# International Financial Relations between Canada and the USA: A joint testing approach

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**Abstract**

The validity of four key international parity conditions (PPP, UIP, CIP and the forward market efficiency hypothesis) is tested in a joint modelling framework, using USA and Canadian data. The joint modelling framework allows for possible interactions among prices, interest rates, exchange rates and it accounts for the effect of the expectations formation. We report evidence for the joint validity of PPP and CIP between the USA and Canada, reflecting the high links in their commodity and capital markets. The weak exogeneity tests reveal some form of a monetary policy transmission mechanism from the USA to Canada.

*JEL classification: C32, F31.*

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## 1. Introduction

In international economics, there are a few parity and equilibrium conditions, which play a key role for the development of the international financial literature. These relationships, which are very simple as theoretical concepts, have been used as cornerstones for the building of more complex theoretical analyses. Such relationships are: the Purchasing Power Parity (PPP), the Covered Interest Parity (CIP), the Uncovered Interest Parity (UIP) and the Forward Market Efficiency Hypothesis (EH). The conditions are thought of as either arbitrage relationships (i.e. the UIP, the CIP) which hold continuously, or as long-run equilibrium relationships (i.e. the PPP).

As a result, a substantial body of the literature has dealt with the empirical testing of the four parity conditions mainly over the post Bretton Woods floating exchange rate period. Most of the studies have tested for the empirical verification of the conditions individually and provide mixed results for their empirical verification. PPP has been the subject of numerous empirical studies (for recent surveys see *inter alia* Taylor and Taylor 2004). Although an increasing number of studies based on long-term historical data have pointed to mean reversion of real exchange rates, the evidence derived from data for the past three decades of floating exchange rates has been less favourable to the PPP hypothesis.

Similarly, a number of studies point to the systematic violation of UIP. This violation can be best explained in terms of the decomposition of UIP into its CIP and forward-versus-spot components. CIP has been generally supported by the empirical evidence. On the contrary, a number of papers have pointed to a bias in the predictions of the growth rate of the (nominal) spot exchange rate implicit in forward premia (for surveys of this evidence, see Sarno and Taylor 2002; Engel 1996; Froot and Thaler 1990).

Recently, a growing body of the empirical literature on international finance advocates for a joint testing of UIP and PPP, based on the argument that the two international parity relationships may not be independent of each other in the long-run, since exchange rates are affected by developments in both commodity and asset markets (e.g. Miyakoshi 2004; Ozmen and Gokcan 2004; Caporale *et al*. 2001; Camarero and Tamarit 1996; Johansen and Juselius 1992; Juselius 1995; MacDonald and Marsh 1997). In a recent paper, Juselius and MacDonald (2004) advocate joint testing for UIP, PPP, and the term spread (TS) hypothesis to account for further possible interactions linking these parity conditions.

In the present paper, we extend this nascent literature by testing for the first time the validity of the UIP, PPP, CIP and EH hypotheses jointly, using data from Canada and the USA. The joint modelling of these conditions allows for possible interactions in the determination of prices, interest rates and exchange rates in the commodity and capital markets and it also takes into account the effect of the expectations formation in the capital markets. The joint modelling of international parity conditions may shed further light on each individual parity condition, thereby increasing the likelihood of establishing well-defined results. In addition, we hope to address a number of unresolved issues. One important issue concerns the exogeneity status of the variables which can indicate causation dynamics governing the formation of prices, interest rates and exchange rates. Traditionally, the USA has been seen as the *dominant* economy. But with increased integration and convergence between the USA and Canadian economy it may be expected that the Canadian variables are equally important in bilateral financial linkages as USA variables. A final issue we address is the extent to which these parity conditions (individually or jointly) hold during the examined sample period. Specifically, we make the distinction between strong and weak form of the parities, thus allowing for even more channels of interaction among the variables.

The four conditions are tested as equilibrium long-run relationships by applying the Johansen multivariate cointegration technique (Johansen, 1995). The model specification used for cointegration allows for different long-run relations and short-run dynamics, as well as for adjustment for specific regime shifts. If the short-run dynamics are different from the long-run relations, the explicit specification of the former is probably crucial for a successful estimation of the latter (see *inter alia* Juselius 1995). Applied in the present work, the methodology allows for more complex short-run dynamics, which may link the variables in question. Taking into account possible regime shifts is also important since such shifts can distort statistical tests that do not account for them. The technique also allows testing for the exogeneity status of the variables.

The present paper investigates the joint validity of the aforementioned conditions between Canada and the USA for the period 1988-2006. The two countries represent an interesting case for research because they are closely related to each other through both commodity and capital flows, as well as through bilateral and multilateral trade agreements such as NAFTA. Nevertheless, the empirical evidence for the validity of the four conditions between Canada and the USA, when tested individually, is at best mixed, but more often indicates their rejection.[1] In the present work, we argue that the joint modelling of all four conditions helps us to exploit possible extra information on the determination and the formation of the variables under consideration and leads to a robust specification, valid statistical inference and well-defined results.

The rest of the paper is organised as follows: Section 2 discusses the theoretical considerations. Section 3 presents the data set and describes the applied work and results. The final section summarises and concludes.

## 2. The theoretical framework

In the absence of barriers to international capital mobility, there are theoretical links among spot and forward exchange rates, interest rates and prices. A simple version of the PPP relationship can be defined by:

$$s_t = p_t - p_t^* \qquad (1)$$

where $s_t$, $p_t$ and $p_t^*$ are the logs of the spot exchange rate, domestic and foreign prices, respectively.

Recent empirical work on PPP has concentrated on the estimation of the following long-run relationship:

$$s_t = \beta_0 + \beta_1 p_t + \beta_2 p_t^* + u_t \qquad (1)$$

[1] In particular: PPP is rejected by Johnson (1990) -when using annual observations-, Flynn and Boucher (1993), Kouretas (1997a) –when using consumer price indices-, Moazzami and Anderson (2003) and Hong and Phillips (2005). The existence of a cointegrating relationship between the Canadian dollar/ US dollar exchange rate and the US and Canadian prices, which can be interpreted as weak evidence in favour of the validity of PPP, is provided by Johnson (1990) –when using quarterly observations-, Choudhry *et al*. (1991), Crowder (1996), Kouretas (1997a) –when using wholesale prices-, Moon and Perron (2004), Villeneuve and Handa (2006) and Hasan (2006). Nevertheless, in the above studies which provide evidence in favour of PPP, the restrictions of symmetry and proportionality are either not tested (Johnson 1990; Choudhry *et al*. 1991; Villeneuve and Handa 2006) or rejected (Crowder 1996; Moon and Perron 2004; Hasan 2006). Feenstra and Kendal (1997) accept long-run PPP, only once a relative traded goods price index and the interest rate differential are included in the model. It should be noted here that within this group of papers, Feenstra and Kendall (1997) and Moazzami and Anderson (2003) emphasise the importance of the effects of both capital and commodity markets on the dynamics and the long-run trends of the Canadian/US dollar exchange rate. Studies testing for the interest parities between the US and Canada provide also mixed results: Boothe (1991) and Tieslau and Rasche (1999) provide support for a UIP version, whereas Kouretas (1997b), Alexius (2001) and Flood and Rose (2002) reject UIP. Kia (1996) accepts CIP, whereas Abeysekera and Turtle (1995) reject CIP.

where $u_t$ is the error term. Strong PPP is implied by the proportionality hypothesis $H_1$ ($\beta_1$=1, $\beta_2$ =-1):

$$s_t = \beta_0 + p_t - p_t^* + u_t \tag{2}$$

However, strong PPP cannot be expected to hold always as an empirical proposition -because of the effects of transportation and information costs and measurement error problems- and is more likely to have the weak form implied by the symmetry hypothesis $H_2$ ($\beta_1$=- $\beta_2$):

$$s_t = \beta_0 + \beta_1 (p_t - p_t^*) + u_t \tag{3}$$

One possible reason for the lack of supporting evidence of the PPP condition is that researchers have overlooked the links between goods and asset markets in the determination of exchange rates (Johansen and Juselius 1992). PPP is likely to be strongly related to the uncovered interest parity (UIP) condition. UIP claims, that in efficient markets with perfect capital mobility, the exchange rate is determined by:

$$\Delta s_t^e = i_t - i_t^* \tag{4}$$

where $i_t$ and $i_t^*$ are nominal interest rates in domestic and foreign currencies, respectively, and $\Delta s_t^e \left(= E_t(s_{t+1}) - s_t\right)$ is the expected depreciation rate of the log of the nominal exchange rate. The argument is that rational investors' actions in purchasing one currency and selling another will move exchange rates until excess profits from uncovered interest arbitrage are eliminated, hence bringing interest rate differentials into line with spot exchange rates and expectations of their movement.

Direct tests of absolute UIP amount to testing equation (4). The evidence often leads to the rejection of the parity under rational expectations and risk neutrality. Therefore, a weak form of UIP can be tested:

$$\Delta s_t^e = \delta\left(i_t - i_t^*\right) \tag{5}$$

where $\delta$ is a positive constant. Equation (5) states that the exchange rate is to return to its equilibrium at a rate proportional to the current interest rate differential.

The empirical violation of UIP leads [takes us] to two further parity conditions (CIP and EH) which are needed for a full understanding of this puzzle. CIP ensures that profitable opportunities in the foreign exchange and interest rate markets do not last for long and that the tendency in these markets is towards equilibrium:

$$f_t - s_t = i_t - i_t^* \tag{6}$$

where $f_t$ is the log of the *k*-period forward rate at time *t*, $s_t$ is the log of the spot rate at time t, and $i_t\left(i_t^*\right)$ is the domestic (foreign) *k*-period interest rate at time *t*.

Since CIP is basically a risk-free arbitrage condition, it is expected to hold across industrial currencies in its absolute form. However, given the existing mixed empirical evidence on the validity of interest parities between the USA and Canada we also test for a weak-form of CIP:

$$f_t - s_t = \gamma\left(i_t - i_t^*\right) \tag{7}$$

where $\gamma$ is a positive constant.

Turning to the EH, the forward rate is considered to be an unbiased predictor of the future spot rate, meaning that if the forward rate is used to predict the future spot rate, the sum of gains will equal the sum of losses:

$$\Delta s_t^e = f_t - s_t \tag{8}$$

Notice that (4) can be easily derived by (6) and (8). Under the hypothesis that the forward rate is an unbiased predictor of the spot rate (eq. 8) and that CIP holds (eq. 6), we can deduce that the interest rate differential becomes an optimal predictor of the rate of depreciation. Essentially, the empirical validity of two out of the three conditions (UIP, ET and CIP), implies also validity of the third (in other words, testing for e.g., CIP and ET means indirect testing for UIP).

A number of authors (see, *inter alia,* Caporale *et al.* 2001; Camarero and Tamarit 1996; and Johansen and Juselius 1992) postulate that since PPP and UIP describe theoretical equilibrium equations in different markets (goods and capital market, respectively) they each define a partial equilibrium relationship. Therefore, in order to find a credible exchange rate determination, both parities have to be taken into account. The following condition for nominal exchange rate determination, as proposed by Dornbusch (1976), can be empirically investigated (Caporale *et al.* 2001):

$$s_t = p_t - p_t^* - \left(\frac{1}{\theta}\right)\left(i_t - i_t^*\right) \tag{9}$$

Eq. (9) states that the nominal exchange rate is jointly determined by the price level differential and the interest rate differential; the speed of adjustment to changes in the latter is given by $\theta$.[2]

Given the number of variables on hand, a more general formulation of the six-dimensional vector $x_t' = (s_t, f_t, i_{c,t}, i_{us,t}, p_{c,t}, p_{us,t})$ that takes into account the short-run dynamics and allows for the effects of the long-run equilibrium conditions as described in equations (1) – (8), is needed. The econometric methodology applied in the present paper is described in the following section.

## 3. The empirical evidence

*3.1 The econometric methodology*

The four conditions are tested as cointegrating relationships by applying the Johansen technique. To this end, we consider a six-dimensional vector stochastic process $x_t$ which includes all variables appearing in equations (1)–(8). A vector autoregressive representation of $x_t$ can be reparameterised in the vector error correction form:

$$\Delta x_t = \sum_{t=1}^{p-1} \Pi_i \Delta x_{t-i} + \Pi x_{t-p} + \psi D_t + \nu_t \tag{10}$$

where $v_t \sim IN(0, \Sigma)$ and $D_t$ contains conditioning variables (e.g. constant, seasonal dummies, specific regime shift dummies). Π is the matrix of the long-run responses and if there exist $r$ cointegrating relationships between the variables, is of reduced rank $r$ . In this case, Π can be expressed as the product of two $N \times r$ matrices $\alpha$ and $\beta'$: $\Pi = \alpha\beta'$ where $\beta$ contains the $r$ cointegrating vectors and $\alpha$ is the loadings matrix, which contains the coefficients with which the cointegrating relationships enter the equations modelling $\Delta x_t$. Johansen provides the test statistics to define the rank $r$ of the matrix Π and to test for linear restrictions on either the parameters of the cointegrating vectors or their loadings.

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[2] Eq. (9) is derived from eqs. (1) and (4) under the assumption that $\Delta s_t^e$ is a function of the gap between the log of the nominal exchange rate and the log of the equilibrium exchange rate $\bar{s}$ as implied by PPP: $\Delta s_t^e = -\theta(s_t - \bar{s})$.

In the present case, linear restrictions on the elements of the matrix $\beta$ test for the validity of the theoretical relations as specified in equations. (1) – (8).[3] Tests on the elements of matrix $\alpha$ (i.e., weak exogeneity tests) can reveal causality dynamics governing the behaviour of the variables under consideration.

*3.2 The data set*

The validity of the four doctrines linking the economies of Canada and the USA is tested in a system context. Monthly, seasonally unadjusted data for the period 1988:12 – 2006:8 are used. Details on the data sources can be found in Appendix A. 1988:12 is chosen as the starting month of the sample simply because data on the forward exchange rate are not available prior to that month. The bilateral nominal exchange rate of the Canadian dollar against the USA dollar, the consumer price indices of the two countries and the interest rate series (Treasury bill rates) for Canada and the USA are all taken from the International Financial Statistics (IFS) database, whereas the 1-month forward Canadian dollar/USA dollar series is taken from the Bloomberg database. All but the interest rate variables are expressed in logs. The spot exchange rate is denoted by *s*, the forward exchange rate by *f*, the consumer price indices are denoted by $p_{us}$, $p_c$ and the interest rate series by $i_{us}$ and $i_c$, where the subscripts *us* and *c* stand for the USA and Canada, respectively. Effective estimation periods are reduced so as to accommodate the lag structure of the estimated models.

*3.3 Unit root tests*

Time series plots of the six series under consideration are given in Figure 1. The observations on prices (in levels) exhibit trending behaviour and may have unit roots. The time plots of exchange and interest rates (in levels) also provide evidence against mean-reversion. In addition, they indicate that there may exist time changes in the drift of the corresponding series. We apply two different sets of unit root tests. The first set reports standard ADF tests, whereas the second set analyses the unit root properties after taking into account the structural changes in the series.

The order of integration is crucial for our conclusions, thereby we present detailed results of ADF unit root tests for our series in Table 1 (Panel A). Because deterministic linear trends seem implausible in the exchange and interest rate series we only include constants and seasonal dummies in the test regressions for the level

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[3] Note that the relations can be individually or jointly formulated as restrictions on the parameters of $\beta$.

series. Hence, no deterministic term appears in the tests for the first differences. Also, because the lag length is known to have an impact on the results of the unit root tests, we perform tests with different lag lengths as suggested by different lag selection criteria. The maximum lag length is set equal to 12. Overall the ADF test results provide some evidence for one unit root in each of the underlying series. However, it is well-known that the ADF test may be distorted in the presence of a shift in the level of the data generation process. Lanne *et al.* (2001, 2002) propose a unit root test with an unknown break date. The test results (reported in Table 1: Panel B) suggest that all series are I(1). We therefore proceed under the assumption that all series are integrated of order 1.

**[Figure 1]**

**[Table 1]**

*3.4 The cointegration rank*

We next consider a multivariate model which allows explicitly for cointegration. The first step in the econometric analysis is the estimation of an unrestricted VAR of the form of (10) for the vector $x_t' = \left(f_t, s_t, i_{c,t}, i_{us,t}, p_{c,t}, p_{us,t}\right)$ using multivariate least squares. Five lagged levels for $x_t$, needed to ensure serially uncorrelated and homoskedastic residuals, seasonal dummies and an unconstrained constant are included in the system. While lack of residual correlation and heteroscedasticity is accepted by this first VAR specification for the residuals of most estimated equations, the normality assumption is seriously violated, possibly due to non-constant parameters. In addition, visual examination of the plots of the series reveals fluctuations in specific time periods (Figure 1). These features support the inclusion of a set of dummies to account for the structural changes observed in the sample period. These structural breaks are essentially effects coming from various economic policy measures pursued in Canada and the USA during the examined period. More analytically, D911 (takes the value 1 in 1991:1) accounts for the increase in Canadian prices due to the introduction of a goods and services tax in January 1991. D92 takes the value 1 in 1992:9 and 1992:11 and it accounts for two high exchange rate volatility episodes in September and November 1992 which provoked increases in interest rates and forced the Bank of Canada to intervene in the money market. Following a period of low interest rates, interest rates rose sharply again in March 1994; D943 accounts for this rise. D98 (takes the value 1 in 1998:10 and 1998:11) accounts for the cut of the federal funds rate by the USA Federal Open Market Committee in October and November 1998 in order to improve capital market conditions in the USA economy. Finally, in September 2005, the Bank of Canada increased its policy rate; D059 (takes the value 1 in 2005:9) accounts for this policy effect. All dummy variables turn out to be significant in the system, whereas their inclusion ameliorates significantly the normality properties of the residuals. The diagnostic tests of the VAR (not reported here but available on request) do not indicate any serious misspecification and thus we proceed to the cointegration rank analysis.[4]

Both the trace and max-eigenvalue tests developed by Johansen (1995) are reported in Table 2 (Panel A). According to the trace test statistic there is evidence for three cointegrating vectors. The maximum eigenvalue test indicates that the cointegrating rank equals two. However, it should be noted here that the critical values of both likelihood ratio tests assume no exogenous variables (e.g., dummies) in the system. Therefore, we also analyse the cointegrating rank of the six variables using the test developed by Saikkonen and Lütkepohl (2000a; 2000b; 2000c) which allows for different specifications of the exogenous variables. The test results (also reported in Table 2: Panel A) suggest that the evidence for $r$=2 is quite robust.

**[Table 2]**

*3.5 Testing for theoretical restrictions*

The estimated coefficients of the two cointegrating vectors (reported in Table 2: Panel B) indicate that the vectors do not necessarily express meaningful relations in an economic sense. Nevertheless, one may notice that in both vectors (i) the coefficients of $f$ and $s$ take values almost equal in magnitude and opposite in sign, implying probably the validity of the efficient market hypothesis, or a long-run relationship involving the forward premium $f-s$, (ii) the domestic and foreign price coefficients take almost equal in magnitude and opposite in sign values providing affirmative evidence for a PPP relationship, (iii) the interest rates obtain opposite in sign and close in magnitude coefficients, indicating probably a long-run relationship involving the interest rate differential $i_c - i_{us}$. In the event that $i_c$ and $i_{us}$ cointegrate, and given that $\Delta s$ is a stationary series, then the relationship $\Delta s - (i_c - i_{us})$, which

[4] Actually, there is some evidence for autocorrelation and non-normality in the residuals of the $i_C$ equation. The inclusion of additional lags might have reduced the problem of autocorrelation, albeit at the cost of diminishing degrees of freedom. Based on the findings of Gonzalo (1994) regarding the robustness of the Johansen procedure with respect to non-normality, we make no further modelling changes.

implies the UIP hypothesis, would also be a valid equilibrium relationship in the long run. Nevertheless, formal testing regarding the structure of the cointegrating space is needed.

Based on these observations, we proceed to the formal specification of the two-dimensional cointegrating space. Table 3 presents the results of a number of likelihood ratio test statistics for alternative hypotheses concerning the specification of the two cointegrating vectors. Hypotheses on a single cointegrating vector framework are initially considered. Single vector testing is just indicative for the specification of each vector, since the restrictions, which govern one cointegrating vector at a time, do not identify restrictions for the structure of the system.

Hypotheses concerning the specification of each individual cointegrating vector ($\beta_1$ or equivalently $\beta_2$) are presented in Table 3: Panel A.[5] $H_1$ assumes a version of the efficiency hypothesis. It should be noted here that the efficiency hypothesis in its strict form implies a cointegrating relationship of the form $f_{t-1} - s_t$, whereas in the present case we test for a relationship of the form $f_t - s_t$, assuming that $f_{t-1} = f_t$ holds in the long run. $H_1$ is accepted by the present data set.[6] $H_2$ assumes cointegration between the forward premium $f - s$ and the interest rate differential $i_c - i_{us}$ implying the strong-form of the CIP hypothesis. $H_2$ is rejected by the data. This is a surprising finding given that CIP is considered to be a risk-free arbitrage condition and most major banks tend to price the forward rate using CIP. One possible explanation for the failure of strong CIP is that our sample includes periods of turbulence in the behaviour of (mainly) Canadian interest rates, thereby creating speculative opportunities for profitable arbitrage. $H_3$ tests for the weak form of CIP (eq. (7)). This restriction can be formulated as: $(1,-1,0,0,\alpha,-\alpha)$. $H_3$ is accepted by the data. $H_4$ assumes that the two interest rates cointegrate with coefficients equal in magnitude and opposite in sign. $H_4$ thus implies the strong-form of the UIP hypothesis, if we consider that $\Delta s$ is an I(0) series. $H_4$ is rejected by the data at the 5% significance level. The failure of strong UIP suggests that USA securities are imperfect substitutes for Canadian ones of equivalent maturity and that

[5] The results would not change, if each hypothesis is assigned either to $\beta_1$ or to $\beta_2$, given that a single hypothesis does not identify the whole space.

[6] Analysis on a vector of the form $x_t' = \left(f_{t-1}, s_t, i_{c,t}, i_{us,t}, p_{c,t}, p_{us,t}\right)$, in which the EH is more properly defined, provides similar results.

market participants require compensation in the form of a risk premium if they are to hold the Canadian dollar. $H_5$ and $H_6$ test for the weak- and strong-form of PPP, respectively. They are both rejected at the conventional 5% significance level. Hypotheses $H_7$ and $H_8$ express joint theoretical restrictions for the specification of the cointegrating vectors. Specifically, $H_7$ implies that both the weak version of PPP (WPPP) and the weak-form of UIP are jointly valid, whereas $H_8$ tests for strong PPP (SPPP) together with weak UIP (see eq. 9). They are both accepted by the present data set. The rejection of hypotheses $H_5$ and $H_6$ and the acceptance of $H_7$ and $H_8$ indicate that, although PPP is not by itself a stationary process, it becomes stationary when combined with a linear combination of interest rates. Thus, the long-run interactions between goods and asset markets should not be ignored. Nevertheless, the outcomes concerning the specification of each individual vector are just indicative for the specification of the cointegration space. Joint testing is needed.

Hypotheses $H_9$ - $H_{15}$ test joint restrictions for both cointegrating vectors. These hypotheses have already been tested for the specification of each individual vector separately (e.g. $H_{10}$ assumes that $\beta_1$ and $\beta_2$ validate the EH and the weak PPP hypothesis, respectively). All but hypotheses $H_9$ and $H_{15}$ are rejected by the data set. However, in $H_9$, which implies a relationship between the exchange rate and relative prices, the signs obtained do not conform to a PPP relationship in $\beta_2$. Therefore, $H_9$ is rejected based on theoretical grounds. As a consequence, the analysis is continued by assuming that the structure of the cointegrating space can be trustfully given by the specification expressed by $H_{15}$. The two vectors are of the form (standard error in parenthesis):

$$\beta_1 : (f - s) - \underset{(0.0097)}{0.081}(i_{us} - i_c)$$

$$\beta_2 : s - p_c + p_{us}$$

$\beta_1$ implies the validity of a weak form CIP between Canada and the USA, whereas $\beta_2$ implies strong PPP between the two economies. One interesting finding is the coefficient of the interest rate differential in $\beta_1$. One would normally expect the speed of adjustment to be higher for CIP, which refers to a forward-looking market, than for PPP, given that arbitrage is more costly in the goods market. However, our analysis indicates the exact opposite. We attribute our finding to possible speculative trading during the sample period. In any case, the results reflect the high degree of integration in the goods and capital markets in the two economies. PPP is accepted in its strong-form, in contrast to previous empirical studies, which test for the validity of the parity taking into account the effects coming from the goods market alone. The results indicate that during the period under consideration, the nominal exchange rate is influenced by both goods and capital market forces.

**[Table 3]**

*3.6 Weak exogeneity tests*

A large number of weak exogeneity tests have been performed. Selected results are reported in the Table 3: Panel C. Hypotheses $H_{16}$ – $H_{21}$ test for weak exogeneity of the six variables with respect to the parameters of the full system of cointegrating vectors. In detail, $H_{16}$, $H_{17}$, $H_{18}$, $H_{19}$, $H_{20}$ and $H_{21}$, test for weak exogeneity of $f, s, p_c, p_{us}, i_c, i_{us}$, respectively, with respect to the parameters of the cointegrating space, i.e., the parameters of $\beta_1$ and $\beta_2$. The test results reveal the complex dynamics that govern the behaviour of the variables in the short run.

Our attention is focused on hypotheses $H_{22}$ and $H_{23}$. $H_{22}$ jointly tests for weak exogeneity of the USA variables (prices and interest rates) with respect to the parameters of the cointegrating space, whereas $H_{23}$ jointly tests for weak exogeneity of the corresponding Canadian variables. Hypothesis $H_{23}$ is rejected by the data at the 1% significance level but $H_{22}$ is not. Therefore, there is some weak evidence that the USA variables are weakly exogenous to the system. This result implies that, in the event of a shock in the USA prices and interest rates, which causes the PPP and CIP relations to move out of equilibrium, all but the USA variables will move in a way to restore equilibrium. The USA variables might thus be considered to be the driving forces of the system. In other words, in the short run the USA variables are not affected by the equilibrium relations between the USA and Canada; however, the Canadian variables move in order to establish the equilibrium relations. In a nutshell, the results provide some evidence for the hypothesis that the USA is still the dominant economy between the two. It seems that the Canadian dollar/ USA dollar rate, the Canadian prices and interest rates are still affected (albeit marginally) by the monetary policy in the USA. In such a context, the exchange rate acts as a channel through which the USA monetary policy is transmitted to the Canadian economy.

## 4. Conclusions

The present study extends the empirical literature on international financial economics, by re-examining the validity of four key parity relationships (PPP, UIP, CIP and EH), between the USA and Canada in a joint framework. We argue that testing the aforementioned conditions in a system context is more appropriate since it allows for dynamic interactions in the determination of prices, interest rates and exchange rates in the goods and capital markets and takes into account the effect of the expectations formation.

In contrast to the results of previous studies, the system analysis provides affirmative evidence in favour of both PPP and CIP. PPP implies that the two economies are considerably linked through trade, whereas CIP indicates a significant degree of integration in the corresponding capital markets. The system analysis also reveals some interesting results concerning the weak exogeneity of the variables. It provides some evidence for the USA variables (prices and interest rates) to be weakly exogenous with respect to the long-run relations. This implies that any shocks hitting the USA variables are passed through to Canadian variables *via* the equilibrium real exchange rate and the CIP relationship. Thus, one may argue that there exists some form of a monetary policy transmission mechanism from the USA to Canada.

## Appendix A.

Data sources: The analysis uses monthly seasonally unadjusted data for the United States and Canada from 1988:12 to 2006:8. All but the forward Canadian dollar/USA dollar series are taken from the International Financial Statistics (IFS) electronic database. These are: The bilateral nominal exchange rate of the Canadian dollar against the USA dollar (IFS code: 156..AE..ZF…), the consumer price index of the USA (IFS code: 11164..ZF…), the consumer price index of Canada (IFS code: 15664..ZF…), the treasury bill rate for the USA (IFS code: 11160C..ZF…) and the treasury bill rate for Canada (IFS code: 15660C..ZF…). The 1-month forward Canadian dollar/USA dollar series is taken from the Bloomberg database (code: CAD1M).

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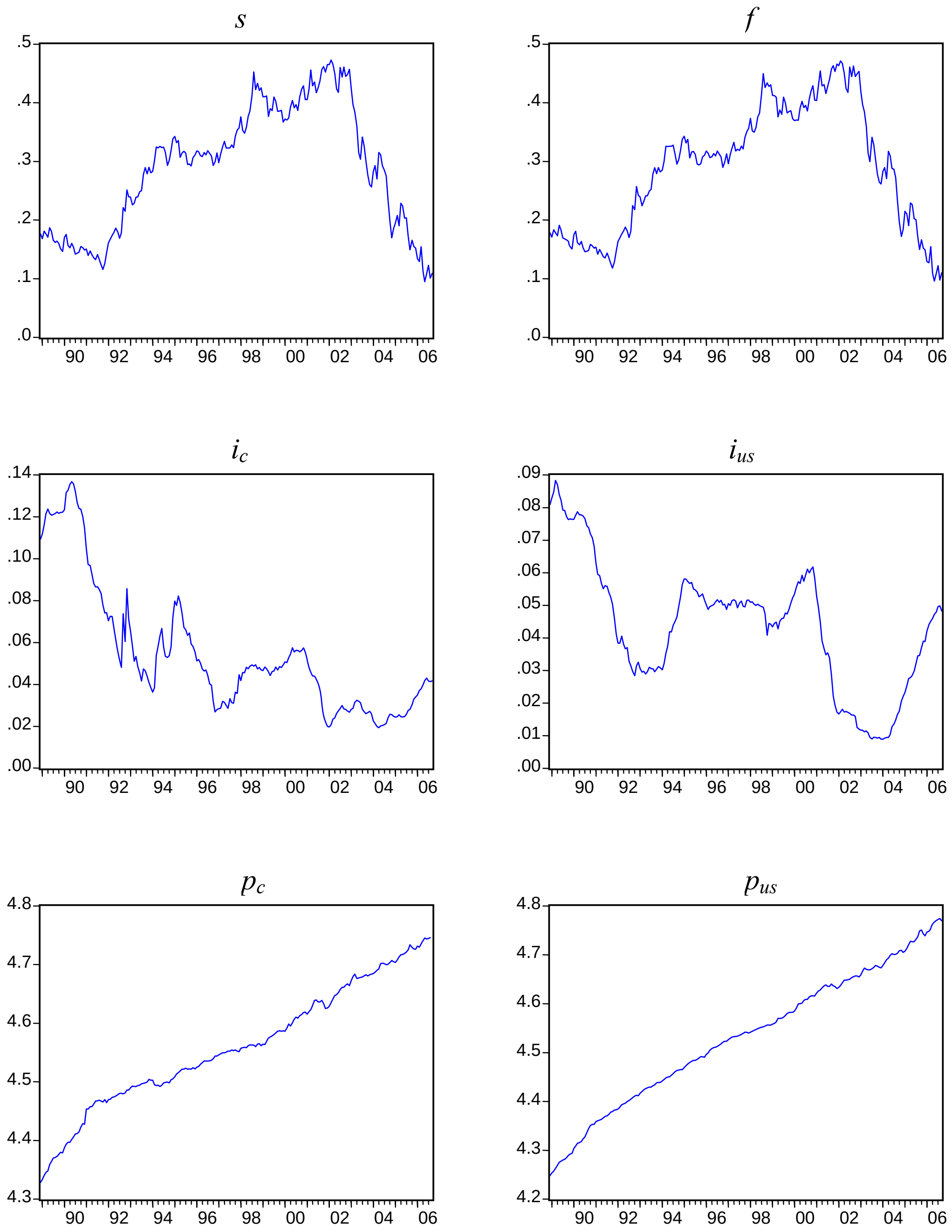
**Figure 1. Plots of the time-series in levels (1988:12-2006:08)**



## Table 1. Unit root tests

Panel A: Augmented Dickey-Fuller tests

| Var. | Lags | | Deterministic terms | Test statistic | Critical values 10% | 5% | 1% |
|---|---|---|---|---|---|---|---|
| $s$ | AIC,HQ,SBC: | 0 | *c,SD* | -0.62 | -2.57 | -2.86 | -3.43 |
| $\Delta s$ | AIC,HQ,SBC: | 0 | | -14.10 | -1.62 | -1.94 | -2.56 |
| $f$ | AIC,HQ,SBC: | 0 | *c,SD* | -0.63 | -2.57 | -2.86 | -3.43 |
| $\Delta f$ | AIC,HQ,SBC: | 0 | | -13.94 | -1.62 | -1.94 | -2.56 |
| $i_c$ | AIC,HQ: | 7 | *c,SD* | -2.62 | -2.57 | -2.86 | -3.43 |
| | SBC: | 4 | *c,SD* | -2.09 | | | |
| $\Delta i_c$ | AIC,HQ: | 6 | | -4.10 | -1.62 | -1.94 | -2.56 |
| | SBC: | 3 | | -7.96 | | | |
| $i_{us}$ | AIC,HQ: | 6 | *c,SD* | -2.40 | -2.57 | -2.86 | -3.43 |
| | SBC: | 3 | *c,SD* | -2.58 | | | |
| $\Delta i_{us}$ | AIC: | 5 | | -3.24 | -1.62 | -1.94 | -2.56 |
| | HQ,SBC: | 2 | | -4.79 | | | |
| $p_c$ | AIC: | 1 | *c,t,SD* | -3.21 | -3.13 | -3.41 | -3.96 |
| | HQ,SBC: | 0 | *c,t,SD* | -3.41 | | | |
| $\Delta p_c$ | AIC,HQ,SBC: | 0 | *c,SD* | -12.48 | -2.57 | -2.86 | -3.43 |
| $p_{us}$ | AIC : | 3 | *c,t,SD* | -3.45 | -3.13 | -3.41 | -3.96 |
| | HQ,SBC: | 2 | *c,t,SD* | -3.79 | | | |
| $\Delta p_{us}$ | AIC : | 2 | *c,SD* | -7.18 | -2.57 | -2.86 | -3.43 |
| | HQ,SBC : | 1 | *c,SD* | -9.99 | | | |

Panel B : Unit root tests allowing for structural breaks

| Var. | Lags | Deterministic terms | Suggested break date | Test statistic | Critical values 10% | 5% | 1% |
|---|---|---|---|---|---|---|---|
| $s$ | AIC,HQ, SBC: 0 | *c, SD* | 2004M3 | -0.64 | -2.58 | -2.88 | -3.48 |
| $\Delta s$ | AIC,HQ SBC: 0 | | 2004M4 | -13.71 | | | |
| $f$ | AIC,HQ, SBC: 0 | *c,SD* | 2004M4 | -0.61 | | | |
| $\Delta f$ | AIC,HQ, SBC: 0 | | 2004M4 | -13.55 | | | |
| $i_c$ | AIC,HQ:7 | *c,SD* | 1992M10 | -2.74 | | | |
| | SBC: 4 | *c,SD* | 1992M10 | -2.19 | | | |
| $\Delta i_c$ | AIC,HQ:6 | | 1992M11 | -3.87 | | | |
| | SBC: 1 | | 1992M9 | -7.53 | | | |
| $i_{us}$ | AIC,HQ:6 | *c,SD* | 1998M10 | -2.53 | | | |
| | SBC: 3 | *c,SD* | 1998M10 | -2.67 | | | |
| $\Delta i_{us}$ | AIC,HQ:5 | | 1998M10 | -3.29 | | | |
| | SBC: 2 | | 1998M10 | -4.55 | | | |
| $p_c$ | AIC : 1 | *c,t,SD* | 1991M1 | -1.05 | -2.76 | -3.03 | -3.55 |
| | HQ,SBC:0 | *c,t,SD* | 1991M1 | -0.88 | | | |
| $\Delta p_c$ | AIC,HQ, SBC: 0 | *c,SD* | 1991M1 | -12.07 | -2.58 | -2.88 | -3.48 |
| $p_{us}$ | AIC : 3 | *c,t,SD* | 2005M8 | -0.82 | -2.76 | -3.03 | -3.55 |
| | HQ,SBC:2 | *c,t,SD* | 2005M8 | -0.81 | | | |
| $\Delta p_{us}$ | AIC,HQ:2 | *c,SD* | 2005M9 | -7.17 | -2.58 | -2.88 | -3.48 |
| | SBC: 1 | *c,SD* | 2005M11 | -9.86 | | | |

*Notes:c, t* and *SD* stand for a constant, a linear trend and seasonal dummies, respectively. AIC=Akaike's Information Criterion; HQ=Hannan-Quinn Criterion; SBC=Schwarz Bayesian Criterion. The unit root tests with one break point and the corresponding critical values (Panel B) are those proposed by Lanne *et al.* (2002). Computations are performed with JMulTi, Version 4.2.

**Table 2: Cointegration analysis**

| **Panel A:** Testing for the cointegration rank | | | | | | | |
|---|---|---|---|---|---|---|---|
| Johansen tests | | | | | | S&L test | |
| Rank | Eigenvalues | $\lambda_{max}$ | $\lambda_{max}(0.95)$ | $\lambda_{trace}$ | $\lambda_{trace}(0.95)$ | LR | CV(95%) |
| 0 | 0.266708 | 53.96 | 39.4 | 139.5 | 94.2 | 165.36 | 83.80 |
| 1 | 0.181238 | 34.39 | 33.5 | 86.19 | 68.5 | 100.82 | 59.95 |
| 2 | 0.130058 | 23.96 | 27.1 | 51.79 | 47.2 | 39.61 | 40.07 |
| 3 | 0.075734 | 13.55 | 21.0 | 27.83 | 29.7 | 14.70 | 24.16 |
| 4 | 0.073153 | 13.07 | 14.1 | 14.28 | 15.4 | 2.27 | 12.26 |
| 5 | 0.007037 | 1.215 | 3.8 | 1.215 | 3.8 | 0.20 | 4.13 |

| **Panel B:** Estimated cointegrating vectors | | | | | |
|---|---|---|---|---|---|
| $f$ | $s$ | $p_c$ | $p_{us}$ | $i_c$ | $i_{us}$ |
| 1 | -1.0024 | -0.0233 | 0.0147 | -0.00091 | 0.00062 |
| -1.2241 | 1 | -1.1102 | 1.0872 | 0.03016 | -0.02110 |

| **Panel C:** Estimated loading factors | | |
|---|---|---|
| | *Coint. Vector (1)* | *Coint. Vector (2)* |
| $f$ | 1.3351 | -0.0229 |
| $s$ | 2.1254 | -0.0215 |
| $p_c$ | -0.0715 | 0.0120 |
| $p_{us}$ | -0.0586 | 0.0179 |
| $i_c$ | -12.247 | -1.8054 |
| $i_{us}$ | 13.041 | -0.2074 |

*Notes:* The S&L test stands for the cointegration test developed by Saikkonen and Lütkepohl (2000). S&L test includes a constant, seasonal dummies and a set of dummies as specified in section 3.4. The number of included lags in the S&L test is determined on the basis of AIC and is set equal to 3. Critical values for S&L are computed from the response surface given in Trenkler (2004). Computations for the S&L test are performed with JMulTi, Version 4.2. The remaining computations (reported in Panels A, B and C) are performed with PcFiml, version 9.0.

**Table 3: Testing for theoretical restrictions and weak exogeneity**

**Panel A:** Restrictions imposed in one vector

| | $f$ | $s$ | $p_c$ | $p_{us}$ | $i_c$ | $i_{us}$ | $\chi^2$ *(df)* | *p-value* |
|---|---|---|---|---|---|---|---|---|
| $H_1$: EH | 1 | -1 | 0 | 0 | 0 | 0 | 6.212 (4) | 0.183 |
| $H_2$: SCIP | 1 | -1 | 0 | 0 | 1 | -1 | 11.343(4) | 0.023 |
| $H_3$: WCIP | 1 | -1 | 0 | 0 | α | -α | 0.783(3) | 0.853 |
| $H_4$: SUIP | 0 | 0 | 0 | 0 | 1 | -1 | 11.149(4) | 0.025 |
| $H_5$: WPPP | 0 | 1 | α | -α | 0 | 0 | 10.900(3) | 0.012 |
| $H_6$: SPPP | 0 | 1 | -1 | 1 | 0 | 0 | 11.128(4) | 0.025 |
| $H_7$: WPPP &WUIP | 0 | 1 | α | -α | β | -β | 2.490(2) | 0.288 |
| $H_8$: SPPP &WUIP | 0 | 1 | -1 | 1 | α | -α | 6.245(3) | 0.100 |

**Panel B:** Joint restrictions for both vectors

| | | $\chi^2$ *(df)* | *p-value* |
|---|---|---|---|
| $H_9$: | $H_3 \cap H_7$ | 3.876(5) | 0.567 |
| $H_{10}$: | $H_1 \cap H_5$ | 30.533(7) | 0.001 |
| $H_{11}$: | $H_1 \cap H_6$ | 35.272(8) | 0.000 |
| $H_{12}$: | $H_4 \cap H_6$ | 59.408 (8) | 0.000 |
| $H_{13}$: | $H_4 \cap H_7$ | 50.295(6) | 0.000 |
| $H_{14}$: | $H_4 \cap H_8$ | 52.246(7) | 0.000 |
| $H_{15}$: | $H_3 \cap H_6$ | 12.589(7) | 0.083 |

**Panel C:** Weak exogeneity tests

| | | $\chi^2$ *(df)* | *p-value* |
|---|---|---|---|
| $H_{16}$ | $H_{15} \cap$ w. exogeneity of $f$ w.r.t. $\beta_1$ ,$\beta_2$ | 15.009(9) | 0.091 |
| $H_{17}$ | $H_{15} \cap$ w. exogeneity of $s$ w.r.t. $\beta_1$ ,$\beta_2$ | 18.833(9) | 0.027 |
| $H_{18}$ | $H_{15} \cap$ w. exogeneity of $p_c$ w.r.t. $\beta_1$ ,$\beta_2$ | 12.646(9) | 0.179 |
| $H_{19}$ | $H_{15} \cap$ w. exogeneity of $p_{us}$ w.r.t. $\beta_1$ ,$\beta_2$ | 21.651(9) | 0.010 |
| $H_{20}$ | $H_{15} \cap$ w. exogeneity of $i_c$ w.r.t. $\beta_1$ ,$\beta_2$ | 26.562(9) | 0.002 |
| $H_{21}$ | $H_{15} \cap$ w. exogeneity of $i_{us}$ w.r.t. $\beta_1$ ,$\beta_2$ | 13.774(9) | 0.131 |
| $H_{22}$ | $H_{15} \cap$ w. exogeneity of $p_{us}, i_{us}$ w.r.t. $\beta_1$ ,$\beta_2$ | 24.763(11) | 0.010 |
| $H_{23}$ | $H_{15} \cap$ w. exogeneity of $p_c, i_c$ w.r.t. $\beta_1$ ,$\beta_2$ | 26.608(11) | 0.005 |

*Notes:* All computations are performed with PcFiml, version 9.0.