Is the Canadian dollar a commodity currency?: An empirical examination of the relationship between the US-Canada exchange rate and commodity prices

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1.0 Introduction

The co-movement between exchange rates and commodity prices has been well documented in the economic literature (Liu et al., 2020; Chen et al., 2010). It has been established that for some currencies such as the Canadian, Australian, and New Zealand dollar, commodity prices can forecast exchange rates (Chen et al., 2010) and hence the term "commodity-currencies". In this project, I examine the relationship between the US-Canada exchange rate and commodity prices. Using monthly time series from December 1972 to April 2017, I perform a cointegration test to establish a long-run relationship between US-Canada exchange rates and total commodity, energy, agriculture, and metals and minerals price indices. The results provided evidence of Canada having a commodity currency. The study is structured as follows; section 2 discusses the theoretical linkages between exchange rates and commodity prices; section 3 discusses the methodology employed; section 4 presents the results; and section 5 concludes.

2.0 Theoretical Framework

This section presents the theoretical underpinning which serves as the foundation to understand the relationship between exchange rates and commodity prices. According to Chen et al. (2010), the theoretical linkage between exchange rates and commodity prices can be explained in two stages. First, they argue that for those countries with commodity currencies, world commodity prices are a key determinant of the value of their exchange rate. Hence, changes in key commodity prices affect their exchange rate. Second, since the nominal exchange rate can be viewed as an asset price, it incorporates expectations about the values of its future fundamentals such as commodity prices; thus, the co-movement of the exchange rate and commodity prices.

Furthermore, Chen et al. (2010), like other studies, cited three alternative explanations for this currency-commodity price relationship. One such explanation is the sticky price model. According to the sticky price model, increases in commodity prices exert inflationary pressure on prices in the exporting country. These prices include exchange rates, real wages, and prices of non-traded goods. The issue here is that prices of non-traded goods and wages are sticky upwards. Hence, the inflationary pressure mainly hits the country's exchange rate, and the efficient relative price between traded and non-traded goods is then restored by currency appreciation.

Another often-cited explanation for the currency-commodity price relationship is the portfolio balance theory. The Portfolio Balance Model states that a commodity exporting country's exchange rate is heavily dependent on foreign-determined asset supply and demand fluctuations. Thus, commodity price increases lead to a balance of payments surplus and an increase in foreign holdings of the country's currency. Both factors, in turn, lead to an increase in the relative demand for the country's currency leading to positive currency returns (see Chen et al., 2010 for further detailed discussions).

The third explanation for commodity-to-currency relationships states that commodity price changes proxy exogenous shocks in a commodity-exporting country's terms of trade (Chen and Rogoff, 2003). Terms-of-trade shocks then lead to a shift in the relative demand for an exporter's currency which, in turn, leads to changes in that exporter's exchange rate (Chen et al., 2010).

3.0 Methodology and Data

This section discusses the data used in this study and the empirical tools needed to investigate the co-movement of the interest variables.

3.1 Empirical Approach

Given that the primary objective of this project is to investigate the long-run relationship between the US-Canada exchange rate and commodity prices, our main empirical technique is the cointegration analysis. It is a common practice in time series analysis to first conduct a stationarity or unit root test before advancing to any further analysis. This step helps to prevent potential issues of spurious or nonsense regression (or correlation) in the analysis. Hence, I present a brief discussion of the Unit Root Test and Cointegration Test.

3.1.1 Unit Root

A unit root test is used to determine whether a time series variable is non-stationary and possesses a unit root. A series is said to be (weakly) stationary if it has a constant mean, constant variance, and constant autocovariance. Two independent variables may be found to be correlated when they are non-stationary. Therefore, to prevent spurious regression, it is necessary to perform a unit root test to ascertain the stationarity status of the series (see Nelson & Plosser, 1982 for a detailed explanation). I use the Augmented-Dickey Fuller (ADF) tests to ascertain the stationarity and non-stationarity statuses of the variables under study (Dickey & Fuller, 1979). The null hypothesis is generally defined as the presence of a unit root and the alternative hypothesis is either stationarity, trend stationarity, or explosive root depending on the test used. The ADF test is based on the model of the first-order autoregressive process:

$$Y_t = \O Y_{t-1} + V_t, \qquad\qquad t = 1 \ldots T$$

Where Ø is the autoregression parameter; Y_t, Y_{t-1} are respective series and the first lag to be examined; V_t is the non-systematic component of the model that meets the characteristics of the white noise process. The null hypothesis is H_0: Ø = 1, that is the process contains a unit root and hence it is non-stationary and is denoted as I (1). The alternative hypothesis is H_1: |Ø| < 1, that is the process does not contain a unit root and is stationary, I (0).

3.1.2 Cointegration

The cointegration test is used to determine if there exists a linear combination of two or more non-stationary time series variables that is stationary (Dolado et al., 1990). The method helps identify long-run relationships or equilibrium for two or more variables. For example, two-time series variables are said to be cointegrated when they move together in the long run. There are several tests for co-integration such as the Engle-Granger test, Johansen test, and Phillips-Ouliaris test. This technique will help achieve the project's objective of investigating the long-run relationship between the US-Canada exchange rate and commodity prices. In this study, I employ both the Engle-Granger Test and Johansen Test to ensure the robustness of the results.

3.2 Data Description

The study uses secondary data on the monthly US-Canada exchange rate, total commodity price index, and price indices for energy, metals and mineral, agriculture, fish, and forestry. This data covers the period from December 1972 to April 2017. It was obtained from Statistics Canada; the commodity price indices are in Table 10-10-0132-01 and exchange rates were in Table 10-10-0009-01.

Table 1: Description of Variables

Variable	*Description*	*Source*
Exchange Rate	United States Dollar in terms of Canadian Dollar, Monthly	Statistics Canada, Table 10-10-0009-01
Total Commodity Price Index	Fisher Commodity Price Index for all commodities, in terms of US Dollar, Monthly	Statistics Canada, Table 10-10-0132-01
Energy	Fisher Commodity Price Index for Energy, in terms of US Dollar, Monthly	
Metals and Minerals	Fisher Commodity Price Index for Metals and Minerals, in terms of US Dollar, Monthly	
Agriculture	Fisher Commodity Price Index for Agriculture, in terms of US Dollar, Monthly	
Fish	Fisher Commodity Price Index for Fish, in terms of US Dollar, Monthly	
Forestry	Fisher Commodity Price Index for Forestry, in terms of US Dollar, Monthly	

4.0 Results

4.1 Descriptive Statistics

Table 2 presents the descriptive statistics of the variables used in this study. The data contains 533 observations for each variable over the period from December 1972 to April 2017. The average US-Canada exchange rate was $1.23 with a minimum of $0.96 and peaked at $1.60 in February 2002. The total commodity price index, which captures the prices of all traded commodities, averaged 333.80 with a standard deviation of 147.88. Prices of Energy also ranged from 101.60 to 2,755.80 with a mean of 753.18. There was a large variance in Energy prices which may be attributed in part to the steep ascent in the price of oil between 2004 and 2008.

Prices of Metals and Minerals, Agriculture, Fish, and Forest had averages of 342.19, 188.89, 634.83, and 264.14 respectively.

Table 2: Descriptive Statistics of Canada-US Exchange rate and Commodity Price Indices

Variable	Obs	Mean	Std. Dev.	Min	Max
Exchange rate	533	1.23	.17	.96	1.6
Total Commodity Prices	533	337.80	147.88	110.3	881.3
Energy	533	753.18	488.75	101.6	2755.8
Metals and Minerals	533	342.19	165.43	102.6	779.9
Agriculture	533	188.89	44.95	125.1	322.9
Fish	533	634.83	363.74	95.1	1503.6
Forest	533	264.14	70.02	107	411

Source: Author's computation using monthly data on the variables obtained from Statistics Canada

4.2 Correlation Analysis

In this section, I undertake a correlation analysis of the variables in levels and at first differences. I am particularly interested in the correlation between the exchange rate against the commodity price variables. The purpose of this is to identify and select the variables that can best predict the exchange rate for further analysis. That is, variables with a low correlation with the US-Canada exchange rate will be omitted from the analysis. Figure 1 presents the correlation between the exchange rate and commodity prices.

Figure 1: Pearson's Correlation Coefficients between US-Canada Exchange rate and the Commodity Prices

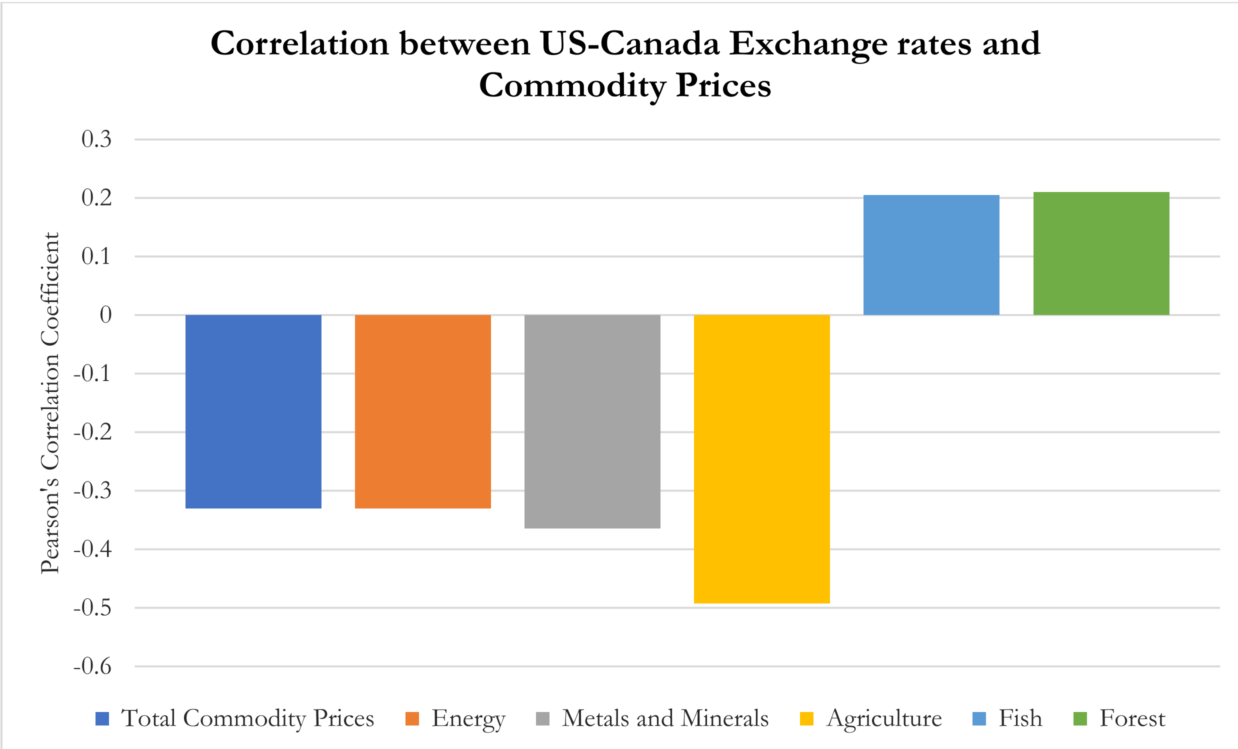


Figure 1 shows that at levels, the US-Canada exchange rate is positively correlated with the prices of Fish and Forest and negatively correlated with total commodity prices, energy, metal and minerals, and agriculture price indices. Agriculture prices have the highest correlation with a correlation coefficient of about –5.00. Second is the price index of Metals and Minerals (-0.364) followed by Energy prices (-0.33). This implies that increases in the prices of agricultural products, metals and minerals, and energy is associated with an appreciation of the Canadian dollar against the US dollar. Forest and Fish prices have the lowest correlation coefficient of about 0.21; hence increases in forest and fish prices are associated with a depreciation of the Canadian dollar against the US dollar. The observed correlations are significant at the 1% level for all the variables.

At first difference, all the commodity prices are negatively correlated with the US-Canada exchange rates. That is, increases in commodity prices are associated with an appreciation of the Canadian currency. As shown in Table 3, the correlations between the exchange rate and Total commodity prices, Metal and Minerals, Energy, and Agriculture prices are significant at a 1% level. However, prices of Fish and Forest are not significant at even a 10% level. Therefore, in further analysis, we focus on the relationship between US-Canada Exchange rates and total commodity prices, energy, metals and minerals, and agriculture.

Table 3: Pearson's Correlation Coefficients between US-Canada Exchange Rate and Commodity Prices

Variable	At Levels	At First Difference
Total Commodity Prices	-0.3300*	-0.4378*
Energy	-0.3302*	-0.3743*
Metals and Minerals	-0.3641*	-0.3886*
Agriculture	-0.4926*	-0.2500*
Fish	0.2054*	-0.0188
Forest	0.2102*	-0.0975

Note: * means p-value is less than 1% significance level, Bonferroni Adjusted

4.3 Unit Root Test

4.3.1 Testing for Unit Root of the US-Canada exchange rate

Figure 2: Line Graph and Correlogram of US-Canada Exchange Rate: At Level and First Difference

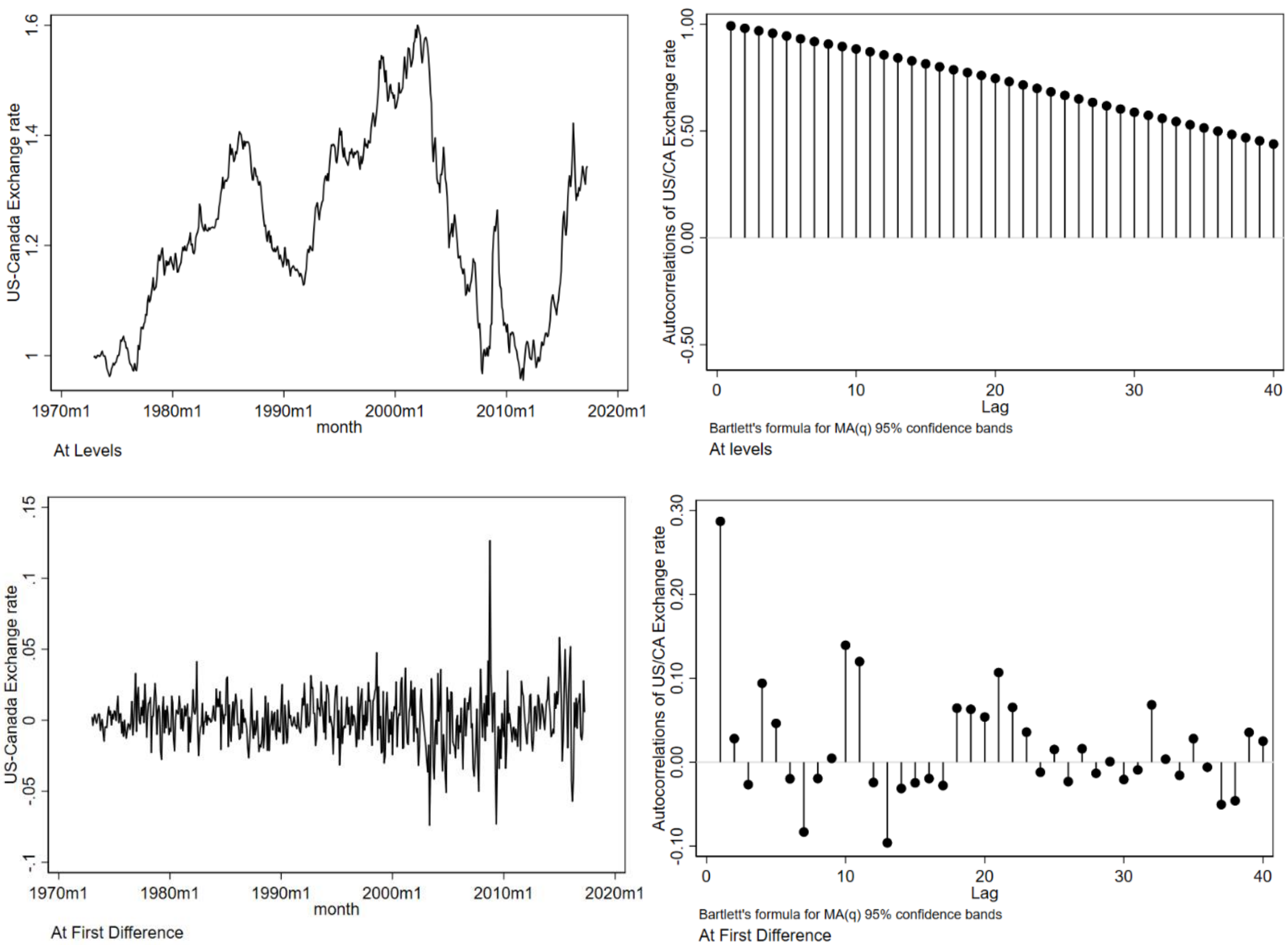
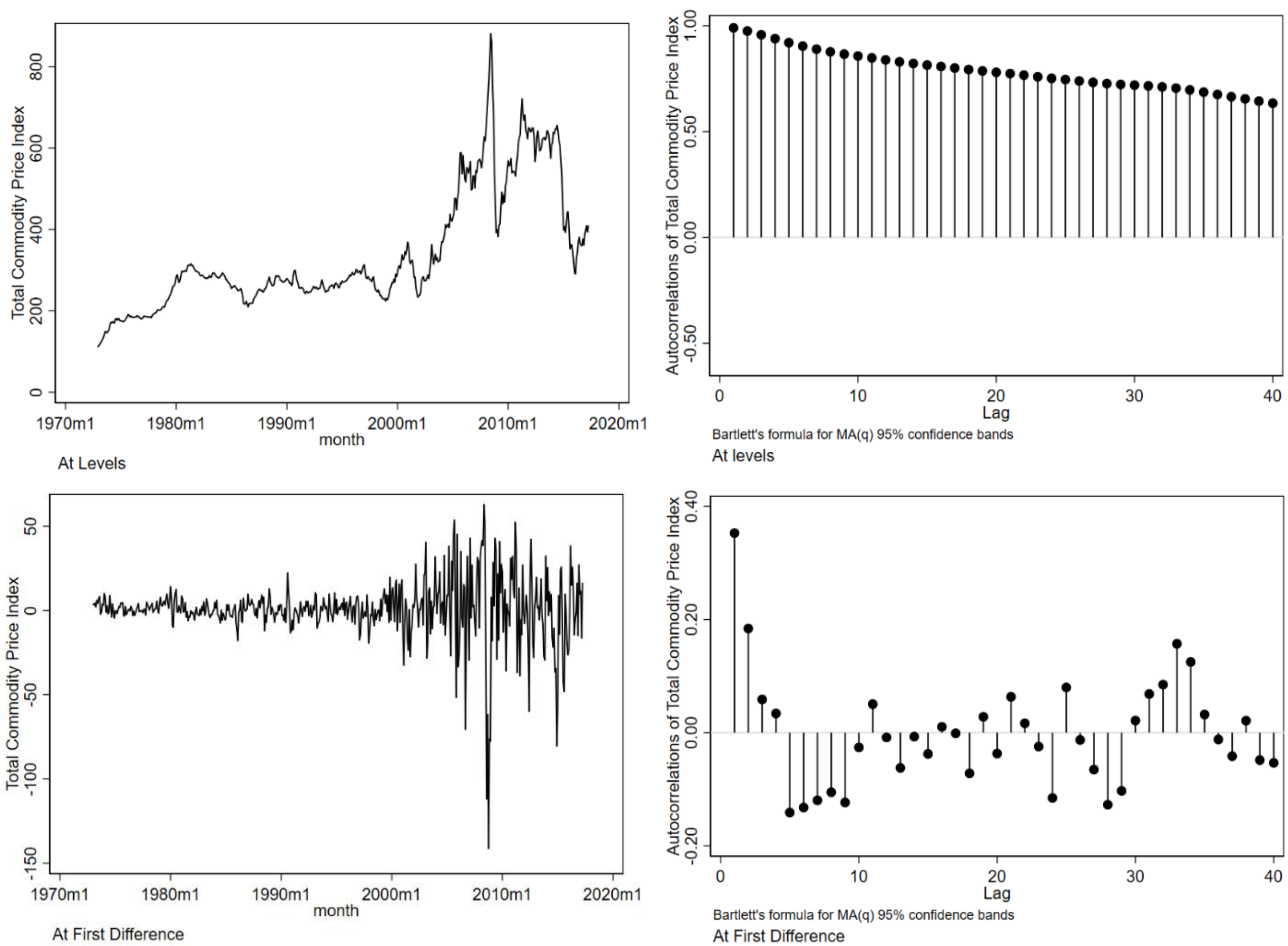


Figure 2 shows the line graph and autocorrelations of the US-Canada exchange both at levels and first difference. At levels, we observe that the movement of the exchange rate over time is a random walk without drift as it appears to be non-stationary. Also, there is no apparent trend in the data. After the first differencing, as shown in frame 3, the movement looks like white noise.

To confirm this observation, I perform an Augmented Dickey-Fuller test of a unit root. The results of the ADF test at levels with optimal lags of 2 show that the exchange rate variable has a unit root (see Appendix A.i). However, it has no unit root at first difference. Hence, the US-Canada exchange rate is integrated into order 1 i.e., I(1).

4.3.2 Testing for Unit Root of Total Commodity Price Index

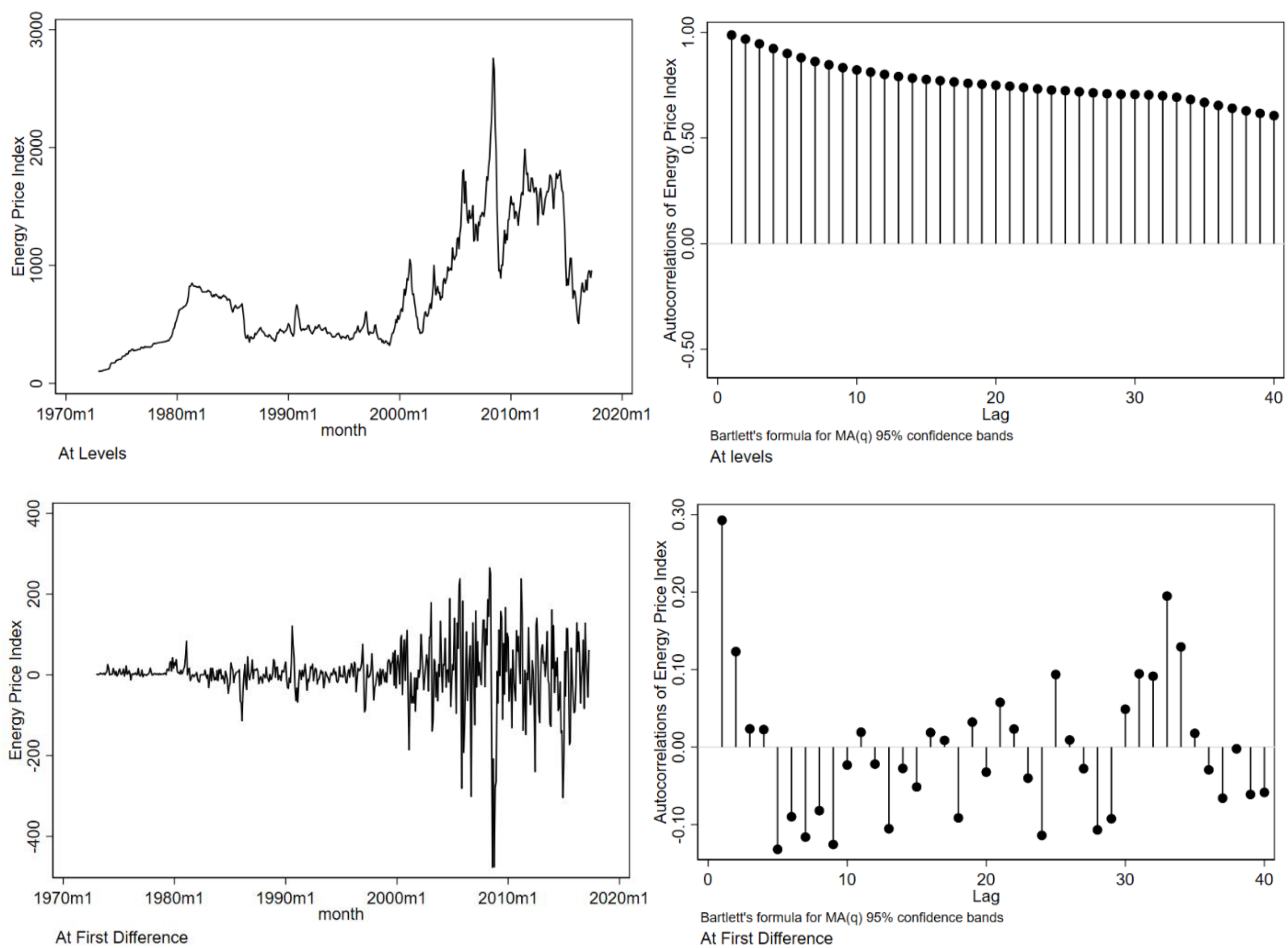
Figure 3: Line Graph and Correlogram of Total Commodity Price Index: At Level and First Difference



In frame 2 of figure 3, we observe an upward trend in the total commodity price index. Frames 3 and 4 suggest that first differencing the variable will make it stationary. Performing the ADF test with the trend and 2 lags show the absence of unit root at a 5% significance level (i.e., the MacKinnon approximate p-value is 0.0472). This implies that the variable is trend stationary. Furthermore, at the first difference, the variable is stationary as well (see Appendix A.ii).

4.3.3 Testing for Unit Root for Energy Price Index

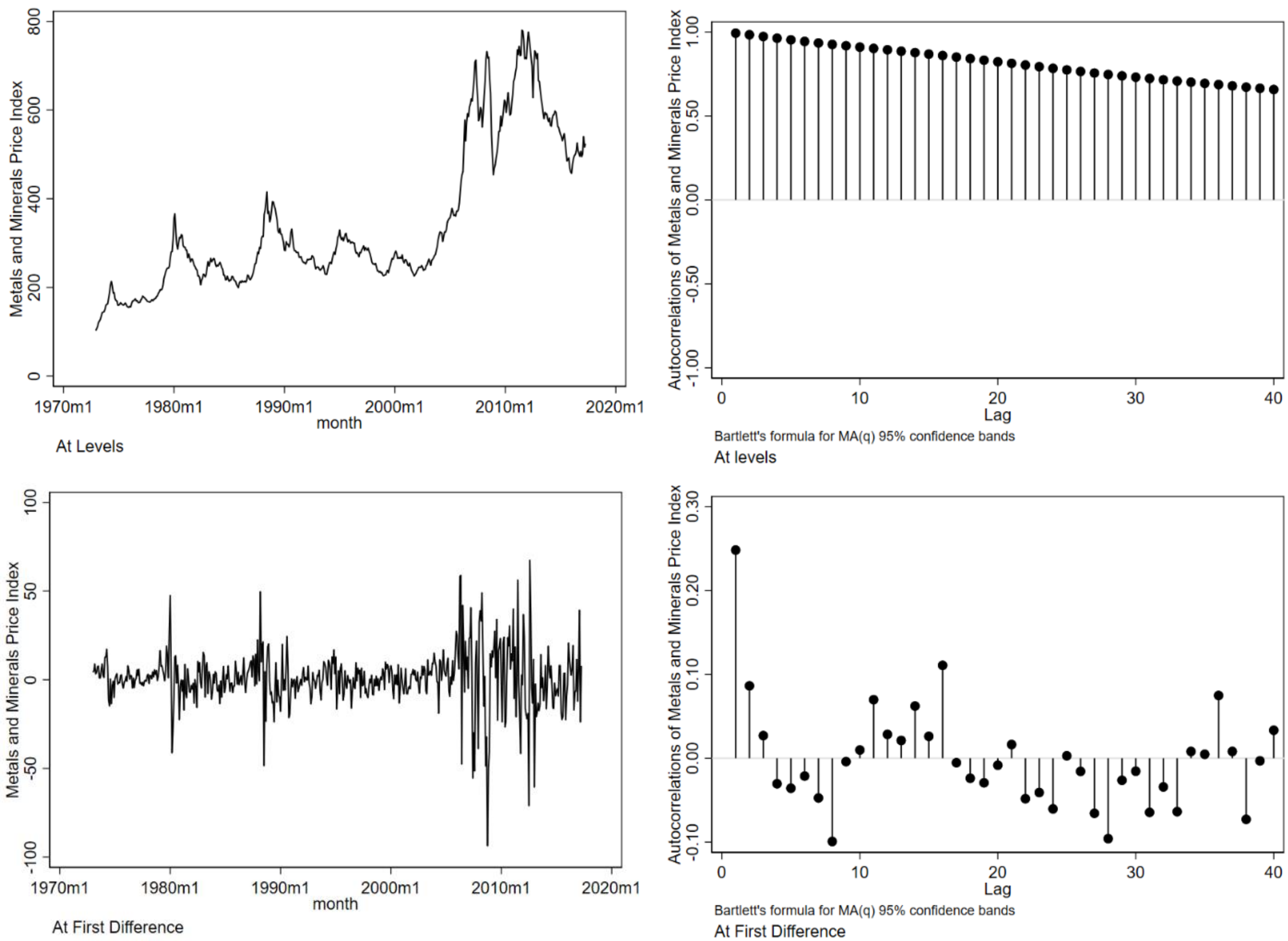
Figure 4: Line Graph and Correlograms of Energy Price Index: At Level and First Difference



The energy price index appears to be trending upwards. Frame 2 in figure 4 above suggests that the series is highly correlated with its past values. From the lag selection, I found the optimal lag to be 2 (see Appendix A.iii). The ADF test of the variables at levels with trend and 2 lags indicates that the variable is trend stationary at a 5% significance level. Also, testing for unit root at first difference reveals that the variable is stationary at first difference as shown in frame 3 of figure 4.

4.3.4 Testing for Unit Root for Metals and Minerals Price Index

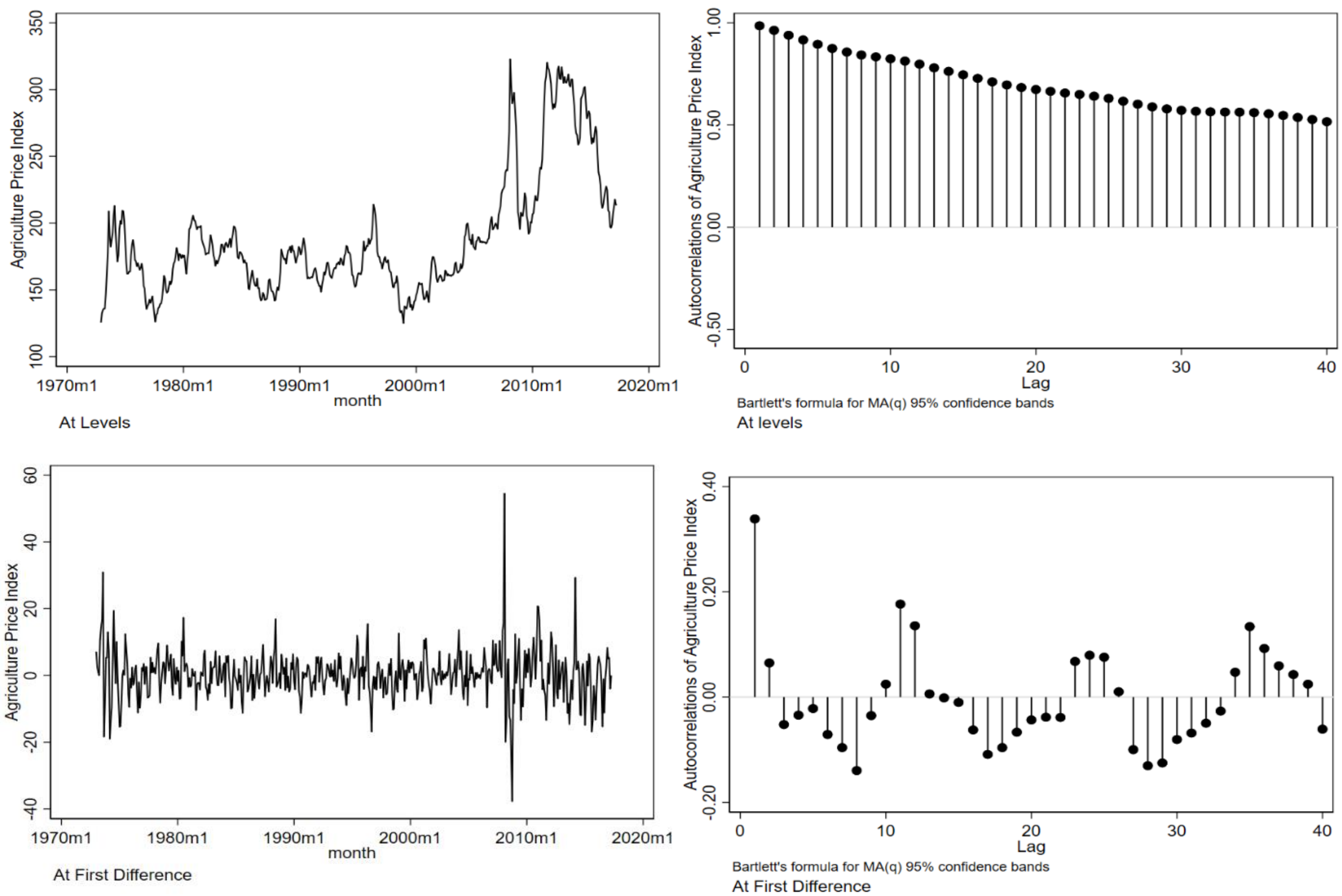
Figure 5: Line Graph and Correlograms of Metals and Minerals Price Index: At Level and First Difference



In figure 5, the line graph in frame 1 shows that the prices of metals and minerals are trending upwards over time and the correlogram suggests the presence of unit root. However, performing the ADF test at levels with the trend and optimal lags of 2 proves the presence of unit root. At first difference, the variable becomes stationary as shown in Appendix A.iv. The first difference line graph and autocorrelation graph shown in frames 3 and 4 above show that the series is stationary at first difference. Hence, the metals and minerals price index is I (1).

4.3.5 Testing for Unit Root for Agriculture Price Index

Figure 6: Line Graph and Correlograms of Agriculture Price Index: At Level and First Difference



The agriculture price index at levels with optimal lags of 2 is non-stationary from the ADF test (as shown in Appendix A.v). Even after adding the trend, the series is still non-stationary. However, when first differenced, the ADF test shows no presence of unit root. This is shown in frames 3 and 4 of figure 6. Therefore, the agricultural price index is integrated of order 1. I.e., I (1).

Table 4: Summary of Augmented Dickey-Fuller Unit Root Test

Variable	Unit Root Status
US-Canada Exchange rate	I (1)
Total Commodity Prices	I (0) with trend, I(1)
Energy	I (0) with trend, I(1)
Metals and Minerals	**I (1)**
Agriculture	**I (1)**

Note: All the variables have an optimal lag of 2.

Table 4 summarizes the results of the unit root tests. I found that the US-Canada exchange rate, Metals and Mineral prices, and Agriculture prices series are integrated into order 1. Energy prices and Total Commodity prices were found to be trend stationary. However, to perform the cointegration test, I will assume that all the variables are I (1).

4.4 Cointegration Test

In this section, I test for long-run relationships between the US-Canada exchange rate and the commodity price indices. Given the results from the unit root tests, all the variables are integrated in order 1. In the literature, the Johansen test is one of the prominent cointegration tests for I (1) series.

4.4.1 Johansen Test for Cointegration

The null hypothesis of the Johansen test is that there are no cointegrating equations while the alternative is that there exist cointegrating equations.

H_o: no cointegrating equations

H_1: H_o is not true.

Decision criteria:

- Rejection at the 5% level.
- Reject the null hypothesis if the value of the Trace and Max statistics > 5% critical value, otherwise, fail to reject the null hypothesis.

Table 5: Johansen Tests for Cointegration

Johansen tests for cointegration
Trend: Constant — Number of obs = 531
Sample: 1973m2 thru 2017m4 — Number of lags = 2

Maximum rank	Params	LL	Eigenvalue	Trace statistic	Critical value 5%
0	30	-6750.8033	.	73.3156	68.52
1	39	-6731.7545	0.06923	35.2180*	47.21
2	46	-6723.2933	0.03137	18.2955	29.68
3	51	-6718.1132	0.01932	7.9354	15.41
4	54	-6715.6383	0.00928	2.9856	3.76
5	55	-6714.1455	0.00561		

Maximum rank	Params	LL	Eigenvalue	Eigenvalue Maximum	Critical value 5%
0	30	-6750.8033	.	38.0976	33.46
1	39	-6731.7545	0.06923	16.9225	27.07
2	46	-6723.2933	0.03137	10.3601	20.97
3	51	-6718.1132	0.01932	4.9498	14.07
4	54	-6715.6383	0.00928	2.9856	3.76
5	55	-6714.1455	0.00561		

* selected rank

Table 5 presents the results of the Johansen Test of cointegration. I performed both the trace test and the maximum eigenvalue test of cointegration to ensure the robustness of the results. From the trace tests, at maximum rank 0, the trace statistic (73.31) is greater than the critical value (68.52) at a 5% significance level. Hence, we reject the null hypothesis of zero cointegrating equations. At maximum rank 1, the trace statistic (35.21) is less than the critical value of 47.21; thus, we fail to reject the null hypothesis of at most 1 cointegrating equation. We conclude that there is one cointegrating equation in the model. The observed results are corroborated by the results from the maximum eigenvalue test of cointegration as shown in Table 5.

5.0 Conclusion

Several studies have empirically investigated the relationship between exchange rates and commodity prices. A large strand of such studies found that exchange rates and commodity prices have both short-run and long-run relationships (for example Liu et al., 2020; Chen et al., 2010). Furthermore, these studies established that commodity prices can predict exchange rates; thus, the term “commodity currency” was coined for the currencies of countries such as Canada, New Zealand, and South Africa. Similar to these studies, I investigated the relationship between the US-Canada exchange rate and the commodity prices of Canada using monthly time series data from December 1972 to April 2017.

The correlation analysis revealed that the US-Canada exchange rate has a negative and significant association with Total Commodity prices, Energy, Metals and Minerals, and Agriculture price indices. This implies that increases in prices of those commodities is associated with an appreciation of the Canadian currency. Also, Fish and Forest price indices had a positive correlation with exchange rates. Furthermore, there is one cointegrating equation between exchange rates and total commodity prices, metals and minerals, energy, and agriculture prices. This provides evidence of a long-run relationship between the US-Canada exchange rate and commodity prices similar to the findings of Liu et al. (2010).

However, these results must be interpreted with caution. This is because although energy and total commodity price indices were found to be trend stationary, I assumed them to be I (1) to undertake the Johansen test of cointegration. A better approach may be to use the Autoregressive Distributed Lag Models (ARDL) since the variables are a combination of I (0) and I (1). Unfortunately, this model is beyond the scope of this project.

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Appendix

A. Unit Root Tests

i. Testing for Unit Root of US-Canada Exchange Rate

Lag Selection

```
. varsoc usd_nspra

Lag-order selection criteria

   Sample: 1973m4 thru 2017m4                            Number of obs = 529
```

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	204.96				.027079	-.771115	-.767955	-.763042
1	1376.91	2343.9	1	0.000	.000324	-5.19816	-5.19184	-5.18202
2	1400.27	46.716*	1	0.000	.000297*	-5.28269*	-5.27321*	-5.25847*
3	1401.05	1.5594	1	0.212	.000298	-5.28186	-5.26922	-5.24956
4	1401.12	.12773	1	0.721	.000299	-5.27832	-5.26252	-5.23795

```
   * optimal lag
   Endogenous: usd_nspra
    Exogenous: _cons
```

Augmented Dickey-Fuller Test for Unit Root

<u>At levels with 2 lags</u>

```
. dfuller usd_nspra, lags(2)

Augmented Dickey-Fuller test for unit root

Variable: usd_nspra                          Number of obs  = 530
                                             Number of lags =   2

H0: Random walk without drift, d = 0
```

	Test statistic	Dickey-Fuller critical value 1%	5%	10%
Z(t)	-1.830	-3.430	-2.860	-2.570

MacKinnon approximate *p*-value for Z(t) = 0.3659.

At first difference

```
. dfuller d.usd_nspra

Dickey-Fuller test for unit root          Number of obs  = 531
Variable: D.usd_nspra                     Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test      ———————— critical value —————————
              statistic           1%           5%          10%
——————————————————————————————————————————————————————————————
 Z(t)           -17.119       -3.430       -2.860       -2.570
——————————————————————————————————————————————————————————————
MacKinnon approximate p-value for Z(t) = 0.0000.
```

ii. Testing for Unit Root of Total Commodity Price Index

Lag Selection

```
. varsoc price_all_commodity

Lag-order selection criteria
```

Sample: 1973m4 thru 2017m4 Number of obs = 529

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-3390.65				21698.7	12.8229	12.826	12.831
1	-2279.14	2223	1	0.000	325.865	8.62436	8.63068	8.64051
2	-2242.93	72.417*	1	0.000	285.251	8.49125	8.50073*	8.51547*
3	-2241.42	3.0341	1	0.082	284.694*	8.48929*	8.50193	8.52159
4	-2241.3	.23195	1	0.630	285.647	8.49263	8.50843	8.533

```
* optimal lag
Endogenous: price_all_commodity
 Exogenous: _cons
```

ADF Test

At level with trend and 2 lags

```
. dfuller price_all_commodity, trend lags(2)

Augmented Dickey–Fuller test for unit root

Variable: price_all_comm~y                Number of obs  = 530
                                          Number of lags =   2

H0: Random walk with or without drift

                                       Dickey–Fuller
                   Test      ──────── critical value ─────────
              statistic           1%           5%          10%
──────────────────────────────────────────────────────────────
 Z(t)            -3.433       -3.960       -3.410       -3.120
──────────────────────────────────────────────────────────────
MacKinnon approximate p-value for Z(t) = 0.0472.
```

At first difference

```
. dfuller d.price_all_commodity

Dickey–Fuller test for unit root          Number of obs  = 531
Variable: D.price_all_co~y                Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey–Fuller
                   Test      ──────── critical value ─────────
              statistic           1%           5%          10%
──────────────────────────────────────────────────────────────
 Z(t)           -15.889       -3.430       -2.860       -2.570
──────────────────────────────────────────────────────────────
MacKinnon approximate p-value for Z(t) = 0.0000.
```

iii. Testing for Unit Root of Energy Price Index

Lag Selection

```
. varsoc energy

Lag-order selection criteria

   Sample: 1973m4 thru 2017m4                           Number of obs = 529
```

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-4024.04				237913	15.2175	15.2207	15.2256
1	-3018.39	2011.3	1	0.000	5331.36	11.4192	11.4256	11.4354
2	-2993.47	49.843*	1	0.000	4870.35*	11.3288*	11.3383*	11.353*
3	-2992.77	1.3996	1	0.237	4875.89	11.3299	11.3426	11.3622
4	-2992.71	.10806	1	0.742	4893.36	11.3335	11.3493	11.3739

```
   * optimal lag
   Endogenous: energy
    Exogenous: _cons
```

ADF Test

At levels with trend and 2 lags

```
. dfuller energy, trend lags(2)

Augmented Dickey-Fuller test for unit root

Variable: energy                          Number of obs  = 530
                                          Number of lags =   2

H0: Random walk with or without drift
```

	Test statistic	Dickey-Fuller critical value 1%	5%	10%
Z(t)	-3.467	-3.960	-3.410	-3.120

MacKinnon approximate *p*-value for Z(t) = 0.0431.

At first difference

```
. dfuller d.energy

Dickey-Fuller test for unit root          Number of obs  = 531
Variable: D.energy                        Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test      -------- critical value ---------
              statistic           1%           5%          10%
--------------------------------------------------------------
 Z(t)           -16.997       -3.430       -2.860       -2.570
--------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```

iv. Testing for Unit Root of Metals and Minerals

Lag Selection

```
. varsoc metmin

Lag-order selection criteria

   Sample: 1973m4 thru 2017m4                        Number of obs = 529
```

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-3450.58				27216.7	13.0495	13.0526	13.0575
1	-2199.22	2502.7	1	0.000	240.888	8.32221	8.32853	8.33836
2	-2182.09	34.27*	1	0.000	226.632*	8.2612*	8.27069*	8.28543*
3	-2181.86	.46723	1	0.494	227.29	8.2641	8.27674	8.2964
4	-2181.85	.0061	1	0.938	228.148	8.26787	8.28367	8.30824

```
   * optimal lag
   Endogenous: metmin
    Exogenous: _cons
```

ADF Test

At levels with 2 lags

```
. dfuller metmin, lags(2)

Augmented Dickey–Fuller test for unit root

Variable: metmin                          Number of obs  = 530
                                          Number of lags =   2

H0: Random walk without drift, d = 0

                                     Dickey–Fuller
                 Test      ———————— critical value —————————
              statistic          1%           5%          10%
──────────────────────────────────────────────────────────────
 Z(t)            -1.555      -3.430       -2.860       -2.570
──────────────────────────────────────────────────────────────
MacKinnon approximate p-value for Z(t) = 0.5063.
```

At first difference

```
. dfuller d.metmin

Dickey–Fuller test for unit root          Number of obs  = 531
Variable: D.metmin                        Number of lags =   0

H0: Random walk without drift, d = 0

                                     Dickey–Fuller
                 Test      ———————— critical value —————————
              statistic          1%           5%          10%
──────────────────────────────────────────────────────────────
 Z(t)           -17.848      -3.430       -2.860       -2.570
──────────────────────────────────────────────────────────────
MacKinnon approximate p-value for Z(t) = 0.0000.
```

v. Testing for Unit Root of Agriculture Price Index

Lag Selection

```
. varsoc agric

Lag-order selection criteria

   Sample: 1973m4 thru 2017m4                             Number of obs = 529
```

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-2761.99				2014.7	10.4461	10.4493	10.4542
1	-1783.77	1956.4	1	0.000	50.0807	6.75151	6.75783	6.76766
2	-1749.88	67.79*	1	0.000	44.2241*	6.62715*	6.63663*	6.65137*
3	-1749.37	1.028	1	0.311	44.3054	6.62898	6.64163	6.66128
4	-1748.61	1.5142	1	0.219	44.3461	6.6299	6.6457	6.67027

```
   * optimal lag
   Endogenous: agric
    Exogenous: _cons
```

ADF Test

At levels with trend and 2 lags

```
. dfuller agric, trend lags(2)

Augmented Dickey-Fuller test for unit root

Variable: agric                       Number of obs  = 530
                                      Number of lags =   2

H0: Random walk with or without drift
```

	Test statistic	Dickey-Fuller critical value 1%	5%	10%
Z(t)	-3.093	-3.960	-3.410	-3.120

MacKinnon approximate *p*-value for Z(t) = 0.1078.

At first difference

```
. dfuller d.agric

Dickey-Fuller test for unit root          Number of obs  = 531
Variable: D.agric                         Number of lags =   0

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test      ———————— critical value —————————
              statistic           1%           5%          10%
——————————————————————————————————————————————————————————————
 Z(t)           -16.186       -3.430       -2.860       -2.570
——————————————————————————————————————————————————————————————
MacKinnon approximate p-value for Z(t) = 0.0000.
```

B. Stata Codes for the Project

```
// Project 1: Relationship between the Canada-US exchange rate commodity prices

// Load the data
use "project1.dta", clear

// Format the date into monthly time variable
gen month = tm(1972m12)+_n-1
format month %tm

// Specify data as time series
tsset month, monthly

// Descriptive Statistics
summarize usd_nspra price_all_commodity energy metmin agric fish forest, separator(10)
// Export to Word
asdoc summarize usd_nspra price_all_commodity energy metmin agric fish forest,
separator(10)

// Correlation between Exchange rate and Commodity prices
// At levels
pwcorr usd_nspra price_all_commodity energy metmin agric fish forest, sig bonferroni

// Generate First Differences of the variables
gen dusd_nspra = d.usd_nspra
gen dprice_all_commodity = d.price_all_commodity
gen denergy = d.energy
gen dmetmin = d.metmin
gen dagric = d.agric
gen dfish = d.fish
gen dforest = d.forest
```

```
// Correlation At first difference
pwcorr dusd_nspra dprice_all_commodity denergy dmetmin dagric dfish dforest, star(0.1)
bonferroni

// Unit Root Test

// Exchange rate
// At levels
twoway (tsline usd_nspra, lcolor(black)), ytitle(US-Canada Exchange rate) ttitle(, color(black))
caption(At Levels) scheme(s1mono)
// Autocorrelations
ac usd_nspra, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none) lpattern(dash))
ytitle(Autocorrelations of US/CA Exchange rate) caption(At levels) scheme(s1mono)
// At First Difference
twoway (tsline d.usd_nspra, lcolor(black)), ytitle(US-Canada Exchange rate) ttitle(,
color(black)) caption(At First Difference) scheme(s1mono)

ac d.usd_nspra, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none) lpattern(dash))
ytitle(Autocorrelations of US/CA Exchange rate) caption(At First Difference) scheme(s1mono)

// Dfuller tests for Exchange rate
// Optimal Lags
varsoc usd_nspra
// optima lags == 2

dfuller usd_nspra, lags(2)
dfuller d.usd_nspra
// Exchange rate is I(1)

// Total Commodity Prices
// At levels
twoway (tsline price_all_commodity, lcolor(black)), ytitle(Total Commodity Price Index)
ttitle(, color(black)) caption(At Levels) scheme(s1mono)
// Autocorrelations
ac price_all_commodity, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none)
lpattern(dash)) ytitle(Autocorrelations of Total Commodity Price Index) caption(At levels)
scheme(s1mono)
// At First Difference
twoway (tsline d.price_all_commodity, lcolor(black)), ytitle(Total Commodity Price Index)
ttitle(, color(black)) caption(At First Difference) scheme(s1mono)

ac d.price_all_commodity, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none)
lpattern(dash)) ytitle(Autocorrelations of Total Commodity Price Index) caption(At First
Difference) scheme(s1mono)

// Dfuller Test for Total Commodity Prices
varsoc price_all_commodity
```

```
// optimal lags == 2
dfuller price_all_commodity, trend lags(2)
// Trend Stationary - I(0) with trend at 5% level
dfuller d.price_all_commodity

// Energy Price Index
// At levels
twoway (tsline energy, lcolor(black)), ytitle(Energy Price Index) ttitle(, color(black)) caption(At Levels) scheme(s1mono)
// Autocorrelations
ac energy, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none) lpattern(dash)) ytitle(Autocorrelations of Energy Price Index) caption(At levels) scheme(s1mono)

// At First Difference
twoway (tsline d.energy, lcolor(black)), ytitle(Energy Price Index) ttitle(, color(black)) caption(At First Difference) scheme(s1mono)

ac d.energy, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none) lpattern(dash)) ytitle(Autocorrelations of Energy Price Index) caption(At First Difference) scheme(s1mono)

// Dfuller Energy
varsoc energy
// Optimal lags == 2
dfuller energy, trend lags(2)
// Trend Stationary - I(0) at 5%
dfuller d.energy


// Metals and Minerals Prices
// At levels
twoway (tsline metmin, lcolor(black)), ytitle(Metals and Minerals Price Index) ttitle(, color(black)) caption(At Levels) scheme(s1mono)
// Autocorrelations
ac metmin, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none) lpattern(dash)) ytitle(Autocorrelations of Metals and Minerals Price Index) caption(At levels) scheme(s1mono)
// At First Difference
twoway (tsline d.metmin, lcolor(black)), ytitle(Metals and Minerals Price Index) ttitle(, color(black)) caption(At First Difference) scheme(s1mono)

ac d.metmin, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none) lpattern(dash)) ytitle(Autocorrelations of Metals and Minerals Price Index) caption(At First Difference) scheme(s1mono)

// Dfuller Metals and Minerals
varsoc metmin
// Optimal lags == 2
dfuller metmin, lags(2)
```

```
dfuller d.metmin
// Metals and Minerals is I(1)


// Agriculture Prices
// At levels
twoway (tsline agric, lcolor(black)), ytitle(Agriculture Price Index) ttitle(, color(black))
caption(At Levels) scheme(s1mono)
// Autocorrelations
ac agric, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none) lpattern(dash))
ytitle(Autocorrelations of Agriculture Price Index) caption(At levels) scheme(s1mono)
// At First Difference
twoway (tsline d.agric, lcolor(black)), ytitle(Agriculture Price Index) ttitle(, color(black))
caption(At First Difference) scheme(s1mono)

ac d.agric, mcolor(black) lcolor(black) ciopts(recast(rline) lcolor(none) lpattern(dash))
ytitle(Autocorrelations of Agriculture Price Index) caption(At First Difference)
scheme(s1mono)

// Dfuller for Agric
varsoc agric
// Optimal Lags == 2
dfuller agric, trend lags(2)
dfuller d.agric
// Agric is I(1)

// Cointegration Tests
vecrank usd_nspra price_all_commodity energy metmin agric, trend(constant) max
```