

The Canadian Dollar and the 2014 Oil Price Plunge: the Creation and Destruction of Realities

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Table of contents:

Abstract	4
Introduction	5
I) Exchange Rate Determination	
A) The Monetary Approach	7
B) Current Account as a Predictor of Exchange Rates	8
C) The Portfolio Balance Approach	8
D) The Post Keynesian Approach	10
II) Exchange Rate Determination: The Canadian Case	
A) A Review of the Literature	13
B) The Impact of Speculation on the Canadian Dollar	18
III/ The 2014 Oil Price Plunge	
A) “Sheiks vs. Shale”: a Look at the Case of Excess Supply	20
B) Impacts and Implications on Canada	23
IV) Empirical Exercise	
A) Problems Associated with Correlation Analysis	25
B) The Suggested Approach	27
C) Data Analysis	
1) Daily Data	29
2) Hourly Data	31
3) Minutely Data	33
4) Per Second Data	35
Concluding Remarks	40
Bibliography	41
Appendices	45

Abstract

The paper starts by relating general exchange rate determination theories. It then lays down exchange rate determination models pertaining to the Canadian dollar. The paper then transitions to the 2014 oil price plunge and attempts to show that expectations and speculation, rather than real economic factors, contributed the most to its happening. Its impacts on Canada, and more precisely on the USD/CAD exchange rate, are then presented. Finally, micro data (daily, hourly, minutely, and per second) is used to back the claim that the Canadian dollar has grown to respond to oil prices in a matter of a few seconds. The per second analysis suggests that the Canadian dollar adjusts to changes in oil prices within 3 seconds at most. Such a pattern can only be achieved by pre-programmed speculative computers. As compared to five major currencies, the superior responsiveness of the Canadian dollar to oil prices stems from an action-reaction sequence that happens over the course of 2 to 3 seconds. Contrary to neoclassical theory, speculation, both on oil futures and the Canadian currency, does have long term impacts on the Canadian dollar. In accordance with Lavoie (2014), this paper supports the claim that “speculative behaviour [...], when excessive, can destabilize flexible exchange rates”.

Introduction

The value of an open economy's currency as compared to that of its trading partners can have important implications on its structure, export competitiveness, and purchasing power of foreign goods and services.

The literature on exchange rate determination is one of the largest in economics (Harvey, 1996). Different schools of thought have attempted to identify and model the economic factors that explain exchange rate fluctuations. The freer an exchange rate system is, the more sensitive it is to changes in those factors. Depending on the school of thought, movements in the exchange rate are either deemed to work in the market's best interest or not so at all and consequently either require policy intervention or not.

Neoclassical economics, for instance, considers exchange rates as being a reflection of differences in economic fundamentals between countries. Fluctuations are deemed to work in the market's best interest and changes in fundamentals, rather than speculative noise, are considered the main determinants of those fluctuations. Government intervention then cannot but cause more harm than good.

The Keynesian and Post Keynesian schools of thought, on the other end of the spectrum, question the role of fundamentals and are reluctant to accept the idea that currency speculation has no impact on exchange rates. A free floating exchange rate, consequently, does not necessarily lead to the most efficient outcome.

This paper will start by laying down two neoclassical exchange rate determination models (the monetary model and the portfolio balance model). It will then present the Post Keynesian model that takes into account market psychology. Exchange rate determination

models pertaining to the Canadian currency will then be presented. Finally, and in light of the 2014 oil price plunge that was accompanied by a significant depreciation of the Canadian currency, the paper will empirically attempt to contribute to the understanding of fluctuations in the value of the Canadian dollar.

I/ Exchange Rate Determination

Before digging into the Canadian case of exchange rate determination, it is useful to examine the factors that generally impact either the demand or supply side of a currency and thus govern exchange rate movements. This section will start by presenting neoclassical explanations of such movements before relating the Post Keynesian vision of the subject.

A/ The Monetary Approach

Many models attempting to explain exchange rate movements have emerged throughout the course of the past five decades. The first worthy of mention is the Monetary Approach. The approach suggests that the exchange rate between two currencies reflects relative price levels in the two concerned countries. In other words, at any point in time, a given amount of country's A or B currency has the same purchasing power in both countries. Balassa (1964) and Samuelson (1964) introduced the concepts of competitive advantage and productivity differentials as determinants of relative prices and thus of exchange rate.

The approach is based on the idea that the equilibrium exchange rate is set in a way that eliminates any possibility of making arbitrage gains by buying a good in a country and selling it as is, but at a higher price, in the other. The Monetary Approach then assumes the following 1) prices and wages perfectly and instantaneously adjust (i.e. there is total absence of stickiness 2) money demand is stable and 3) purchasing power parity always hold.

Because of the dissimilarity between the model's assumptions and actual real world circumstances, it has been suggested that the Monetary Approach is, at best, limited to explaining exchange rate movements in the long term (Dornbusch, 1976; Frenkel, 1976; Mussa, 1976). According to Obstfeld and Rogoff (2000) the model remains a weak predictor of

exchange rate movements even in the long term. The general consensus suggests an overall weak performance of the model both in the short and long term (Visser, 1989; Levich, 1985).

B/ Current Account as a Predictor of Exchange Rate

The volume of imports and exports between a given country and its trading partners partly explains the demand for a country's currency on international markets, and can consequently contribute in explaining and predicting the currency's value and hence its exchange rate *vis à vis* other currencies. The reason behind that is that trade is generally made using the exporter's currency. The importer has to exchange a given amount of its currency in exchange for the exporter's. This means, in other words, that demand for the exporter's currency increases while that for the importer's decreases. Theoretically speaking, this should manifest itself by an appreciation of the exporter's currency and a depreciation of the importer's. The empirical validity of that theory remains unclear with some studies finding a significant link between terms of trade and exchange rate movements (Rodriguea, 1980; Dornbusch and Fisher, 1980) while others fail to find any (Fortin, 1999).

C/ The Portfolio Balance Approach

Since the 1960s, many refined and sub- models trying to make the Monetary Approach apply to more cases emerged in the literature. The Portfolio Balance Approach extends the scope of the Monetary Approach by adding an important component of exchange rate determination: non-trade international capital flows. Simply put, it suggests that investors adjust their bond holdings by comparing the domestic interest rate to that of foreign countries.

All other things equal, a profit-maximizing investor would prefer to transfer her wealth to the country that offers the highest interest rate on its bonds. An international capital flow

ensues and, depending on the parameters, affects the demand and supply sides of each currency in a predictable way. This, in turn, is deemed to determine the evolution of exchange rates.

While both the Monetary Approach and the Portfolio Balance Approach positively link interest rates and the value of a currency in international markets, the causal effect happens through different channels. In the Monetary Approach, a rise in interest rates yields a decrease in the money supply, which causes a fall in prices. The exchange rate then appreciates so that Purchasing Power Parity continues to hold. In the Portfolio Balance Approach, the exchange rate appreciation happens through the asset market. A rise in interest rate, everything else constant, will increase the demand for the domestic currency (and hence its value) by making it more attractive to investors.

In the real world, given the rapid speed at which exchange rates adjust to news of interest rate changes, the Monetary Approach stands no chance of offering the best explanation of exchange rate movements. The change either happens through the asset market as the Portfolio Balance Approach suggests, or yet by the means of investors' beliefs and expectations as Post Keynesian economists suggest. The infinitely higher volatility of exchange rate movements as compared to that of changes in economic parameters leaves the Post Keynesian approach as the only potential candidate for explaining real world exchange rate movements.

In spite of its improvement over the Monetary Approach, the Portfolio Balance Approach still tests poorly in empirical exercises (MacDonald and Taylor, 1989; Levich, 1985). The general consensus seems to point to a general failure of neoclassical approaches to exchange rate determination (Dornbusch, 1987; MacDonald and Taylor, 1989). As Harvey (1996) concludes, "by their own admission, orthodox economics has failed to explain exchange rates."

D/ The Post Keynesian Approach

Financial factors drive currency prices, not “real” ones. John. T Harvey (2006)

One of the main tenets of the Post Keynesian Approach revolves around the idea that expectations, rather than actual economic happenings, represent the most important determinant of exchange rates. Market participants act according to a set of mental rules that guide their forecasts and expectations. Harvey (2006) summarizes the five psychological mechanisms that together shape the rules applied by investors when making financial decisions.

Availability means that more recent and dramatic currency price movements will be thought of as more frequent and therefore likely; representativeness causes agents to assume that there must be some underlying logic to recent price movements (even if it is not quite evident to them); anchoring is especially important during periods of volatility since agents’ shift their anchor from levels to rates of change; the desire to follow conventional wisdom leads agents to follow trends; and forecast substantiation means that as currency prices move in expected directions, so agents gain confidence and push it even further.

The Post Keynesian Approach also accords a very significant role to speculative capital flows, or in other words capital flows which are not done for the sake of future trade. Walter (1991) estimates that at least 90 percent of capital flow volume is unrelated to any real trade activity. With the computerization and then the robotization of the financial sector, the tendency cannot but be on the rise since then.

Both neoclassical economists and Post Keynesians agree that financial investment and speculation comprises the vast majority of international capital flows since at least the 1970s. The main difference is that, for the former group, such transactions end up cancelling each other in the long term which makes them simply white noise in the short term. On the other hand, Post

Keynesians view such flows as capable of altering real economic dynamics both in the short and long runs.

The literature comparing the predictive accuracy of Post Keynesian models to neoclassical ones is rather limited. Harvey both pioneered and made the greatest contribution to the field so far. Harvey (2005) compares two neoclassical models (a Purchasing Power Parity model and a monetary model) to a Post Keynesian model that takes market psychology into consideration and finds the latter to be clearly superior in terms of predictive accuracy.

Moosa (2007) conducts a similar empirical test and also finds a predictive superiority of the Post Keynesian model in spite of adjusting the models' construction to take potential critiques of Harvey's approach into consideration. Compared to Harvey (2005), Moosa (2007) makes the following methodological adjustments:

- 1) Adding interest rate as an explanatory variable in the money demand function of the monetary model. While Harvey (2005) implies that interest rate affects exchange rates only through the speculative channel, Moosa (2007) takes into consideration the non-speculative impacts of interest rate on exchange rates. Most notably, these include their effect on price levels and Purchasing Power Parity.
- 2) Instead of comparing the t-statistics of individual explanatory variables, Moosa (2007) uses non-nested model selection tests and predictive accuracy tests. Moosa's approach allows to directly compare the goodness of fit of the different models instead of passing by the significance of each explanatory variable.

3) Harvey uses the first difference of the exchange rate in his Post Keynesian model while he uses the log level in his monetary model. In order to avoid the critique of “comparing apples to oranges”, Moosa (2007) uses the log of the exchange rate in both models.

Moosa (2007) concludes by maintaining that “Harvey’s results are corroborated despite the use of a different data frequency, four exchange rates (as opposed to one), and different model evaluation criteria.”

The available, though limited, literature does suggest a predictive superiority of the Post Keynesian approach as compared to neoclassical ones. More research is definitely needed to better demonstrate the potential of the Post Keynesian approach in exchange rate determination.

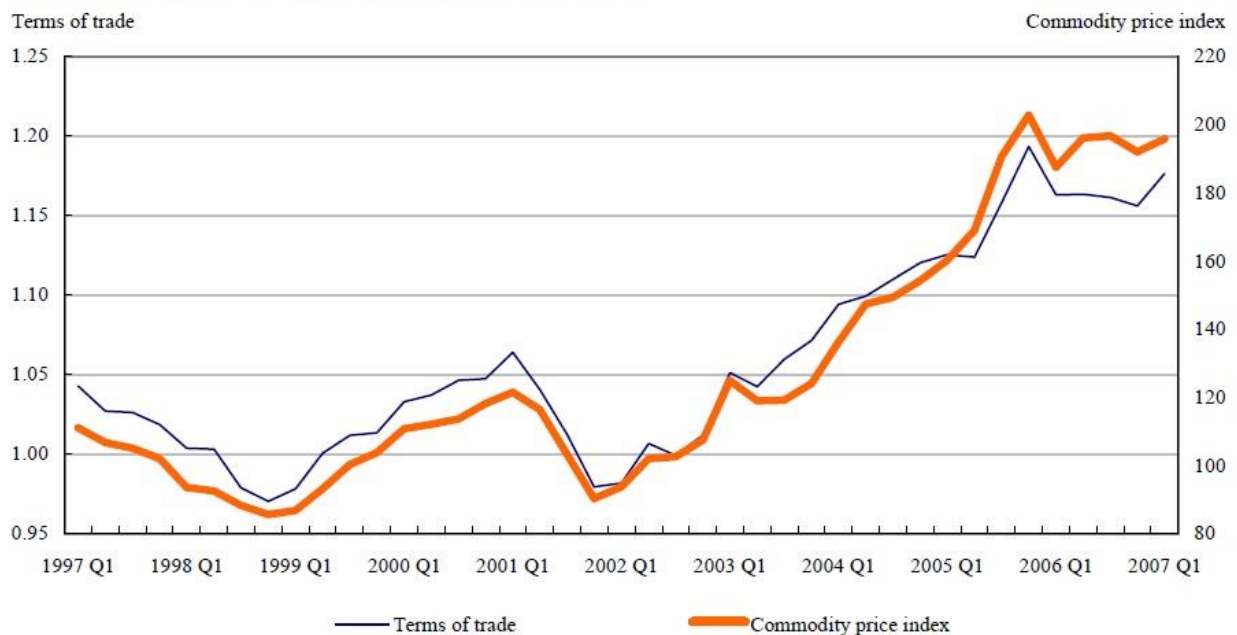
The next section will turn to the major theoretical frameworks that have attempted to explain fluctuations in the value of the Canadian currency.

II/ Exchange Rate Determination: The Canadian Case

Note: In this sub-section, and in order to be in conformity with Helliwell et al. (2005), the USD/CAD exchange rate represents the number of US cents per Canadian cents. In trading jargon, the X/Y exchange rate refers to the amount of currency Y per unit of currency X. The latter definition will be used in the rest of the paper.

Given that commodity exports have historically represented a very significant share of Canadian total exports, and because commodity prices are directly linked to the terms of trade (figure 1), all models attempting to explain movements in the exchange rate of the Canadian currency have at least one commodity price component. The implementation of the Canada-US Free Trade Agreement in 1987 and the North American Free Trade Agreement (NAFTA) in 1994 led to an important increase in Canadian commodity exports which, in turn, led to higher sensitivity of the USD/CAD exchange rate to commodity price fluctuations.

Commodity prices and Canada's terms of trade



Notes: Q1 = first quarter. Terms of trade have been calculated by the author.

Figure 1)

Source: Macdonald (2005)

Efforts to assess the factors impacting the USD/CAD exchange rate and to predict its future evolution date back to at least the early 1990s. Already at that time, the Bank of Canada

was finding it useful to invest in understanding and predicting exchange rate movements to better evaluate the general Canadian economic outlook. Amano and van Norden (1993) developed the traditional Keynesian RDXF (Research Department Experimental Forecasting) model based on an equation (the Commodity Price Exchange rate or CPE) that links the USD/CAD exchange rate to movements in commodity prices, nominal interest rate differential, and public debt to GDP ratios. Despite the fact that the Amano and van Norden model was perceived as an important innovation at the time, it has major downfalls. First, it implies a negative correlation between energy prices and the Canadian dollar. It is indeed hard to reconcile that implication with the fact that Canada has been a net energy exporter since at least the 1990s and continued to be even more so in the 2000s. Another downfall is its inability to explain the 40 percent appreciation of the Canadian dollar as compared to the American dollar between 2003 and 2007 (figure 2; note: exchange rate is defined as the number of US cents per Canadian dollar).

Figure 2)

Source: Helliwell, Issa, Lafrance, and Zhang (2005)

Actual vs. dynamic simulation (US cents)



* Estimated over 1975–99 period. Simulation begins in 1975.

Because of those inaccuracies, and in an attempt to improve its forecasting power, the CPE has been repetitively modified since its inception in 1993. Djoudad and Tessier (1999) introduced variables relating to budgetary conditions and productivity and found that the growing Canadian public indebtedness could explain up to 20 percent of the Canadian dollar's depreciation against the U.S. Dollar in the 1990s.

Helliwell et al. (2005) further improved the CPE by building the NEMO (Nominal Exchange rate MOdel). Its equation takes into consideration non-energy commodity prices, labour productivity differentials with the U.S., short term interest rate differential with the U.S., the value of the U.S Dollar compared to other currencies', and a measure of risk perception in international markets. Most notably, the model predicts a positive effect of higher commodity prices on the value of the Canadian dollar. It also indicates that it takes almost five years for the exchange rate to adjust to its fundamentals. Moreover, the model assigns a negative effect on the Canadian dollar when labour productivity in the manufacturing sector grows faster in Canada than in the U.S. The model results in a very good fit between the predicted and the actual evolution of the exchange rate (figure 3).

The very good fit leads the authors to argue that

The implication of our findings for monetary policy is that the monetary authorities in their deliberations should assume that the Canadian dollar reflects economic fundamentals, except in extraordinary circumstances when exchange markets are obviously disrupted.

Actual vs. dynamic simulation (US cents)

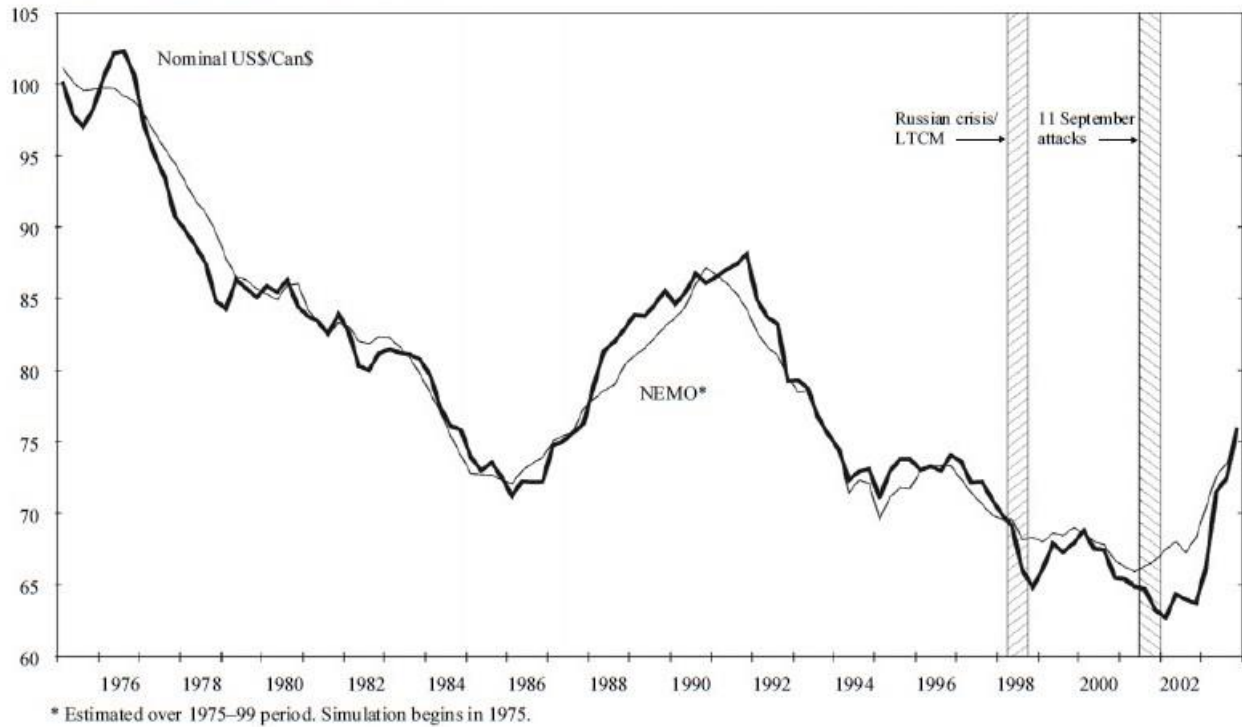


Figure 3)

Source: Helliwell, Issa, Lafrance, and Zhang (2005)

Issa et al. (2006) made a very important contribution to the understanding of the Canadian exchange rate's historical evolution. Using an equation that takes three variables into consideration (a commodity price index that excludes energy, an energy price index, and an interest rate differential between Canada and the U.S.), the authors found that the effect of higher energy prices on the Canadian dollar has been negative in the 1970s and 1980s, but became positive starting in the early 1990s. The reasoning behind that is that higher energy prices tend to have a negative effect on the global economy which, among other things, tends to decrease the demand for Canadian exports and consequently depreciates the currency. At the same time, higher energy prices, through the terms of trade, have an appreciating effect on the currency of energy exporters. It is worth noting that Canada has been a net energy exporter since the early 1970s (Issa et al., 2006). The authors estimate that the first effect dominated the second

throughout the 1970s and 1980s, but that the balance was inverted in the 1990s as Canadian exports of natural gas and oil increased. By running a regression over the whole 1973-2005 period, the authors find an insignificant R^2 of 0.026. Its value, however, rises to around 0.25 when the data is split between the pre and post 1993 period. The study attributes this variation to the change in the relationship's sign and approximates it to have happened in 1993. When the 1973-2005 period is studied, the model's coefficients cancel each other over time resulting in an apparently insignificant relationship.

Using different methodologies on a panel of currencies, Cayen et al. (2010) found that commodity prices and the U.S debt to GDP ratio explain between 36 and 96 percent of exchange rate variations. More precisely, the authors found that at least 30 percent of the Canadian dollar's appreciation *vis-à-vis* the American between 2002 and 2007 can be explained by rising commodity prices, while another 30 percent can be attributed to the depreciation of the American dollar.

Beine et al. (2012) used an innovative approach to disentangle the USD depreciation from the CAD appreciation that together led to the nearly 50 percent appreciation of the USD/CAD exchange rate between 2002 and 2007. They found that the appreciation of the exchange rate can be decomposed into a 42 percent appreciation of the Canadian dollar and a 58 percent depreciation of the American. The authors attributed the first component to the rise in commodity prices over the 2002-2007 period.

Studies in the literature challenging the status of the Canadian dollar as a commodity currency are somewhat hard to come by but not totally absent. Chen and Rogoff (2002), for instance, found mixed results for the effect of commodity prices on the Canadian dollar, and that at least in the short term. This contrasts with their findings about the Australian and New

Zealand dollars which they argue are strongly and stably influenced by movements in commodity prices. Similarly, Cashin et al. (2004) use data on the world prices of 44 commodities to assess which currencies of the 58 under investigation present evidence of a long-run relationship between national real exchange rate and real commodity prices. The study similarly finds that the Canadian dollar cannot be considered a commodity currency.

All in all, and despite the counter-indications mentioned above, there appears to be a clear consensus on the existence of a positive relationship between commodity prices and the Canadian dollar. In fact, it could even be argued that the Canadian currency has already become a petro-currency (Blecker & Seccareccia, 2014).

B) The Impacts of Speculation on the Canadian Dollar

As previously mentioned, neoclassical economists and Post Keynesians agree that the vast majority of capital flow is made for purely speculative motives. What they disagree on is whether or not this speculation results in long run effects on exchange rates, and whether or not there is an ensuing market inefficiency.

As an example of the neoclassical approach, Daw et al. (2000), after finding a significant relationship between commodity prices and the Canadian dollar, contend that fundamentals, rather than noise trades, are responsible for the behaviour of the exchange rate. Speculation, at worst, can lead to overshooting in the short term. This led them to conclude, in agreement with the Bank of Canada's position, that government intervention in the exchange rate market risks resulting in more harm than good.

Such a position is far from being uncontested, especially by the Post Keynesian school of thought. In her Master's thesis' concluding remarks, Ghasemi highlights (2012):

Taken all together, although energy price index seem to play an essential role nowadays in determining the movements of the Canadian exchange rate, it has to be noted that the correlation between energy prices and the movements of the Canadian dollar may actually be the result of the agent's perceptions of oil price changes rather than the actual energy prices themselves.

Leaving aside the academic literature, given the strength of the consensus on the relationship between the Canadian dollar and commodity prices, and the fact that widely trusted organizations like the Bank of Canada adhere to it, the Canadian currency seems a perfect target for speculation for the simple reason that changes in commodity and oil prices work as a predictor of the currency's future value. As speculators trade Canadian dollars according to movements in commodity prices, the relationship gains further strength and makes the loonie an even more attractive target for speculation. With that in mind, claims that speculation has only short term overshooting effects on the Canadian currency become doubtful. The empirical section of this paper will attempt to show that speculation has grown to have a significant impact on the Canadian dollar both in the short and long term. Before that, the next section will shed light on the 2014 oil price plunge which pushed the USD/CAD exchange rate to a ten-year high.

III/ The 2014 Oil Price Plunge and its Impacts on Canada

The price of the world's most traded commodity was halved during the second half of 2014. This represents one of the most consequential economic events since the 2007 financial crisis. Canada, which now ranks as the fourth largest oil producer in the world, was so harshly hit that fears of a new recession resurfaced after six years of recovery. This section will first analyse the excess supply argument as a potential explanation of the price fall. It will then briefly relate how Canada has been affected so far.

A/ "Sheiks vs. Shale": a Look at the Case of Excess Supply

Most academics, journalists, and economic analysts attributed the fall in prices to a global situation of excess supply coupled with a weak overall economic growth. In order to examine the accuracy of that supposition, it is useful to survey recent events that have the potential of either perturbing the supply or the demand side of the international oil market.

"The supply shock created by a surge in North American oil production will be as transformative to the market over the next five years as was the rise of Chinese demand over the last fifteen." International Energy Agency, 2013

U.S. oil production witnessed indeed a massive upsurge since 2007. The U.S. produced less than 8 percent of the world's crude oil in 2008. By 2014, it produced around 12 percent (EIA, 2014). In terms of volume, total American oil production increased by nearly 88 percent in only six years. Behind this revolution is what the World Energy Council calls "tight oil". This unconventional form of oil now represents nearly half of U.S. total production (EIA, 2014).

It should be noted that the current burgeoning state of American production significantly contrasts with the humble beginnings of the tight oil enterprise. Until 2011, tight oil's resource potential was practically absent from both the U.S. and international oil map. Technological improvements in hydraulic fracturing and increased drilling efficiency then completely changed the story. By the end of 2011, the volume and profitability of tight oil production reached totally unexpected levels. Massive investments boosted drilling intensity and allowed oil production from tight oil formations to be multiplied by a staggering sevenfold since 2008.

The surge in American output substantially altered the international oil trade map. Figures from the International Energy Agency show an unequivocal American ambition to lower reliance on oil imports in general, and on non-North-American imports in particular. In fact, US imports of crude oil and petroleum products as a share of U.S. consumption went from 66 percent in 2008 to 48 percent in 2014 while non-Canadian imports as a share of US consumption went from 54 percent to 31 percent over the same period. Moreover, total American imports of crude oil and petroleum products decreased by 33% from 2006 to 2014 while non-Canadian imports decreased by an astounding 49% over that period (EIA).

Both the importance of the American tight oil revolution and the desire to decrease U.S. reliance on imports are undeniable. Given the scale and the speed of the change and the fact that the U.S. has been by far the world's top net importer for the past forty years, the argument that excess supply is behind the 2014 oil price plunge seems plausible. In order to make a final statement on the validity of the argument, one needs to look at the recent evolution of non-American oil supply as well as that of global demand.

“This near-40% plunge is thanks partly to the sluggish world economy, which is consuming less oil than markets had anticipated, and partly to OPEC itself, which has produced more than markets expected.” The Economist, December 6th, 2014

The truthfulness of the above statement, which reflects the position of many economic analysts, depends on what is meant by the ambiguous term of “market expectations”. Keeping our focus on real figures, one can say that OPEC production decreased by 3 percent in 2013 compared to 2012. Furthermore, OPEC member states kept a relatively constant supply since at least 2008 while total non-American production has been more or less constant since 2005 (EIA). OPEC’s production continued falling in the first two quarters of 2014. Compared to 2013 levels, it decreased by 2 percent in the first quarter and then by another 1 percent in the second one (OPEC, 2014). Finally, and most importantly, world oil consumption exceeded production in two of the three years between 2011 and 2013 (as prices averaged two times current ones).

It seems that real demand and supply mechanisms do not so indisputably point the finger to a global situation of excess supply, let alone one capable of explaining a halving of oil prices in the course of four months that now already spanned over more than a year. A more plausible scenario than real excess supply would be that, as North American production continued to increase in 2014, the *fear* or the *expectation* of excess supply in the forthcoming horizon greatly amplified, or even triggered, a panic among investors which resulted in a substantial downward pressure on oil prices.

B/ Impacts and Implications on Canada

In an interview on CNBC, Harold Hamm, CEO of one of the largest tight oil producers, stated that American production already peaked and that it is going to decline by more than 20 percent by the end of the year because of low oil prices (Anan, 2015).

If vulnerability to price dips describes American unconventional oil production then extreme vulnerability characterises Canadian production. Several oil sands projects have a breakeven of more than \$90 per barrel (Maugeri, 2013). It should also be noted that Canada sells as much as 95 percent of its production to the United States at a price discount averaging 15 to 20 American dollars. Due to the low supply elasticity, production cannot but continue in the short to medium term even if prices do not cover costs.

According to the Conference Board of Canada, the federal and provincial governments are on a path of losing a combined \$14 billion in revenue (The Globe and Mail, 2015). CIBC Economics forecasted Alberta to sink into recession in 2015 with a GDP declining by 0.3 percent compared to a 4.1 growth in 2014.

Aside from all the ripple effects associated with the worsening situation, the 2014 oil price plunge provided further evidence as to the degree to which the Canadian currency has grown to depend on oil prices. In fact, as oil prices were around \$100 a barrel, the American and Canadian dollar were relatively on par. The loonie started depreciating as oil prices neared an eleven years low. In turn, the USD/CAD exchange rate reached an 11 years high in September of 2015 (figure 4).

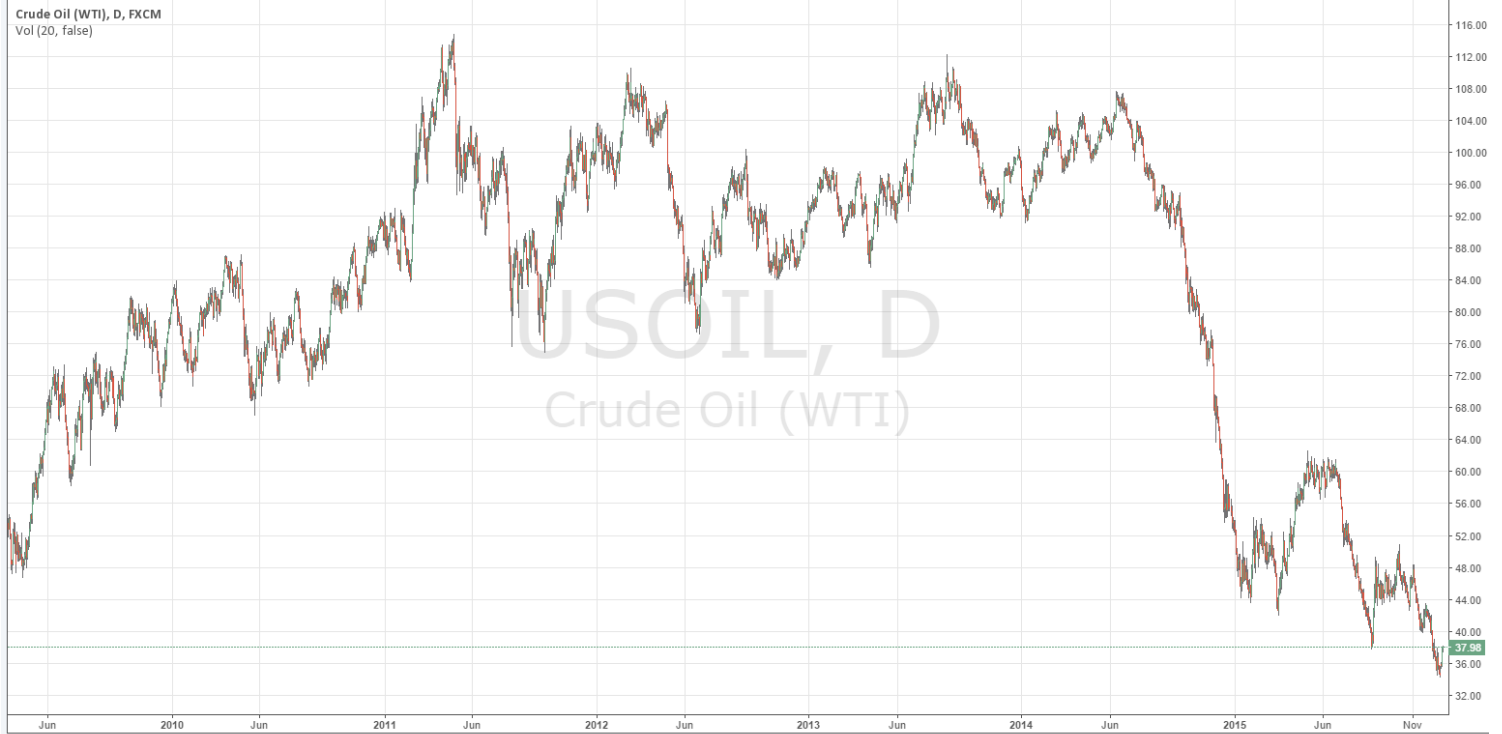
Published on TradingView.com, December 24, 2015 15:08 EST

FX:USDCAD, D 1.38461 ▲ +0.00029 (+0.02%) O:1.38432 H:1.38742 L:1.38173 C:1.38461



Published on TradingView.com, December 24, 2015 15:09 EST

FX:USOIL, D 37.98 ▲ +0.13 (+0.34%) O:37.85 H:38.15 L:37.36 C:37.98



Source: Dailyfx.com

Figure 4) Evolution of the USD/CAD exchange rate and WTI oil prices between June, 2010 and December, 2015

IV) Empirical Exercise

This empirical exercise aims to innovatively add to the understanding of the relationship between commodity prices and the Canadian dollar. Aside from correlation testing, it also aims to have a say on the contribution of speculation. Because oil is, as well as seen as, the most important component of Canadian commodity exports, this exercise will settle for studying the link between the Canadian dollar and crude oil prices.

A) Problems Associated with Correlation Analysis

Aside from the difficulties in assessing the impact of speculation on exchange rate movements, empirically testing for the correlation between a given currency and oil prices presents at least two major challenges.

1) Accounting for Changes in the Value of the Reference Currency

An increase in the value of the USD/CAD exchange rate, for instance, can result from any of the following four scenarios:

- A USD appreciation coupled with a CAD depreciation.
- A USD appreciation coupled with a CAD stagnation.
- A USD depreciation coupled with a more pronounced CAD depreciation.
- A USD appreciation coupled with a less pronounced CAD appreciation.

In other words, the same movement can either mean that the currency under study gained, lost, or stagnated in value. This obviously makes any analysis that does not take changes in the value of the reference currency (the USD in this case) extremely biased and even useless. The major

difficulty consists in finding a way to measure the evolution of the American dollar's "worth" or "value".

In an attempt to deal with the problem, studies of commodity currencies have generally incorporated a variable that captures the value of the USD, as compared to a basket of currencies, into their model. This approach, however, does not come without shortcomings. Should a USD index be used? If yes, then which currencies should be included in it and what weights should be assigned to each? New indexes are popping up every year: some are based on historical trade shares with the U.S. (the U.S. Dollar Index), some are based on current trade shares with the U.S (the Trade Based U.S. Dollar Index), others use an equal weighting of a set of currencies (the Dow Jones FXCM Dollar Index), while still others use international trade data (the Wall Street Journal Dollar Index).

Rather than using an index as a proxy for the value of a currency, Beine et al. (2012) use what they refer to as a "currency component". Their approach is independent of any weighting scheme and other sources of subjectivity and bias. The methodology consists in taking the movement of a number of exchange rates against a common currency over a day and from there assessing the evolution of the common currency's value. For instance, if the common currency depreciates against all others, its value is deemed to have decreased over the day. In spite of the fact that the "currency component" approach solves the problem of the subjectivity and potential bias associated with weight distribution, it is a technically challenging approach that adds unnecessary complexity for the purpose of this paper.

B) The Suggested Approach

In her Master's thesis on the impact of commodity prices on the Canadian dollar, Ghasemi (2012) writes:

Unfortunately, the exchange rate equation could not be estimated on a daily basis since, with the possible exception of oil prices internationally, such data is non-existent. Although the time scale of the observations may be considered a hindrance, especially when using lagged values, the limited available evidence does raise some questions about the robustness of the Bank of Canada exchange rate equation.

Such a concern seems perfectly rational and legitimate. In fact, the lower the data frequency, the more limited a study's ability to assess the sensitivity of an action-reaction sequence.

With the degree of sophistication of the foreign exchange market, one would expect a reaction to any shock to happen over the course of a much shorter period than a quarter. The major contribution of the current paper consists in using micro data. Rather than using an observation every quarter, as most studies on the subject do, this empirical investigation uses, not daily data as Ghasemi (2012) wished, but per second data.

It is worth noting that the exercise's aim is not to quantify the degree to which the Canadian currency is a function of oil prices. As previously mentioned, the accuracy of any quantification efforts is faced with the challenging task of measuring the evolution of the reference currency's value. In spite of the fact that quantification cannot but be useful for understanding economic events, this paper leans on the side of precaution and settles for determining whether the Canadian currency is more sensitive to oil prices than other currencies, and if so, the degree to which the sensitivity is instantaneous versus delayed.

To do so, the analysis will be based on the simple linear regression of the first difference of six exchange rates (USD/CAD, EUR/USD, USD/JPY, GBP/USD, USD/NZD, and USD/AUD) on the first difference of oil prices (represented by Western Texas Intermediate (WTI) prices). The exchange rates were chosen so as to show a reduction in value when the American Dollar depreciates (see page 13 for a general definition of exchange rates). Comparing the responsiveness of the Canadian dollar to changes in oil prices to that of five different currencies rids the analysis of the bothersome task of incorporating a measure of the American currency's value in the regression. In fact, changes in the USD will simultaneously and similarly affect the six exchange rates. Consequently, responsiveness differences can solely be attributed to the degree to which each currency is dependent on oil prices.

Rolling regressions will be used to better take relationship variations over time in consideration. Daily, hourly, minutely, and per second data will in turn be analysed and interpreted to assess each currency's responsiveness to oil prices.

For the daily, hourly, and minutely analysis, the following simple linear equation will be used:

$$\Delta X_t = \Delta WTI_t + \text{error}_t$$

With $X \in \{ \text{USD/CAD, EUR/USD, USD/JPY, GBP/USD, USD/NZD, and USD/AUD} \}$, and WTI_t the price of oil at time t quoted in American Dollars. First-difference data is used because it is found to be stationary for all time frequencies and all seven variables (Appendix 2). In the data analysis section, t_dWTI stands for the t value of the coefficient associated with the first-difference of the independent variable ($dWTI$). The periods under investigation were determined by the available data at the time of writing.

It should be noted that the relatively high R^2 and t values in all regressions ought to be explained by the fact that, everything else constant, an increase in the value of the USD automatically leads to a fall in oil prices and a depreciation of the six exchange rates. These last two events happen simultaneously as they are two faces of the same coin. That, in the case of commodity exporting countries (Canada, New Zealand, and Australia), exacerbates the already negative correlation between exchange rates and commodity prices. Conversely, for commodity importing countries (Japan, Great Britain, and EU), the negative correlation is partly or fully cancelled by the direct effect of commodity prices on exchange rates.

C) Data Analysis

1) Daily Data

The daily data analysis covers the period between December 13th, 2007 and October 26th, 2015 (a total of 1975 observations). Each regression uses 250 successive observations for a total of 1726 regressions run for each of the six exchange rates. The results are summarized in figures 5 to 7. Given the fact that the regressions do not use lagged values but still suggest a superior CAD responsiveness to oil prices as compared to the five other currencies, one can gather that the Canadian dollar responds to oil prices within the day. Hourly data will now be analysed to have a closer look at the relationship.

Cumulative R2 Distribution of Daily Rolling Regressions

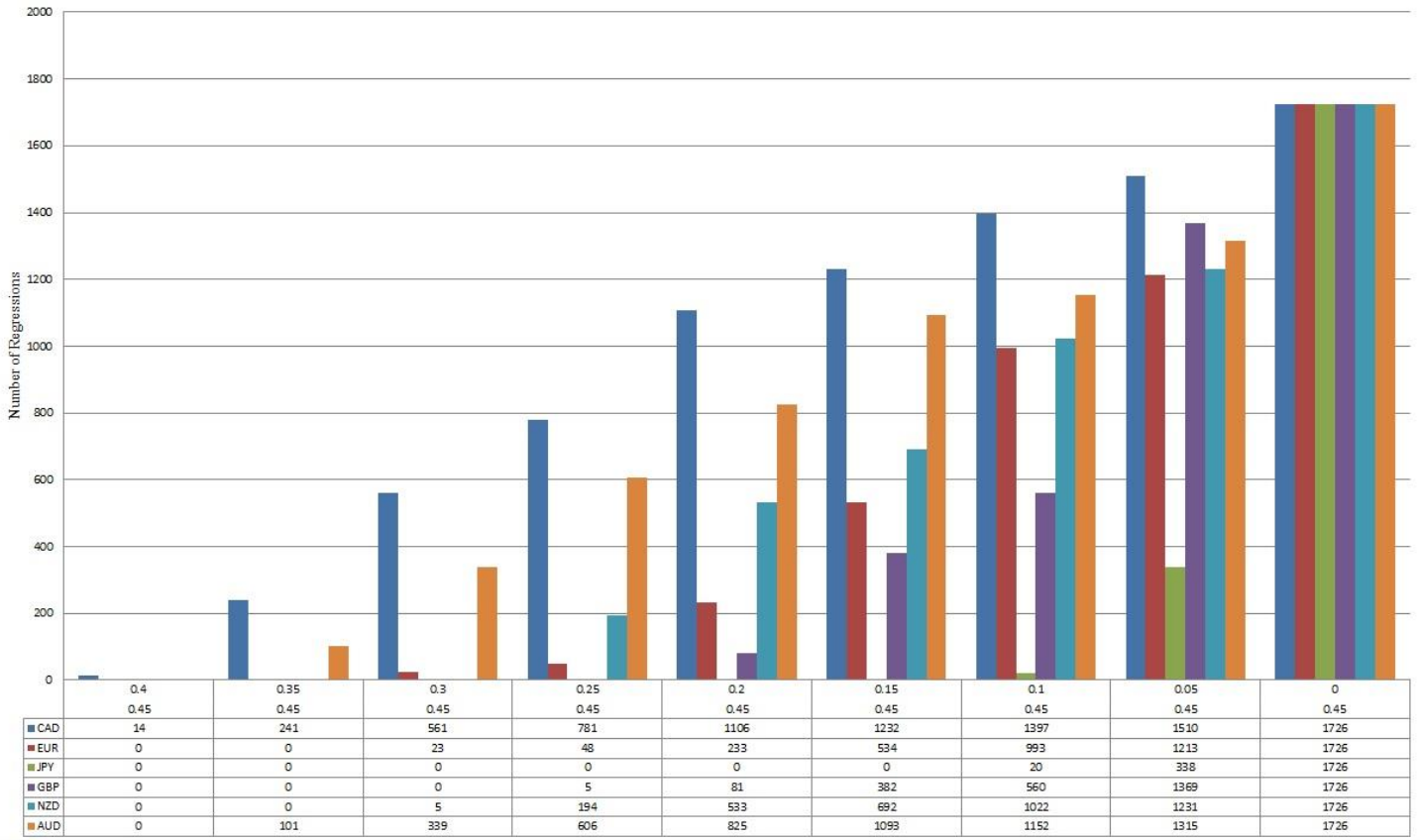


Figure 5)

Median R2 Scores of Daily Rolling Regressions

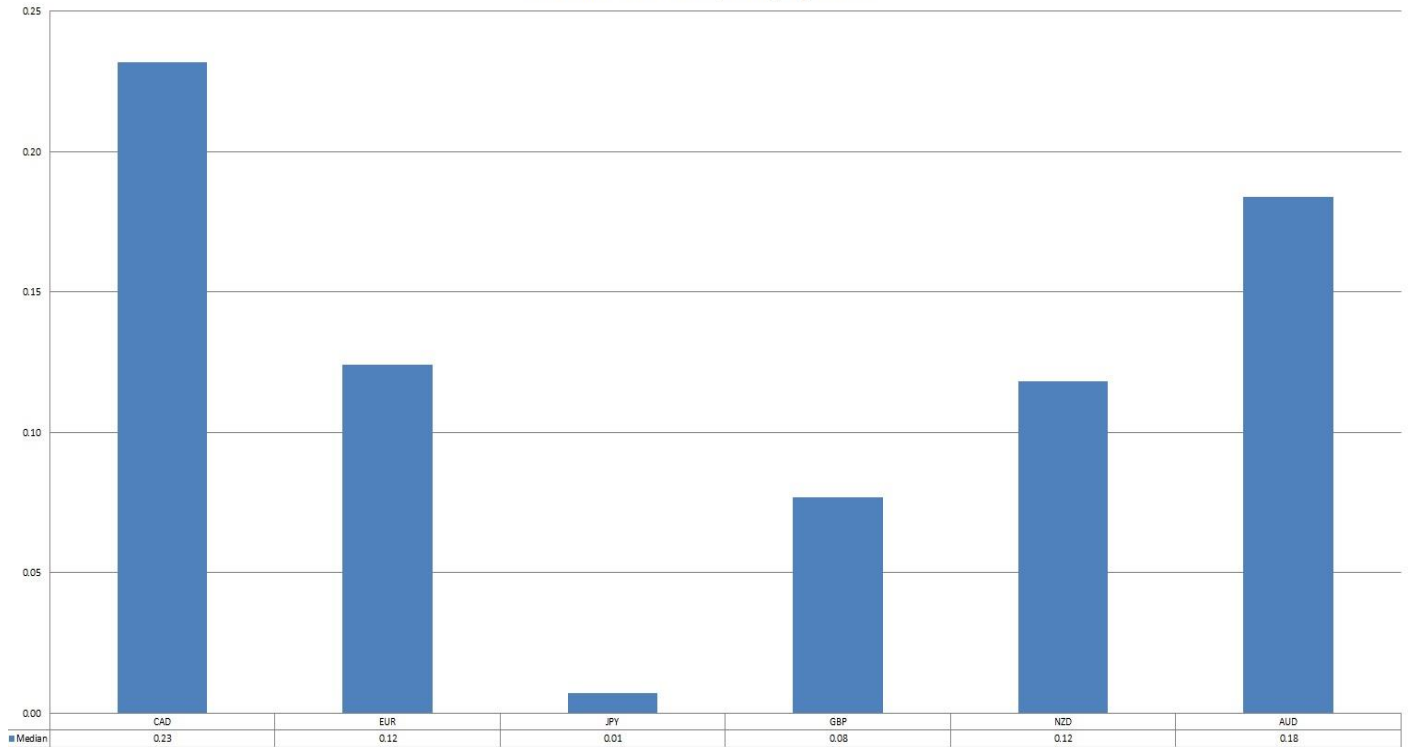


Figure 6)

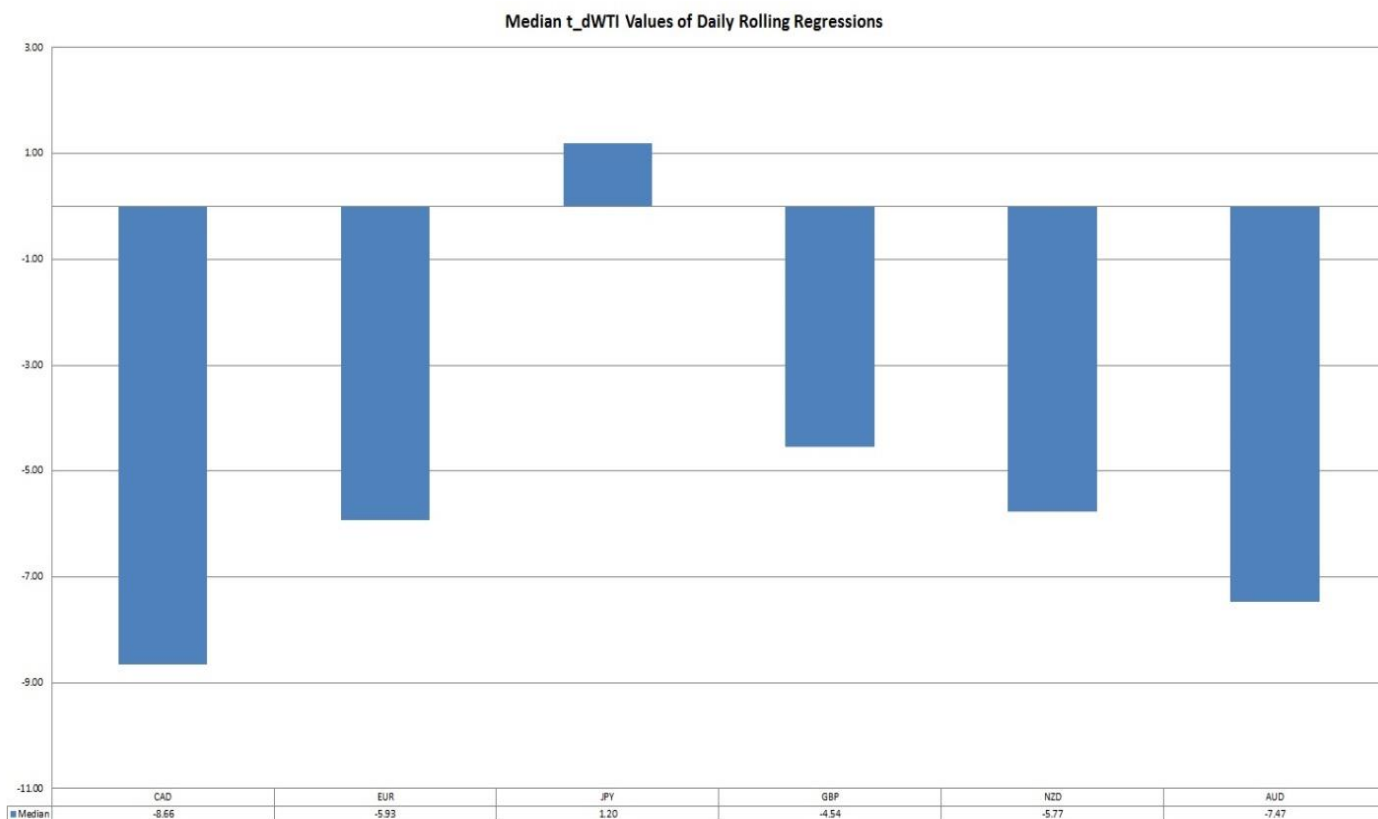


Figure 7)

2) Hourly Data

The hourly data analysis covers the period between July the 3rd, 2015 and November the 16th, 2015 (a total of 2308 observations). Each regression uses 525 successive observations for a total of 1784 regressions run for each of the six exchange rates. The results are summarized in figures 8 to 10.

As for the case of daily data, hourly data also show a superior CAD correlation with oil prices as compared to the five other currencies. In fact, the superiority seems to be even more pronounced. Given that both the exchange rate's value and oil prices were taken at the exact same point in time, the results suggest that the responsiveness happens over a still shorter period of time than an hour.

Cumulative R2 Distribution of Hourly Rolling Regressions

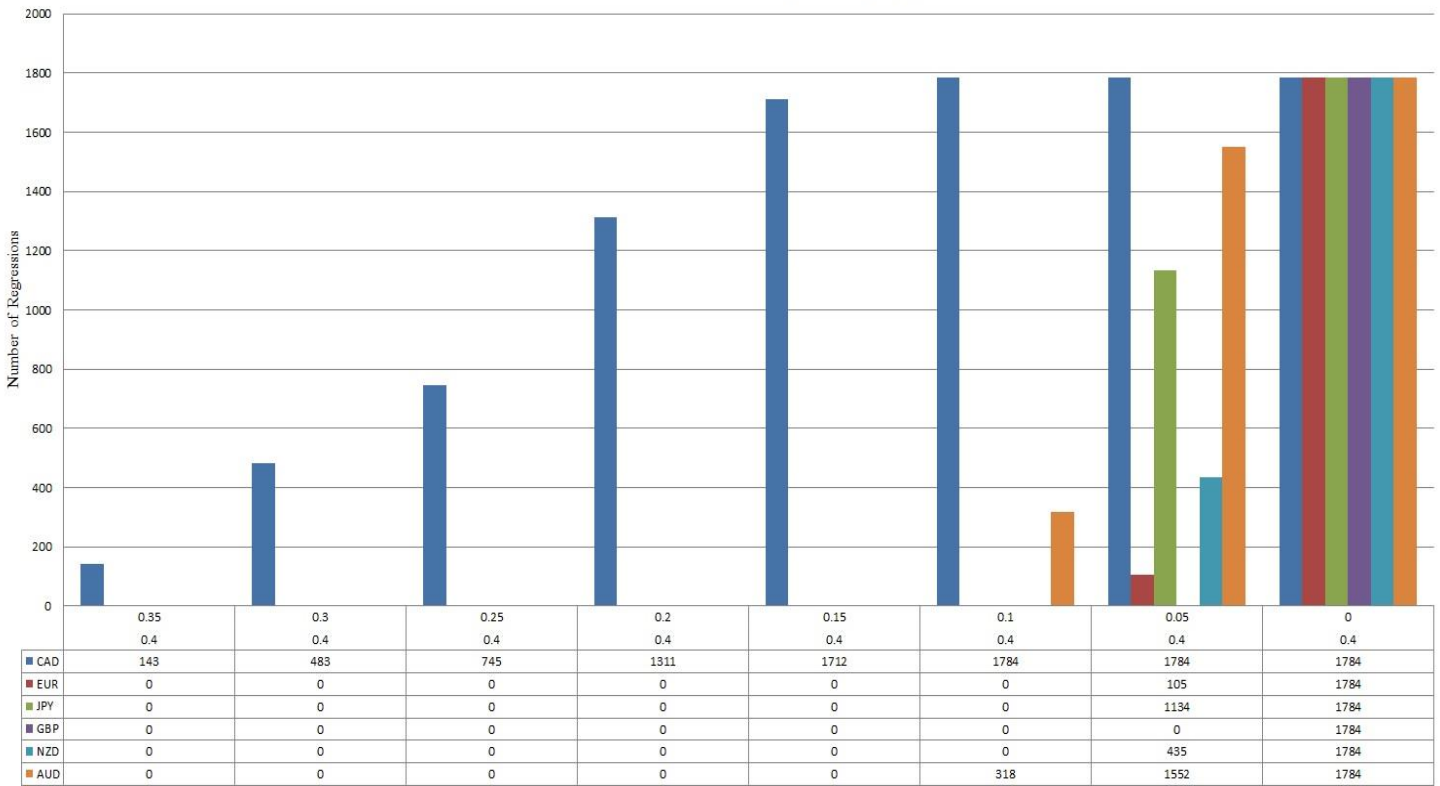


Figure 8)

Median R2 Scores of Hourly Rolling Regressions

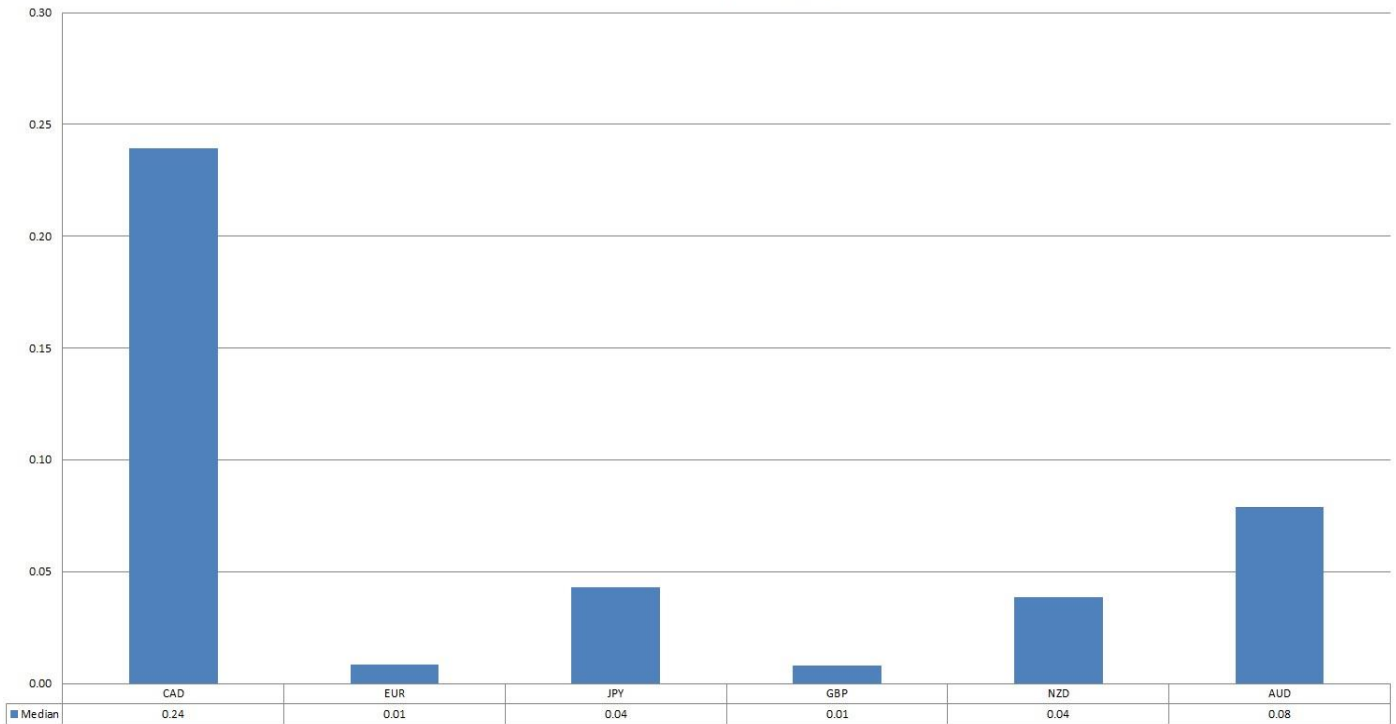


Figure 9)

Median t_{dWTI} Values of Hourly Rolling Regressions

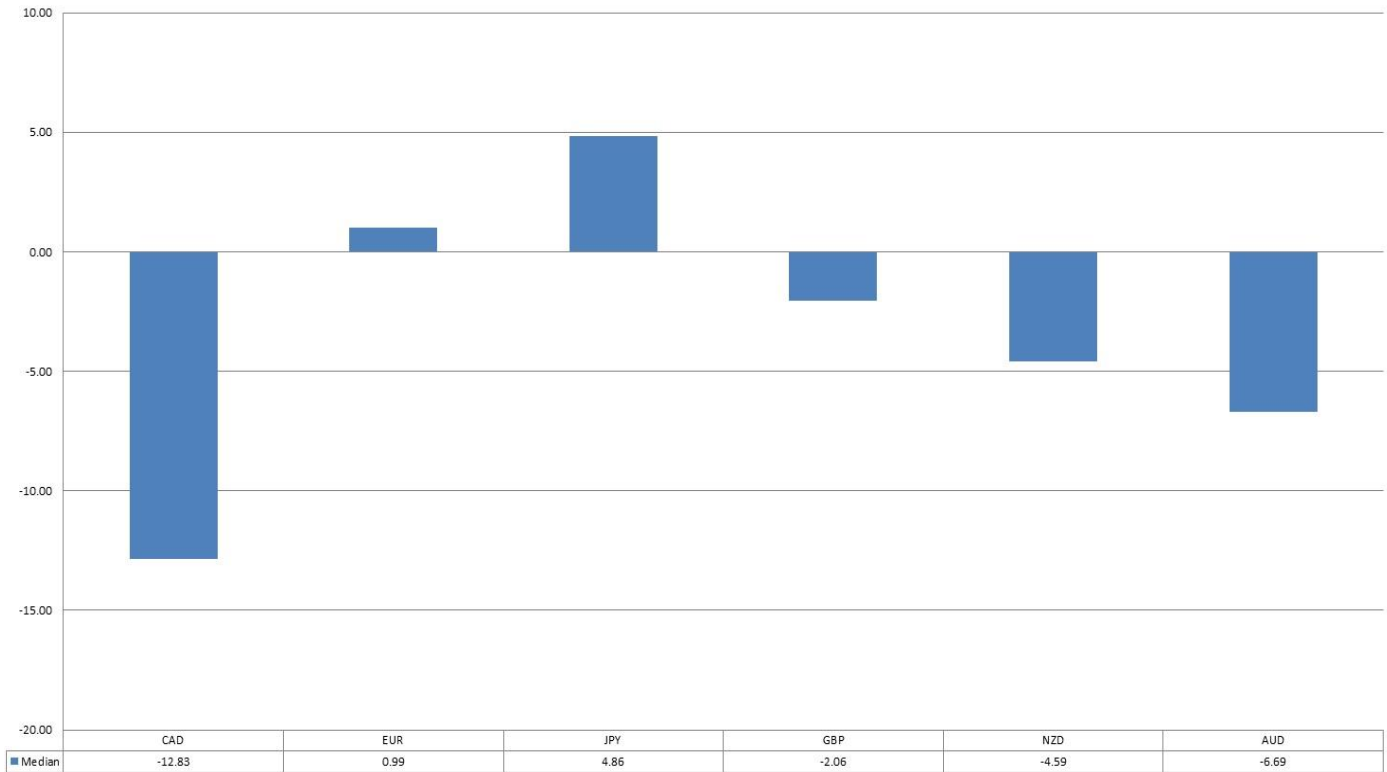


Figure 10)

3) Minutely Data

The minutely data analysis covers the period between October 29th and November 13th, 2015 (a total of 16,441 observations). Each regression uses 1,440 successive observations for a total of 15,001 regressions run for each of the six exchange rates. The results are summarized in figures 11 to 13.

The results suggest that even minutely data of regressions not using lagged values show a clear superiority of CAD correlation with oil prices as compared to the five other currencies. In fact, nearly 80 percent of the regressions using the CAD give an R score which is superior to 0.15 as compared to an average of 0 percent for the other currencies. These results imply that the sensitivity between the Canadian dollar and oil prices happens within the seconds of each minute. The highest available frequency data then needs to be analysed: per second data.

Cumulative R2 Distribution of Minutely Rolling Regressions

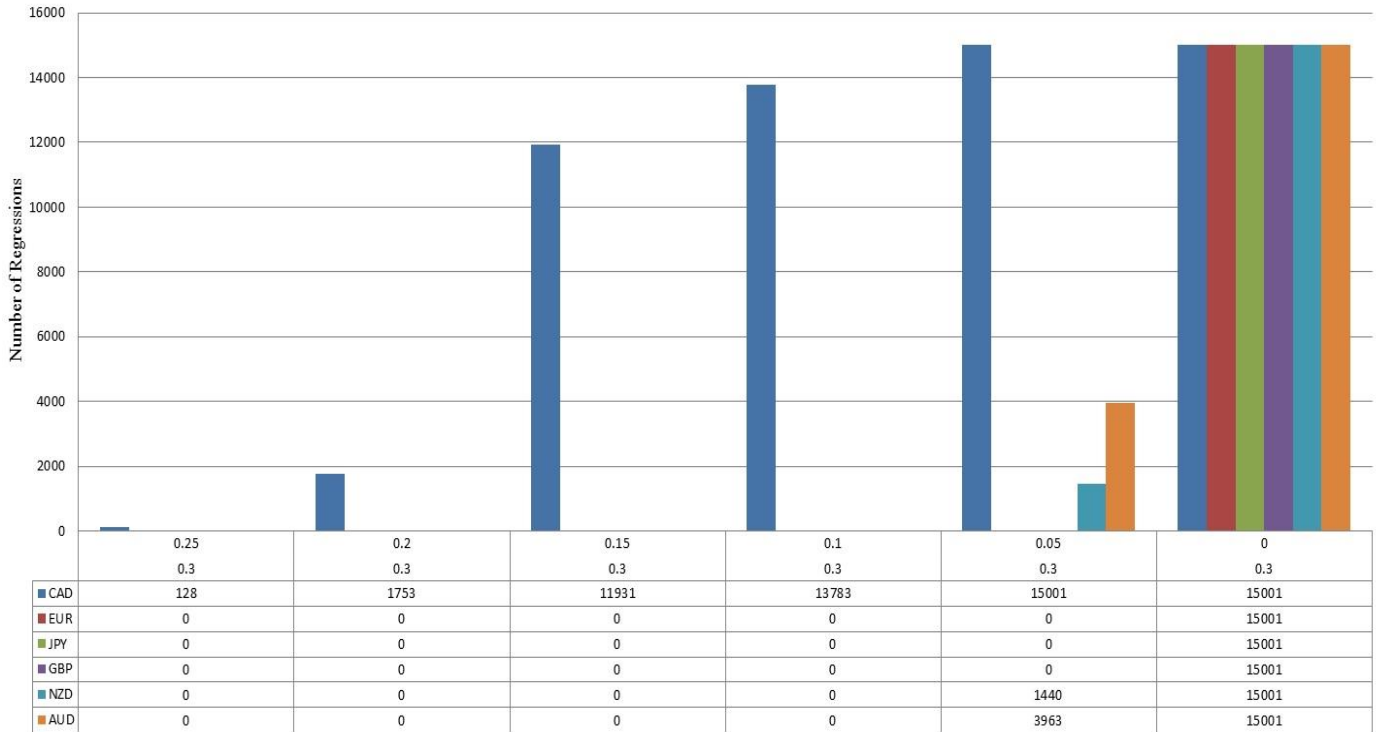


Figure 11)

Median R2 Scores of Minutely Rolling Regressions

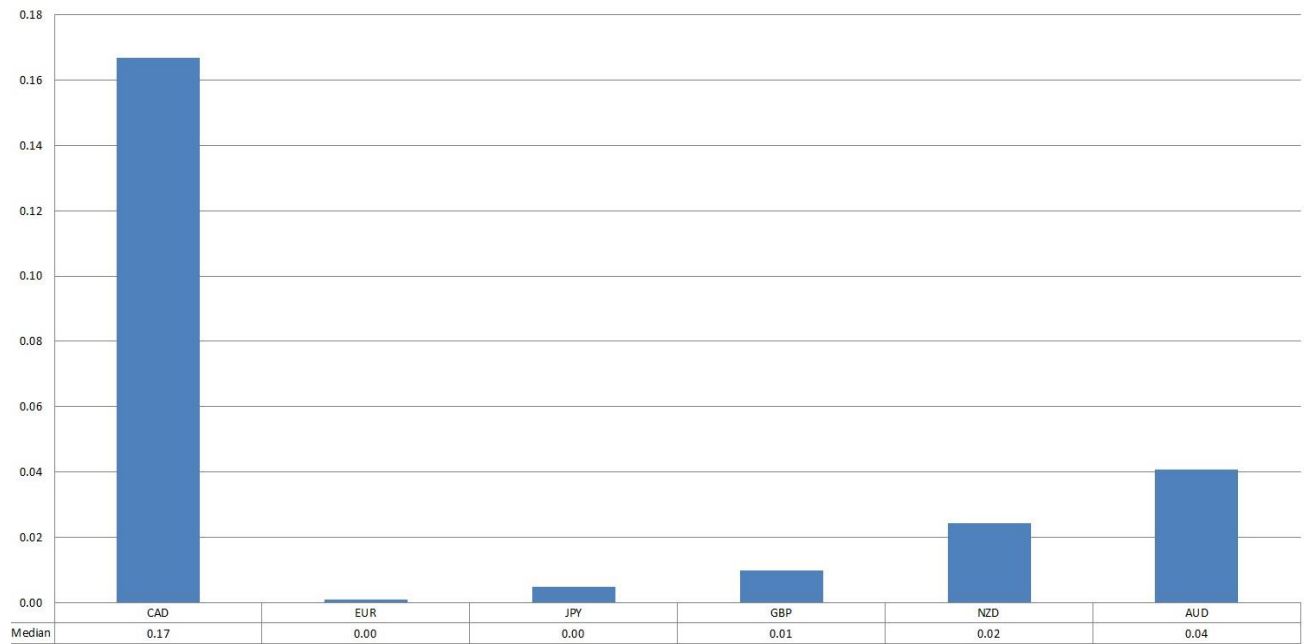


Figure 12)

Median t_dWTI Values of Minutely Rolling Regressions

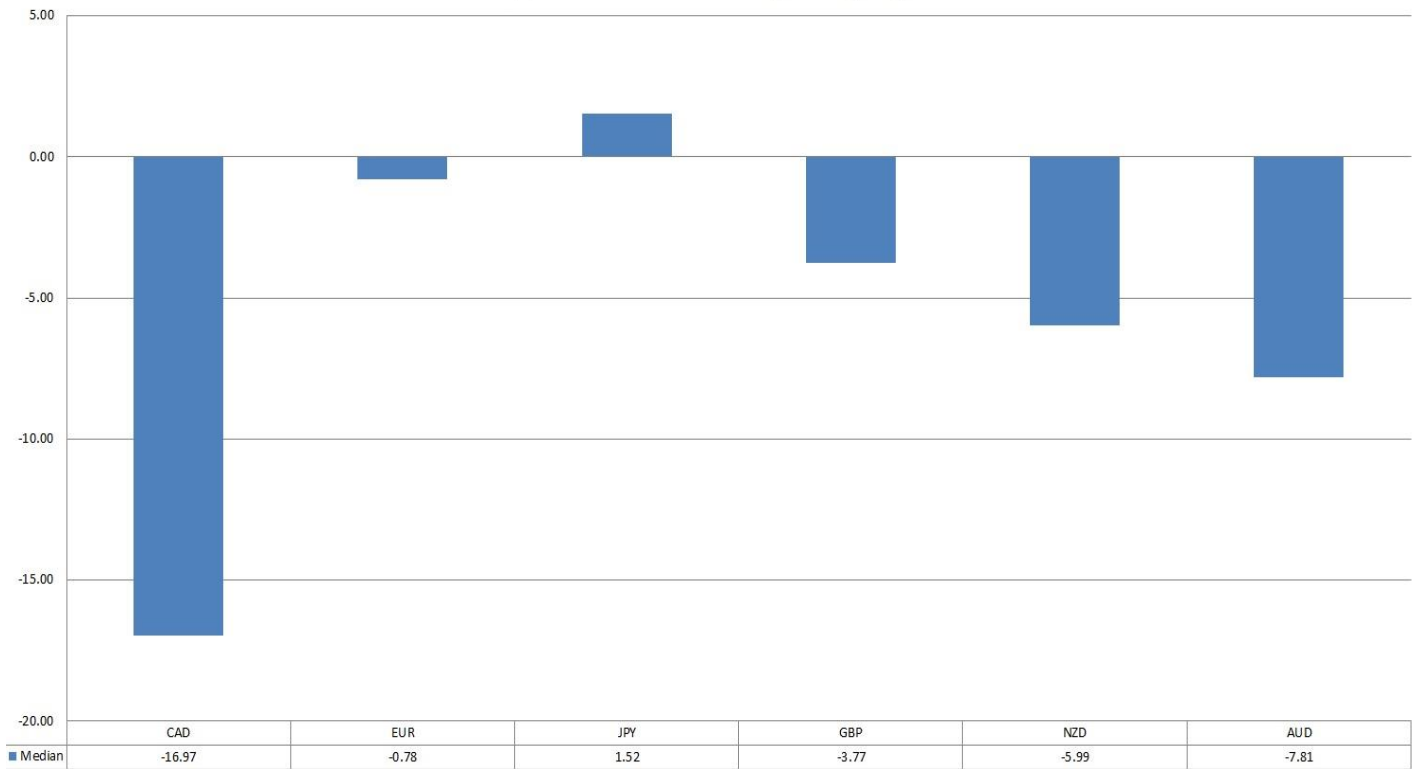


Figure 13)

4) Per Second Data

The per second data analysis covers the period between October 19th and 30th, 2015.

Six lags of the independent variable will be used such that the model's equation is:

$$\Delta \text{USD/CAD}_t = \text{USD/CAD}_t - \text{USD/CAD}_{t-1} = \sum x(\text{WTI}_{t-i} - \text{WTI}_{t-1-i}) + \text{error}$$

With $i \in \{0, 1, 2, 3, 4, 5, 6\}$ and $x \in \{a, b, c, d, e, f, g\}$

The table in figure 14 summarizes the results of 10 regressions each of which covering the six busiest hours of the 10 business days between October 19th and 30th, 2015.

	T Values of Coefficients							
	DifWTI	L1.DifWTI	L2.DifWTI	L3.DifWTI	L4.DifWTI	L5.DifWTI	L6.DifWTI	R ²
October 19th	-13.34	-21.68	-9.77	-5.56	-1.43	1.00	-0.09	0.0515
October 20th	-14.62	-24.20	-6.99	0.07	0.07	-0.96	-0.81	0.0493
October 21st	-14.15	-25.96	-4.64	-0.39	-0.12	-1.09	-0.27	0.0562
October 22nd	-18.38	-32.09	-6.30	-3.50	-0.56	0.25	1.61	0.0726
October 23rd	-16.41	-32.56	-10.18	-4.24	-1.27	-0.13	1.07	0.0712
October 26th	-16.64	-31.93	-9.92	-3.54	-2.11	0.32	0.30	0.0792
October 27th	-13.78	-26.11	-9.19	-3.39	1.61	1.22	-0.30	0.0551
October 28th	-17.16	-35.68	-8.73	-1.97	-1.57	-0.58	-2.21	0.0985
October 29th	-18.12	-40.89	-11.78	-4.85	-1.32	-1.42	-0.57	0.1083
October 30th	-17.04	-28.87	-7.92	-1.43	0.07	-0.29	2.84	0.0657
10 Days Average	-15.96	-30.00	-8.54	-2.88	-0.66	-0.17	0.16	0.0708

Figure 14)

As the table shows, the non-lagged regressor and the first two lagged ones have, in all ten regressions, very significant negative coefficients with the most significant being that of the first lag. By the 4th lag, the coefficient becomes completely insignificant. It should be noted that the R² values present a rather biased measure of the overall relationship's strength due to the absence of a measure of the American dollar's value.

The superior responsiveness of the Canadian dollar to changes in oil prices as compared to the five other currencies then stems from an action-reaction sequence that happens over the course of 2 to 3 seconds. It is safe to say that the Canadian currency reacts almost instantaneously to oil prices.

Such sensitivity cannot in any way be explained by real oil trade. In fact, according to the National Energy Board, Canadian crude oil and bitumen exports amounted to 18 billion dollars between January and May 2015. Assuming daily trade happens over 8 hours, and a constant flow, the figure amounts to approximately 6,000 Canadian dollars per second. If oil prices rise from \$40 to \$50 in a second (in reality prices change by, at most, 10 cents in a second), Canadian revenues increase by less than \$1,500. It is clearly irrational to believe that such a change would have any effect whatsoever on the demand for, and hence the value of the Canadian dollar.

It is also clear that such a behavioural pattern cannot be achieved by human beings. It would take much more than 3 seconds for a person to notice the new WTI quote, compare it to the preceding one, and make a buy or sell order accordingly.

The pattern suggests that computers buy or sell Canadian dollars every second based on the movement of oil prices. In case prices fall, even by 1 cent, they position themselves on the side of the American dollar expecting, and thus causing, a CAD depreciation. The inverse is true if prices rise. As more and more capital moves according to those rules, the relationship gains further strength.

The faster one gains access to the new oil price and the lower the transaction costs, the more the potential gains. Fortunately, or unfortunately, an average person using commonly available trading software cannot make any gains. The reason is that trading software work as an intermediary between banking institutions and traders. In addition to the premium that goes to the platform, passing by a third party slows down the trading process and makes it completely unprofitable. By the time the average trader's computer gains access to the new oil quote, the USD/CAD exchange rate will have already adjusted.

That said, and given the fact that the regressions have very significant first and second lag coefficients, one can gather that some parties are in a privileged enough position to make profits by simply putting in place an automated trading program. Using the available per second data, and assuming no transaction costs, I estimate that returns of around 1.43 percent can be made in only six hours by simply buying Canadian dollars when the price of oil increases and selling them when it decreases.

To relax the zero transaction costs assumption, the table in figure 15 shows the returns on investment for different transaction costs. 1 year Returns on Investment (ROI_y) were calculated by compounding the returns over 6 hours (ROI_{6h}) such that $(1 + ROI_{6h})^{2*260} - 1 = ROI_y$. Foreign exchange markets are, on average, open 260 days a year. I chose to multiply that by 2 rather than 4 because I used the six busiest hours in the day to calculate ROI_{6h}. Unfortunately, the processing capacity of my computer did not allow me to go through all the necessary steps to estimate the returns over a full day.

Cost per Transaction (in USD)	ROI _y
0	155073%
0.005	57739%
0.01	21418%
0.015	7891%
0.02	2862%
0.025	996%
0.03	305%
0.031	231%
0.032	171%
0.033	122%
0.034	82%
0.035	49%
0.036	22%
0.037	0%

Figure 15)

Knowing the real figure of major banking institutions remains a mystery. What one can say with certainty is that it is less than \$0.037 U.S. By comparison, the same transaction would have cost me, or the average trader, around \$0.70.

Maier and DeProtto (2008) find that the Canadian dollar grew over time to react more quickly to both energy and non-energy price changes. The empirical section of this paper suggests that it has grown to react to oil prices at such a speed that only an automated and highly sophisticated system can achieve. In a way, the evolution of the Canadian currency is, at least partly, programmed to respond to changes in financial factors like oil prices in a given and predetermined way.

As more capital moves according to the mentioned rules, the Canadian dollar becomes increasingly sensitive to oil prices regardless of how much Canadian oil is actually being produced. Real economic happenings only seem to be secondary. More than anything else, the long term correlation between the Canadian dollar and oil prices will depend on the weight and the number of players playing the game. The most frightening part of all is that it is a winning game that has no referee.

Concluding Remarks

The paper started by presenting neoclassical exchange rate determination models. The research consensus seems to point to a failure of those models in explaining, let alone forecasting, exchange rate movements. The Post Keynesian approach appears to be more promising. More research is, however, needed to prove its superiority.

After making the case for a consensus on the positive relationship between the Canadian dollar and commodity prices, the paper turned to the last major event in the history of the loonie: its 30 percent depreciation as a result of the 2014 halving of oil prices. The paper attempted to show that, in spite of the massive increase in North American production in recent years, real economic events cannot possibly explain the speed and magnitude of the price fall. There seems to be a clear fingerprint of the power of expectations and speculation.

The paper ended by empirically showing that the Canadian dollar has evolved to adjust to new oil prices in a matter of two to three seconds and that such a pattern cannot be explained by actual oil trade, but by a speculative and automated decision making process. In a way, the Canadian dollar continuously adjusts to the slightest change in oil prices as if the last oil quote will remain unchanged in the long term. The musical chairs nature of the financial market does not allow to “wait and see”.

At any point in time, the short term is nothing more than a guess of how the long term ought to be. One wonders on what basis such a guess is made given that economic variables are never allowed to freely interact between each other. The term “guess” or “expectation” may even be inappropriate in the current context. In fact, in the case of the Canadian dollar for instance, the sensitivity is primarily based on the weight and number of players trading Canadian dollars

according to movements in oil prices. The more dollars are sold when prices fall, the more significant the ensuing depreciation, the more the potential gains. Never has economics been less scientific, and never have we been more at the mercy of speculators.

Bibliography

- Aba, S. And Laidler, D. (2001) “The Canadian Dollar: Still a Commodity Currency.”
Backgrounder (C.D. Howe Institute), January 11.
- Anan, Ritesh. "Continental Resources CEO: U.S. Oil Production Will Stoop To 700,000 Barrels In A Year - Continental Resources, Inc. (NYSE:CLR)." *Benzinga*. 22 Apr. 2015.
- Balassa, B. (1964) “The Purchasing Power Parity Doctrine: A Reappraisal” *Journal of Political Economy*, 72, pp. 584-96.
- Berman, Arthur. "U.S. Shale Boom May Come To Abrupt End." *OilPrice.com*. 26 Jan. 2015.
- Blecker, R. A. and Seccareccia, M. (2014) “Would a North American monetary union protect Canada and Mexico against the ravages of ‘Dutch disease’? A Post-Financial Crisis Perspective”, *Banking, Monetary Policy and Political Economy of Financial Regulation, Essays in the Tradition of Jane D’Arista*, ed. by G. Epstein, T. Schlesinger, and M. Vernengo, Cheltenham, U.K.: Edward Elgar, 2014, pp. 171-202.
- Branson, W. and Henderson D. (1985) “The Specification and Influence of Asset Markets.” *Handbook of International Economics*, Vol. 2, 750–805, edited by R. Jones and P. Kenen. Amsterdam: North-Holland.
- Brian, D, and Maier, P (2008) “The Canadian Dollar and Commodity Prices: Has the Relationship Changed over Time?”, Bank of Canada Discussion Paper
- Cashin, P., Céspedes, L. F. and Sahay, R. (2004) “Commodity Currencies and the Real Exchange Rate,” *Journal of Developmental Economics*, Vol. 75: pp. 239-268.
- Cayen, JP, Coletti, D, Lalonde, R, and Maier, P (2010) “What Drives Exchange Rates? New Evidence from a Panel of U.S. Dollar Bilateral Exchange Rates”, Bank of Canada Working Paper

- Chinn, M. (1999) "Productivity, Government Spending and the Real Exchange Rate: Evidence for 109 OECD Countries," *Equilibrium Exchange Rates*, edited by R. MacDonald and J. Stein. Boston: Kluwer Academic Publishers.
- Corden, W.M. (1981) "The Exchange Rate, Monetary Policy and North Sea Oil: The Economic Theory of the Squeeze on Tradeables" *Oxford Economic Papers*, New Series, vol. 33, July, pp. 23-46.
- Curry, B., & McCarthy, S. (2015, January 20). Oil slide to shave billions off federal and provincial government revenue.
- Davidson, P. (2008, July 30). Crude Oil Prices: "Market Fundamentals" or Speculation? Challenge
- Djoudad, R. and Tessier, D. (1999) "Quelques resultants empiriques relatifs à l'évolution du taux de change Canada/États-Unis," Paper presented at the Canadian Economics Association meetings, Toronto, 28–30 May.
- Djoudad, R., Murray, J., Chan, T., and Daw, J. (2000) "The Role of Chartists and Fundamentalists in Currency Markets: The Experience of Australia, Canada, and New Zealand," In *Revisiting the Case for Flexible Exchange Rates*, pp. 167–206. Proceedings of a conference held by the Bank of Canada, November 2000. Ottawa: Bank of Canada.
- Dornbusch, R. (1976) "Expectations and Exchange Rate Dynamics." *Journal of Political Economy*, 84 (6), pp. 1161–76.
- Dornbusch, R. and Fischer, S. (1980) "Exchange Rates and the Current Account." *The American Economic Review*, Vol. 70(5): pp. 960-971.
- Dornbusch, R. (1987). Exchange Rate Economics: 1986. *The Economic Journal*, 97, 1-18.
- Fong, F. (2006) "Determinants of the Canada-US Exchange Rate: From Commodities to Current Account." *Western Undergraduate Economics Review*, pp. 7-14.
- Fortin, P. (1999) "The Canadian Standard of Living: Is There a Way Up?" C.D. Howe Institute Benefactors Lecture. < www.cdhowe.org >.
- Frenkel, J. (1976) "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence" *Scandinavian Journal of Economics* 78 (2), pp. 200–24.

- Ghasemi, S. (2013) "An Analysis of the Effects of Exchange Fluctuations on Employment, Output, and Productivity in Canada." Thesis submitted in partial fulfillment of the requirements For the M.Sc. degree in Systems Science.
- Harvey, J. (2006). Post Keynesian versus neoclassical explanations of exchange rate movements: A short look at the long run. *Journal of Post Keynesian Economics*, 161-179.
- Helliwell, J., Issa, R., Lafrance, R. and Zhang, Q. (2005) "NEMO: A Canadian-U.S. Dollar Exchange Rate Equation" In *Canada and the Global Economy*. Proceedings of a conference held at the Bank of Canada, November 2004
- Isfeld, G. (2015, February 17). Alberta will sink into recession this year, as provincial fortunes turn amid oil's collapse, CIBC predicts.
- Issa, R., Lafrance, R. and Murray, J. (2008). "The turning black tide: energy prices and the Canadian dollar." *Canadian Journal of Economics*, 41(3), 737-759.
- "KEY WORLD ENERGY STATISTICS." International Energy Agency (IEA), 2007. <http://large.stanford.edu/courses/2011/ph240/demori1/docs/key_stats_2007.pdf>.
- Lavoie, M. (2014). Open-economy macroeconomics. In *Post-Keynesian Economics: New Foundations* (pp. 492-494). Cheltenham, Gloucestershire: Edward Elgar Pub.
- Levich, R (1989) "Empirical Studies of Exchange Rates: Price Behaviour, Rate Determination, and Market Efficiency. In *Handbook of International Economics* (pp979-1040). Amsterdam: North Holland.
- MacDonald, R., & Taylor, M. (1989). Economic analysis of foreign exchange markets: An expository survey. In *Exchange rates and open economy macroeconomics* (pp. 3-107). Oxford, OX, UK: B. Blackwell.
- Market Snapshot: Canadian 2014 Energy Export Revenues Reached a Record High of \$129 Billion. (2015, July 15). Retrieved December 3, 2015, from <https://www.nbc-one.gc.ca/nrg/ntgrtd/mrkt/snpsht/2015/07-02xprtrvns-eng.html>
- Maugeri, Leonardo. "THE SHALE OIL BOOM: A U.S. PHENOMENON." [Http://belfercenter.org/](http://belfercenter.org/). Harvard Kennedy School, 1 June 2013.
- "MEDIUM-TERM OIL MARKET REPORT 2015." [Https://www.iea.org](https://www.iea.org). International Energy Agency (IEA), 2015. <<https://www.iea.org/Textbase/npsum/MTOMR2015sum.pdf>>.
- Murray, J., Antia, Z. and Zelmer, M. (2000) *International Financial Crises and Flexible*

exchange Rates: Some Policy Lessons from Canada. Technical Report No. 88. Ottawa: Bank of Canada.

Moosa, I. (2007). Neoclassical versus Post Keynesian models of exchange rate determination: A comparison based on nonnested model selection tests and predictive accuracy. *Journal of Post Keynesian Economics*, 169-185.

Mussa, M. (1976) "The Exchange Rate, the Balance of Payments, and Monetary and Fiscal Policy under a Regime of Controlled Floating." *Scandinavian Journal of Economics* 78 (2), pp. 229–48.

Obstfeld, M. and Rogoff, K. (2000) "New Directions for Stochastic Open Economy Models" *Journal of International Economics*, 50, pp. 117-153.

"OPEC Monthly Oil Market Report." *Opec.org*. OPEC, 16 Mar. 2015.

<http://www.opec.org/opec_web/static_files_project/media/downloads/publications/MO_MR_March_2015.pdf>.

"OPEC Monthly Oil Market Report." OPEC, 10 Dec. 2014.

<http://www.opec.org/opec_web/static_files_project/media/downloads/publications/MO_MR_December_2014.pdf>.

Rodriguez, C.A. (1980) "The Role of Trade Flows in Exchange Rate Determination: A Rational Expectations Approach." *The Journal of Political Economy*, Vol. 88(6), pp. 1148-1158.

Samuleson, P.A. (1964) "Theoretical Notes on Trade Problems." *Review of Economics and Statistics* 46, pp. 335-346.

"Sheikhs v Shale." *The Economist*. The Economist Newspaper, 1 Dec. 2014.

<<http://www.economist.com/blogs/freeexchange/2014/12/money-talks-december-1st-2014>>.

Taylor, A. and Taylor, M. (2004) "The Purchasing Power Parity Debate." *Journal of Economic Perspectives* 18 (4), pp. 135–58.

United States Census Bureau. (n.d.). Retrieved from <https://www.census.gov/foreign-trade/balance/c5700.html#2006>

Walter, A. (1991). *World power and world money: The role of hegemony and international monetary order*. New York: St. Martin's Press.

Appendix 1/ Data sources

DATA	SOURCE
Dow Jones FXCM Dollar Index	Yahoo Finance
Bloomberg Commodity Index	bloombergindexes.com
WSJ USD Index	The Wall Street Journal Website
US Dollar Trade Weighted Index	Federal Reserve System Board of Governors
US Dollar Index	Investing.com
Daily WTI Prices	US Energy Information Administration
Daily exchange rates (six pairs)	Meta Trader 4 Software
Hourly exchange rates (six pairs) and WTI	Meta Trader 4 Software
Minutely exchange rates (six pairs) and WTI	Meta Trader 4 Software
Per Second USD/CAD and WTI	Ninja Trader Software

Appendix 2) Augmented Dickey-Fuller Tests Results (p-values)

Hypothesis (apply for daily, hourly, minutely, and per second data):

H_0 : Variable is Stationary

H_a : Variable is Not Stationary

Reject H_0 if $p > 0.05$

1) Daily data

→ Exchange Rate and WTI Levels

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag, no trend	0.7907	0.6723	0.8466	0.0285	0.3968	0.5744	0.5320

Decision: Reject H_0 for all variables. There is significant evidence that all variables are not stationary.

→ First Difference of Exchange Rates and WTI, without trend

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Decision: Do not reject H_0 for all variables. There is significant evidence that all variables are stationary.

→ First Difference of Exchange Rates and WTI, with trend

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Decision: Do not reject H_0 for all variables. There is significant evidence that all variables are stationary.

2) Hourly Data

→ Exchange Rate and WTI Levels

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag, no trend	0.0352	0.5757	0.4329	0.2616	0.3160	0.1593	0.0422

Decision: Reject H_0 for all variables. There is significant evidence that all variables are not stationary.

→ First Difference of Exchange Rates and WTI, without trend

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Decision: Do not reject H_0 for all variables. There is significant evidence that all variables are stationary.

→ First Difference of Exchange Rates and WTI, with trend

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Decision: Do not reject H_0 for all variables. There is significant evidence that all variables are stationary.

3) Minutely Data

→ Exchange Rate and WTI Levels

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag, no trend	0.7361	0.6555	0.6640	0.7625	0.6536	0.3580	0.9617

Decision: Reject H_0 for all variables. There is significant evidence that all variables are not stationary.

→ First Difference of Exchange Rates and WTI, without trend

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Decision: Do not reject H_0 for all variables. There is significant evidence that all variables are stationary.

→ First Difference of Exchange Rates and WTI, with trend

	CAD	EUR	JPY	GBP	NZD	AUD	WTI
No lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Decision: Do not reject H_0 for all variables. There is significant evidence that all variables are stationary.

4) Per Second (CAD only)

→ USD/CAD Levels, no trend, no lag

Oct 19 th	Oct 20 th	Oct 21 st	Oct 22 nd	Oct 23 rd	Oct 26 th	Oct 27 th	Oct 28 th	Oct 29 th	Oct 30 th
0.9678	0.3572	0.9285	0.5024	0.7660	0.0139	0.7468	0.9507	0.7163	0.9965

Decision: Reject H_0 for 9 out of the 10 days. There is significant evidence that the data is not stationary.

→ USD/CAD First Difference, no trend

	Oct 19 th	Oct 20 th	Oct 21 st	Oct 22 nd	Oct 23 rd	Oct 26 th	Oct 27 th	Oct 28 th	Oct 29 th	Oct 30 th
No lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Decision: Do not reject H_0 for all 10 days. There is significant evidence that the data is stationary.

→ USD/CAD First Difference, with trend

	Oct 19 th	Oct 20 th	Oct 21 st	Oct 22 nd	Oct 23 rd	Oct 26 th	Oct 27 th	Oct 28 th	Oct 29 th	Oct 30 th
No lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 lag	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6 lags	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Decision: Do not reject H_0 for all 10 days. There is significant evidence that the data is stationary.