A simple but flexible and insightful model for empirical research on the feasibility of monetary union between small and large countries

Rosmy Jean Louis
Department of Economics and Finance
Malaspina University-College
900 Fifth Street
Nanaimo, BC, Canada V9R5S5
Rosmy.JeanLouis@viu.ca

Abstract

Following Mundell (1961, 1973a, b), the empirical literature on the feasibility of monetary union between countries has evolved in two directions. One strand has capitalized on the SVAR methodology to analyze the degree of shocks asymmetry while the other has focused on the importance of risk-sharing to determine whether market and federal transfer mechanisms are capable of smoothing consumption. Interestingly, research undertaken under both approaches tends to suggest that monetary union between Canada and the United States is not feasible because shocks are mostly asymmetric and there is little cross-border risk sharing between the two countries, hence the argument for an independent central bank. However, the powerful intuition from the second strand of the literature is that once risk-sharing is taken into consideration, arguments against the feasibility of monetary union collapse if anchored on 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 and or states. In this paper we raise a much more fundamental question and suggest a modified approach to assess the feasibility of monetary union between small and large countries. Since the issue of monetary union between Canada and the United States has become more of a political than an academic debate, we believe a more sensible approach is to ask the research question with a different twist: How good of a job has the Bank of Canada or any central bank done in smoothing shocks through the setting of interest rate? We develop a simple but intuitive model and arrive at a monetary policy reaction function for small open economies that encompasses most of the existing reaction functions in the literature. This model offers additional insights as to how monetary policy is conducted for small open economies.

JEL Codes: E52, E58, F33, F42, F47
Keywords: Monetary policy usefulness, monetary policy reaction function, SVAR, and differential shocks
Introduction

It has been over four decades since Mundell’s (1961) breakthrough has fathered the theory of optimum currency areas (OCA), with further work by McKinnon (1963) on the relative degree of openness of economies and Kenen~(1969) on the relative degree of output diversification to maintain a fixed exchange rate system well noted. Mundell ‘s (1973a,b) contributions on international risk-sharing works 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 found in Mundell’s (1961, 1973a, b) original works: business cycle synchronization /shocks asymmetry and international risk-sharing. It is worth noting that it took more or less three decades for the proper econometric techniques and software to develop before the theory could be fully tested empirically. The contributions of Sims (1980, 1986), Cooley and Leroy (1985), Blanchard and Quah (1989), Galí (1992), Asdrubali, Sørensen, and Yosha (1996), have paved the way for the voluminous empirical literature on the feasibility and intricacies of monetary union currently available. The first strand of the empirical literature focuses on discussions about 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 the assumptions of wage and price rigidities compatible with the Keynesian framework and are estimated using mostly the structural vector autoregression (SVAR) technique. These regroup the contributions of Bayoumi and Eichengreen~(1994), Chamie et al. (1994), Deserres et al. (1994), and Dupasquier et al. (1997) on the prevalence of idiosyncratic shocks across member countries; Eichengreen (1993) and Blanchard and

The second strand of the literature centers mostly around the importance of risk-sharing. In an influential paper, Asdrubali, Sørensen, and Yoshia (1996) (hereafter ASY) developed a simple framework for quantifying the amount of risk shared by regions within a country and/or nations within a monetary union. The novel feature of their approach is that it provides researchers a single framework to identify the various channels of risk sharing, which were often examined in isolation. A number of papers have built upon this contribution to analyze various aspects of economic integration (see Antia et al. 1999; Sørensen and Yoshia 1998; Méltiz and Zumer, 1999, Del Negro, 1998; Crucini, 1999; Athanasoulis and van Wincoop, 1998; Ostergaard et. al. 2002, and Balli et al. 2008, to cite just a few).

Research on the importance of asymmetric shocks for countries contemplating a monetary union is among the most controversial. Consensus is hard to come by as nationalistic sentiments and personal interests often get in the way and the SVAR technique used to extract the shocks is prone to serious criticisms since a same model identified with different restrictions, though based on economic theory, may produce conflicting results. The main weakness underlying the arguments on asymmetric shocks against the feasibility of monetary union is that, within a same country, different regions are indeed subjected to idiosyncratic shocks where some experience economic downturns while others are booming. Yet, a one-size-fits-all independent monetary policy is still being implemented by the central banks, though it has been recognized that such policy is incapable of smoothing shocks uniformly across provinces/states. As understood 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, though partially, the failures of monetary policy to address "asymmetric" shocks. Sala-i-Martin and Sachs (1992) find that monetary policy is not that effective in eliminating asymmetric output shocks among heterogeneous states of the US but the income smoothing provided to the states by the central government through transfers is indeed very essential in making the US the successful "monetary union" it currently is.

What is also powerful from the second strand of the literature is that once risk-sharing is taken into consideration, arguments against the feasibility of monetary union collapse if anchored on 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 bring about fiscal mechanisms into place as is currently the case in well-known economic unions such as Canada, the United States and the EU (not too sure about the EU).

Why is there a need for a different approach in assessing 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 United States there are still regions that are subjected to asymmetric shocks. Although fiscal and market mechanisms do smooth a portion of these shocks, there is still a substantial portion that remains unsmoothed, between 14 and 37 percent for Canada
according to Antia et al. (1999) and Mélitz and Zummer (1998) respectively, and 25 percent for the United States as per Asdrubali et al. (1996). There are still “have” and “have not” provinces/states. Therefore, for two independent countries contemplating the prospect of a monetary union, feasibility of monetary union shall not only contemplate 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 that turns out to be greater will surely indicate the path to take.\(^1\) 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 but it is also a more difficult and time consuming endeavor since it also requires counterfactual experiments to be conducted. In this paper, we do not take this road but we instead raise a much more fundamental question and suggest a modified approach to assess the feasibility of monetary union between small and large countries. Since the issue of monetary union between Canada and the United States has become more of a political than an academic debate, we believe a more sensible approach is to ask the research question with a different twist in relation to this matter: How good of a job has the Bank of Canada done in smoothing shocks through the setting of interest rate? To this end, we develop a simple but intuitive model and arrive at a monetary policy reaction function for small open economies that encompasses most of the existing reaction functions in the literature. This model offers additional insights as to how monetary policy is conducted for small open economies.

\(^1\) Antia et al. (1999) have leaned towards this direction but did not get to the point to measure the net benefit of independent monetary policy nor to factor in the possibility of welfare improvement via the smoothing channels if Canada and the United States were to enter a monetary union. Although Balli et al. (2009) is a more in-depth study on the channels of risk-sharing among Canadian provinces, the authors’ objectives were not to assess the feasibility of monetary
We use what can be termed a two-stage VAR approach at the empirical level to show how the model can be estimated and to shed light on the usefulness of monetary policy in smoothing shocks. In the first stage, bivariate SVAR models similar to both Blanchard and Quah (1989) and Bayoumi and Eichengreen (1994) are estimated to extract the structural aggregate demand (AD) and supply (AS) shocks for Canada, Mexico, and the United States. The differential of those shocks are calculated for each pair Canada-US and Mexico-US. In the second stage, unrestricted VARs with differential real interest rate, 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 these shocks. Using quarterly data from OECD Economic Outlook and the International Financial Statistics (IFS) for the period 1970 – 2008, we find that on average less than 7 and percent of the variance in differential interest rate can be explained by differential AS and AD shocks combined for Canada and less than 3.5 percent 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 mainly 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 briefly explains the methodology and the data. Section 4 discusses the empirical results. Finally, Section 5 concludes the paper.
Section 2  A Simple Model of Monetary Policy Effectiveness

This section presents a simple model to assess the effectiveness of monetary policy. We assume that there are only two countries in the world: Home and Foreign. Each country is endowed with a central bank that claims to conduct monetary policy independently. 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:

\[
\begin{align*}
    i_t &= a + b + c \\
    i_t^* &= a + b + d
\end{align*}
\]

\( a \) and \( b \) are either AD and AS shocks or just AD or AS shocks decomposed into two subcategories of shocks and \( c \) and \( d \) are actual or expected magnitude of these shocks in each country. The time scripts are dropped out for the shocks for simplicity of exposition. AD shocks could be decomposed into two shocks real or nominal or a combination of the two. Similar reasoning holds for the AS shocks, say labor unrests and technological glitches.

However, this distinction does not matter that much at this point in time. Equations (1) and (2) simply states 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. Clearly, \( c \) can be greater than, equal, or less than \( d \). If \( c = d \) over time, then \( i_t = i_t^* \), a common currency is not an issue for the two countries. However, the bottleneck is if \( c \neq d \). 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 it is not, there are benefits that would accrue to countries under a monetary union to offset their potential costs. This whole discussion suggests that it

\[\text{We use asterisk for the foreign country's variables.}\]
is not the level of interest rate that should matter when assessing the feasibility of monetary union but rather the differential.

Solving for \((a + b)\) in (2) and substitute in (1) we obtain:

\[
\ell_e = \ell_e^* + (c - d)
\]  

(3)

Setting \((c - d) = e\), for the small open economy, the overall picture can be represented by the following:

Imperfect capital mobility equation:

\[
i_t = i_t^* + e_t
\]  

(4)

Equation (4) is a monetary policy reaction function that shows interest rate from the domestic economy is imported from the foreign country with adjustment 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 same, higher or lower than the foreign interest rate depending on the relative strength of the shocks that hit or 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 so internationally. This line of reasoning is in line with the small-large country hypothesis of Mundell (1961). We are not aware of whether previous authors have come up with such a simplistic but intuitively powerful specification of the monetary policy setting for a country. It turns out the picture portrayed here is also valid for all G7 countries but Japan (See Jean Louis, 2009). The appeal of this specification is that it accounts for the possibility of mistakes by central bankers to step too hard on the break to counter shocks. In a more dynamic setup, the error term, \(e_t\), can also be interpreted as expected differential disturbances. The domestic
interest rate does not have to be contemporaneously correlated with the foreign interest rate either. It all depends on which central banker makes the announcement first. If the foreign (large) country moves first, then \( i_t = i_{t-1}^e + \epsilon_t \) in the opposite case; \( i_t = i_{t+1}^e + \epsilon_t \)

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

\[
i_t = r_t + \pi_{t+1} + \omega_t
\]

\[
i_t^* = r_t^* + \pi_{t+1}^* + \omega_t^*
\]

In the limiting case that the sensitivity of investment to real interest rate is the same across countries of relatively the same degree of economic development and also for convenience, the IS equations for both domestic and foreign countries are given by equations (5) and (6), respectively:

\[
Y_t = A - br_t + \epsilon^d_t
\]

\[
Y_t^* = A^* - br_t^* + \epsilon^d_t^*
\]

Aggregate supply equations are given by:

\[
\hat{\pi}_t = d\hat{u}_t + \epsilon^s_t
\]

\[
\hat{\pi}_t^* = d\hat{u}_t^* + \epsilon^s_t^*
\]

Where \( \hat{\pi}_t \) is the deviation of the anticipated rate of inflation from its target \( (\pi_t - \pi) \), \( \hat{\mu}_t \) is the wedge between natural and the actual rate of unemployment \( (u_n - u_t) \), and \( d \) is the sacrifice ratio or the term that captures the tradeoff between inflation and unemployment and we assume that it is identical for both foreign and domestic countries to simplify the math. As
will become clear later, the sacrifice ratio needs not be similar across countries. The typical supply equation is \((\pi_t - \pi^*) = -d(u_t - u_n)\).

Solving for \(e_t\) in (4), assuming expected rate of inflation is actual inflation, and substituting (5) and (6) in, we obtain:

\[
e_t = i_t - i_t^* = (r_t - r_t^*) + (\pi_t - \pi_t^*) + (\omega_t - \omega_t^*)
\]

(11)

Since \(\hat{\pi}_t = \pi_t - \pi^*\) and \(\hat{\pi}_t^* = \pi_t^* - \pi^*\), we solve for the difference between

\[
(\pi_t - \pi_t^*) = (\hat{\pi}_t - \hat{\pi}_t^*) + (\pi^* - \pi) = d(\hat{u}_t - \hat{u}_t^*) + (e_t - e_t^*) + (\pi^* - \pi)
\]

(12)

Solving for the real interest rates in (7) and (8) and taking the differential, we obtain

\[
(r_t - r_t^*) = (A - A^*) - (Y_t - Y_t^*) + (\rho_t - \rho_t^*)
\]

(13)

Substituting (13) and (12) into (11) we obtain

\[
e_t = (i_t - i_t^*) = (A_t - A_t^*) + (Y_t - Y_t^*) + (\rho_t - \rho_t^*) + (\alpha_t - \alpha_t^*) + (\pi_t - \pi_t^*) + (\pi^* - \pi) = W_t
\]

(14)

Where

\[
W_t = (A_t - A_t^*) + (Y_t - Y_t^*) + d(\pi_t - \pi_t^*)
\]

By looking at (14), it becomes evident that had we assumed different sacrifice ratio, we would have had different coefficients for the deviation of unemployment rate to its natural level across countries. Equation (14) clearly 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 monetary policy’s objective is to solely to combat inflation may be misleading or incomplete because there are much more variables that enter the monetary policy reaction function than what the central bank conveys to the general public. There is a wide range of policy reaction functions encompassed in (14), ranging from Taylor (1993), Fuhrer and Moore (1995), to the various implied in structural vector autoregression (SVAR) and in VAR models such as Artis and Ehrmann (2006), Lalonde and St-Amant (1994), Dupasquier et al. (1997), Kuszczak and Murray (1987), Chamie et al.
(1994), DeSerres and Lalonde (1994), Cushman and Zha (1997), 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 a linear combinations of 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 and Artis and Ehrmann have come close to the intuition of Equation (14) but fell short of grasping 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 foreign and domestic shocks. Recent papers by Del Negro and Obiols-Homs (2001), Bhuiyan (2008), Klyuev (2008), Swiston and Bayoumi (2008) all suffer from the same flaws. We cannot assess the effectiveness of monetary policy in smoothing shocks with their models in our determination of whether a country should keep its central bank or not.

Equation (14) is flexible in that any sets of variables that might be of interest to researchers can be incorporated in the equation system by further decomposing the shocks. Moreover, with the insights 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, interesting dynamics that can come to light with the solution of a quadratic loss function. However, we are not sure how much of a difference it can make empirically.

The strong message our model sends across is that differential interest rate matters not only for speculative purposes but also for altering the path of the economy. Since we are living in
globalized world, small open economies do pay close attention to what the larger economies are doing much more so than being publicized and more frequently than being assumed.

Section 3 Methodology and Data

Estimating Equation (14) empirically may posit quite a number of challenges. The structural shocks 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 what measures of differential interest rate should be used, the estimated residuals of the regression of domestic interest rate on foreign interest rate or the simple arithmetic difference. There are a number of complications here too. Nominal interest rates and inflation rates may be $I(1)$ or $I(0)$, hence the real interest rate differential. Moreover, though estimates of the simple OLS regression are consistent, the estimated standard errors from that regression are not normally distributed even in large samples. Since there is no one-step approach available to arrive at the shocks and examine their linkages with the differential interest rate, we therefore need a more eclectic approach. It is worth emphasizing that there are a number of shortcuts that will not work for the research question at hand. Arguably, one might estimate a VAR with differential interest rate as one of the variables or two separate VARs with the short-term interest rate of each country in their respective VARs and compute the differential shocks. Well, in the former case, the policy reaction function would be one where differential interest rate responds to the total shocks not the magnitude $c$ or $d$ contemplated in Equations (1) and (2) above. In the latter, we would end up with the differential of monetary policy shocks as a function of the differential AD and AS shocks, which surely contradict the dynamic of policy setting in our model. In light of all the controversies that may arise, we therefore suggest the following steps:
1) Obtain the residuals \( \hat{\varepsilon}_t \) as the monetary policy shock variable using Stock and Watson (1993) dynamic OLS (DOLS) estimator. This involves estimation of the form

\[
i_t = \delta_0 + \delta_1 \varepsilon^*_t + \sum_{j=p}^{p} \lambda_j \Delta \varepsilon^*_t + e_t
\]

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.

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 a la Blanchard and Quah (1989) and/or a la Bayoumi and Eichengreen (1994) (hereafter, BQ and BE, respectively) to obtain \((\varepsilon^d_t)\) and \((\varepsilon^s_t)\) for each country, hence the differentials of these variables.

3) Regress \( \hat{\varepsilon}_t \) on the differential shocks across countries or use a VAR with these variables to obtain the variance decomposition.

\[
\hat{\varepsilon}_t = \beta_0 + \beta_1 (\varepsilon^d_t - \varepsilon^d_t^*) + \beta_2 (\varepsilon^s_t - \varepsilon^s_t^*) + \nu_t
\]

There are a number of approaches that can be taken in Step 3 whether it is partial autocorrelation or a smoothing technique or a variance analysis or any other suitable methods, we shall arrive at the portion of these shocks that are smoothed and the portion that remains unsmoothed in the vein of Asdrubali, Sorensen, and Yosha (1996). Using Ordinary Least Squares, for example, the coefficient estimate of each differential variable will tell us about the response of monetary authorities holding other variables’ influences constant. The sign of the coefficient will shed light on the direction of monetary policy and the t-statistics will inform as to whether the response is significant or not. If demand shocks that affect the
small economy are stronger than those of the large country, then the differential AD shock will be positive. We shall 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-US and Mexico-US. At this stage, we only experiment with the differential interest rate as the arithmetic difference. The quarterly data on unemployment rate, output, prices, short-term interest rates for Canada and the US were taken from OECD Economic Outlook. Output and prices data for Mexico were also taken from the same sources but data on short-term interest rate were downloaded from the International Financial Statistics (IFS) Database. Data on unemployment rate are not available for Mexico. As a result, the SVAR models a la BQ could not be estimated for Mexico. The data span the period 1970:1 – 2008:4. Since the interest rate data for Mexico starts in 1978q1, all the SVAR models a la BE (1994) were estimated over a shorter sample period to facilitate comparisons.

The data were tested for unit roots using ADF, PP, and DF-GLS tests. We rely on the DF-GLS test results since it is a more robust test. The estimations were performed with a trend and a constant and all the variables but the US short-term interest rate were found to be integrated of order 1, suggesting VAR in differences to be the appropriate formulation. We report in Table 1 the unit root results.

Although the BE model accords with the unit root outcomes, the original BQ models was estimated with the first difference of log GNP and the level of unemployment rate since BQ had found the latter to be stationary. Hamilton (1994, Ch. 20, pages 651-656) offers the following prescriptions in estimating VARs:
One option is to ignore the nonstationarity altogether and simply estimate the VAR in levels, relying on standard t and F distributions for testing any hypotheses. This strategy has the following features to recommend it. (1) The parameters that describe the system’s dynamics are estimated consistently. (2) Even if the true model is a VAR in differences, certain functions of the parameters and hypothesis tests based on a VAR in levels have the same asymptotic distribution as would estimates based on differenced data. (3) A Bayesian motivation can be given for the usual t or F distributions for test statistics even when the classical asymptotic theory for these statistics is nonstandard.

We therefore follow a strategy that keeps us on the safe side of the road. We estimate three versions of the BQ-type SVAR models for Canada and the US: one in difference in line with the unit root tests, one similar to the original BQ model, and one in level. For the BE-type SVAR models, we estimate two versions one in difference and the other in level for all three countries since there is not much controversy there. Each bivariate SVAR model is identified with the restrictions that AD shocks have no permanent effects on output in the long-run.

Since the SVAR technique has become standard in the literature, there is no need to regurgitate its exposition here. The interested reader may consult any advanced time series econometrics textbook such as Enders (2004) or Hamilton (1994). Nonetheless, we present here the infinite moving average representation with the long-run restriction imposed for the BE-type model:

\[
\begin{bmatrix}
\Delta y_t \\
\Delta p_t
\end{bmatrix} = \sum_{i=0}^{\infty} L^i
\begin{bmatrix}
0 & \alpha_{12,i} \\
\alpha_{21,i} & \alpha_{22,i}
\end{bmatrix}
\begin{bmatrix}
\varepsilon_t^d \\
\varepsilon_t^s
\end{bmatrix}
\]

(15)

For the BQ-type model, we only need to replace the second variable with the unemployment rate in level 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 anticipate output and prices to move in the same direction in response to a demand shock and in opposite direction to a supply shock for the BE-type models. We 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 surely increase due to a positive
supply shock and stabilize somewhere above the baseline to reflect the permanent effect of the supply disturbance but the response of unemployment may vary over time. In the short-run, unemployment may rise or fall but should eventually return to the natural rate in the long-run. We further analyze the variance decomposition of the unrestricted VAR in Step 3 above with differential interest rate, differential AD and AS shocks and shed lights on the usefulness of keeping a differential interest rate with the US in the case of Canada and Mexico.

Section 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 NAFTA member 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 VARs a la BQ were estimated with 8 lags and those a la BE were estimated with 5 and 4 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 impulse responses for each country are shown in Figures 1 to 12. The VARs estimated in levels clearly deliver predictions that are closer to the theoretical underpinnings of the AD-AS model and superior to VARs estimated in difference or quasi-difference. For examples, we find that the VAR in levels a la BQ for Canada (Figure 1) displays a positive response of output to both demand and supply shocks whereas the unemployment rate declines to remain
negative for quite some time before getting closer to the baseline. The permanent effect of supply disturbances on output is observed while demand disturbances display a humped shaped pattern in line with the long-run identification restriction imposed. This picture perfect is an exception to the rule, none of the remaining VARs estimated produces similar response patterns. The results are not sensitive to the lag length adopted, which were actually quite large in most cases. Therefore we can conclude that the data do not unveil the dynamics of the economies as was expected in theory.

**Figures 1 to 12 about here**

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. We take that same path here only to make a point. Table 2 provides conflicting results into the feasibility of monetary union between the NAFTA member countries. The BQ model in level for the pair Canada-US 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 weaker cross correlation of the shocks for the pair Mexico-US (0.16 and 0.14). The BQ model in difference and in quasi difference for Canada and the BE model in level for Mexico produce correlations that are negligible ranging from -0.002 to 0.04. Despite the 14 years of data extra we are endowed with, our results surprisingly do not fall too far apart from BE (1994) who found a correlation of supply disturbances of -0.47 for Canada-US and -0.59 Mexico-US. Their correlation of demand disturbances is 0.30 for Canada-US and -0.12 for Mexico. If anything these results suggest is that little or nothing has changed for Canada-US.
economic integration but Mexico-US’s has improved considerably over time. This is of course a notable spillover benefit of the signing of NAFTA.

The point that we also want to make here is that the correlations of shocks between Canada-US and Mexico-US inform us about the magnitude of shocks that central bankers must handle with keeping a differential with the US interest rate. In few words, 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, therefore \(c\) and \(d\) are large and this explains why each country needs their own monetary policy. Let us take this line of reasoning one step further. If it is true that \(c\) and \(d\) is large, then we shall 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 percent of the variability in differential interest rate or less for Canada and less than 3.5 percent for Mexico. Table 3 shows the results. Regardless of the model considered, at no point has any of the differential shocks explained 10 percent of the differential interest rate. Theoretically, there is not much of a response of differential interest rate to expect from differential AS shocks because demand management policies are mostly ineffective in addressing supply shocks.\(^3\) The same goes for the variance decomposition. In 5 of the 6 models estimated for Canada, the percentage of the variability in interest rate accounted for by differential AD shocks is greater than that of the differential AS shocks. We find the opposite pattern in the 3 models estimated for Mexico.

In short, the lack of symmetry of shocks may dictate that monetary union is not feasible across NAFTA members but this does not necessarily mean that central banks in the two small economies have done a great job insulating their economies from shocks by keeping a

\(^3\) 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. The same applies for a positive supply shock.
differential with the US interest rate. Recent financial meltdown in the US that has brought the world to its knees is a good example of how impotent monetary policy can be in time of distress. 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 effect of monetary policy on the real sector unless the US has come out of the crisis. It could still be argued that the regulatory framework in Canada has helped a great deal from avoiding a catastrophe; the same could be said for some states in the US. What this paper has shown is that there is no good excuse for Canada even less so for Mexico to refute monetary union with the US. Usefulness of independent monetary policy due to shocks asymmetry, nationalistic sentiments, presumed cultural differences just do not add up as valid arguments. At the political forefront, it may not be in the interest of the United States to form a monetary union with Canada since Canada has been fulfilling the role of a soft hand for the US in international conflicts. The US may not want to openly blow this cover by showing a higher level of economic integration with Canada. If monetary union were to take place between Canada-US and Mexico-US, it would be important both Canada and Mexico to at least make sure they put in place structures 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 agreements that exists between states and provinces. A monetary union between Canada and the US would function at least in the same way Ontario and Prince Edward Island are in a monetary union. It is well known that PEI and Ontario are subject to asymmetric shocks and monetary policy conducted by the Bank of Canada cannot alleviate both provinces concurrently. Federal transfer, capital and credit markets mechanisms though in place still leave a sizable portion of the shocks unsmoothed.
There are two shortcomings to the paper but none stems from the insights of the theoretical model. Empirically, we use the differential real interest rate as the arithmetic difference as opposed to estimate the policy shock as per Step 1 above. We do not know how much it would have changed the results of the variance decomposition. In the extreme, perhaps, we might have found a greater importance of differential interest rate to shocks smoothing that would take the analysis in a different direction. Therefore one must be cautious in generalizing the empirical findings of this paper at this point. We definitely plan to explore further with the estimated differential interest rate to document any changes to the results. Also, we do not know whether higher order VARs could produce results that differ substantially from the bivariate VARs. There are definitely a number of venues to explore with this simple but flexible theoretical model of this paper.

Section 5 Conclusion

Our objective in this paper was to provide a simple but flexible and insightful model to empirically assess the feasibility of monetary union between small and large countries. This model offers a fresh and an innovative way of determining the feasibility of monetary union by shifting the burden to the central banks that so often get credits for their effectiveness in smoothing asymmetric shocks. We establish that differential interest rate across countries is a reflection of the size and magnitude of shocks that central bankers expect to accommodate and therefore a large portion of this differential interest rate variability should be explained by the differential shocks across countries. We use Canada, Mexico, and the United States as our springboard to illustrate how this model can be implemented in practice. Our preliminary results show that on average less than 7 percent of the variance in differential real interest rate can be explained by differential AD and AS shocks combined for Canada. These figures are less than 3.5 percent for Mexico. We therefore conclude that effectiveness of monetary
policy in smoothing shocks in Canada and in Mexico cannot serve as an excuse to refute a North American monetary union. Since these results are preliminary, care must be exercised in quoting these findings. Our objective in the near future is to address the caveats related to the measure of the differential interest rate.
Reference List


---

4 Sorry! This reference list is grossly incomplete. Since we are on a rush to upload this paper to the CEA website, we will have a reference list later that is harmonized with the works cited in the core of this paper.


### Table 1  Unit Root Tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF</th>
<th>PP</th>
<th>DF-GLS</th>
<th>DF-GLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With Intercept only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Canada</td>
<td>-2.82</td>
<td>-2.52</td>
<td>-1.62</td>
<td>-1.43</td>
</tr>
<tr>
<td>Output Mexico</td>
<td>-2.57</td>
<td>-2.31</td>
<td>-1.10</td>
<td>1.68**</td>
</tr>
<tr>
<td>Output US</td>
<td>-2.70</td>
<td>-2.87</td>
<td>-2.76</td>
<td>2.20**</td>
</tr>
<tr>
<td>CPI Canada</td>
<td>-2.40</td>
<td>-0.60</td>
<td>-1.30</td>
<td>-0.37</td>
</tr>
<tr>
<td>CPI Mexico</td>
<td>-0.67</td>
<td>-0.16</td>
<td>-1.10</td>
<td>0.57</td>
</tr>
<tr>
<td>CPI US</td>
<td>-1.67</td>
<td>-1.04</td>
<td>-0.81</td>
<td>0.11</td>
</tr>
<tr>
<td>Unemployment Rate Canada</td>
<td>-1.94</td>
<td>-1.89</td>
<td>-1.56</td>
<td>-1.30</td>
</tr>
<tr>
<td>Unemployment Rate US</td>
<td>-3.49**</td>
<td>-3.11</td>
<td>-2.64</td>
<td>-2.06**</td>
</tr>
<tr>
<td>short-term rate Canada</td>
<td>-2.88</td>
<td>-2.48</td>
<td>-2.65</td>
<td>-2.04**</td>
</tr>
<tr>
<td>short-term rate Mexico</td>
<td>-2.81</td>
<td>-2.70</td>
<td>-2.02</td>
<td>-1.82***</td>
</tr>
<tr>
<td>short-term rate US</td>
<td>-3.84**</td>
<td>-2.83</td>
<td>-3.64</td>
<td>-1.42</td>
</tr>
<tr>
<td>Real –rate Canada</td>
<td>-2.63</td>
<td>-2.72</td>
<td>-2.53</td>
<td>-2.17**</td>
</tr>
<tr>
<td>Real –rate Mexico</td>
<td>-2.77</td>
<td>-2.60</td>
<td>-1.36</td>
<td>-1.22</td>
</tr>
<tr>
<td>Real-rate US</td>
<td>-2.32</td>
<td>-2.82</td>
<td>-2.24</td>
<td>-1.53</td>
</tr>
</tbody>
</table>

The critical values at 1, 5, and 10 percent are respectively -4.02, -3.44, and -3.14 for the ADF and the PP tests, and -3.52, -2.98, and -2.70 for the DF-GLS test. The unit root tests were performed with trend and intercept as exogenous variables. With just an intercept, the DF-GLS critical values are -2.58, -1.94, and -1.62.

### Table 2  Correlation of Supply and Demand Shocks with the United States

<table>
<thead>
<tr>
<th>Correlation of</th>
<th>Demand Shocks</th>
<th>Supply Shocks</th>
<th>Demand Shock</th>
<th>Supply Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Canada</td>
<td>Mexico</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BQ Model in Level</td>
<td>-0.47</td>
<td>-0.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BQ Model in Difference</td>
<td>-0.002</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BQ Model as per BQ(1989)</td>
<td>-0.04</td>
<td>-0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE Model in Level</td>
<td>0.34</td>
<td>0.32</td>
<td>-0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>BE Model in Difference</td>
<td>0.30</td>
<td>0.38</td>
<td>0.16</td>
<td>0.14</td>
</tr>
</tbody>
</table>
### Table 3

**VARIANCE DECOMPOSITION OF DIFFERENTIAL REAL INTEREST RATE:**

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>Rate Shock</th>
<th>AD Shock</th>
<th>AS Shock</th>
<th>S.E.</th>
<th>Rate Shock</th>
<th>AD Shock</th>
<th>AS Shock</th>
<th>S.E.</th>
<th>Rate Shock</th>
<th>AD Shock</th>
<th>AS Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>BQ Model in Difference</strong></td>
<td><strong>BE Model in Difference</strong></td>
<td><strong>BQ Model as in BQ(1989)</strong></td>
<td><strong>BE Model in Level</strong></td>
<td><strong>BE Model in Difference</strong></td>
<td><strong>BQ Model in Level</strong></td>
<td><strong>BE Model in Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.03</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.89</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
<td>7.33</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>1.29</td>
<td>98.68</td>
<td>1.08</td>
<td>0.24</td>
<td>1.11</td>
<td>97.15</td>
<td>2.83</td>
<td>0.01</td>
<td>10.19</td>
<td>99.76</td>
<td>0.16</td>
<td>0.08</td>
</tr>
<tr>
<td>3</td>
<td>1.38</td>
<td>98.53</td>
<td>0.96</td>
<td>0.51</td>
<td>1.19</td>
<td>92.08</td>
<td>3.84</td>
<td>4.08</td>
<td>11.26</td>
<td>99.10</td>
<td>0.15</td>
<td>0.75</td>
</tr>
<tr>
<td>4</td>
<td>1.46</td>
<td>97.60</td>
<td>1.35</td>
<td>1.06</td>
<td>1.31</td>
<td>86.01</td>
<td>5.42</td>
<td>8.57</td>
<td>12.43</td>
<td>98.35</td>
<td>0.26</td>
<td>1.40</td>
</tr>
<tr>
<td>8</td>
<td>1.64</td>
<td>97.81</td>
<td>1.23</td>
<td>0.96</td>
<td>1.55</td>
<td>85.08</td>
<td>6.46</td>
<td>8.47</td>
<td>15.11</td>
<td>97.94</td>
<td>0.64</td>
<td>1.42</td>
</tr>
<tr>
<td>12</td>
<td>1.71</td>
<td>97.94</td>
<td>1.16</td>
<td>0.90</td>
<td>1.64</td>
<td>84.80</td>
<td>6.60</td>
<td>8.60</td>
<td>16.69</td>
<td>97.97</td>
<td>0.66</td>
<td>1.37</td>
</tr>
<tr>
<td>40</td>
<td>1.76</td>
<td>98.03</td>
<td>1.10</td>
<td>0.87</td>
<td>1.69</td>
<td>84.75</td>
<td>6.67</td>
<td>8.59</td>
<td>19.61</td>
<td>98.02</td>
<td>0.64</td>
<td>1.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>BQ Model as in BQ(1989)</strong></td>
<td><strong>BE Model in Level</strong></td>
<td><strong>BE Model as in BQ(1989)</strong></td>
<td><strong>BE Model in Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.03</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.93</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
<td>7.16</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>1.29</td>
<td>98.68</td>
<td>0.89</td>
<td>0.43</td>
<td>1.17</td>
<td>98.96</td>
<td>0.94</td>
<td>0.10</td>
<td>10.05</td>
<td>99.98</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>3</td>
<td>1.38</td>
<td>98.36</td>
<td>0.78</td>
<td>0.86</td>
<td>1.25</td>
<td>97.51</td>
<td>1.27</td>
<td>1.22</td>
<td>11.27</td>
<td>97.81</td>
<td>0.55</td>
<td>1.64</td>
</tr>
<tr>
<td>4</td>
<td>1.46</td>
<td>97.29</td>
<td>1.50</td>
<td>1.21</td>
<td>1.34</td>
<td>95.28</td>
<td>2.62</td>
<td>2.10</td>
<td>12.51</td>
<td>96.57</td>
<td>0.60</td>
<td>2.82</td>
</tr>
<tr>
<td>8</td>
<td>1.64</td>
<td>97.48</td>
<td>1.36</td>
<td>1.16</td>
<td>1.57</td>
<td>93.80</td>
<td>3.57</td>
<td>2.63</td>
<td>15.76</td>
<td>96.21</td>
<td>0.54</td>
<td>3.25</td>
</tr>
<tr>
<td>12</td>
<td>1.71</td>
<td>97.60</td>
<td>1.30</td>
<td>1.10</td>
<td>1.64</td>
<td>93.55</td>
<td>3.70</td>
<td>2.74</td>
<td>17.44</td>
<td>96.05</td>
<td>0.50</td>
<td>3.45</td>
</tr>
<tr>
<td>40</td>
<td>1.76</td>
<td>97.69</td>
<td>1.24</td>
<td>1.08</td>
<td>1.69</td>
<td>93.38</td>
<td>3.79</td>
<td>2.83</td>
<td>19.87</td>
<td>95.85</td>
<td>0.46</td>
<td>3.69</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>Rate Shock</th>
<th>AD Shock</th>
<th>AS Shock</th>
<th>S.E.</th>
<th>Rate Shock</th>
<th>AD Shock</th>
<th>AS Shock</th>
<th>AVERAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.02</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.98</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
<td>7.25</td>
</tr>
<tr>
<td>2</td>
<td>1.29</td>
<td>98.84</td>
<td>1.16</td>
<td>0.00</td>
<td>1.23</td>
<td>98.46</td>
<td>1.38</td>
<td>0.16</td>
<td>10.12</td>
</tr>
<tr>
<td>3</td>
<td>1.39</td>
<td>97.17</td>
<td>2.57</td>
<td>0.26</td>
<td>1.32</td>
<td>96.73</td>
<td>1.88</td>
<td>1.39</td>
<td>11.27</td>
</tr>
<tr>
<td>4</td>
<td>1.46</td>
<td>96.22</td>
<td>2.85</td>
<td>0.93</td>
<td>1.41</td>
<td>94.48</td>
<td>2.75</td>
<td>2.77</td>
<td>12.47</td>
</tr>
<tr>
<td>8</td>
<td>1.65</td>
<td>95.22</td>
<td>4.01</td>
<td>0.78</td>
<td>1.61</td>
<td>93.88</td>
<td>3.33</td>
<td>2.80</td>
<td>15.44</td>
</tr>
<tr>
<td>12</td>
<td>1.71</td>
<td>95.06</td>
<td>4.18</td>
<td>0.76</td>
<td>1.68</td>
<td>93.79</td>
<td>3.39</td>
<td>2.82</td>
<td>17.07</td>
</tr>
<tr>
<td>40</td>
<td>1.76</td>
<td>94.96</td>
<td>4.30</td>
<td>0.75</td>
<td>1.73</td>
<td>93.76</td>
<td>3.42</td>
<td>2.82</td>
<td>19.74</td>
</tr>
</tbody>
</table>

**AVERAGES:**

<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>Rate Shock</th>
<th>AD Shock</th>
<th>AS Shock</th>
<th>AVERAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.02</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
<td>7.25</td>
</tr>
<tr>
<td>2</td>
<td>1.29</td>
<td>98.84</td>
<td>1.16</td>
<td>0.00</td>
<td>10.12</td>
</tr>
<tr>
<td>3</td>
<td>1.39</td>
<td>97.17</td>
<td>2.57</td>
<td>0.26</td>
<td>11.27</td>
</tr>
<tr>
<td>4</td>
<td>1.46</td>
<td>96.22</td>
<td>2.85</td>
<td>0.93</td>
<td>12.47</td>
</tr>
<tr>
<td>8</td>
<td>1.65</td>
<td>95.22</td>
<td>4.01</td>
<td>0.78</td>
<td>15.44</td>
</tr>
<tr>
<td>12</td>
<td>1.71</td>
<td>95.06</td>
<td>4.18</td>
<td>0.76</td>
<td>17.07</td>
</tr>
<tr>
<td>40</td>
<td>1.76</td>
<td>94.96</td>
<td>4.30</td>
<td>0.75</td>
<td>19.74</td>
</tr>
</tbody>
</table>
Figure 1  Impulse Responses for Canada based on the BQ Model in Level

Response to Structural One S.D. Innovations

Response of LYCAN to Shock1

Response of LYCAN to Shock2

Response of UT_RATE_CAN to Shock1

Response of UT_RATE_CAN to Shock2
Figure 2  Impulse Responses for the US based on the BQ Model in Level

Response to Structural One S.D. Innovations

Response of LYUS to Shock1

Response of LYUS to Shock2

Response of UT_RATE_US to Shock1

Response of UT_RATE_US to Shock2
Figure 3  Impulse Responses for Canada based on the BQ Model in Quasi-Difference

Response to Structural One S.D. Innovations

Response of DLYCAN to Shock1

Response of DLYCAN to Shock2

Response of UT_RATE_CAN to Shock1

Response of UT_RATE_CAN to Shock2

31
Figure 4  Impulse Responses for the US based on the BQ Model in Quasi-Difference

Response to Structural One S.D. Innovations

Response of DLYUS to Shock1

Response of DLYUS to Shock2

Response of UT_RATE_US to Shock1

Response of UT_RATE_US to Shock2
Figure 5  Impulse Responses for Canada based on the BQ Model in Difference

Response to Structural One S.D. Innovations

- Response of DLYCAN to Shock1
- Response of DLYCAN to Shock2
- Response of D_UR_CAN to Shock1
- Response of D_UR_CAN to Shock2

[Graphs showing impulse responses over time]
Figure 6  Impulse Responses for the US based on the BQ Model in Difference

Response to Structural One S.D. Innovations

Response of DLYUS to Shock1

Response of DLYUS to Shock2

Response of D_UR_US to Shock1

Response of D_UR_US to Shock2
Response to Structural One S.D. Innovations

Response of LYCAN to Shock1

Response of LYCAN to Shock2

Response of LCPI_CAN to Shock1

Response of LCPI_CAN to Shock2
Figure 8  Impulse Responses for the US based on the BE Model in Level

Response to Structural One S.D. Innovations

Response of LYUS to Shock1

Response of LYUS to Shock2

Response of LCPI_US to Shock1

Response of LCPI_US to Shock2
Figure 9  Impulse Responses for Mexico based on the BE Model in Level

Response to Structural One S.D. Innovations

Response of LYMEX to Shock1

Response of LYMEX to Shock2

Response of LCPI_MEX to Shock1

Response of LCPI_MEX to Shock2
Figure 10  Impulse Responses for Canada based on the BE Model in Difference

Response to Structural One S.D. Innovations

Response of DLYCAN to Shock1

Response of DLYCAN to Shock2

Response of DLCPI_CAN to Shock1

Response of DLCPI_CAN to Shock2
Figure 11  Impulse Responses for the US based on the BE Model in Difference
Figure 12  Impulse Responses for Mexico based on the BE Model in Difference

Response to Structural One S.D. Innovations

Response of DLYMEX to Shock1

Response of DLYMEX to Shock2

Response of DLCPI_MEX to Shock1

Response of DLCPI_MEX to Shock2