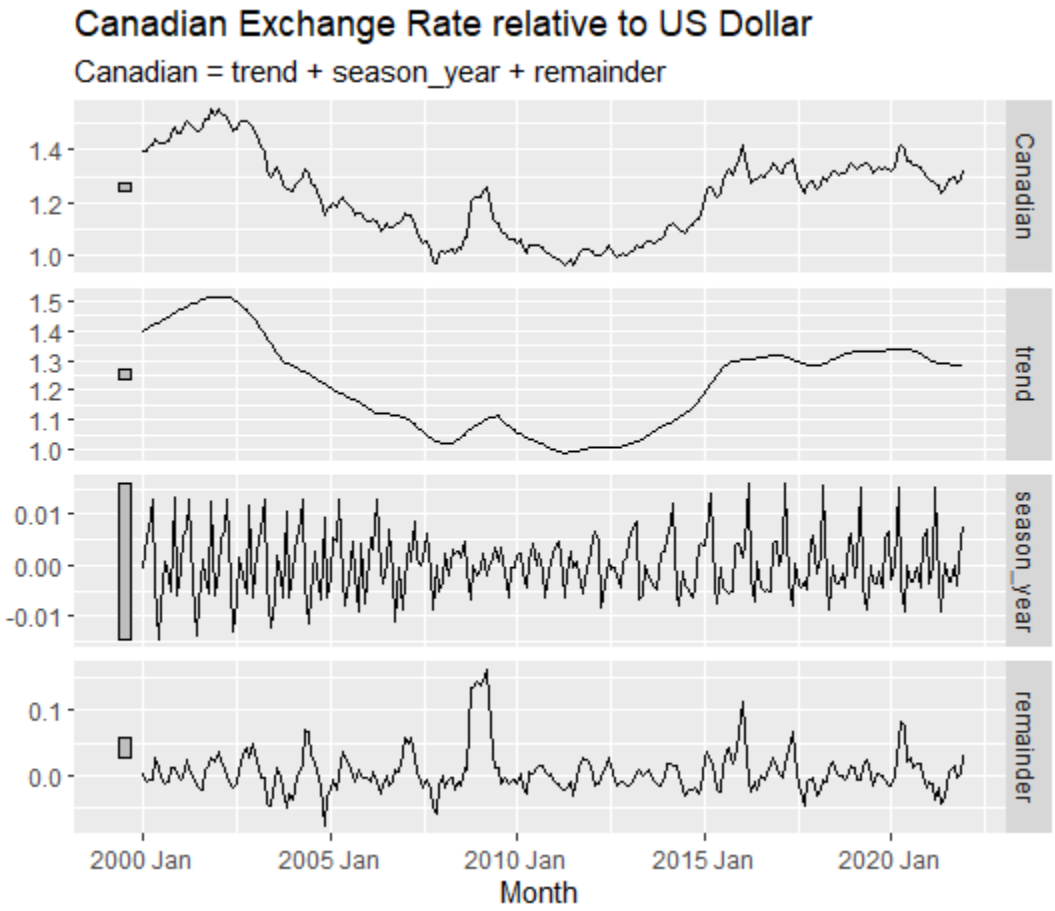


Figure 6- The Canadian Dollar Exchange Rate Decomposition



Figures 5 and 6 show a small amount of seasonality and trend over time. When forecasting this data, I used the data starting from January 2000, up until December 2021 in the training sample. For the testing sample, I used January 2022 to December 2022. We acquired monthly data for 2022 which we can compare our forecast to the actual data. I selected the best model based on the goal of minimizing out-of-sample RMSE.

3.2 Exponential Smoothing Methods

The first models I examined were the Exponential Smoothing Methods. The exponential smoothing methods I used are Simple Exponential Smoothing, Holt's method, Damped, Holt-Winters additive seasonality method with a damped trend, and Holt-Winters multiplicative seasonality method with a damped trend.

Figure 7- Exponential Smoothing Models Part 1

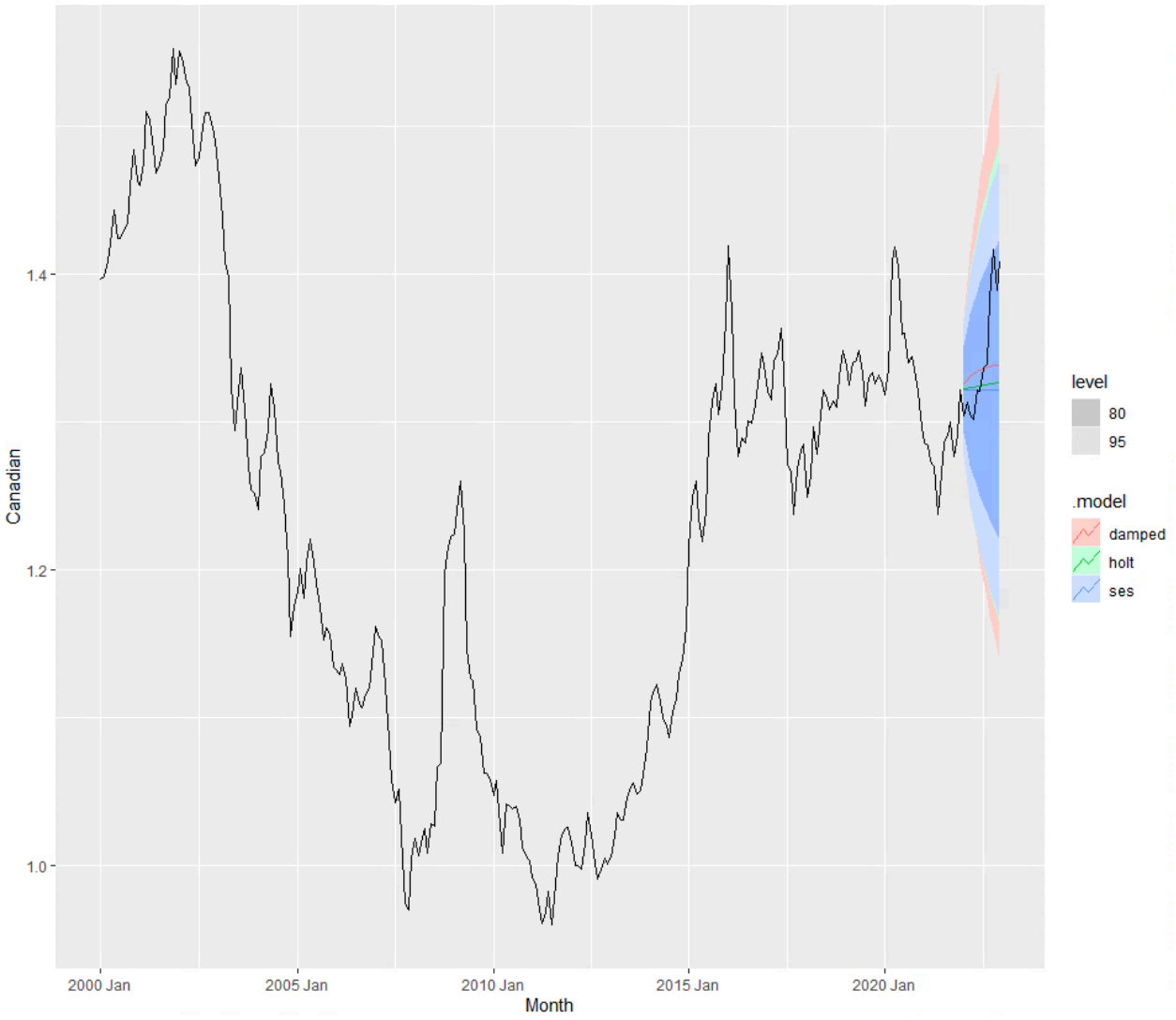
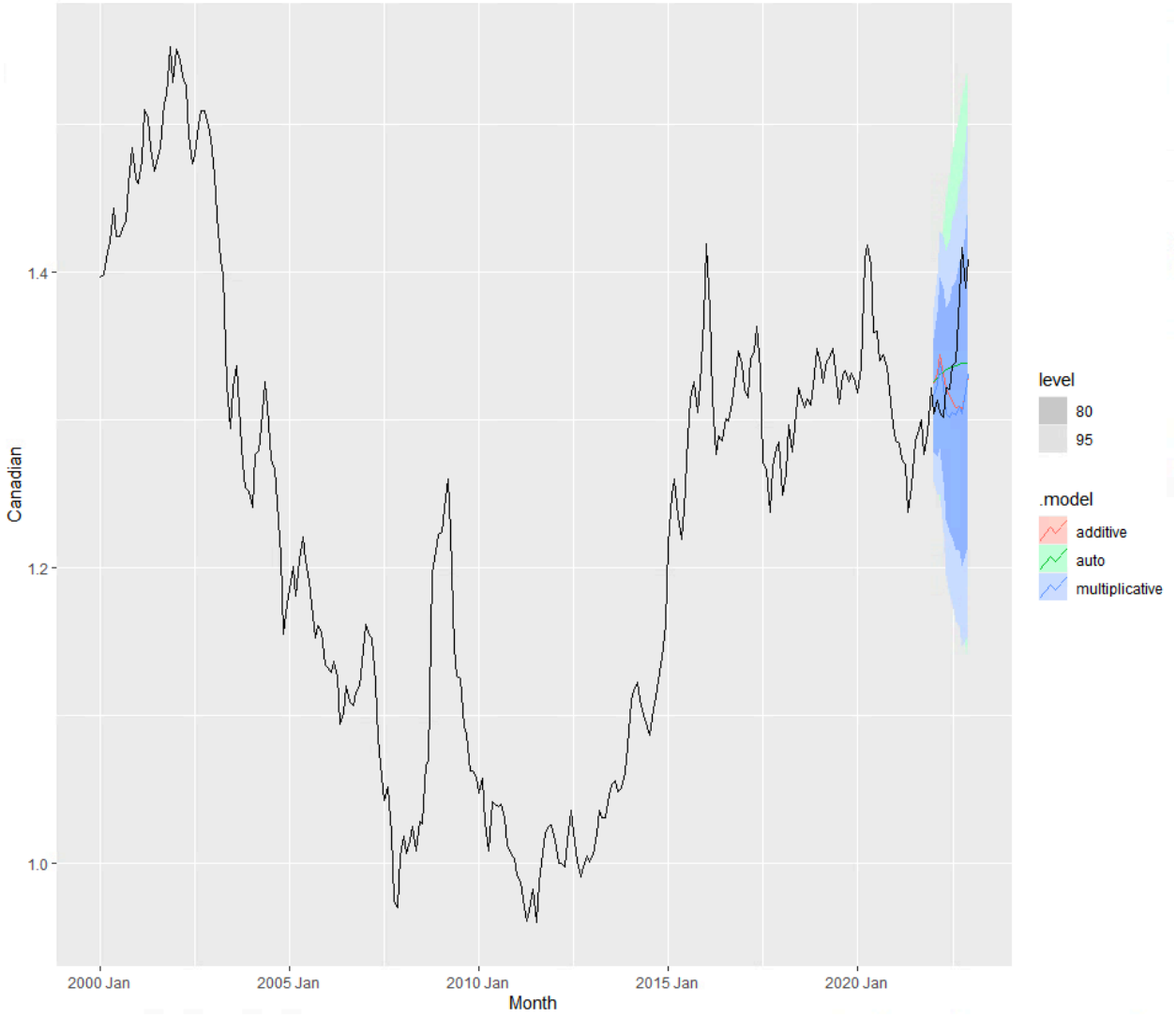


Figure 8- Exponential Smoothing Models Part 2



Figures 7 and 8 show the forecasting predictions of these models through December 2022 and compare them to the actual data. The damped trend shows a bold, increasing trend that aligns with the actual data. The Holt's and Simple Exponential Smoothing forecasts show the exchange rate increasing a little but otherwise staying stable. The additive and multiplicative models both forecast the exchange rate increasing rapidly and decreasing just as rapidly within the span of 12 months. However, this is not accurate at all when it comes to the actual data since the forecast for the 12 months shows it increasing significantly, strengthening the value of the US dollar, before starting to decrease slightly towards the end of the year in December. Overall, the damped model seems to be the best at forecasting the exchange rate for the year 2022.

TABLE 1: Exponential Smoothing Forecasts

Method	BIC	AICC	RMSE
Simple Exponential Smoothing	-507	-518	0.0228
Holt	-495	-512	0.0229
Damped	-497	-518	0.0225
Additive	-392	-451	0.0245
Multiplicative	-344	-402	0.0269
Auto	-497	-518	0.0225

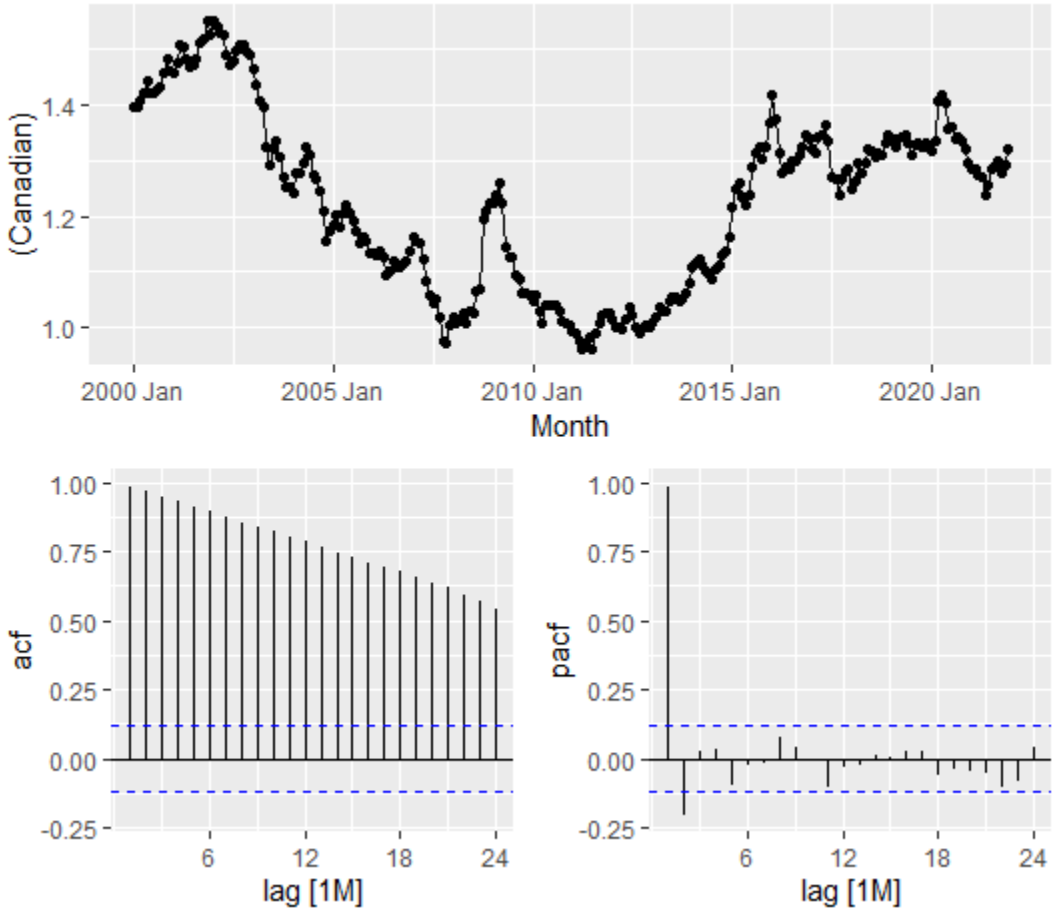
In Table 2, after minimizing AICc, BIC, and training sample RMSE and comparing it across all of the Exponential Smoothing models, we can see that the damped method had the lowest RMSE number and therefore is the best model out of this method to move forward with.

3.3 ARIMA Method

Preliminary Testing

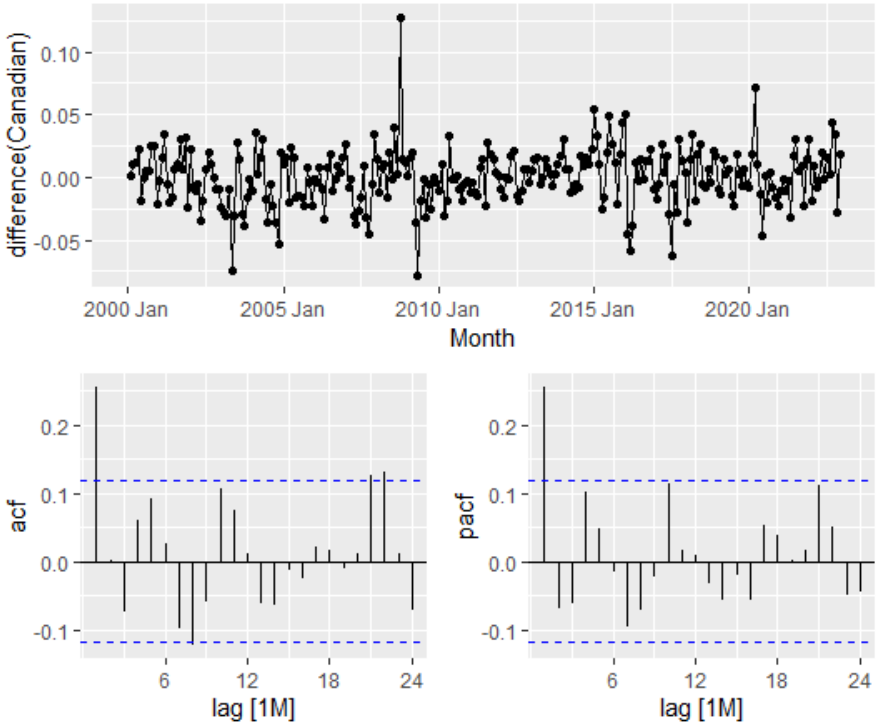
Prior to estimating ARIMA models, we tested for a unit root and a white noise process so we can tell if the data is stationary or non-stationary. Since the data is non-stationary, we differenced the data and continued with the ARIMA forecasting methods.

Figure 9- Raw data ACF and PACF



In Figure 9, ACFs are slowly decaying and are well above the confidence interval. Consequently, the data has a unit root, meaning it is non-stationary. Furthermore, after doing the unit root test, the data contained a p-value of 0.01 which is less than 0.05 so we fail to reject the null hypothesis that the data has a unit root.

Figure 10 - Differenced Data



In Figure 10, we see the differenced data. The ACFs data is stationary as you can see it slowly converges to 0. Furthermore, after doing the unit root test, the p-value came back as 0.1 which is greater than 0.05 which means we can reject the null hypothesis that it has a unit root and continue to forecast the ARIMA models.

Estimating ARIMA Models

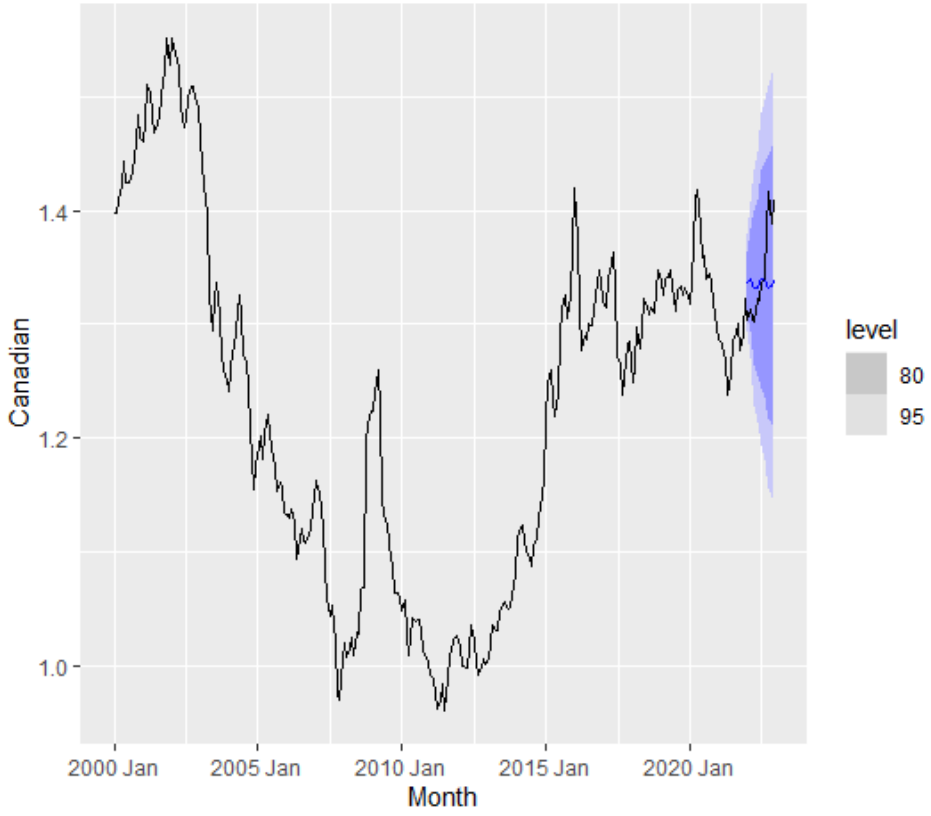
The predicted model we used is an ARIMA(0, 1, 3) - since the data is differenced once, and there are three lags every time it converges to 0. When I went to test the model in R, the system came back with two more models, ARIMA(0, 1, 1) and ARIMA(3, 1, 2).

TABLE 2: ARIMA Forecasts

Method	BIC	AICC	RMSE
ARIMA(0,1,3)	-1244	-1258	0.0217
ARIMA(0,1,1)	-1250	-1257	0.0220
ARIMA(3,1,2)	-1241	-1262	0.0214

In Table 3, after minimizing AICc, BIC, and training sample RMSE and comparing it across all of the ARIMA models, we can see that ARIMA(3, 1, 2) had the lowest RMSE and therefore is the best model out of this method to move forward with.

Figure 11-ARIMA Forecast



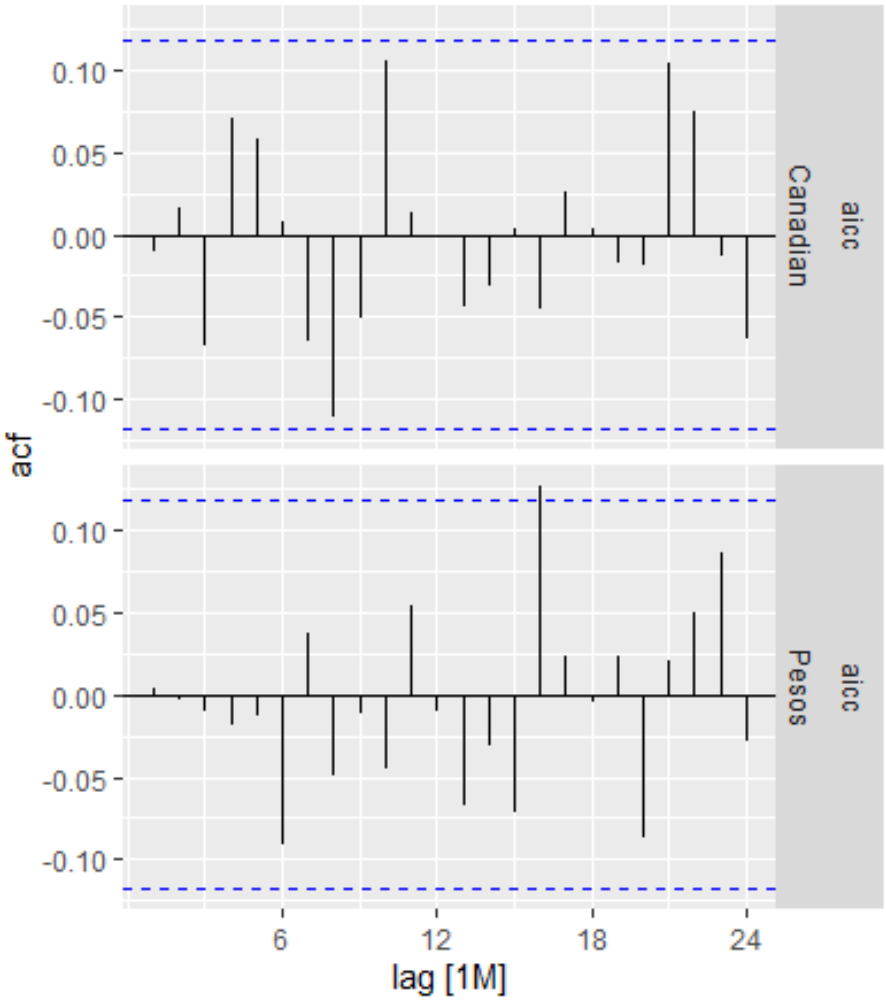
In Figure 11, we can see the forecasted ARIMA(3, 1, 2) model. It shows the forecasted data fluctuating up and down for the year 2022 but isn't quite lining up with the actual data presented. After conducting the Ljung-Box test for ARIMA, the p-value came back as 0.562 which means that the residuals for the model are white noise.

3.4 VAR Method

Model Estimation

For the VAR Method, the Mexican Peso exchange data was used to compare to the Canadian dollar. Since both of the currencies share a strong relationship with the USD, sharing the country's border and historically correlating the highest in comparison to our currency. The Mexican Peso's data was also non-stationary so differencing the data and running a unit root test resulted with a p-value of 0.01. After running an AICC and BIC test for the data - AICC came back with a VAR(3) forecast with 3 lags and the BIC came back with a VAR(2) forecast with 2 lags. When looking at the data and the numbers, the better model among the two was the AICC model with the VAR(3) model.

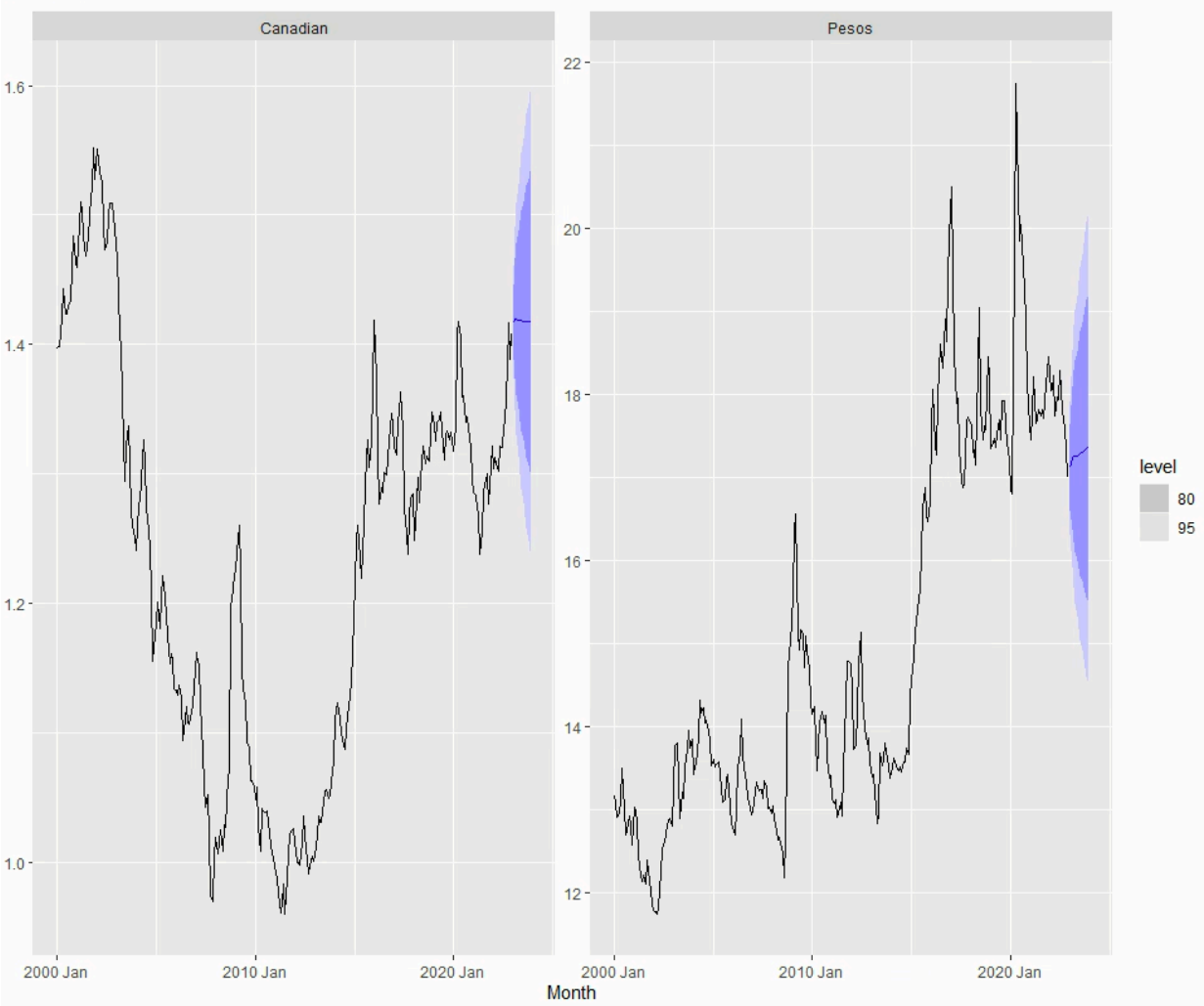
Figure 12 - White noise residuals



In Figure 12, output for the Ljung-Box test can be examined for the VAR(3) model. The residuals came back as a white noise process since all of the spikes are within the confidence interval. This ensures that the model is good to forecast the data.

VAR Forecasting

Figure 13- VAR Forecasts



In Figure 13, I have forecasted the Canadian Dollar as well as the Mexican Peso. For the Canadian Dollar, you can see that it stabilizes and there is not much increasing or decreasing. On the other hand, you can also see the Mexican Peso which increases steadily over the 12-month period. Overall, the VAR forecast isn't the most accurate or the best portrayal when compared to the actual data.

4 Conclusion

TABLE 3: Comparing the best models

	Damped Model	ARIMA(3, 1, 2)	VAR (3 lags)
In-sample RMSE	0.0225	0.0214	0.0217
Out-of-sample RMSE	0.0391	0.0422	0.0407

Table 4 shows the best forecasts from the Exponential Smoothing methods, ARIMA methods, and VAR Methods. As discussed, the Damped model was the best from the Exponential Smoothing methods, ARIMA(3, 1, 2) was the best from the ARIMA Methods, and VAR(3) was the best from the VAR methods. I calculated the in-sample and out-of-sample RMSE for all three models. When it comes to the in-sample RMSE, ARIMA has the best model with the lowest RMSE at 0.0214. However, when it comes to out-of-sample, the damped model had the lowest RMSE number at 0.0391. When looking at both of the forecasts, I felt that the damped model had the best forecast for the year 2022.

Figure 14- Optimal Model

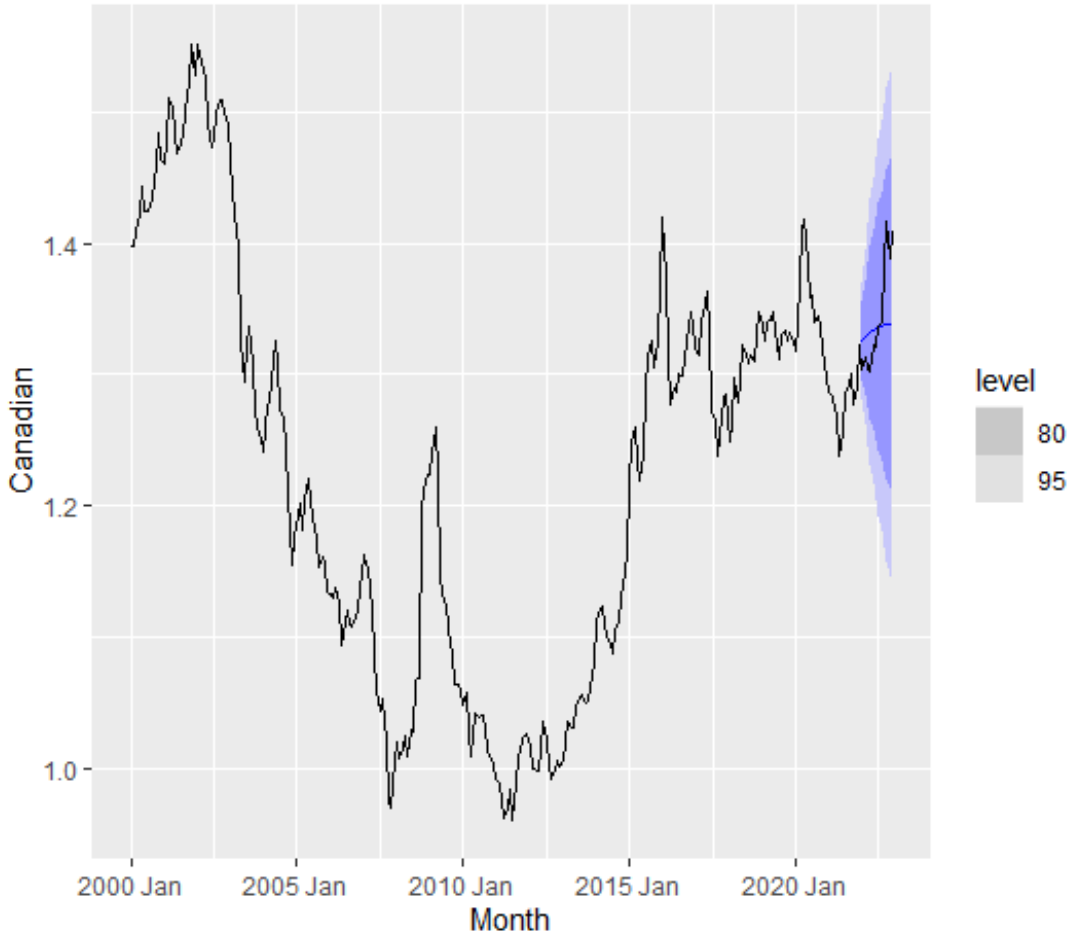


Figure 14 shows the damped model forecast for the year 2022 compared to the actual data. As you can see, it isn't the most accurate model but it does show the exchange rate of the Canadian Dollar increasing as the actual data does. When interpreting the forecast for 2022, the value of the US dollar was very strong since it takes 1.4 CAD to buy 1 USD towards the end of the year.

Predicting and forecasting closer to the actual data has been quite hard since there are a lot of outside variables and factors that play a role such as monetary policies, change of government officials, weather, etc. Events such as COVID-19 and its repercussions are difficult to predict and forecast. Furthermore, the supply and demand of agricultural products in the international market determine the value of the Canadian dollar. Trade policies shift under different government administrations which can either limit or open up agricultural trade. For example, if Canada and the US grow through a period of bad relations, trade policies can

consequently undermine the value of the Canadian dollar and vice versa. The same concept goes for government policies such as subsidies and tariffs which can affect the production and export of Canadian agricultural products. Perhaps the most unpredictable out of all of the factors is the weather. Droughts, hurricanes, floods, earthquakes, or even volcanoes, are famously known to completely destroy crops and halt exports for the foreseeable future.

To conclude, the value of the dollar in comparison to other countries highly affects U.S. trade demand on agricultural exports. Real interest rates, supply & demand of domestic and foreign currency, and amounts of individual commodities impact trade-weighted exchange rate - in turn, affecting agricultural trade. Long-term growth is mostly driven by foreign economic conditions, and short-term growth is heavily influenced by changes to exchange rates. If the trade-weighted exchange rate for a commodity increases, American farmers receive less revenue because the cost importers pay in USD increases. This applies inversely as well, indicating the importance of the relationship between exchange rates and our economic integrity.

5 References

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