BUSINESS CYCLES OF SMALL OPEN ECONOMIES

AN INVESTIGATION INTO NEWS DRIVEN

AN INVESTIGATION INTO NEWS DRIVEN BUSINESS CYCLES OF SMALL OPEN ECONOMIES

ΒY

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Abstract

In this thesis we examine the news driven business cycle hypothesis which posits that business cycles might arise purely on the basis of expectations of future changes. Although the news shocks literature often concentrates on news about future technological changes, we on the other hand, study news about a country interest rate and a monetary policy interest rate in the context of small open economies (SOEs). Country interest rate news shocks refer to the anticipated changes in the rate at which the SOE borrows/lends in the international financial markets. Monetary policy news on the other hand refers to the anticipated changes of the policy rate usually transmitted to the public through 'forward guidance'. We argue that such pieces of news about interest rates change the expectations of economic agents and influence current economic activity without any actual change ever occurring. Further, we extend our SOE framework to study an optimal monetary policy rule for Canada.

In Chapter 2, we examine how anticipated changes in future country interest rates influence the business cycles of emerging SOEs like Argentina and Mexico. To this end, we introduce country interest rate news shocks in a SOE model. We use annual Argentine data from 1900-2005 to estimate our model using Bayesian methods. We find that anticipated shocks to country interest rates explain a good deal of variations in the growth rate of investment and trade balance-output ratio of Argentina. The model also generates business cycles statistics that are consistent with those of Argentina. We find similar results for Mexico as well.

In Chapter 3, we extend our SOE framework of Chapter 2 to a New Keynesian SOE model in order to explore the role of monetary policy news shocks in Canadian business cycles. Once again, we perform a Bayesian estimation of the model with Canadian and US data from 1981Q3-2012Q4. The novel feature of the monetary policy rule employed in this study is the inclusion of US interest rate deviations in the Canadian monetary policy rule motivated by the highly correlated US and Canadian short term nominal interest rates over the above mentioned time period. Our estimation results show that the response coefficient of Canadian monetary policy to US interest rate deviations is indeed positive. Moreover, both the unconditional and conditional variance decomposition of variables in the model reveal that although monetary policy news shocks explain some of the variation in the growth rate of output and consumption, overall they are not a major source of Canadian business cycles. However, they explain a good portion of the variation in money supply growth and inflation in Canada.

Chapter 4 builds on the New Keynesian Dynamic Stochastic General Equilibrium (DSGE) framework developed in Chapter 3. In this chapter, we ask the following

question: does reacting to US interest rate changes help the central bank achieve its mandate? To this end, we represent the mandate of the central bank by a loss function which is a linear combination of the variances of inflation, output gap and nominal interest rate changes which the central bank seeks to minimize. The weights attached to each of the three terms of the loss function represent different policy regimes. We assess the performance of the estimated interest rate rule of Chapter 3 with and without reaction to US interest rate deviations in achieving the central bank's mandate under different policy regimes. We find that under the estimated rule, reacting to US interest rate deviations neither helps nor hurts the central bank to achieve its mandate. Next, we ask the following questions: what values of the policy coefficients would minimize the loss function and would the optimal simple rule include US interest rate deviations in it? We find that the optimal rule has a positive coefficient on US interest rate deviations (larger than its Bayesian estimate) for all the policy regimes. It also has a large coefficient on inflation. Therefore, our analysis suggests that the central bank should include US interest rate deviations in its reaction function and should react even more aggressively to US interest rate changes and inflation than it did based on our Bayesian estimates.

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Last but not the least, I would like to thank my family– my parents, my husband and my one-year-old son for their relentless support and sacrifices to help reach me where I am today. It is because of their constant motivation, I could preserve the persistence- a quality I found of utmost importance in the course of my research.

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Declaration of Academic

Achievement

Chapter 2 is co-authored with my supervisor, Marc-Andre Letendre. He proposed the idea and then we worked collaboratively on model simulation and estimation. In the write-up of the chapter, he provided his comments on the draft I prepared and then I made necessary revisions.

I am the sole author of other chapters.

Chapter 1

Introduction

The quest to identify the sources of business cycle fluctuations is an ever evolving endeavor in the macroeconomic literature. Following Kydland and Prescott (1982) many modern theories assume that economic fluctuations are driven by changes in current fundamentals, such as aggregate productivity. However, over the last several years there has been a resuscitation of a theory in which business cycles can arise without any change in fundamentals at all. Theories of this sort, known as expectations driven business cycles, originally proposed by Pigou (1929) and popularized by Beaudry and Portier (2004) posit that business cycles might arise on the basis of expectations solely. They argue that if favorable news about future productivity can set off a boom today, then a realization of productivity which is worse than expected can induce a recession without any actual reduction in productivity itself ever occurring.

Although technological news shocks are widely studied in the news shocks literature,

in this thesis we focus on expected future changes in interest rates. In particular, we explore how anticipated changes in country interest rates at which the SOE borrows or lends in the international financial markets and policy interest rates affect the business cycles of small open economies (SOEs) in chapters to follow.

In Chapter 2, we explore the contribution of anticipated country interest rate shocks in the business cycles of emerging economies like Argentina and Mexico. Although Neumeyer and Perri (2005); Uribe and Yue (2006); García-Cicco et al. (2010), among others, have studied the role played by unanticipated country interest rate shocks in emerging economies, we are the first to introduce anticipated country interest rate shocks in the literature. To this end, we add one-year ahead country interest rate news shocks to the SOE model proposed by García-Cicco et al. (2010) (GCPU hence forth). Given the volatile nature of emerging economies, we believe that expectations about future interest rates at which these countries can borrow in the future may have important consequences on their economy. Hence, we argue that such shocks can be a potential source of business cycles in small emerging economies like Argentina and Mexico.

We use GCPU's annual Argentine data to perform a Bayesian estimation—a method that estimates a model's parameters by maximizing the likelihood of observing the data for a given model. The estimation results show that country interest rate news shocks explain a significant share of variances in the growth rate of investment and trade balance-output ratio of Argentina. The model also generates business cycles that are consistent with Argentine data. We test the robustness of our results in four different ways and under all these scenarios, we find that country interest rate news shocks are important in explaining variance of investment growth and variance of trade balance-output ratio relative to GCPU.

In Chapter 3, we study the role of monetary policy news shocks in the business cycles of Canada, another SOE. Milani and Treadwell (2012) and Gomes et al. (2017) have investigated the role of such shocks for the US economy and found that anticipated changes in the policy rates play a larger role in influencing US business cycle than unanticipated policy shocks. But, the role of monetary policy news shocks in Canadian business cycles is unknown. Therefore, in the same vein as Milani and Treadwell (2012) and Gomes et al. (2017) we argue that anticipated changes in the policy rate may affect economic activity in Canada as well by changing economic agents' expectations of future policy rates. The central bank may signal such future changes in the policy rate through forward guidance– a statement from the central bank about the future values of the policy rate.

We use a New Keynesian small open economy (NK SOE) model similar to Dib (2011) and add one-year ahead monetary policy news shocks in the monetary policy rule. The unique feature of the monetary policy rule adopted in this study is the reaction of Canadian monetary policy to US Federal Funds rate changes motivated by the high correlation of 0.70 between US and Canadian short term nominal interest rates over 1981Q3-2012Q4. Moreover, in an open-economy Bayesian Vector Autoregressive (VAR) model Bhuiyan (2012) finds that federal funds rate shocks have significant impact on Canadian variables and this rate (along with other foreign variables) is important for setting the over night target rate in Canada. However, we incorporate US interest rate changes in a Canadian monetary policy rule in a full-information DSGE model. We also estimate the model with Bayesian methods and Canadian and US data from 1981Q3-2012Q4. The estimation results show that, indeed the response coefficient of Canadian monetary policy to US interest rate changes is positive, 0.27. A variance decomposition of the model suggests that monetary policy news shocks are not a significant driver of Canadian business cycles. We once again test the robustness of these results in different ways which confirm the findings mentioned above.

Chapter 4 builds on the New Keynesian DSGE framework developed in Chapter 3. In this chapter we ask the following question: does reacting to US interest rate deviations help the central bank achieve its mandate? Following Meenakshi and Mendes (2007); Tomura (2009); Verona et al. (2017) among others, we represent the mandate of the central bank by a loss function which is a linear combination of the variances of inflation, output gap and nominal interest rate changes. The objective of the central bank is to minimize this loss function. This exercise tells us what values of the policy rule coefficients would minimize the loss function and whether the optimal simple rule includes US interest rate deviations. Once again, we find that the optimal rule has a positive coefficient on US interest rate deviations (larger than its Bayesian estimate) for all the policy regimes. It also has a large coefficient on inflation. Therefore, according to our results, the central bank should respond to US interest rate deviations even more aggressively than we found in our Bayesian estimate.

This thesis contributes to the news literature along two dimensions: (i) it introduces and quantifies the impact of country interest rate news shocks in the news literature (ii) it assesses the importance of monetary policy news shocks in Canadian business cycles in a NK SOE set-up which allows the Canadian monetary policy to react to US interest rate deviations. This thesis also contributes the literature on optimal monetary policy by unveiling that in addition to output and inflation, an optimized monetary policy rule for Canada should respond to US interest rate changes contrary to the traditional view where monetary policy only responds to output and inflation.

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Chapter 2

The Role of Interest Rate News Shocks in Business Cycles of Emerging Economies

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2.1 Introduction

The question "what drives business cycles" has been and will likely remain a focal point in macroeconomic research. Extensive work has already been done in the context of large developed economies (e.g. US and Europe) and small developed economies. The last decade or so has seen an increased focus on the drivers of business cycles in emerging economies. Macroeconomists have attempted to identify the shocks that explain business cycles of emerging economies.¹

Our work is a continuation of research on business cycles in emerging economies. Emerging economies, unlike the developed ones, are characterized by a highly volatile and counter cyclical interest rate.² Neumeyer and Perri (2005) have documented that in emerging economies the interest rate at which the SOE borrows/lends in the international financial market is an important determinant of its economic activity and output volatility. In the same vein Uribe and Yue (2006) shed light on the intricate inter-relationships between country spreads, the world interest rate and emerging economies business cycles. They found that country spreads drive business cycles and vice versa. García-Cicco et al. (2010) (GCPU henceforth) on the other hand introduces a debt elastic country premium as a reduced form financial friction and argue that it is the existence of significant financial frictions that explain the peculiar and volatile nature of emerging economies over the business cycle. They also show that permanent technology shocks explain very little of Argentine business cycles and argue that (unanticipated) interest rate shocks are rather important specially in explaining variations in the growth rate of investment and the trade balance-output ratio. Therefore, the role of (surprise) interest rate shocks in emerging economies business cycles is well emphasized in the literature.

 $^{^1\}mathrm{Some}$ early examples are Neumeyer and Perri (2005); Uribe and Yue (2006); Aguiar and Gopinath (2007)

²Neumeyer and Perri (2005); Uribe and Yue (2006); García-Cicco et al. (2010); Fernández and Gulan (2015) have documented this.

Given the recent resurgence of the interest in expectations based cycles³, one wonders how important shifts in expectations are for emerging economies business cycles. Given the relative fragility of emerging countries' economies and financial markets compared to developed ones, expectations about future prospects may have notable consequences on the former. Events or expectations of events that are external to a country like Argentina or Mexico can impact the rate at which these countries can borrow in the present and the rate at which they expect to borrow in the future. Hence, we argue that the role of exogenous interest rates shifts and especially anticipated shifts can potentially be important factors to consider when looking for important drivers of business cycles of emerging economies.

As a starting point, we take the SOE model with financial frictions proposed by GCPU and add anticipated (one-year ahead) shocks to the interest rate. While the role of expected changes in the future total factor productivity of a SOE has been analyzed by Jaimovich and Rebelo (2008) we are the first to study the effect of expected changes in country interest rates. We estimate our model using Bayesian methods and GCPU annual data for Argentina (1900-2005)⁴. We find that interest rate news shocks explain 31% of the variance in the growth rate of investment and 59% of the variance in the trade balance-output ratio. We test the robustness of this key result in four different ways.

³See for example Jaimovich and Rebelo (2008); Barsky and Sims (2011); Schmitt-Grohé and Uribe (2012); Beaudry and Portier (2014).

⁴We use the same observables that GCPU used: growth rate of output, growth rate of consumption, growth rate of investment, and the trade balance-output ratio.

First, we add marginal efficiency of investment (MEI) shocks to the model. Those shocks, which date back to at least Greenwood et al. (1988) have been found to influence investment dynamics, hence they compete directly with anticipated interest rate shocks. Adding MEI shocks as well as an anticipated component to all of the shocks in the model leads to the augmented model comprised of anticipated components for stationary technology shocks, nonstationary technology shocks, preference shocks, domestic spending shocks, MEI shocks and interest rate shocks. Here again the explanatory power of anticipated interest rate shocks is not affected.

Second, we estimate our model using GCPU annual Mexican data (1900-2005). We find once more that interest rate news shocks are important. They explain 23% of the variance of investment growth and 45% of the variance of trade balance-output ratio.

Third, we test that our results are not sensitive to the specific form of reduced-form financial friction adopted. In a model including bond holding costs instead of a debtelastic interest rate anticipated interest rate shocks still explain about 20% variance of growth rate of investment and 52% variance of trade balance-output ratio.

Finally, we estimate our model with Argentine quarterly data from 1994Q2-2012Q4. Switching from annual to quarterly data allows us to include interest rate as an observable in the estimation process. Once again we find that interest rate news shocks are important in explaining about 12% of the variance of investment growth and 28% of the variance of trade balance-output ratio.

The rest of the chapter is organized as follows. Section 2.2 describes the model environment. Section 2.3 explains how we estimate our model and discuss the model's implications. Section 2.4 presents the sensitivity analysis outlined in the four paragraphs above. Section 2.5 concludes.

2.2 Model

2.2.1 Production

Our model builds on GCPU.⁵ Output, Y_t , is given by the aggregate production function

$$Y_t = a_t K_t^{\alpha} (X_t h_t)^{1-\alpha} \tag{2.1}$$

where K_t denotes the stock of physical capital at the beginning of period t and h_t denotes hours worked in period t. Exogenous variables a_t and X_t represent stationary and non-stationary productivity shocks respectively. As GCPU argue, these two sources of aggregate volatility do not only capture variations in technology, they include other disturbances which may cause variations in total factor productivity such as terms of trade shocks. The stationary productivity shock follows a first-order

⁵Notation convention: lowercase variables are stationary while uppercase variables grow stochastically.

auto regressive process in logs given by

$$\log(a_{t+1}) = \rho_a \log(a_t) + \varepsilon_{a,t+1}$$
(2.2)

where $-1 < \rho_a < 1$. The unanticipated component of a_{t+1} is represented by $\varepsilon_{a,t+1}$ which is an $iid(0, \sigma_{\varepsilon_a})$ random variable.

The growth rate of X_t is $g_t = \frac{X_t}{X_{t-1}}$ where the logarithm of g_t follows an AR(1) process of the form

$$\log\left(\frac{g_{t+1}}{\bar{g}}\right) = \rho_g \log\left(\frac{g_t}{\bar{g}}\right) + \varepsilon_{g,t+1} \tag{2.3}$$

where $-1 < \rho_g < 1$ and \bar{g} is the average gross growth rate of X_t . The unanticipated component of g_{t+1} is represented by $\varepsilon_{g,t+1}$ which is an $iid(0, \sigma_{\varepsilon_g})$ random variable.

2.2.2 Preferences

The representative household supplies labour and rents out capital in competitive labour and capital markets. The representative household derives utility from consumption (C) and disutility from working. Its preferences are described by the expected utility function

$$\mathbb{E}_{0} \sum_{t=0}^{\infty} \beta^{t} \nu_{t} \frac{\left[C_{t} - \theta \omega^{-1} X_{t-1} h_{t}^{\omega}\right]^{1-\gamma} - 1}{1-\gamma}$$
(2.4)

where ν_t denotes a preference shock which evolves as

$$\log\left(\nu_{t+1}\right) = \rho_{\nu}\,\log\left(\nu_{t}\right) + \varepsilon_{\nu,t+1} \tag{2.5}$$

where $-1 < \rho_{\nu} < 1$. The unanticipated component of ν_{t+1} is represented by $\varepsilon_{\nu,t+1}$ which is an $iid(0, \sigma_{\varepsilon_{\nu}})$ random variable. As argued in Correia, Neves and Rebelo (1995) GHH utility helps produce a countercyclical trade balance.

2.2.3 Constraints

The small country faces the period-by-period budget constraint

$$Y_t + \frac{D_{t+1}}{1+r_t} = D_t + C_t + S_t + I_t + \frac{\phi}{2} K_t \left(\frac{K_{t+1}}{K_t} - \bar{g}\right)^2$$
(2.6)

where D_t represents the country's debt with the rest of the world at the beginning of period t. This debt must be repaid in period t. The country accumulates new debt in period t by issuing and selling D_{t+1} units of bonds to the rest of the world. Each bond issued in t pays one unit of consumption in period t + 1. The rate of return (or interest rate) on bonds issued in period t is denoted r_t which implies that the price of a bond is given by $\frac{1}{1+r_t}$. The left side of the budget constraint represents the resources available in period t while the right side shows how these resources are used. I_t denotes investment in physical capital. We limit the variance of investment by imposing capital adjustment costs. An Exogenous variable S_t represents domestic spending shocks. Detrended spending is defined as $s_t = \frac{S_t}{X_{t-1}}$ and evolve as follows

$$\log\left(\frac{s_{t+1}}{s}\right) = \rho_s \log\left(\frac{s_t}{s}\right) + \varepsilon_{s,t+1} \tag{2.7}$$

where $-1 < \rho_s < 1$ and s denotes the value of detrended spending in the steady state. The unanticipated component of s_{t+1} is represented by $\varepsilon_{s,t+1}$ which is an $iid(0, \sigma_{\varepsilon_s})$ random variable.

The stock of capital evolves according to

$$K_{t+1} = (1 - \delta)K_t + I_t \tag{2.8}$$

where $\delta \in (0, 1)$ is the depreciation rate of capital.

2.2.4 Interest Rate Process

There are many different ways to model the interest rate faced by the small open economy in the literature.⁶ Since our work is closely related to that of GCPU, we adopt their setup and make r_t a combination of the world interest rate (r^*) , a debt elastic risk premium and an exogenous random component (μ_t) as follows

$$r_t = r^* + \psi \left(e^{\frac{\tilde{D}_{t+1}}{X_t} - \bar{d}} - 1 \right) + e^{(\mu_t - 1)} - 1$$
(2.9)

⁶See for example Neumeyer and Perri (2005), Uribe and Yue (2006), GCPU, Álvarez-Parra et al. (2013).

where $r^* = \frac{1}{\beta} \bar{g}^{\gamma}$. The variable \tilde{D}_t denotes the aggregate level of external debt per capita. Individual agents do not take into account of the effect of \tilde{D} on r when deciding on the amount they wish to borrow or lend. In equilibrium we impose $\tilde{D}_t = D_t$.

To close the SOE model (see Schmitt-Grohé and Uribe (2003)) it has been customary for researcher to adopt a debt elastic interest rate setup where the debt elasticity parameter ψ is set to a very small number. GCPU deviated from that custom and interpreted the premium term as a reduced form financial friction and estimated ψ . They estimated ψ using a Bayesian inference method and Argentine annual data from 1900-2005. They found the estimated value to be 2.8 which is several order of magnitude greater than what is typically assumed. For example, the calibrated value of ψ used by Aguiar and Gopinath (2007); Schmitt-Grohé and Uribe (2003) is 0.001. We maintain the specification of GCPU and estimate ψ .

The novelty of our setup appears in the exogenous component included in (2.9). Consider the AR(1) process

$$\log\left(\mu_{t}\right) = \rho_{\mu} \log\left(\mu_{t-1}\right) + \varepsilon_{\mu,t} + \varepsilon_{\mu,t-1}^{1} \tag{2.10}$$

where $\varepsilon_{\mu,t} \sim iid(0, \sigma_{\mu}^2)$ and $\varepsilon_{\mu,t-1}^1 \sim iid(0, \tilde{\sigma}_{\mu}^2)$. As usual, μ_t depends on its own lagged value and on the unanticipated innovation $\varepsilon_{\mu,t}$ realized in period t. The last element $\varepsilon_{\mu,t-1}^1$ represents a piece of news that was received in period t-1 (hence subscript t-1) and which helps predict μ one period later (hence the superscript 1).

Therefore in period t agents learn the value of $\varepsilon_{\mu,t}$ which allows them to calculate μ_t and r_t but they also learn the value of $\varepsilon_{\mu,t}^1$ which helps them forecast/anticipate the value of μ_{t+1} and r_{t+1} using the forecasting equation

$$\mathbb{E}_t \log\left(\mu_{t+1}\right) = \rho_\mu \log\left(\mu_t\right) + \varepsilon_{\mu,t}^1. \tag{2.11}$$

Therefore, the representative agent in this economy chooses sequences for C, h, D, I, K and Y to maximize (2.4) subject to equations (2.1)-(2.3) and (2.5)-(2.10) and the no-Ponzi game condition

$$\lim_{j \to \infty} \mathbb{E}_t \left(\frac{D_{t+j}}{\prod_{s=0}^j} (1+r_s) \right) \le 0$$
(2.12)

2.3 Estimation and Results

2.3.1 Model Solution and Estimation

The model described above does not allow an analytical solution for commonly used parameter values. Hence numerical solution methods will be used. Before solving the model numerically we make it stationary. The deterministic version of our model implies a balanced growth path where h is constant while Y, K, I, C and D grow at rate \bar{g} . We detrend variables as follows: $c_t = C_t/X_{t-1}$, $y_t = Y_t/X_{t-1}$, $i_t = I_t/X_{t-1}$, $d_t = D_t/X_{t-1}$, and $k_t = K_t/X_{t-1}$. The stationary version of the model is solved using a first-order linear approximation method as implemented in Dynare.

Following GCPU we calibrate technology and preference parameters γ , $\delta \alpha$, ω , θ , β and steady-state debt \bar{d} . Unless otherwise indicated the values of calibrated parameters we employ are reported in Table A.2.1.

All remaining parameters are estimated using Bayesian estimation methods as implemented in Dynare. To easily compare our results to those of GCPU most of our analysis uses their annual data for Argentina covering the period 1900-2005 and our estimation relies on the very same set of observables which are the level of the trade balance-output ratio as well as the growth rates of output, consumption and investment.⁷

Let tby^A denote the trade balance-output ratio in Argentina. Let $g^A_{y,t}$, $g^A_{c,t}$ and $g^A_{i,t}$ denote the growth rate of GDP, consumption and investment respectively in Argentina. We use the following measurement equations

$$g_{y,t}^{A} = \log\left(\frac{y_t}{y_{t-1}} g_{t-1}\right)$$
 (2.13)

$$g_{c,t}^{A} = \log\left(\frac{c_{t}}{c_{t-1}}g_{t-1}\right)$$
(2.14)

$$g_{i,t}^{A} = \log\left(\frac{i_{t}}{i_{t-1}} g_{t-1}\right)$$
(2.15)

⁷Growth rates are first differences of logged data.

$$tby^A = \frac{tb_t}{y_t} \tag{2.16}$$

While estimating the model, we consider one-year ahead interest rate news shocks. We estimate the parameters governing the stochastic process of productivity $(\bar{g}, \rho_g, \sigma_{\varepsilon_g}, \rho_a, \sigma_{\varepsilon_a})$, interest rate $(\rho_{\mu}, \sigma_{\varepsilon_{\mu}}, \tilde{\sigma}_{\varepsilon_{\mu}})$, domestic spending $(\rho_s, \sigma_{\varepsilon_s})$, preference $(\rho_{\nu}, \sigma_{\varepsilon_{\nu}})$ and the parameters governing the degree of capital adjustment costs (ϕ) and debt elasticity of interest rate (ψ) . We also estimate four non-structural parameters which represent the standard deviations of i.i.d. measurement errors on the observables. For each measurement error standard deviation, the prior's upper bound is set at 25% of the standard deviation of the corresponding observable. We impose uniform prior distributions on all estimated parameters just like GCPU do.

Table A.2.2 presents the prior and posterior distributions for two models. The model without anticipated news shocks is denoted M1 while our model with anticipated interest rate shock is denoted M2. Everything else across the two models is identical. The estimation uses 25,000 Monte Carlo Markov Chains. The log data density (LDD) increases as we add interest rate news shocks to the model reflecting a better fit. Point estimates are very similar across models. The most notable change is the increase in the debt-elasticity parameter from 2.92 to 3.70. Therefore, the addition of anticipated country-spread shocks do not eliminate the need to include a reduced-form financial friction to match the data.

2.3.2 Results

Table A.2.3 presents variance decomposition results. As the right panel of the table demonstrates interest rate news shocks are very important. They explain 31% of the variance of the growth rate of investment and 59% of the variance of the trade balance-output ratio. The explanatory power of technology shocks, preference shocks and domestic spending shocks changes very little when we include interest rate news shocks. However, unanticipated interest rate shocks become less important. The share of the variance of investment they explain falls from 61% to 26%. The share of variance of the trade balance-output ratio they explain falls from 78% to 25%. GCPU found that surprise country premium shocks explain a very high fraction of the variance of investment growth and trade balance output ratio. Our results refine theirs by showing that surprise interest rate shocks, while still important, explain a much smaller fraction of those variables once anticipated shocks are considered. The variance decomposition results suggest that anticipated interest rate shocks are dominant drivers of Argentina's investment and trade balance over the period 1900-2005.

Figure A.1 displays the time paths of the observables and their counterparts produced by the model. The estimated model and shocks match the observables very well. Figuring out correlations across variables from Figure A.1 is difficult so we provide correlation calculations in Table A.2.4. Overall, the correlations produced by both models are very similar. Another correlation that is typically reported in the open-
economy macro literature is the correlation of the trade balance-output ratio with GDP. In our model the correlation between the log of output and the trade balance-output ratio is -0.12. To calculate the corresponding correlation using Argentine data we need to use some detrending method. We use the HP filter⁸ and find a correlation equal to -0.33.

Figure A.2 represents the autocorrelation function produced by our model with anticipated interest rate shocks and its counterpart in Argentine data. Our model (like the financial frictions model of GCPU is producing an autocorrelation function for the trade balance-output ratio that is very close to the one in the data.⁹

In the next section we discuss the responses triggered by interest rate news shocks in our model.

2.3.3 Impulse Response Functions

In this section we interpret the impulse response functions (IRFs) obtained from our estimated model. The impulse responses in Figure A.3 show the variables in deviations from their steady-state values. Hence, the country's external debt is exactly zero when its impulse response is equal to $-\bar{d} = -0.007$.

The small open economy is in steady state in period zero (not shown in the responses) and receives news in period one about a one standard deviation increase (6.9 percent-

⁸Smoothing parameter equal to 6.25.

 $^{^9{\}rm GCPU}$ show that the small open economy RBC model fails to produce a downward slopping autocorrelation function of trade balance-to-output ratio.

age points) in the interest rate at which it will borrow/lend in the international financial market one period (one year) later. In response to this news the country increases its net exports to repay 71% of its external debt (debt at the end of period 1 is 0.0018) in order to avoid high debt repayments in the future. This is accomplished by reducing consumption and investment while waiting for the anticipated increase in r. To understand how the model delivers decreases in those variables we look at first-order conditions.

Let's start from the bond Euler equation which is given by

$$\lambda_t = \frac{\beta}{g_t^{\gamma}} \mathbb{E}_t \lambda_{t+1} (1+r_t) \tag{2.17}$$

where λ_t denotes the marginal utility of consumption. By iterating on the above equation and using equation (2.9) to eliminate $1 + r_{t+1}$ we obtain

$$\lambda_t = \beta^2 \mathbb{E}_t \lambda_{t+2} [1 + r_t] \times [r^* + \psi(-) + e^{\mu_{t+1} - 1}]$$
(2.18)

where μ_{t+1} includes the anticipated component $\varepsilon^1_{\mu,t}$ observed in period t (see equation (2.10)). Similarly by iterating on the capital Euler equation¹⁰ we obtain

$$\lambda_t = \beta^2 \mathbb{E}_t \lambda_{t+2} [1 + MPK_{t+1} - \delta] \times [1 + MPK_{t+2} - \delta]$$
(2.19)

¹⁰Abstracting from adjustment costs.

where MPK denotes the marginal product of capital. Therefore, if the return on bonds (from period t to t+2) is expected to increase due to a positive $\varepsilon_{\mu,t}^1$ received in period t, by arbitrage the future return on capital must also increase. In absence of TFP shocks, for future returns on capital to increase current period investment must decrease in order to lower the future capital stock. This explains the observed fall in investment in Figure A.3.

The figure also shows a drop in consumption in the period the news is received. The anticipated increase in r_2 implies that current consumption becomes more expensive relative to future consumption so C_1 is below steady state. The labor first-order condition¹¹ can be re-written to show that h_t depends exclusively on a_t , g_t and K_t . In the current exercise a and g remain constant hence h_t follows K_t (that is, h_t is determined by the marginal product of labor which falls when K falls). Since K is a predetermined variable output does not adjust at all in period 1. As a result, the trade balance must increase when the news is received since consumption and investment both fall.

In period 2 the interest rate shock is realized and r_2 is 5 percentage points above its steady-state value.¹² The country becomes a net lender and remains a lender for a few years while the interest rate reverts to its steady state. Having built a stock of net foreign assets to avoid the hardship that an increase in r would impose on a

¹¹See equation (23) in Appendix C.

¹²Recall that the country interest rate is debt elastic so the decrease in d reduces r somewhat.

debtor country, the SOE slowly depletes its net foreign assets and enjoys many years of consumption above steady state.

2.4 Anticipated Interest Rate Shocks in Alternative Setups

The results presented in Section 3 lead to the conclusion that anticipated interest rate shocks are important drivers of investment and trade balance-output ratio for the period 1900-2005 in Argentina. In a framework borrowed from GCPU we find that anticipated interest rate shocks explain a greater share of the variance of investment growth and trade balance-output ratio than surprise interest rate shocks. In this section we consider alternative setups to verify the robustness of this key result.

2.4.1 Bond Holding Costs

Instead of arbitrarily including a debt elasticity term as in equation (2.9) an alternative (but just as arbitary) way of closing the SOE model is to introduce portfolio adjustment costs in the country's budget constraint (see Schmidt-Grohé and Uribe (2003)). To verify if the specific reduced form financial friction appearing in our model is crucial to our result we modify our model by replacing (3.22) and (2.9) by

$$Y_t + \frac{D_{t+1}}{1+r_t} = D_t + C_t + S_t + I_t + \frac{\phi}{2} K_t \left(\frac{K_{t+1}}{K_t} - \bar{g}\right)^2 + \frac{\psi}{2} Y_t \left(\frac{D_{t+1}}{Y_t} - \bar{d}\right)^2 \quad (6')$$

$$r_t = r^* + exp^{(\mu_t - 1)} - 1 \tag{9'}$$

In this alternative set up anticipated country spread shocks are still important in explaining investment and trade balance. They explain about 20% of the variance of the growth rate of investment and about 50% of the variance of the trade balance-output ratio. The autocorrelation function of trade balance-output ratio and the second moments produced from this exercise look very similar to the ones reported in Figure A.2 and Table A.2.4, respectively, and are therefore omitted.¹³

2.4.2 Competing Shocks

In this section we add shocks that are naturally competing with anticipated interest rate shocks. First we add marginal efficiency of investment (MEI) shocks since those shocks have been found to influence investment dynamics. We modify the capital accumulation equation as follows

$$K_{t+1} = (1 - \delta)K_t + I_t m_t \tag{2.20}$$

where m_t represents an MEI shock.

Second, we add a one-year ahead anticipated component to all shocks included in the $\overline{}^{13}$ The log data density is 635.

model.¹⁴ For example, the stochastic process for MEI shocks is

$$\log(m_{t+1}) = \rho_m \log(m_t) + \varepsilon_{m,t+1} + \varepsilon_{m,t}^1$$
(2.21)

where $-1 < \rho_m < 1$. The unanticipated component of m_{t+1} is represented by $\varepsilon_{m,t+1}$ which is an $iid(0, \sigma_{\varepsilon_m})$ random variable while the anticipated component is represented by $\varepsilon_{m,t}^1$ which is an $iid(0, \tilde{\sigma}_{\varepsilon_m})$.

Table A.2.5 shows the variance decomposition produced by the model with MEI shocks and a complete set of one-period ahead news shocks. We see that interest rate news shocks are still very important. They explain about 26% of variance in growth rate of investment and about 73% of the variance in trade balance-output ratio.

2.4.3 Mexico: 1900-2005

Next, we estimate our model with the annual Mexican data (1900-2005) used by GCPU. We use the same four observables– growth rate of output, consumption, investment and trade balance-output ratio. The results show that interest rate news shocks explain about 23% of variance of growth rate of investment and 45% of variance of trade balance-output ratio.

¹⁴Nonstationary technology shocks, stationary technology shocks, MEI shocks, preference shocks and domestic spending shocks.

2.4.4 Country Interest Rate as an Observable

In the analysis above the interest rate in the model is not forced to match its counterpart in the data. As a final check we include the country interest rate as another observable which imposes discipline on the interest rate in our model. Emerging country interest rates data are available for the recent period only thus we switch from annual to quarterly frequency data to avoid working with a very small number of observations. In this section we employ quarterly Argentine data from 1994Q2-2012Q4 which covers a more recent period than the GCPU annual data. We use five observables namely the trade balance-output ratio (tby), the country interest rate as well as the growth rates of output (g_y) , consumption (g_c) and investment $(g_i)^{15}$. The country interest rate data we use are from Uribe and Yue (2006) and is the sum of J.P. Morgans EMBI+ stripped spread and the US real interest rate. Their country interest rate series is demeaned (we denote it r_t^A) so the measurement equation we use for the interest rate is $r_t^A = r_t - r^*$.

Our quarterly model includes one-year ahead news shocks. Hence equation (2.10) becomes

$$\log\left(\mu_{t}\right) = \rho_{\mu} \log\left(\mu_{t-1}\right) + \varepsilon_{\mu,t} + \varepsilon_{\mu,t-4}^{4} \tag{2.10'}$$

where $\varepsilon_{\mu,t-4}^4$, the anticipated component of μ_t , was realized and observed in period t-4. We recalibrate parameters β , δ and \bar{d} before estimating the model. Parameter

¹⁵Growth rates are calculated as log first-differences. The growth rates of consumption, investment and output differ markedly in out quarterly data set. This is not consistent with our model so we demeaned all three growth rates series.

values can be found in appendix A.2.1.

Table A.2.7 presents a comparison of variance decomposition between models M1 and M2 both estimated with quarterly Argentine data and using the same set of priors. Once again M2 represents our model and M1 represents a version of it without interest rate news shocks. We find that including anticipated interest rates raises the log data density (LDD) from 838 to 850 indicating some improvement in fitting the observables. Interest rate news shocks explain 12% of the variance of investment growth, 28% of the variance of the trade balance-output ratio and 48% of the variance in the country interest rate. In this case adding interest rate news shocks do not reduce the explanatory power of surprise interest rate shocks. It is the trend technology shocks that become irrelevant.

Figure A.4 shows the time paths of the observables as well as the time paths produced by the model and the estimated shocks. Again, the model tracks the observables very closely. Table A.2.8 presents the second moments obtained from quarterly Argentine data. The model without interest rate news shocks produces a correlation between g_i and g_y that is closer to that in the data whereas the model with interest rate shocks better captures the correlation of g_y with tby as well as the correlation of g_i with r. In both models the interest rate and the trade balance-output ratio are negatively correlated with output as in Argentine data.¹⁶

¹⁶The model with news shocks produces correlation $(\log(y), tby) = -0.23$ and correlation $(\log(y), r) = -0.23$. In our HP filtered data these correlations are -0.8 and -0.64 respectively.

Finally, Figure A.5 presents the autocorrelation of trade balance-to-output ratio obtained from quarterly Argentine data and the model. Despite the fact that the model does not produce autocorrelations as large as those in the data, the model is able to capture the overall downward slopping pattern of the autocorrelation function of trade balance-output ratio.

2.5 Conclusion

Unanticipated interest rate shocks have been identified as important drivers of emerging economies' business cycles. Empirical work suggests there is a strong negative correlation between economic activity and cost of borrowing in the international financial markets faced by emerging economies. However the role of interest rate news shocks have not been uncovered in the literature. To this end, we introduce interest rate news shocks in a set-up borrowed from GCPU. We estimate our model with annual Argentine data from 1900-2005. Interestingly, we find that anticipated interest rate shocks explain 29% of the variance of investment growth and 56% of the variance of the trade balance-output ratio. The fit of the model measured by the log data density also increase marginally when we include interest rate news shocks.

We test the sensitivity of our results in many different ways. First, we include MEI shocks and a news component to each shock of the model. We find that interest rate news shocks still explain 26% of the variance of growth rate of investment and

73% variance of trade balance-output ratio. Second, we estimated our model with Mexican annual data from 1900-2005 and in that case also we find that interest rate news shocks are important. They explain 23% of the variance of investment growth and 45% of the variance of the trade balance-output ratio. Third, we take the bond adjustment cost term out of the interest rate equation and place it in the budget constraint. Still, interest rate news shocks explain about 20% of variance of growth rate investment and 52% of variance of trade balance-output ratio.

Finally, to provide even stronger evidence we include interest rates as an observable in the Bayesian estimation. Doing so imposes discipline on the behaviour of interest rate shocks. Since interest rate data is only available for the recent time period, we employ a shorter sample of quarterly data from 1994Q2-2012Q4. Once again interest rate news shocks appear important explaining 12% variance of growth rate of investment and 28% variance of trade balance-output ratio.

Taken together, the evidence presented above strongly suggests that interest rate news shocks are important drivers of the business cycles of emerging small open economies.

Appendix A

A.1 Figures







Figure A.2: M2: Autocorrelation Function of TB/Y (1900-2005)



Figure A.3: Impulse response Functions-Anticipated Interest Rate Shock



Figure A.4: M2: Historical and smoothed paths (1994Q2 - 2012Q4)



Figure A.5: M2: Autocorrelation Function of TB/Y (1994Q2-2012Q4)

A.2 Tables

Table A.2.1: Calibrated Parameters

Parameter	γ	δ	α	ω	θ	β	\overline{d}
Values	2	0.1255	0.32	1.6	2.24	0.9224	0.007

	Prior Distri	bution		Posterior Distribution				
Parameters	Distribution	Min	Max	Me	Mean			
				M1	M2	M2 5%	M2 95%	
\overline{g}	Uniform	1	1.03	1.01	1.01	1.00	1.02	
$ ho_g$	Uniform	-0.99	0.99	0.26	0.23	-0.40	0.96	
$ ho_a$	Uniform	-0.99	0.99	0.86	0.86	0.79	0.94	
$ ho_{ u}$	Uniform	-0.99	0.99	0.85	0.83	0.74	0.93	
$ ho_s$	Uniform	-0.99	0.99	0.39	0.45	-0.08	0.96	
$ ho_{\mu}$	Uniform	-0.99	0.99	0.90	0.87	0.77	0.98	
$\dot{\phi}$	Uniform	0	8	5.03	4.61	3.18	6.05	
ψ	Uniform	0	5	2.92	3.70	2.46	5.00	
$\sigma_{arepsilon_q}$	Uniform	0	0.2	0.01	0.01	0.00	0.02	
$\sigma_{arepsilon_a}$	Uniform	0	0.2	0.03	0.03	0.03	0.04	
$\sigma_{arepsilon_{ u}}$	Uniform	0	1	0.55	0.52	0.33	0.69	
$\sigma_{arepsilon_s}$	Uniform	0	0.2	0.05	0.06	0.00	0.11	
$\sigma_{arepsilon_{\mu}}$	Uniform	0	0.2	0.05	0.04	0.02	0.06	
$ ilde{\sigma}_{arepsilon_{\mu}}$	Uniform	0	0.2	n/a	0.07	0.04	0.10	
,	Measurement	t errors						
σ_{y}^{me}	Uniform	0.0001	0.013	0.006	0.0052	0.0001	0.0094	
σ_c^{me}	Uniform	0.0001	0.019	0.0074	0.0070	0.0001	0.0126	
σ_i^{me}	Uniform	0.0001	0.051	0.04	0.0379	0.0215	0.0510	
σ_{tby}^{me}	Uniform	0.0001	0.013	0.0031	0.0035	0.0001	0.0062	
Log data density				632	636			

Table A.2.2: Prior and Posterior Distributions (1900-2005)

	M1 (LDD= 632)			M2 (LDD= 636)				
Shock	g_y	g_c	g_i	tb/y	g_y	g_c	g_i	tb/y
Stationary tech	86.51	48.94	14.57	0.92	86.03	49.94	16.14	0.64
Nonstationary tech.	4.31	1.82	0.49	0.29	4.54	1.94	0.58	0.30
Preference	6.37	44.04	23.92	20.77	6.10	43.79	26.07	15.38
Interest rate	2.80	5.14	60.89	77.61	1.02	1.75	25.60	24.52
Domestic spending	0.02	0.07	0.12	0.42	0.03	0.11	0.22	0.43
Anticipated interest rate					2.29	2.48	31.39	58.72

Table A.2.3: Variance Decomposition: M1 vs M2

Table A.2.4: Moments, Argentina (1900-2005)

	g_y	g_c	g_i	tby
Std. deviation				
Data	5.30	7.05	20.40	5.20
M1	6.25	8.60	17.83	5.08
M2	6.35	8.58	17.99	5.21
Correl. with g_y				
Data		0.72	0.67	-0.04
M1		0.76	0.33	-0.02
M2		0.77	0.35	-0.05
Correl. with tby				
Data		-0.27	-0.19	
M1		-0.30	-0.21	
M2		-0.29	-0.21	

shock	g_y	g_c	g_i	tby
Stationary tech	67.21	36.77	5.02	1.1
Nonstationary tech.	6.67	3.04	0.41	0.32
Preference	7.63	35.79	23.49	10.7
Interest rate	0.20	1.95	4.85	7.11
Domestic spending	0.02	0.19	0.12	0.19
MEI	5.70	4.45	12.49	0.15
Anticipated stationary tech.	3.18	0.70	0.10	0.59
Anticipated nonstationary tech.	1.94	0.38	0.05	0.34
Anticipated preference	0.03	2.40	0.08	1.09
Anticipated interest rate	1.98	10.69	25.84	73.27
Anticipated domestic spending	0.01	0.11	0.06	0.71
Anticipated MEI	5.43	3.54	27.49	4.43

Table A.2.5: Variance Decomposition with Competing Socks (1900-2005)

A.2.1 Quarterly Model

We convert the values of β and δ used in our annual model to a quarterly frequency: $\beta = 0.98$ and $\delta = 0.03$. Also, we set $\bar{d} = 2$ to have a steady state value of tb/y of about 0.03 which is the average value of the trade balance output ratio in our quarterly data set.

	Prior Distri	bution		Posterior Distribution			
Parameters	Distribution	Min	Max	Me	ean		
				M1	M2	M2 5%	M2 95%
ρ_g	Uniform	-0.99	0.99	0.92	0.15	-0.59	0.90
$ ho_a$	Uniform	-0.99	0.99	0.96	0.90	0.85	0.95
$ ho_{ u}$	Uniform	-0.99	0.99	0.81	0.76	0.64	0.89
$ ho_s$	Uniform	-0.99	0.99	-0.15	-0.13	-0.84	0.73
$ ho_{\mu}$	Uniform	-0.99	0.99	0.56	0.98	0.96	0.99
ϕ	Uniform	0	8	19.45	19.53	18.85	19.99
ψ	Uniform	0	5	0.51	0.43	0.24	0.63
$\sigma_{arepsilon_{a}}$	Uniform	0	0.2	0.01	0.002	0.000	0.005
$\sigma_{arepsilon_a}$	Uniform	0	0.2	0.01	0.013	0.011	0.015
$\sigma_{arepsilon_{ u}}$	Uniform	0	1	0.15	0.136	0.112	0.159
$\sigma_{arepsilon_s}$	Uniform	0	0.2	0.02	0.022	0.002	0.036
$\sigma_{arepsilon_{\mu}}$	Uniform	0	0.2	0.02	0.013	0.011	0.015
$ ilde{\sigma}_{arepsilon_{\mu}}$	Uniform	0	0.2	n/a	0.041	0.026	0.053
	Measurement	t errors					
σ_{y}^{me}	Uniform	0.0001	0.0051	0.0040	0.0028	0.0005	0.0047
σ_c^{me}	Uniform	0.0001	0.0066	0.0040	0.0030	0.0001	0.0051
σ_i^{me}	Uniform	0.0001	0.0243	0.0195	0.0173	0.0116	0.0241
σ_{tbu}^{me}	Uniform	0.0001	0.0119	0.0027	0.0024	0.0001	0.0043
σ_r^{me}	Uniform	0.0001	0.0114	0.0110	0.0076	0.0031	0.0114
Log data density				838	849		

Table A.2.6: Prior and Posterior Distributions (1994Q2-2012Q4)

Table A.2.7: Variance Decomposition : M1 vs M2 (Argentina 1994Q2 - 2012Q4)

		M1 (LDD=	=838)		M2 (LDD=849)				
shock	g_y	g_c	g_i	tb/y	r	g_y	g_c	g_i	tb/y	r
Stationary tech	70.27	38.40	9.53	3.68	1.88	96.86	47.16	10.88	3.73	2.18
Nonstat. tech.	28.86	29.56	16.47	50.05	12.68	1.48	1.03	0.74	0.70	0.37
Preference	0.52	23.84	19.54	9.88	14.07	0.58	36.14	17.12	10.24	8.53
Interest rate	0.35	8.18	54.38	36.26	71.26	0.71	13.75	59.25	56.62	41.01
Domestic spend.	0.00	0.02	0.08	0.13	0.10	0.00	0.04	0.13	0.23	0.10
Int. rate news						0.38	1.89	11.88	28.47	47.82

Statistics	g_y	g_c	g_i	tby	r_{obs}
Correlation with g_y					
Data		0.76	0.67	0.16	0.02
M1		0.79	0.40	-0.26	0.02
M2		0.70	0.30	-0.07	-0.05
Correlation with r					
Data		-0.04	0.11	0.72	
M1		-0.15	-0.24	0.77	
M2		-0.15	-0.10	0.69	

Table A.2.8: Argentina (1994Q2-2012Q4)

A.3 Optimality Conditions

Household's optimality conditions with respect to c_t , h_t , d_{t+1} , and k_{t+1} ,

$$\lambda_t = \nu_t \, \left(c_t - \frac{\theta}{\omega} \, h_t^{\omega} \right)^{(-\gamma)} \tag{A.1}$$

$$\theta h_t^{\omega - 1} = a_t (1 - \alpha) g_t^{1 - \alpha} \left(\frac{k_t}{h_t}\right)^{\alpha}$$
(A.2)

$$\lambda_t = \mathbb{E}(1+r_t) \,\frac{\beta}{g_t^{\gamma}} \,\lambda_{t+1} \tag{A.3}$$

Note, in the benchmark case without MEI shocks, $m_t=1$ in the equation below.

$$\lambda_{t} \left(\frac{1}{m_{t}} + \phi \left(\frac{g_{t}k_{t+1}}{k_{t}} - \bar{g} \right) \right) = \beta \frac{1}{g_{t}^{\gamma}} \mathbb{E}_{t} \lambda_{t+1} \left[\alpha \frac{y_{t+1}}{k_{t+1}} + \frac{1 - \delta}{m_{t+1}} - \frac{\phi}{2} \left(\frac{g_{t+1}k_{t+2}}{k_{t+1}} - \bar{g} \right)^{2} \right] \\ + \beta \frac{1}{g_{t}^{\gamma}} \mathbb{E}_{t} \lambda_{t+1} \left[\phi \frac{g_{t+1}k_{t+2}}{k_{t+1}} \left(\frac{g_{t+1}k_{t+2}}{k_{t+1}} - \bar{g} \right) \right]$$
(A.4)

A.4 Data Appendix

Annual Data

We obtained the annual data from Martin Uribe's website

http://www.columbia.edu/~mu2166/rbc_emerging/rbc_emerging.html

This is the same data set that was used by GCPU.

Quarterly data

We obtained the quarterly data from Martin Uribe's website

http://www.columbia.edu/~mu2166/book/empirics/

GDP: INDEC (http://www.indec.gov.ar/)

Investment (gross capital formation):

INDEC for base 1993 (http://www.indec.gov.ar/);

FIEL for base 1986 (http://www.fiel.org/)

Imports of goods and services as percentage of GDP :

INDEC for base 1993 (http://www.indec.gov.ar/);

FIEL for base 1986 (http://www.fiel.org/)

Exports of goods and services as percentage of GDP :

INDEC for base 1993 (http://www.indec.gov.ar/);

FIEL for base 1986 (http://www.fiel.org/)

Consumption (household final consumption expenditure as percentage of

GDP): INDEC (http://www.indec.gov.ar/)

Interest rate:

cohttp://www.columbia.edu/~mu2166/book/irs

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Chapter 3

The Role of Monetary Policy News Shocks in Canadian Business Cycles: A Bayesian Approach

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3.1 Introduction

Much of the monetary economics literature (both structural VARs and general equilibrium models) considers exogenous shocks to monetary policy which are unanticipated by the private sector. But in reality, anticipated changes in monetary policy may have important consequences on economic activity. A potential source of monetary policy news shocks is the practice of 'forward guidance' through which a central bank provides information about the future course of the policy rate (Rudebusch and Williams (2008); Den Haan (2013); Ben Zeev et al. (2017)). In this vein Milani and Treadwell (2012) and Gomes et al. (2017) investigate the role of monetary policy news shocks in US business cycles in the context of a closed economy. They argue that these shocks play a larger role in influencing US output than unanticipated policy shocks. However, the role of monetary policy news shocks in Canadian business cycles is unknown. We address this question in a small open economy set-up in this study.

We use a New Keynesian small open economy (NK SOE) model with monopolistic competition in the intermediate-goods sector and add one-year ahead monetary policy news shocks in the monetary policy rule. Following Dib (2006, 2011) and Ireland (2001, 2003), we assume that the central bank adjusts a linear combination of short term nominal interest rate and money supply growth in response to deviations of output and inflation from their steady state values.¹ In addition, we introduce a new component in the Canadian monetary policy rule namely the US interest rate changes. This unique feature of our model is motivated by the high correlation of 0.70 between US and Canadian short term nominal interest rates estimated over 1981Q3-2012Q4.² Bhuiyan (2012) also assumes that the Bank of Canada responds to a number of foreign variables including federal funds rate in setting the overnight rate

¹Ireland (2003) explains that a policy rule which responds to money supply growth on top of output and inflation, is more general and flexible in the sense that when estimated, such a rule allows the response coefficients to be zero. When the response coefficient to money supply growth is zero, the policy rule becomes a Taylor (1993) rule. Therefore, it is most convenient to leave each of the three terms there and estimate them.

²Following Dib (2011) our data set starts from 1981Q3 since the Bank of Canada abandoned M1 targeting by the middle of 1981.

target in an open-economy Bayesian SVAR model for Canada. He finds that federal funds rate shocks have significant impact on Canadian variables and that external shocks are important contributors to Canadian output fluctuations. Therefore, it is worth incorporating US interest rate changes in the Canadian monetary policy rule in a DSGE model like ours. We also include a news component to other stochastic processes which include total factor productivity (TFP), domestic spending, marginal efficiency of investment (MEI), US inflation and US interest rates.

We estimate the model with Bayesian methods using Canadian and US data from 1981Q3-2012Q4. We perform both unconditional and conditional variance decomposition of the model. The unconditional variance decomposition shows that monetary policy news shocks explain about 7% of the variation of output and consumption growth, 22% of the variation of inflation and 34% of the variation of money supply growth. In the conditional variance decomposition as well monetary policy news shocks retain very similar explanatory power for all the time horizons. We also perform a number of robustness checks including (i) the exclusion of the US interest rate changes from the Canadian monetary policy rule (ii) varying the interest elasticity of output (iii) estimating a version of the model where the number of shocks is equal to the number of observables. Once again results are similar to those of the benchmark case mentioned above. Altogether, our results suggest that monetary policy news shocks are not a major contributor to Canadian business cycles. Our findings are in line with those found in the literature.³

Our study builds on the large and growing literature on expectation-driven business cycles led by Beaudry and Portier (2004) in its modern form. We divide the existing news literature into two categories- (i) Studies exploring the role of news shocks in a closed economy context include Beaudry and Portier (2006a, 2007); Christiano et al. (2007); Den Haan and Kaltenbrunner (2009); Barsky and Sims (2011); Gunn and Johri (2011); Milani and Treadwell (2012); Schmitt-Grohé and Uribe (2012); Gunn and Johri (2013a); Kurmann and Otrok (2013); Born et al. (2013); Ben Zeev and Khan (2015); Fujiwara and Waki (2015); Gomes et al. (2017) among others. (ii) Studies incorporating news shocks in an open-economy set-up include Jaimovich and Rebelo (2008); Nam et al. (2010); Beaudry et al. (2011); Gunn and Johri (2013b); Fratzscher and Straub (2013); Gunn and Johri (2016); Nam and Wang (2017) among others. Ours is an addition to the latter.

The rest of the chapter is organized as follows. Sections 3.2 and 3.3 present the model and symmetric equilibrium respectively. Section 3.4 describes the data, calibration procedure and the Bayesian methods used to estimate the model. Section 3.5 reports and discusses the results. Section 3.6 analyzes the impulse response functions generated by the model. Section 3.7 reports the sensitivity tests and section 3.8 concludes.

³Gomes et al. (2017) find that monetary policy news shocks explain 9.66%, 12.46%, 5.49% and 14.59% of the variation of growth rate of output, consumption, investment and hours respectively for the US economy. Milani and Treadwell (2012) on the other hand find that such shocks explain 15-25% of medium-run output fluctuations of the US economy depending on the model specification.

3.2 Model

The model is similar to Dib (2006, 2011). There are four agents-a representative household, a representative final-goods-producing firm, a continuum of intermediategoods-producing firms and a monetary authority. The final-goods-producing firms produce goods that they sell on a perfectly competitive market. Each intermediategoods-producing firm on the other hand produces a distinct intermediate good which it sells on a monopolistically competitive market. The economy is small since home agents take the world nominal interest rate and prices as given.

3.2.1 Households

The representative household's preferences over consumption, c_t , hours, h_t , and real money balances, $\frac{M_t}{P_t}$, are represented by the following utility function similar to Greenwood et al. (1988), Chari et al. (2002) and Gail (2002).

$$\mathbb{E}_{0}\sum_{t=0}^{\infty}\beta^{t}\psi_{t}\frac{\left[\left(\eta c_{t}^{\nu}+l_{t}(1-\eta)\left(\frac{M_{t}}{P_{t}}\right)^{\nu}\right)^{\frac{1}{\nu}}-\theta\omega^{-1}h_{t}^{\omega}\right]^{1-\gamma}-1}{1-\gamma}$$
(3.1)

The household holds real money balances in order to facilitate transactions and it is introduced with consumption using a CES function. η is a share parameter and ν represents interest elasticity of the money demand function. Both ψ and l are kinds of preference shocks. l specifically represents a shock to the demand for real money balances. These shocks follow an autoregressive process of order one, AR(1) in logarithms presented by

$$\log\left(\psi_{t}\right) = \rho_{\psi} \log\left(\psi_{t-1}\right) + \varepsilon_{\psi,t} \tag{3.2}$$

and

$$\log\left(l_{t}\right) = \rho_{l}\,\log\left(l_{t-1}\right) + \varepsilon_{l,t} \tag{3.3}$$

where $-1 < \rho_{\psi}, \rho_l < 1$ represent autoregressive coefficients. The serially uncorrelated contemporaneous components $\varepsilon_{\psi,t}$ and $\varepsilon_{l,t}$ are $iid(0, \sigma_{\varepsilon_{\psi}}^2)$ and $iid(0, \sigma_{\varepsilon_{l}}^2)$ respectively. These are the unanticipated innovations realized in period t.

The stock of capital evolves according to

$$k_{t+1} = (1 - \delta)k_t + i_t n_t \tag{3.4}$$

where $\delta \in (0, 1)$ is the depreciation rate of capital and n_t represents marginal efficiency of investment (MEI) shocks which evolves according to

$$\log\left(n_{t}\right) = \rho_{n} \log\left(n_{t-1}\right) + \varepsilon_{n,t} + \varepsilon_{n,t-4}^{4} \tag{3.5}$$

where $-1 < \rho_n < 1$ represents the autoregressive coefficient, $\varepsilon_{n,t}$ is an $iid(0, \sigma_{\varepsilon_n}^2)$ and

 $\varepsilon_{n,t-4}^4$ is an $iid(0,\sigma_{\varepsilon_{nnews}}^2)$. The budget constraint of the household is represented by

$$\frac{R_{kt}}{P_t}k_t + \frac{W_t}{P_t}h_t + \frac{M_{t-1} + B_{t-1} + T_t + D_t}{P_t} + \frac{e_t B_{t-1}^{\star}}{P_t} = c_t + s_t + i_t + \frac{e_t B_t^{\star}}{\kappa_t P_t R_t^{\star}} + \frac{\phi_k}{2}k_t \left(\frac{k_{t+1}}{k_t} - 1\right)^2 + \frac{M_t + \frac{B_t}{R_t}}{P_t} \quad (3.6)$$

The representative household enters period t with k_t units of capital, M_{t-1} units of nominal money balances, B_{t-1} units of nominal domestic bonds and B_{t-1}^{\star} units of nominal net foreign bonds. The household supplies labour and capital to domestic intermediate firms and earn nominal factor income $W_t h_t + R_{kt} k_t$. W_t and R_{kt} represent the nominal wage rate and rental rate of capital respectively. The household receives lump-sum nominal transfer, T_t , from the central bank and nominal dividends, D_t , from intermediate-goods-producing firms. e_t is the nominal exchange rate measured as the price of foreign currency in terms of domestic currency. R_t and R_t^{\star} denote the gross nominal domestic and US interest rates between periods t and t+1 on domestic bonds, B_t , and US bonds, B_t^{\star} , respectively. The exogenous variable s_t represents domestic spending shocks which evolve as follows

$$\log\left(\frac{s_t}{s}\right) = \rho_s \log\left(\frac{s_{t-1}}{s}\right) + \varepsilon_{s,t} + \varepsilon_{s,t-4}^4 \tag{3.7}$$

where $-1 < \rho_s < 1$ and s denotes the value of spendings in steady state. The unanticipated component of s_t is represented by $\varepsilon_{s,t}$ which is an $iid(0, \sigma_{\varepsilon_s}^2)$ random variable. The last element of equation (3.7), $\varepsilon_{s,t-4}^4$, represents a piece of news about domestic spending that was received in period t-4 (hence subscript t-4) and which help predict domestic spending four quarters later (hence the superscript 4). The anticipated component, $\varepsilon_{s,t-4}^4$ is $iid(0, \sigma_{\varepsilon_{snews}}^2)$. We maintain the same assumptions for other news shocks as well.

During period t, the household may purchase new domestic bonds, B_t , and new foreign bonds, B_t^{\star} , in the domestic and international financial markets. However, in the international financial markets, they must pay a risk premium that is increasing in the foreign debt-to-output ratio. The price of foreign bonds is decreasing in the foreign-debt-to-output ratio which is reflected in the risk premium term below

$$\kappa_t = exp(-\frac{\chi e_t \tilde{B}_t^*}{P_t y_t}) \tag{3.8}$$

where χ measures the level of risk premium and \tilde{B}_t^{\star} is the average stock of aggregate foreign debt. The risk premium term ensures that the steady-state is unique and induces stationarity of the model. The world gross nominal interest rate R_t^{\star} is exogenous and follows the AR(1) process given by

$$\log\left(R_{t}^{\star}\right) = \rho_{R^{\star}} \log\left(R_{t-1}^{\star}\right) + \varepsilon_{R^{\star},t} + \varepsilon_{R^{\star},t-4}^{4} \tag{3.9}$$

where $-1 < \rho_{R^{\star}} < 1$. The unanticipated shock to R_t^{\star} is represented by $\varepsilon_{R,t}$ which is $iid(0, \sigma_{\varepsilon_R^{\star}}^2)$ and the anticipated shock, $\varepsilon_{R^{\star},t-4}^4$ is $iid(0, \sigma_{\varepsilon_R^{\star}news}^2)$.

Therefore, the representative household in this economy chooses sequences for c_t , m_t , h_t , k_{t+1} , b_t and b_t^{\star} in order to maximize equation (3.1) subject to equations (3.2)-(3.9). The associated optimality conditions are presented in the appendix B.4.1.⁴

3.2.2 The Final-goods-producing Firm

The final good, y_t is produced by a representative perfectly competitive firm which uses a continuum of intermediate goods indexed by $j \in (0, 1)$.

$$y_t \le \left(\int_0^1 y_{jt}^{\frac{\theta_y - 1}{\theta_y}} dj\right)^{\frac{\theta_y}{\theta_y - 1}} \tag{3.10}$$

where $\theta_y > 1$ represents constant elasticity of substitution between intermediate goods. y_{jt} denotes time t input of intermediate good j. Given the final-good price, P_t and intermediate-good price, P_{jt} , the final-good-producer maximizes its profit given below subject to equation (3.10) with respect to y_{jt} .

$$P_t y_t - \int_0^1 P_{jt} y_{jt} dj$$
 (3.11)

The profit maximization of the final-good-producing firm yields the following input demand function for good y_i

$$y_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\theta_y} y_t \tag{3.12}$$

⁴The lower case letters correspond to real variables e.g. $m_t = M_t/P_t$ with the exception of e_t which represents nominal exchange rate.

The final-good price index satisfies

$$P_{t} = \left(\int_{0}^{1} P_{jt}^{1-\theta_{y}} dj\right)^{\frac{1}{1-\theta_{y}}}$$
(3.13)

3.2.3 The Intermediate-goods-producing Firm

The intermediate-goods-producing firm j hires k_{jt} and h_{jt} to produce output according to the following constant-returns-to scale production function:

$$y_{jt} = k_{jt}^{\alpha} (a_t h_{jt})^{1-\alpha}$$
(3.14)

where a_t is a technology shock which is common to all intermediate firms and evolves according to the following AR(1) process.

$$\log\left(a_{t}\right) = \rho_{a}\,\log\left(a_{t-1}\right) + \varepsilon_{a,t} + \varepsilon_{a,t-4}^{4} \tag{3.15}$$

where $-1 < \rho_a < 1$ represents the autoregressive coefficient and $\varepsilon_{a,t} \sim iid(0, \sigma_{\varepsilon_a}^2)$ and $\varepsilon_{a,t-4}^4 \sim iid(0, \sigma_{\varepsilon_{anews}}^2)$. Intermediate goods are imperfect substitutes in producing the final good so the intermediate firm j can set the price P_{jt} that maximizes its profit. Following Rotemberg (1996), firm j faces a quadratic cost of adjusting its prices across periods. The price adjustment costs (PAC) are measured in terms of final goods and given by

$$PAC_{jt} = \frac{\phi_p}{2} y_t \left(\frac{P_{jt}}{\pi P_{jt-1}} - 1\right)^2$$
(3.16)

where π is the steady state value of the domestic inflation rate. In the presence of such PAC, the price mark-up becomes endogenous and the intermediate firm's problem is dynamic. Therefore, the intermediate firm's profit maximization problem is

$$\max_{k_{jt},h_{jt},P_{jt}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \frac{D_{jt}}{P_t}$$
(3.17)

subject to the demand curve it faces, equation (3.12) and the production technology (3.14). $\beta^t \lambda_t$ is the firm's discount factor. The instantaneous nominal profit function is defined as

$$D_{jt} = P_{jt}y_{jt} - R_{kt}k_{jt} - W_th_{jt} - P_tPAC_{jt}$$
(3.18)

Although the first-order conditions associated with this optimization problem are presented in appendix B.4.2, we reproduce the first-order condition with respect to P_j , equation (B.9) here, for convenience.

$$\frac{1}{q_t} = \frac{\theta_y - 1}{\theta_y} + \frac{\phi_p}{\theta_y} \frac{\pi_t \left(\frac{\pi_t}{\bar{\pi}} - 1\right)}{\bar{\pi}} - \frac{\beta \phi_p}{\theta_y} \mathbb{E}_t \left(\frac{\pi_{t+1} \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\pi_{t+1} - 1}{\bar{\pi}} - 1\right)}{\bar{\pi}} \frac{y_{t+1}}{y_t}\right)$$
(3.19)

 q_t is the price mark-up which measures the ratio of price to marginal cost which is equal to $\frac{\lambda_t}{\xi_t}$ where $\xi_t > 0$ is the Lagrange multiplier associated with the production technology (3.14). Moreover, condition (3.19) implies that price-markup responds endogenously to exogenous shocks in the presence of price-adjustment costs. If prices are perfectly flexible, $q_t = \frac{\theta_y}{\theta_y - 1}$.

3.2.4 The Monetary Authority

Following Dib (2011) and Ireland (2001) we assume that in order to conduct monetary policy the central bank manages a linear combination of short term nominal interest rate, R_t and the money growth rate, $\mu_t = \frac{M_t}{M_{t-1}}$ in response to changes in output, y_t and inflation, $\pi_t = \frac{P_t}{P_{t-1}}$, and another new factor discussed below. The monetary policy rule evolves according to

$$\log\left(\frac{R_t}{\bar{R}}\right) = \rho_R \log\left(\frac{R_{t-1}}{\bar{R}}\right) + a_\mu \log\left(\frac{\mu_t}{\bar{\mu}}\right) + a_y \log\left(\frac{y_t}{\bar{y}}\right) + a_\pi \log\left(\frac{\pi_t}{\bar{\pi}}\right) + a_{R^\star} \log\left(\frac{R_t^\star}{\bar{R}^\star}\right) + \log(z_t) \quad (3.20)$$

where \bar{R} , $\bar{\mu}$, \bar{y} , $\bar{\pi}$ and \bar{R}^{\star} are steady state values of R_t , μ_t , y_t , π_t and R_t^{\star} . If a_{μ} and $a_{R^{\star}}$ are equal to 0 and $a_y > 0$ and $a_{\pi} > 0$, monetary policy follows Taylor (1993) rule. One unique feature of equation (3.20) is the inclusion of US interest rate deviations in Canadian monetary policy rule which is motivated by the high correlation, 0.70, observed between R_t and R_t^{\star} in the data (1981Q3-2012Q4). The exogenous component, z_t , representing monetary policy shocks evolves according to

$$\log\left(z_{t}\right) = \rho_{z}\,\log\left(z_{t-1}\right) + \varepsilon_{z,t} + \varepsilon_{z,t-4}^{4} \tag{3.21}$$

where $-1 < \rho_z < 1$ represents the autoregressive coefficient and $\varepsilon_{z,t}$ is an $iid(0, \sigma_{\varepsilon_z}^2)$ random variable representing unanticipated monetary policy innovations realized in period t. The last element $\varepsilon_{z,t-4}^4 \sim iid(0, \sigma_{\varepsilon_{znews}}^2)$ is the anticipated monetary policy shock which is observed four periods ahead of its realization. With the above specification of monetary policy, money is endogenous. The monetary authority adjusts money supply to accommodate money demand. The newly created money is circulated in the economy as lump-sum transfers to the households, so that $T_t = M_t - M_{t-1}$.

3.3 Symmetric Equilibrium

In a symmetric equilibrium all the intermediate-goods-producing firms make identical decisions so that

$$P_{jt} = P_t, y_{jt} = y_t, k_{jt} = k_t, h_{jt} = h_t, \text{ and } D_{jt} = D_t$$

during each period $t \ge 0$. Furthermore, the market clearing conditions $M_t = M_{t-1} + T_t$, $B_t = 0$, $\tilde{B}_t^{\star} = B_t^{\star}$ must hold for all $t \ge 0$ and the market clearing condition for the
final goods market is

$$y_{t} = c_{t} + s_{t} + i_{t} + \frac{e_{t}B_{t}^{\star}}{\kappa_{t}P_{t}R_{t}^{\star}} - \frac{e_{t}B_{t-1}^{\star}}{P_{t}} + \frac{\phi_{k}}{2}k_{t}\left(\frac{k_{t+1}}{k_{t}} - 1\right)^{2} + \frac{\phi_{p}}{2}y_{t}\left(\frac{P_{t}}{\pi P_{t-1}} - 1\right)^{2}$$
(3.22)

where $\frac{e_t B_t^{\star}}{\kappa_t P_t R_t^{\star}} - \frac{e_t B_{t-1}^{\star}}{P_t}$ represents trade balance. The optimality conditions are presented in Appendix B.3 where all the small case letters denote real variables e.g. $r_{kt} = \frac{R_{kt}}{P_t}$, $w_t = \frac{W_t}{P_t}$, $m_t = \frac{M_t}{P_t}$, $b_t^{\star} = \frac{B_t^{\star}}{P_t^{\star}}$ and $\tilde{e_t} = \frac{e_t P_t^{\star}}{P_t}$ denotes real exchange rate. We assume that the real exchange rate is one under the assumption of law of one price.⁵

3.4 Calibration, Data and Estimation

The model is solved using a first-order linear approximation method as implemented in Dynare. The parameters described in Table B.1.1 are set prior to estimation. The preference parameter ω is set to 1.6 which is common in the literature whereas the technology parameters α , δ , θ_y and χ are calibrated following Dib (2011). The value of θ_y implies a mark-up of price over marginal cost equal to 20 percent which is also used in Ireland (2001).

The non-calibrated parameters are estimated using Bayesian methods and Canadian and US data over the time period 1981Q3-2012Q4. Following Dib (2011) the data set starts from 1981Q3 since the Bank of Canada abandoned M1 targeting by the middle

 $^{{}^{5}}$ It would be interesting to adapt Smets and Wouters (2007) to a SOE set-up and investigate the role of monetary policy news shocks therein.

of 1981. The set of observables include the level of the trade balance-output ratio, Canadian and US 3-month T-bills as well as the growth rates of output, consumption, investment, the price level of Canada and US, and real money balances.⁶

Let tby denote the trade balance-output ratio, $R_{t,obs}$ and $R_{t,obs}^{\star}$ denote Canadian and US 3-month t-bill rates respectively. Both $R_{t,obs}$ and $R_{t,obs}^{\star}$ are de-trended by regressing them on a constant and a time trend. Also let $g_{y,t}$, $g_{c,t}$ and $g_{invest,t}$, $g_{P,t}$, $g_{m,t}$ and $g_{P^{\star},t}$, denote the growth rate of GDP, consumption, investment, Canadian price level (measured by the Consumer Price Index), real money balances (measured by $\frac{M2+}{P_t}$) and US price level (measured by the Consumer Price Index) respectively. We use the following measurement equations

$$g_{y,t} = \log\left(\frac{y_t}{y_{t-1}}\right) \tag{3.23}$$

$$g_{c,t} = \log\left(\frac{c_t}{c_{t-1}}\right) \tag{3.24}$$

$$g_{invest,t} = \log\left(\frac{i_t}{i_{t-1}}\right) \tag{3.25}$$

$$g_{p,t} = \log\left(\frac{P_t}{P_{t-1}}\right) \tag{3.26}$$

$$g_{m,t} = \log\left(\frac{m_t}{m_{t-1}}\pi_t\right) \tag{3.27}$$

$$tby_t = \frac{tb_t}{y_t} \tag{3.28}$$

⁶Growth rates are first differences of logged data.

$$R_{t,obs} = R_t - \bar{R} \tag{3.29}$$

$$R_{t,obs}^{\star} = R_t^{\star} - \bar{R^{\star}} \tag{3.30}$$

$$g_{P^\star,t} = \pi_t^\star - \bar{\pi^\star} \tag{3.31}$$

All the observables (except for tby) are demeaned so that they have mean of zero both in the model and in the data. We estimate the parameters governing the stochastic process of productivity (ρ_a , σ_{ε_a} , $\sigma_{\varepsilon_{anews}}$), MEI (ρ_n , σ_{ε_n} , $\sigma_{\varepsilon_{nnews}}$), money demand (ρ_l , σ_{ε_l}), preference (ρ_{ψ} , $\sigma_{\varepsilon_{\psi}}$), monetary policy (ρ_z , σ_{ε_z} , $\sigma_{\varepsilon_{znews}}$), domestic spending (ρ_s , σ_{ε_s} , $\sigma_{\varepsilon_{snews}}$), US inflation (ρ_{π^*} , $\sigma_{\varepsilon_{\pi^*}}$, $\sigma_{\varepsilon_{\pi^*news}}$) and the parameters governing the degree of capital adjustment costs (ϕ_k), price adjustment costs (ϕ_p), interest rate sensitivity to output gap a_y , inflation gap a_{π} , money supply gap a_{μ} , US interest rate gap a_{R^*} and the preference parameters (ν and η). Table B.1.2 presents the prior and posterior distributions of the estimated parameters and Appendix B.2 report the diagnostic results of the estimation. Figure B.19 provides the historical and simulated time paths of the observables.

While estimating the model, we consider one year (four quarters) ahead news shocks. The estimation uses 2.5 million MCMC chain of which the first 1.25 million are dropped. The small estimated value of a_y is consistent with Bailliu et al. (2015), Dib (2006) and Dib (2011) whose estimated values are 0.0776, 0.0806 and 0.001 respectively. However, Murchison (2009) and Dong (2013) estimate a_y to be 0.62 and 0.93 respectively for Canada. Dong (2013) documents that because of the presence of limited exchange rate pass-through, his benchmark model implies less output volatility resulting in a higher coefficient for the central banks response to output deviations. Therefore, we run some sensitivity tests around values of a_y in Section 3.7 in order to check the robustness of our results.

3.5 Results

Table B.1.4 reports the unconditional variance decomposition (associated with the estimates reported in Table B.1.2) which shows that Canadian monetary policy news shocks explain about 7% of the variation of output and consumption growth, 22% of the variation of inflation and 34% of the variation of money supply growth. Our results are also consistent with those of Gomes et al. (2017) who find that monetary policy news shocks explain about 10%, 12% and 5% of the variation of output, consumption and investment growth respectively in the US economy.⁷ The explanatory capacity of surprise monetary policy shocks is also in line with Gomes et al. (2017) who find that surprise monetary policy shocks explain about 8%, 13% and 3% of the variation of output, consumption and investment growth respectively for the US economy. Our results show that monetary policy news shocks do not appear as a significant driver of Canadian investment and the trade balance which are mostly explained by TFP shocks, MEI shocks, preference shocks, surprise US interest rate shocks and US

⁷Milani and Treadwell (2012) find that monetary policy news shocks account for about 15-25% of the fluctuations of US output gap. They do not report the contribution of these shocks to US growth rate of consumption, investment etc. They also find that surprise monetary policy shocks explain less than 2% of US output fluctuations.

interest rate news shocks. The fact that surprise US interest rate shocks are important for Canadian economy is consistent with the findings of Bhuiyan (2012).

Next, we look at the conditional variance decomposition of the benchmark model, M1 across different time horizons reported in Table B.1.5. We choose the time periods (1, 4, 8, 12, 20 and 40) following Ireland (2006) where each period represents a quarter. The results show that monetary policy news has very similar explanatory capacity across all six time horizons. Moreover, the explanatory power of monetary policy news shocks is very similar in the unconditional and conditional variance decompositions of the benchmark model, M1.

Table B.1.6 and Table B.1.7 report the conditional variance decomposition for unanticipated and anticipated US interest rate shocks respectively for the benchmark model (M1). The explanatory capacity of these shocks are very similar across the conditional and unconditional variance decomposition (reported in Table B.1.4).

Therefore, our results suggest that monetary policy news shocks are not a significant source of Canadian business cycles. The explanatory capacity of these shocks is specially limited for investment and trade balance.⁸

⁸We restrain from including trend shocks in this model since Bolaños et al. (2012) who study the relative importance of including trend shocks and financial frictions in characterizing the business cycles in 12 emerging and 12 developed economies, find that on average trend shocks play a larger role in generating economic fluctuations in emerging economies relative to developed SOEs lending support to the findings in Aguiar and Gopinath (2007).

3.6 Impulse Response Functions

3.6.1 Monetary Policy News

In this section we interpret the impulse response functions (IRFs) obtained from our benchmark model and shown in Figures B.20, B.21 and B.22. In the discussion below, variables with an upper bar denote their corresponding steady state values.

We begin the analysis with consumers since they are the only agents active in the domestic bonds market and hence are affected by the news. They learn in period 1 that four periods later the domestic interest rate, R_5 will be higher than it would have been if the economy had stayed in steady state. Therefore, they want to position themselves accordingly for the expected increase in R_5 which will make borrowing on domestic market more expensive and lending on domestic market more profitable. Since consumers can borrow from abroad when the domestic interest rate increases, it is profitable for them to lend in the domestic market in period 5 to take advantage of the higher R_5 . We know that domestic bonds are always in zero net supply so if $R_1 < \bar{R}$ then it must be that there is an increase in the demand for domestic bonds to increase their price in period 1 and to lower R_1 since $Price = \frac{1}{R}$.

Therefore, the consumers would want to save/lend in period 1 to build up a stock of domestic bonds that will have a higher return starting in period 5. In order to save in period 1, they lower consumption (hence $c_1 < \bar{c}$). If consumers demand fewer units

of goods, then intermediate firms experience a decrease in demand and would then lower their prices. Hence, $P_1 < P_0 = \bar{P}$ and $\pi_1 = \frac{P_1}{P_0} < \bar{\pi}$. Also, less demand for goods means that firms produce less $(y_1 < \bar{y})$ and reduce their demand for labour $(h_1 < \bar{h})$ and capital so factor prices w_1 and r_{k_1} are lower than in steady state. Moreover, they would also like to have more income/output when period 5 arrives. To generate more income/output in the future they need to build up their capital stock (with capital adjustment costs it would be very costly to wait until period 4 to increase capital). Hence I_1 is a little higher than \bar{I} . Since output falls, consumers need to borrow from abroad to finance their investments. An initial trade balance deficit is consistent with $B_1^* < \bar{B}^*$.

Comparing our IRFs with those of Gomes et al. (2017)'s closed economy model, we see that on impact of the news, investment moves in opposite directions in the two models– in our model investment rises where as in Gomes et al. (2017) investment falls.⁹ In our SOE set-up, it is possible for the households to increase investment even when domestic output falls by borrowing from abroad. While comparing the results, we should keep in mind that the two models differ not only with respect to openness to the international financial market, they have different underlying structures which could also contribute to differences in the results. However, in both models monetary policy news shocks have contractionary effects before it materializes. Moreover, the

⁹Milani and Treadwell (2012) report only the IRFs of output gap and inflation. In their paper current output gap depends on expected and lagged output gaps and on the ex-ante real interest rate where as in our model output gap is defined as the gap between current and steady state level of output. Hence, we restrain from comparing them. Inflation falls in both models on impact of the news.

other variables e.g. output, consumption, hours, wages, rental rate of capital and inflation move in the same direction on impact of the news in both models.

3.7 Sensitivity Tests

We conduct a number of sensitivity tests in order to check the robustness of the results of the benchmark model (M1). Table B.1.8 reports the percentage of fluctuations in growth rate of output, consumption, investment, trade balance, inflation and money supply explained by monetary policy news shocks in four different versions of this model (discussed below) based on unconditional variance decomposition. In all these cases monetary policy news shocks retain similar explanatory capacity as found in the benchmark model, M1.

First, we set a_{R^*} to zero in order to check if results are sensitive to Canadian interest rates being a function of US interest rate changes. Let's call this model M2. The unconditional variance decomposition of the model, reported in Table B.1.8 shows that monetary policy news shocks retain similar explanatory power compared to M1 even when a_{R^*} is zero. For convenience, we have reproduced the unconditional variance decomposition results of M1 in Table B.1.8. Next, Table B.1.9 shows the conditional variance decomposition when a_{R^*} is zero.

Second, we set a_y to be 0.25 and call this model M3. Although several studies including Bailliu et al. (2015); Beaudry and Portier (2006b); Dib (2011); Alpanda et al. (2014) report a_y to be close to zero, there are a few studies e.g. Dong (2013); Murchison (2009) that estimate a_y to be very large as discussed in section 3.5. Therefore, it is worth investigating if the value of a_y influences the explanatory power of monetary policy news shocks. Our results from unconditional and conditional variance decomposition reported in Table B.1.8 and B.1.10 respectively, show that monetary policy news shocks retain similar explanatory power as found in M1.

Next, we get rid off some of the shocks that did not have a lot of explanatory capacity in model M1 based on the results reported in B.1.4 in order to obtain a version of the model where the number of shocks is equal to the number of observables, 9, to better identify the estimated parameters.¹⁰ Let's call this model M4. Both the unconditional and conditional variance decomposition results of this model reported in Table B.1.8 and B.1.11 confirm the findings of model M1.

3.8 Conclusion

The study explores the contribution of monetary policy news shocks to Canadian business cycles in a NK SOE framework. The model incorporates nominal and real rigidities in the form of price adjustment costs and capital adjustment costs. Motivated by the high correlation of 0.70 observed between Canadian and US 3-month t-bill rates from 1981Q3-2012Q4, we introduce a new component in the central bank's

¹⁰More specifically, we get rid off domestic spending shocks including both surprise and news components, TFP news shocks, US interest rate news shocks and US inflation news shocks. Smets and Wouters (2007) also have number of shocks equal to the number of observables.

reaction function namely, the US interest rate deviation from its steady state. The central bank is assumed to adjust a linear combination of short term nominal interest rate and money supply growth in response to inflation deviations, output deviations and US interest rate deviations from their steady-state values. We then estimate the model with Bayesian methods and Canadian and US data. We perform both unconditional and conditional variance decompositions of the model and the results show that Canadian monetary policy news shocks are not a major contributor to Canadian business cycles. More specifically, the unconditional variance decomposition shows that monetary policy news shocks explain about 7% of the variation of output growth and consumption growth, 22% of the variation of inflation and 34% of the variation of money supply growth. In the conditional variance decomposition as well monetary policy news shocks retain very similar explanatory power. The explanatory power of these shocks is specially limited for investment and trade balance of Canada. We have also tested the robustness of our results in three different ways which reconfirm the results of the benchmark model discussed above. Therefore, our results suggest that although monetary policy news shocks explain a good fraction of variation in inflation and money supply growth, overall, they are not a major contributor to Canadian business cycles.

Appendix B

B.1 Tables

Table $B.1.1$:	Calibrated	Parameters
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Parameter	γ	α	ω	θ_y	β	\bar{d}	χ
Values	2	0.33	1.6	6	0.98	-0.27	0.0054

parameters	Distribution	Min	Max	Prior Mean	Std.Dev	Posterior mean	5%	95%
ρ_a	beta			0.70	0.20	0.97	0.96	0.98
ρ_z	beta			0.70	0.20	0.92	0.89	0.95
$ ho_R\star$	beta			0.70	0.20	0.64	0.58	0.71
ρ_s	beta			0.70	0.20	0.90	0.85	0.95
ρ_n	beta			0.70	0.20	0.94	0.92	0.97
$ ho_l$	beta			0.70	0.20	0.64	0.57	0.70
$ ho_\psi$	beta			0.70	0.20	0.98	0.96	0.99
$\rho_{\pi}\star$	beta			0.70	0.20	0.43	0.27	0.58
$ ho_R$	beta			0.70	0.20	0.80	0.60	0.99
σ_a	inv-gamma			0.01	2	0.008	0.007	0.009
σ_{anews}	inv-gamma			0.01	2	0.003	0.002	0.004
σ_s	inv-gamma			0.01	2	0.01	0.0026	0.0250
σ_{snews}	inv-gamma			0.01	2	0.02	0.01	0.03
σ_z	inv-gamma			0.01	2	0.02	0.02	0.03
σ_{znews}	inv-gamma			0.01	2	0.03	0.03	0.04
$\sigma_R \star$	inv-gamma			0.01	2	0.007	0.006	0.008
$\sigma_{R^{\star}news}$	inv-gamma			0.01	2	0.004	0.003	0.005
$\sigma_{\pi}\star$	inv-gamma			0.01	2	0.002	0.0015	0.0021
$\sigma_{\pi^{\star}news}$	inv-gamma			0.01	2	0.002	0.0016	0.0022
σ_ψ	inv-gamma			0.01	2	0.12	0.06	0.17
σ_l	inv-gamma			0.01	2	1.02	0.89	1.16
σ_n	inv-gamma			0.01	2	0.04	0.03	0.05
σ_{nnews}	inv-gamma			0.01	2	0.01	0.002	0.02
a_{π}	gamma			1.5	3	3.64	2.74	4.52
a_{μ}	uniform	0	3	1.5	0.87	2.85	2.67	3
$a_{R^{\star}}$	uniform	0	1	0.50	0.29	0.27	0.00	0.58
a_y	uniform	0	0.45	0.225	0.13	0.007	0.00	0.02
ϕ_k	gamma			20	1	22.87	21.30	24.50
ϕ_p	gamma			10	1	5.30	4.89	5.73
ν	uniform	-6	0	-3	1.73	-5.88	-6.00	-5.72
η	uniform	0	0.99	0.495	0.29	0.99	0.9860	0.99

Table B.1.2: Prior and Posterior Distributions, LDD=3483.44

	g_y	g_c	g_i	tby	π_{obs}	μ_{obs}	$R^{\star}{}_{obs}$	R_{obs}	π^{\star}_{obs}
Std. deviation									
Data	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.002
Model $(M1)$	0.04	0.05	0.05	0.03	0.04	0.05	0.01	0.02	0.002
Correl. with g_y									
Data		0.37	0.61	0.25	-0.24	-0.35	-0.15	-0.48	0.03
Model $(M1)$		0.97	-0.18	0.14	0.57	-0.57	0.04	-0.01	0.01

Table B.1.3: Moments, Canada (1981Q3-2012Q4)

Table B.1.4: Unconditional Variance Decomposition: M1 (Benchmark Model)

Shock	g_y	g_c	g_{invest}	tby	π_{obs}	μ_{obs}
TFP	6.71	3.95	14.16	3.98	2.99	3.04
Anticipated TFP	1.87	0.40	1.25	5.01	0.21	0.21
Domestic spending	0.00	0.00	0.03	0.25	0.01	0.01
Anticipated domestic spending	0.06	0.0.7	0.35	9.99	0.08	0.08
MEI	0.48	0.32	21.36	31.69	0.16	0.19
Anticipated MEI	0.02	0.01	1.28	1.40	0.00	0.01
Money demand	52.29	58.57	0.03	1.41	24.91	22.98
Preference	0.25	1.84	5.13	18.66	0.33	0.23
Monetary policy	12.41	13.21	0.00	0.45	31.33	20.49
Anticipated monetary policy	6.86	7.26	0.05	0.30	22.11	33.63
US int. rate	17.20	12.91	46.72	17.00	15.22	16.37
Anticipated US int. rate	1.42	1.11	8.36	9.08	2.24	2.32
US inflation	0.12	0.10	0.23	0.06	0.08	0.08
Anticipated US inflation	0.31	0.25	1.06	0.73	0.34	0.36

Table B.1.5: Conditional Variance Decomposition: M1 (benchmark model)

				J						
	Quarters Ahead									
Observables	1	4	8	12	20	40				
g_y	5.07	7.03	6.87	6.87	6.86	6.86				
g_c	5.20	7.32	7.27	7.27	7.27	7.27				
g_{invest}	0.05	0.05	0.05	0.05	0.05	0.05				
tby	1.11	0.58	0.44	0.41	0.40	0.37				
π_{obs}	19.43	19.07	20.60	21.42	21.97	22.11				
μ_{obs}	24.26	22.21	28.87	31.55	33.22	33.64				

The Variation Share of Monetary Policy News Shocks

		Quarters Ahead								
Observables	1	4	8	12	20	40				
$\overline{g_y}$	13.73	17.73	17.24	17.23	17.22	17.21				
g_c	8.10	13.06	12.94	12.93	12.93	12.92				
g_{invest}	43.42	48.70	46.89	46.77	46.77	46.75				
tby	50.96	32.49	24.54	23.24	22.78	20.97				
π_{obs}	15.54	16.33	15.70	15.45	15.28	15.23				
μ_{obs}	20.04	21.24	18.29	17.22	16.56	16.39				

Table B.1.6: Conditional Variance Decomposition: M1 (benchmark model)

The Variation Share of Surprise US Interest Rate Shocks

Table B.1.7: Conditional Variance Decomposition: M1 (benchmark model)

	Quarters Ahead									
Observables	1	4	8	12	20	40				
g_y	0.47	0.68	1.42	1.42	1.42	1.42				
g_c	0.08	0.45	1.10	1.11	1.11	1.11				
g_{invest}	6.81	6.17	8.27	8.37	8.36	8.36				
tby	6.79	11.44	11.61	11.26	11.67	11.16				
π_{obs}	1.57	1.51	2.16	2.27	2.24	2.24				
μ_{obs}	1.96	1.78	2.53	2.43	2.34	2.34				

The Variation Share of US Interest Rate News Shocks

Table B.1.8: Unconditional Variance Decomposition Across Models

		1 MIOIN	Juary I	oncy	TICMB	JHOURS
Model Versions	g_y	g_c	g_{invest}	tby	π_{obs}	μ_{obs}
M1	6.86	7.26	0.05	0.30	22.11	33.63
M2	7.67	8.04	0.06	0.31	25.44	36.01
M3	10.79	11.38	0.35	0.68	37.98	39.96
M4	9.41	9.95	0.04	0.45	28.06	40.14

The Variation Share of Monetary Policy News Shocks

	Quarters Ahead								
Observables	1	4	8	12	20	40			
g_y	5.77	7.85	7.68	7.68	7.67	7.67			
g_c	5.86	8.11	8.05	8.05	8.05	8.05			
g_{invest}	0.06	0.06	0.06	0.06	0.06	0.06			
tby	1.23	0.63	0.48	0.45	0.44	0.40			
π_{obs}	21.97	21.53	23.30	24.35	25.16	25.44			
μ_{obs}	26.16	24.25	30.45	33.28	35.32	36.01			

Table B.1.9: Conditional Variance Decomposition: M2 $(a_R^{\star}=0)$

The Variation Share of Monetary Policy News Shocks

Table B.1.10: Conditional Variance Decomposition: M3 $\left(a_y=0.25\right)$

	Quarters Ahead									
Observables	1	4	8	12	20	40				
g_y	7.72	11.12	10.82	10.81	10.80	10.80				
g_c	7.71	11.53	11.40	11.39	11.39	11.38				
g_{invest}	0.40	0.36	0.35	0.35	0.35	0.35				
tby	2.14	1.13	0.86	0.82	0.79	0.74				
π_{obs}	24.93	25.21	28.19	30.56	33.61	36.78				
μ_{obs}	29.49	28.86	31.27	33.32	36.01	38.86				

The Variation Share of Monetary Policy News Shocks

Table B.1.11: Conditional Variance Decomposition: M4 (number of shocks equal to the number of observables)

The Variation Share of Monetary Policy News Shocks

	Quarters Ahead									
Observables	1	4	8	12	20	40				
g_y	7.09	9.42	9.43	9.43	9.42	9.42				
g_c	7.08	9.95	9.97	9.97	9.96	9.96				
g_{invest}	0.04	0.04	0.04	0.04	0.04	0.04				
tby	1.30	0.78	0.65	0.61	0.61	0.56				
π_{obs}	25.16	24.13	26.14	27.14	27.85	28.06				
μ_{obs}	29.37	26.73	34.54	37.61	39.59	40.15				

B.2 Convergence Diagnostics



Figure B.1: Univariate Convergence Diagnostics: M1 (1)



Figure B.2: Univariate Convergence Diagnostics: M1 (2)



Figure B.3: Univariate Convergence Diagnostics: M1 (3)



Figure B.4: Univariate Convergence Diagnostics: M1 (4)



Figure B.5: Univariate Convergence Diagnostics: M1 (5)



Figure B.6: Univariate Convergence Diagnostics: M1 (6)



Figure B.7: Univariate Convergence Diagnostics: M1 (7)



Figure B.8: Univariate Convergence Diagnostics: M1 (8)



Figure B.9: Univariate Convergence Diagnostics: M1 (9)



Figure B.10: Univariate Convergence Diagnostics: M1 (10)



Figure B.11: Univariate Convergence Diagnostics: M1 (11)



Figure B.12: Multivariate Convergence Diagnostics: M1

B.2.1 Priors and Posteriors



Figure B.13: Priors and Posteriors: M1(1)



Figure B.14: Priors and Posteriors: M1(2)



Figure B.15: Priors and Posteriors: M1(3)



Figure B.16: Priors and Posteriors: M1(4)

B.2.2 Smoothed Shocks



Figure B.17: Smoothed Shocks: M1(1)



Figure B.18: Smoothed Shocks: M1(2)



B.2.3 Historical and Smoothed paths

Figure B.19: Historical and Smoothed paths (1981Q3-2012Q4)

B.3 Impulse Response Functions



Figure B.20: Impulse Response Functions-Monetary Policy News Shocks (Figure 1)



Figure B.21: Impulse Response Functions-Monetary Policy News Shocks (Figure 2)



Figure B.22: Impulse Response Functions-Monetary Policy News Shocks (Figure 3)

B.4 Optimality Conditions

B.4.1 Optimality Conditions of the Households

The optimality conditions are derived under the assumption of symmetric equilibrium. Household's optimality conditions with respect to c_t , m_t , h_t , b_t , b_t^* and k_{t+1} are presented below.

$$\eta \left(\left(\eta \, c_t^{\nu} + l_t \left(1 - \eta \right) \, m_t^{\nu} \right)^{\frac{1}{\nu}} - \frac{\theta}{\omega} \, h_t^{\omega} \right)^{(-\gamma)} \left(\eta \, c_t^{\nu} + l_t \left(1 - \eta \right) \, m_t^{\nu} \right)^{\frac{1}{\nu} - 1} \, c_t^{\nu - 1} = \lambda_t \quad (B.1)$$

$$l_{t} (1-\eta) \left(\left(\eta c_{t}^{\nu} + l_{t} (1-\eta) m_{t}^{\nu} \right)^{\frac{1}{\nu}} - \frac{\theta}{\omega} h_{t}^{\omega} \right)^{(-\gamma)} \left(\eta c_{t}^{\nu} + l_{t} (1-\eta) m_{t}^{\nu} \right)^{\frac{1}{\nu}-1} c_{t}^{\nu-1} = \lambda_{t} - \frac{\beta \lambda_{t+1}}{\pi_{t+1}}$$
(B.2)

$$\theta \left(\left(\eta \, c_t^{\nu} + l_t \left(1 - \eta \right) \, m_t^{\nu} \right)^{\frac{1}{\nu}} - \frac{\theta}{\omega} \, h_t^{\omega} \right)^{(-\gamma)} \, h_t^{\omega - 1} = \lambda_t \, w_t \tag{B.3}$$

$$\frac{1}{R_t} = \beta \, \frac{\lambda_{t+1}}{\lambda_t \, \pi_{t+1}} \tag{B.4}$$

$$\frac{1}{\kappa_t R^{\star}_t} = \beta \, \frac{\lambda_{t+1}}{\lambda_t \, \pi^{\star}_{t+1}} \frac{\tilde{e}_{t+1}}{\tilde{e}_t} \tag{B.5}$$

$$\lambda_{t} \left(\frac{1}{n_{t}} + \phi \left(\frac{k_{t+1}}{k_{t}} - 1 \right) \right) = \beta \mathbb{E}_{t} \lambda_{t+1} \left[r_{kt+1} + \frac{1 - \delta}{n_{t+1}} - \frac{\phi_{k}}{2} \left(\frac{k_{t+2}}{k_{t+1}} - 1 \right)^{2} \right] + \beta \mathbb{E}_{t} \lambda_{t+1} \left[\phi_{k} \frac{k_{t+2}}{k_{t+1}} \left(\frac{k_{t+2}}{k_{t+1}} - 1 \right) \right]$$
(B.6)

B.4.2 Optimality Conditions of the Intermediate-good-producing

Firms

$$w_t q_t = \frac{y_t (1 - \alpha)}{h_t} \tag{B.7}$$

$$r_{kt} q_t = \alpha \frac{y_t}{k_t} \tag{B.8}$$

$$q_t^{(-1)} = \frac{\theta_y - 1}{\theta_y} + \frac{\phi_p}{\theta_y} \frac{\pi_t \left(\frac{\pi_t}{\bar{\pi}} - 1\right)}{\bar{\pi}} - \frac{\beta \phi_p}{\theta_y} \mathbb{E}_t \left(\frac{\pi_{t+1} \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{\pi_{t+1} - 1}{\bar{\pi}} - 1\right)}{\bar{\pi}} \frac{y_{t+1}}{y_t}\right) \tag{B.9}$$

B.5 Data Appendix

Canadian GDP:

http://www.columbia.edu/ mu2166/book/empirics/

Canadian gross capital formation:

http://www.columbia.edu/ mu2166/book/empirics/

Canadian final consumption expenditure:

http://www.columbia.edu/ mu2166/book/empirics/

Canadian trade balance:

http://www.columbia.edu/ mu2166/book/empirics/

Canadian Consumer Price Index (CPI):

https://research.stlouisfed.org/fred2/series/CANCPIALLQINMEIUS

Canadian M2+:

https://research.stlouisfed.org/fred2/data/MABMM203CAQ189S.txt

Canadian Population (aged over 15):

Table 051-0001 Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual (persons)(1,2,6,7)

Canadian 3-month Treasury Bill Rate:

v122541, Table 176-0043: Financial market statistics, Canada; Treasury bill auction

- average yields: 3 month

US 3-month Treasury Bill Rate:

https://research.stlouisfed.org/fred2/series/TB3MS

US Consumer Price Index (CPI):

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Chapter 4

Does Reacting to US Interest Rate Changes Help the Bank of Canada Fulfill its Mandate?

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4.1 Introduction

In this chapter, we use the NK DSGE model of Chapter 3 to study optimal monetary policy for Canada. According to Verona et al. (2017) there are two traditions in the literature regarding the study of optimal monetary policy. On the one hand, Wood-ford (2011) and the following literature study social welfare maximizing policies.¹ In

¹See for example Faia and Monacelli (2007); Kobayashi et al. (2008); Curdia and Woodford (2010); Gertler and Karadi (2011); Woodford (2012); Fiore and Tristani (2013); Hirakata et al.

this strand of literature an optimal monetary policy is the one that maximizes the households' utility function. On the other hand, others argue that an optimal monetary policy is the one that best achieves a central bank's mandate to intertemporally minimize its loss function.² This loss function is usually defined as a weighted sum of the variances of inflation, output gap and of nominal interest rate changes. According to Svensson (2010); Adolfson et al. (2011); Verona et al. (2017), although the first approach allows for theory consistent Ramsey policy, it is more complex, less robust, not necessarily implementable, difficult to verify and sensitive to all distortions in the economy. Verona et al. (2017) also argue that the latter is more suitable for models with financial frictions and that the issue of implementability is important when we try to identify a policy rule that a central bank can actually pursue. Therefore, like Verona et al. (2017), we adopt the second approach in this study.³

The estimated monetary policy rule obtained in Chapter 3 provides evidence that the Canadian central bank reacted to changes in US interest rates over the period 1981Q3-2012Q4. Was this the optimal rule to follow? This is one of the questions we address in this study. To this end, we represent the mandate of the central bank by a quadratic loss function which is a weighted sum of the variances of inflation, output gap and nominal interest rate changes.

^{(2013);} Lambertini et al. (2013); Quint and Rabanal (2014).

²See for example Castelnuovo and Surico (2004); Dieppe et al. (2005); Jung et al. (2005); Lippi and Neri (2007); Sala et al. (2008); Adolfson et al. (2011); Nisticò (2012); Huang and Davis (2013); Gelain et al. (2013).

 $^{^{3}}$ Several studies have followed this approach for Canada e.g.Cayen et al. (2006); Meenakshi and Mendes (2007); Tomura (2009).

We begin with an exercise where we ask whether the central bank would have done better or worse (in terms of its loss function) if it did not react to US interest rates, holding everything else equal. To answer this question we simulate the model estimated in Chapter 3 and we calculate the value of the loss function for the case where the response coefficient of Canadian monetary policy to US interest rate deviations is 0.27 and we compare it to the value of the loss function under the assumption that the central bank does not react to US interest rates. We find that the value of the loss function is the same under these two scenarios. Hence, dropping the US interest rate from the monetary policy rule of Chapter 3 neither helps nor hurts the central bank in minimizing its loss function.

Next, we ask what values of the monetary policy coefficients would best achieve the central banks mandate (and minimize its loss function)? Would such an optimal interest rule respond to US interest rate changes? To answer these questions we obtain an optimal simple rule (OSR) for Canada under different policy regimes reflected in different weights attached to the three terms of the loss function. Now we search over all the policy coefficients that would minimize the loss function taking the rest of the parameters fixed at their Bayesian estimates. Hence, the OSR produces the optimal values of the interest rate rule parameters for which the loss function is minimized and the central bank's mandate is fulfilled. This exercise allows us to verify whether the OSR includes a positive response coefficient to US interest rate changes and if it is possible to attain a lower level of loss compared to the loss associated with the estimated policy rule. We found that for all the policy regimes considered, the optimal rule has a positive coefficient on US interest rate deviations and a large coefficient on inflation (larger than the one estimated in Chapter 3). Moreover, the optimized rules produce smaller losses compared to the estimated rule for all the policy regimes. Hence, our analysis suggests that the central bank can gain by following the optimized rule over the estimated rule and the optimized rule does include US interest rate deviations in it. All together, in an economy that resembles our artificial economy of Chapter 3, the central bank should include US interest rate deviations in its reaction function and should react even more aggressively to inflation than it did based on our Bayesian estimates in order to better fulfill its mandate.

Section 4.2 discusses the monetary policy rules, Section 4.3 describes policy makers' preference and different policy regimes, Section 4.4 analyzes the optimal simple rules for different policy regimes and Section 4.4 concludes.

4.2 Monetary Policy Rules

We retain the NK DSGE framework developed in Chapter 3. Except for the monetary policy rule coefficients, all parameter values adopted or estimated in Chapter 3 are also used here. Recall that the monetary policy rule augmented with US interest rate deviations is

$$\log\left(\frac{R_t}{\bar{R}}\right) = \rho_R \log\left(\frac{R_{t-1}}{\bar{R}}\right) + a_\mu \log\left(\frac{\mu_t}{\bar{\mu}}\right) + a_y \log\left(\frac{y_t}{\bar{y}}\right) + a_\pi \log\left(\frac{\pi_t}{\bar{\pi}}\right) + a_R \log\left(\frac{R_t}{\bar{R}^\star}\right) + \log(z_t) \quad (4.1)$$

where \bar{R} , $\bar{\mu}$, \bar{y} , $\bar{\pi}$ and \bar{R}^{\star} are steady-state values of R_t , μ_t , y_t , π_t and $R_t^{\star 4}$. Let's treat this monetary policy rule as the benchmark rule and call it M1. Interest rate responses to deviations of money supply growth, output, inflation and US interest rate from their steady state values are captured by a_{μ} , a_y , a_{π} and $a_{R^{\star}}$ respectively. The above interest rate rule also features interest rate smoothing captured by ρ_R . If a_{μ} and $a_{R^{\star}}$ are equal to 0 and $a_y > 0$ and $a_{\pi} > 0$, monetary policy follows a Taylor (1993) rule. The exogenous component, z_t , represents monetary policy shocks. The policy outcomes of this benchmark rule represented by (4.1) will be compared with a rule where Canadian monetary policy does not react to US interest rate deviations (i.e. $a_{R^{\star}} = 0$). Let's call this interest rate rule M2 which is presented by

$$\log\left(\frac{R_t}{R}\right) = \rho_R \log\left(\frac{R_{t-1}}{R}\right) + a_\mu \log\left(\frac{\mu_t}{\mu}\right) + a_y \log\left(\frac{y_t}{y}\right) + a_\pi \log\left(\frac{\pi_t}{\pi}\right) + \log(z_t) \quad (4.2)$$

We keep everything else unchanged of the benchmark model as we compare the policy outcomes of M1 and M2.

⁴Maintaining the notation of Chapter 3 R_t is the gross nominal Canadian interest rate, μ_t is the growth rate of money supply, y_t is the output, π_t is the Canadian inflation rate and R_t^* is the gross nominal US interest rate.

4.3 Canadian Monetary Policy with and without Reaction to US Interest Rate Deviations

Following Verona et al. (2017), we assume that the preferences of the policymaker include a primary goal of price stability and a goal of stabilization of output around potential output. There is also an objective of minimizing the volatility of changes in the policy interest rate, consistent with the fact that central banks typically feature interest rate smoothing (see e.g. Aguiar and Martins (2005)). Analytically, the central bank's mandate may be described as the objective of minimizing a weighted average of the variances of inflation, output gap and nominal interest rate changes:

$$LF = \alpha_{\pi} var(\pi) + \alpha_{y} var(y - \bar{y}) + \alpha_{R} var(\Delta R)$$
(4.3)

where ΔR is the change in nominal interest rate. The loss function (4.3) reflects the mandate for central banks to achieve output and inflation stability. In addition, the last term of the loss function (4.3) is the averseness of the central bank to fluctuating the nominal policy interest rate.⁵ We also consider α_R to be zero (LF1 to LF4) in order to check if the results vary. This general loss function in (4.3) is flexible enough to encompass a wide range of policy regimes, corresponding to different emphases on price, output and interest rates stability, depending on the specific weights α_{π} , α_y and α_R respectively. In the empirical literature, many studies provide estimates for

⁵This type of loss function has been used to study optimal monetary policy for Canada by Cayen et al. (2006); Meenakshi and Mendes (2007); Tomura (2009).

these weights (see e.g. Lippi and Neri (2007), Adolfson et al. (2011) and Ilbas (2012)). We consider three policy regimes and six different parameterization of their relative weights as reported in Table C.1.1. Our weights are in line with those often used in the literature (see e.g. Verona et al. (2017); Ehrmann and Smets (2003)). The first policy regime, LF1 represents a strict inflation targeting regime. The second policy regime is one of flexible inflation targeting in which the central bank also aims at stabilizing the output gap. Here we consider three alternative values for the coefficient attached to output presented by LF2, LF3 and LF4. LF5 and LF6 represent flexible inflation targeting regimes in which the central bank further aims at reducing the volatility of the nominal policy interest rate. In addition, we run a case, LF_{equal} where we assign equal weights of 1 to inflation, output gap and interest rate changes.

We now compare the loss functions generated by M1 and M2 under the policy regime LF_{equal} in which $\alpha_{\pi} = \alpha_y = \alpha_R = 1$. First, we compute the loss function for M1 where $a_{R^{\star}} = 0.27$. In M1, $var(\pi) = 0.0014$, $var(y - \bar{y}) = 0.0289$ and $var(\Delta_R) = 0.0001$. Therefore, the value of the loss function associated with M1 is

$$LF = 1(0.0014) + 1(0.0289) + 1(0.0001)$$
(4.4)

$$\Rightarrow LF = 0.0304$$

Now, we compute the loss function for M2 where where $a_{R^{\star}} = 0.6$ In M2, $var(\pi)$,

⁶While computing the loss functions for M1 and M2, we only change a_{R^*} from 0.27 to 0 and simulate the model to obtain the resulting changes in $var(\pi)$, $var(y - \bar{y})$ and $var(\Delta_R)$. The

 $var(y - \bar{y})$ and $var(\Delta R)$ are the same as in M1. Consequently, the value of the loss function for M2 is the same as M1, 0.0304. Therefore, as we change the value of $a_{R^{\star}}$ from 0.27 to 0, the value of the loss function remains unchanged irrespective of policy regimes.

4.4 An Optimal Simple Rule Under Different Policy Regimes

The optimal monetary policy is a combination of the policy coefficients that achieves the lowest possible value of the loss function. Therefore, the central bank's problem is

$$\min_{\rho_R, a_y, a_\pi, a_\mu, a_{R^\star}} \alpha_\pi var(\pi) + \alpha_y var(y - \bar{y}) + \alpha_R var(\Delta R)$$
(4.5)

We conduct our analysis for a set of policymakers' preferences considering different policy regimes and parameterization of their relative weights as reported in Table C.1.1 and discussed in Section 4.2.

We use Dynare's Optimal Simple Rule (OSR) programme to find the combination of policy coefficients that minimizes the above loss function under different policy regimes and report the results in Table C.1.2.⁷ As we search over the policy coefficients

calibrated and estimated values of the model can be found in B.1.1 and B.1.2.

⁷According to the Dynare manual, the OSR command computes optimal simple policy rules for linear-quadratic problems which consists of choosing a subset of model parameters to minimize

 a_{π} , a_y , a_{μ} , $a_{R^{\star}}$ and ρ_R , we set the parameter bounds similar to Verona et al. (2017) over the following ranges: $1.01 \leq a_{\pi} \leq 4$, $0.001 \leq a_y \leq 1$, $0 \leq a_{\mu} \leq 4$, $0 \leq a_{R^{\star}} \leq 4$ and $0 \leq \rho_R \leq 0.9$.⁸ We treat $a_{R^{\star}}$ in the same way as a_{π} , and a_{μ} . Table C.1.2 shows that for all the policy regimes $a_{R^{\star}}$ is positive and even bigger than its Bayesian estimate of 0.27. Therefore, regardless of the policy regime, the central bank should respond to US interest rate deviations even more aggressively than it did based on our estimated value in order to minimize the loss function and fulfill its mandate.

Table C.1.2 also shows that the inflation coefficient of the optimized rule takes the largest value allowed in our search, namely 4 for all policy regimes.⁹ Next, we remove the upper bounds of the policy coefficients in order to check whether in an unbounded search a_{R^*} is still positive keeping the lower bounds the same and report the results in Table C.1.3.¹⁰ Once again, we find that a_{R^*} is positive and much bigger than its Bayesian estimate of 0.27 confirming that the central Bank should respond to US interest rate changes even more aggressively in order to minimize the loss function

the weighted (co)-variance of a specified subset of endogenous variables, subject to the first order conditions of the model. The OSR solves linear quadratic problems of the type resulting from combining the specified quadratic loss function with a first order approximation to the models equilibrium conditions. The reason is that the first order state-space representation is used to compute the unconditional (co)-variances. Hence, OSR will automatically select order=1.

⁸The lower bounds of a_{π} and a_y are set to ensure that the Taylor principle is satisfied. Although for a_y Verona et al. (2017) use a lower bound of 0.01, we lower the lower bound to 0.001 to accommodate its Bayesian estimate of 0.007. For all the policy coefficients, we use their Bayesian estimates as the initial values in the OSR programme.

⁹Verona et al. (2017) also find the inflation coefficient to be at the upper bound, 4 for different Taylor rule specifications under different policy regimes.

¹⁰While estimating a Ramsey policy, Schmitt-Grohé and Uribe (2007) used (0,3) as parameter bounds for inflation coefficient, output coefficient and interest rate smoothing parameter of the Taylor rule. They also removed the upper bounds as an experiment and found the inflation coefficient to be 332 and output coefficient to be 0.

regardless of the policy regime.

The last column of Table C.1.2 and C.1.3 shows the losses associated with the optimized rules for each policy regime in the bounded and unbounded searches respectively. Compared to the loss associated with the estimated interest rate rule (0.0304), the optimized rules produce smaller losses for each policy regime in both searches. Therefore, the central bank can gain by following a optimized rule instead of the estimated rule although the exact magnitude of gain depends on the policy regime followed. Under the policy regime LF_{equal} , the gain from following the optimized rule over the estimated rule is 1.94% and 6.91% in the bounded and unbounded cases respectively.¹¹

4.5 Conclusion

The study builds up on the NK DSGE framework developed in Chapter 3 where we introduced a new component in the Canadian monetary policy rule namely, the US interest rate changes. A Bayesian estimation of our model showed that the response coefficient of Canadian monetary policy to US interest rate deviations is indeed positive, 0.27. But does reacting to US interest rate deviations help the central bank fulfill its mandate? This is one of the questions we ask in this study. In order to answer this question, we represent the mandate of the central bank by a loss function

¹¹We calculate the gain as $100 * \frac{Loss_{M1} - Loss_{LF_{equal}}}{Loss_{M1}}$ where a positive value means the optimized rule performs better than the estimated one.

which is a linear combination of the variances of inflation, output gap and nominal interest rate changes. The objective of the central bank is to minimize this loss function. We assess the performance of the estimated interest rate rule with and without reaction to US interest rate deviations in minimizing the loss function under different policy regimes. We find that keeping everything else unchanged, increasing the response coefficient of Canadian monetary policy to US interest rate deviations from 0 to 0.27 leaves the loss function unchanged. Hence, with the estimated Canadian monetary policy rule, responding to US interest rate changes does not help or hurt the central bank in fulfilling its mandate. Next, we ask the following questions: what values of the policy coefficients would minimize the loss function and would such an optimal simple rule include US interest rate deviations in it? Taking all the other parameters as given, we search over the policy coefficients that would minimize the loss function. Indeed, the optimal rule has a positive coefficient on US interest rate deviations (larger than its Bayesian estimate) for all the policy regimes. Moreover, it has a large coefficient on inflation. Such optimized interest rate rules produce smaller losses compared to the estimated rule regardless of the policy regimes. Therefore, our analysis suggests that in an economy that resembles our artificial economy, the central bank should include US interest rate deviations in its reaction function and should react even more aggressively to inflation and US interest rate changes than it did based on our Bayesian estimates.

Appendix C

C.1 Tables

Loss functions	α_{π}	α_y	α_R
LF1	1	0	0
LF2	1	1	0
LF3	1	0.5	0
LF4	1	0.1	0
LF5	1	0.5	0.1
LF6	1	0.1	0.1
LF_{equal}	1	1	1

Table C.1.1: Loss Functions and Monetary Policy Regimes

Table C.1.2: Optimal Monetary Policy Rules Under Different Policy Regimes(Bounded)

Policy Regimes	a_{π}	a_{μ}	a_y	$a_{R^{\star}}$	ρ_R	Minimized Loss
LF1	4	0.29	0.001	0.97	0.85	0.00102
LF2	4	4	0.001	4	0.86	0.02975
LF3	4	4	0.001	4	0.61	0.01543
LF4	4	0.44	0.001	2.20	0.90	0.00390
LF5	4	4	0.001	4	0.61	0.01543
LF6	4	0.45	0.001	2.27	0.90	0.00391
LF_{equal}	4	4	0.001	4	0.84	0.02981

Policy Regimes	a_{π}	a_{μ}	a_y	$a_{R^{\star}}$	$ ho_R$	Minimized Loss
LF1	74.54	0.09	0.15	1.99	1.76	0
m LF2	57.41	1.79	0.001	54.08	21.93	0.02825
m LF3	65.47	0.99	0.003	24.99	2.66	0.01408
LF4	84.76	11.17	0.02	32.33	0.14	0.00299
m LF5	76.89	0.85	0.001	29.92	5.23	0.01409
m LF6	105.53	0.44	0.001	40.82	1.46	0.00283
LF_{equal}	57.06	1.83	0.001	53.69	21.79	0.02830

Table C.1.3: Optimal Monetary Policy Rules Under Different Policy Regimes (Unbounded)

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Chapter 5

Conclusion

In this thesis we investigate the theory of news driven business cycles, reincarnated in its modern form by Beaudry and Portier (2004). According to this theory, business cycles may arise solely on the basis of expectations. We take a full-information modelbased approach to conduct an empirical investigation into the relevance of interest rate news shocks in the business cycles of small open economies (SOEs). In particular, we quantify the contribution of country interest rate news shocks and monetary policy news shocks in an SOE context. Moreover, we extend our monetary SOE model to study an optimal monetary policy rule for Canada.

In Chapter 2, we follow the work of García-Cicco et al. (2010) and ask the following question: Do anticipated changes in future country interest rates influence the business cycles of emerging SOEs? In order to answer this question, we introduce country interest rate news shocks in a SOE model. We use annual Argentine data from 1900-2005 to estimate our model using Bayesian methods. We find that anticipated shocks to interest rates explain a significant share of variation in the growth rate of investment and trade balance-output ratio. The model also generates business cycles statistics that are consistent with those of Argentina. We test the sensitivity of our results in many different ways which reconfirm the results of the benchmark model mentioned above. Taken together, there is strong evidence suggesting that country interest rate news shocks are a major driver of the business cycles of emerging SOEs like Argentina and Mexico.

Chapter 3 explores the contribution of monetary policy news shocks in Canadian business cycles. In the same vein as Milani and Treadwell (2012); Gomes et al. (2017) we argue that monetary policy news shocks may affect economic activity by changing the expectations of forward looking economic agents of future policy interest rates. The central banks usually provide information about the future course of monetary policy through forward guidance. Since Milani and Treadwell (2012); Gomes et al. (2017) find that monetary policy news shocks have larger effects on US output compared to surprise monetary policy shocks, it is worth investigating the role of such shocks in Canadian economy. In order to do so we use a New Keynesian Small Open Economy (NK SOE) model similar to Dib (2006) and Dib (2011) and perform a Bayesian estimation using Canadian and US data from 1981Q3-2012Q4 to quantify the contribution of monetary policy news shocks in Canadian economy. The unique feature of our model is the inclusion of US interest rate deviations in the Canadian monetary policy rule motivated by the high correlation between US and Canadian short term nominal interest rates over the time period mentioned above. The variance decomposition of the model reveal that monetary policy news shocks have moderate explanatory power in explaining variations of the growth rate of output and consumption. Although these shocks explain a good portion of the variations in Canadian inflation and money supply growth, their capacity to explain fluctuations in investment and trade balance is limited. We also check the robustness of our results in different ways which re-confirm the results mentioned above.

Building on the model of Chapter 3, Chapter 4 asks the following question: does reacting to US interest rate changes help the central bank fulfill its mandate? To answer this question, we represent the mandate of the central bank by a loss function which is a linear combination of the variances of inflation, output gap and nominal interest rate changes which the central bank seeks to minimize. We assess the performance of the estimated interest rate rule with and without reaction to US interest rate deviations in minimizing the loss function under different policy regimes. We find that under the estimated policy rule reacting to US interest rate changes leaves the loss function unchanged. Next, we ask the following questions: what values of the policy coefficients would minimize the loss function and would the optimal simple rule include US interest rate deviations in it? Taking the other parameters as given, we now search over the policy coefficients that would minimize the loss function. Indeed, the optimal rule has a positive coefficient on US interest rate movements (larger than its Bayesian estimate) for all the policy regimes. Moreover, it has a large coefficient on inflation. Therefore, in an economy like ours, the central bank should include US interest rate deviations in its reaction function and should react even more aggressively to inflation and US interest rate changes than it did based on our Bayesian estimates in order to minimize the loss function.

In regard to the future research, it would be interesting to asses the contribution of monetary policy news shocks for Canada in a model allowing for real exchange rates to vary. Future research may also explore the role of country interest rate news shocks in explaining the variance of consumption of durable goods. Chapter 2 shows that country interest rate news shocks explain a good deal of variation in the growth rate of investment but not of consumption. Since consumption of durable goods behave much like investment, it is worth investigating the role of these shocks in explaining variations of consumption of durables and hence consumption as a whole.

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