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A regime-shifting approach to modeling the Canadian-US dollar exchange rate: Four decades of the post-Bretton Woods float

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Abstract

The purpose of this study is to establish a theory-consistent econometric model for the Canadian-US dollar exchange rate over the post-Bretton Woods floating period, 1975 - 2018. In pursuing the objective this paper assigns importance to allowing for a regime shift in 2003 observed in the time series data of the exchange rate. The overall empirical results support the fundamental-based view of the long-run exchange rate determination. This study also examines long-run and short-run influences of oil prices on the exchange rate dynamics because of the anticipated significant role for the US-Canada dyad.

Keywords: Canadian-US dollar exchange rate, Economic fundamentals, Oil prices, Regime-shifting analysis, Partial cointegrated vector autoregressive models.
JEL classification codes: C32, C50, F31.

1 Introduction

Macroeconomic variables have played critical roles in the workings of theoretical foreign exchange rate models developed in literature on international finance. A number of empirical studies have thus been conducted to seek solid evidence supporting stable relationships between major macroeconomic variables and floating exchange rates. Evidence revealed by wide-ranging quantitative studies in literature has been mixed, so that it is still difficult for us to reach a decisive conclusion about the existence of such stable relationships in an empirical context. See, for example, Meese and Rogoff (1988), Edison and Pauls (1993), Issac and De Mel (2001), Sarno (2005) and Kurita (2007). These difficulties have also led to theoretical research aiming at the explanation of observed deviations in exchange rates from macroeconomic fundamentals; see Engel and West (2005), Bacchetta and Van

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Wincoop (2013) and Balke, Ma, and Wohar (2013), *inter alia*. In order to improve our understanding of exchange rate dynamics and to implement effective exchange rate policy, it is important to accumulate empirical evidence concerning the roles of economic fundamentals in the behavior of floating exchange rates.

Using non-linear econometric techniques developed by Kurita and Nielsen (2019), this paper aims to achieve a theory-consistent econometric model for the Canadian-US dollar exchange rate over the post-Bretton Woods period. In pursuing the objective of modeling the floating Canadian-US dollar rate, this paper demonstrates the importance of allowing for a regime change as well as various outliers recorded in long-span multivariate time series data to be studied.

Canada and the US stand out as a pair of states with a truly unique relationship - long-standing allies with the most extensive demilitarized and peaceful borders in the world. In a classic work, Doran (1984) identified three multifaceted dimensions of the Canada-US relationship: political-strategic; trade-commercial; and psychological-cultural. Studies of the US and Canada along each of the preceding dimensions are vast in scope and provide an excellent foundation for research on various aspects of this interstate dyad[1]. Within the trade and commercial dimension, the present research focuses on exchange rates. The overall objective is to identify patterns and also look into any anomalies that emerge from time series analysis.

While the two states are highly connected with each other, the relationship is not one of precise equals. This dyad is highly asymmetrical in important ways (Hale, 2012, p.8). With a much smaller population than the US, Canada depends more on trade for national wealth and partners for the US are more diverse than those of Canada (Anderson, 2011, pp.8-9). One particular concern that is much greater for Ottawa than Washington DC spills over from the political-strategic dimension into economics: border security. For Canada, keeping the border with the US open is vital - even a brief closure imposes huge costs. For example, in addition to loss of life and property, the 9/11 attacks also endangered Canadian economic health (James, 2012, pp.81-84). Calls for greater border security and even temporary closure became quite intense in the immediate aftermath of the attacks. While traffic became quite slow, Ottawa at least averted what would have been serious collateral damage from an outright closure of the border.

Both the US and Canada feature extractive industries to a significant degree within their respective economic profiles. However, natural resources - as reflected upon by a former federal cabinet minister and provincial premier - are more central to the Canadian economy (Prentice and Rioux 2017, p.21)[2]. Canadian oil production increased steadily over several decades to produce the situation as just described. As a specific illustration of the commodity's size and importance, Prentice and Rioux (2017, p.26) observe that many would be surprised to learn that

> "it is Canada - not Saudi Arabia - that serves as the largest oil exporter into the US marketplace."

[1] Among many studies across the three dimensions of Canada/US relations, a few from the last decade include Anderson and Sands (2011), Hale (2012) and James (2012).

[2] Prentice and Rioux (2017, page 21) said: "Put simply, no other country in the world sits on a comparable inventory of oil, natural gas, uranium, hydroelectric, wind, solar and tidal resources. Equally germane is that none of the world's other industrial democracies comes even close. We are unique in the potential and in the possibilities we possess."

This pattern possesses important implications for currency exchange, along with many other aspects of the Canada-US dyad. One especially relevant and specific point, following on from centrality of natural resources, is that the Canadian dollar is distinguished as a petrocurrency (Antweiler, 2016). Thus any model of exchange rates must reserve a central role for oil in attempting to figure out the dollar's value relative to other currencies. We will explore long-run and short-run aspects of influences from oil prices on the behavior of the Canadian-US exchange rate over the sample period of interest.

Existing quantitative studies in literature concentrating on the Canadian-US dollar exchange rate used cointegration methods to explore interpretable long-run economic relationships; see Kouretas (1997), Cushman (2000), Francis, Hasan and Lothian (2001), and Abbott and De Vita (2002). These studies were conducted in a linear-model framework, and their empirical results were mixed in terms of testing the validity of the fundamental-based view of the exchange rate between the two currencies. Given various structural breaks occurring in the global economy in recent years, non-linear modeling methodology allowing for regime shifts and outliers is a promising approach to analyzing the Canadian-US dollar exchange rate. Furthermore, it is important to extend the observation periods previously studied in the existing papers and to update time series data in order that various quantitative information in recent years, such as the global economic recession over 2008-2009, can be incorporated into econometric study. Hence, this paper adopts a regime-switching approach to modeling time series data for the Canadian-US dollar exchange rate over the extended sample period ranging from the first quarter in 1975 to the fourth quarter in 2018, denoted as 1975Q1 - 2018Q4 hereafter.

The results presented in this paper are supportive of the view that the two countries' macroeconomic variables have formed the core elements of the long-run behavior of the exchange rate. More specifically, the empirical results of this study are interpretable from the viewpoint of a monetary exchange rate model known in international finance literature. We can thus draw practical implications from these results in the context of effective foreign exchange rate policy that assigns importance to monetary aggregates and interest rates. Although we focus on the modeling of the Canadian-US dollar exchange rate, the methodology employed in this paper is applicable to the study of various other exchange rates. In this sense, this paper, along with a recent empirical study by Castle and Kurita (2019), provides a methodological basis for future econometric studies of floating exchange rates.

The rest of this paper is organized into five sections. Section 2 presents a theoretical exchange rate model which gives impetus to a study of the Canada-US dyad. Section 3 reviews econometric methodology utilized in this paper. Section 4 provides a historical review focusing on the political economy of Canada. Section 5 conducts a regime-shifting time series analysis of the exchange rate. Concluding remarks are provided in Section 6. As a notational convention, let $I(d)$ denote a process integrated of order d, so that $I(0)$ signifies a mean-zero stationary process. All econometric analyses in this paper were carried out using *PcGive* (Doornik and Hendry, 2018; Doornik, 2018).

2 Exchange rate theory

In this section we provide an exchange rate model which comprises macroeconomic variables for two countries, home and foreign countries. With a view to providing a basis for an empirical study of the Canadian-US dollar exchange rate, we assume that the home

and foreign countries correspond to Canada and the US, respectively. We also assume the time series data of economic variables in this model are viewed as the realizations of $I(1)$ stochastic processes. See Castle and Kurita (2019) for a class of exchange rate models similar to the one developed in this section.

First, we present the uncovered interest parity (UIP) condition that is built on long-term bond yields:

$$s_{t+1}^e - s_t = b_t - b_t^* + \rho_t, \tag{1}$$

where s_t is the log of the Canadian-US dollar spot exchange rate, *i.e.* the log of the Canadian dollar price of a unit of the US dollar, s_{t+1}^e is its one-period ahead market expectation, b_t is the bond yield in Canada, b_t^* is the bond yield in the US and ρ_t represents unobserved risk premium. Note the superscript $*$ denotes a US variable henceforth. With regard to s_{t+1}^e, we assume the following expectation formation based on Frankel (1979):

$$\Delta s_{t+1}^e = s_{t+1}^e - s_t = -\phi(s_t - \bar{s}_t) + \pi_{t+1}^e - \pi_{t+1}^{*,e} \qquad \text{for} \quad 0 < \phi < 1, \tag{2}$$

where $\bar{s}_t$ is a fundamental-based value of s_t and π_{t+1}^e is the market expectation of one-period ahead inflation in Canada. In the spirit of monetary exchange rate models incorporating regime shifts, we assume that $\bar{s}_t$ is specified to be

$$\bar{s}_t = \lambda f_t + \tau_t \qquad \text{for} \quad 0 < \lambda < 1, \tag{3}$$

where τ_t is a regime-dependent intercept and f_t represents a class of traditional fundamentals (see Flood and Rose, 1995) defined as

$$f_t = m_t - m_t^* - \xi(y_t - y_t^*),$$

in which m_t and y_t are the log of nominal broad money and the log of real output in Canada, respectively. In the rest of this paper we assume $\xi = 1$ by following Engel and West (2005).

Furthermore, suppose that $\pi_{t+1}^e - \pi_{t+1}^{*,e}$ in (2) can be approximated as a difference between the two countries' short-term interest rates, $i_t - i_t^*$, in which i_t is the Canadian short-term interest rate. The justification of this approximation stems from inflation targeting policy, which utilizes short-term interbank interest rates as policy tools to influence inflation expectations. We thus assume

$$\pi_{t+1}^e - \pi_{t+1}^{*,e} = \theta\,(i_t - i_t^*) \qquad \text{for} \quad \theta > 0. \tag{4}$$

Combining (1), (2), (3) and (4) yields the reduced form

$$s_t = \frac{\theta}{\phi}\,(i_t - i_t^*) - \frac{1}{\phi}(b_t - b_t^* + \rho_t) + \lambda f_t + \tau_t,$$

which indicates a close connection between the exchange rate and a class of macroeconomic variables.

By assuming that the risk premium term ρ_t is mean-zero stationary, this reduced-form equation allows us to conceive the following linear combination as a candidate of the underlying long-run economic relationship or equilibrium correction mechanism:

$$s_t - \frac{\theta}{\phi}(i_t - i_t^*) + \frac{1}{\phi}(b_t - b_t^*) - \lambda f_t - \tau_t \sim I(0), \tag{5}$$

which means the linear combination results in a mean-zero stationary series. One of the primary objectives in this study is to examine whether or not (5) is valid as the long-run equilibrium relationship underlying the Canada-US economic time series data. If (5) is empirically judged to be the equilibrium combination, we are also interested in how each of the variables, the exchange rate in particular, reacts to deviations from the long-run equilibrium. Moreover, the log of oil price, represented by p_t^{oil}, can also play a significant role in the empirical long-run relationship, although it may be difficult to justify the presence of p_t^{oil} in (5) from a theoretical standpoint.

3 Econometric methodology

This section provides a review of the econometric method which is to be utilized in this paper. We start the review by introducing a cointegrated vector autoregressive (CVAR) model, developed by Johansen (1988, 1996) for the purpose of analyzing non-stationary $I(1)$ time series data. See Juselius (2006) as well as Hunter, Burke and Canepa (2017) for recent developments in the CVAR methodology. Let X_t be a p-dimentional time series $X_t = (x_{1,t}, \ldots, x_{p,t})'$, which satisfies, given the starting observations $X_1, \ldots, X_k$,

$$\Delta X_t = \alpha\left(\beta', \gamma\right)\begin{pmatrix} X_{t-1} \\ 1 \end{pmatrix} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t, \quad \text{for} \quad t = k+1, ..., T, \tag{6}$$

where the error sequence ε_t has independent and identical normal $IN(0, \Omega)$ distributions conditional on the starting values; the parameters are given as $\alpha, \beta \in \mathbf{R}^{p\times r}$ for $r < p$, $\Gamma_i \in \mathbf{R}^{p\times p}$, $\gamma \in \mathbf{R}^r$ and $\mu \in \mathbf{R}^p$. Introduce the following three conditions: (i) define $P(z)$ as

$$P(z) = (1-z)I_p - \alpha\beta' z - \sum_{i=1}^{k-1} \Gamma_i (1-z) z^i,$$

and the roots of $P(z)$ are outside the unit circle or at one, (ii) $\text{rank}(\alpha) = \text{rank}\,(\beta) = r$ and (iii) $\text{rank}\,(\alpha_\perp' \Gamma \beta_\perp) = p - r$, in which $\alpha_\perp$ and $\beta_\perp$ are the orthogonal complement of α and β, respectively, and $\Gamma = I_p - \sum_{i=1}^{k-1} \Gamma_i$. Under these conditions X_t is seen as an $I(1)$ process subject to a moving-average representation, which enables us to investigate various asymptotic properties of estimators and test statistics derived from X_t. We assume these three conditions are satisfied in the rest of this section. The parameters (β', γ) and α are referred to as cointegrating and adjustment vectors, respectively; r is called cointegrating rank. See Johansen (1996) for further details of the three conditions.

Let $X_t = (Y_t', Z_t')'$ for $Y_t \in \mathbf{R}^m$, $Z_t \in \mathbf{R}^{p-m}$ and $m \geq r$. The parameters and error terms are also expressed as

$$\alpha = \begin{pmatrix} \alpha_y \\ \alpha_z \end{pmatrix}, \Gamma_i = \begin{pmatrix} \Gamma_{y,i} \\ \Gamma_{z,i} \end{pmatrix}, \ \mu = \begin{pmatrix} \mu_y \\ \mu_z \end{pmatrix}, \ \varepsilon_t = \begin{pmatrix} \varepsilon_{y,t} \\ \varepsilon_{z,t} \end{pmatrix} \text{ and } \Omega = \begin{pmatrix} \Omega_{yy} & \Omega_{yz} \\ \Omega_{zy} & \Omega_{zz} \end{pmatrix}.$$

The joint CVAR model (6) is then broken down into a conditional or partial model for Y_t and a marginal model for Z_t:

$$\Delta Y_t = \omega \Delta Z_t + (\alpha_y - \omega\alpha_z)\left(\beta', \gamma\right)\begin{pmatrix} X_{t-1} \\ 1 \end{pmatrix} + \sum_{i=1}^{k-1} \Gamma_{y.z,i} \Delta X_{t-i} + \varepsilon_{y,t},$$

$$\Delta Z_t = \alpha_z\left(\beta', \gamma\right)\begin{pmatrix} X_{t-1} \\ 1 \end{pmatrix} + \sum_{i=1}^{k-1} \Gamma_{z,i} \Delta X_{t-i} + \varepsilon_{z,t},$$

where

$$\omega = \Omega_{yz}\Omega_{zz}^{-1},\ \Gamma_{y.z,i} = \Gamma_{y,i} - \omega\Gamma_{z,i},\ \varepsilon_{y.z,t} = \varepsilon_{y,t} - \omega\varepsilon_{z,t},$$

and

$$\begin{pmatrix} \varepsilon_{y.z,t} \\ \varepsilon_{z,t} \end{pmatrix} = IN\left\{\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \Omega_{yy} - \Omega_{yz}\Omega_{zz}^{-1}\Omega_{zy} & 0 \\ 0 & \Omega_{zz} \end{pmatrix}\right\},$$

If $\alpha_z = 0$ holds, the above partial and marginal models are simplified to

$$\Delta Y_t = \omega\Delta Z_t + \alpha_y\left(\beta', \gamma\right)\begin{pmatrix} X_{t-1} \\ 1 \end{pmatrix} + \sum_{i=1}^{k-1}\Gamma_{y.z,i}\Delta X_{t-i} + \varepsilon_{y,t}, \tag{7}$$

$$\Delta Z_t = \sum_{i=1}^{k-1}\Gamma_{z,i}\Delta X_{t-i} + \varepsilon_{z,t}, \tag{8}$$

and Z_t is then said to be weakly exogenous (see Engle, Hendry and Richard, 1983) with respect to α_y, (β', γ) and the other parameters of the partial model (7). Weak exogeneity means these parameters can be estimated from the partial model (7) with no loss of information, so that it is unnecessary to estimate the marginal model (8) for that estimation purpose. Focusing on the study of (7) is more beneficial in terms of various standpoints. If the dimension of X_t is large and the number of observations is small, it will be difficult to select correctly the cointegrating rank r from the analysis of the joint CVAR model (6). If Z_t is affected by a number of outliers, that will also give rise to difficulties in empirical modeling based on (6). In these cases the analysis of (7) can be more efficient than that of (6) in that we do not have to model Z_t. See Harbo, Johansen, Nielsen and Rahbek (1998) for further details of benefits in use of the partial CVAR model.

Kurita and Nielsen (2019) have extended the partial CVAR model (7) in such a way that X_t is subject to a class of deterministic shifts as in Johansen, Mosconi and Nielsen (2000) and that ε_t is a martingale difference sequence instead of an independent Gaussian sequence. For the use of this extended model, it is necessary to determine the number of regimes q, or the number of regime shifts $q-1$, and the length of each regime $T_j - T_{j-1}$ for $j = 1, ..., q$ in the sequence $0 = T_0 < T_1 < \cdots < T_q = T$. In addition, a class of impulse dummy variables corresponding to initial observations for each regime needs to be introduced in (7):

$$D_{j,s} = \begin{cases} 1 & \text{for } s = T_{j-1}, \\ 0 & \text{otherwise,} \end{cases} \quad \text{for} \quad j = 1, ..., q \quad \text{and} \quad s = 1, \ldots, T.$$

By using this, a class of indicators is defined as

$$E_{j,t} = \sum_{i=1}^{T_j - T_{j-1}} D_{j,t-i} = \begin{cases} 1 & \text{for } T_{j-1} < t \leq T_j, \\ 0 & \text{otherwise,} \end{cases} \quad \text{and} \quad E_t = \left(E_{1,t}, \ldots, E_{q,t}\right)'.$$

Given j and t for $1 \leq j \leq q$ and $T_{j-1} + k < t \leq T_j$ respectively, the partial CVAR model with level shifts proposed by Kurita and Nielsen (2019) is given as

$$\Delta Y_t = \omega\Delta Z_t + \alpha_y\left(\beta', \Upsilon'\right)\begin{pmatrix} X_{t-1} \\ E_t \end{pmatrix} + \sum_{i=1}^{k-1}\Gamma_{y.z,i}\Delta X_{t-i} + \sum_{i=1}^{k}\sum_{j=2}^{q}\Psi_{j,i}D_{j,t-i} + \varepsilon_{y.z,t}, \tag{9}$$

for $\Upsilon' = (\gamma_1, \ldots, \gamma_q) \in \mathbf{R}^{r\times q}$ and $\Psi_{j,i} \in \mathbf{R}^{m\times p}$. Note E_t captures various level shifts inside the cointegrating combinations, while $D_{j,t-i}$ for $2 \leq j \leq q$ and $1 \leq i \leq k$ fills the regime

transition periods. Kurita and Nielsen (2019) studied a partial CVAR model with broken linear trends, in addition to (9). See also Castle and Kurita (2019) for a detailed empirical study using (9).

The overall cointegrating relationships, $\beta' X_{t-1} + \Upsilon' E_t$, are interpretable as long-run equilibrium relationships embedded in (9). They are subject to regime shifts represented by $\Upsilon' E_t$, a distinguishing feature of the extended partial CVAR model. We are then interested in the empirical question of whether or not the theory-based equilibrium relationship, see (5), is revealed as a member of the class of empirical cointegrating relationships estimated from the data. The general-to-specific modeling principle (see Hendry, 1995, *inter alia*) suggests we should first estimate a well-formulated unrestricted partial VAR model and choose its cointegrating rank r by means of quasi partial likelihood ratio (PLR) tests studied in Kurita and Nielsen (2019). The selection of r then allows us to seek a specific model by placing restrictions on the estimates $(\hat{\beta}', \hat{\Upsilon}')$. We anticipate that a set of imposed restrictions will contribute to revealing that cointegrating combination which coincides with the equilibrium relationship, (5), backed up by the exchange rate theory. Furthermore, $\hat{\alpha}_y$ shows the way each variable in Y_t adjusts deviations from the long-run equilibrium. In summary, the estimated component (in levels) of (9), that is,

$$\hat{\alpha}_y \left(\hat{\beta}', \hat{\Upsilon}'\right) \begin{pmatrix} X_{t-1} \\ E_t \end{pmatrix}$$

conveys quantitative information on how the underlying equilibrium correction mechanism works in the partial system. In this sense $\hat{\alpha}_y$ and $(\hat{\beta}', \hat{\Upsilon}')$ are viewed as a set of parameters of most interest in cointegrated VAR analysis. The restriction of these parameters leads to further model reduction, thereby allowing us to estimate a parsimonious vector equilibrium correction model.

4 A historical review focusing on the political economy of Canada

Given the economic model and econometric methodology described above, we set up a class of economic variables to be studied as follows:

$$X_t = \left(s_t, i_t - i_t^*, b_t - b_t^*, f_t, p_t^{oil}\right)'.$$

All of these variables were introduced in Section 2. An overview of quarterly time series data for these variables over 1975Q1 - 2018Q4 is presented below as Figure 1. See the Appendix for further details of the data. Note that all the annual interest rates have been divided by 4 so that they can approximate to quarterly-basis interest rates.

Figure 1 (a), (b), (c) and (d) show that all the data exhibit non-stationary trending behavior, indicating that they should be treated as the realizations of $I(1)$ stochastic processes rather than stationary ones. Hence, we should make use of the CVAR method reviewed above, in order to analyze the data displayed in Figure 1.

One of the most distinguishing features of the above data is a steady decline in s_t (the appreciation of the Canadian dollar) which started in 2003; see Figure 1 (a). The Iraq War broke out in March 2003, resulting in a steady rise in oil prices; see Figure 1 (d). Full-scale war almost always entails uncertainty and economic disruption. Canadians in

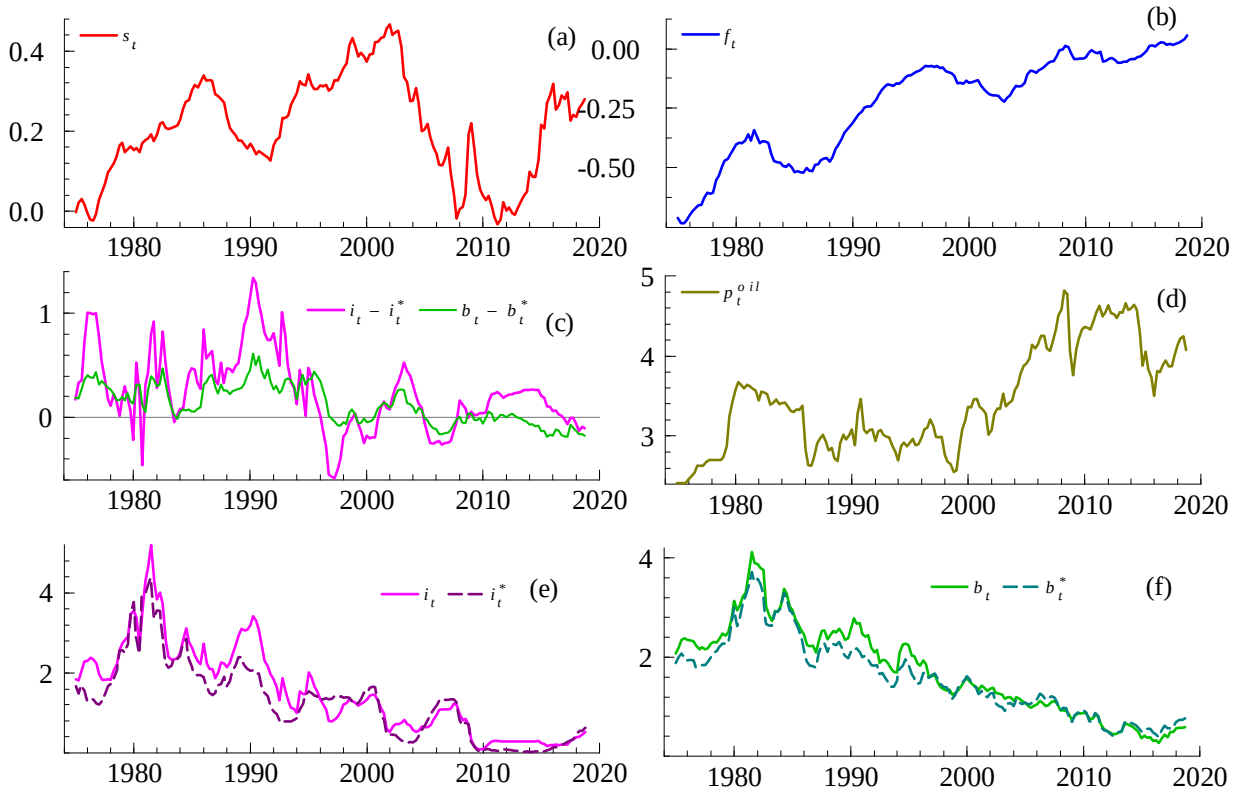

Figure 1: An overview of the data for X_t

general did not like the Iraq War and tensions increased between Ottawa and Washington during that time frame. Volatility therefore might have been sufficient to cause a shift in the time series for the exchange rate that subsequently took hold.

One should also note that there are a series of fluctuations in the short-term interest rate differential, $i_t - i_t^*$, around the early 1980s as displayed in Figure 1 (c), which also records an overview of the bond yield differential, $b_t - b_t^*$. All of the interest rate series are also individually reported in Figure 1 (e) and (f). In the face of high inflation rates, the US Federal Reserve started a new method of monetary policy in October 1979 by treating monetary aggregates as policy targets and maintained this policy until October 1982 (OECD, 1983). As a result of this policy shift, the US short-term interest rate was subject to wider variation than before during this period, as shown in Figure 1 (e). The figure also indicates this period appears to be characterized by volatile interest rates in Canada, along with a step rise in the oil price p_t^{oil} and its subsequent fairly stable behavior, as shown in Figure 1 (d). We will review below further details of Canadian history around this period in a political economy context, bearing in mind the importance of oil for the Canadian economy.

One of the most intense events in Canadian history took place on 20 May 1980: the Quebec Referendum. Tensions between the province of Quebec and federal government came to a head in the late 1970s after the Parti Québécois (PQ) assumed power. The leader of the party, René Lévesque, became premier in November 1976 and instituted policies intended to preserve and promote the French language, with a short-term goal

of greater autonomy and a long-term objective of independence. These measures did not sit well with the federalist government in Ottawa, led by Pierre Trudeau, which wanted Canada to say united under a strong state.

Lévesque's confrontations with Ottawa culminated in a referendum, with a question announced on 20 December 1979 and a vote six months later, as per above. The question itself focused on sovereignty-association – an inherently confusing concept that caused subsequent debate, perhaps, to include pedantry and become even more vituperative than it would have been otherwise. On 20 May 1980 the referendum failed, with 40.44% voting 'yes' and 59.56% voting 'no'. The campaign left a legacy of disappointment and even anger among those who had voted 'yes'. Tensions between Ottawa and Quebec City continued unabated, with the PQ staying in power all the way into 1985.

Like the Quebec Referendum, the National Energy Program (NEP) disrupted the Canadian political economy and reflected tensions within the federal system between Ottawa and the provincial capitals[3]. Prime Minister Trudeau believed in a strong central government with regard to both political institutions and economic policy. In addition, Trudeau's principal base of popularity existed in the eastern provinces that consumed rather than produced energy. Liberal support in the energy producing province of Alberta bordered on non-existent, at least in terms of seats in parliament, and that would be unlikely to change any time soon.

With the preceding political factors thinly concealed at best, the federal budget announced in October 1980 included the National Energy Program (NEP), which would go on to become one of the most controversial public policies in Canadian history. Ottawa justified introduction of the NEP as an essential measure in response to uncertainties caused by oil shocks from the 1970s. The Yom Kippur War and Iranian Revolution disrupted the world's energy supply and thereby reinforced growing concerns about inflation and relatively limited economic growth. The Bank of Canada also had identified economic problems, such as the onset of double-digit inflation, which could be cited in support of the NEP as a means toward stabilization.

Implementation of the NEP, according to Finance Minister Allan MacEachen, had become essential because of ongoing challenges. The program aimed for

> "security of supply and ultimate independence from the world oil market; opportunity for all Canadians to participate in the energy industry; particularly oil and gas, and to share in the benefits of its expansion; and fairness, with a pricing and revenue-sharing regime which recognizes the needs and rights of all Canadians." (Government of Canada, 1980)

The NEP included multiple policies that became controversial and stayed that way throughout its existence. The Petroleum Gas Revenue Tax (PGRT) instituted a double-taxation system with the explicit intention of keeping energy prices in Eastern Canada below world levels – from the standpoint of oil producing provinces, this stood as a blatant attempt at income redistribution. Anger became most visible in Alberta, the leading energy-producing province and a location not well-disposed toward Trudeau in the first place.

[3] A wide range of studies take up the politics and economics of the NEP, with Doern and Toner (1985) as an authoritative treatment. A review of the literature from the decade after the advent of the NEP appears in James and Michelin (1990; see also James 1990, 1993a and 1993b for analysis of strategic interaction between the federal government and Alberta).

The NEP exacerbated tensions in place and contributed to Western alienation that crystallized into a political movement and even a series of political parties over the course of subsequent years.

5 An econometric analysis of Canada-US data

This section conducts a detailed econometric study of the Canada and US quarterly time series data displayed in the previous section. The sample period for estimation is 1975Q1 - 2018Q4. We use the regime-shifting partial CVAR model, (9), in which $X_t = (Y_t', Z_t')'$ consists of

$$Y_t = (s_t, i_t - i_t^*, b_t - b_t^*, f_t)' \quad \text{and} \quad Z_t = p_t^{oil},$$

by assuming that p_t^{oil} is weakly exogenous with respect to the parameters of interest. This section is organized into four sub-sections so as to carry out a thorough econometric analysis of the data.

5.1 Testing cointegrating rank

In order to undertake likelihood-based tests for the cointegrating rank of the partial VAR model, it is necessary to choose the number of regimes q and the lag order k, along with the selection of various unrestricted variables. The graphic display in the last section indicates some evidence for a structural change in the exchange rate s_t which occurred in early 2003, coinciding with the outbreak of the Iraq War. In order to reinforce the selection of early 2003 as a structural-break point, we conducted auxiliary single-equation Markov-switching analysis (see Hamilton, 1989, 1990; Doornik, 2018) of the exchange rate both in levels (s_t) and in differences (Δs_t). A set of regime classifications based on this analysis is presented in Figure 2, which indicates that the whole sample period can be split into two regimes in early 2003; note that the areas in white represent Regime 1 while the shaded areas depict Regime 2, based on Markov-switching regressions. The overall evidence in Figures 1 and 2 thus justifies us in setting the regime change point at 2003Q1, which results in $q = 2$ and $\Upsilon' = (\gamma_1, \gamma_2)$. The model's lag order is set at 3, due to the significance of some of the autoregressive regressors with $k = 3$. These selections lead to $T_1 = 115$ and $T = 179$ by taking into account the starting observations, so that $T_1/T \approx 0.642$. A set of indicator variables is also included in the model unrestrictedly to fill the regime transition period.

A preliminary regression study has indicated the presence of two outliers in the residuals of the equation for $i_t - i_t^*$: one in 1980Q2 and the other in 1981Q1. These outliers are presumably associated with those policy changes and political fluctuations which were reviewed in the previous section. These outliers need to be handled in econometric analysis, so we have incorporated a pair of unrestricted indicator variables in the model, $\mathsf{D}_{1980Q2,t}$ and $\mathsf{D}_{1981Q1,t}$, which are assigned 1 in 1980Q2 and 1981Q1, respectively, and are assigned 0 otherwise. See Doornik, Hendry and Nielsen (1998) for further details of indicator variables in CVAR models. Moreover, the preliminary analysis has revealed serial correlation problems with the residuals of the $i_t - i_t^*$ equation in the first regime period. In response to the problems we have added a pair of lagged second-order differenced terms, $\Delta^2(i_{t-5} - i_{t-5}^*)E_{1,t}$ and $\Delta^2(i_{t-6} - i_{t-6}^*)E_{1,t}$, to the model in an unrestricted manner. In addition, $\Delta^2 s_{t-7}E_{2,t}$ has been added to the model unrestrictedly to improve upon its fit

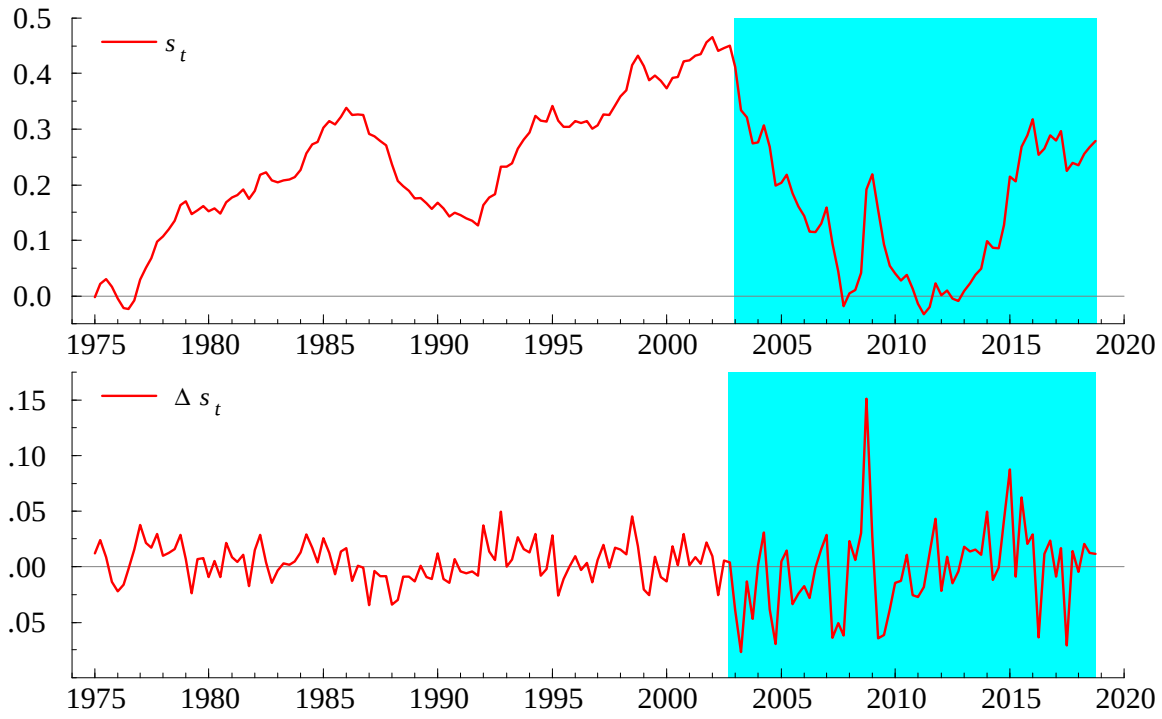

Figure 2: Regime classifications based on Markov-switching regressions

in the second regime. See Kurita and Nielsen (2009) for further details of this type of adjustment. They suggested that a class of unrestricted second-order differenced terms should be used in order to mitigate residual diagnostic problems in a VAR system without affecting the validity of asymptotic theory for cointegration.

A graphic diagnostic analysis has been performed with respect to a set of residual series obtained from the partial VAR model; see Figure 3. The first, second and third columns in the figure display scaled residuals, scaled residual densities (against the standard normal distribution) and autocorrelated functions, respectively. There is little evidence against the assumption of no residual autocorrelation, although the observed residuals do not meet the conditions of normality and homoskedasticity; there seem to be autoregressive conditional heteroskedasticity (ARCH; see Engle, 1982) problems in the residuals. The absence of serial correlation can justify CVAR-based econometric study in the context of quasi maximum likelihood analysis assuming martingale difference sequence innovations; see Kurita and Nielsen (2019) for further details. It is also known that a class of CVAR models is robust to residual diagnostic problems such as ARCH; see Cheung and Lai (1993), Gonzalo (1994), Rahbek, Hansen and Dennis (2002) and Kurita (2013) for further details. We are therefore justified in proceeding to the analysis of the cointegrating rank of this regime-shifting partial VAR model.

Row <1> in Table 1 reports a sequence of PLR test statistics for the choice of cointegrating rank using this partial VAR model. The reported p-values are calculated from a response-surface table provided in Kurita and Nielsen (2019) using the method of Gamma-distribution approximation (see Nielsen, 1997; Doornik, 1998 and 2003). The selection of $r = 1$ is supported by the tests at the 5% significance level, and this selection is also deemed to be consistent with the exchange-rate model in Section 2. Hence, we place the

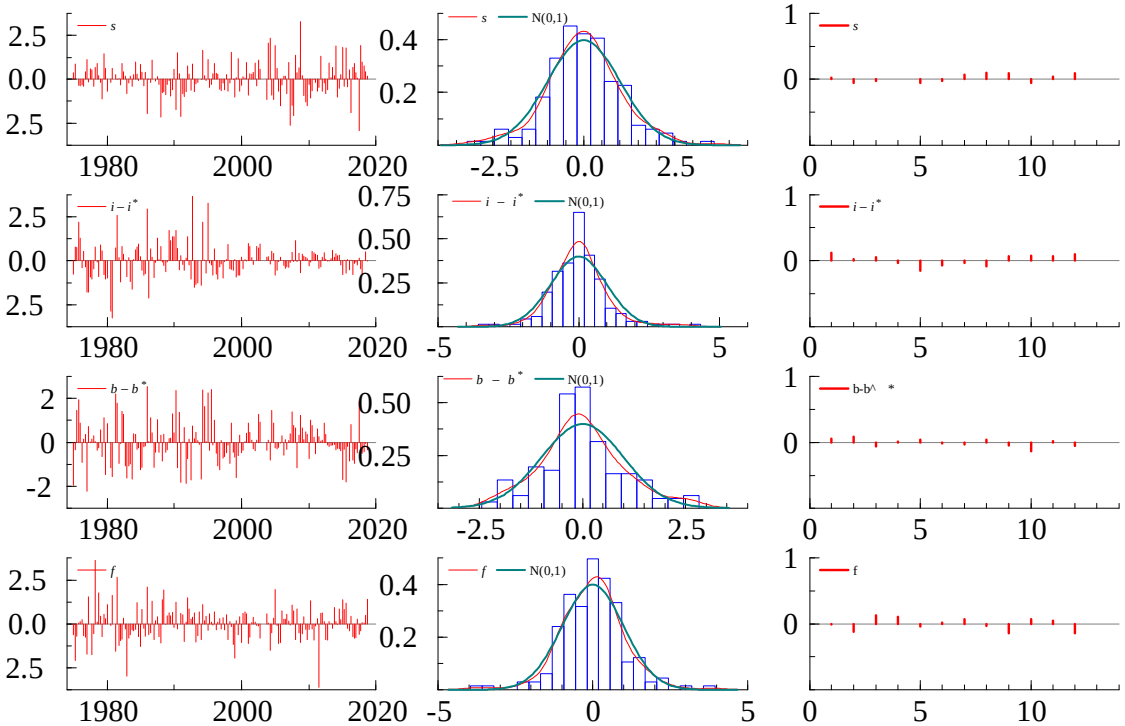

Figure 3: A graphic diagnostic analysis of the residuals

	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$
<1> PLR	94.504[0.001]**	49.524[0.063]	24.302[0.248]	8.195[0.453]
<2> PLR	61.999[0.067]	34.480[0.250]	16.329[0.433]	0.895[0.993]

Note. Figures in square brackets denote p-values: <1> based on the simulated distributions of Kurita and Nielsen (2019) and <2> based on those from Doornik (2003).
** denotes significance at the 1% level.

Table 1: Testing for cointegrating rank in the PVAR(4) system with a level shift

restriction of $r = 1$ on the partial VAR model, which results in a partial CVAR with $r = 1$ and lays the foundation for the study of an empirical equilibrium relationship. As a comparative analysis we have also estimated a partial VAR model with the restriction of no regime shift, that is, $\gamma_1 = \gamma_2$; otherwise this partial model is the same as that estimated above. The test statistics are displayed in the second row of Table 1 denoted by <2>, suggesting there is no evidence for cointegration in this case. This discrepancy stems from the difference in model specification, thus allowing us to infer that the inclusion of a level shift around 2003 in the partial system is critical in revealing evidence for a cointegrating relationship from the data.

5.2 Revealing the long-run equilibrium relationship

This sub-section starts off with a review of the candidate long-run relationship, which is now reformulated in a manner consistent with the partial CVAR model subject to a

regime shift:

$$s_{t-1} - \frac{\theta}{\phi}(i_{t-1} - i^*_{t-1}) + \frac{1}{\phi}(b_{t-1} - b^*_{t-1}) - \lambda f_{t-1} - \gamma_1 E_{1,t} - \gamma_2 E_{2,t} \sim I(0), \qquad (10)$$

the basis of which is given by (5) in Section 2. Equation (10) is to be seen as the benchmark structure when checking and interpreting several restrictions on the cointegrating and adjustment vectors. The restriction of $r = 1$ in use of the regime-shifting partial system enables us to estimate the adjustment vector as well as the cointegrating vector, which is normalized with respect to s_t so that it can be in line with (10). The estimates of the parameters and their standard errors (in brackets) are presented in Table 2. The results reported in the table indicate that the estimates of the cointegrating coefficients for p^{oil}_{t-1} and $E_{2,t}$ are insignificant at the 5% level. In addition, the estimate for the adjustment coefficient of f_t is judged to be insignificant, suggesting that f_t is weakly exogenous with respect to the cointegrating parameters.

$$\hat{\alpha}_y \begin{pmatrix} \hat{\beta} \\ \hat{\Upsilon} \end{pmatrix}' \begin{pmatrix} X_{t-1} \\ E_t \end{pmatrix} = \begin{pmatrix} \underset{(0.011)}{-0.044} \\ \underset{(0.073)}{-0.263} \\ \underset{(0.030)}{-0.120} \\ \underset{(0.007)}{0.003} \end{pmatrix} \begin{pmatrix} \underset{(-)}{1} \\ \underset{(0.124)}{-0.402} \\ \underset{(0.309)}{2.000} \\ \underset{(0.159)}{-0.386} \\ \underset{(0.082)}{0.013} \\ \underset{(0.273)}{-0.742} \\ \underset{(0.350)}{-0.035} \end{pmatrix}' \begin{pmatrix} s_{t-1} \\ i_t - i^*_t \\ b_t - b^*_t \\ f_t \\ p^{oil}_{t-1} \\ E_{1,t} \\ E_{2,t} \end{pmatrix},$$

Table 2: Adjutment and cointegrating vectors

Thus, placing a set of zero restrictions on these three estimates leads to the updated results recorded in Table 3, for which the PLR test statistic against no restrictions is

$$\hat{\alpha}_y \begin{pmatrix} \hat{\beta} \\ \hat{\Upsilon} \end{pmatrix}' \begin{pmatrix} X_{t-1} \\ E_t \end{pmatrix} = \begin{pmatrix} \underset{(0.011)}{-0.048} \\ \underset{(0.076)}{-0.280} \\ \underset{(0.031)}{-0.124} \\ \underset{(-)}{0} \end{pmatrix} \begin{pmatrix} \underset{(-)}{1} \\ \underset{(0.104)}{-0.365} \\ \underset{(0.247)}{1.866} \\ \underset{(0.146)}{-0.358} \\ \underset{(-)}{0} \\ \underset{(0.064)}{-0.680} \\ \underset{(-)}{0} \end{pmatrix}' \begin{pmatrix} s_{t-1} \\ i_t - i^*_t \\ b_t - b^*_t \\ f_t \\ p^{oil}_{t-1} \\ E_{1,t} \\ E_{2,t} \end{pmatrix},$$

Table 3: Restricted adjutment and cointegrating vectors

0.261[0.967] with its p-value according to $\chi^2(3)$ given in square brackets. The null hypothesis of the set of zero restrictions is not rejected at the 5% level, so that we are

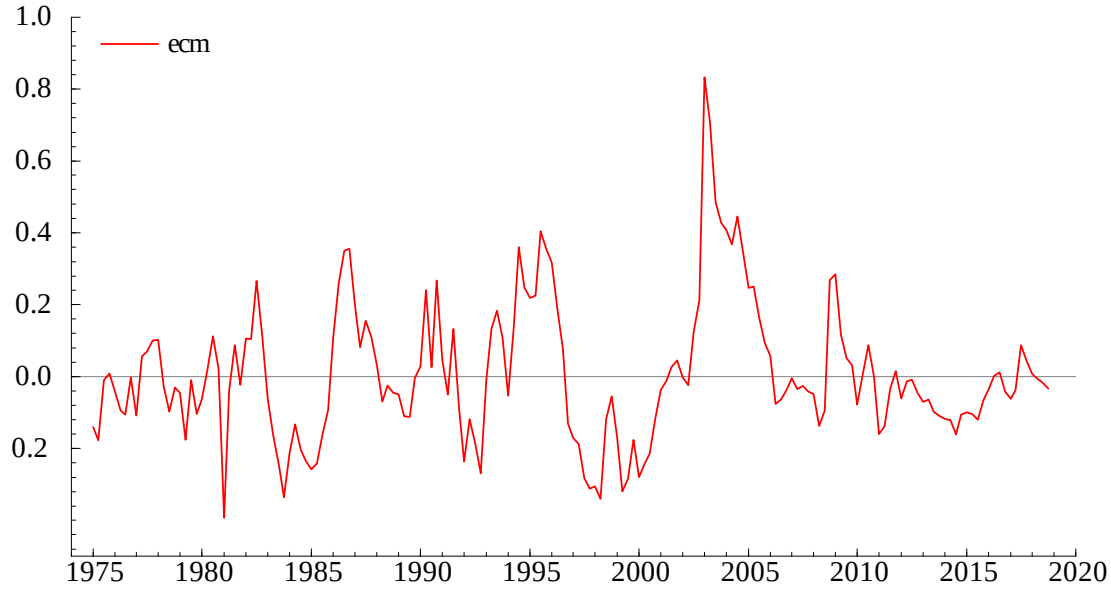

Figure 4: An overview of the restricted cointegrating relationship

justified in eliminating p_{t-1}^{oil} and $E_{2,t}$ from the cointegrating combination and in treating f_t as a non-modelled variable without any loss of information for inference purposes.

By using the estimates reported in Table 3, one can express the restricted cointegrating relationship as the following empirical equilibrium correction mechanism:

$$ecm_{t-1} = s_{t-1} - 0.365(i_{t-1} - i_{t-1}^*) + 1.866(b_{t-1} - b_{t-1}^*) - 0.358 f_{t-1} - 0.68 E_{1,t} \sim I(0), \quad (11)$$

to which the three endogenous variables, s_t, $i_t - i_t^*$ and $b_t - b_t^*$, significantly react in the partial CVAR system. Equation (11) coincides with the theory-based long-run relationship (10) in terms of the coefficients' signs and magnitudes. Furthermore, $E_{2,t}$ is absent from ecm_{t-1}, which is seen as evidence indicating the presence of a level shift in such a way that the cointegrating combination is a mean-zero stationary series throughout the observation period. In other words, the long-run value of s_t in the second regime is well represented by the combination of the economic fundamentals and interest rate differentials.

Furthermore, we make use of an *ex post* testing procedure mentioned by Harbo *et al.* (1998) so as to verify that p_t^{oil} is empirically judged to be weakly exogenous for the class of parameters of interest. We introduce an autoregressive equation for Δp_t^{oil}, which contains ecm_{t-1} as well as all the other lagged stochastic regressors in differences, along with the set of deterministic regressors such as $\mathsf{D}_{1980Q2,t}$ and $\mathsf{D}_{1981Q1,t}$. Next, the parameters of this equation are estimated to check whether or not the coefficient for ecm_{t-1} is significantly different from zero. The PLR test statistic for the null hypothesis of the zero restriction is 1.699[0.192] with its p-value according to $\chi^2(1)$, thus resulting in the non-rejection of the hypothesis. The validity of the weak-exogeneity assumption with respect to p_t^{oil} has been ensured in the analysis of the data.

Figure 4 presents an overview of the time series of ecm_t from 1975 to 2018. Although there are some outliers around 2003 in the series, its overall behavior appears to be a mean-zero stationary, as expected from the non-rejection of the restrictions imposed on

the cointegrating vector; see Table 3. Recall that in Section 5.1 we filled in the regime transition period with a class of unrestricted indicators, so that those outliers found in Figure 4 were addressed in the CVAR-based modeling of the data. The term ecm_{t-1} will play a critical role in the derivation of a parsimonious model.

5.3 A vector equilibrium correction model

We are in a position to estimate a parsimonious vector equilibrium correction model (VECM) conditional on not solely p_t^{oil} but also on f_t, which has been judged to be weakly exogenous for the cointegrating vector. Although it has been found that p_t^{oil} plays no significant role in the cointegrating linkage, there is a possibility that a class of short-run dynamics, Δp_t^{oil}, Δp_{t-1}^{oil} and Δp_{t-2}^{oil}, can play crucial roles in accounting for the dynamics of the exchange rate. The estimation of a VECM is useful for the objective of checking this possibility. All the variables are now transformed to the first-order differences so that they can be consistent with the VECM formulation. As a result of eliminating insignificant regressors from each equation of the system, the following parsimonious VECM has been obtained:

$$\begin{aligned}\Delta s_t &= -\underset{(0.011)}{0.091}\ \Delta p_t^{oil} + \underset{(0.06)}{0.153}\ \Delta s_{t-1} - \underset{(0.009)}{0.031}\ \Delta(i_{t-1} - i_{t-1}^*) + \underset{(0.098)}{0.357}\ \Delta f_{t-2} \\ &\quad - \underset{(0.009)}{0.043}\ ecm_{t-1} - \underset{(0.022)}{0.039}\ D_{2,t-1} + \underset{(0.021)}{0.037}\ D_{2,t-2} + \underset{(0.056)}{0.177}\ \Delta^2 s_{t-7} E_{2,t},\end{aligned} \tag{12}$$

$$\begin{aligned}\Delta(i_t - i_t^*) &= -\underset{(0.055)}{0.126}\ \Delta(i_{t-2} - i_{t-2}^*) - \underset{(0.61)}{1.193}\ \Delta f_{t-2} - \underset{(0.058)}{0.144}\ ecm_{1,t-1} + \underset{(0.126)}{0.803}\ \mathsf{D}_{1981Q1,t} \\ &\quad + \underset{(0.146)}{0.723}\ \mathsf{D}_{1980Q2,t}, + \underset{(0.039)}{0.121}\ \Delta^2(i_{t-5} - i_{t-5}^*)E_{1,t} + \underset{(0.044)}{0.235}\ \Delta^2(i_{t-6} - i_{t-6}^*)E_{1,t}\end{aligned}$$

$$\begin{aligned}\Delta(b_t - b_t^*) &= \underset{(0.022)}{0.062}\ \Delta(i_{t-1} - i_{t-1}^*) - \underset{(0.059)}{0.118}\ \Delta(i_{t-2} - i_{t-2}^*) - \underset{(0.024)}{0.099}\ ecm_{1,t-1} \\ &\quad + \underset{(0.016)}{0.051}\ \Delta^2(i_{t-6} - i_{t-6}^*)E_{1,t} + \underset{(0.06)}{0.192}\ \mathsf{D}_{1980Q2,t},\end{aligned}$$

where the standard error for each coefficient is given as a small figure in parentheses.

In interpreting the estimation results we focus on the first equation (12), which is the ECM for s_t, the variable of interest in our study. This equation should be discussed in three aspects.

First, it should be noted that Δp_t^{oil} plays a highly significant role in the first equation, indicating the importance of oil prices in accounting for the short-run dynamics of the Canadian-US dollar exchange rate. This evidence is in contrast to the structure of the long-run economic relationship ecm_{t-1}, from which p_{t-1}^{oil} is absent, suggesting that the price of oil is of little importance as a constituent of the long-run value of the exchange rate. Neither Δp_{t-1}^{oil} nor Δp_{t-2}^{oil} has been judged to be significant in the Δs_t equation, which is an indication of the contemporaneous oil-price dynamics playing a critical role in the dynamics of the exchange rate.

Next, we turn attention to the roles of other significant short-run dynamics in the first equation. The term $\Delta(i_{t-1} - i_{t-1}^*)$ has a significant negative coefficient, indicating that an expansion of the short-term interest rate differential brings about an appreciation of the Canadian currency. This coefficient is interpretable in the context of international capital

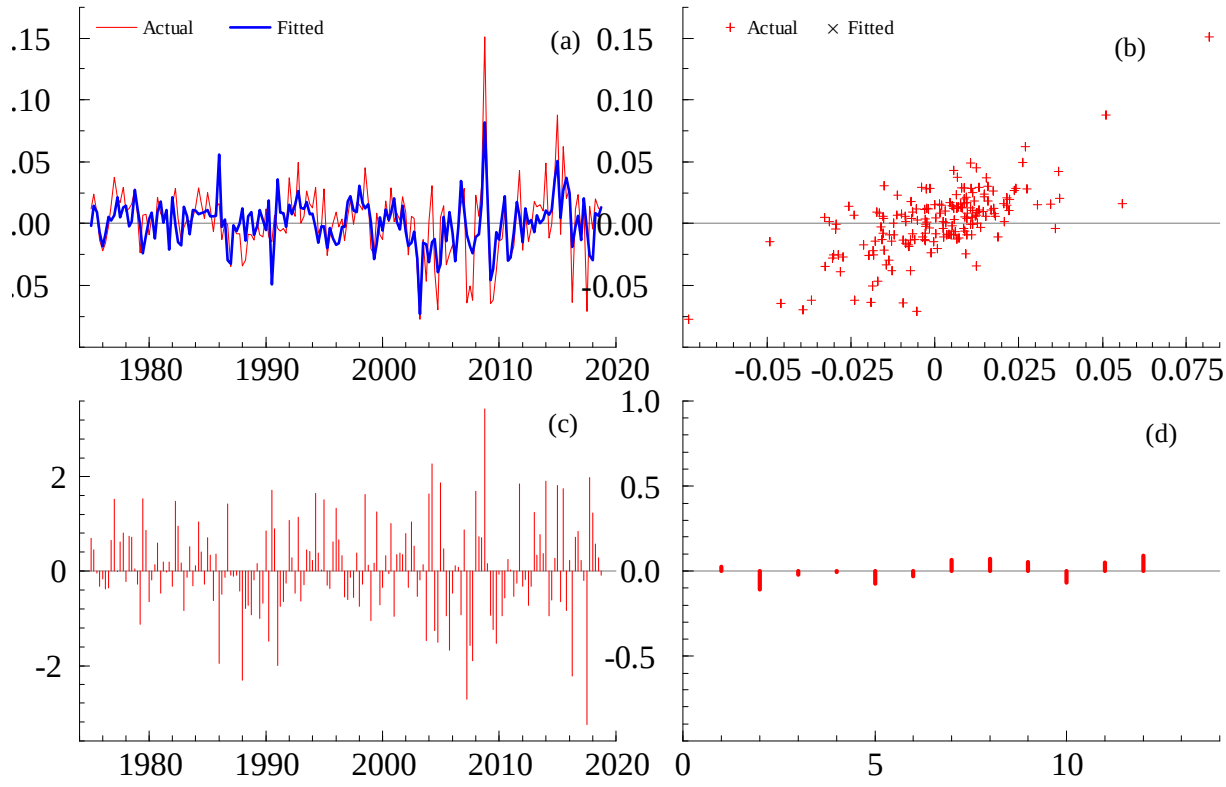

Figure 5: Actual and fitted values, scaled residuals and residual autocorrelation with regard to the Δs_t equation

movements driven by relative profitability, although $i_{t-1} - i^*_{t-1}$ should be interpreted as representing the underlying inflation-expectation formation (4). One can thus see the difference between the roles of the short-term interest rate differential in the short-run and long-run contexts. In addition, Δf_{t-2} has a significant positive impact on Δs_t, evidence which is to be seen as consistent with its long run impact on the exchange rate as found in (11). We can thus argue that a class of economic fundamentals constitutes short-run and long run factors for the Canadian-US dollar exchange rate in line with the well-known monetary models for exchange rates.

Third, as expected, the Canadian-US dollar exchange rate reacts highly significantly to disequilibrium errors represented by ecm_{t-1}. This feedback effect should be treated as evidence for the presence of a stable long-run economic relationship among the exchange rate, the economic fundamentals and the interest rate differentials.

Figure 5 (a) and (b) present the actual values of Δs_t, together with its fitted values from the Δs_t equation in the VECM above; Figure 5 (a) displays them over the sample period while they are shown as a scatter plot in Figure 5 (b). The scaled residuals of this equation are recorded in Figure 5 (c), and the residual autocorrelation function is plotted in Figure 5 (d). Overall, the fitted values have tracked fairly well a number of ups and downs in the observations, as shown in Figure 5 (a) and (b), resulting in the finding that the residuals are free from serial correlation problems, as shown in Figure 5 (c) and (d). Figure 5 can be seen as additional evidence for the importance of the set

of macroeconomic variables in accounting for the dynamics of the Canadian-US dollar exchange rate.

5.4 Forecasting the exchange rate

This sub-section examines the forecasting performance of a full VEC system by focusing on the exchange rate variable. Following Almass and Kurita (2019), we will compare a series of out-of-sample forecasts derived from the system with those from a random walk model with a drift, denoted as a RWM, a benchmark model which has frequently been used in a comparative forecasting study in literature since Meese and Rogoff (1983). The trivariate model in Section 5.3 was conditional on a set of contemporaneous variables, which implies that the model should be viewed as an open system which is incapable of generating out-of-sample forecasts without using contemporaneous information. It is therefore imperative to estimate a full or closed system for X_t by treating all the variables as endogenous, in order to conduct a multi-step dynamic forecasting of the Canadian-US dollar exchange rate. Forecast accuracy is measured using root mean square errors (RMSEs) as well as mean absolute percentage error (MAPEs).

Steps (s)	$s = 3$	$s = 6$	$s = 9$	$s = 12$	$s = 15$
<1> Ratios of RMSEs (FS/RWM)	1.125	0.879	0.872	0.751	0.563
<2> Ratios of MAEs (FS/RWM)	1.152	0.873	0.793	0.752	0.579

Table 4: Comparisons of multi-step out-of-sample forecasts

First, we obtained the estimates of parameters for the full system (FS) and RWM using the observations from 1975Q1 - 2015Q1, *i.e.* with the final 15 observations reserved for out-of-sample forecasts. Second, both the FS and the RWM were employed to generate a sequence of 15 out-of-sample forecasts of the Canadian-US dollar rate in levels over the steps (s) of 3, 6, 9, 12 and 15 months. Finally, we calculated RMSEs and MAPEs with respect to each step using all of the out-of-sample forecasts. Table 4 <1> records the ratios of RMSEs calculated from the FS forecasts (numerators) and RWM forecasts (denominators), while Table 4 <2> presents those of MAPEs from these two models. Although both ratios for the shortest horizon ($s = 3$) are greater than 1, all the other ratios are well below 1 and tend to be smaller with an increase in s. These results imply that, as the forecast horizon increases, the RMSEs and MAPEs derived from the FS have a tendency to be smaller than those from the RWM. The evidence reported in this table enables us to argue that the overall long-range forecasting performance of the FS is better than that of the RWM, which bolsters up the reliability of the regime-shifting equilibrium correction mechanism as a long-range forecasting device.

6 Concluding remarks

This paper has established a theory-consistent econometric model for the Canadian-US dollar exchange rate over the post-Bretton Woods floating period, 1975 - 2018. In the process of the model construction we assigned importance to taking account of a regime shift in 2003 and various outliers in the early 1980s detected in the long-span time series data to be analyzed. The results of the empirical investigation supported the validity of

a fundamental-based view of foreign exchange rates with respect to the determination of a long-run value of the Canadian-US dollar rate.

This study also explored long-run and short-run effects of oil prices on the dynamics of the dollar rate. It has been demonstrated that oil prices play a critical role in accounting for the short-run dynamics of the Canadian-US dollar exchange rate.

The overall results of this econometric study are considered to be informative and useful for the purpose of advancing further economic-policy coordination between the two countries. At the same time, important limitations exist for what can be achieved in the short-term through coordination of interest rates or other fundamentals of each economy. This is because oil-price dynamics impact upon the exchange rate in a contemporaneous way.

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Appendix:

(Data definitions and sources)

Data definitions:
s_t : the log of the spot Canadian-US dollar exchange rate; Source <1>.
i_t : the Canadian short-term interest rate in decimal form(divided by 4); Source <1>.
i_t^* : the US short-term interest rate in decimal form (divided by 4); Source <1>.
b_t : the Canadian long-term interest rate in decimal form (divided by 4); Source <1>.
b_t^* : the US long-term interest rate in decimal form (divided by 4); Source <1>.
f_t : $m_t - m_t^* - (y_t - y_t^*)$
m_t : the log of the Canadian money stock
(M3, Index 2015=100 and seasonally adjusted); Source <1>.
m_t^* : the log of the US money stock (M3, Index 2015=100 and seasonally adjusted); Source <1>.
y_t : the log of the Canadian gross domestic product
(Index 2015=100 and seasonally adjusted); Source <1>.
y_t^* : the log of the US gross domestic product (Index 2015=100 and seasonally adjusted); Source <1>.
p_t^{oil} : the log of spot crude oil price (West Texas Intermediate); Source <2>.

Sources:
<1> OCED Main Economic Indicators in OECD iLibrary (https://www.oecd-ilibrary.org/)
<2> Federal Reserve Bank of St. Louis, Spot Crude Oil Price: West Texas Intermediate (WTI) [WTISPLC], retrived from FRED, Federal Reserve Bank of St. Louis (https://fred.stlouisfed.org/series/WTISPLC).
All the sources were accessed on July 11th, 2019.

References

[1] Abbott, A., De Vita, G. 2002. Testing the long-run structural validity of the monetary exchange rate model. *Economics Letters* 75, 157-164.

[2] Almaas, S.S., Kurita, T. 2019. Modelling the real yen–dollar rate and inflation dynamics based on international parity conditions. *Journal of Asian Economics* 61, 51-64.

[3] Anderson, G. 2011. Introduction: *Forgotten Partnership Redux*: The Enduring Framework of Forgotten Partnership. In Greg Anderson and Christopher Sands, eds. *Canada-U.S. Relations in the 21st Century.* Amherst, NY: Cambria Press, 1-12.

[4] Anderson, G., Christopher S. 2011. *Canada-U.S. Relations in the 21st Century.* Amherst, NY: Cambria Press.

[5] Antweiler, W. 2016. Does the US-Canada bond yield difference really predict the exchange rate? https://wernerantweiler.ca/blog.php?item=2016-06-10

[6] Bacchetta, P. Van Wincoop, E., 2013. On the unstable relationship between exchange rates and macroeconomic fundamentals. *Journal of International Economics* 91, 18-26.

[7] Balke, N.S., Ma, J., Wohar, M. E. 2013. The contribution of economic fundamentals to movements in exchange rates. *Journal of International Economics* 90, 1-16.

[8] Castle, J.L., Kurita, T. 2019. Modelling and forecasting the dollar-pound exchange rate in the presence of structural breaks, Department of Economics Discussion Paper, University of Oxford, Ref: 866.

[9] Cheung, Y.W., Lai, K.S. 1993. Finite-sample sizes of Johansen's likelihood ratio tests for cointegration. *Oxford Bulletin of Economics and Statistics*, 55, 313-328.

[10] Cushman, D.O. 2000. The failure of the monetary exchange rate model for the Canadian-US dollar. *Canadian Journal of Economics/Revue canadienne d´éonomique* 33, 591-603.

[11] Doornik, J.A. 1998. Approximations to the asymptotic distributions of cointegration tests. *Journal of Economic Surveys* 12, 573-593.

[12] Doornik, J.A. 2003. Asymptotic tables for cointegration tests based on the gamma-distribution approximation.
Available in: https://www.doornik.com/research/coigamma_tables.pdf

[13] Doornik JA. 2018. *Econometric Analysis with Markov Switching Models* - PcGive 14: Volume 5. Timberlake Consultants Ltd.

[14] Doern, B., Toner, G. 1985. *The Politics of Energy: The Development and Implementation of the NEP*. Toronto: Methuen. Doran, Charles F. 1984. *Forgotten Partnership: Canada-U.S. Relations Today*. Baltimore, MD: Johns Hopkins University Press. Government of Canada. 1980. The Budget. www.budget.gc.ca/pdfarch/1980-plan-eng.pdf

[15] Doornik, J.A., Hendry, D.F. 2018. *Modelling Dynamic Systems* - PcGive 14: Volume 2. Timberlake Consultants Ltd.

[16] Doornik, J. A., Hendry, D. F. and Nielsen, B. 1998. Inference in cointegrating models: UK M1 revisited. *Journal of Economic Surveys* 12, 533-572.

[17] Doran, C.F. 1984. *Forgotten Partnership: Canada-U.S. Relations Today*. Baltimore, MD: Johns Hopkins University Press.

[18] Edison, H.J., Pauls, B.D. 1993. A re-assessment of the relationship between real exchange rates and real interest rates: 1974–1990. *Journal of Monetary Economics* 31, 165-187.

[19] Engel, C., West, K.D. 2005. Exchange rates and fundamentals. *Journal of Political Economy* 113, 485-517.

[20] Engle, R.F. 1982. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica* 50, 987-1007.

[21] Engle, R.F., Hendry, D.F., Richard, J.F. 1983. Exogeneity. *Econometrica* 51, 277-304.

[22] Flood, R.P., Rose, A.K. 1995. Fixing exchange rates a virtual quest for fundamentals. *Journal of Monetary Economics* 36, 3-37.

[23] Francis, B., Hasan, I., Lothian, J.R. 2001. The monetary approach to exchange rates and the behaviour of the Canadian dollar over the long run. *Applied Financial Economics* 11, 475-481.

[24] Frankel, J.A. 1979. On the mark: A theory of floating exchange rates based on real interest differentials. *American Economic Review* 69, 610-622.

[25] Gonzalo, J. 1994. Five alternative methods of estimating long-run equilibrium relationships. *Journal of Econometrics* 60, 203-233.

[26] Government of Canada. 1980. *The Budget.* October 28. Ottawa, Canada: Department of Finance Canada.

[27] Hale, G. 2012. *So Near Yet So Far: The Public and Hidden Worlds of Canada-US Relations.* Vancouver: UBC Press.

[28] Hamilton J.D. 1989. A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica* 57, 357-384.

[29] Hamilton J.D. 1990. Analysis of time series subject to changes in regime. *Journal of Econometrics* 45, 39-70.

[30] Harbo, I., Johansen, S., Nielsen, B., Rahbek, A. 1998. Asymptotic inference on cointegrating rank in partial systems. *Journal of Business and Economic Statistics* 16, 388-399.

[31] Hendry, D.F. 1995. *Dynamic Econometrics*. Oxford: Oxford University Press.

[32] Hunter, J., Burke, S.P., Canepa, A. 2017. *Multivariate Modelling of Non-stationary Economic Time Series*. Palgrave Macmillan..

[33] Isaac, A. G. and De Mel, S. 2001. The real-interest-differential model after 20 years. *Journal of International Money and Finance* 20, 473-495.

[34] James, P. 1990. The Canadian national energy program and its aftermath: A game-theoretic analysis. *Canadian Public Policy* 16 174-190.

[35] James, P. 1993a. A reply to "Comment on 'Energy politics in Canada, 1980-1981: Threat power in a sequential game'". *Canadian Journal of Political Science* 26, 65-68.

[36] James, P. 1993b. Energy politics in Canada, 1980-1981: Threat power in a sequential game. *Canadian Journal of Political Science* 26, 31-59.

[37] James, P. 2012. *Canada and Conflict*. Oxford: Oxford University Press.

[38] James, P, Michelin, R. 1989. The Canadian national energy program and its aftermath: Perspectives on an era of confrontation. *American Review of Canadian Studies* 19, 59-8l.

[39] Johansen, S. 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control* 12, 231-254.

[40] Johansen, S. 1996. *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*. 2nd printing. Oxford: Oxford University Press.

[41] Johansen, S., Mosconi, R., Nielsen, B. 2000. Cointegration analysis in the presence of structural breaks in the deterministic trend. *Econometrics Journal* 3, 216-249.

[42] Juselius, K. 2006. *The Cointegrated VAR Model: Methodology and Applications*. Oxford: Oxford University Press.

[43] Kouretas, G.P. 1997. The Canadian dollar and purchasing power parity during the recent float. *Review of International Economics* 5, 467-477.

[44] Kurita, T. 2007. A dynamic econometric system for the real yen–dollar rate. *Empirical Economics* 33, 115-149.

[45] Kurita, T. 2013. Exploring the impact of multivariate GARCH innovations on hypothesis testing for cointegrating vectors. *Communications in Statistics-Simulation and Computation* 42, 1785-1800.

[46] Kurita, T., Nielsen, B. 2009. Cointegrated vector autoregressive models with adjusted short-run dynamics. *Quantitative and Qualitative Analysis in Social Sciences* 3, 43-77.

[47] Kurita, T., Nielsen, B. 2019. Partial cointegrated vector autoregressive models with structural breaks in deterministic terms. *Econometrics* 7, 42, special issue *Celebrated Econometricians: Katarina Juselius and Søren Johansen*.

[48] Meese, R.A., Rogoff, K.S. 1983. Empirical exchange rate models of the seventies. Do they fit out of sample?. *Journal of International Economics* 14, 3-24.

[49] Meese, R.A., Rogoff, K.S. 1988. Was it real? The exchange rate-interest differential relation over the modern floating-rate period. *Journal of Finance* 43, 933-948.

[50] Nielsen, B. 1997. Bartlett correction of the unit root test in autoregressive models. *Biometrika* 84, 500-504.

[51] OECD. 1983. *OECD Economic Surveys: USA*

[52] Prentice, J., Rioux, J.S. 2017. *Triple Crown: Winning Canada's Energy Future*. Toronto: HarperCollins Publishers, Ltd.

[53] Rahbek, A., Hansen, E., Dennis, J.G. 2002. ARCH innovations and their impact on cointegration rank testing. Centre for Analytical Finance working paper, 22, 15.

[54] Sarno, L. 2005. Towards a solution to the puzzles in exchange rate economics: Where do we stand?. *Canadian Journal of Economics* 38, 673-708.