# University of Saskatchewan

**RESEARCH PAPER FOR ECON 809**

# RELATIONSHIP BETWEEN THE CANADA-US EXCHANGE RATE AND COMMODITY PRICES

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## 1. INTRODUCTION

This paper explores the dynamic relationship between the Canada-US exchange rate and commodity prices specific to Canada. According to the paper "Can exchange rates forecast commodity prices" by Chen, Y.-C., Rogoff, K.S., Rossi, B. (2010), commodity currency exchange rate have extraordinarily robust power in predicting global commodity prices, both in-sample and out of sample, and against a variety of alternate benchmarks. Moreover in the paper, these commodity currencies are considered to include Australian, Canadian and New Zealand dollars, as well as the South African Rand and the Chilean peso. These currencies are considered the commodity currencies because they exhibit a tight link with commodity prices in the sense that the countries of these currencies produce and export a great deal of primary commodity products, from energy related goods to minerals and agriculture food products. Canada's economy is export oriented where exports of primary commodity products take a significant proportion of its gross domestic product. The exports are mainly made up of crude petroleum, timber, metals and agricultural food products. Given that Canada relies heavily on the exports of primary commodity products to gain earning, global commodity price fluctuations would have an impact on the countries exchange rate through shocks in the terms of trade. This is an assertion supported by Ferrero et al. (2012). Ferrero et al. (2012) highlighted that world commodity price fluctuations affects a greater proportion of commodity exporting countries, therefore causing a major shock in the terms of trade of such countries, leading to changes in the exporter's exchange rate.

Following from this assertion and the inspiration of the paper by Chen, Y.-C., Rogoff, K.S., Rossi, B. (2010), my paper sought to examine the relationship between the Canada-US exchange rate and commodity price indices specific to Canada in two parts. In part I, I look at the relationship between the log of the nominal Canada-US spot exchange rate and the log of the total of all commodity price index of Canada deflated by the US CPI. In part II, I further examine the cointegrating properties of commondity price index components of Canada namely agriculture, metals and minerals, energy, fish, and forestry.

The remaining section of the paper is arranged as follows: section two describes the data and the methodology, section three describes the empirical analysis and results, section four contains analysis and results for part II of this paper and section five contains the conclusion.

## 2. DATA DESCRIPTION

In this paper, the main idea is to explore the relationship between exchange rate and commodity price index components. To carry out my analysis, I use data on the nominal Canada-US spot exchange rates, commodity price indices specific to Canada and the US CPI index. The nominal Canada-US spot exchange rates, commodity price indices specific to Canada data is a monthly time series data for the period January 1972 to April 2017 collected from Statistics Canada where commodity prices are set using the Fisher commodity price index and the exchange rate reflects Canadian Cents-per United State Dollars. The commodity price indices consist of 6 series, including, total of all commodity prices, agriculture, metals and minerals, energy, fish, and forestry price indices. Further, the US CPI is sourced from the US Bureau of Labour Statistics. The total of all commodity price index is deflated by the US CPI in order to get closer to a measure of the terms of trade. Also, the nominal Canada-US spot exchange rates and deflated total of all commodity prices was transformed using a log transformation. The following are graphs of these variables.

**Figure 1: Log of Nominal Canada – US Spot Exchange Rate**

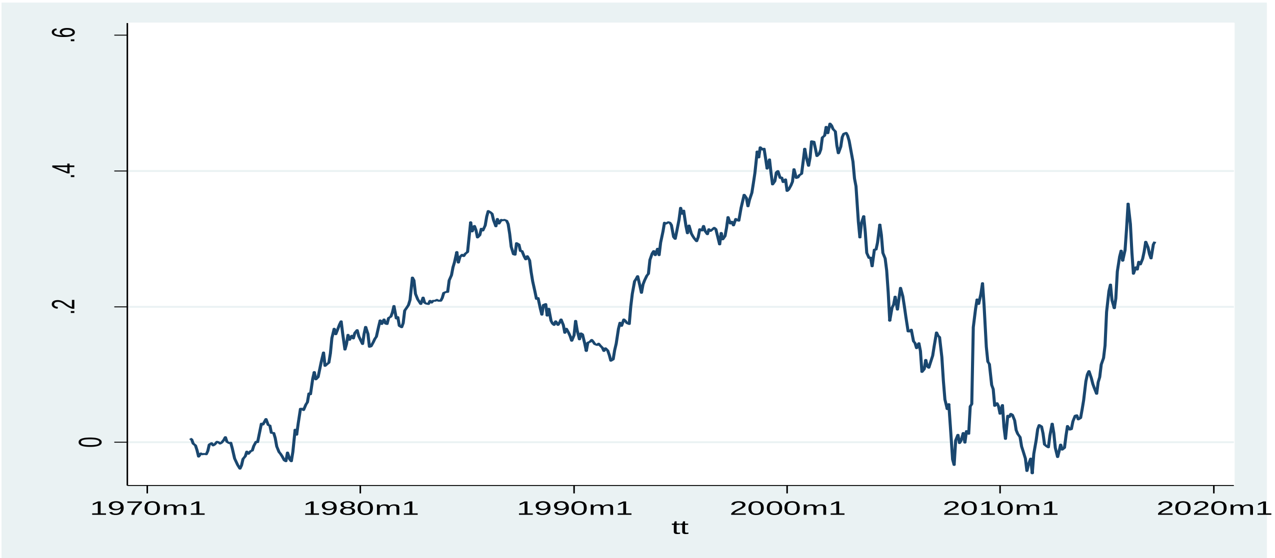

**Figure 2: Log of Total Commodity Prices Deflated by US CPI**

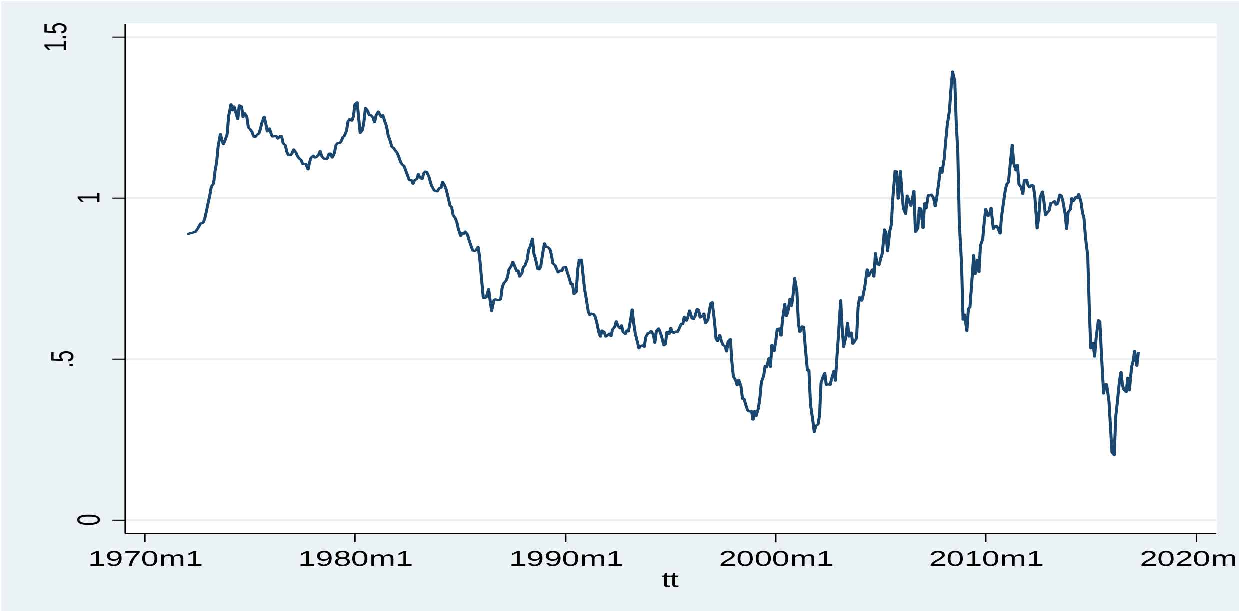


Figure 1 depicts a graph of the log of nominal Canada – US spot exchange rate from January 1972 to April 2017. Figure 2 also shows a graph of the log of total commodity prices deflated by US CPI for the same time period. Both graphs does not depict a clear indication of the presence of a trend, however for the purpose of the analysis of this paper, I include a constant and a trend.

**Figure 3: Relationship between the Log of Canada – US Spot Exchange Rate and the Log of Total Commodity Prices Deflated by US CPI.**

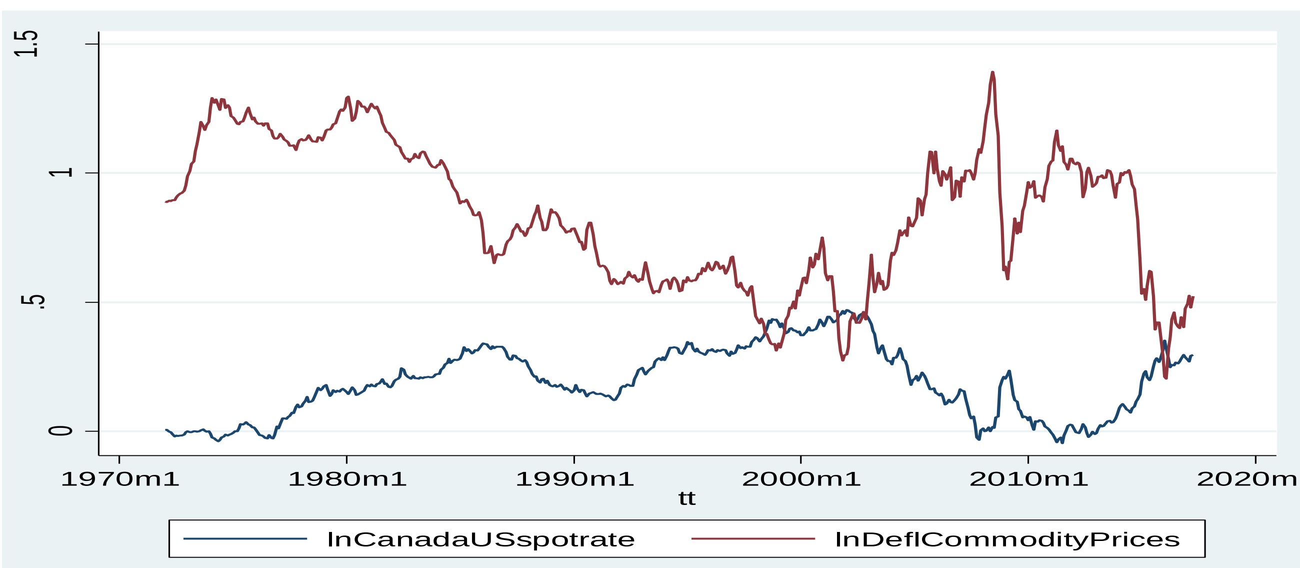

Figure 3 illustrates the relationship between the log of Canada – US spot exchange rate and the log of total commodity prices deflated by US CPI for the time period January 1972 to April 2017. It can be seen from the graph that these two variables exhibit a negative relationship. This indicates that when commodity prices are increasing, the Canada – US exchange rate is decreasing. This means that the Canadian dollar appreciates when it commodity prices increases, implying that the Canadian dollar is moving in line with the prices of its commodities.

## 3. EMPIRICAL METHODS AND RESULTS

The framework for the empirical work is the present value approach of Chen, Rogoff and Rossi (2010) which highlights the forward looking nature of the nominal exchange rate. Following from Campbell and Shiller (1987), Engel and West (2005) were the first to relate the nominal exchange rate and the discounted sum of its expected future fundamentals.

Chen, Rogoff and Rossi (2010) extended the framework to capture commodity price indices as a unique exchange rate fundamental for countries whose currencies are regarded as a "commodity price". Chen et al (2010) in their investigation provided a strong evidence to support the present value approach to the nominal exchange rate and found exchange rates forecasted exogenous changes in commodity prices well, but not vice versa. The key impact of the present value approach was that exchange rates granger causes commodity prices, after accounting for instabilities such as structural breaks. Looking at the impact of the nominal exchange rate as a forward looking variable, we begin to understand the impact of commodity prices on the exchange rate.

### A. Unit Root Analysis

The Unit root test will provide information about the stationary properties and the order of integration among the two variables under study. Therefore, to test the relationship between the log of Canada-US spot exchange rate and the log of deflated commodity prices by US CPI and to ensure that the results are valid without persistence of shocks and to avoid the problem of spurious regression, it must be ensured that the data is stationary or trend-stationary. Hence, the variables must be tested for random walk with or without drift. A series that follows a random walk with or without drift is known as a unit root process, meaning the root is equal to one. Various unit root test exist, however none is uniformly most powerful. As a result, depending on the type of data or the type of analysis we try to do, some might work better than others.

This study applied both the Augmented Dickey-Fuller Test (Dickey and Fuller, 1979) and DF-GLS (Elliot et al., 1996) unit root tests with an intercept and a trend or without trend to check the stationary of the variables. In both unit root tests, the Akaike Information Criterion (AIC) was used to determine the optimal lag length. Further, Imperative in performing a unit root test is to first determine the appropriate lag length to run the test: a lag too small can bias the test through the presence of serial correlation in the remaining errors; a lag too big can destroy the power of the test. A useful rule of thumb for determining the *p*-max (18 in this study) was suggested

by Schwert(1989):

$$p_{\max} = \left[ 12 \cdot \left( \frac{T}{100} \right)^{1/4} \right]$$

The Augmented Dickey-Fuller test tests the null hypothesis that a time series $y_t$ is non-stationary against the alternative that that $y_t$ is stationary. ADF test is set upon estimating the regression:

Δyt=β0+β1t+βyt−1+δ1Δyt−1+δ2Δyt−2+…

We test the hypothesis that: $H_o$: β=0 against the one sided alternative that $H_a$: β<0. The results of the unit root tests are summarized in table 1

**Table 1: Results of Augmented Dickey Fuller and DF – GLS Unit Root Test**

| **Variables** | **Aug. Dickey-Fuller (Test) statistics** | | **DF - GLS Test Statistics** | | **Conclusion** |
|---|---|---|---|---|---|
| **Levels** | **Without Trend** | **With Trend** | **Without Trend** | **With Trend** | |
| lnCanadaUSspotrate | -1.917 (13) | -1.880 (13) | -0.705 | -1.565 | I(1) |
| lnDeflCommodityPrices | -2.112 (2) | -2.551 (2) | -1.559 | -1.917 | I(1) |
| | | | | | |
| **First Difference** | | | | | |
| dlnCanadaUSspotrate | -6.314* (12) | -6.320* (12) | -4.338* | -4.523* | I(0) |
| dlnDeflCommodityPrices | -13.276* (1) | -13.270* (1) | -5.684* | -5.122* | I(0) |

*Notes: (i) In the Augmented Dickey Fuller (ADF) test, the optimal lag length is provided in parenthesis in the test statistics section. The lag length were determined using the Akaike Information Criterion. (ii). * depicts significance at 5% level*

The results reported in table one indicate that the Augmented Dickey Fuller (ADF) test and the DF-GLS test have the tendency of failing to reject the null hypothesis of unit root for the levels of all the variables. Therefore in levels, the variables were found to be I(1) indicating that the variables are non-stationary. However, in first difference, both the Augmented Dickey Fuller (ADF) and DF-GLS tests rejected the null hypothesis of unit root meaning that that these tests found the variables to be stationary. All the results of the above test are displayed in Appendix (Appendix 1 – Appendix 20)

B. Cointegration Analysis

Two variables are said to be cointegrated if their linear combination is integrated of order 0, i.e. I(0) which intuitively means that the variables do not drift too far apart from each other. Hence in a model with $Y_t$ and $X_t$ variables that are non-stationary processes, if there exists a $\beta$ such that $Y_t$- $\beta X_t$, then the variables are co-integrated. This means that even if unit root processes exist in the two independent variables, together the regression of one variable on the other will not be spurious anymore. However, if the variables are not cointegrated, the regressions would still be spurious. The concept was initially introduced by Engel and Granger (1987) who concluded that "If each element of a vector of time series $x_t$, is stationary only after differencing, but a linear combination $\alpha' x_t$, need not be differenced, the time series $x_t$ have been defined to be co-integrated of order (1, 1) with co-integrating vector $\alpha$." I use both the Engel and Granger residual based approach and the Johansen cointegration test to ascertain the presence of a long-run integrating relation among the variables. The Johansen cointegration test was used because it tests a system and can report more than one cointegrating vectors. To carry out these tests, the procedure specifies a null hypothesis that indicates that the log likelihood of the unconstrained model including the co-integrating equations is not significantly different from the log likelihood of the constrained model that does not include the cointegrating equations. We reject the null hypothesis if the models are significantly different and conclude that there is possible cointegration. The results of the co-integrating unit root test is shown in table 2

**Table 2: Results of Co-integration Tests**

Engel and Granger residual based approach

```
. reg lnCanadaUSspotrate lnDeflCommodityPrices
```

| Source | SS | df | MS |
|---|---|---|---|
| Model | 5.74866301 | 1 | 5.74866301 |
| Residual | 4.31846103 | 542 | .00796764 |
| Total | 10.067124 | 543 | .018539823 |

| | |
|---|---|
| Number of obs = | 544 |
| F( 1, 542) = | 721.50 |
| Prob > F = | 0.0000 |
| R-squared = | 0.5710 |
| Adj R-squared = | 0.5702 |
| Root MSE = | .08926 |

| lnCanadaUSspotrate | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lnDeflCommodityPrices | -.3809464 | .0141823 | -26.86 | 0.000 | -.4088054 | -.3530875 |
| _cons | .5108232 | .0125125 | 40.83 | 0.000 | .4862443 | .535402 |

```
. varsoc e
```

Selection-order criteria
Sample: 1972m5 - 2017m4 Number of obs = 540

| lag | LL | LR | df | p | FPE | AIC | HQIC | SBIC |
|---|---|---|---|---|---|---|---|---|
| 0 | 544.943 | | | | .007809 | -2.0146 | -2.0115 | -2.00666 |
| 1 | 1499.12 | 1908.4 | 1 | 0.000 | .000229 | -5.54489 | -5.53867 | -5.529 |
| 2 | 1507.69 | 17.134* | 1 | 0.000 | .000222 | -5.57292 | -5.56359* | -5.54907* |
| 3 | 1508.82 | 2.2642 | 1 | 0.132 | .000222* | -5.57341* | -5.56097 | -5.54162 |
| 4 | 1508.86 | .08944 | 1 | 0.765 | .000223 | -5.56987 | -5.55433 | -5.53013 |

Endogenous: e
Exogenous: _cons

```
. dfuller e, trend regress lags(3)

Augmented Dickey-Fuller test for unit root         Number of obs   =       540

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.981            -3.960            -3.410            -3.120
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1373

------------------------------------------------------------------------------
D.e          |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           e |
         L1. |  -.0225359   .0075587    -2.98   0.003    -.0373842   -.0076876
         LD. |   .1839734    .043033     4.28   0.000     .0994387     .268508
        L2D. |  -.0630929   .0436363    -1.45   0.149    -.1488129     .022627
        L3D. |  -.0143312   .0430934    -0.33   0.740    -.0989845    .0703222
      _trend |  -7.04e-06   4.27e-06    -1.65   0.099    -.0000154    1.34e-06
       _cons |   .0022149   .0013324     1.66   0.097    -.0004024    .0048322
------------------------------------------------------------------------------
```

We must note that we have to use different critical values when testing the residuals for cointegration, because the residuals are obtained from estimation. The asymptotic critical values for the ADF statistic at 5% sig level for a regression is -3.37. Since the absolute value of the test statistic of 2.981 is less than the absolute critical value, we fail to reject the hypothesis that there is no cointegration in the whole sample at the 5% significance level.

Johansen Cointegration test

```
. varsoc lnCanadaUSspotrate lnDeflCommodityPrices

   Selection-order criteria
   Sample:  1972m5 - 2017m4                     Number of obs      =       540
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  484.139                      .000575  -1.7857  -1.77948   -1.7698   |
  |  1 |  2592.75  4217.2    4  0.000  2.4e-07  -9.58055   -9.5619  -9.53286  |
  |  2 |  2632.24  78.977*   4  0.000  2.1e-07* -9.71199*  -9.6809* -9.63251* |
  |  3 |  2635.82  7.1609    4  0.128  2.1e-07  -9.71043  -9.66692  -9.59917  |
  |  4 |  2637.14  2.6436    4  0.619  2.1e-07  -9.70051  -9.64457  -9.55746  |
  +---------------------------------------------------------------------------+
   Endogenous:  lnCanadaUSspotrate lnDeflCommodityPrices
    Exogenous:  _cons
```

```
. vecrank lnCanadaUSspotrate lnDeflCommodityPrices, trend(trend) lags(2)

                    Johansen tests for cointegration
Trend: trend                                          Number of obs =     542
Sample:  1972m3 - 2017m4                                       Lags =       2
------------------------------------------------------------------------------
                                                      5%
maximum                                    trace    critical
  rank    parms       LL        eigenvalue  statistic    value
    0       8      2638.0278          .      16.7113*   18.17
    1      11      2644.6397     0.02410      3.4874     3.74
    2      12      2646.3834     0.00641
------------------------------------------------------------------------------
```

For our test, the null hypothesis when Rank=0 is that there is no cointegration, meaning they have no long-run association. Since our trace statistics is less than our 5% critical value, we fail to reject the null hypothesis. Hence, there exist no cointegration among the variables.

C. Var Model

Since the conclusion from the Johansen cointegration test found that there are no long run relationship between the two variables, an unrestricted Vector Autoregression (VAR) model is run in order to determine whether there exists any short run relationship between the log of Canada-US Spot Exchange Rate and the log of total commodity prices deflated by US CPI. The results is displaced in appendix 21. Looking at the p-values on the table (See appendix 21) we find that the lags of the log of total commodity prices deflated by US CPI are statistically significant at 5% significance level. Implying that the log of commodity prices deflated by US CPI might contain information that will helps us predict the log of Canada-US Spot Exchange Rate. Also, the results show that the log of Canada-US Spot Exchange Rate does not contain any information that will helps us predict the log of commodity prices deflated by US CPI.

i. Diagnostic Tests for Checking the Var Model

a) LM Test for Residual Autocorrelation

This test implements a Lagrange multiplier (LM) test for autocorrelation in the residuals of VAR models, which was presented in Johansen (1995):

**Table 3: Results of LM Test for Residual Autocorrelation**

```
. varlmar,

  Lagrange-multiplier test
```

| lag | chi2 | df | Prob > chi2 |
|---|---|---|---|
| 1 | 6.9241 | 4 | 0.13995 |
| 2 | 8.2604 | 4 | 0.08249 |

```
  H0: no autocorrelation at lag order
```

Null Hypothesis: There is no autocorrelation. Using the p-value and a 5% significance level, we fail to reject the null hypothesis that there is no autocorrelation in the residuals for lag 1, hence this test gives no hint that our VAR model is maybe misspecified.

b) Test for Normally Distributed Disturbances

The Jarque- Berra test, skewness test and the kurtosis test were all used to test whether the Canada-US Spot Exchange Rate and all the other variables are normally distributed.

**Table 4: Results of Test for Normally Distributed Disturbances**

```
. varnorm, jbera skewness kurtosis

  Jarque-Bera test
```

| Equation | chi2 | df | Prob > chi2 |
|---|---|---|---|
| lnCanadaUSspotrate | 1145.187 | 2 | 0.00000 |
| lnDeflCommodityPrices | 94.334 | 2 | 0.00000 |
| ALL | 1239.521 | 4 | 0.00000 |

The null hypothesis is residuals are normally distributed. Using the p-value and a 5% significance level, we can reject the null hypothesis for the variables. Hence, the conclusion that the residuals are not normally distributed. Non-normal distributed disturbances indicate a possible misspecification of the model. Full results shown in appendix 22.

c) VAR Stability Analysis

**Table 5: Results of Test for VAR Stability**

```
. varstable

   Eigenvalue stability condition
```

| Eigenvalue | Modulus |
|---|---|
| .9876585 | .987658 |
| .9721058 | .972106 |
| .3293127 | .329313 |
| .1850754 | .185075 |

```
   All the eigenvalues lie inside the unit circle.
   VAR satisfies stability condition.
```

The results indicate that all the eigenvalues lie inside the unit circle hence the VAR satisfies stability condition.

D. Granger Causality

Now, we check the joint causality of the relationship between the log of Canada-US spot exchange rate and the log of price of all commodities deflated by the US CPI.

**Table 6: Results of Granger Causality Test**

```
. vargranger

   Granger causality Wald tests
```

| Equation | Excluded | chi2 | df | Prob > chi2 |
|---|---|---|---|---|
| lnCanadaUSspotr~e | lnDeflCommodity~s | 4.3309 | 2 | 0.115 |
| lnCanadaUSspotr~e | ALL | 4.3309 | 2 | 0.115 |
| lnDeflCommodity~s | lnCanadaUSspotr~e | 4.4989 | 2 | 0.105 |
| lnDeflCommodity~s | ALL | 4.4989 | 2 | 0.105 |

The null hypothesis for the Granger Causality Test is that all the log of Canada-US Spot Exchange Rate lagged variable does not cause or has no explaining power in predicting the log of deflated price of all Commodities and the vice versa. At 5% significance level, the test statistics show that we cannot reject the null hypothesis in both cases.

## 4. PART II

So far we have only looked at the reflects the patterns and trends of the total of all commodity price index specific to Canada and the Canadian – US spot exchange rate. In this section, we have a closer look at the major components of the commodity price indices of Canada namely energy, metals and minerals, agriculture, fish and forestry. Here, I consider whether these components share the same permanent shocks. That is I want to determine whether these price indices are cointegrated or not.

Data for the commodity price indices were sourced from the Statistics Canada database.

To proceed with my analysis, a unit root analysis is used to determine whether the variables are stationary or not. Similarly, I applied both the Augmented Dickey-Fuller Test (Dickey and Fuller, 1979) and DF-GLS (Elliot et al., 1996) unit root tests with an intercept and a trend to check the stationary of the variables.

The results indicated that the Augmented Dickey Fuller (ADF) test has the tendency of failing to reject the null hypothesis of unit root for the levels of all these variables except the ADF test for Forestry, which indicated a rejection of our null hypothesis of unit root. Also the DF-GLS test with trend showed some tendency of failing to reject the null hypothesis of unit root for the levels for some of the lags of all the variables. Therefore in levels, almost all the variables were found to be I(1) indicating that the variables are non-stationary. However, in first difference, both the Augmented Dickey Fuller (ADF) and DF-GLS tests rejected the null hypothesis of unit root meaning that that these tests found the variables to be stationary. All the results of the above test are displayed in Appendix (Appendix 23 – Appendix 52)

The Johansen cointegration test was performed to ascertain the presence of a long-run integrating relation among these variables. To carry out this test, the procedure specifies a null hypothesis that indicates that the log likelihood of the unconstrained model including the co-integrating equations is not significantly different from the log likelihood of the constrained model that does not include the cointegrating equations. An unrestricted model will be used in our analysis. The Akaike Information Criterion is used to determine the optimal lag length to perform the test. From the Johansen test, we conclude that there is the existence of 2 cointegrating relationships among the variables. However, we are unable to determine which of the variables are cointegrated.

Following from the cointegration analysis, we realise that there exist a long run relationship among variables. There we model the variables using a Vector Error Correlation Model (VECM) in order to capture both the short run and the long run relationship that exist between the variables. With an optimal lag length of 2, the result of the VECM is displayed as appendix 54. Energy price index appears to have a short run relation with agriculture price index at 5% significance level. However, there is no short run relations between energy and the other variables namely metals and mineral, fish and forestry. We also reject the existence of a short run relationship between agriculture and fish, metals and minerals and forestry at 5% significance level. Further, the results indicate a short run relationship between metals and minerals price index, agriculture price index and energy price index at 5% significance level. There is no short run relationship between the fish price index and the remaining variables.

Finally, a diagnostic test is done to ascertain the stability of the VECM. From the Langrage Multiplier Test, we reject the null hypothesis of on autocorrelation in the residuals for the first 2 lags (See appendix 55). The test for normality of the residuals using the Jarque-Bera test indicates that the residuals of all the price indices are not normally distributed (See appendix 56). However, the stability test shows that the Eigen values all lie within the unit root circle, hence we can conclude that the VECM satisfies stability condition.

# 5. CONCLUSION

This paper did an empirical investigation of the relationship between the Canada-US exchange rate and commodity prices specific to Canada using monthly observations on Canada-US spot exchange rate and commodity price indices consisting of 6 series, including, total of all commodity prices, agriculture, metals and minerals, energy, fish, and forestry price indices. The first part of this paper sort to analyse the relationship between Canada – US exchange rate and the total of all commodity prices in Canada. A unit root analysis using the Augmented Dickey-Fuller Test and DF-GLS tests showed that the variables are non-stationary at levels however, they are stationary after first differencing. A cointegration analysis is conducted, which proved that there is no cointegration relation between the two variables. The key insight of the Present Value approach employed in the paper by Chen, Rogoff and Rossi (2010) and adopted for this paper is that exchange rates granger causes commodity prices, after accounting for instabilities such as structural breaks. From the Granger Causality Wald test performed in this paper, it was realized that commodity prices does not granger cause the exchange rate and vice versa at 5% significance level. This contradicts the findings of Chen, Rogoff and Rossi (2010), that exchange rates predict world price commodity movements.

In the second part of this paper, unlike the deflated price of all commodities, the other price indices namely energy, metals and minerals, agriculture, fish and forestry are found to be cointegrated meaning that they do not drift too far apart from each other. They are all integrated of order 2 indicating that all variables share two shocks.

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