Palombizio and Morris, 1:8
http://dx.doi.org/10.4172/scientificreports.402

Open Access Scientific Reports

Research Article Open Access

Forecasting Exchange Rates using Leading Economic Indicators

Ennio Palombizio[1]* and Ian Morris[2]

[1]2405 Eden Valley Drive, Oakville, Ontario L6H6K9, Canada
[2]1040 Hollington St., Apt.# 12, Ottawa, Ontario K1Z6K9, Canada

Abstract

The Canadian Dollar leads the way in the recent volatility of foreign exchange markets and much speculation into why this holds has followed. Fluctuations in oil/commodity prices have been considered, yet do not fully explain the volatility. This paper considers various economic indicators, selects the most impactful, and finalizes a model. The variables with the most impact come down to unemployment rate, oil price, consumer confidence index and wheat prices. Ultimately, through in- and out-of- sample forecasting, we find that the model is not fully able to accurately forecast short term fluctuations yet does well in expressing longer term forecasts.

Keywords: Foreign exchange; Forecasting; Time series; Economic indicators; Canada; Canadian dollar; Currency

JEL Classification: F31, F37, C51, C52, C53, E47

Introduction

In the last 20 years, foreign exchange markets have grown at an incredible rate in terms of volume and money invested. From 1944 to 1971, the foreign exchange market was relatively static due to many countries being part of the Bretton-Woods agreement, in which many of the world's currencies were closely pegged to the US dollar and a corresponding gold rate (Globe investor). Prior to this, currencies were on the gold standard, pegged to the Gold price. After Bretton-Woods, currencies were allowed to float and the modern foreign exchange market was born.

Since then, the market has been relatively dynamic, and this dynamism and volatility has only increased in the last twenty years. One of the most volatile currencies amongst the world's richest nations has been the Canadian dollar. Many have wondered why the Canadian dollar shows the volatility it has shown in the last twenty years, and specifically in the last ten. We have experienced a time of all-time lows as well as all-time highs. These periods of extremes and high volatility translate into a significant amount of money lost, but also much money gained. Certainly, if one was to find a way to model the volatility and various cycles of the Canadian dollar, the result would be an extremely profitable one. The goal of this paper is to consider the various factors that may cause the fluctuations in the Canadian dollar value, the magnitude of the effects these factors have, and whether they are significant enough to be included in a general model of Canadian dollar changes. Through some basic statistical information and some more sophisticated econometric methods, one should be able to estimate an adequate model for analyzing trends and even making accurate predictions.

Finally, we intend to review our final model and compare it with real world results. This will allow us to determine whether the final model is relevant enough to be considered a good forecaster of the Canadian dollar movements and whether firms should invest using this model or not.

Literature Review

There have been many papers and/or articles in which the authors attempt to model exchange rate volatility. This topic has become especially important with the increased interest in investing in foreign exchange markets. A key starting point would be "*Empirical Exchange Rate Models of the Seventies*" [1]. The main focus of the paper was to compare various Time Series and Structural models of exchange rates and exchange rate movements based on in-sample and out-of-sample forecasting accuracy. They found that the simple Random Walk model predicts as well as or better than other, more sophisticated, models. Some models were best over particular time horizons but overall the Random Walk proved consistently better. The main reason behind this was considered to be that there existed many unforeseeable shocks and extreme policy changes. Structural biases such as oil price shocks and changes in macroeconomic policy regimes were believed to have played a key role.

For some time, many attempts to beat the Random Walk model came close but it would not be until "*Exchange Rates and Fundamentals: Evidence on long-horizon predictability*" [2] that significant findings came through. When reviewing this literature, there were two papers which offered some important areas of guidance. Mark showed how Non-Linear and Non-Parametric Models were beaten by Random Walk and exchange rates, particularly in the short and medium run, were very difficult to predict. However, he found that long run changes in spot prices were predictable because exchange rates return to their fundamentals over time. Exchange rates were regressed on deviations from fundamentals and improvements were found with consistent results for all tested currencies, except for the Canadian dollar. This particular result supports what was mentioned earlier about the Canadian dollar being one of the most difficult rates to model and predict.

A third paper which was looked at for guidance was "*A Leading Indicators Approach to the Predictability of Currency Crises: The Case of Turkey*" [3]. This paper does not necessarily aim to model currency accurately enough to make forecasts but it aims to obtain forecasts to predict future potential crises in the currency. The focus of this paper is on the Turkish Lira only. However, it is applicable for the purposes of our paper in that it uses macroeconomic indicators in modeling the Turkish lira. This paper helped with ideas on methodology and

***Corresponding author:** Ennio Palombizio, 2405 Eden Valley Drive, Oakville, Ontario L6H6K9, Canada, Tel: 905-330-4741; E-mail: eap@cogeco.ca

Received January 03, 2012; **Published** October 24, 2012

Citation: Palombizio E, Morris I (2012) Forecasting Exchange Rates using Leading Economic Indicators. 1:402. doi:10.4172/scientificreports.402

considering which indicators, in general, can affect a currency; despite that the indicators may not be the same for all currencies, there may be some similarities.

An additional paper that dealt directly with issues of the Canadian dollar was "*The Canadian Dollar and Commodity Prices: Has the Relationship Changed over Time?*" [4] gave some key insight into the relationships that exist. The focus of their article dealt primarily with determining how the recent increase of commodity prices affects the Canadian dollar, using the Bank of Canada exchange rate formula and comparing simulations to actual data.

Their objectives and results are somewhat similar to some of key points that will be made throughout this paper. Although the increase in Canadian dollar value in response to increases in commodity prices over the past five years is not fundamentally different than in previous decades, the stability of the results differ over certain time periods. Also, they take into account the possibility that the parameters in the exchange rate equation may have shifted over time. They also find the importance of changing factors and changing financial environments over time and depending on the certain events of a particular time period [4]. After reviewing their paper and observing this paper's initial results, it becomes evident how key time was to this study. Since, in our paper, we make use of quarterly data of the last 10 years, we did not have a great issue with changes over time, but it was important to always keep this in mind when developing our results.

Data Description

This paper makes use of quarterly data from 1999Q1 to 2008Q4 for all of our variables. The data was obtained from Source OECD (main economic indicators). Also, data on consumer confidence was obtained from The Conference Board of Canada. An obvious first step was to identify our key variable, the CAD/USD exchange rate. The exchange rate used was the direct rate so that our dataset is in terms of Canadian dollars per US dollar. As such, an increase signifies depreciation in the Canadian dollar and a decrease implies an appreciation in the Canadian dollar. We then continued in considering many economic variables as potential candidates for our finalized model to forecast the exchange rate.

Right away, some important macroeconomic indicators considered were the GDP, Unemployment rate, Trade Balance, Government Balances, CPI and CPI of Raw Materials, Money Supply (M2) and Consumer Confidence Index. GDP is considered to be quite significant because it essentially summarizes activities within an economy and economic theory stresses this as one of the most important indicators of an economy's well being. Unemployment rate is important because of the important relations it has with many other indictors in theory, but also because the proportion of the labour without a job can often indicate the overall health of an economy. The trade balance (or Net Exports) was thought to be especially important to the Canadian economy since, Canada is a net exporter (up until recently) and this would usually imply Canadian goods are competitive and in high demand globally. Also, the government balances summarize a country's fiscal policies and this is thought to have an impact on the perception of a country's government on the world stage.

Money Supply is a very important variable for the purposes of the exchange rate, because of the direct relationship that increasing money supply (printing more money) can depreciate (or devalue) the currency and it gives insight into the monetary policies put forth by a country's central bank. This then, takes us to the Consumer Price Index (CPI), which gives an idea of any inflationary/deflationary effects occurring in the economy. Also included is the CPI for Raw Materials, given the importance of commodities and raw materials to Canada's economy; and changes in these prices could be a strong indicator of dollar volatility.

Finally, the Consumer Confidence Index is a good indicator of how the people view the health of their country's economy and it could reflect particular economic habits of the people. Other variables considered were various interest rates, such as the overnight money market rate, the 3 month government bond (T-Bill) rate and the 10+ year government bond rate. These rates are keys to the central bank's monetary policies through their open market operations and these operations have direct impacts on exchange rate fluctuations. As already mentioned, Canada's economy shows some dependence on commodities prices due to its' vast supply of natural resources, and so the price of Oil (Brent Crude), Gold (Bullion) and Wheat were also taken into consideration. Finally, since Canada has a very active and very global equity and investment market, the TSX composite index numbers were looked at as a possible indicator.

To provide a more accurate growth rate for our variables, we used the log difference formula to obtain our growth rates. All variables were then deseasonalized. This was achieved by running a regression on the seasonal dummy variables, and the coefficients were then subtracted from the original values. This will help provide a more favorable estimation model that makes seasonality, which affects many time series variables, a non-issue here. If these are not looked at and removed, they can be mixed in with any trends we may find in our tests and skew the final results and model.

In order to narrow down which of the candidate variables can explain more of the trends in the Canadian dollar fluctuations, they were checked for correlations with the exchange rate variable and were also regressed upon the dependent variable, the exchange rate growth rate, as explained in the previous paragraph.

The results of the correlation table and the regression led to the selection of four explanatory variables to be our leading indicators (Table 1). These were the most correlated (whether positively or negatively) and were the most significant in terms of the regression and the respective t-tests:

Unemployment

This is the Canadian unemployment rate for those 15 years and older. The reasoning behind including the unemployment rate in this model is to capture a potential second order effect via the Phillips curve relationship. Although, there have been periods in history where the Philips curve did not hold well (ex. Stagflation in the 1970's), it is reasonable to assume the usual negative relationship between unemployment and inflation. The transmission mechanism is as follows; high unemployment → lower inflation (falling price level)

		Exrate growth
Unempl growth	Lag 1	0.2180
	Lag 2	0.2390
Oil growth	Lag 1	-0.2571
	Lag 2	0.2389
Wheat growth	Lag 1	-0.0667
	Lag 2	-0.3102
Consmr growth	Lag 1	0.0439
	Lag 2	-0.2768

Table 1: Correlation with exchange rate growth.

via the Phillips curve → lower exchange rate (appreciation). This of course assumes PPP holds and that the price level in the U.S. remains constant or at least is not falling at the same rate as the price level in Canada. There is however, a potential offsetting effect with an increased unemployment rate. A rise in unemployment could signal capital flight, which would lead to a rise in exchange rates (depreciation). The idea behind this possibility is that firm owners could begin getting rid of their workers as a precursor to closing up shop. In an environment with a high level of foreign investment such as the case in Canada, these firm owners could move their businesses and/or capital elsewhere. This will exert pressure on the Canadian dollar to depreciate through two mechanisms. The first being through the pressure found within the foreign exchange market. The demand for Canadian dollars will fall and there will be a selloff of Canadian dollars in the event of these firm owners fleeing the Canadian market. Another mechanism that exerts pressure on the Canadian dollar to depreciate is through the open economy goods market equilibrium. In the open economy goods market equilibrium, savings less investments equates to the current account. With a decrease in investments, this leads to disequilibrium where savings less investments is in excess of the current account. Equilibrium is only restored when the interest rate falls, which is exactly what exerts pressure on the Canadian dollar to depreciate (Figure 3).

Oil

This is the price for crude oil (Brent) in US$. This could potentially be a useful leading indicator as it is an early indication of inflation. Although, prices can been seen to be sticky in the short run due to an assortment of factors (ex. wage contracts), the price for crude oil is much more volatile. Krugman and Obstfeld [5] name raw materials prices as one of the three main sources of demand and cost pressures that affect the price level. Raw materials such as oil are sold in markets where prices adjust rapidly. This rapid adjustment is the justification of using the crude oil price as a leading indicator for exchange rate movements. This effect leads to the belief that the price of oil will signal a pending increase in the general price level, which in turn, leads to currency depreciation. There is however, another component to the effect of the price of oil on the Canadian economy. Canada is a net exporter of oil, and thus, benefits when the price of oil rises. This increase in income will increase aggregate demand in the economy, which will lead to a currency appreciation (Figure 3).

Consumer confidence index

This is provided by the Conference Board of Canada. Expectations

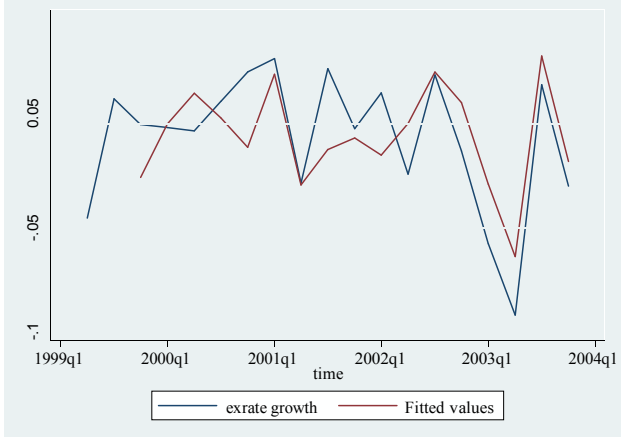

Figure 1: In-Sample forecast.

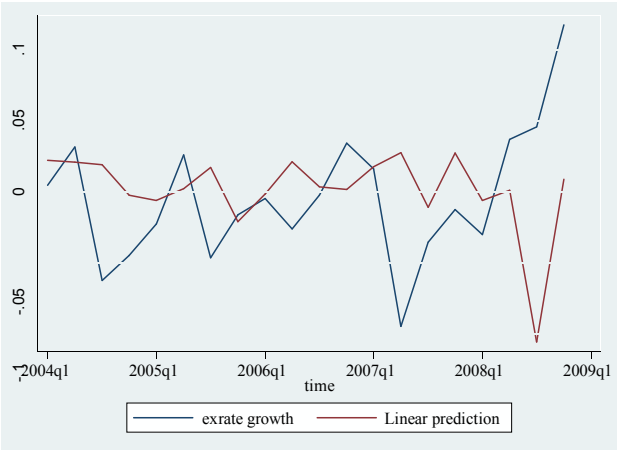

Figure 2: Out-of-Sample forecast.

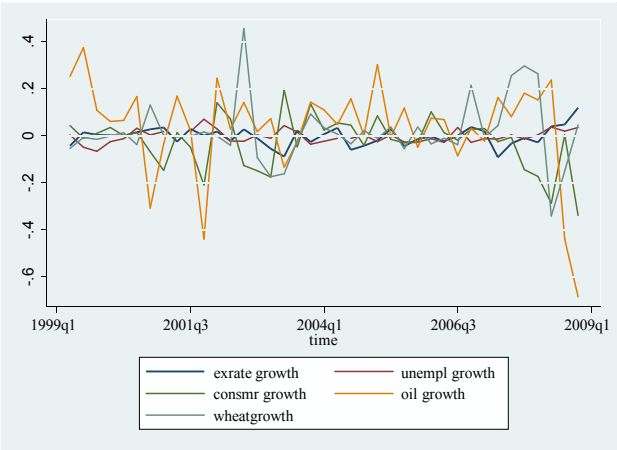

Figure 3: All variables (growth rates).

are ever important in the economy and this is a potential leading indicator for exchange rate changes. As mentioned earlier, it gives a good indication of what the Canadian perception is of the health of the Canadian economy. Some believe this is to be an excellent indicator of overall health of an economy because consumers are the key agents to any economy and it is like a look within the engine of the economy. A rise in consumer confidence leads to a more secure environment in which investors might be looking to invest. This influx of investment will lead to an appreciation of the Canadian dollar. Apart from investment, it implies consumers feel secure enough in their economy to consume as much as they can and work to their full potentials (Figure 3).

Wheat

This is the per metric ton price in Canadian dollars for wheat. The price of wheat is sold in a market where prices respond quite rapidly to supply and demand shocks. As a result, the stickiness of prices that usually occur for the general price level is not a problem with prices of wheat and other products sold in a similar market environment. The price of wheat and the exchange rate should move in the same direction. This will exert pressures on the overall price level to move with it and can serve as a leading indicator of the price level. The increase in the price level leads to a currency depreciation. It is important to remember the importance of wheat and wheat products as exports to

the Canadian economy. Although, it may not be as valuable or precious as oil or minerals/metals, it is still an important export nonetheless and the demand is present.

By looking at the correlations, the lagged values of unemployment seem to move in the same direction as exchange rates (Table 1). This is not surprising one way or the other, as we have outlined previously why these two variables would move in the same direction. Using these correlations as a gauge, the two most recent growth rates (2008Q3, 2008Q4) for unemployment of 1.6% and 3.2%, respectively, give an indication that exchange rates will be growing in the next 6 months. The two most recent oil growth rates of -44% and -69% give an indication that the exchange rate will depreciate in the next 3 months, followed by an appreciation in the following 3 months. The two most recent wheat growth rates of -15% and 4% give no indication of currency movement in the next 3 months, due to the very low correlation between exchange rates and the one period lag of wheat. However, there is indication that in the following 3 months, there will be an appreciation, given by the strength of correlation with the second period lag for wheat. For consumer growth, the two most recent values of 0% and -34% yield no indication of which direction exchange rates will go in the next 3 months, but the following 3 months, the exchange rate looks like it will depreciate. Finally, the two most recent growth rates of housing prices of 0% and 1% show no indication of direction in the next 3 months due to the very low correlation of the first period lag, but there is indication of depreciation in the following 3 months (Figure 3).

Empirical Strategy

In-sample forecasts

In order to set up our forecast strategy, we split our 40 observations in half, with observations 1-20 corresponding to the in-sample group and observations 21-40 corresponding to the out-of- sample group. We will run a regression with the in-sample group, in order to obtain our coefficient estimates that will be used on the out-of-sample group. Firstly, many time series data are correlated with their lagged values and require autoregressive models for prediction. To check for the possibility of correlation between our dependent variable and its' lagged values, we ran a correlogram in STATA. The results gave no indication of correlation between the dependent variable (exrategrowth) and its lagged values. This served as a good starting point for setting up our estimation model. This enabled us to proceed without assuming an autoregressive model. Our regression model is as follows:

$$exrate_t = \beta_0 + \beta_1 *unempl_{t-1} + \beta_2 *unempl_{t-2} + \beta_3 *oil_{t-1} + \beta_4 *oil_{t-2} + \beta_5 *wheat_{t-1} + \beta_6 *wheat_{t-2} + \beta_7 *consmr_{t-1} + \beta_8 *consmr_{t-2} + u_t$$

The variable exrate is the Canadian/US dollar exchange rate, unempl is the Canadian unemployment rate and consmr is the consumer confidence index, while the other variables in the regression do not need clarification. All of the above variables are expressed in terms of growth rates and are deseasonalized. In order to seasonally adjust our data, we ran a regression on seasonal dummy variables and subtracted the coefficients obtained from the original values. Ordinary Least Squares (OLS) estimation was used to obtain the predicted coefficients. These coefficients were then used to predict the in-sample values for exrate.

	RW	Model	Difference
6 months	.0191	.0344	.0153
1 year	.0434	.0312	-.0122
2 year	.0346	.0305	-.0041
4 year	.0355	.0340	-.0015

Table 2: Root mean square error.

Out-of-sample forecasts

Our out-of-sample forecasts were obtained by applying our coefficient estimates generated from our in-sample regression to our out-of-sample observations. Our forecast relies on the assumption that our dependent and explanatory variables are stationary variables and contain no unit roots. If this is not the case, our model will break down and more sophisticated transformations would be needed to make our variables stationary. We conducted an Augmented Dickey-Fuller (ADF) test to help identify any possible unit roots. The results found that there were no unit roots, thus our dependent variable appears stationary. We also conducted a Phillips-Perron unit root test, and similar results were found.

The strength of this out-of-sample forecast can be determined by comparing this to that of the random walk model. The random walk model has gained much attention in exchange rate modeling as it has been shown to consistently outperform the most sophisticated forecasting models. To determine if our out-of-sample forecast performs better than the random walk, we compare the standard errors of the two models. This is a similar comparison Meese and Rogoff [1] looked at in their paper as well as Mark [2] in his. So by considering their testing methodology, our results should follow a similar structure.

Results

In-sample forecast

In-sample forecast seems to fit the actual values pretty well, apart from 2001Q3 (Figure 1). The exchange rate depreciated 2.6% and the fitted model predicted a 1.3% appreciation. Apart from that wrong prediction, the fitted model seems to fit the actual data just fine. In OLS estimation results (Table 3) the second period lags on all variables were not statistically different than 0 at conventional significance levels. The coefficient of consmr (lag 1) is 0.22, which indicates that a 1% increase in the consumer confidence index will lead to a 0.22% increase in exchange rates. This is significant at the 5% significance level. The sign on this coefficient does not seem to make sense, economically speaking. As previously mentioned, the expectation in place with regards to this variable was that the relationship between the consumer confidence index and exchange rate growth should be negative. The coefficient of the first lag of wheat was 0.15 and is statistically significant at the 5% significance level. This is the expected sign on the coefficient as previously postulated. The adjusted R squared value is 0.27, which shows that 27% of the variations in the data could be explained by our model.

To check for autocorrelation of our residuals, we implemented two strategies to identify autocorrelation. The first strategy is the famous Durbin-Watson test for autocorrelation. The test returns a result of approximately 2, which means there is no autocorrelation present. To reaffirm our previous results, we implemented another popular check for autocorrelation, the Box-Ljung Q test. A p-value of 0.05 means that we cannot reject the null hypothesis of no-autocorrelation at a 95% confidence interval and our p-value here is 0.83, which shows once again, that there is no autocorrelation present.

Out-of-sample forecast

For our out-of-sample period, beginning from the 2004Q1 and ending at 2008Q4, our model failed to predict substantial changes in

		1	2	3	4	5
Oil						
	Lag 1	0.0119	-0.0373			
		(0.0827)	(0.0523)			
	Lag 2	0.1195	0.0191			
		(0.0779)	(0.0512)			
Consumer						
	Lag 1	0.2229**		0.1810		
		(0.0811)		(0.0764)**		
	Lag 2	0.0898		0.0714		
		(0.0967)		(0.0762)		
Wheat						
	Lag 1	0.1491**			0.0737	
		(0.0667)			(0.0627)	
	Lag 2	0.0103			-0.0384	
		(0.0678)			(0.0629)	
Unemployment						
	Lag 1	0.7452				0.0859
		(0.5377)				(0.2885)
	Lag 2	0.0650				-0.0219
		(0.2837)				(0.2893)
Constant		-0.0077	-0.0066	-0.0057	-0.0056	-0.0066
		(0.0074)	(0.0084)	(0.0072)	(0.0081)	(0.0086)
R^2		0.6331	0.0393	0.2958	0.1164	0.0066
Adjusted R^2		0.2661	-0.0980	0.1952	-0.0098	-0.1353

Table 3: OLS Estimates (In-Sample).

the exchange rate. For instance, in 2007Q2, our model predicted 2.7% depreciation, when there was actually a 9.5% appreciation! Another instance of stark divergence occurs at the end of 2008. Our model predicted an 11% appreciation in 2008Q3, followed by 1% depreciation in 2008Q4. In reality, the exchange rate depreciated 4.5% in 2008Q3, followed by an 11% depreciation in 2008Q4! Despite these failings, our model seemed to predict some movements in the exchange rate. For example, during 2007, our model followed the direction and trend of the exchange rate movements closely.

Our model seemed to predict the depreciation of 2006Q4; however the timing was off by at least a quarter (Figure 2). This could lie in the speed of foreign exchange markets relative to other markets. In 2006Q4, the exchange rate depreciated 3.4%, but our model showed 0% growth in that quarter. By the next quarter however, our model predicts 1.7% depreciation, followed by the peak of 2.7% depreciation in 2007Q2. The forecasting strengths of exchange rate models are often gauged against the random walk model, as per the strategy used by Meese and Rogoff [1]. Table 2 shows the values of the standard errors (RMSE) of both the random walk and our model over different time horizons. The difference between the standard errors is shown in the last column. The random walk outperforms our model on a 6 month time horizon, as indicated by the positive sign of our difference value. However, in subsequent time horizons of one, two, and four years, our model does better in terms of lower RMSE than the random walk. Our model shows more stability in the RMSE than does that of the random walk. This shows promise, especially for longer term forecasts. It would be interesting to see further years ahead to see how our model's predictive power fairs against the random walk. It is fair to say, however, that our model did fairly well in forecasting the Canadian dollar relative to Meese and Rogoff's or Mark's results for the Canadian dollar, which was the only currency of the ones they selected to give them issues. This is most likely explained by the fact that our model is specifically designed for Canadian dollar modeling purposes, and the Canadian dollar is probably a currency that requires this type of specific estimation.

Conclusion

Our model seems to perform fairly well when predicting values of the exchange rate movements in-sample, however when extending our model to forecast out-of-sample movements in the exchange rate, there does not seem to be that same predictive power and does not instill great confidence in the model. Our in-sample forecast produced statistically significant coefficients for two leading indicators. The first being the first lag of the consumer confidence index. This leading indicator predicts that a 1% increase in the consumer confidence index will lead to a 0.23% rise in exchange rates. The positive sign on this coefficient is rather puzzling. The increase in consumer confidence should lead to a currency appreciation; however this model fails to capture that direction. The second leading indicator to show a statistically significant coefficient was the first lag of wheat. This leading indicator predicts that a 1% increase in wheat prices will lead to a 0.15% rise in exchange rates. This result falls in line with the previously mentioned economic theory of price effects. In our out-of-sample forecast, our model fails to reliably predict exchange rate movements. The model failed to predict large swings in the exchange rates throughout the out-of-sample period, however at points, showed some sign of movement predictability, as limited as they were.

In order to gauge the strength of our forecast model, we compared our model to that forecasted by that of the random walk. The random walk outperforms our model at a time horizon of 6 months. However, beyond 6 months, our model outperforms the random walk. This model is a very limited model in the sense that the in-sample period is quite small (five years), thus the estimated coefficients could have been different if we widened the scope of our sample, even when keeping in line with having stationary variables. To enhance this models predictive power, a larger in-sample size should be used. Despite this

model's shortcomings, it does show promise in predicting longer term changes in the exchange rate. It is also important to note that a key difficulty that affects the predictability of the Canadian dollar is one of changing priorities in terms of impactful variables. For example, oil has not always been overly important in dictating Canadian dollar movements, yet in the last 10 years it has gained significance in moving the dollar. Historically, however, gold may have had more importance as well as fiscal and monetary policies of the government and central bank, respectively. It is likely however that the actions of the Canadian government will not have major impacts relative to the rest of the world seeing as Canada, is considered a small economy; assuming the actions are not drastic. Due to all of this, perhaps it is best to have an ever changing or 'revolving door' model for forecasting Canadian dollar volatility which can easily be altered and is ready to adapt to changing economic times. Overall, these findings have simply confirmed the complexity of the Canadian dollar, its volatility and its difficulty to predict amongst an already seemingly unpredictable foreign exchange market. This translates into a significant amount of potential profits, but also potential losses.

References

1. Meese RA, Rogoff K (1983) Empirical Exchange Rate Models of the Seventies. J Int Econ 14: 3-24.
2. Mark NC (1995) Exchange Rates and Fundamentals: Evidence on Long-Horizon Predictability. Am Econ Rev 85: 201-218.
3. Kibritcioglu B, Kose B, Ugur G (1999) A Leading Indicators Approach to the Predictability of Currency Crises: The Case of Turkey. General Directorate of Economic Research: The Undersecretariat of Treasury, Ankara, Turkey.
4. Maier P, DePratto B (2008) The Canadian Dollar and Commodity Prices: Has the Relationship Changed over Time? International Dept., Bank of Canada.
5. Krugman PR, Obstfeld M (2003) International Economics: Theory and Policy. (6thedn), Addison Wesley, USA.