An Alternative Approach to Empirically Assess the Feasibility of Monetary Union between Small and Large Countries*

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Abstract

A large body of research shows that monetary union is not feasible if shocks are mostly asymmetric and there is little cross-border risk-sharing between countries; hence the argument for independent central banks. Instead, in this paper, we argue that once risk-sharing is taken into consideration, arguments against the feasibility of monetary union become invalid if focused only on asymmetric shocks. Asymmetric shocks arising from specialization in production may represent new opportunities and, in turn, better risk-sharing for economic agents. This paper proposes an alternative approach to assess the feasibility of monetary union between small and large countries, and uses Canada, Mexico, and the United States as a springboard to underscore the merits of such approach. As the issue of monetary union between Canada, Mexico, and the United States has been vigorously debated in Canadian and Mexican academic and non-academic circles, we raise a simple question with a novel twist: How good a job have, say, the central banks of Canada and Mexico, done in smoothing shocks through setting of interest rates?

JEL Codes: E52; E58; F33; F42; F47.

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1 Introduction

It has been nearly five decades since Mundell's (1961) seminal contribution that originated the theory of optimum currency areas (OCA), with subsequent contributions by McKinnon (1963) on the relative degree of openness of economies and by Kenen (1969) on the relative degree of output diversification to maintain a fixed exchange rate system. Later, Mundell's (1973a&b) contributions on international risk-sharing have made an even more compelling argument for a common currency by showing that better reserve pooling and portfolio diversification can mitigate asymmetric shocks, since each country holds claims against each trading partner's output.

The subsequent literature on optimum currency areas has developed around the two themes introduced in Mundell's (1961, 1973a&b) original works: (i) business cycle synchronization/shocks asymmetry and (ii) international risk-sharing. However, until 1980, these theories could not be fully tested empirically on account of the lack of suitable econometric techniques and/or the availability of necessary econometric software.[1] The contributions of Sims (1980, 1986), Cooley and Leroy (1985), Blanchard and Quah (1989), Galí (1992) and Asdrubali *et al.* (1996) spurred a voluminous amount of empirical literature on the feasibility and intricacies of monetary union. One strand of the empirical literature focuses on discussions about the feasibility of monetary union by testing whether countries are subjected to asymmetric shocks in order to assess the potential costs and benefits of such endeavor. The models are built on assumptions of wage and price rigidities that are compatible with the Keynesian framework, and are estimated using mostly the structural vector autoregression (SVAR) technique. These include the contributions of Bayoumi and Eichengreen (1994), Chamie *et al.* (1994), DeSerres and Lalonde (1994), and Dupasquier *et al.* (1997) on the prevalence of idiosyncratic shocks across member countries; those of Eichengreen (1993), and Blanchard and Katz (1992) on the role of labor mobility; and of Sachs and Sala-i-Martin (1992), von Hagen (1992), and Bayoumi and Masson (1995) on the effect of government transfers on the formation of currency unions.

A second strand of the literature centers mostly around the importance of risk-sharing. In an influential paper, Asdrubali *et al.* (1996) developed a simple framework for quantifying the amount of risk shared by regions within a country or nations within a monetary union. The novel feature of their approach was that it provided researchers with a single framework

[1] Renfro (2004) gives a detailed account of the history of econometric software development.

to identify the various channels of risk-sharing, which were often examined in isolation. The papers that followed this line of work include, among many others, Sørensen and Yosha (1998), Mélitz and Zumer (1999), Del Negro (1998), Crucini (1999), Athanasoulis and van Wincoop (2001), Kalemi-Ozcan *et al.* (2001) and, more recently, Balli *et al.* (2011).

Research on the importance of asymmetric shocks for countries contemplating a monetary union is amongst the most controversial. This is, in part, due to the conflicting results obtained with the SVAR technique. For instance, the same model estimated with different lag lengths or identified with different restrictions (though based on economic theory) may produce conflicting results. The main weakness underlying the arguments that asymmetric shocks work against the feasibility of monetary union is that, within the same country, different regions are subject to idiosyncratic shocks, where some are adversely affected by economic shocks, while others are not. However, a one-size-fits-all independent monetary policy is still being implemented by the central bank of that country, although it has been recognized that such a policy is incapable of smoothing shocks uniformly across provinces/states. As has emerged from the second strand of the literature, for prospective and existing members of a monetary union, risk-sharing (income smoothing) via fiscal and market mechanisms is extremely important for the functioning of the union since it remedies, albeit partially, the failures of monetary policy to address *asymmetric* shocks. Sachs and Sala-i-Martin (1992) show that monetary policy is not totally effective in eliminating asymmetric output shocks among heterogeneous states of the United States (US), while the income smoothing achieved by federal government transfers is indeed very essential in making the US a successful monetary union.[2]

In this paper, we propose an alternative way to empirically assess the feasibility of monetary union between small and large economies. Firstly, studies that rely on the symmetry of shocks to recommend monetary union negate the fact that in successful monetary unions such as Canada and the US, there are still regions that are subject to asymmetric shocks. Although fiscal and market mechanisms smooth a portion of these shocks, there is still a substantial portion that remains unsmoothed, about 20% for Canada according to Balli *et al.* (2011), and 25% for the US as per Asdrubali *et al.* (1996). There are still "have" and "have not" provinces/states.

[2]Note that once risk-sharing is taken into consideration, arguments against the feasibility of monetary union become invalid if they anchored to asymmetric shocks. In fact, asymmetric shocks might even represent opportunities for economic agents from both sides as market liberalization takes place across borders. Consequently, risk-sharing (income smoothing) may increase welfare across provinces/states. Put differently, countries that are subject to asymmetric shocks can still form a monetary union as long as capital and money markets are liberalized and there is a firm determination from the part of the interested partners to put fiscal mechanisms into place, as is currently the case in well-known economic unions such as Canada, the US and the EU.

Therefore, for two independent countries contemplating the prospect of a monetary union, the feasibility of monetary union should not only rest on the symmetry of shocks (or lack thereof) or the absence of cross-country consumption smoothing via market mechanisms to argue for or against independent monetary policy.

A more sensible approach is to compare the portion of shocks that remain unsmoothed under the current level of economic integration with the portion that would remain unsmoothed after factoring in all the benefits of a common currency. Whichever turns out to be greater will indicate the path to take. This line of research offers a more convincing argument for or against monetary union, since it embodies the contributions of monetary policy, market and fiscal mechanisms in smoothing shocks and the portion of shocks that cannot be smoothed. However, this approach is a difficult and a time-consuming endeavor, since it requires undertaking counterfactual experiments. In this paper, we do not take this route, but instead we raise a more fundamental question and suggest a modified approach to evaluate the feasibility of monetary union between small and large countries. As the issue of monetary union between Canada, Mexico and the United States has been vigorously debated in Canadian and Mexican academic and non-academic circles, we raise a simple question with a novel twist: How good a job have, say, the central banks of Canada and Mexico, done in smoothing shocks through setting of interest rates? To this end, we develop a simple but intuitive model and arrive at a monetary policy reaction function for small open economies that is new to the existing literature. Our model offers additional insights as to how monetary policy is conducted in a small open-economy context.

Our empirical application uses a two-stage vector autoregression (VAR) approach to illustrate the usefulness of monetary policy in smoothing shocks. In the first stage, bivariate SVAR models similar to those of Blanchard and Quah (1989), and Bayoumi and Eichengreen (1994) are estimated to extract structural aggregate demand (AD) and aggregate supply (AS) shocks for Canada, Mexico and the US. The differential of these shocks are calculated for each pair (Canada-US and Mexico-US). In the second stage, unrestricted VARs with differential interest rates, and differential AD and differential AS shocks are estimated to obtain the forecast error variance decomposition in order to determine what percentage of the variability in the differential interest rate can be attributed to the differential shocks. Based on quarterly observations over 1970–2008, we find that, on average, less than 7% of the variance in the differential interest rate can be explained by differential AS and AD shocks combined for Canada, and less than

3.5% for Mexico, across all models estimated. These results therefore suggest that the rejection of a possible monetary union between Canada, Mexico and the US should not encroach greatly on the effectiveness of independent monetary policy to smooth shocks.

The rest of the paper is organized as follows: Section 2 presents the underlying theoretical model. Section 3 explains the methodology and the data, and also presents the result of the unit root test. Section 4 discusses the main empirical results. Finally, Section 5 concludes the paper.

2 A simple model of monetary policy effectiveness

This section presents a simple model to evaluate the effectiveness of monetary policy. Our model is based on the observation that shocks do not necessarily hit different regions or economies at the same intensity, and therefore the difference in strength requires different responses.[3] In the same vein that a time series can be decomposed into its permanent (trend) and transitory (cycle) components, we postulate that every shock has two components: its actual materialization and its intensity or strength relative to other places where it has also materialized. We assume that there are only two countries in the world: home and foreign (indicated by an asterisk). Each country is endowed with a central bank that conducts independent monetary policy. One country is small while the other is large. Each country sets a short-term interest rate i to smooth shocks, which takes the following form:[4].

$$i_t = a + b + c, \tag{1}$$

$$i_t^* = a + b + d, \tag{2}$$

where a and b are either (i) aggregate demand (AD) and aggregate supply (AS) shocks, respectively, or (ii) just AD or AS shocks decomposed into two subcategories of shocks; and c and d are either the relative actual or expected strengths of these shocks in each country, respectively. For simplicity, time subscripts for shocks are suppressed. AD shocks could be decomposed into

[3] For example, the financial crisis of 2008, which engulfed the banking system of the United States and many large European countries, prompted large-scale policy interventions in these countries. By comparison, the relative stability of the Canadian banks in the recent crisis did not result in bank failures or government bank bailouts. See Bordo *et al.* (2011) for a related discussion.

[4] It is customary to assume that it is not the level of interest rate that responds to shocks but rather the deviation of the interest rate from some baseline level predicted by a reaction function that should respond to shocks. If we set that baseline level to zero, or provide the justification that the baseline is there to smooth the normal state of shocks, our specification still stands

two shocks, real or nominal, or a combination of the two. Similar reasoning holds for the AS shocks, say labor unrest and technological glitches. However, this distinction does not greatly matter. Equations (1) and (2) simply state that interest rate in each country shares a common component $(a + b)$ that is synchronized with the portions of the shocks that are similar and require the same response. Depending on the relative strength of the shocks faced or anticipated, provisions are made in the magnitude of c and d for home and foreign, respectively.[5]

Clearly, c can be greater than, equal to or less than d. If $c = d$ over time, then $i_t = i_t^*$, implying that a common currency is not an issue for the two countries. However, a problem arises when $c \neq d$. Those who argue against monetary union believe the difference is large across countries, while those who take the opposite view believe that it is relatively small. If the difference is not small, some benefits will accrue to countries under a monetary union to offset their potential costs. This whole discussion suggests that it is not the level of interest rates that should matter when assessing the feasibility of monetary union but rather the differential.

Solving for $(a + b)$ in (2) and substituting in (1), we obtain:

$$i_t = i_t^* + (c - d). \tag{3}$$

Setting $(c - d) = e$, for the small open economy, the overall picture can be represented by the following *imperfect capital mobility equation*:

$$i_t = i_t^* + e_t. \tag{4}$$

Equation (4) is a monetary policy reaction function that shows that the interest rate from the domestic economy is imported from the foreign country with adjustments made to smooth differential shocks. In its simplest form, it states that the domestic short-term interest rate follows a random walk. It will be lower than, equal to or higher than the foreign interest rate depending on the relative strength of the shocks that hit or are expected to hit both economies. The policy reaction function depicted in (4) is for a small open economy that is tied to the large economy by trade and is afraid of capital flight. The central bank may be independent domestically but not internationally. This line of reasoning is in line with the small–large country hypothesis of Mundell (1961). The appeal of this specification is that it accounts for the possibility of mistakes by central banks in "stepping hard on the brakes" to

[5]See Appendix A for additional properties of Equations 1 and 2.

counter shocks. In a more dynamic setup, the error term, e_t, can also be interpreted as expected differential of disturbances. The domestic interest rate does not have to be contemporaneously correlated with the foreign interest rate either. It all depends on which central bank makes the announcement first. If the foreign (large) country moves first, then $i_t = i^*_{t-1} + e_t$; in the opposite case, $i_t = i^{*e}_{t+1} + e_t$. Also, there is no reason to believe that if the two economies have a flexible exchange in place, exchange rate shock is not captured in e_t, for in a two-country model we cannot talk about differential exchange rate shock, by definition. Exchange rate shock is such shock that would justify c different from d, for example.

The international Fisher equations for both domestic and foreign countries are given by Equations (5) and (6), respectively:

$$\begin{aligned} i_t &= r_t + \pi^e_{t+1} + \omega_t, && (5) \\ i^*_t &= r^*_t + \pi^{e*}_{t+1} + \omega^*_t, && (6) \end{aligned}$$

where r refers to the real interest rate, π^e is the expected inflation rate and ω represents the country risk premium. In the limiting case that the sensitivity of investment to the real interest rate is similar across countries of relatively equal degree of economic development, the investment-saving equations for both domestic and foreign countries are given by Equations (7) and (8), respectively:

$$\begin{aligned} Y_t &= A - \gamma r_t + \varepsilon^d_t, && (7) \\ Y^*_t &= A^* - \gamma r^*_t + \varepsilon^{d*}_t, && (8) \end{aligned}$$

where Y is the level of output, A is the autonomous expenditure, γ represents the sensitivity of gross investment to the real interest rate and ε^d (ε^s) is the AD (AS) shock. Aggregate supply equations are given by:

$$\begin{aligned} \widehat{\pi}_t &= \phi \widehat{\mu}_t + \varepsilon^s_t, && (9) \\ \widehat{\pi}^*_t &= \phi \widehat{\mu}^*_t + \varepsilon^{s*}_t, && (10) \end{aligned}$$

where $\widehat{\pi}_t$ is the deviation of the anticipated rate of inflation from its target $(\pi^e_{t+1} - \overline{\pi})$, $\widehat{\mu}_t$ is the wedge between natural and the actual rate of unemployment $(u_n - u_t)$, and ϕ is the sacrifice ratio or the term that captures the tradeoff between inflation and unemployment, which we assume to be identical for both foreign and domestic countries to simplify the calculation. As will become clear later, the sacrifice ratio does not need to be identical across countries. The typical supply equation is $(\pi^e_{t+1} - \overline{\pi}) = -\phi(u_n - u_t)$.

Assuming that expected rate of inflation is equal to actual inflation, substituting (5) and (6) in (4) to solve for e_t, we obtain:

$$e_t = i_t - i^*_t = (r_t - r^*_t) + (\pi^e_{t+1} - \pi^{e*}_{t+1}) + (\omega_t - \omega^*_t). \tag{11}$$

Since $\hat{\pi}_t = \pi^e_{t+1} - \overline{\pi}$ and $\hat{\pi}^*_t = \pi^{e*}_{t+1} - \overline{\pi}^*$, we solve for the difference:

$$\begin{aligned} (\pi^e_{t+1} - \pi^{e*}_{t+1}) &= (\hat{\pi}_t - \hat{\pi}^*_t) + (\overline{\pi} - \overline{\pi}^*) \\ &= \phi(\widehat{\mu}_t - \widehat{\mu}^*_t) + (\varepsilon^s_t - \varepsilon^{s*}_t) + (\overline{\pi} - \overline{\pi}^*). \end{aligned} \tag{12}$$

Equation 12 states that difference in inflation expectations across countries is a reflection of differences in expectations about deviations of unemployment rates from their natural levels, supply shocks, and inflation rate targets. Solving for the real interest rates in (7) and (8) and taking the differential, we obtain:

$$(r_t - r^*_t) = \frac{1}{\gamma}[(A - A^*) - (Y_t - Y^*_t) + (\varepsilon^d_t - \varepsilon^{d*}_t)]. \tag{13}$$

Equation 13 postulates that difference in real interest rates across countries is a reflection of differences in autonomous expenditures, output levels, and demand shocks.[6] Substituting (12) and (13) into (11), we obtain:

$$\begin{aligned} e_t &= (i_t - i^*_t) \\ &= \frac{1}{\gamma}(\varepsilon^d_t - \varepsilon^{d*}_t) + (\varepsilon^s_t - \varepsilon^{s*}_t) + (\omega_t - \omega^*_t) + W_t, \end{aligned} \tag{14}$$

where $W_t = \frac{1}{\gamma}[(A - A^*) - (Y_t - Y^*_t)] + \phi(\widehat{\mu}_t - \widehat{\mu}^*_t)$.

By looking at (14), it becomes clear that had we assumed different sacrifice ratios, we would have had different coefficients for the deviation of unemployment rate from its natural level

[6] Again here, there is no reason to believe that demand shocks do not contain exchange rate shocks even when exchange rate is not modeled explicitly. One should see the demand shock term as a catchall term for all shocks that can originate from the demand side of the economy. For example, in our two-country framework, we can model exchange rate explicitly by adding an extra term ρq_t to Equation 7 for the small country, where q is the real exchange rate ($= \xi P^*/P$, and ξ is the nominal exchange rate, P and P^* are the respective domestic and foreign prices). Equation 13 would then be augmented by this last term (ρ times q).

across countries. Equation (14) tells us that the differential interest rate observed across countries is a reflection of the differential shocks small countries expect to accommodate. Therefore, the view that the objective of monetary policy is solely to combat inflation may be misleading or incomplete because there are additional variables that enter the monetary policy reaction function other than what a central bank usually conveys to the general public. There is a wide range of policy reaction functions that contain variables found in (14), ranging from Taylor (1993), and Fuhrer and Moore (1995), to the various implied in SVAR and in VAR models such as Kuszczak and Murray (1987), Lalonde and St-Amant (1993), Chamie *et al.* (1994), DeSerres and Lalonde (1994), Dupasquier *et al.* (1997), Cushman and Zha (1997), and Artis and Ehrmann (2006), among others. With the exception of Cushman and Zha (1997) and Artis and Ehrmann (2006), VAR-based monetary policy reaction functions consist of a short-term interest rate as linear combinations of structural shocks associated with the variables that enter the system. This modeling approach creates a false sense of monetary policy independence for small countries that is not justified theoretically. Cushman and Zha (1997) and Artis and Ehrmann (2006) have come close to the intuition of Equation (14) but fell short of accommodating the dynamics of the differential interest rate. Although they have incorporated foreign variables in their VARs, their monetary policy reaction functions are still a linear combination of actual (not differential) foreign and domestic shocks. Papers by Del Negro and Obiols-Homs (2001), Bhuiyan (2008), Klyuev (2008) and Bayoumi and Swiston (2009) all suffer from the same flaws. We cannot assess the effectiveness of monetary policy in smoothing shocks with their models in our setting of whether a country should keep its central bank or not.

Equation (14) is flexible in that any set of variables that might be of interest to researchers can be incorporated in the equation system by further decomposing the shocks. Moreover, with the insight gathered from this equation, one can take the analysis one step further by looking at the central bank as an institution whose objective is to choose differential interest rate in order to minimize the influence of unwanted differential AD and AS shocks on output and inflation. There are, of course, additional interesting dynamics that can be obtained with the solution of a quadratic loss function. However, we are not sure how much of a difference it may make empirically.

A strong message that emerges from our model is that differential interest rate matters not only for arbitrage purposes but also for altering the path of the economy. In today's globalized world, small open economies pay close attention to what the larger economies are doing much more often than is publicized and more frequently than is assumed.

3 Methodology and data

Estimation of Equation (14) may pose quite a number of challenges. The structural shocks, and hence their differentials, are normally distributed but the differential interest rate may or may not follow the same distribution. Moreover, it is not clear as to which measures of differential interest rate should be used: the estimated residuals of the regression of the domestic interest rate on the foreign interest rate or the simple arithmetic difference. A number of additional complications arise. Nominal interest rates may be $I(1)$ or $I(0)$, and hence the differential interest rate order of integration is uncertain. Moreover, although estimates of the simple ordinary least squares (OLS) regression are consistent, the estimated standard errors from OLS regression are not normally distributed even in large samples. Since no unique approach is available to arrive at the shocks and examine their linkages with the differential interest rate, we therefore need to embrace a more eclectic approach. It is worth emphasizing that a number of shortcuts will not work for the research question at hand. Arguably, one might either (a) estimate a VAR with differential interest rate as one of the variables, or (b) two separate VARs with the short-term interest rate of each country in their respective VARs, and compute the differential shocks. In the former case, the policy reaction function would be one where the differential interest rate responds to the total shocks rather than the magnitude of c or d contemplated in Equations (1) and (2) and embodied in Equation (4).[7] In the latter case, we would end up with the differential of the monetary policy shocks as a function of the differential AD and AS shocks, which would certainly contradict the dynamic policy setting of our model.[8] In light of all the controversies that may arise, we therefore suggest the following steps:

- **Step 1:** Obtain the residual $\hat{e}_t$ as the monetary policy shock variable using Stock and Watson's (1993) dynamic OLS (DOLS) or any other robust estimator. This involves an

[7]For example, a trivariate VAR of $x_t = [\Delta y, \Delta\pi, (i - i^*)]'$ produces a moving average representation of:

$$\begin{bmatrix} \Delta Y_t \\ \Delta\pi \text{ or } \pi_t \\ i_t - i_t^* \end{bmatrix} = \begin{bmatrix} \overline{\gamma}\Delta Y_t \\ \overline{\gamma}\Delta\pi \text{ or } \pi_t \\ \overline{\gamma}i_t - i_t^* \end{bmatrix} + \sum\nolimits_{j=0}^{\infty} \begin{bmatrix} \theta_{11}(j) & \theta_{12}(j) & \theta_{13}(j) \\ \theta_{21}(j) & \theta_{22}(j) & \theta_{23}(j) \\ \theta_{31}(j) & \theta_{32}(j) & \theta_{33}(j) \end{bmatrix} \begin{bmatrix} \varepsilon_{t-j}^{s} \\ \varepsilon_{t-j}^{d} \\ \varepsilon_{t-j}^{i-i^*} \end{bmatrix}$$

Or, more compactly, $x_t = \gamma + \sum_{j=0}^{\infty} \theta_j \varepsilon_{t-j}$. The last equation is the monetary policy reaction function, and each equation is a linear combinations of shocks. This contravenes Equations 4 and 14.

[8]As can be seen from the previous footnote, by replacing the differential interest rate with either i_t or i_t^* we can extract the actual shocks for each country, using some identification scheme. Again, this is in sharp contrast with Equations 4 and 14.

estimation of the form:

$$i_t = \delta_0 + \delta_1 i_t^* + \sum_{j=-p}^{p} \lambda_j \Delta i_{i-j}^* + e_t.$$

Where there is evidence of a one-to-one relationship, the differential interest rate is a simple arithmetic difference and may be used instead, since it is stationary.

- **Step 2:** Since the SVAR methodology is the most popular and the most controversial tool that can be used to extract the shocks, we recommend a simple bivariate SVAR model either à la Blanchard and Quah (1989) and/or à la Bayoumi and Eichengreen (1994) (henceforth BQ and BE, respectively) to obtain (ε_t^d) and (ε_t^s) for each country, and hence the differentials of these variables.

- **Step 3:** Regress $\hat{e}_t$ on the differential shocks across countries or use a VAR with these variables to obtain the variance decomposition:

$$\hat{e}_t = \beta_0 + \beta_1(\varepsilon_t^d - \varepsilon_t^{d*}) + \beta_2(\varepsilon_t^s - \varepsilon_t^{s*}) + \nu_t.$$

A number of approaches can be taken in Step 3, including partial autocorrelation, a smoothing technique, variance analysis or any other suitable methods. Irrespective of the method chosen, we should arrive at the portion of these shocks that are smoothed and the portion that remains unsmoothed, along the lines of Asdrubali *et al.* (1996). Using OLS,[9] for example, the coefficient estimate of each differential variable will tell us about the response of monetary authorities, holding all other effects constant. The sign of the coefficient will indicate the direction of monetary policy, while the t-statistic will inform us whether the response is significant or not. If the demand shocks that affect a small economy are stronger than those of the large economy, the differential AD shock will be positive. We therefore expect monetary policy to be contractionary in relative terms, which translates into a positive differential interest rate.

We follow the steps described above for Canada and the US, and Mexico and the US, and experiment with the differential interest rate as: (a) an arithmetic difference, (b) the residual of the DOLS cointegrated equation of Stock and Watson (1993) and (c) the residual of the autoregressive distributed lag (ARDL) bounds testing approach for cointegration suggested by

[9]The standard errors from OLS are correct in this application since only unanticipated regressors from the first-stage regression enter the second regression. See Pagan (1984), model 4, for a demonstration of this result.

Pesaran *et al.* (2001).[10] Quarterly data on unemployment rates, output and prices were taken from the OECD's Economic Outlook. Policy rates for Canada (i.e. bank rate) and the US (i.e. federal funds rate) were obtained from Statistics Canada. The short-term policy rate for Mexico, which is proxied by the three-month Treasury bill, was taken from the International Financial Statistics published by the IMF. Due to the unavailability of Mexican unemployment rate, the BQ SVAR model could not be estimated for Mexico. The sample period is 1970:Q1–2008:Q4. Since the interest rate series for Mexico starts in 1978Q1, all BE SVAR models were estimated over a shorter sample period to facilitate comparisons.

As a first step, we test the order of integration of the variables that enter the model. We apply the DF-GLS test of Elliott *et al.* (1996) for our unit root test. When testing for a unit root, we allow for both a constant and a constant plus the deterministic time trend in the regression. The DF-GLS test is based on applying the well-known Dickey–Fuller τ-test to locally demeaned or demeaned and detrended series. It is generally more powerful than the standard augmented Dickey–Fuller unit root test. Ng and Perron (2001) studied the size and power properties of the DF-GLS test in finite samples. They recommended using a modified Akaike Information Criterion (AIC) for selecting the lag length. The results in Table 1 show that the variables are non-stationary, as the null hypothesis of a unit root cannot be rejected at the conventional 5% level of significance.

The unit root findings in the variables raises the question whether to estimate the SVAR in levels (i.e. with the variables in non-stationary form), or using the first-differenced method (i.e. with the variables in stationary form) or in a VAR that imposes cointegration (i.e. in an error-correction model).[11] Although the BE model accords with the unit root outcomes, the original BQ model was estimated with the first difference of the logarithm of gross national product (GNP) and the level of unemployment rate, as the latter was found to be stationary. For completeness, we estimate three versions of the BQ-type SVAR models for Canada and the US: one with the difference in line with the unit root tests, one similar to the original BQ model

[10] It is important to note that the residuals of the DOLS and ARDL equations are proxies for the differential interest rate. For example, by isolating the error term in Step 1 for the DOLS representation, the left hand side of the regression equation becomes the difference between the actual domestic interest rate and the combination of past, present and future values of the change in the foreign interest rate. In fewer words, this proxy captures all relevant information content of the foreign interest rate. A simpler proxy could have been the error term of the Engle and Granger (1987) cointegration equation: ($i_t = \delta_0 + \delta_1 i_t^* + e_t$ where $\hat{e}_t = i_t - (\hat{\delta}_0 + \hat{\delta}_1 i_t^*)$ converges to $(i_t - i_t^*)$ when $\hat{\delta}_0 \cong 0$ and $\hat{\delta}_1 \cong 1$), but the drawbacks of the OLS estimator of δ_1 is well documented in the literature (see, Stock and Watson, 1993).

[11] We tested the null hypothesis of no cointegration using the DOLS method of Stock and Watson (1993) for several bivariate SVARs. Cointegration is present only for Canada when output and price enter the SVAR, although these results appear to be sensitive to the number of lags used. These results are available on request.

and one in levels. We justify the specification in levels based on the Monte Carlo results of Lin and Tsay (1996).[12] For the BE-type SVAR models, we estimate two versions: one in difference and the other in levels for all three countries since this topic is not very controversial. Each bivariate SVAR model is identified with the restrictions that AD shocks have no permanent effects on output in the long term. Since the SVAR technique has become standard in the literature, it is not necessary to regurgitate its exposition here. Interested readers are referred to Enders (2010) or Hamilton (1994) for more details. Nonetheless, we present the infinite moving average representation with the long-run restriction imposed for the BE-type model:

$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \sum_{i=1}^{\infty} L^i \gamma_j \begin{bmatrix} 0 & \alpha_{12,i} \\ \alpha_{21,i} & \alpha_{22,i} \end{bmatrix} \begin{bmatrix} \varepsilon_t^d \\ \varepsilon_s^s \end{bmatrix} \tag{15}$$

For the BQ-type model, we only need to replace the second variable with the unemployment rate in levels or in first difference. We scrutinize the impulse responses to determine whether they fall in line with the prescriptions of the actual AD-AS model. We expect output and prices to move in the same direction in response to a demand shock and in opposite directions to a supply shock for the BE-type models. We also expect output and unemployment to move in opposite directions in response to a demand shock, whereas the response to a supply shock may vary between output and unemployment. Output should increase in response to a positive supply shock and stabilize somewhere above the baseline to reflect the permanent effect of the supply disturbance; however, the response of unemployment may vary over time. In the short term, unemployment may rise or fall, but it should eventually return to the natural rate in the long term. We further analyze the variance decomposition of the unrestricted VAR described in Step 3 above with differential interest rate, differential AD and AS shocks to emphasize the usefulness of keeping a differential interest rate from the US for both Canada and Mexico.

4 Empirical results

The purpose of this section is to use data on output, prices, unemployment rate and short-term interest rates for all three North American Free Trade Agreement (NAFTA) member

[12] A considerable amount of literature on this issue tends to suggest that even if the variables have unit roots, it is still desirable to estimate an SVAR in levels. Sims *et al.* (1990) show that the estimated coefficients of a VAR are consistent and the asymptotic distribution of individual estimated parameters is standard (i.e. the asymptotic normal distribution applies) when variables have unit roots and some variables form a cointegrating relationship. See also Hamilton (1994, pp. 561–562) for a related discussion.

countries to obtain the structural AD and AS shocks. The differentials of these shocks, along with the differential interest rate are then used in a second VAR to compute the percentage of the variability in differential interest rate, that can be explained by the differential shocks as stipulated in Equation (14).

The BQ-type VARs were estimated with eight lags and the BE-type VARs were estimated with five and four lags for the models in levels and in difference, respectively. Each country's model was estimated with the same number of lags to facilitate comparison across the board. We chose the highest lag length recommended by the AIC plus one extra lag to this end. The VARs estimated in levels clearly deliver predictions that are closer to the theoretical underpinnings of the AD-AS model and are superior to VARs estimated in difference or quasi-difference. For example, we find that the BQ VAR in levels for Canada displays a positive response of output to both demand and supply shocks, whereas the unemployment rate declines and remains negative for quite some time before getting closer to the baseline. A permanent effect of supply disturbances on output is observed, while demand disturbances display a humped pattern in line with the long-run identification restriction imposed. This result is, however, an exception to the rule: none of the remaining VARs estimated produced similar response patterns. The results are not sensitive to the lag lengths adopted, which were actually quite large in most cases.[13]

It is customary in the literature to compute the cross-correlation of the shocks after the analysis of the impulse responses to conjecture whether a monetary union is feasible or not when the focus is solely on shocks asymmetry or lack thereof.[14] We take the same path here only to make a point. Table 2 provides conflicting results into the feasibility of monetary union amongst the NAFTA member countries. The BQ model in levels for the Canada-US pair shows that both AD and AS shocks are negatively correlated (-0.47 and -0.46, respectively), while the BE models in both levels and differences show that they are positively correlated (0.32 and 0.35 on average). The BE model in difference shows a positive but weak cross-correlation of the shocks for the Mexico-US pair (0.16 and 0.14). The BQ model in difference and in quasi-difference for Canada and the BE model in levels for Mexico produce correlations that are negligible, ranging from -0.002 to 0.04. Despite the additional 14 years of data used here, our results–surprisingly–do not fall too far apart from those of Bayoumi and Eichengreen (1994),

[13]Impulse responses are available upon request.

[14]Normally, a negative (positive) correlation of shocks means monetary union is feasible based on risk sharing (symmetrical shocks) arguments. In fewer words, there is always an argument for monetary union.

who found a correlation of supply disturbances of -0.47 for Canada-US and -0.59 for Mexico-US. Their correlation of demand disturbances is 0.30 for Canada-US and -0.12 for Mexico-US. If anything, these results suggest is that little or nothing has changed for Canada-US economic integration, whereas Mexico-US integration has improved considerably over time. This is, of course, a notable spillover benefit of the formation of NAFTA.

The point that we also want to make here is that the correlations of shocks between Canada and the US and between Mexico and the US inform us about the magnitude of shocks that central banks in Mexico and/or Canada must handle while keeping a differential with the US interest rate. Briefly, these correlations tell us that the portion of shocks that are common between the pairs of countries ($a + b$ as per Equations (1) and (2)) are small, and therefore c and d are large. This explains why each country needs their own monetary policy. Let us take this line of reasoning one step further. If it is the case that c and d are large, then we should expect a great portion of these shocks to explain the variance of the differential interest rate. Unfortunately, this is not the case. Differential AD and AS shocks combined could only explain 7% or less of the variability in differential interest rate for Canada and less than 3.5% for Mexico. Table 3 shows the results. Regardless of the model considered, at no point do any of the differential shocks explain 10% of the differential interest rate. Theoretically, we cannot expect much of a response in the differential interest rate to differential AS shocks because demand management policies are mostly ineffective in addressing supply shocks.[15] The same goes for the variance decomposition. In five of the six models estimated for Canada, the percentage of the variability in the interest rate accounted for by differential AD shocks is greater than that of the differential AS shocks. We find the opposite pattern in the three models estimated for Mexico.

We test for cointegration between the two short-term interest rates for the US and Canada, and for the US and Mexico using the DOLS method of Stock and Watson (1993) and the autoregressive distributed lag (ARDL) model of Pesaran *et al.* (2001) to obtain the residuals, which serve as proxies for differential interest rate. The DOLS models were estimated with two, four, and six leads and lags, whereas the ARDL models were estimated with two, four, and six lags. For each variant of these models, an estimate of the differential interest rate was

[15] In an AD-AS model, if monetary policy is used to counter an inverse supply shock, prices will surely rise beyond the level of the supply shock outcome. A positive supply shock gives rise to lower prices and higher output levels. To counter that effect, contractionary monetary policy is implemented, AD decreases and prices are now lower than the new equilibrium price of the positive supply shock.

extracted, and this enters a VAR with differential AD and AS shocks. The results are presented in Tables 4 and 5. As can be seen, differential AD and AS shocks combined cannot account for more than 15% of the variation in differential interest rate when the DOLS is estimated with four leads and four lags for Canada. The results (not reported here) do not vary much with two or six leads and lags, or with two or six lags in the case of the ARDL model. In the case of Mexico, the new measures of the differential interest rate produce quite a different picture. We find that differential AD and AS shocks explain, on average, 37% and 8% (27% and 11%), respectively of the variation in the DOLS (ARDL) differential interest rate after 40 quarters. The BE model in levels shows a huge 55% influence of differential AD shocks on differential interest rate disturbances, while the BE model in difference shows a 20% influence. These findings suggest that setting interest rates to smooth idiosyncratic shocks plays a greater role in Mexico than in Canada, and therefore Mexico, not Canada, should advocate an independent monetary policy.

We also undertake further analysis by extracting shocks from BQ SVAR models and BE SVARs in levels, difference and quasi-difference estimated with four and six lags across the board. In Tables 6 and 7, we present the results for the variance decomposition of differential interest rate using the DOLS and ARDL methods for the SVAR models estimated with four lags. All other results are available in a supplement to conserve space. Overall, we found no significant differences from earlier findings based on the arithmetic difference between the two interest rates for Canada; differential AD and AS supply shocks continue to explain little of the variation in the differential interest rate. For Mexico, these shocks explain a greater proportion, on average, of the variability in differential interest rate. The figure lies anywhere from 6% to 46% for differential AD shocks and from 3% to 19% for differential AS shocks after eight quarters. It all depends on the lag lengths and the type of SVAR model estimated, and the number of leads and/or lags incorporated in the DOLS or ARDL models to compute the differential interest rate.

In general, we have shown that the lack of shock symmetry may dictate that monetary union is not feasible across potential member countries, but this does not necessarily mean that monetary policy setting in these countries should necessarily get the full credit for insulating their economies from shocks by keeping a differential with the US interest rate or the interest rate of the potential anchor country. The recent global financial crisis has demonstrated how ineffective monetary policy can be in times of depression or downturn. Despite the massive cuts in interest rates in Canada and other parts of the world, there is no guarantee that the Canadian economy can fully recover on its own after the 18-month lag anticipated to see the effects of monetary policy on the real sector unless the US (its most important trading partner) comes out of the crisis. It could still be argued that the regulatory framework in Canada has helped a great deal in avoiding a catastrophe; the same could be said for some states in the US. What this paper has shown is that, in contrast with Mexico, there is no good excuse for Canada to refute monetary union with the US. The usefulness of independent monetary policy due to shock asymmetry, nationalistic sentiments and presumed cultural differences just do not add up as valid arguments. If monetary union were to take place between Canada and the US and/or between Mexico and the US, it would be important for both Canada and Mexico to at least make sure they put structures in place that guarantee at least the current socio-economic welfare they are now enjoying and expect to continue to enjoy at home in the future, and a legal framework allowing for prompt and costless dispute resolution. We are referring here to the same type of binding agreement that exists between states and provinces. A monetary union between Canada and the US, for example, would function at least in the same way that Ontario and Prince Edward Island are in a monetary union. It is well-known that Prince Edward Island and Ontario are subject to asymmetric shocks, and monetary policy conducted by the Bank of Canada cannot alleviate both provinces concurrently.[16] Federal transfer, capital and credit market mechanisms, though in place, still leave a sizable portion of the shocks unsmoothed.

It is worth noting that the NAFTA member countries are used in this paper as an illustration of how the approach suggested to investigate monetary union might work, though we have expended a quantity of ink on it. We could have used any other economic bloc. NAFTA was a natural choice for the simple reason that it has only three member countries. Also, Canada has witnessed considerable controversy about joining the US and Mexico in a monetary union. Of course, now is not the time for this consideration because the US economy is still sluggish, the Canadian dollar hovers roughly equal to the US dollar, and the Canadian economy is currently in a much better shape than that of the US, despite Canada's trade dependence on the US. Therefore, in passing judgment on this paper, it is imperative not to reignite the political debate on the North American monetary union but rather to focus on the academic debate. In this

[16]Georgopoulos (2009) provides further evidence that common monetary policy in Canada imposes serious costs on provinces that do not move along the same wavelength. In fact, he measures the differential regional effects of monetary policy shocks in Canada and finds that primary industry-based provinces are more strongly and adversely affected by a contractionary monetary policy shock than manufacturing-based provinces such as Ontario.

respect, this paper offers a novel approach to investigate the costs of forming a monetary union by focusing on the effectiveness of monetary policy in smoothing idiosyncratic shocks.

5 Conclusions

Our objective in this paper has been to provide a simple but flexible and insightful model to empirically assess the feasibility of monetary union between small and large countries. Our model offers a fresh and innovative way of determining the feasibility of monetary union by shifting the burden to the central banks, which so often get the credit for their effectiveness in smoothing asymmetric shocks. We establish that the differential interest rate across countries is a reflection of the size and magnitude of shocks that central banks expect to accommodate, and therefore a large portion of this differential interest rate variability must explain the differential shocks across countries. We use Canada, Mexico and the United States as a case study to illustrate how our model could be implemented in practice, though the argument for Canada to join in a union with Mexico differs from the argument to join in a union with the United States (see, among others, Lalonde and St-Amant (1993), Jean Louis (2004) and Jean Louis and Simons (2007) for further details). Our results show that, on average, less than 7% of the variance in the differential interest rate can be explained by differential AD and AS shocks combined for Canada. These figures are less than 3.5% for Mexico when the differential interest rate is a simple arithmetic difference. However, when we estimate the differential interest rate using DOLS and ARDL, the results for Canada did not change but those for Mexico did; we find the differential AD shocks explain more than 30% of the differential interest rate. The results for Mexico vary depending on the model and the number of lags, but in most cases, differential AD shocks explain a good portion of the variation in the differential interest rate. We therefore surmise that the effectiveness of monetary policy in smoothing shocks in Canada cannot serve as an excuse to refute a North American monetary union. Mexico, by contrast, can hold such position, despite the disparities that exist when comparing these two economies.

A General specification of equations 1 and 2

Equations 1 and 2 could be generally represented as:

$$i_t = \alpha_1 a + \alpha_2 b + \alpha_3 c, \tag{A.1}$$

$$i_t^* = \beta_1 a + \beta_2 b + \beta_3 d, \tag{A.2}$$

where the slope coefficients are the sensitivity of interest rate to the different shocks. If we consider a as positive AD shocks and there is no supply shock, $\alpha_1 > 0$ indicating that interest rate rises if the central bank foresees inflation might deviate from its targeted level and $\alpha_3 > 0$ to reduce the relative strength of the shocks. If there is only positive supply shock, $a = 0$, and $\alpha_2 < 0$ in case the central bank wants to bring inflation to target and further boost output, $\alpha_3 < 0$ would further enhance that stance in smoothing the relative intensity of that shock. If the central bank has to deal with both AD and AS shock, c would represent the combined effects of the relative strengths of these two shocks. In such cases, α_3 can be greater, less than, or equal to zero depending on which shocks dominate or not, and still would capture the differential effects of the shocks anticipated in relation to similar combination of shocks affecting the foreign country. Of course, similar interpretations apply to the foreign country's equation. In line with the near-rationality argument of Akerlof, Dickens, and Perry (1996) and Fortin and Dumont (2000), the postulation of (A.1) and (A.2) allows for the policy responses to be the same or differ across countries, though a and b are the same. It is more common than not to believe that economic agents react similarly to shocks of the same nature; setting $\alpha_1 = \beta_1 = 1$, $\alpha_2 = \beta_2 = -1$, and $\alpha_3 = \beta_3 = 1$ simplifies the two equations accordingly to state that if one were to decompose the policy instrument of each central bank into two components; one part would be for the portion of the shocks that they believe is similar to their counterpart and the other portion would be for the part they believe or anticipate to be dissimilar. It can also be insinuated from Equations (1) and (2) that the central bank responds in the same way to demand and supply shocks by keeping the coefficients of a and b at $+1$, but this is not so in reality. The $+1s$ coefficients are there to state that we are dealing with two shocks (AD) and (AS) or one shock (AD) that can be monetary and nonmonetary or (AS) that can be technological and non-technological. Distinguishing between the sign of the coefficients may lead to the misinterpretation that we are talking about the difference between two shocks. As can be seen:

$$i_t = a - b + c, \tag{A.3}$$

$$i_t^* = a - b + d, \tag{A.4}$$

Substituting $a - b$ from (A.4) in (A.3) produces an equation that is similar to Equation (3), hence Equation (4), without loss of insights.

Table 1: DF-GLS unit root tests

Variable	Intercept	Intercept & trend
Output Canada	1.32	-1.95
Output Mexico	1.06	-1.10
Output US	1.33	-2.75*
CPI Canada	-0.37	-1.29
CPI Mexico	-0.40	-1.40
CPI US	0.18	-0.81
Unemployment rate Canada	-0.77	-1.05
Unemployment rate US	-0.98	-1.41
Short-term rate Canada	-1.28	-1.88
Short-term rate Mexico†	-1.38	-1.55
Short-term rate US	-1.53	-2.77*
Real interest rate Canada	-1.64	-2.13
Real interest rate Mexico†	-1.21	-1.36
Real interest rate US	-1.53	-2.23

Note: Sample period: 1970Q1–2008Q4. DF-GLS refers to Elliott *et al.*'s (1996) unit root test. Critical values with an intercept only are: -2.58 (1%), -1.94 (5%) and -1.61 (10%). Critical values with an intercept and a linear trend are: -3.51 (1%), -2.97 (5%) and -2.68 (10%). CPI: consumer price index. †: 1978Q4–2008Q4. * indicates statistical significance at the 10% level.

Table 2: Correlation of supply and demand shocks with the United States

	Canada		Mexico	
	ε_t^d	ε_t^s	ε_t^d	ε_t^s
BQ model in levels	-0.47	-0.46		
BQ model in difference	-0.002	0.03		
BQ model	-0.04	-0.02		
BE model in levels	0.34	0.32	-0.02	0.04
BE model in difference	0.30	0.38	0.16	0.14

Note: ε_t^d: demand shock; ε_t^s: supply shock; BQ: Blanchard and Quah (1989); BE: Bayoumi and Eichengreen (1994).

Table 3: Variance decomposition of the differential interest rate

Period	Canada						Mexico		
(quarters)	δ_t^i	δ_t^d	δ_t^s	δ_t^i	δ_t^d	δ_t^s	δ_t^i	δ_t^d	δ_t^s
	BQ model in difference			BE model in difference			BE model in difference		
1	100.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00
2	98.68	1.08	0.24	97.15	2.83	0.01	99.76	0.16	0.08
3	98.53	0.96	0.51	92.08	3.84	4.08	99.10	0.15	0.75
4	97.60	1.35	1.06	86.01	5.42	8.57	98.35	0.26	1.40
8	97.81	1.23	0.96	85.08	6.46	8.47	97.94	0.64	1.42
12	97.94	1.16	0.90	84.80	6.60	8.60	97.97	0.66	1.37
40	98.03	1.10	0.87	84.75	6.67	8.59	98.02	0.64	1.34
	BQ model			BE model in levels			BE model in levels		
1	100.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00
2	98.68	0.89	0.43	98.96	0.94	0.10	99.98	0.01	0.01
3	98.36	0.78	0.86	97.51	1.27	1.22	97.81	0.55	1.64
4	97.29	1.50	1.21	95.28	2.62	2.10	96.57	0.60	2.82
8	97.48	1.36	1.16	93.80	3.57	2.63	96.21	0.54	3.25
12	97.60	1.30	1.10	93.55	3.70	2.74	96.05	0.50	3.45
40	97.69	1.24	1.08	93.38	3.79	2.83	95.85	0.46	3.69
	BQ model in levels			Averages			Averages		
1	100.00	0.00	0.00	100.00	0.00	0.00	100.00	0.00	0.00
2	98.84	1.16	0.00	98.46	1.38	0.16	99.87	0.09	0.04
3	97.17	2.57	0.26	96.73	1.88	1.39	98.46	0.35	1.19
4	96.22	2.85	0.93	94.48	2.75	2.77	97.46	0.43	2.11
8	95.22	4.01	0.78	93.88	3.33	2.80	97.08	0.59	2.34
12	95.06	4.18	0.76	93.79	3.39	2.82	97.01	0.58	2.41
40	94.96	4.30	0.75	93.76	3.42	2.82	96.93	0.55	2.52

Note: δ_t^i: differential interest rate of own shocks; δ_t^d: differential demand shock; δ_t^s: differential supply shock; BQ: Blanchard and Quah (1989); BE: Bayoumi and Eichengreen (1994). The figures in this table tell us what percentage of the variance in the differential interest rate is explained by a country's own dynamics, differential AS shocks and differential AS shocks.

Table 4: Variance decomposition of the differential interest rate based on DOLS (four leads, four lags) and AIC-based SVAR models

Period	Canada						Mexico		
(quarter)	δ_t^s	δ_t^d	δ_t^i	δ_t^s	δ_t^d	δ_t^i	δ_t^s	δ_t^d	δ_t^i
	BQ model in difference			BE model in difference			BE model in difference		
1	0.85	0.15	99.00	0.09	0.28	99.63	0.11	7.61	92.28
2	0.72	0.13	99.15	1.77	0.23	98.00	1.27	4.99	93.74
3	2.50	0.48	97.01	2.00	0.60	97.40	3.44	7.26	89.30
4	2.20	0.74	97.06	2.25	0.52	97.23	8.49	31.48	60.03
8	2.85	3.03	94.13	2.16	0.86	96.98	12.33	39.26	48.42
12	4.83	3.22	91.95	2.05	0.88	97.07	13.32	41.83	44.85
40	5.47	3.30	91.23	2.01	0.89	97.10	13.66	42.77	43.57
	BQ model			BE model in levels			BE model in levels		
1	0.00	0.80	99.20	0.84	0.06	99.10	3.45	2.00	94.56
2	0.05	0.71	99.24	2.22	0.34	97.44	6.63	2.92	90.45
3	0.05	1.82	98.13	3.48	0.36	96.16	10.60	3.04	86.35
4	0.63	1.93	97.43	3.08	0.33	96.59	11.93	2.50	85.56
8	2.08	7.36	90.56	2.88	0.53	96.59	9.16	7.88	82.95
12	1.89	11.69	86.42	2.80	0.55	96.65	8.45	9.84	81.71
40	1.84	12.88	85.28	2.76	0.55	96.69	8.17	10.57	81.26
	BQ model in levels			Averages			Averages		
1	0.21	0.03	99.77	0.40	0.26	99.34	1.78	4.80	93.42
2	0.58	2.04	97.37	1.07	0.69	98.24	3.95	3.96	92.10
3	0.81	1.71	97.48	1.77	0.99	97.24	7.02	5.15	87.83
4	1.60	2.01	96.39	1.95	1.11	96.94	10.21	16.99	72.80
8	3.75	3.43	92.82	2.75	3.04	94.21	10.75	23.57	65.68
12	3.79	3.99	92.22	3.07	4.07	92.86	10.89	25.83	63.28
40	3.83	4.17	91.99	3.18	4.36	92.46	10.92	26.67	62.41

Note: δ_t^i: differential interest rate of own shocks; δ_t^d: differential demand shock; δ_t^s: differential supply shock; BQ: Blanchard and Quah (1989); BE: Bayoumi and Eichengreen (1994). The figures in this table tell us what percentage of the variance in the differential interest rate is explained by a country's own dynamics, differential AS shocks and differential AS shocks.

Table 5: Variance decomposition of the differential interest rate based on ARDL (four lags) and AIC-based SVAR models

Period	Canada						Mexico		
(quarters)	δ_t^s	δ_t^d	δ_t^i	δ_t^s	δ_t^d	δ_t^i	δ_t^s	δ_t^d	δ_t^i
	BQ model in difference			BE model in difference			BE model in difference		
1	0.06	0.02	99.92	0.32	0.22	99.46	0.57	0.01	99.42
2	0.41	0.55	99.04	1.02	0.40	98.58	3.59	0.22	96.19
3	0.48	0.64	98.88	1.05	0.61	98.33	8.52	13.90	77.58
4	0.90	1.55	97.55	4.50	2.14	93.36	8.33	15.64	76.03
8	1.39	2.12	96.50	5.02	4.15	90.84	8.52	19.74	71.73
12	1.53	2.15	96.32	5.04	4.30	90.66	8.59	19.96	71.45
40	1.55	2.15	96.30	5.04	4.31	90.65	8.60	19.97	71.43
	BQ model			BE model in levels			BE model in levels		
1	0.00	0.02	99.98	0.10	0.09	99.81	1.80	2.34	95.86
2	0.41	0.81	98.78	1.19	0.88	97.93	1.79	2.42	95.79
3	0.44	0.95	98.60	1.46	1.10	97.43	4.68	7.25	88.07
4	1.11	1.91	96.98	2.17	4.78	93.04	5.98	54.70	39.32
8	2.02	2.52	95.46	2.72	6.17	91.11	6.46	54.83	38.71
12	2.06	2.78	95.16	2.72	6.22	91.06	6.55	55.00	38.45
40	2.06	2.79	95.14	2.72	6.22	91.06	6.57	55.00	38.43
	BQ model in levels			Averages			Averages		
1	0.68	0.33	98.99	0.23	0.14	99.63	1.18	1.18	97.64
2	1.32	3.95	94.73	0.87	1.32	97.81	2.69	1.32	95.99
3	1.57	5.71	92.72	1.00	1.80	97.19	6.60	10.57	82.82
4	1.64	5.88	92.48	2.07	3.25	94.68	7.16	35.17	57.68
8	2.40	5.84	91.76	2.71	4.16	93.13	7.49	37.29	55.22
12	2.41	5.85	91.74	2.75	4.26	92.99	7.57	37.48	54.95
40	2.41	5.85	91.74	2.76	4.27	92.98	7.58	37.48	54.93

Note: δ_t^i: differential interest rate of own shocks; δ_t^d: differential demand shock; δ_t^s: differential supply shock; BQ: Blanchard and Quah (1989); BE: Bayoumi and Eichengreen (1994). The figures in this table tell us what percentage of the variance in the differential interest rate is explained by a country's own dynamics, differential AS shocks and differential AS shocks.

Table 6: Variance decomposition of the differential interest rate based on DOLS (four leads, four lags) and *ad hoc* lag-based SVAR models

Period	Canada						Mexico		
(quarters)	δ_t^s	δ_t^d	δ_t^i	δ_t^s	δ_t^d	δ_t^i	δ_t^s	δ_t^d	δ_t^i
	BQ model in levels			BE model in levels			BE model in levels		
1	0.00	0.00	1.00	0.00	0.01	0.99	0.07	0.11	0.81
2	0.00	0.01	0.99	0.00	0.03	0.97	0.08	0.11	0.81
3	0.02	0.01	0.97	0.01	0.03	0.97	0.08	0.12	0.80
4	0.02	0.01	0.97	0.01	0.03	0.96	0.09	0.13	0.78
8	0.06	0.02	0.92	0.02	0.08	0.90	0.09	0.18	0.73
12	0.07	0.04	0.89	0.04	0.13	0.83	0.09	0.18	0.73
40	0.08	0.06	0.86	0.11	0.18	0.71	0.08	0.32	0.60
	BQ model in difference			BE model in difference			BE model in difference		
1	0.01	0.00	0.99	0.01	0.00	0.98	0.01	0.02	0.98
2	0.01	0.01	0.99	0.01	0.01	0.98	0.02	0.03	0.96
3	0.02	0.01	0.98	0.02	0.01	0.97	0.03	0.03	0.95
4	0.02	0.02	0.96	0.02	0.01	0.97	0.04	0.02	0.94
8	0.03	0.09	0.89	0.04	0.01	0.95	0.04	0.06	0.90
12	0.03	0.10	0.87	0.04	0.01	0.95	0.04	0.09	0.87
40	0.03	0.10	0.87	0.04	0.01	0.95	0.04	0.16	0.80
	BQ model			Averages			Averages		
1	0.01	0.00	0.99	0.00	0.00	0.99	0.04	0.07	0.90
2	0.00	0.00	1.00	0.00	0.01	0.98	0.05	0.07	0.88
3	0.02	0.00	0.97	0.02	0.01	0.97	0.05	0.07	0.87
4	0.02	0.00	0.97	0.02	0.01	0.97	0.06	0.08	0.86
8	0.05	0.00	0.95	0.04	0.04	0.92	0.07	0.12	0.82
12	0.06	0.00	0.94	0.05	0.06	0.90	0.06	0.14	0.80
40	0.06	0.00	0.94	0.06	0.07	0.87	0.06	0.24	0.70

Note: δ_t^i: differential interest rate of own shocks; δ_t^d: differential demand shock; δ_t^s: differential supply shock; BQ: Blanchard and Quah (1989); BE: Bayoumi and Eichengreen (1994). The figures in this table tell us what percentage of the variance in the differential interest rate is explained by a country's own dynamics, differential AS shocks and differential AS shocks.

Table 7: Variance decomposition of the differential interest rate based on ARDL (four lags) and *ad hoc* lag-based SVAR models

Period	Canada						Mexico		
(quarters)	δ_t^s	δ_t^d	δ_t^i	δ_t^s	δ_t^d	δ_t^i	δ_t^s	δ_t^d	δ_t^i
	BQ model in levels			BE model in levels			BE model in levels		
1	0.01	0.01	0.98	0.02	0.01	0.97	0.05	0.17	0.78
2	0.05	0.01	0.94	0.03	0.01	0.96	0.05	0.17	0.78
3	0.05	0.02	0.92	0.04	0.02	0.94	0.05	0.17	0.78
4	0.05	0.03	0.92	0.04	0.02	0.94	0.05	0.17	0.78
8	0.06	0.03	0.91	0.04	0.02	0.93	0.05	0.17	0.77
12	0.06	0.03	0.91	0.04	0.02	0.93	0.05	0.18	0.77
40	0.06	0.03	0.91	0.05	0.03	0.93	0.05	0.19	0.76
	BQ model in difference			BE model in difference			BE model in difference		
1	0.00	0.01	0.99	0.00	0.05	0.95	0.01	0.02	0.98
2	0.03	0.02	0.95	0.04	0.05	0.91	0.02	0.02	0.96
3	0.03	0.03	0.94	0.04	0.06	0.90	0.03	0.02	0.95
4	0.05	0.03	0.92	0.06	0.06	0.89	0.03	0.02	0.94
8	0.06	0.04	0.90	0.07	0.06	0.88	0.03	0.03	0.94
12	0.06	0.04	0.90	0.07	0.06	0.88	0.03	0.03	0.94
40	0.06	0.04	0.90	0.07	0.06	0.88	0.03	0.03	0.94
	BQ model			Averages			Averages		
1	0.00	0.04	0.96	0.01	0.02	0.97	0.03	0.10	0.88
2	0.05	0.04	0.91	0.04	0.02	0.94	0.03	0.10	0.87
3	0.05	0.04	0.90	0.04	0.03	0.92	0.04	0.10	0.86
4	0.06	0.04	0.89	0.05	0.04	0.91	0.04	0.10	0.86
8	0.07	0.05	0.88	0.06	0.04	0.90	0.04	0.10	0.86
12	0.07	0.05	0.88	0.06	0.04	0.90	0.04	0.10	0.86
40	0.07	0.05	0.88	0.06	0.04	0.90	0.04	0.11	0.85

Note: δ_t^i: differential interest rate of own shocks; δ_t^d: differential demand shock; δ_t^s: differential supply shock; BQ: Blanchard and Quah (1989); BE: Bayoumi and Eichengreen (1994). The figures in this table tell us what percentage of the variance in the differential interest rate is explained by a country's own dynamics, differential AS shocks and differential AS shocks.

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