Economics 809 - Project two

A. Foroozande Nejad

Contents

1 Introduction: 2

2 Theory: 3

3 Data description: 4

4 Unit root and cointegration tests: 8

5 Granger causality: 10

6 Stability analysis and diagnostic tests: 12

7 Conclusion: 13

1 Introduction:

The main objective of this paper is to examine the relation between the Canadian dollar exchange rate and commodity price indices concerning the present value approach. Canada adopted the policy of floating exchange rate in the early 1970s. The fluctuating value of the Canadian dollar can be linked to other variables in the economy. One question is, do exchange rates have forecasting power over global commodity prices? To answer that, I utilize various unit root, cointegration tests, and system-based approaches to realize the nature of the data and discover the relation between them subsequently. The predictability of commodity prices plays a crucial role in the policymaking and central banks' decisions of the countries that heavily rely on importing or exporting commodities. Canada top exports are Crude Petroleum (\$66.6B), Cars (\$41B), Gold (\$12.9B), Refined Petroleum (\$12.3B), and Vehicle Parts (\$11.3B) (OEC, country profile [1]), which puts the country in the group of commodity currencies as defined by Chen and Rogoff (2003). These countries are major exporters of commodities that their currencies are linked to their respective commodities prices.
The present value asserts that the exchange rate (due to its forward-looking characteristics) reveals information about future commodity prices. To test the validity of mentioned correlation, I use Canadian exchange rate data, fisher commodity price indexes, and the US CPI and present my findings in this paper.

[1]OEC Canada profile: https://oec.world/en/profile/country/can

2 Theory:

The commodity prices have a great significance for Canada's terms of trade, as any change observable to market participants vastly alters the expected export income and future exchange values. The expectation of future income, in turn, affects the exchange rate. In other words, according to the present value approach, nominal exchange rates contain signals about the expectation of future prices. We can demonstrate this relation as:

$$E(s_{t+h} - s_t) = \beta f_t \quad [2] \tag{1}$$

(1) is the relationship between fundamentals and exchange rate. This relationship can take many forms. Since nominal exchange rate can be viewed as an asset price. Thus, it incorporates expectations about the values of its future fundamentals, such as commodity prices.

$$s_t = \gamma \sum_{j=0}^{\infty} \psi^j E(f_{t+j}|I_t) + z_t \quad [3] \tag{2}$$

In this method, the nominal exchange rate is the sum of discounted fundamentals where ψ and γ are structural parameters, and I_t is the information available at period t.

This is based on exchange rates being endogenously determined in equilibrium with other macroeconomic variables. Thus, it is challenging to predict exchange rate changes based on reduced-form models (Chen and Rogoff (2003)). Intuitively, equation (2) shows that exchange rates [4] can predict exogenous commodity prices even if vice versa does not hold. To examine the hypothesis that equation (2) holds, I utilize two approaches. First, if both exchange rate and fundamentals are I(1), it could be a sign that they are connected. If fundamentals have a unit root and the discount factor is near one, the net present value condition implies that exchange rates are near random walks.". The exchange rates are forward-looking, implying they react to relevant expected economic variables. This feature helps us predict backward-looking variables such as price indexes, which is an indirect approach to examine the relation between the mentioned variables, and it only provides evidence in favor of the theory. The second approach is to test for in-sample Granger-causality between nominal exchange rate and fundamentals. Equation (2) implies that nominal exchange rate Granger-causes an infinite series of future commodity prices (Chen, Y. C., Rogoff,

[2] Rossi, B. (2013). Exchange rate predictability. Journal of economic literature, 51(4), 1063-1119.

[3] Chen, Y. C., Rogoff, K. S., & Rossi, B. (2010). Can exchange rates forecast commodity prices?. The Quarterly Journal of Economics, 125(3), 1145-1194.

[4] Exchange rate could be real or nominal. However, in this paper, we focus on nominal exchange rate due to frequency and accuracy of data

K. S., & Rossi, B. (2010)). Thus, if the lagged predictor has significant explanatory power for exchange rates over the full-sample, then it is evidence in favor of the present value approach.

3 Data description:

This paper only focuses on the Canadian dollars exchange rate. United States dollar, closing spot rates are from Statistics Canada. Table 10-10-0009-01 Foreign exchange rates in Canadian dollars, Bank of Canada, monthly, from January 1972 to April 2017.
Price indexes of major Canadian export commodities are from Statistics Canada. Table 10-10-0132-01 Fisher commodity price index, United States dollar terms, Bank of Canada, monthly, from January 1972 to April 2017. The data purposefully starts (from January 1972) when Canada adopted the policy of floating exchange rate. And data ends when the Bank of Canada has changed the number, frequency, and calculation methodology of its published foreign exchange (Table 10-10-0009-01). Total commodity index contains sub-categories including agriculture, forestry, fish, metals and minerals and Energy. CPI for All American Urban Consumers is retrieved from the U.S. Bureau of labor statistics website (Series Id: CUUR0000SA0). The data includes all items in the U.S. city average, all urban consumers, and it is monthly and not seasonally adjusted, from January 1972 to April 2017.
It is crucial for our analysis to determine whether there are trends[5] or seasonality in the data. Thus, I use graphic visualization to improve my understanding of the characteristics of the data and make a qualitative comparative analysis between the striking features of data.
To capture the relation between trade and exchange rate, we need to account for imports. In this paper, I used the US CPI index as a proxy for goods import. The total commodity price indices are deflated by the US CPI to give us a more accurate representation.

[5] In the unit root, we can not both test for unit root and trend simultaneously. Therefore, we have to presuppose the existence or lack of trend in the data. I use graphs to make that decision.

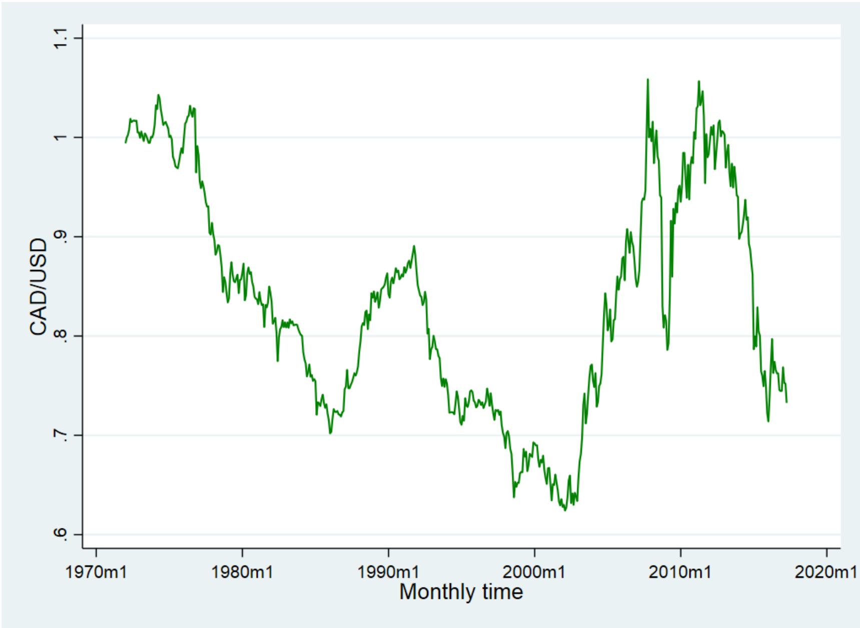

Figure 1: Canadian Dollars closing exchange rate, United States dollar terms

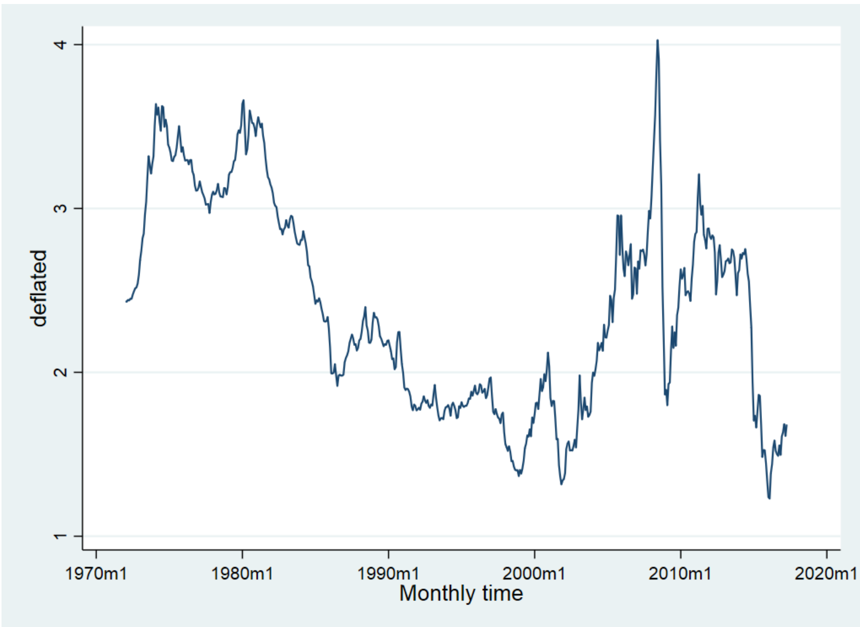

Figure 2: Total commodity price index (deflated), United States dollar terms

Both figures show a downward trend until the early-2000s. However, it fluctuates in the second of the graph. Previously[6], when I compared the exchange rate and total commodity price indices, it appears that there is a negative correlation between the two variables prior-mid-2000s and a positive correlation post-mid-2000s. However, it is evident that the relation between the two variables in figure one and two is positive. This distinction becomes evident when we look at the scatter plots.

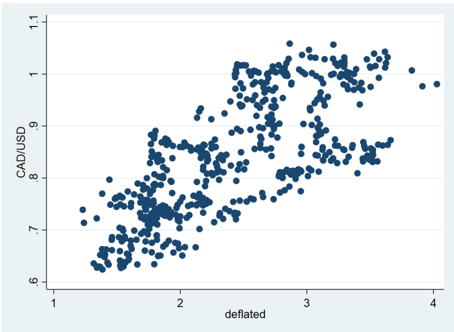

Figure 3: After CPI deflation

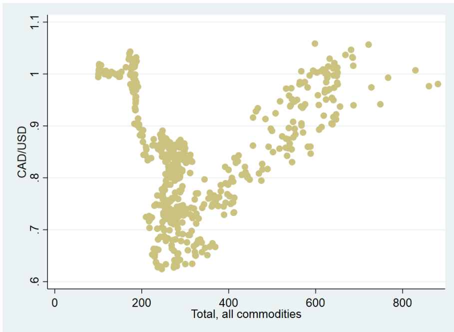

Figure 4: Before CPI deflation

The figures show while commodity prices were increasing in the second half in the question range. However, they were decreasing in the relative term. This trend follows the present value approach. If the market participants observe a decreasing relative price (a fundamental), then the exchange rate should drop accordingly. For example, if market participants observe an increase in productivity and constant demand, the relative price will decrease in the future. Consequently, the exchange rate decreases according to the present value approach.
Based on Figures one and two, I can not affirmatively determine the existence of structural breaks and seasonality in the data. However, I assume a trend in the data in future tests. The question arises that are mentioned characteristics also observable in all the sub-categories. To further investigate this question, I make use of graphs.

[6]Project one, the graph related to total commodity price index

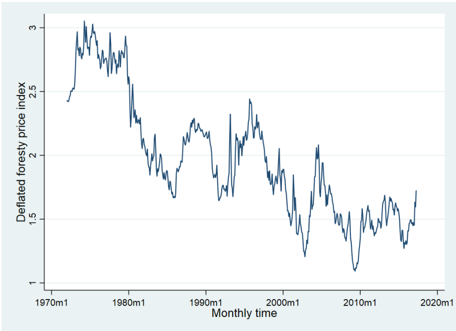

Figure 5: Foresty price index

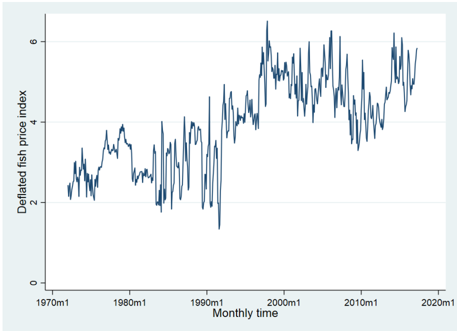

Figure 6: Fish price index

Figure 7: Agriculture price index

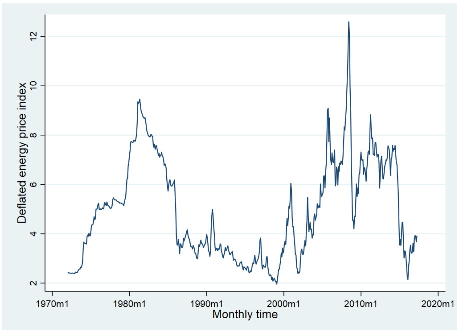

Figure 8: Energy price index

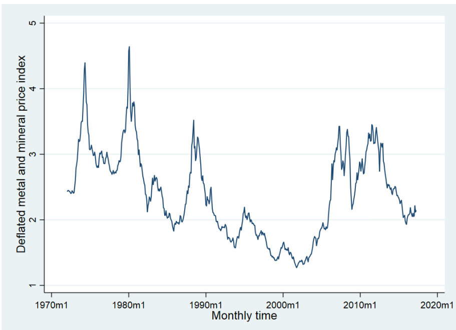

Figure 9: Minerals price index

Figure 10: Total ex-energy price index

It is evident that in all deflated variables except the energy sub-category, the data is trending. This provides more evidence for the decision of the existence of a trend in the main data. Contrary to the other four sub-categories, the deflated fish price index is increasing. The energy price index is the most volatile of all, particularly post-mid-2000s, and there is no overall trend in data.

The other issue is the existence of seasonality [7] in fish and agriculture data. To further prove this hypothesis, I will conduct more tests.

4 Unit root and cointegration tests:

If fundamentals have unit root and this characteristic is also present in the exchange rate, then it can be a case in favor of the present value approach. It is also crucial to check for cointegration between sub-categories. If cointegration exists, we have to account for that in a system-based approach. Because there is no uniformly most powerful unit root test, I utilize different tests to see if the results confirm on another.

ACF : If the correlogram of variable displays slow decay (i.e., non-stationary) can be an indicative of a unit root (however, a process can be stationary but very persistent process). Assuming the random walk is $Y_t = \sum_{s=1}^{t} \epsilon_s$ then:

$$\gamma_{tj} = E\left(\sum_{s=1}^{t} \epsilon_s \sum_{s=1}^{t-j} \epsilon_s\right) = (t-j)\sigma^2$$

Hence:

$$\rho_{jt} = \frac{\gamma_{jt}}{\sqrt{\gamma_{0t}}\sqrt{\gamma_{0(t-j)}}} = \frac{t-j}{\sqrt{t}\sqrt{t-j}} = \frac{\sqrt{t-j}}{\sqrt{t}} = \sqrt{1-\frac{j}{t}}$$

Clearly, the decay is very slow, and completely washes out for $t \to \infty$[8].

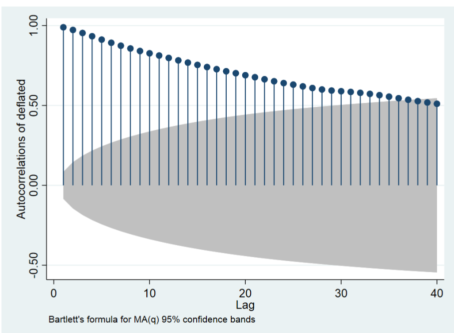

Figure 11

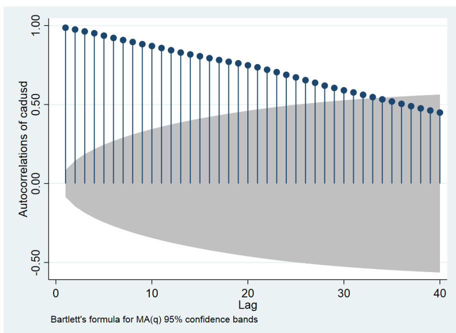

Figure 12

[7] Seasonally adjusted data could improve the practicability of data

[8] Sudiksha Joshi,(2019)

Based on the ACF result, both variables are unit root since the correlogram is decreasing slowly. If this is the consistent result in other test results, then it could be evidence in favor of the present value approach. Additionally, it is also a signal for a trend in data which confirms my supposition in the previous part [9].

Unit root circle: Assume characteristic equation is equal to $y_t + \alpha y_{t-1} + \beta y_{t-2} = \epsilon_t$ if we use $\mathcal{Z}$ then we could write it as $1 + \alpha z^{-1} + \beta z^{-2} = 0$. There

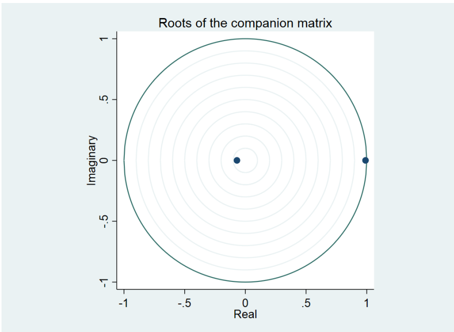

Figure 13: log exchange rate

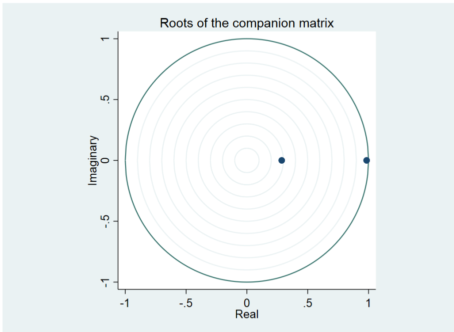

Figure 14: log deflated PCom

are several ways to test the existence of unit root, and there is not a test that is uniformly most powerful. Based on unit root circle, both variables have root equal to one and all of their roots are inside the circle. Thus, the true process is either a random walk with drift or without it (Ashish Rajbhandari, stata[10]). In the second part, I assumed that there is a trend in the data, which implies both variables are trend stationary. The unit circle results confirm the outcome of ACF.

ADF test: Augmented Dickey-Fuller is a better test because of the existing autocorrelation in the model. We assumed the existence of a trend in the data. Thus, under the null hypothesis, the true process is a random walk with drift.

$$\Delta y_t = \alpha + \delta t + \beta y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta y_{t-i} + \epsilon_t \tag{4}$$

$$H_0 : \beta = 1$$
$$H_1 : \beta \neq 1$$

I determine the optimal lag and perform the Augmented Dickey-Fuller in Stata. As shown in the appendix, test statistic across all tests is lower than

[9]slow decaying ACF is a signal for trend

[10]Unit-root tests in Stata: https://blog.stata.com/2016/06/21/unit-root-tests-in-stata/

one percent critical value, which means we fail to reject the null hypothesis. Thus, the true process is a random walk with drift.

KPSS and GLS detrended augmented Dickey–Fuller test: Under DFGLS, the null hypothesis is a random walk with drift with two specific alternative ones. First, the series is stationary around a linear time trend, or the series is stationary around a possible nonzero mean with no time trend (Ashish Rajbhandari, stata[11]). As shown in the appendix, test statistic across all tests is lower than one percent critical value, which means we fail to reject the null hypothesis, implying the true process is a random walk with drift.
In the KPSS test, the null hypothesis is that process y is trend-stationary. Based on the output of this test in Stata, we reject the hypothesis. The DF-GLS test fails to reject its null of a unit root. Also, the KPSS test results are similar, which is supportive evidence of a unit root in the series.

Unit root test result: Across all the unit root tests, the outcomes point toward the existence of unit root in the log of deflated commodity price index and the exchange rate. Based on the present value approach, if fundamentals have a unit root and the discount factor is near one, the exchange rates are random walks (Rossi, B. (2013)). The conducted tests all point toward the validity of that statement.

Test/Projection	Null hypothesis	Result
ACF		Random walk with drift
Unit root circle		Random walk with drift
ADF	Random walk with drift	Fail to reject
DFGLS	Random walk with drift	Fail to reject
KPSS	Trend stationary	Reject

5 Granger causality:

In the theory section, I discussed that according to present value approach:

$$s_t = \gamma \sum_{j=0}^{\infty} \psi^j E(f_{t+j}|I_t) + z_t \ ^{12}$$

This Equation implies that the exchange rates must Granger-cause fundamentals. Thus, testing for the existence of Granger-causality provides em-

[11]Unit-root tests in Stata: https://blog.stata.com/2016/06/21/unit-root-tests-in-stata/

[12]Chen, Y. C., Rogoff, K. S., & Rossi, B. (2010). Can exchange rates forecast commodity prices?. The Quarterly Journal of Economics, 125(3), 1145-1194.

pirical support for the theory. If this is correct then we should reject the null that $\beta_0 = \beta_1 = 0$.

$$\mathbb{E}_t \Delta cp_{t+1} = \beta_0 + \beta_1 \Delta s_t + \beta_2 cp_t$$

It is noteworthy to mention that this is not a robust test, and there is a possibility of parameter instability. The other question is if exchange rates Granger-cause fundamentals, does the reverse also hold?
First, I conduct Granger test to determine if exchange rates Granger-cause deflated commodity prices. To do that, we have to choose the lag order. The optimal lag order across all information criteria is two (In this paper, the chosen information criteria is HQIC based on sample size).
Next, due to variables being I(1), we run an overfit Granger test. And we reject that exchange rates Granger-causing commodity prices. This potentially could be evidence against the present value approach. However, several possibilities might hinder the forecasting ability of the model
There are several reasons that might cause this. I did not incorporate parameters instability [13] in the analysis, structural breaks and missing fundamentals.
Parameter predictability might change over time, and there is no guarantee that a predictor maintains its usefulness in all subsets. This issue is also present in the relevant literature. There are ways to the existence of this issue. First, we can use tests for parameter instability (such as Andrewsí (1993) QLR test), or we can check for sub-sample forecasting ability. Also, ignoring structural breaks can create biasedness within the model. The existence of structural breaks is also tied to parameter instability. By conducting several tests, we can be confident that there are several structural breaks in the data.

As it is evident by figure 16, while both variables seem to follow similar trends, the magnitude of reaction changes over time. Giacomini and Rossi (2010a) also point towards this issue " the estimates of exchange rate models with economic fundamentals are plagued by parameter instabilities". A modified version of the Granger-causality test to tackle instability is suggested by Rossi (2005b). Contrary to the traditional Granger-causality tests, it detects predictive ability even if it appears only in a sub-sample or the predictive relationship changes over time.
The other issue is missing fundamentals. After including CPI as a proxy of import, the relation between the two variables became more evident. It is possible that we can improve the forecasting of the model by including other

[13] controlling for parameter instabilities is vital in the exchange rate–fundamental connection (Chen, Y. C., Rogoff, K. S., & Rossi, B. (2010))

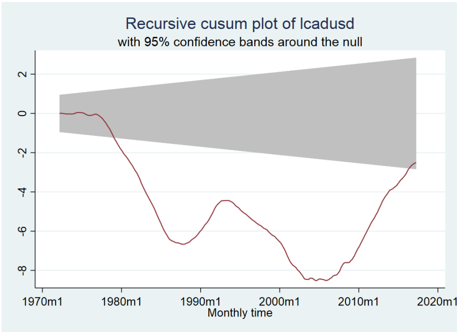

Figure 15: Subcusum test

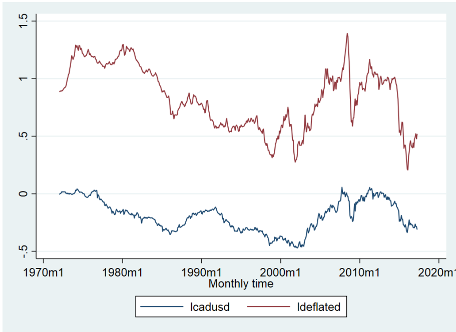

Figure 16: Pcom and exchange rate

fundamentals. Macro fundamentals such as interest rate differential, inflation differential, money output could be potentially missing fundamentals.

6 Stability analysis and diagnostic tests:

In the previous section, I used the vector of error correction model. VECM assumes that the model is correctly specified, and to test this assumption, I use diagnostic testing. Additionally, the Johansen test uses the assumption of normal errors. I check its validity with several tests such as autocorrelation tests, tests for nonnormality, ARCH-LM test, stability analysis (Chaban, slides 8). If autocorrelation exists, the estimated model violates the assumption of no autocorrelation in the errors, and our forecasts may be inefficient. Based on the Lagrange-multiplayer test, there is no autocorrelation in lags (we fail to reject the null). Thus, OLS is consistent.
When VECM is estimated using Johansen (1988) procedure, normality is needed because the procedure uses maximum likelihood. Under the Jarque-Bera test, the null hypothesis states that the residuals of variables are normally distributed. Based on the result, we reject the null. Therefore, residuals of these variables are not normally distributed. Another important characteristic is the stability of the model. The goal of the stability test is to check if unit-roots are inside the root circle.

7 Conclusion:

This paper examined the relationship between the Canadian dollar exchange rate and commodity prices indexes. I utilized two methods to test the present value approach. In the unit root and cointegration tests (section 4), all the results pointed out the potential relation of exchange rate and commodity prices by showing that both variables are I(1). However, this is a hint towards the existence of a possible link and does not prove it.
Furthermore, the present value approach implies that exchange rates Granger-causes fundamentals, in this case, deflated commodity prices. I put this statement to test, and the result was contradictory. The outcome was anticipated mainly for the existence of parameter instability and structural breaks. This point is also raised by other papers. The solution to this problem is the use of the modified version of Granger-causality suggested by Rossi (2005b).