An analysis of the Canadian and US currency components in the business cycle

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Major Paper presented to the

Department of Economics of the University of Ottawa

in partial fulfillment of the requirements of the M.A. Degree

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Ottawa, Ontario
2009

Acknowledgement

I would like to thank Professor Serge Coulombe for his guidance and feedback on this report. I would also like to thank him and his colleagues Professors Michel Beine and Charles S. Bos for providing the data for the currency, energy price, and non-energy commodity components.

Abstract

Beine, Bos, and Coulombe (2009) derive the currency, energy price and non-energy commodity components to show that Canada suffers from the Dutch Disease. They noted that the currency components "reflect the autonomous evolution of currencies independently of the numeraire they are measured[1]" and the energy price and non-energy commodity components are "independent of the evolution of the US dollar.[2]"The aim of this report is to use the Canadian and US currency components and the price components to see if any of the components have any effect on the real GDP of Canada and the US. This report will use the vector autoregression (VAR) and the error correction models to show that the prices more than the currency components have an effect on the Canadian real GDP and business cycle. It will also show that it is the US currency component rather than Canadian currency component that have an effect on Canada. The US business cycle and real GDP will be shown in the report to be affected by the US domestic factors. It can provide policymakers more insight on how to deal with future expansions and recessions because monetary and fiscal policy can have an effect on the domestic currency.

[1] See Beine, Bos, and Coulombe (2009) for more details on how the currency components were derived.
[2] See Beine, Bos, and Coulombe (2009) on how the energy and non-energy components were derived.

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1. Introduction

Canada and the United States, when faced with a recession (expansion), demonstrate a trend of negative (positive) growth in GDP and an increase (decrease) in unemployment. Net exports, a small component of the GDP, tends to increase (decrease) during a recession (an expansion) (Williamson, 2004 and Romer, 2005). The real exchange rate plays a large role in determining the level of goods a country exports and imports. According to economic theory, a real depreciation of the domestic currency means that the amount of goods a domestic country can export increases and the amount of goods the country imports decreases, assuming the Marshall-Lerner condition holds.

It is not simple to establish a relationship between the real exchange rate and real GDP. One reason is that different types of macroeconomic shocks do not affect the real exchange rate the same way it does with output (Chadha and Prasad, 1997). Studies by different economists showed that nominal and real shocks affect the real exchange rate and output differently. Chadha and Prasad (1997) use vector auto-regressions to show that real demand and nominal shocks have the largest impact on the Japanese real effective exchange rate and that supply shocks impacts Japan's relative output. Backus (1986) uses the vector auto-regression for the Canada/US exchange rate and finds that real shocks are more likely to affect the Canada/US exchange rate permanently than nominal shocks.

It is difficult to create a model that involves the real exchange rate because it is based on the long run purchasing power parity (PPP). The PPP theory is not supported by empirical evidence (Devereux, 1997 and Krugman and Obstfeld, 2009). Cushman (2007) finds that the real exchange rate trends tend to exhibit non-linear behavior.

Amano and van Norden (1995) use the error correction approach to show that the Canada/US real exchange rate and the energy and non-commodity prices have a statistically significant relationship. Beine, Bos, and Coulombe (BBC in the following) (2009) question the accuracy of the Amano and van Norden (1995) report citing that the report has not taken into account the possible effects of exogenous shocks to the US dollar that would bring changes to the commodity prices as well as the Canadian dollar. They argue that the use of real exchange rates can "lead to misleading results since autonomous movements of the US dollar affect both the Canadian exchange rate and the prices of energy and commodities." [3]

[3] See Beine, Bos, and Coulombe (2009) for further analysis.

BBC (2009) derive currency, energy price and non-energy commodity components and use that to suggest that the Canadian economy suffered from what is called the Dutch Disease. According to BBC (2009), the currency components "reflect an autonomous evolution of currencies independently of the numeraire they are measured" and the energy price and non-energy commodity components are "independent of the evolution of the US dollar."[4]

This report will use the Canadian and American currency components and the price components to see if they affect domestic real GDP and business cycles. It will also investigate if changes to the domestic GDP and business cycle are attributed to the variation of the domestic currency or the currency of another country. The quarterly data covers the period 1973 to 2007. I find that the US currency component, the energy price component and non-energy commodity component have an effect on the real Canadian gross domestic product (GDP). The relationship between the US currency component and US real GDP is not robust.

The first step in the analysis is to perform unit root test which show that the Canadian and American currency and price components are not stationary but are I(1). The next step is to make the data stationary by taking the first difference of the currency components, the energy price and non-energy commodity components and the log of the real GDP. I also use the Hodrick-Prescott filter to extract the cyclical components of the series of the real GDP and the currency components. The next step in the analysis is to examine the correlations between the currency components, the energy price and non-energy commodity components and the real GDP of Canada and the United States. Afterwards, I perform cointegration tests on the currency and price components as well as the real GDP to see if the linear combination of these variables is stationary. This is followed by a vector auto-regression (VAR) analysis of the currency components, and the real GDP for both the first difference and cyclical components. An error correction model will also be derived the same way as in Amano and van Norden (1997) and BBC (2009). The only difference in this analysis is that output will be added to the model.

The paper will be arranged as follows. The second section will focus on the currency components derived and used by BBC (2009) together with the energy price and non-energy commodity components also derived by them to show that the Canadian economy suffered

[4] See Beine, Bos, and Coulombe(2009)

from Dutch Disease and the various external macroeconomic shocks to the real exchange rate and the relative output discussed by Chadha and Prasad (1997). The third section will have a discussion on the type of data that was used for this report. This is followed by the fourth section that contains the procedures used for estimating the results. The fifth section will contain the results. The sixth section will discuss possible data limitations of this study and its possible extensions. This is followed by the conclusion.

2. Review of currency and energy price components

Currency components are new concepts introduced by BBC (2009). They are what BBC (2009) call "the reflection of the autonomous evolution of currencies independent of the numeraire they measure". They derive the Canadian and US currency components by "extracting them from the bilateral Canadian and US exchange rate" (BBC, 2009). According to BBC (2009), the Canadian currency component "captures the strength of the CAD" and the US currency component "captures the strength of the USD."[5] BBC (2009) also derive the energy price and non-energy commodity components which they explain are "independent of the US dollar." The energy price and non-energy commodity components are derived by using the US currency component "to extract the effect of the USD from energy and commodity prices."[6] (BBC, 2009)

In their analysis of the Dutch Disease in Canada, BBC(2009) focus on the Canada/US exchange rate where they derive two currency factors, the Canadian currency component and the US currency component. If the bilateral exchange rate data is used for analysis, it can lead to misleading results. Amano and van Norden (1995) find that the Canada/US exchange rate has a significant relationship with the commodity and energy prices over the 1972 to 1993 period. BBC (2009) use the same exchange rate and price data as Amano and van Norden (1995) for three periods: 1) 1972 to 2007 (whole period) , 2) 1972 to 1993 (the period Amano and van Norden period), and 3) 1983 to 2007 (the period Canada becomes a net exporter of energy[7]) . They find that the relationship is not robust.

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[5] See Beine, Bos, and Coulombe (2009) for more details on how they derive the currency components.
[6] See Beine, Bos, and Coulombe (2009) for more details on how they derive the energy price and non-energy commodity components.
[7] This information came from the Beine, Bos, and Coulombe (2009) article.

BBC (2009) use the Canada and US currency components and the energy price and non-energy commodity components to show that the Dutch Disease exists in Canada. Dutch Disease exists when a boom in the domestic country's natural resources leads to a real appreciation of its currency, making its manufacturing goods "less competitive" with those of their foreign counterparts, and causing the "de-industrialization of its economy" (InvestorWords, 2009).[8] BBC(2009) noted that two conditions must hold to prove that Canada suffers from the Dutch Disease, 1) "the evolution of the Canadian currency should be driven by the evolution of energy and/or commodity prices" and 2) "part of the appreciation associated with commodity prices should negatively affect Canadian employment in the manufacturing sector." They show that both conditions hold.

By using the Amano and van Norden (1995) approach, BBC (2009) find that the energy prices have a positive relationship with the US currency component (appreciation of the US currency) but not with the Canadian currency component in the 1972 to 1993 period. They also find that commodity and energy prices cause the appreciation of the Canadian currency component but not the US currency components, which confirm the first condition holds. The bilateral exchange rate would not detect a presence of the Dutch Disease. BBC (2009) noted that it is because the "bilateral CAD/USD would reject the case of a positive correlation between the Canadian currency and the commodity and energy prices."

Using the exchange rate in this type of analysis can be misleading because the US dollar is part of both the Canada/US bilateral exchange rate and the energy and commodity prices. BBC (2009) did point out that "exogenous shocks to the US dollar will affect both commodity prices and the Canadian dollar." For this report, I use the Canadian and US currency components instead of the Canada/US exchange rate for analyzing the effect of the exchange rate on business cycle. I also use the energy price and non-energy commodity components instead of the energy and commodity prices.

To show that the second condition holds, BBC (2009) use the Canadian and US currency components to see their effect on employment in the Canadian manufacturing sector. They find that the appreciation of the Canadian currency component has a negative effect on the Canadian manufacturing sector while the U.S. currency component has a negative effect on it.

[8] Definition of Dutch Disease is also found in Beine, Bos, and Coulombe (2009).

They also use the currency components to see if they had any effect on the level of employment in different manufacturing sectors in Canada. BBC (2009) find that the Canadian currency component has an effect on some of the manufacturing sectors and the US currency components on some other sectors.

In this report, I use real GDP of Canada and the US instead of using the level of employment in the manufacturing sector in Canada for analyzing the currency components. The effect of the currency components on the real GDP will be different from the effect of the currency components from the manufacturing goods because they represent only 14% of the real GDP. [9]

In a study that is related to this report, Chadha and Prasad (1997) use vector autoregression (VAR) to determine which type of shocks have an impact on the real exchange rate and aggregate output fluctuations and identify which shocks affect the real effective exchange rate and the relative output in Japan. They find that the supply shock has a positive and permanent effect on relative output. Chadha and Prasad (1997) also find that the demand shock has a positive permanent effect and the supply shock has a negative permanent effect on the real exchange rate.

The findings of Chadha and Prasad (1997) confirm that it is not easy to establish a relationship between the real exchange rate and real output. In this report, I use the Canadian and US currency components to see if there is a relationship between these new measures of exchange rate and the business cycle.

3. Data used in the report

The data I use in this report are the quarterly data of the Canadian real GDP, US real GDP, Canadian currency component, US currency component, energy price component, commodity (non-energy) price component, and the real interest differential.[10] The sample data in this report is for three periods: 1) 1972 to 2007 (the whole period), 2) 1972 to 1993 (the period Amano and van Norden (1995) use in their paper), and 3) 1983 to 2007 (BBC (2009) use in their report, the period where Canada becomes a net exporter of energy).

[9] The percentage is from the Statistics Canada data for May 2008.
[10] See Appendices B and C which contain all the data sources and the CANSIM number from Statistics Canada for this report and the Beine, Bos, and Coulombe (2009) respectively.

3.1 Real Gross Domestic Product (GDP)

The Canadian and US real GDP are the "expenditure based" GDP that was obtained from Statistics Canada's CANSIM database. Statistics Canada (2009) defined expenditure based GDP as "adding the final expenditures of the four sectors of the economy: persons, businesses, governments, and non-residents." As for the real GDP, it was defined by Statistics Canada as "...calculated in terms of expenditure as components of income based GDP..." Using the real GDP is appropriate in this case because as Statistics Canada (2009) pointed out, the real GDP is a good indicator of how healthy the economy is. In this report, I take the natural logarithm of the real GDP (real GDP in the following) and use it for the analysis.[11]

3.2 Currency Components

The currency components, price components, and real interest rate differential are the data used in the BBC (2009) article and given to me by the authors. The authors note that Canadian and American currency components "reflect the autonomous evolution of currencies."The currency and price components are appropriate in this case because it was already shown to be more useful than the bilateral exchange rate.

3.3 Energy price and non-energy commodity components

BBC (2009) noted that energy and non-energy components "capture the evolution of energy and commodity prices and are independent of the choice of a numeraire".[12]

3.4 Real interest rate differential

The real interest rate differential is defined as the difference between the Canadian real interest rate and the US real interest rate.[13] It is appropriate to add the real interest rate differential because it is the nominal interest rate that is used as a tool in monetary policy but the real interest rate takes inflation into account.

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[11] Even though the log of the real GDP is used in the report, it will be referred to as the real GDP.
[12] See Beine, Bos, and Coulombe (2009) to see how the currency and price components were calculated.
[13] See Amano and van Norden(1995)

4. Estimation Procedures

In this section, I explain the statistical and econometric analysis done in this paper.

4.1 Unit Root Test

Before econometric models can be used, some tests must be used first in order to avoid the problem of the spurious regression. A spurious regression exists when the regression exhibits a statistically significant relationship between two variables that are unrelated in any case. It can occur when the variables are not stationary. The test that can determine whether or not a variable has a structural break is called a unit root test. There are many types of unit root tests but this report will be restricted to just four: 1) Augmented Dickey-Fuller (ADF) test, 2) Philips-Perron (PP) test, and 3) Ng-Perron MZa test, and 4) Ng-Perron MZt test.

The ADF test is a stronger version of the Dickey-Fuller unit root test, which takes autocorrelation into account (Hill, Griffiths, and Lim, 2008). The PP test can be used for the weakly dependent or heterogeneous data (Phillips and Perron, 1988). This can be useful especially for the currency components data which were originally from panel data. The Ng-Perron tests tend to be stronger than the Phillips-Perron data because it takes into account negative moving-average errors. In all cases, the null hypothesis states that there is a unit root and the alternative hypothesis states that the variable does not contain the unit root. The null hypothesis would be rejected if the t-statistic is larger than its critical value.

To turn the series into a first difference series, one would take the difference between the series in time t and time t-1. If the first difference series contain no unit root then the variables of those series are considered to be I(1). An alternative way of making the series stationary is to use the Hodrick-Prescott (HP) filter to extract cyclical components by removing the trend from the series (See Hodrick and Prescott (1997)). These same unit root tests prove that the first difference and cyclical component variables are stationary.

4.2 Correlations

In the paper, I check to see if there is a pairwise correlation between the currency components, price components and the real GDP. Williamson (2004) defines a positive (negative) correlation as a "relationship between two economic time series when a straight line fit to a scatter plot of the two variables have a positive (negative) slope." The correlation coefficient is used for measuring how strong the relationship is between two variables. If the sign of the correlation coefficient is positive (negative), then the two variables are positively (negatively) correlated. The closer the correlation coefficient is to the absolute value of 1, the stronger the relationship is between the two variables.

4.3 Cointegration Tests

This analysis uses Johansen's co-integration test to see if the I(1) variables have similar trends (Hill, Griffiths, and Lim, 2008). If the series are found to have no integration then the residuals are not stationary which implies that according to econometric theory, the VAR should be used rather than the error correction model. If the series are co-integrated then the error correction model can be used and there would be no need to take the first difference between these two variables because the two series could be stable across the mean.

4.4 Granger causality test

Before I make use of the VAR and error correction models, I use the Granger causality test for the currency components, price components and the real GDP of Canada and the US in order to see if one variable can predict the movements of the other variable. Two Granger causality tests will be performed, one for the first difference variables and the other for the cyclical component variables.

4.5 VAR and Error Correction Model

In this report both the VAR and the error correction model will be used in the analysis for the purpose of robustness. The VAR is useful in seeing the relationship between the dependent variable and its past values and the past values of other variables. It also shows whether one variable influences another. In this case, the VAR will be used to see if the real GDP is influenced by the currency components or vice versa. The error correction model will also be useful because it will show how much, for example, the real GDP (aggregate output) can be affected by the currency components.

All the tests will use the whole period of 1972 to 2007 with the exception of the VAR and error correction models. In their cases, three periods would be used 1) 1972 to 2007 whole sample, 2) 1972 to 1993, the sample first used by Amano and van Norden (1995) and later used by BBC (2009), and 3) 1983 to 2007, the period when Canada became a net exporter of oil and gas as mention by BBC (2009).

5. Results

5.1 Graphical Analysis

Just like in the BBC (2009) article, the assumption in this report is that the positive (negative) change in the Canadian and American currency components implies the depreciation (appreciation) of the domestic currency.

Figure 1: The evolution of real GDP across time

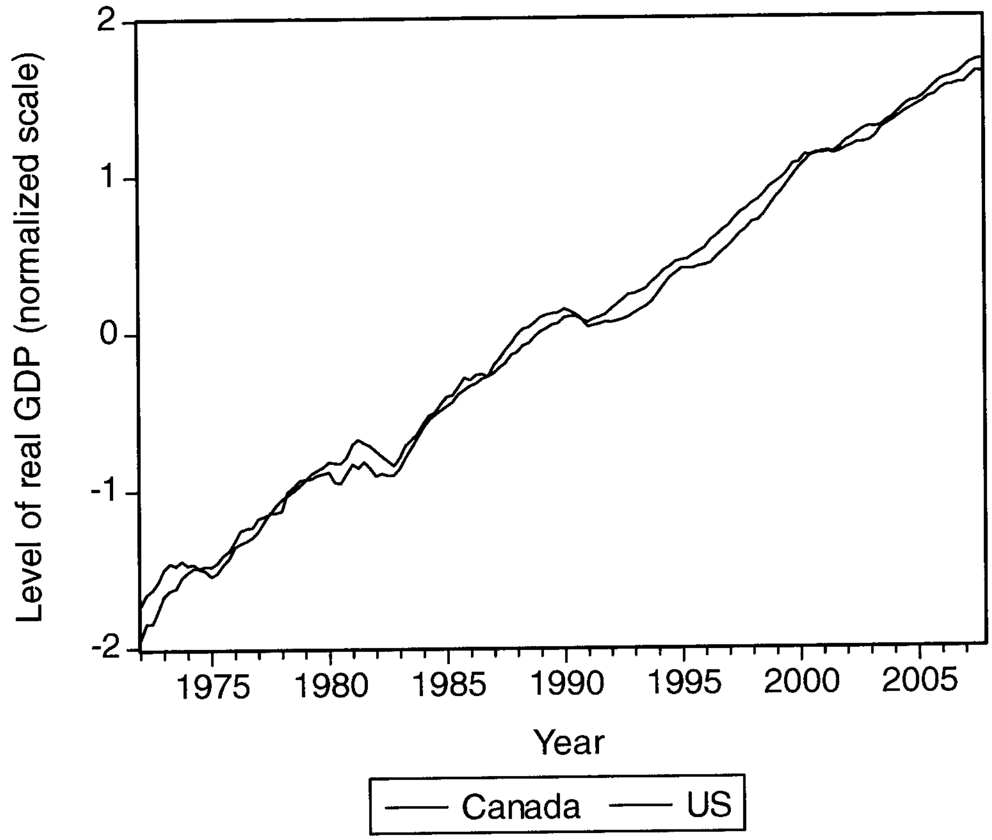


Figure 1 shows that the Canadian and US real GDP move together and exhibit an upward trend. It is not surprising since Canada, a country with a small open economy depends heavily on the United States for trade. If the US real GDP increases (decreases) then it is likely the Canadian real GDP would also increase (decrease). The illustration shows that US real GDP declines in 1975 (US only), 1981, from 1981 to 1983, and from 1990-1991 and the Canadian real GDP decline from 1981 to 1983 and 1990 to 1991. According to the National Bureau of Economic Research(NBER) definition of recession, these periods are when Canada and the US have suffered from a recession[14]. The illustration also shows that from 1991 to 2001, Canada and the US experienced a rapid growth in the real GDP. This is the period when both countries had experienced an expansion (See Colecchia and Schreyer (2002)).

[14] The definition of a recession came from the Business Cycle Dating Committee in the National Bureau of Economic Research; go to www.nber.org from more information on how the business cycle is dated.

Figure 2: Currency components of Canada and US

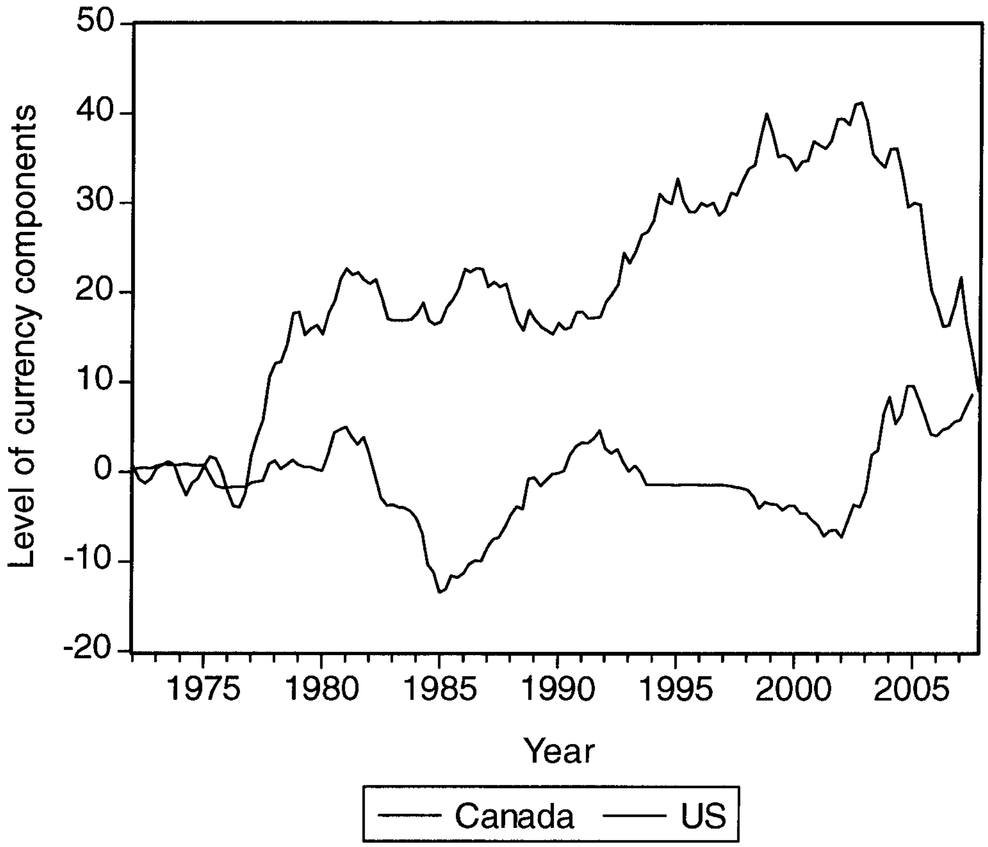
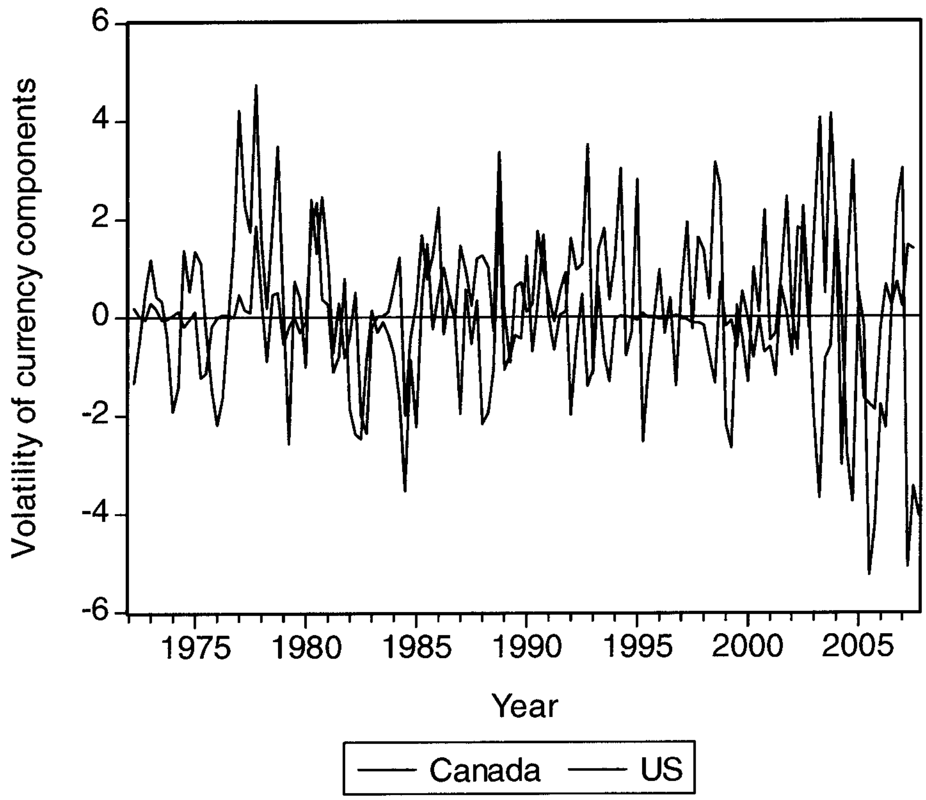


Figure 2 shows the level of currency components for Canada and the United States from 1972 to 2007. An increase (decrease) in the level of the currency components means that the Canadian or US dollar is experiencing a depreciation (an appreciation). Clearly, it shows that the components of the two countries are independent. It also shows that in the mid 1970s until 1979, Canada experiences higher levels of depreciation than the United States. From 1980 to the 1985, the illustration shows that the US dollar experiences a higher rate of appreciation than the Canadian dollar did. The illustration also shows that from 1985 until the 1990 recession, the US dollar depreciated more than the Canadian dollar appreciated. After the recession, the two countries experienced a technological shock which led to a long period of sustained growth. (See Colecchia and Schreyer (2002)).It changed when the US dollar weakened in 2003; the US currency component shows a sharp depreciation in the US dollar. This indicates that the movement in the currency is mostly driven by the actions in the US.

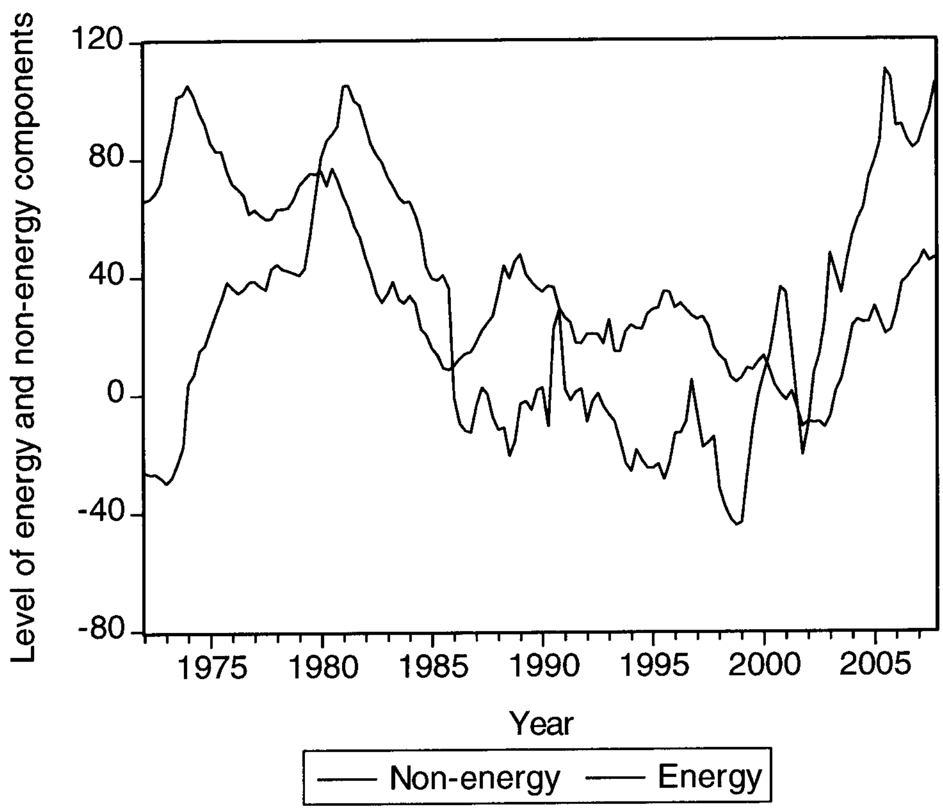
The first difference of the currency components of Canada and the United States from 1972 to 2007 is illustrated in Figure 3. The illustration shows that the Canadian currency appears to be more volatile during the whole period in comparison to the United States. The standard deviation is a good measurement of how volatile the series can be. The higher the standard deviation, the more volatile the currency component is. In this case, the standard deviations for the Canadian and US currency component are 1.78 and 1.15 respectively.

Figure 3: First difference of currency components



One explanation why the Canadian dollar is more volatile than the US dollar is given by BBC (2009) where they write that, "...this may partly have been caused by the fact that the Canadian dollar is not such an important currency internationally." Another explanation is because the US economy is the largest in the world. It has the ability to influence world prices, unlike Canada, whose economy is most likely to be influenced by them.

Figure 4: Energy price and Non-Energy commodity components



According to Figure 4, the energy price component appears to be lagging behind the non-energy commodity components until 2000 when the phenomenon is reversed. This is pointed out already by BBC (2009), when they extract the price components from the prices and the US dollar. The energy price and non-energy commodity components also appear to be correlated with each other.

Figure 5: Canadian currency component, its trend, and its short-run (SR) component

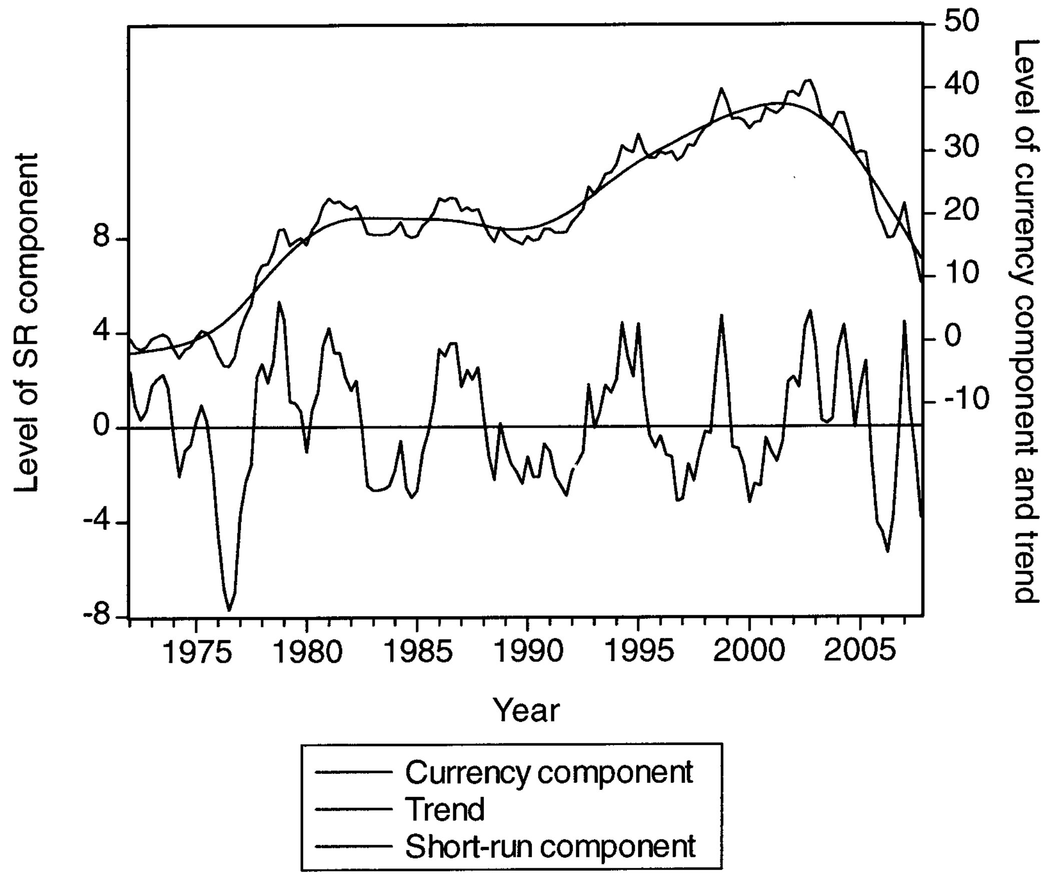


Figure 5 shows the levels of Canadian currency component, its trend and its short-run component from 1972 to 2007. It illustrates that the currency component does not fluctuate around a linear trend. The cycle shows that Canada experiences a sharp temporary appreciation after the 1973 oil crisis until 1975, which is when the recession in the US ended and the Canadian dollar returns to its original levels. The Canadian dollar experiences another temporary appreciation of its currency in 1979 when the Iranian revolutionary crisis leads to another oil price shock (See Barsky and Kilian (2004)). In the 1981-1982 and 1990-1991 recessions, Canada experiences a sharp temporary appreciation of its currency. The 1981-82 Recession was caused by tight monetary policy. In 1990-91, Canada had a deeper recession than the US because Canada continued its tight monetary policy (Jackson, 1999). This policy leads to higher domestic interest rates which in turn lead to a temporary appreciation of the domestic currency. During the mid-1990s expansion, the Canadian dollar depreciated. From

2000 to 2003, the Canadian dollar experiences a sharp depreciation which is followed by a sharp appreciation of its currency (Isidore, 2004).

Figure 6: US currency component, its trend, and its SR component

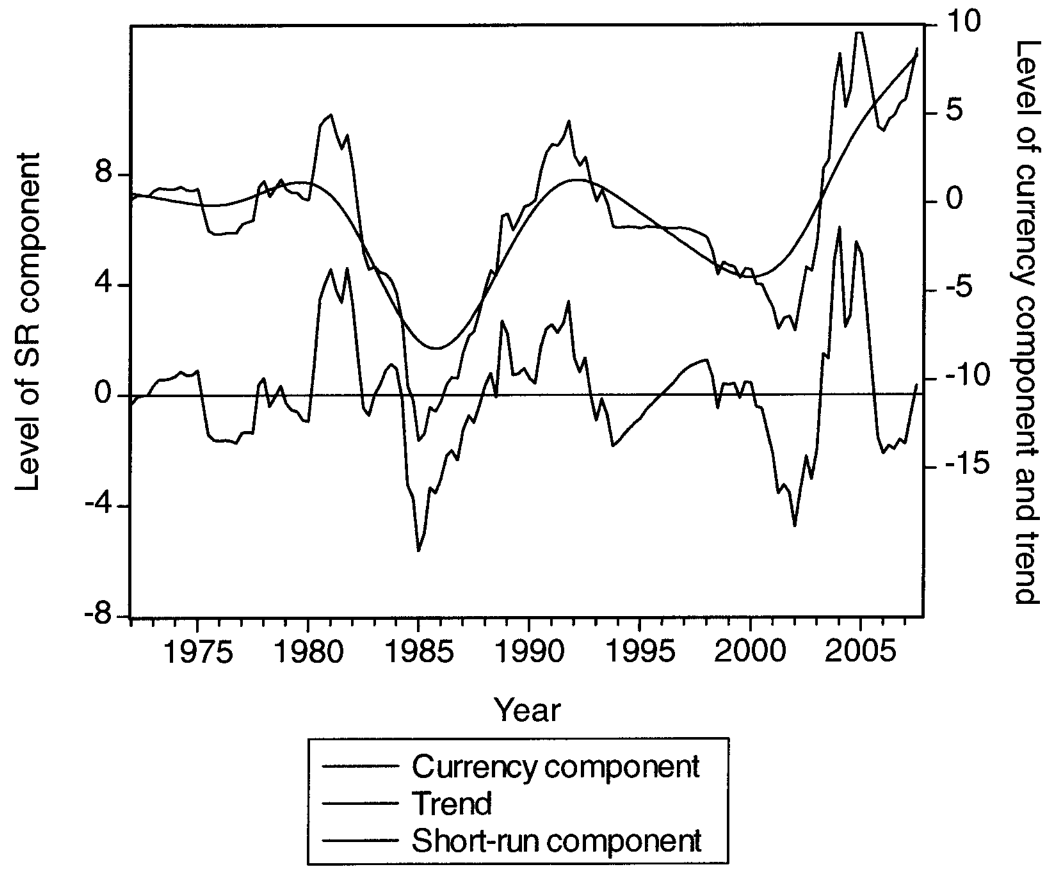


Figure 6 illustrates the evolution of the US currency component, its trend and its cycle which is derived by HP filtering from 1972 to 2007. The illustration shows that the currency component, unlike the real GDP, does not exhibit an upward trend. Despite the oil crisis in 1973, the US dollar appears to make very little movement unlike the Canadian currency. The US dollar did experience a sharp depreciation in 1980-1981 and then a sharp temporary appreciation from 1981 to 1985. During the 1980s, the US experiences a recession because the Federal Reserve implemented a tight monetary policy, leading to an appreciation of its currency (Krugman and Obstfeld, 2009). From 1985 to 1992, the US experiences a depreciation of its currency. This is followed by an appreciation of its currency during the time of the technological boom (Colecchia and Schreyer (2002)). Despite the recession in 2000, the US dollar continues to appreciate until 2003, when its dollar becomes weak.

Figure 7: Canadian real GDP, its trend, and its cycle

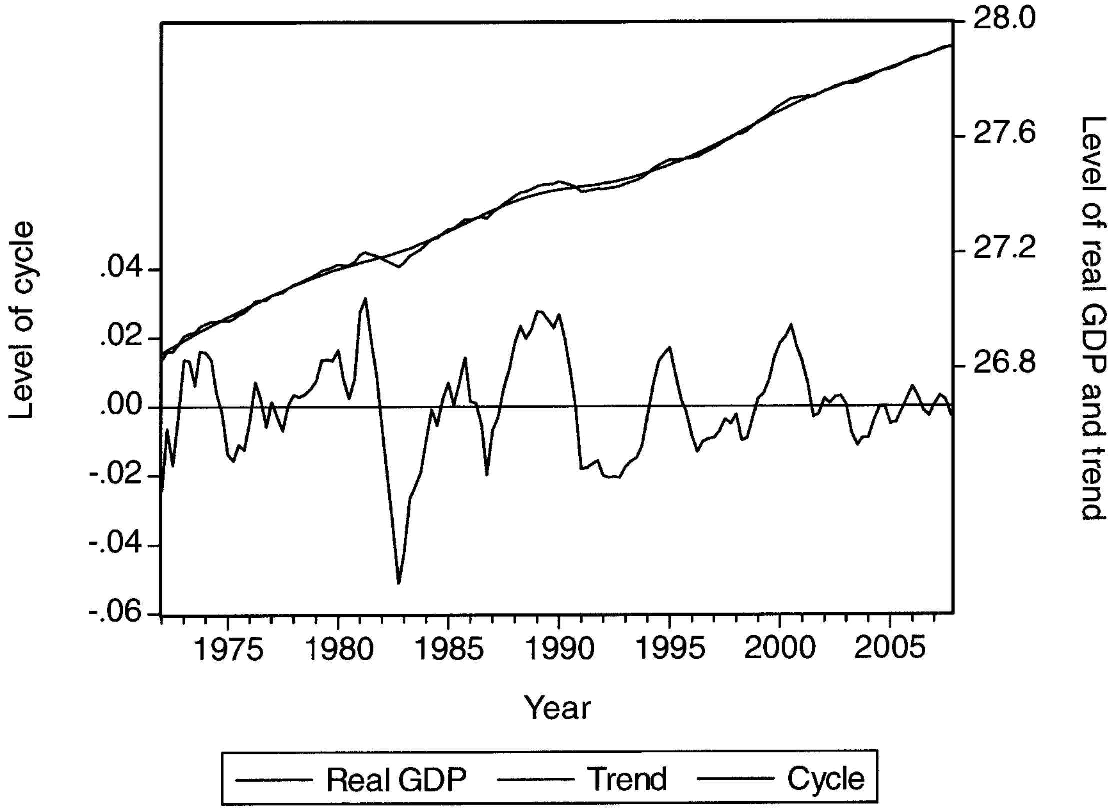


Figure 7 shows the Canadian real GDP fluctuating around its linear trend for the 1972 to 2007 period. It also shows the cyclical component, represented by the cycle in Figure 7, fluctuating around 0 and appearing to be stationary. The results confirm the findings of Hodrick and Prescott (1997) that the series of the cyclical component are stationary.[15] The illustration also shows that in the cycle, Canada suffered from a large decline in the real GDP from 1981 to 1982. During that time, the Bank of Canada adopted a contractionary monetary policy which led to a recession (Krugman and Obstfeld, 2009). This occurred again in 1990-

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[15] Hodrick and Prescott (1997) introduced the HP filter for removing the trend from the output using the equation: $\min_{\{g_t\}_{t=-1,}^{T}}\{\sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T}[(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2\}$. For quarterly data in my case, I use λ =1600. Hodrick and Prescott(1997) find that cyclical components are not stationary if $\lambda = \infty$.

1991. In the mid-1990s, Canada experiences a positive growth in real GDP due to the investment in information and communication technology (Colecchia and Schreyer (2002)). The September 11th terrorist attacks and a weak US dollar caused the growth in the Canadian GDP to slow down[16].

Figure 8: US real GDP, its trend, and its cycle

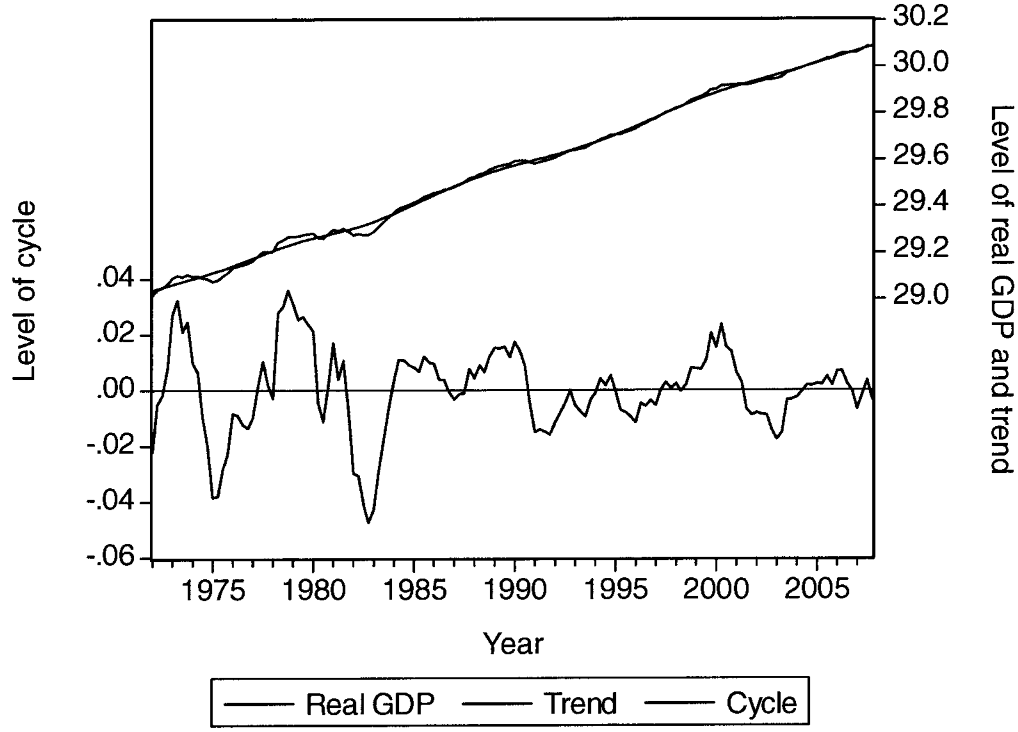

Figure 8 shows the US real GDP, its trend and its cycle from 1972 to 2007. The cycle shows that the US suffered from a large decline in the real GDP from 1973 to 1975. During that time, the US was in a recession because of the 1973 oil crisis. The oil crisis led to an increase in imported prices, which had a negative impact on the US goods and service (since the US is a net importer of oil). Higher gas prices led to a decline in aggregate demand for gas which also hurt the US economy. The Iranian revolutionary crisis in 1979 also had a negative impact on the US economy. It led to an increase in oil prices around the world. In the 1980s, the Federal Reserve had adopted a tight monetary policy which led to higher interest rates and a decrease in money demand. The US had another recession in 1990, which is because of the

[16] Information is from the Department of Finance website.

increase in oil prices due to the first Gulf War. There was also a credit crisis in the early 1990s where the banks restricted credit and mortgage approvals. In the mid-1990s, the US real GDP increased because of a technological boom. The growth rate of the US real GDP slowed down in 2000 and led to the 2001 recession after the "tech-bubble burst" and terrorist attacks in the US (Cornish, 2008).

5.2 Unit Root Tests

In this paper, I use three types of unit root tests: 1) Augmented Dickey-Fuller (ADF) test 2) Phillips-Perron (PP) test and 3) Ng-Perron (NP) unit root test. The null hypothesis for the tests is that variable contains a unit root and the alternative is that the series does not contain a unit root. If there is a unit root, then the series is said to be non-stationary. There are four types of the Ng-Perron test statistics, the MZa, MZt, MSB, and MPT. In this report, the focus will be on the first two. MZa is a modified version of the PP test which takes into account the serial correlation factor and a series that is convergent (Ng and Perron, 1996).[17]

Table 1: Unit Root Tests

Variables	Level				First Difference				Cyclical Components			
	Augmented Dickey-Fuller	Phillips-Perron (PP)	Ng-Perron MZa	Ng-Perron MZt	Augmented Dickey-Fuller (ADF)	Phillips-Perron (PP)	Ng-Perron MZa	Ng-Perron MZt	Augmented Dickey-Fuller (ADF)	Phillips-Perron (PP)	Ng-Perron MZa	Ng-Perron MZt
Can. curr. comp.	-1.738	-1.591	-1.3455	-0.8159	-8.032*	-7.986*	-21.32*	-3.190*	-5.093*	-4.318*	-35.18*	-4.098*
US curr. comp.	-2.417	-1.7396	-20.84*	-3.11*	-4.127*	-8.649*	-22.94*	-3.349*	-4.812*	-3.653*	-89.42*	-6.086*
Can. real GDP	-2.600	-2.991	-6.541	-1.798	-7.784*	-7.893*	-3.531	-1.206	-5.484*	-4.086*	-12.01**	-2.43**
US real GDP	-3.018	-3.041	-18.31**	-3.00**	-8.776*	-8.804*	-9.35**	-2.06**	-4.083*	-4.088*	-14.101*	-2.64*
Energycomp[a]	-1.660	-1.273	-3.212	-0.9593	-5.191*	-8.542*	-39.19*	-4.397*	-	-	-	-
Non-energy comp[a]	-2.209	-1.657	-4.931	-1.5614	-4.282*	-8.413*	-26.46*	-3.637*	-	-	-	-

Period is from 1972 to 2007. The unit root test for the level of real GDP includes a constant and a trend, the level of currency components, 1st difference of all the series include a constant but no trend, cyclical components include no constant for the ADF and PP tests and a constant for the Ng-Perron test. *, **, assumest the null hypothesis of the presence of no unit root is rejected at the 1%, 5% level respectively, a- These price components are considered to be exogenous.

According to table 1, the null hypothesis of the ADF and PP test for all the level variables of the currency components, the price components and the real GDP cannot be rejected. But in the case of the Ng-Perron test, the results are mixed. For the Canadian

[17] See Ng and Perron (1996) for more information on the Z and M tests.

currency component, Canadian real GDP and the price components, I cannot reject the null hypothesis of the presence of a unit root. The null hypothesis for the US currency component and the US real GDP is rejected using the Ng-Perron test.

Overall, the results are consistent with the findings of Nelson and Plosser (1982) that shows that the real GDP does not revert to its trend. It is also consistent with the findings of Meese and Rogoff (1983) who find that the exchange rate does follow a random walk. With the possibility of data not being stationary, level variables will not be used in this paper. This is because the consequence of using non-stationary variables is that the regression would be a spurious one. This also means that there could be a statistically significant relationship between variables even though according to economic theory they do not really have one (Hill, Griffiths, and Lim, 2008).

To solve the spurious regression problem, one would either take the first difference or extract the cyclical components. In this case, I do both. According to table 1, the null hypothesis for the first difference of the currency components, the price components and the log of the Canadian and American real GDP is rejected at the one percent level using the ADF and PP tests. In the case of the Ng-Perron M tests, all the first differences of the non-stationary variables are rejected at the one percent level, except for the US real GDP which had the null hypothesis rejected at the five percent level and the Canadian real GDP did not reject the null hypothesis at all.

The null hypothesis for the cyclical components is also rejected for all three tests at the one percent level, except for the cyclical components of the Canadian real GDP, where the null hypothesis was rejected at the five percent level. The unit root test is based on the assumption that there is a constant and no trend, except for the Ng-Perron tests[18]. The results show overall, that the first difference and the cyclical components can be used for regression.

[18] Ng-Perron tests, using E-VIEWS, did not permit me to use no constant as an option, so I had no choice but to use the option of assuming there is a constant.

5.3 Correlations

Table 2 shows the pairwise correlation between cyclical components of I(1) variables.

Table 2: Pairwise correlations between cyclical components from HP filter variables

	Canadian currency component	US currency component	Canada real GDP	US real GDP
Canadian currency component	1			
US currency component	0.116426	1		
Canada Real GDP	0.102940	-1.92×10^{-7}	1	
US Real GDP	0.152746	-0.031618	0.718138	1

Period is from 1972 to 2007.

The results in table 2 show that the cyclical component of the Canadian currency component has a weak positive relationship with the US business cycle. It also shows that the Canadian business cycle has a strong positive relationship with the US business cycle. This result is not surprising because Canada's economy is heavily dependent on the United States.

Table 3 shows the correlations between the first differences of the I(1) variables.

Table 3: Pairwise correlations between first difference variables

	Canadian currency component	US currency component	Non-energy price component	Energy price component	Canada real GDP	US real GDP
Canadian currency component	1					
US currency component	0.010103	1				
Non-energy price component	-0.141119	0.344166	1			
Energy price component	-0.171816	0.196106	0.024841	1		
Canada real GDP	0.020858	0.023521	0.231092	0.158692	1	
US real GDP	0.054387	-0.053049	0.164289	-0.084562	0.540995	1

Period is from 1972 to 2007.

The results in table 3 show that the first difference of the Canadian currency component has a negative and weak relationship with the first difference of the non-energy price component. It also shows that there is also a relationship between the first differences of Canada's GDP and the energy price component. This relationship is also weak but positive. The results mean that if prices of energy and non-energy commodity goods increase then that would help the Canadian economy. One explanation is that because Canada is a net exporter of commodity and energy, an increase in World or Global prices in energy and commodity goods can lead to an increase in income for the Canadian exporters. The first differences of the Canadian currency component and the energy components have a significant relationship with each other. In their case, they are negatively correlated. This implies that when the prices of energy increases, the Canadian dollar appreciates. This is consistent with the findings of Amano and van Norden (1995) and BBC (2009). The first differences of the US real GDP and the non-energy price component are positively correlated. This result is not surprising since the United States is the world's largest economy and is a net importer of natural resources.

The first differences of the US currency component and the energy component also have a positive relationship. This means that there is a relationship between the price of energy increasing and the US dollar depreciating against foreign currencies. As a net importer of energy, when the US dollar depreciates against other currencies (especially countries that are net exporters of energy), the price of energy becomes relatively more expensive for the Americans to purchase. At the one percent level, the correlations show that there is a positive statistically significant relationship between the first differences of US currency component and non-energy component, Canadian real GDP and the non-energy price component, and the Canada and US real GDP. They all have a weak relationship with the exception of the Canada and US real GDP which had a strong relationship.

5.4 Johansen's cointegration tests

In this paper, the Johansen's cointegration test is used to see if there is a co-integration between the currency components and the real GDP[19]. According to the unit root tests, the results show that all the variables are likely to be I(1). I use the cointegration tests to see if a linear relationship between these variables exists. If the variables are co-integrated then the error correction model can be used. If the variables are not co-integrated then the error correction model is not useful for the analysis and the vector auto-regression model should be used. In this case, the series must be transformed into first difference series or into cyclical components.

The energy price and non-energy commodity components (also known in the paper as price components) did not enter the equation because 1) Amano and van Norden(1995) find that prices were correlated with the Canada/US real exchange rate, 2) BBC (2009) find that they were correlated with the Canadian currency components and 3) because in this paper, they are taken to be exogenous. In testing for cointegration, only endogenous variables can be used (See Johansen (1988)). The type of test taken is based on the assumption that there is a linear deterministic trend. The null hypothesis in this test is that there is no co-integration while the alternative hypothesis shows that there is co-integration.

The results are obtained from the use of the Johansen cointegration test for both the trace and eigenvalue rank test with respect to the currency components for Canada and United States. They are also from the log of the real GDP for the same earlier mentioned countries – pairwise or overall – showing no cointegration between the series. This indicates that the currency components and the GDP do not share the same type of trends. In that case, taking the first difference or removing the trend from the series is essential.

5.5 Granger's causality test

The Granger causality test is first derived by Granger (1969) to see if one variable has the ability to forecast the other variable. Granger (1969) defines causality as, "if we are better able to predict X_t using all available information than if the information apart from Y_t had

[19] No table was shown in the Johansen's cointegration test because there is no sign of cointegration between the currency components and the real GDP at the 5% level.

been used". Even though, for example, x "Granger Causing" y means that x can have the ability to predict y, it is not the same as x having an effect on y. The equation that Granger (1969) derived to check for causality is:

$$X_t = \sum_{j=1}^{m} \alpha_j X_{t-j} + \sum_{j=1}^{m} \beta_j Y_{t-j} \text{ and } Y_t = \sum_{j=1}^{m} \beta_j X_{t-j} + \sum_{j=1}^{m} \alpha_j Y_{t-j} \quad \ldots$$ [20]

where X and Y are stationary variables, m represents the number of lags, α is the coefficient of the dependent variable's lagged value and β is the coefficient of the lagged variable which is different from the dependent variable.

The F test would be needed to see if:

$$\beta_1 = \beta_2 = \cdots = \beta_m = 0 \quad \ldots$$ [21]

The null hypothesis is that X (Y) does not Granger Cause Y (X) and the alternative hypothesis is that X (Y) does Granger Cause Y (X). Granger (1969) assumes in this case that the variables are stationary. This means that in this report, the first difference and the cyclical components have to be used for the Granger causality test.

For this report, three lags are used in testing for Granger causality. These equations are:

$$X_t = \alpha_1 X_{t-1} + \beta_1 Y_{t-1} \; and \; Y_t = \alpha_1 Y_{t-1} + \beta_1 X_{t-1} \text{ for the 1}^{\text{st}} \text{ lag,}$$

$$X_t = \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} \; and \; Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \beta_1 X_{t-1} + \beta_2 X_{t-2} \text{ for the 2}^{\text{nd}} \text{ lag,}$$

$$\text{and } X_t = \alpha_1 X_{t-1} + \alpha_2 X_{t-2} + \alpha_3 X_{t-3} + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \beta_3 Y_{t-3} \; and \; Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \alpha_3 Y_{t-3} + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \beta_3 X_{t-3} \text{ for the 3}^{\text{rd}} \text{ lag,} \quad \ldots$$ [22]

where X and Y may represent any of the following: The first difference and cyclical components of the Canadian and US currency components, Canadian and US real GDP, the first differences of energy price and non-energy commodity components, and X ≠ Y. The Canadian and US currency components are denoted by "Δecan" and "Δeus" respectively for

[20] See Granger (1969) for more details about how he derived this equation.
[21] Null hypothesis equation from Granger (1969).
[22] Equation is from Granger (1969).

the first differences and "ccecan" and "cceus" respectively for the cyclical components. The Canadian and US real GDP are denoted as "Δlry_ca" and "Δlry_us" for the first differences and "cchpca" and "cchpus" respectively for the cyclical components. The first differences of the non-energy commodity components and energy price components are denoted as "Δnonenergy" and "Δenergy" respectively. If the null hypothesis cannot be rejected, then it implies that the movement of X (Y) cannot be explained by the past values of Y(X). The results are said to be robust if they are consistent for all three lags.

Table I of the appendix presents the results for the Granger causality test for all the first differences of I (1) variables. It shows that the null hypothesis of the Canadian currency component not "Granger causing" the price components and the Canada and US real GDP cannot be rejected and vice versa. The results are the same for all three lags, meaning that the results are robust in this case. This indicates that the price components and the Canada and US real GDP are not a good forecast for the Canadian components and it means that the Canadian currency component cannot be explained by past values of the energy price component, non-energy commodity component, and the real GDP. It also means that the Canadian currency component is not a good forecast for the Canada and US real GDP and the price components.

The results show that the null hypotheses, US currency component does not Granger Cause the energy price component and the Canada and US real GDP and these variables do not Granger Cause the US currency component cannot be rejected for all three lags. The results indicate that the US currency component is not a good forecast for the real GDP and the price components. Table 4 presents the significant results for the Granger Causality test from Table I for the first differences of I(1) variables.

Table 4: Granger Causality Test

Variables	Lag 1	Lag 2	Lag 3
1.Δecan does not G.C. Δeus	2.95075***	1.47169	2.32491***
2. Δeus does not G.C. Δecan	2.29603	1.07812	0.87609
3.Δnonenergy does not G.C. Δeus	0.48098	4.02231**	1.52565
4. Δeus does not G.C. Δnonenergy	4.46235**	2.23014	1.39969
5. Δyus does not G.C. Δyca	10.2121*	6.01173*	3.60431**
6. Δyca does not G.C. Δyus	3.23088***	1.11673	1.43013

Sample is from 1972 – 2007 *,,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively**

The results, from table 4 line 1, show that the null hypothesis, which states that the Canadian currency component "does not Granger Cause" the US currency component, is rejected. This is the case for the first and third lags at the 10% level but not for the second lag. This indicates that changes in the Canadian currency component being a good predictor of the US currency component is not robust of all three lags. Line 2 shows that the US currency component is not a good forecast for the Canadian currency component and that the results are robust.

Table 4 lines 3 and 4 present the Granger causality test between the US currency component and the non-energy commodity component. Lag 2 of line 3 shows that the movement of the US currency component can be explained by past movements of the non-energy component. The results are not robust because they do not show consistency with results in different lags. At the 5% level for the first lag of line 4 again shows a rejection of the null hypothesis. This is not the case for the second and third lags.

Lines 5 and 6 do show that the US real GDP has the ability to predict the Canada real GDP at the 5% level for all three lags. These results are not surprising because Canada depends on the US more than the United States depends on Canada.

Table II in the appendix presents the results of the Granger Causality test for the cyclical components of the Canadian and American currency components and the real GDP and the first differences of energy price and non-energy commodity components and the currency components of Canada and the US. The null hypothesis of the Canadian currency component "does not Granger Cause" the Canadian and US real GDP for all three lags and vice versa. It is not surprising that the Canadian currency component is not a good predictor of the Canadian and US real GDP because the real GDP is made up of variables other than net exports. Net exports make up a small percentage of the real GDP in comparison to consumption.

Table 5 contains the significant results from Table II in the appendix.

Table 5: Granger Causality test

Variables	Lag 1	Lag 2	Lag 3
1.cceus does not G.C. ccecan	0.09412	5.67468*	4.42544*
2.ccecan does not G.C. cceus	0.61572	1.69736	1.10432
3.Δnonenergy does not G.C. ccecan	0.98594	1.55121	0.97988
4.ccecan does not G.C. Δnonenergy	4.00271**	1.71488	1.87791
5. Δenergy does not G.C. ccecan	1.31808	0.94749	1.80918
6. ccecan does not G.C. Δenergy	2.85172***	1.42739	1.37925
7.Δnonenergy does not G.C. cceus	1.31792	2.98045***	2.70324**
8. cceus does not G.C. Δnonenergy	2.17949	3.18028**	2.34299***
9.cchpus does not G.C. cchpca	16.0995*	7.20840*	4.88750*
10. cchpca does not G.C. cchpus	4.67571**	5.14902*	3.58428**
11.Δnonenergy does not G.C. cchpca	5.13625**	1.61747	2.10165
12. cchpca does not G.C. Δnonenergy	0.40043	0.77744	0.91660
13.Δnonenergy does not G.C. cchpus	9.06900*	3.51664**	2.22589***
14.cchpus does not G.C. Δnonenergy	0.64663	0.31526	0.71310

Sample from 1972 to 2007. *,,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively**

For the first lag of table 5, line 1, the lack of rejection of the null hypothesis implies that the US currency component "does not Granger Cause" the Canadian currency component. However, both lags 2 and 3 show a rejection at the 1% level. On the other hand, all three lags in lines 2, 3, and 5 do not show any evidence of a rejection at any level.

Lines 4 and 6 show the cyclical component of the Canadian currency component having the ability to predict the non-energy and energy components at the 5% and 10% level respectively in the first lag but not for the second and third lags. It is surprising in this case because Canada has a small open economy and small economies do not influence worldwide prices. It could be as a result of Canada being a net exporter of both energy and non-energy commodities. The results, overall, are not robust because the results are not the same in different lags.

Table 5 lines 7 and 8 show the results of the Granger Causality test for the non-energy and energy price components and the cyclical components of the US currency component. The results in line 7 show that at the second and third lags, the non-energy component is a good forecast for the US currency components. The results in line 8 for lag 2 at the 5% level and lag 3 at the 10% level indicate that the movements of the non-energy commodity component can be explained by past movements of the US currency component.

Lines 9 and 10 of table 5 present the results for the Canadian and US real GDP. At the 1% level and for all three lags, the US real GDP "does Granger Cause" the Canadian real GDP. The same holds true at the 5% level where the Canadian real GDP "does Granger Cause" the real GDP of the US. This means that the US business cycle is a good forecast of the Canadian business cycle and vice versa. When two variables Granger Cause each other, as in X "Granger Causes" Y and Y "Granger Causes" X, this means that the same external factors affecting X would also affect Y. In this case, X and Y represent the Canadian and US real GDP.

Line 11, at the 5% level of the first lag, shows that the non-energy component "does Granger Cause" the cyclical component of Canadian real GDP. This is not the case with results for the second and third lags where there is no rejection of the null hypothesis. This implies that the results are not robust. Line 12 shows the Canadian real GDP not having the ability to forecast the non-energy commodity prices.

The results of the Granger causality tests for the non-energy component and the cyclical component for the US real GDP are found in lines 13 and 14. Line 13 of table 5 shows the non-energy commodity component has the ability to predict the US real GDP because non-energy commodity component "does Granger Cause" the US real GDP for all three lags at the 10% level. This is not the case for line 14.

Overall, the Granger Causality tests indicate that the currency components are neither good predictors of the real GDP nor the past values of the real GDP a good indicator of the future if the currency components were taken to be the exogenous variables. This is not surprising because the real exchange rate is a PPP based measurement and the theory of PPP is not supported by empirical evidence.[23] This does not necessarily mean that the currency components will not have an effect on the real GDP; it shows that the currency components cannot provide sufficient information to predict the real GDP.

[23] See Krugman and Obstfeld (2009)

5.6 Vector Auto Regression (VAR)

Since the cointegration tests had shown that there is no cointegration between the currency components and the real GDP overall and pairwise, either the series have to be transformed into first difference series or cyclical components must be extracted from the series. Both the first difference series and the cyclical components are discussed in this section.

The equation that was used for the cyclical components in table 6a) and 6b) is:

$$y_t = c + \sum_{i=1}^{2} \alpha_i cchpca_{t-i} + \sum_{i=1}^{2} \beta_i cchpus_{t-i} + \sum_{i=1}^{2} \gamma_j ccecan_{t-i} + \sum_{i=1}^{2} \delta_i cceus_{t-i} + \varepsilon_t$$

where y is represented by cchpca, cchpus, ccecan, and cceus.

The equation for table 7 is:

$$y_t = c + \sum_{i=1}^{2} \alpha_i cchpca_{t-i} + \sum_{i=1}^{2} \beta_i cchpus_{t-i} + \sum_{i=1}^{2} \gamma_j \Delta \mathrm{ecan}_{\mathrm{t-i}} + \sum_{i=1}^{2} \delta_i \Delta \mathrm{eus}_{t-i} + \varepsilon_t$$

where y = cchpca, cchpus, Δecan, and Δeus. The variables cchpca and cchpus are the cyclical components of the Canadian and American real GDP respectively, ccecan and Δecan are the cyclical component and the first difference of the Canadian currency component respectively, cceus and Δeus are the cyclical components and the first difference of the US currency component respectively.

Tables 6a and 6b present the results of the vector autoregression estimates of the cyclical components for the sub-periods 1972 to 2007, 1972 to 1993 (period that was used by Amano and van Norden (1995) for their estimates), and 1983 to 2007 (period when Canada becomes a net exporter of energy) in columns 1 and 4, 2 and 5, and 3 and 6 respectively.

Table 6 a): Vector autoregression(VAR) of the cyclical components

			Dependent Variables					
			CCHPCA(Canadian real GDP)			CCHPUS(US real GDP)		
		Columns	1	2	3	4	5	6
Parameter	Variable	Variable Name	1972Q3 - 2007Q3	1973Q2 - 1993Q4	1983Q1 - 2007Q3	1972Q3- 2007Q3	1973Q2 - 1993Q4	1983Q1- 2007Q3
α_1	CCHPCA(-1)	Canadian real GDP lagged at t-1	1.00192* (-0.0935)	0.914853* (-0.12896)	1.000333* (-0.10966)	0.20278*** (-0.1096)	0.237405 (-0.15107)	0.2551* (-0.0917)
α_2	CCHPCA(-2)	Canadian real GDP lagged at t-2	-0.2464* (-0.0887)	-0.14412 (-0.12286)	-0.213** (-0.10213)	-0.30504* (-0.10404)	-0.297** (-0.14392)	-0.2775* (-0.0854)
β_1	CCHPUS(-1)	US real GDP lagged at t-1	0.270282* (-0.08093)	0.30763* -0.11014	0.359788* (-0.13122)	1.016531* (-0.09492)	1.019422* (-0.12901)	0.912124* (-0.10977)
β_2	CCHPUS(-2)	US real GDP lagged at t-2	-0.137577 (-0.08397)	-0.194*** (-0.11352)	-0.2595** (-0.12891)	-0.130616 (-0.09848)	-0.174959 (-0.13297)	-0.089903 (-0.10784)
γ_1	CCECAN(-1)	Canadian currency component lagged at t-1	0.000319 (-0.0003)	-0.000209 (-0.00063)	0.000141 (-0.00034)	-3.49E-05 (-0.00039)	0.000689 (-0.00074)	0.0005*** (-0.0003)
γ_2	CCECAN(-2)	Canadian currency component lagged at t-2	-0.00023 (-0.0003)	0.000246 (-0.00062)	0.000101 -0.00034	-3.70E-05 (-0.00039)	-0.00064 (-0.00072)	3.06E-04 (-0.0003)
δ_1	CCEUS(-1)	US currency component lagged at t-1	0.000232 (-0.0005)	0.001482 (-0.00092)	-0.000399 (-0.00048)	0.000417 (-0.00059)	2.18E-05 (-0.00108)	0.000257 (-0.0004)
δ_2	CCEUS(-2)	US currency component lagged at t-2	-0.000479 (-0.0005)	-0.0018** (-0.00092)	0.000164 (-0.00049)	-0.000425 (-0.00059)	-0.000357 (-0.00108)	-5.00E-05 (-0.0004)
-	C	Constant	1.61E-05 (-0.0005)	-0.000106 (-0.00077)	0.000176 (-0.00051)	2.22E-05 (-0.00058)	2.23E-05 (-0.0009)	0.000317 (-0.00043)
		R^2	0.835854	0.837585	0.875544	0.801829	0.811447	0.853527

The number in parenthesis represent the standard error of the regression. *,, and *** denote the null hypothesis of the estimated coefficient equal to zero rejected 1%, 5%, and 10% respectively.**

According to column 2 of table 6a, the Canadian real GDP has a negative and significant relationship with the second lagged value of US currency component at the 5% level. Columns 1, 2, and 3 show a significant relationship between the Canadian real GDP and its first lagged value for all three periods. It also shows that there is no robust relationship between the Canadian real GDP and its second lagged value. This is because their relationship was insignificant in the 1972 to 1993 period. The same columns, however, do show a positive and robust relationship between the Canadian real GDP and the first lagged value of the US real GDP at the 1% level.

Columns 4, 5, and 6 show the results of the VAR when the US real GDP is the dependent variable. The results indicate that there is a negatively significant relationship between the US real GDP and the Canadian currency component at the 10% level in the 1983 to 2007 period. It has a relationship with the first lagged value of the Canadian real GDP for the 1972 to 2007 and 1983 to 2007 periods. The US real GDP has a significant relationship with the second lagged value of the Canadian real GDP (negative relationship) and its own first lag (positive relationship) at the 10% and 5% respectively. The goodness of fit is very high for the models in all three periods.

Table 6 b): Vector autoregression(VAR) of the cyclical components

Parameter			Dependent Variable					
			CCECAN (Canadian currency comp.)			CCEUS (US currency comp.)		
		Columns	1	2	3	4	5	6
	Variable	Variable Name	1972Q3-2007Q3	1973Q2-1993Q4	1983Q1 - 2007Q3	1972Q3 - 2007Q3	1973Q2 - 1993Q4	1983Q1 - 2007Q3
α_1	CCHPCA(-1)	Canadian real GDP lagged at t-1	-37.7648 (-22.05)	-18.27759 -22.904	-22.43134 (-30.7091)	-16.67991 (-15.5725)	-26.36031 (-16.1932)	-18.09119 (-22.6331)
α_2	CCHPCA(-2)	Canadian real GDP lagged at t-2	17.8292 (-20.93)	4.99259 (-21.8208)	-12.14867 (-28.6017)	24.99901 (-14.7781)	33.8618** (-15.4274)	43.3570** (-21.0799)
β_1	CCHPUS(-1)	US real GDP lagged at t-1	8.78559 (-19.089)	6.215828 (-19.5604)	-32.19243 (-36.7475)	17.31668 (-13.482)	17.1196 (-13.8293)	14.74212 (-27.0836)
β_2	CCHPUS(-2)	US real GDP lagged at t-2	18.20854 (-19.807)	15.33915 (-20.1606)	67.9764*** (-36.1012)	-22.4837 (-13.9886)	-14.6509 (-14.2536)	-53.877** (-26.6072)
γ_1	CCECAN(-1)	Canadian currency component lagged at t-1	1.0193* (-0.079)	1.044675* (-0.112)	0.928829* (-0.09407)	-0.051363 (-0.05566)	-0.116562 (-0.07902)	-0.056826 (-0.06933)
γ_2	CCECAN(-2)	Canadian currency component lagged at t-2	-0.291* (-0.078)	-0.2722** (-0.109)	-0.254799* (-0.09573)	0.09711*** (-0.05532)	0.10898 (-0.07724)	0.121653 -0.07056
δ_1	CCEUS(-1)	US currency component lagged at t-1	0.3695* (-0.118)	0.253 (-0.1637)	0.348704** (-0.13538)	1.10807* (-0.08319)	1.202313* (-0.11573)	0.965292* (-0.09978)
δ_2	CCEUS(-2)	US currency component lagged at t-2	-0.423* (-0.118)	-0.28*** (-0.16334)	-0.475046* (-0.13694)	-0.2811* (-0.08326)	-0.3567* (-0.11548)	-0.12981 (-0.10093)
C	Constant		-0.00026 (-0.1173)	-0.025092 (-0.13651)	-0.045516 -0.14255	0.002428 (-0.08282)	-0.002732 (-0.09651)	-0.004577 -0.10506
R^2			0.721954	0.779655	0.679839	0.792127	0.819238	0.796836

The number in parenthesis represent the standard error of the regression. *,, and *** denote the null hypothesis of the estimated coefficient equal to zero rejected 1%, 5%, and 10% respectively**

When the Canadian currency component is used as a dependent variable, the results show that it has a robust relationship with its own first lag at the 1% level and at the 5% level for its own second lag. Its relationship with the US currency component is not that robust. Columns 1, 2, and 3 show that the Canadian currency component has a significant relationship with the first lagged value of the US currency component at the 1% level and at the 5% level respectively. Column 2 shows no significant relationship with the Canada or US real GDP, with the exception of the second lagged value of US real GDP at the 10% level.

According to columns 4, 5, and 6, the US currency component and the second lagged value of the Canadian real GDP have a statistically significant positive relationship at the 10% level for the whole period. The results also show that the US currency component has a statistically significant relationship with all of its own lagged values with the exception of second lagged value of the US currency component in the 1983 to 2007 period. According to columns 5 and 6, the US currency component has a positive and significant relationship at the 5% level with the Canadian real GDP for periods 1973 to 2007 and for 1983 to 2007.

Table 7a and 7b summarizes the results of the cyclical components of the Canadian and American real GDP and the first different variables of the currency components.

Table 7a): Vector autoregression(VAR) of the cyclical components of real GDP and first difference of currency components

			Dependent Variable					
			CCHPCA			CCHPUS		
		Column	1	2	3	4	5	6
Parameter	Variable	Variable Name	1972Q4-2007Q3	1972Q4-1993Q4	1983Q1 2007Q3	1972Q4-2007Q3	1972Q4-1993Q4	1983Q1 2007Q3
α_1	CCHPCA(-1)	Canadian real GDP lagged at t-1	1.05087* (-0.0914)	0.922175* (-0.12526)	1.04621* (-0.1082)	0.193267 (-0.10893)	0.18214 (-0.14953)	0.23006** (-0.09084)
α_2	CCHPCA(-2)	Canadian real GDP lagged at t-2	-0.309* (-0.0868)	-0.22*** (-0.11525)	-0.23** (-0.1046)	-0.32237* (-0.10345)	-0.31081** (-0.13758)	-0.2727* (-0.08788)
β_1	CCHPUS(-1)	US real GDP lagged at t-1	0.2772* (-0.078)	0.341273* (-0.10351)	0.29844* (-0.1291)	1.015675* (-0.09333)	1.037316* (-0.12356)	0.94111* (-0.1084)
β_2	CCHPUS(-2)	US real GDP lagged at t-2	-0.15*** (-0.0816)	-0.204*** (-0.10572)	-0.22*** (-0.1316)	-0.125449 (-0.09732)	-0.170566 (-0.1262)	-0.099764 (-0.11055)
γ_1	ΔECAN(-1)	Canadian currency component lagged at t-1	0.000189 (-0.0003)	-0.000465 (-0.00056)	0.000106 (-0.0003)	-0.000202 (-0.00036)	0.000123 (-0.00067)	-0.000415 (-0.00026)
γ_2	ΔECAN(-2)	Canadian currency component lagged at t-2	-0.000194 (-0.0003)	-0.000276 (-0.00056)	-0.00023 (-0.0003)	0.00031 (-0.00036)	0.000595 (-0.00067)	-0.000174 (-0.00027)
δ_1	ΔEUS(-1)	US currency component lagged at t-1	0.000401 (-0.0004)	0.00167** (-0.0008)	-0.00011 (-0.0005)	0.000284 (-0.00054)	0.000269 (-0.00095)	-3.70E-05 (-0.00038)
δ_2	ΔEUS(-2)	US currency component lagged at t-2	0.000247 (-0.0005)	0.000585 (-0.00082)	-0.00043 (-0.0004)	0.001078** (-0.00055)	0.001851*** (-0.00097)	0.00012 (-0.00037)
-	C	Constant	0.000119 (-0.0005)	0.000278 (-0.00075)	0.000258 (-0.0005)	-1.49E-05 (-0.00058)	-0.000179 (-0.0009)	0.00027 (-0.00043)
R^2			0.846558	0.853919	0.874425	0.810531	0.825963	0.850982

The number in parenthesis represent the standard error of the regression. *,, and *** denote the null hypothesis of the estimated coefficient equal to zero rejected at 1%, 5%, and 10% respectively.**

According to columns 1, 2, and 3 of table 7a, the first and second lags of both Canada and the US real GDP have a significant relationship with the Canadian real GDP at the 1% and 5% level respectively. The Canadian real GDP has a positive and robust relationship with first lagged values of the Canada and US real GDP. It also has a negative relationship with the second lagged values of the Canada and US real GDP. The Canadian real GDP had a relationship with the first lagged value of the US currency component at the 5% level for the 1972 to 1993 period only.

Columns 4, 5, and 6, of table 7a show that VAR results for the US real GDP as the dependent variable. The results show the US real GDP having a significant relationship with the first lagged value of the Canadian real GDP at the 5% level for the 1983 to 2007 period. It also has a robust and negative relationship with the second lagged value of the Canadian real GDP and with its own first lag at the 5% and 1% level respectively. The second lagged value of the real GDP does not have a robust relationship with the US real GDP (dependent variable) because it is not significant for the whole period (1972 to 2007).

Table 7b shows the results of the VAR with the currency components of Canada and the US as the dependent variables.

Table 7b): Vector autoregression(VAR) of cyclical components of real GDP and first difference of currency components

			Dependent Variable					
			ΔECAN			ΔEUS		
		Column	1	2	3	4	5	6
Parameter	Variable	Variable Name	1972Q4-2007Q3	1972Q4-1993Q4	1983Q1 2007Q3	1972Q4-2007Q3	1972Q4-1993Q4	1983Q1 2007Q3
α_1	CCHPCA(-1)	Canadian real GDP lagged at t-1	-38.908 (-26.729)	-13.4673 (-27.057)	-33.5912 (-36.743)	-12.2419 (-17.677)	-31.39*** (-18.5185)	-1.275957 (-24.8009)
α_2	CCHPCA(-2)	Canadian real GDP lagged at t-2	20.016 (-25.383)	0.395213 (-24.894)	-6.59784 (-35.544)	25.68467 (-16.787)	34.45169** (-17.0386)	47.86108** (-23.9916)
β_1	CCHPUS(-1)	US real GDP lagged at t-1	9.3213 (-22.901)	1.422759 (-22.359)	-27.3193 (-43.847)	20.18626 (-15.145)	26.6535*** (-15.3029)	-12.1375 (-29.5961)
β_2	CCHPUS(-2)	US real GDP lagged at t-2	10.178 (-23.878)	8.05459 (-22.836)	67.67116 (-44.715)	-23.1267 (-15.792)	-15.6913 (-15.6298)	-39.08884 (-30.1819)
γ_1	ΔECAN(-1)	Canadian currency component lagged at t-1	0.3488* (-0.087)	0.29255* (-0.1208)	0.28569* (-0.1041)	-0.08004 (-0.0577)	-0.121367 (-0.08266)	-0.08569 (-0.07029)
γ_2	ΔECAN(-2)	Canadian currency component lagged at t-2	-0.1115 (-0.089)	-0.01201 (-0.1208)	-0.17609 (-0.1085)	0.022721 (-0.0590)	-0.017069 (-0.08268)	0.04904 (-0.07326)
δ_1	ΔEUS(-1)	US currency component lagged at t-1	0.241*** (-0.132)	0.171146 (-0.1725)	0.204778 (-0.1532)	0.33672* (-0.0870)	0.410409* (-0.11806)	0.18906*** (-0.10342)
δ_2	ΔEUS(-2)	US currency component lagged at t-2	-0.0689 (-0.134)	0.018005 (-0.1762)	-0.09579 (-0.1494)	-0.05159 (-0.0888)	0.008503 (-0.12059)	-0.071057 (-0.10081)
-	C	Constant	0.0693 (-0.142)	0.237047 (-0.1629)	-0.04531 (-0.1738)	0.049515 (-0.0937)	0.020123 (-0.11148)	0.13684 (-0.11731)
R^2			0.1565	0.129265	0.144802	0.147979	0.234571	0.200707

The number in parenthesis represent the standard error of the regression. *,, and *** denote the null hypothesis of the estimated coefficient equal to zero rejected at 1%, 5%, and 10% respectively.**

According to columns 1, 2, and 3, the Canadian currency component had a robust and significant relationship with its own first lagged variable at the 1% level and a relationship with the first lagged value of the US currency component at the 10% level for the 1972 to 2007 period. The US currency component, according to columns 4, 5, and 6, had a robust and positive relationship with its own first lag at the 10% level. It did not have a robust relationship with the first and second lagged values of the Canadian real GDP.

For the analysis of the first difference variables, the equation used is:

$$\Delta y_t = c + \sum_{i=1}^{2} \alpha_i \Delta yca_{t-i} + \sum_{i=1}^{2} \beta_i \Delta yus_{t-i} + \sum_{i=1}^{2} \gamma_j \Delta ecan_{t-i} + \sum_{i=1}^{2} \delta_i \Delta eus_{t-i} + \varepsilon_t$$

where, Δyca is the 1st difference of the log of Canada`s real GDP, Δyus is the 1st difference of the log of the US real GDP $\Delta ecan$ is the 1st difference of the Canadian currency component, and Δeus is the 1st difference of the American currency component.

Tables 8a and 8b summarize that result of the VAR estimates for the 1st difference equation in all three periods, 1972 to 2007, 1972 to 1993, and 1983 to 2007.

Table 8a):VAR of the first difference variables

			Dependent Variable					
			ΔYCA			ΔYUS		
		Column	1	2	3	4	5	6
Parameter	Variable	Variable Name	1972Q4-2007Q3	1972Q4-1993Q4	1983Q1-2007Q3	1972Q4-2007Q3	1972Q4-1993Q4	1983Q1-2007Q3
α_1	ΔYCA(-1)	Canadian real GDP lagged at t-1	0.30061* (-0.0946)	0.25094*** (-0.12778)	0.24616** (-0.1131)	0.149692 (-0.11224)	0.173315 (-0.1498)	0.15699 (-0.0986)
α_2	ΔYCA(-2)	Canadian real GDP lagged at t-2	-0.02637 (-0.0890)	-0.0099 (-0.1226)	-0.05869 (-0.1062)	-0.0183 (-0.1056)	0.00343 (-0.1438)	-0.1444 (-0.0926)
β_1	ΔYUS(-1)	US real GDP lagged at t-1	0.26349* (-0.0816)	0.278427** (-0.1119)	0.37635* (-0.1306)	0.212777** (-0.09688)	0.217258 (-0.1312)	0.22888** (-0.1138)
β_2	ΔYUS(-2)	US real GDP lagged at t-2	0.062581 (-0.0845)	0.057426 (-0.116)	0.05330 (-0.1329)	0.088747 (-0.10026)	0.045948 (-0.1360)	0.27448** (-0.1158)
γ_1	ΔECAN(-1)	Canadian currency component lagged at t-1	0.000389 (-0.0003)	-2.48E-05 (-0.00065)	0.000206 (-0.00034)	-0.00013 (-0.0004)	0.000276 (-0.0008)	-0.00038 (-0.0003)
γ_2	ΔECAN(-2)	Canadian currency component lagged at t-2	-0.00024 (-0.0004)	-0.0001 (-0.0007)	-0.00023 (-0.00036)	0.00026 (-0.00041)	0.000397 (-0.0008)	-0.00017 (-0.0003)
δ_1	ΔEUS(-1)	US currency component lagged at t-1	2.44E-05 (-0.0005)	0.000907 (-0.0009)	-0.0004 (-0.0005)	-2.07E-05 (-0.00061)	-0.00048 (-0.0011)	-6.07E-05 (-0.0004)
δ_2	ΔEUS(-2)	US currency component lagged at t-2	-0.00024 (-0.0005)	-0.00069 (-0.00095)	-0.0008 (-0.0005)	0.000649 (-0.00062)	0.000915 (-0.0011)	-0.00016 (-0.0004)
-	C	Constant	0.003067 (-0.1418)	0.00303** (-0.0013)	0.00291** (-0.0012)	0.00413 (-0.09374)	0.003885* (-0.0015)	0.00403* (-0.001)
R^2			0.156489	0.27394	0.30958	0.147979	0.15453	0.2509

The number in parenthesis represent the standard error of the regression. *,, and *** denote the null hypothesis of the estimated coefficient equal to zero rejected 1%, 5%, and 10% respectively.**

Table 8a columns 1, 2, and 3 show the VAR results for the Canadian real GDP as the dependent variable. It shows that the Canadian real GDP has a robust and positive relationship with its own first lagged value at the 10% level and a positive and robust relationship with the first lagged value of US real GDP. Columns 4, 5, and 6 of the same table show that the US real GDP has a significant relationship between the first lag at the 5% level for the 1972 to 2007 and 1983 to 2007 periods. It also has a significant relationship with the second lagged value for only the 1983 to 2007 period.

Table 8b): VAR of the first difference variables

			Dependent Variables					
			ΔECAN			ΔEUS		
		Column	1	2	3	4	5	6
Parameter	Variable	Variable Name	1972Q4-2007Q3	1972Q4-1993Q4	1983Q1-2007Q3	1972Q4-2007Q3	1972Q4-1993Q4	1983Q1-2007Q3
α_1	ΔYCA(-1)	Canadian real GDP lagged at t-1	-29.7127 (-24.219)	-6.10555 (-23.448)	-34.562 (-33.6547)	-18.9747 (-16.182)	-30.944*** (-16.318)	-21.5556 (-24.013)
α_2	ΔYCA(-2)	Canadian real GDP lagged at t-2	-7.52829 (-22.7879)	-11.6322 (-22.499)	-29.077 (-31.593)	6.87804 (-15.225)	12.29474 (-15.658)	10.83541 (-22.542)
β_1	ΔYUS(-1)	US real GDP lagged at t-1	2.713185 (-20.9061)	-1.73461 (-20.538)	-28.069 (-38.845)	13.5706 (-13.968)	14.25482 (-14.293)	-2.7611 (-27.717)
β_2	ΔYUS(-2)	US real GDP lagged at t-2	32.43087 (-21.634)	17.4611 (-21.291)	94.9262** (-39.532)	2.27758 (-14.455)	9.987845 (-14.82)	-18.5293 (-28.207)
γ_1	ΔECAN(-1)	Canadian currency component lagged at t-1	0.364484* (-0.08676)	0.30936* (-0.1195)	0.321113* (-0.10223)	-0.08437 (-0.05796)	-0.12056 (-0.0832)	-0.11856 (-0.0729)
γ_2	ΔECAN(-2)	Canadian currency component lagged at t-2	-0.11278 (-0.089)	-0.01466 (-0.1209)	-0.1846*** (-0.10729)	0.020997 (-0.0595)	-0.00282 (-0.0842)	0.037692 (-0.0766)
δ_1	ΔEUS(-1)	US currency component lagged at t-1	0.21719*** (-0.13134)	0.142946 (-0.1722)	0.14968 (-0.1478)	0.35108* (-0.08776)	0.45396* (-0.1198)	0.26242** (-0.1055)
δ_2	ΔEUS(-2)	US currency component lagged at t-2	-0.07672 (-0.13296)	0.01098 (-0.1735)	-0.1629 (-0.14417)	-0.02857 (-0.0888)	0.030011 (-0.1208)	-0.01209 (-0.1029)
-	C	Constant	0.085198 (-0.00048)	0.24592 (-0.2288)	-0.0845 (-0.3427)	0.02263 (-0.0006)	-0.02863 (-0.1592)	0.346482 (-0.2445)
R^2			0.846558	0.12965	0.16484	0.81053	0.208997	0.127775

The number in parenthesis represent the standard error of the regression. *,, and *** denote the null hypothesis of the estimated coefficient equal to zero rejected 1%, 5%, and 10% respectively.**

According to table 8b, columns 1, 2, and 3, the Canadian currency component has a robust and positive relationship with its own first lag. It also has a statistically significant and negative relationship with its own second lag for just the 1983 to 2007 period and with the second lagged value of the US real GDP at the 5% level. Columns 4, 5, and 6 show the results of VAR for the US currency component. The results show that the US currency component has a positive and robust relationship with its own first lag at 5%. It also has a statistically significant and negative relationship with the Canadian real GDP in the 1972 to 1993 period.

Overall, all the results show that there is no statistically significant relationship between the real GDP and the domestic currency using the currency components. The relationship of the dependent variables is robust between its own lagged values, especially the first lagged values. There were some relationships between the US currency component and the Canadian real GDP and between the Canadian dollar and the US real GDP but the relationship is not robust for different periods. This indicates that the currency components do not have a strong relationship with the real GDP.

5.7 Error Correction Model

I use the error correction model in the same type of way as Amano and van Norden (1995) and BBC (2009). The difference in my case is that the dependent variable will be the real GDP instead of the real exchange rate and currency components. The price components cannot be included in the same regression as the Canadian currency components because it was found to be correlated with each other (BBC, 2009).[24] The equation for the first difference variables that does not include the energy and non-energy component is:

$$1)\ \Delta y_t = c + \alpha y_{t-1} + \beta_1 x_{t-1} + \beta_2 rdiff_{t-1} + \beta_3 \Delta x_t + \varepsilon_t$$

y_t is the Canada or US real GDP, x_t is either "ecan" (the Canadian currency component) or "eus" (the US currency component). The real interest rate differential is represented by "rdiff" (defined as the Canadian real interest rate – US real interest rate)[25]. I also use the error correction model to analyze the effects of the US currency component and the energy and non-energy commodity components. The equation in this case is:

$$2)\ \Delta y_t = c + \alpha y_{t-1} + \beta_2 rdiff_{t-1} + \beta_4 eus_{t-1} + \beta_5 \Delta energy_t + \beta_6 \Delta nonenergy_t + \varepsilon_t$$

where y is the Canadian real GDP, eus is the long run US currency component, Δenergy and Δnonenergy are the short run energy and non-energy price components respectively.

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[24] This result was found in Beine, Bos, and Coulombe (2009)
[25] Equation is from Amano and van Norden (1995) and Beine, Bos, and Coulombe (2009)

Table 9 summarizes the results for Canada. Columns 1, 3, and 5 show the results using equation 1 and columns 2, 4, and 6 show the results using equation 2. According to column 1, the real GDP has a statistically significant relationship with the speed of adjustment (parameter α) and the real interest rate differential. The results imply that 1% increase in the real interest rate differential would lead to a decline in the Canadian real GDP by 0.21%.

Table 9: Error Correction Model for Canada(First difference)

Parameter	Variables	Variable Name	Dependent variable: ΔYCA(Canada real GDP)					
		Column	1	2	3	4	5	6
		Period	1972Q2-2007Q4	1972Q2 2007Q4	1972Q2-1993Q4	1972Q2-1993Q4	1983Q1 2007Q4	1983Q1 2007Q4
C	C	Constant	0.226368** (0.093343)	0.180412* (0.053412)	-0.114722 (0.265637)	0.230492 (0.142698)	0.482748* (0.095844)	0.446585* (0.099542)
α	LRY_CA(-1)	Speed of adjustment	-0.007932** (0.003454)	-0.006244* (0.001945)	0.004786 (0.009868)	-0.008109 (0.005268)	-0.017301* (0.003509)	-0.01585* (0.003602)
β_1	ECAN(-1)	LR Can. curr. comp.	4.22E-05 (8.37E-05)	-	-0.000217 (0.000183)	-	0.000147*** (8.22E-05)	-
β_2	RDIFF(-1)	SR real int. diff.	-0.002112* (0.000373)	-0.002013* (0.000349)	-0.002835* (0.000732)	-0.001798* (0.000642)	-0.00238* (0.000388)	-0.002672* (0.000372)
β_3	ΔECAN	SR Can. curr. comp.	-0.000114 (0.000337)	-	-0.000544 (0.000604)	-	-0.000395 (0.000317)	-
β_4	EUS(-1)	LR US curr. comp.	-	-0.00038* (0.00012)	-	-0.000558* (0.000188)	-	-0.000133 (0.00012)
β_5	ΔENERGY	SR energy	-	0.000149** (6.05E-05)	-	0.00017*** (9.81E-05)	-	0.000183* (5.15E-05)
β_6	ΔNONENERGY	SR non-Energy	-	0.000394* (0.000126)	-	0.000491* (0.000183)	-	0.000355* (0.000122)
R-squared			0.202255	0.314291	0.236702	0.367799	0.341189	0.438087
Durbin-Watson stat			1.326407	1.446735	1.489584	1.527722	1.525451	1.638011
Nobs			143	143	87	87	100	100

*, **, and *** denotes the null hypothesis rejected at 1%,5%, and 10% respectively,
Standard error is in parenthesis

According to economic theory, if the real interest rate is higher in the foreign country than the domestic country, then by interest rate parity, the foreign country's currency is expected to appreciate against the domestic currency, which means that the prices of foreign goods will become more expensive than the domestic country's goods. This would help improve exports and thus the GDP. Therefore, the results do have the correct sign (negative). It also shows that there is no statistically significant relationship between the short run and long run levels of the domestic currency which is represented by the Canadian currency components.

Column 3 shows the results for the second period, also known as the Amano and van Norden (1995) period. For a model to be good, the speed of adjustment must be statistically significant. This is not the case for this model. It only shows the real interest rate differential to be statistically different from 0 at the 1% level. The results imply that an increase in the real interest rate differential would lead to a decrease in the Canadian real GDP.

Column 5 shows the results for the third period, which is known as the period where Canada becomes a net exporter of energy. The real GDP has a highly statistically significant relationship with the speed of adjustment and real interest rate differential. It also has a statistically significant relationship with the Canadian currency component in the long run. It implies that when the Canadian currency depreciates then the economy improves. Just like the results in the whole period, the signs of the coefficients are consistent with economic theory. The only difference between the results for the 1972 to 2007 and that of the 1983 to 2007 periods is for the latter period, the long run Canadian currency component is statistically significant from 0 at the 10% level.

The results show that the short run Canadian currency component does not have a significant relationship with the GDP and the long run Canadian currency component does not have a robust relationship with the real GDP. This implies that the Canadian real GDP is not really affected by strength of the Canadian dollar. Columns 2, 4, and 6 of the same table, show the results using the US currency component and the price components instead of the Canadian currency component.

For both the whole subsample and the Amano and van Norden (1995) period, the results show the US currency component in the long run has a negative and significant relationship with the Canadian real GDP and an appreciation of the US currency component improves the real GDP of Canada. It also shows that for all three periods, the short run prices have an effect on real GDP, which is a very small one. It does indicate that as a net exporter of the commodity and energy. An increase in the world energy and commodity prices can improve the Canadian real GDP. The results also reveal that an appreciation of the Canadian currency component does not show a negative effect on the real GDP of Canada because that is offset by the positive effects produced by both the energy and non-energy industries.

Table 10 summarizes the results for the United States.

Table 10: Error Correction Model for US(First difference)

Parameter	Variable	Variable Name	Dependent Variable: ΔYUS (US real GDP)		
		Column	1	2	3
		Period	1972Q2-2007Q3	1972Q2-1993Q4	1983Q1-2007Q3
C	C	Constant	0.071084 (0.068716)	0.008853 (0.179948)	0.597424* (0.095144)
α	LRY_US(-1)	Speed of adjustment	-0.002122 (0.002319)	6.87E-06 (0.006157)	-0.01974* (0.00319)
β_1	EUS(-1)	LR US curr.comp.	-0.000231 (0.000148)	-0.000465** (0.000231)	0.000284** (0.000113)
β_2	RDIFF(-1)	SR Int. Rate. Diff	-0.001** (0.00044)	-0.001298*** (0.000779)	-0.00222* (0.00036)
β_3	ΔEUS	SR US curr.comp.	-0.000198 (0.000599)	-0.000709 (0.000963)	0.000623 (0.000399)
R-squared			0.055761	0.09614	0.351531
Durbin-Watson stat			1.389097	1.366263	1.839126
Nobs			142	87	99

***, **, and *** denotes the null hypothesis rejected at 1%,5%, and 10% respectively, Standard error is in parenthesis**

The results, in columns 1 and 2, show that the model is not a good one because it does not converge and the dynamic process is not well represented. The estimated coefficient for the speed of adjustment is not statistically significant from 0. Column 6 shows the results for the period of 1983 to 2007. It shows that the US real GDP has a highly statistically significant relationship with the speed of adjustment and the real interest rate differential; both of their estimated coefficients are negative. It also shows that the null hypothesis of the long run US currency component can be rejected at the 5% level. Its estimated coefficient is positive, signalling the results that are consistent with economic theory. The short run US currency component was statistically insignificant from 0 for all three periods.

The equation for the cyclical components which does not include the energy and non-energy components is:

$$1)\ y_t = c + \alpha y_{t-1} + \beta_1 ecan_{t-1} + \beta_2 rdiff_{t-1} + \beta_3 x_t + \varepsilon_t$$

where y_t is the cyclical component of the real GDP and x_t represents the cyclical component of the currency components. The variables cchpus, cchpca, ccecan, and cceus represent the cyclical components of the US real GDP, the Canadian real GDP, Canadian currency component, and the US currency component respectively. In this analysis, I use the error correction model to see the effects of the US currency component and the energy and non-energy components on the cyclical component of the Canadian real GDP.

The equation that I use which includes the price components is:

$$2)\ y_t = c + \alpha y_{t-1} + \beta_2 rdiff_{t-1} + \beta_4 eus_{t-1} + \beta_5 \Delta energy + \beta_6 \Delta nonenergy + \varepsilon_t$$

where y is the cyclical component of the Canadian real GDP, $\Delta energy$ represents the first difference of the energy component, and $\Delta nonenergy$ represents the first difference of the non-energy commodity component.

Table 11 summarizes the results for Canada in columns 1, 3, and 5, using equation 1 and in columns 2, 4, and 6, using equation 2.

Table 11: Error Correction Model for Canada(Cyclical component from HP filter)

Parameter	Variables	Variable Name	Dependent Variable: CCHPCA(Canada real GDP)					
		Column	1	2	3	4	5	6
			1972Q2-2007Q4	1972Q2-2007Q4	1972Q2-1993Q4	1972Q2-1993Q4	1983Q1 2007Q4	1983Q1-2007Q4
C	C	Constant	0.002865** (0.001286)	0.000845 (6.38E-04)	0.003233*** (0.001656)	0.002427*** (0.001233)	0.004955* (0.00246)	0.000538 (6.13E-04)
α	CCHPCA(-1)	Lagged value of Can. real GDP	0.868397* (0.038505)	0.856544* (0.036945)	0.890739* (0.049592)	0.864639* 0.045683	0.870076* (0.037403)	0.842178* (0.035863)
β_1	ECAN(-1)	LR Can. curr. comp.	-7.10E-05 (4.97E-05)	-	6.89E-05 (0.000111)	-	-0.000137 (8.38E-05)	-
β_2	RDIFF(-1)	SR real int. diff.	-0.001154* (0.000346)	-0.000958* (0.000322)	-0.002297* (0.000668)	-0.001389* (0.000523)	-1.02E-03* (3.84E-04)	-0.000728** (0.000313)
β_3	CCECAN	SR Can. curr. comp.	0.000267 (0.000223)	-	-4.95E-04 (4.16E-04)	-	3.93E-04 (0.000262)	-
β_4	EUS(-1)	LR US curr.comp	-	-0.000244** (0.000115)	-	-0.000254 (0.000174)	-	-0.000266* (0.000101)
β_5	ΔENERGY	SR Energy	-	0.000338* (0.00012)	-	0.000454** (0.000173)	-	0.00022*** (0.000121)
β_6	ΔNONENERGY	SR Non-energy	-	0.000163* (5.86E-05)	-	0.00021** (9.31E-05)	-	0.000145* (5.09E-05)
R-squared			0.792555	0.812905	0.807236	0.832583	0.851076	0.866984
Durbin-Watson stat			1.333335	1.383666	1.537366	1.492582	1.389708	1.343465
Nobs			143	143	87	87	100	100

*, **, and *** indicates that the null hypothesis rejected at 1%,5%, and 10% respectively. Standard error is in parenthesis.

According to the results in table 11, real GDP has no statistically significant relationship with the short and long run currency components for all three periods. The results also show that it own lagged value (parameter α) and the real interest rate differential are statistically significant with the cyclical component of the Canada real GDP. The negative sign of the coefficient of the real interest rate differential indicates that an increase in this variable will have a negative impact on the Canadian business cycle.

Table 11 columns 2, 4, and 6 show the regression where the US long run currency component and the short run price components are used as explanatory variables instead of the Canadian currency component. According to these results, the lagged value of the real GDP and the real interest rate differential are significant at the 1% level for all 3 subsample periods. It also shows that the energy and non-energy price components have a robust relationship with the Canadian real GDP at the 5% and 10% respectively. Since the signs of both the coefficients are positive, this indicates that an increase in both the energy and commodity prices can help the Canadian business cycle.

Columns 2, 4, and 6 also show the very important result that the US currency component in the long run has a significant relationship with the Canadian real GDP for all periods except for 1972 to 1993. The sign of the coefficient is negative in all cases. This implies that when the Canadian dollar depreciates against US dollar, the Canadian exports become more affordable for the Americans to purchase more Canadian goods. The results of the currency component of the Canadian real GDP had the same result as the first difference of the Canadian real GDP used as the dependent variable in table 9. Once again, the results are consistent with the economic theory and it showed that the model had a better fit than the original model.

Table 12 shows the results of the Error Correction Model for the United States. In all three periods, there is a statistically significant relationship between real interest rate differential and the cyclical component of the US real GDP and between the lagged value of the US real GDP level and the US real GDP.

Table 12: Error Correction Model for US(Cyclical component from HP filter)

Parameter	Variable	Variable Name	Dependent Variable: CCHPUS (US real GDP)		
		Column	1	2	3
			1972Q2-2007Q3	1972Q2-1993Q4	1983Q1-2007Q3
C	C	Constant	0.001173 (0.000759)	0.003348** (0.001549)	0.000903*** (0.000534)
α	CCHPUS(-1)	Lagged value of US Real GDP	0.840519* (0.04172)	0.834274* (0.05204)	0.817869* (0.039141)
β_1	EUS(-1)	LR US curr.comp.	-0.00012 (0.000179)	4.05E-06 (0.000308)	-0.000242** (0.000113)
β_2	RDIFF(-1)	SR Int. Rate. Diff	-0.00102** (0.000393)	-0.001719* (0.000635)	-0.000767* (0.000278)
β_3	CCEUS	SR US curr.comp.	0.000137 (0.000394)	-0.00058 (0.000701)	0.000696** (0.000269)
R-squared			0.768673	0.783949	0.832024
Durbin-Watson stat			1.40109	1.3515	1.654165
Nobs			142	87	99

*, **, and *** denotes the null hypothesis rejected at 1%,5%, and 10% respectively. Standard error is in parenthesis.

According to columns 1, 2, and 3, (results of 1972 to 2007, 1972 to 1993, and 1983 to 2007 respectively), the results show that the null hypothesis for the estimated coefficients of the short run and long run currency component are not significantly different from 0. For the last sub-period 1983 to 2007, where Canada becomes a net exporter of energy, there exists a positive and statistically significant relationship between the short run currency component and the real GDP and between the long run currency component and the real GDP. This does make economic sense since a positive change in currency components (depreciation of US dollar) does improve the trade balance which in turn improves the GDP, assuming that the Marshall-Lerner condition holds. There is also a negatively statistically significant relationship between the long run currency component and the real GDP.

The results show overall that the Canadian economy is driven by energy and commodity prices. It also shows that the Canadian economy is driven by the US currency component more than the Canadian currency component. The effects of the various shocks on the real GDP are different for the same effects on the exchange rate. With 85% of the exports from Canada going to US, the results are not surprising. One explanation of why I obtain these types of results is because the depreciation of US dollar just has a negative effect on the Canadian economy, while the depreciation of Canadian dollar has both a negative and a positive effect on the Canadian economy. The negative effect of a depreciation of the Canadian currency component is associated with a decrease in energy and non-energy commodity prices which in turn hurt the resource sector of the Canadian economy.[26] The positive effect improves the trade balance and strengthens the Canadian economy. The results also show that the US economy is driven by the real interest rate differential more than the US currency component. The real interest rate is affected by fiscal and monetary policy implying the US economy is mostly affected by domestic policy.

6. Data Limitations and Extensions

In this section, I discuss why not all of the results are robust and make suggestions about what future research can be done based on the findings.

Some of the results are found not to be robust in this paper because the parameters are sensitive to changes to the time periods. The sign, magnitude and the significance of the parameters change whenever I compare the results using the whole period (1972-2007), the Amano and van Norden(1995) period (1972-1993), and the period when Canada becomes a net exporter of energy(BBC,2009) which is 1983-2007. The data does not include the period when the financial crisis in 2008 and the 2008 recession have occurred. I believe that if the data for that important time period have been added, the parameters would change.

The results from the error correction model with the US real GDP as the dependent variable indicate that the model is not good for the US, especially the first difference. By using the first difference US real GDP, I find that the speed of adjustment is not statistically significant for all periods with the exception of the 1983 to 2007 period. When I use the cyclical components of the US real GDP as the dependent variable, I find that none of the independent variables except for the real interest rate differential is significant for the whole

[26] Beine, Bos, and Coulombe (2009) found that the energy and non-energy components are correlated with the appreciation of the Canadian currency component.

period and the Amano and van Norden (1995) period. In the last period, the US currency component in the short and long run are statistically significant. One explanation is because the US is not an export-based economy and is a net importer of oil and gas (BBC, 2009). Since the US economy is influenced more by the domestic policy, the relationship between the level of unemployment (another indicator of the business cycle) and the currency component can be looked at. The relationship between the domestic government spending and the currency component is also another option. Currently, the US is running a high budget deficit; therefore, the relationship could be more significant for the US than the relationship between the US currency component and the expenditure based GDP.

When I use the VAR, it shows that all the dependent variables had a robust relationship with its own lagged values. Hill, Griffiths, and Lim (2008) note that the impulse response and variance decompositions can be used to look at different shocks to see if it has an effect on the currency components. The analysis by Backus (1986), Blanchard and Quah (1989), Clarida and Gali (1994), and Chadha and Prasad (1997) can be followed to see if monetary, real demand, and real supply shocks have any effect on the Canadian or US currency component. The study of currency components can be extended to studying other macroeconomic variables in the future.

7. Conclusion

This paper finds evidence that the energy and non-energy commodity prices have a positive effect on the Canadian economy and business cycle. The results also show that the US currency component influences the Canadian economy more than the Canadian currency component does. The explanation for the main results is a depreciation in the US currency component leads to negative effect on the Canadian economy by means of the trade balance. However, a depreciation of the Canadian currency component results in a positive effect on the trade balance. Since this positive effect comes with a decrease in both the energy and non-energy commodity prices, that produces an overall resultant negative impact on the resource sector of the Canadian economy.[27]

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[27] Beine, Bos, and Coulombe (2009) find that the energy and non-energy components are positively correlated with an appreciation of the Canadian currency component.

REFERENCES

- Amano, R.A. and S. van Norden (1995), Terms of Trade and Real Exchange Rates: The Canadian Evidence, *Journal of International Money and Finance*, 1995, 83-104.
- Amano, R. A. & van Norden, S. (1998), Oil prices and the rise and fall of the US real exchange rate, *Journal of International Money and Finance*, 17(2), 299-316.
- Backus, D. (1986). The Canadian--U.S. Exchange Rate: Evidence from a Vector Autoregression. *The Review of Economics and Statistics*, *68(4)*, 628-637.
- Bank of Canada (1995). Why Monetary Policy Matters: A Canadian Perspective, from http://www.bank-banque-canada.ca/en/ragan_paper/inflation.html.
- BBC News. (2006, May 15). *Weak US dollar weighs on markets*. Retrieved August 10, 2009, from http://news.bbc.co.uk/2/hi/business/4767049.stm
- Barsky, R., & Kilian, L. (2004). Oil and the Macroeconomy Since the 1970s. *NBER Working Papers Series*, from http://www.nber.org/papers/w10855
- Beine, M., Bos, C., & Coulombe, S. (2009). Does the Canadian Economy Suffer from Dutch Disease? Retrieved August 7, 2009, from http://aix1.uottawa.ca/~scoulomb/pages/BBC-May.pdf
- Blanchard, O. J., & Quah, D. (1989). The Dynamic Effects of Aggregate Demand and Supply Disturbances. *The American Economic Review*, *79(4)*, 655-673.
- Campa, J. M. and L. S. Goldberg (2001), Employment versus Wage Adjustment and the U.S. Dollar, *The Review of Economics and Statistics*, 83(3), 477-489.
- Chadha, B., & Prasad, E. (1997). Real Exchange Rate Fluctuations and the Business Cycle: Evidence from Japan. *Staff Papers - International Monetary Fund*, *44(3)*, 328-355.
- Clarida, R., and Gali, J., (1994). Sources of Real Exchange Rate Fluctuations: How Important Are Nominal Shocks? *Carnegie-Rochester Conference Series on Public Policy, 41*, 1-56.
- Colecchia, A. and P. Schreyer (2002), "The Contribution Of Information And Communication Technologies To Economic Growth In Nine OECD Countries", *OECD Economic Studies No.34*, 2002/1.
- Cornish, D. (2008, October 27). *What Were the Major Causes of the 2001 Recession?* Retrieved August 17, 2009, from http://ezinearticles.com/?What-Were-the-Major-Causes-of-the-2001-Recession?&id=1622929
- Cushman, D. O. (2008). Real Exchange Rates May Have Nonlinear Trends. *International Journal of Finance and Economics*, *13*, 158-173.
- Department of Finance (2008, November 12), *Budget 2001: Budget Plan - Chapter 2: Global Economic Slowdown and Implications for Canada*, from http://www.fin.gc.ca/budget01/bp/bpch2-eng.asp
- Devereux, M. B. (1997). Real Exchange Rates and Macroeconomics: Evidence and Theory. *The Canadian Journal of Economics*, *30(4a)*, 773-808
- Dornbusch, R. (1976). The Theory of Flexible Exchange Rate Regimes and Macroeconomic Policy. *The Scandinavian Journal of Economics*, *78(2)*, 255-275.
- "Dutch Disease." InvestorWords. 1 Sep. 2009 <//http://www.investorwords.com/1604/dutch_disease.html
- Evans, M. D. (2002). FX Trading and Exchange Rate Dynamics. *The Journal of Finance*, *57(6)*, 2405-2447.

- Goodhart, C. (1988). The Foreign Exchange Market: A Random Walk with a Dragging Anchor. *Economica, New Series, 55(220)*, 437-460.
- Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica, 37(3)*, 424-438.
- Greene, W. H. (2008). *Econometric Analysis*. Upper Saddle River: Pearson Education Inc.
- Hill, C., Griffiths, B., & Lim, G. (2008). *Principles of Econometrics*. United States of America: John Wiley and Sons.
- Hodrick, Robert J., Prescott, Edward C. (1997). Postwar U.S. Business Cycles. *Journal of Money, Credit and Banking,* volume 29.
- Isidore, C. (2004, November 10). *What a sagging dollar means for you - Nov. 10, 2004*. from http://money.cnn.com/2004/11/10/news/economy/weakdollar/
- Jackson, A. (1999, June 4). *FROM LEAPS OF FAITH TO LAPSES OF LOGIC*. From http://www.irpp.org/archive/policyop/jun99/jackson.pdf
- Johansen, S. (1988), Statistical Analysis of Cointegrating Vectors. *Journal of Economic Dynamics and Control, 12,* 231-254.
- Krugman, P. R., & Obstfeld, M. (2009). *International Economics: Theory and Policy (Addison-Wesley Series in Economics).* Melbourne: Addison Wesley Longman
- Meese, R., and K. Rogoff (1983) 'Empirical models of the exchange rate: do they fit out of sample?' *Journal of International Economics* 14, 3-24
- Mendoza, E. G. (1995). The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations. *International Economic Review*, *36(1)*, 101-137.
- Nelson, Charles R., Plosser, Charles R. (1982). Trends and random walks in macroeconomic time series: Some evidence and implications. *Journal of Monetary Economics*, volume 10, issue 2.
- Perron, P., and S. Ng (1996) "Useful Modifications to Unit Root Tests with Dependent Errors and Their Local Asymptotic Properties." *Review of Economic Studies 63*, 435-465.
- Phillips, P., and P. Perron (1988) "Testing for a Unit Root in Time Series Regression." *Biometrika* 75,335-346.
- Prescott, Edward C. (1986). Theory Ahead of Business Cycle Management, from http://www.minneapolisfed.org/research/QR/QR1042.pdf.
- Romer, David. (2005). Advanced Macroeconomics. New York: McGraw-Hill.
- Walsh, Carl E. (1993). What Caused the 1990-1991 Recession. *Economic Review, Federal Reserve Bank of San Francisco, 2*.
- Williamson, S. D. (2004). *Macroeconomics*. Toronto: Pearson Education Canada Inc.

APPENDIX A: TABLES

Table I: Granger's (1969) causality test for first difference variables

a) Variables	Lag 1	Lag 2	Lag 3
1.Δecan does not G.C. Δeus	2.95075***	1.47169	2.32491***
2. Δeus does not G.C. Δecan	2.29603	1.07812	0.87609

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

b) Variables	Lag 1	Lag 2	Lag 3
1.Δnonenenergy does not G.C. Δecan	0.00526	0.26720	0.70793
2.Δecan does not G.C. Δnonenergy	0.039505	0.96053	0.65199

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

c) Variables	Lag 1	Lag 2	Lag 3
1.Δenergy does not G.C. Δecan	0.64762	1.12692	1.15127
2.Δecan does not G.C. Δenergy	0.00577	0.00564	0.25438

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

d) Variables	Lag 1	Lag 2	Lag 3
1.Δyca does not G.C. Δecan	0.77569	0.33653	1.09716
2.Δecan does not G.C. Δyca	1.86600	0.96991	0.66557

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

e) Variables	Lag 1	Lag 2	Lag 3
1.Δyus does not G.C. Δecan	0.18418	0.75016	0.61794
2.Δecan does not G.C. Δyus	0.05797	0.54362	0.59762

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

f) Variables	Lag 1	Lag 2	Lag 3
1.Δnonenergy does not G.C. Δeus	0.48098	4.02231**	1.52565
2.Δeus does not G.C. Δnonenergy	4.46235**	2.23014	1.39969

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

g) Variables	Lag 1	Lag 2	Lag 3
1.Δenergy does not G.C. Δeus	0.00663	0.08412	0.52402
2.Δeus does not G.C. Δenergy	0.32333	0.81006	1.78767

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

h) Variables	Lag 1	Lag 2	Lag 3
1.Δyca does not G.C. Δeus	0.21665	0.12580	0.44918
2.Δeus does not G.C. Δyca	0.14981	0.62024	1.03917

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

i) Variables	Lag 1	Lag 2	Lag 3
1.Δyca does not G.C. Δnonenergy	1.04472	0.40754	0.40162
2.Δnonenergy does not G.C. Δyca	0.61152	0.31731	0.17265

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

j) Variables	Lag 1	Lag 2	Lag 3
1.Δyus does not G.C. Δnonenergy	0.70475	1.19635	0.72243
2.Δnonenergy does not G.C. Δyus	1.57030	1.24791	1.59764

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

k) Variables	Lag 1	Lag 2	Lag 3
1.Δyca does not G.C. Δenergy	0.22830	0.18166	0.25980
2.Δenergy does not G.C. Δyca	1.04511	0.96597	0.52667

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

l) Variables	Lag 1	Lag 2	Lag 3
1.Δyus does not G.C. Δenergy	0.75948	0.73553	0.58554
2.Δenergy does not G.C. Δyus	1.45792	0.89823	1.44003

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

m) Variables	Lag 1	Lag 2	Lag 3
1.Δyus does not G.C. Δyca	10.2121*	6.01173*	3.60431**
2.Δyca does not G.C. Δyus	3.23088***	1.11673	1.43013

Sample is from 1972 – 2007 *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

Table II: Granger's(1969) causality test for cyclical component from HP filter variables

a) Variables	Lag 1	Lag 2	Lag 3
1.cceus does not G.C. ccecan	0.09412	5.67468*	4.42544*
2.ccecan does not G.C. cceus	0.61572	1.69736	1.10432

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

b) Variables	Lag 1	Lag 2	Lag 3
1.cchpca does not G.C. ccecan	0.30119	0.46191	0.00219
2.ccecan does not G.C. cchpca	1.32317	1.01535	0.86672

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

c) Variables	Lag 1	Lag 2	Lag 3
1.cchpus does not G.C. ccecan	1.12593	1.29493	0.91881
2.ccecan does not G.C. cchpus	0.00107	0.03546	0.63794

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

d) Variables	Lag 1	Lag 2	Lag 3
1.Δnonenergy does not G.C. ccecan	0.98594	1.55121	0.97988
2.ccecan does not G.C. Δnonenergy	4.00271**	1.71488	1.87791

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

e) Variables	Lag 1	Lag 2	Lag 3
1.Δenergy does not G.C. ccecan	1.31808	0.94749	1.80918
2.ccecan does not G.C. Δenergy	2.85172***	1.42739	1.37925

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

f) Variables	Lag 1	Lag 2	Lag 3
1.cchpca does not G.C. cceus	0.33685	0.52396	0.38851
2.cceus does not G.C. cchpca	0.97644	0.53367	0.59495

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

g) Variables	Lag 1	Lag 2	Lag 3
1.cchpus does not G.C cceus	0.00807	0.16704	0.15223
2.cceus does not G.C cchpus	0.001664	0.37837	1.61017

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

h) Variables	Lag 1	Lag 2	Lag 3
1.Δnonenergy does not G.C. cceus	1.31792	2.98045***	2.70324**
2.cceus does not G.C. Δnonenergy	2.17949	3.18028**	2.34299***

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

i) Variables	Lag 1	Lag 2	Lag 3
1.Δenergy does not G.C. cceus	0.64088	0.11910	1.80918
2.cceus does not G.C. Δenergy	0.58831	0.63016	0.31218

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

j) Variables	Lag 1	Lag 2	Lag 3
1.cchpus does not G.C. cchpca	16.0995*	7.20840*	4.88750*
2.cchpca does not G.C. cchpus	4.67571**	5.14902*	3.58428**

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

k) Variables	Lag 1	Lag 2	Lag 3
1.Δecan does not G.C. cchpca	1.59856	0.79832	0.61970
2.cchpca does not G.C. Δecan	0.17781	0.48263	0.28606

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

l) Variables	Lag 1	Lag 2	Lag 3
1.Δeus does not G.C. cchpca	0.58014	0.55625	0.56298
2.cchpca does not G.C. Δeus	1.30534	1.12460	0.45737

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

m) Variables	Lag 1	Lag 2	Lag 3
1.Δnonenergy does not G.C. cchpca	5.13625**	1.61747	2.10165
2.cchpca does not G.C. Δnonenergy	0.40043	0.77744	0.91660

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

n) Variables	Lag 1	Lag 2	Lag 3
1.Δenergy does not G.C. cchpca	0.31059	0.01542	0.43510
2.cchpca does not G.C. Δenergy	0.60234	0.59738	0.35001

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

o) Variables	Lag 1	Lag 2	Lag 3
1.Δecan does not G.C. cchpus	0.16854	0.98140	0.74824
2. cchpus does not G.C. Δecan	0.05603	0.31194	0.52606

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

p) Variables	Lag 1	Lag 2	Lag 3
1.Δnonenergy does not G.C. cchpus	9.06900*	3.51664**	2.22589***
2.cchpus does not G.C. Δnonenergy	0.64663	0.31526	0.71310

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

q) Variables	Lag 1	Lag 2	Lag 3
1.Δenergy does not G.C. cchpus	0.45715	0.33724	0.71744
2.cchpus does not G.C. Δenergy	1.55454	1.20974	0.92244

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

r) Variables	Lag 1	Lag 2	Lag 3
1.Δeus does not G.C. cchpus	0.49762	1.68138	1.50724
2.cchpus does not G.C. Δeus	0.58721	0.41544	0.03696

Sample from 1972 to 2007. *,**,*** denotes the null hypothesis X does not Granger Cause (G.C.) Y rejected at 1%, 5%, and 10% respectively

APPENDIX B: DATA SOURCES AND VARIABLES

- ECAN: Canadian currency component, Source: Professors Beine, Bos, and Coulombe, 2009
- EUS: US currency component, Source: Professors Beine, Bos, and Coulombe, 2009
- PPAREAL: Non-energy commodity component, Source: Professors Beine, Bos, and Coulombe, 2009
- PPEREAL: Energy price component, Source: Professors Beine, Bos, and Coulombe, 2009
- RDIFF: Real interest rate differential, Source: Professors Beine, Bos, and Coulombe, 2009
- RY_US: United States gross domestic product (GDP); Chained (2000) dollars (v21581591), Source: Statistics Canada, CANSIM II
- RY_CAN: Canada gross domestic product (GDP); Chained (2002) dollars (Dollars) seasonally adjusted at annual rates, at market prices (v1992067) Source: Statistics Canada, CANSIM II
- Statistics Canada. "Gross domestic product at basic prices, by industry (monthly)." Statistique Canada – Tableaux sommaires. 13 Aug. 2009 <http://www40.statcan.gc.ca/l01/cst01/gdps04a-eng.htm>.

APPENDIX C: DATA SOURCES AND VARIABLES FROM BEINE, BOS, AND COULOMBE (2009) ARTICLE:

- S_t : vector of daily exchange rates against the USD (number of USD for one unit of domestic currency): Canadian dollar (CAD), British pound (UKP), Japanese Yen (JPY), Euro (EUR); Australian Dollar (AUS); source: Datastream.
- E_t: Canadian nominal effective exchange rate, trade-weighted (code: V37426), source: Statistics Canada CANSIM II.
- P_t: Bivariate vector of monthly commodity price indexes;
  -Total commodity price index excluding energy in USD terms (1980=100); code V36383; source: Statistics Canada CANSIM II.

-Energy price index in USD terms (1980=100); code V36383; source: Statistics Canada CANSIM II.

- $r_t = \ln\left(\frac{1}{s_t} * \frac{q_{us,t}}{q_{ca,t}}\right)$ =: log of the real CAD/USD exchange rate where $q_{us,t}$ is the US GDP deflator (2000=100), computed by the ratio of gross domestic product current dollars (code V121951) and gross domestic product chained 2000 dollars (code v21581591); source: Statistics Canada CANSIM II.
- $q_{ca,t}$ is the monthly Canadian GDP deflator (2000=100), implicit price index (2002=100) (code V1997756); source: Statistics Canada CANSIM II.
- $idiff_t$: 3 months interest rate differential between Canada and the US, monthly frequency; computed as *idiff* = *ican* – *ius* where *ican* is the 3 month prime corporate paper rate (code: V122491) and *ius* is the US 3 month commercial paper rate adjusted (code: V122141); source: Statistics Canada CANSIM II.