The Macroeconomic Effects of Monetary Policy in a Small-Open Economy: Narrative Evidence from Canada

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December 7, 2016

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Abstract

We use narrative evidence along with a novel database of real-time data and forecasts from the Bank of Canada's staff economic projections from 1974 to 2015 to construct a new measure of monetary policy innovations and estimate the effects of monetary policy in Canada. We find that a one percentage point increase in our new shock series leads to a 0.7 per cent decrease in real GDP and a 0.4 per cent fall in the price level. We show that it is crucial for these results to take into account the structural break in the conduct of monetary policy caused by the introduction of inflation targeting in 1992. Moreover, we provide evidence that spillovers from U.S. monetary policy shocks lead to a very similar drop in Canadian GDP and a rise in the short run of the price level.

Keywords: monetary policy, narrative identification, real-time data, real-time forecasts, business cycles.
JEL classification: E31, E32, E43, E52, E58

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1 Introduction

The identification of monetary policy shocks has generated a vast literature in empirical macroeconomics. Much of this literature uses vector autoregressions (VARs), identified with different approaches and finds that the effects of monetary policy in the U.S. are relatively modest, with peak decline estimates ranging between 0.3 and 1 per cent for output following a 100 basis points monetary innovation. The estimates for inflation range between a positive response (coined the "price puzzle" by Eichenbaum (1992) and Sims (1992)), to small negative, depending on the identification strategy used (e.g. Leeper et al. (1996), Christiano et al. (1996, 1999), Bernanke and Mihov (1998), Bernanke et al. (2005), Uhlig (2005)). However, (Romer and Romer (2004), R&R henceforth) find much larger effects of U.S. monetary policy shocks using narrative methods. This strategy employs historical records to construct a series of intended interest rate changes at meetings of the *Federal Open Market Committee* (FOMC) and then isolate the innovations to these interest rate changes that are orthogonal to the Federal Reserve's information set. A 100 basis points from the R&R shock series translates into output and inflation peak declines larger than 4 per cent. Coibion (2012) reconciles the differences between R&R and the previous studies, suggesting that the effects of monetary policy are more likely medium-sized (i.e. about 2 per cent for output and inflation).[1] On the international side, the evidence on the effects of monetary policy comes mostly from VAR methods, frequently applied for various countries; however the evidence from the narrative approach is still scarce. One notable exception is Cloyne and Hürtgen (2016) who use historical documents to construct a detailed real-time and forecast data set for the U.K. and apply the narrative approach to estimate the effects of monetary policy. They find estimates roughly in line with those of Coibion (2012) for the U.S. To our knowledge, it is the only paper to apply the narrative approach to a country different than the U.S.[2]

The narrative approach offers a natural way to tackle the three main challenges facing the identification of monetary policy shocks. First, interest rates and other macroeconomic quantities are determined simultaneously, as policymakers react to changes in the economy

[1] For a great integration of this long literature, see the exhaustive recent survey by Ramey (2016).

[2] The narrative approach has also been employed to identify fiscal shocks; see Romer and Romer (2010) and Ramey (2011) for the U.S. and Cloyne (2013) for the U.K.

and expect to affect it through their actions. Additionally, policy changes do not only depend on the current state of the economy, but also on anticipated future macroeconomic developments as central banks dedicate considerable efforts to forecast the future state of the economy. Finally, policymakers base their decisions on real-time data, which can differ considerably from final revised data often used in many studies.

Our paper applies the narrative approach to Canada, a small-open economy with its own specific institutional details, and provides new evidence on the effects of monetary policy. As in R&R, the first stage of our analysis is to identify the exogenous component of monetary policy. To do this, we use historical documents to construct a series of intended changes in monetary policy and a novel and proprietary database of real-time data and forecasts assembled from the Bank of Canada's staff economic projections from 1973 to 2015. The staff projections are analogous to the Greenbook forecasts prepared by the Federal Reserve Board staff; it is judgemental in the sense that the forecasts are based on different sources of information and economic models. We then use this data set to isolate the innovations to the intended policy changes that are orthogonal to the policymakers' information set.

With our new series of monthly monetary policy innovations in hand, we follow Coibion (2012) and Cloyne and Hürtgen (2016) and proceed to the second stage of our analysis, where we estimate a monthly VAR that includes our new innovations measure (ordered last) as the relevant policy rate, along with real GDP, the price level and commodity prices.[3] Following a 100 basis points monetary policy shock, real monthly output has a peak decline of 0.7 per cent about 18 months after the shock and roughly zero after three years, while the price level (CPI) response is weaker and takes longer to materialize, falling by 0.4 per cent after three years. Overall, we find that monetary policy shocks in Canada generate output effects that are qualitatively in line with narrative evidence for other countries, as Coibion (2012) for the U.S. and Cloyne and Hürtgen (2016). Importantly, we show that it is crucial for these results to depart from R&R and Cloyne and Hürtgen (2016) in two important ways: (i) by controlling for U.S. interest rates as well as the USD/CAD exchange rate in

[3]Most of the studies estimating the effects of monetary policy with monthly data use industrial production due to data availability. These studies argue that because it is highly correlated with real GDP, it is a good proxy for output. We show that the impulse response patterns of real GDP and industrial production are similar, but that the peak response of industrial production is almost twice as large.

the policymakers' information set, and (ii) by accounting for the structural break in the conduct of monetary policy caused by the introduction of inflation targeting (IT) in 1992. We then examine the robustness of our main results to many alternative specifications and assumptions: impulse responses estimated using Jordà (2005)'s local projections approach; different first-stage specifications, measures of output and inflation, VAR assumptions, subperiods; as well as using quarterly data. We find that our results are robust to all these changes. We also find a large price puzzle when we replace our new shock series with a standard measure of monetary policy such as the Bank rate in the VAR. Finally, given Canada's large commercial and financial ties with the U.S., we examine how our main results compare with the response of Canadian real GDP and inflation to U.S. monetary policy shocks. On the one hand, we find very similar responses of Canadian real GDP to U.S. monetary policy shocks, with output reaching a peak decline of 0.8 per cent after 18 months. On the other hand, Canadian inflation rises for about 20 months to a peak 0.5 due to the positive exchange rate pass-through from the depreciation of the Canadian dollar, and then falls when the effect of lower Canadian GDP starts to dominate.

The remainder of the paper is organized as follows. Section 2 details our methodology. It discusses the first-stage regression and data construction. Section 3 shows the estimates of our first-stage regression and presents our new measure of monetary policy shocks for Canada. Section 4 presents the macroeconomic effects of monetary policy in Canada while Section 5 provides many robustness tests. Section 6 concludes.

2 Methodology

Our strategy to identify monetary policy shocks for Canada follows the narrative approach pioneered by R&R for the U.S. and adapted by Cloyne and Hürtgen (2016) for the U.K. This section presents our methodology: how we adapt the narrative approach to the institutional details regarding the historical conduct of monetary policy in Canada, how we specify the first-stage regression, and finally we provide a description of our database construct of real-time data and staff forecasts.[4]

[4]For sake of clarify, from hereon we will follow Cloyne and Hürtgen (2016)'s notation as closely as possible.

2.1 Identification and the first-stage regression

There are well-known econometric issues related to the estimation of the effects of monetary policy shocks, as researchers need to disentangle the endogenous and exogenous movements in the policy instrument. First, interest rates and macroeconomic variables are determined simultaneously; second, policymakers react not only to current economic conditions but also to anticipated future economic developments. Third, policymakers based their decisions on real-time data; however, data availability often restrain researchers to only employ final revised data.

We use the following equation to formally represent the identification problem:

$$S_t = f(\Omega_t) + \mu_t \tag{1}$$

The intended monetary policy variable (S_t) is a combination of systematic component $f(\Omega_t)$, where the function (f) captures the systematic reaction of the policymakers to their information set (Ω_t) and an exogenous component (μ_t) that reflects unexpected changes in monetary policy. The identification problem thus arises from trying to isolate the μ_t innovations while imperfectly observing S_t and Ω_t.

There are many studies that uses VARs to tackle the simultaneity problem. This literature imposes a timing restriction: for example, Christiano et al. (1996, 1999)'s benchmark model assumes that a first block of variables such as output, prices, and commodity prices do not respond to monetary policy shocks within the same period, while monetary policy is allowed to react contemporaneously to the first block of variables. They called this identification strategy the "recursiveness assumption". Other papers in the literature have used factor-augmented VARs (Bernanke et al. (2005)) to exploit a larger set of data as a better proxy of the policymakers' information set, or used sign restrictions (Faust (1998), Uhlig (2005)) to identify the innovations μ_t. However, most of these studies overlook the last two important issues mentioned above: the policymakers's information set (Ω_t) not only consider past and current economic conditions but also include nowcasts and forecasts, and their decisions are based on available data at the time of the decision (i.e. real-time).[5]

[5] Central banks devote a lot of resources monitoring the economy and forecasting the future path of macroeconomic variables (e.g. See Romer and Romer (2000) and Croushore and Stark (2001) for the

The R&R identification strategy —the narrative approach –tackles all three issues above, as it regresses intended policy rate changes on real-time backdata data and staff forecasts from the Federal Reserve's Greenbooks, thus isolating the component of monetary policy orthogonal to the information set.

We apply the R&R approach to identify monetary policy shocks μ_t for Canada.[6] In the first stage of this approach, we need a series of intended changes in monetary policy and a set of macroeconomic variables to control for the Bank of Canada's information set. One of the major contribution of R&R was to use the minutes of the FOMC meetings to construct a series of intended changes in the target Federal Funds rate (FFR), as the Federal Reserve did not always target it explicitly.[7] A handy feature of the Canadian monetary policy framework is that the Bank has always use a target interest rate explicitly (Courchene (1979), Fettig (1994)), even when it emphasized targeting the money supply.[8] Specifically, we construct our intended policy rate using the *target for the overnight rate* from February-96 onward, the *operating band for the overnight rate* between April-94 to February-96, and the *Bank rate* between 1973 to April-94.[9] This framework is very similar as in the U.K., where the policy rate (also called the Bank rate) has always been the relevant policy target (Batini and Nelson (2009), Cloyne and Hürtgen (2016)).[10]

Federal Reserve (U.S.), Duguay and Poloz (1994), Poloz et al. (1994) and Dorich et al. (2013) for the Bank of Canada). Moreover, there can be stark differences of using ex-post revised vs. real-time data when estimating monetary policy reaction functions (e.g. Orphanides (2001, 2003) or Molodtsova et al. (2008)).

[6]We use the term "narrative" because we use various historical documents to (1) construct the intended policy target; (2) construct our database of real-time data and staff forecasts, and (3) to justify the estimation procedure below.

[7]The Volcker's disinflation 1979–82 period is an example when the Federal Reserve was not targeting explicitly the FFR.

[8]During the 1975–82 period, while the Bank publicly stated that its objective was to target the growth rate of the money stock, it achieved this by setting short-term interest rates at levels that would bring the monetary conditions consistent with the Bank's views of inflationary pressures (e.g. Fortin (1979), Sparks (1979), Racette and Raynauld (1994) and Longworth (2003)).

[9]The operating band for the overnight rate has been introduced in April-94, nearly two years before the introduction of the target rate (which is set as the mid point of the operating band). Before February-96, even if the Bank rate has always been the key interest rate at which the Bank lends to chartered banks, we use the operating band as our intended policy rate between April-94 and February-96 because the operating band was introduced as a first step to provide more transparency to monetary policy (Lundrigan and Toll (1998). See Appendix A for more details on the construction of our intended policy rate series and a backgrounder on the key interest rates (such as the Bank rate) at the Bank of Canada.

[10]Also note that the Bank rate, the operating band for the overnight rate, or the target for the overnight rate are not market rates but policy rates announced by the Bank of Canada. It is similar to the intended target FFR that R&R construct from the FOMC documents, and to the U.K. Bank rate used by Cloyne and Hürtgen (2016).

The next step in the derivation of our monetary policy shock series is to remove from the intended policy rate the systematic component $f(\Omega_t)$, thereby addressing the three econometric issues mentioned above. The regression we estimate is

$$\begin{aligned}\Delta i_m =& \alpha + \beta_1 i_{t-d14} + \sum_{h=1}^{3} \rho_h u_{t-h} + \sum_{j=-1}^{2} \gamma_j \hat{y}^f_{m,j} + \sum_{j=-1}^{2} \delta_j \pi^f_{m,j} \\ &+ \sum_{j=-1}^{2} \theta_j (\hat{y}^f_{m,j} - \hat{y}^f_{m-1,j}) + \sum_{j=-1}^{2} \phi_j (\pi^f_{m,j} - \pi^f_{m-1,j}) \\ &+ \beta_2 FFR_{t-d14} + \beta_3 ER_{t-d14} + \beta_4 \Delta FFR_{m-m_{-1}} \beta_5 \Delta ER_{m-m_{-1}} + \epsilon_m\end{aligned} \tag{2}$$

where the dependent variable (Δi_m), the change in the intended policy rate, is measured at a meeting-by-meeting frequency as indicated by the subscript m. The subscript j denotes the quarter of the real-time data or forecast relative to the meeting date, while subscripts $t-h$ and $t-d14$ refer to information from the previous months and two weeks relative to the meeting date, respectively (and not to information from a previous meeting). Specifically, we follow Cloyne and Hürtgen (2016) and regress the change in the intended policy target rate (Δi_m) between two meetings on the one- and two-quarter ahead forecasts of real GDP growth ($\hat{y}^f_{m,j}$) and inflation ($\pi^f_{m,j}$) as well as the nowcast and the real-time 1-quarter lag. We also include the revisions to the forecasts relative to the previous round of forecasts (e.g. $\hat{y}^f_{m,j} - \hat{y}^f_{m-1,j}$) since both the level and change in the forecasts can be important determinants of the Bank's behavior. To control for economic developments between meetings, we include the intended policy rate two weeks before the meeting and the (real-time) rates of unemployment for the previous three months.[11]

The third line of equation (2) departs from R&R and Cloyne and Hürtgen (2016) as we also control for the levels and changes of the U.S. FFR (FFR_{t-d14}) and the logarithm of the USD/CAD nominal exchange rate (ER_{t-d14}) two weeks before the meeting.[12] Canada is a small-open economy with close ties to the U.S., and these variables are included to capture any tendency for the Bank to react to interest rates movements in the U.S. as well

[11]As mentioned by Cloyne and Hürtgen (2016), using forecasts to identify monetary policy shocks has a further advantage since they summarize a wider range of macroeconomic information as well as the anticipated movements in the economy. Our approach thus allows us to identify shocks without including a large set of variables as in the data-rich FAVAR approach of Bernanke et al. (2005).

[12]In Section 5 below, we show that our results are robust to using a seven-day lag instead of 14 days.

as the changes in the value of the Canadian dollar relative to its U.S. counterpart. For example, Fortin (1979), Courchene (1981), and various press releases (e.g. Bank of Canada (1992, 1993)) all point to the Bank reacting to movements in U.S. rates and/or changes in the USD/CAD exchange rate at different points in time. Racette and Raynauld (1992) and Lubik and Schorfheide (2007) provide empirical evidence that the nominal exchange rate has been part of the Bank of Canada policy rule.

While R&R and Cloyne and Hürtgen (2016) use the estimated residuals from their analogous equation (2) over their whole sample of meetings, we make another important departure and break the estimation into two sub-samples of meetings: the first sub-sample includes all those meetings preceding the inflation-targeting period (i.e. pre-1992) and the second sub-sample regroup all meetings afterward (1992-on). The reason for doing this is three-fold: first, there is evidence suggesting a change in the Bank's reaction function. For example, Rowe and Yetman (2002) show that there was a major change in the Bank's objectives near the time formal inflation targets were announced (i.e. in 1992). Moreover, Courchene (1981) and Howitt (1986), among others, provide evidence that the Bank was following U.S. interest rates and exchange rates developments very closely before the inflation-targeting period (pre-1992).[13] More recent papers argue that since the beginning of inflation-targeting in 1992, the Bank has been using economic forecasts and other current economic indicators more thoroughly to assess whether monetary conditions need to be tightened or eased (for example, see Montador (1995), Duguay and Poloz (1994), Macklem (2002), Dorich et al. (2013) and various *Monetary Policy Reports* (MPRs)). Second, we will show in the next section that our regression estimates of equation (2) strongly support this change in the reaction function, as the response of the intended policy rate (Δi_m) to changes in the USD/CAD exchange rate and U.S. FFR and to real GDP growth and inflation forecasts changes drastically in the first vs. the second sub-sample. Third, as we will show in Section 4, the effects of monetary policy are markedly different when one does not break the first-stage estimation to account for the IT-period.

[13]For example, Courchene (1981) has a whole chapter titled "1980: Riding the U.S. roller coaster", arguing that Canada was simply a side passenger in the U.S. monetary policy roller coster of the early 1980s. Also, Howitt (1986) states that the Bank's policy after 1979 consisted of resisting any long-term depreciation of the Canadian dollar and short-term fluctuations in that rate caused by temporary changes in U.S. interest rates.

The last step is to take the estimated residuals from equation (2) for each sub-sample and splice them together to create our new meeting-by-meeting series of monetary policy innovations. This new series, which can be interpreted an exogenous change that is not taken in response to information about current and future economic developments, will then be converted into a monthly basis and used in the second stage (section 4) as the monetary policy variable in a VAR to quantify the effects of monetary policy on macroeconomic variables.

2.2 Data construction

When constructing our data-set for the first-stage regression (equation 2), we need to match the variables forming the Bank's information set (Ω_t) with the intended policy rate variable. As noted above, our intended policy rate is constructed using the Bank rate from 1973 up to March-94, the operating band for the overnight rate between April-94 to February-96, and the target for the overnight rate afterward.[14] We use the changes in this series as the left-hand side variable in equation (2).

To build the information set (Ω_t), we first use a novel and proprietary database of real-time data and forecasts for real GDP and inflation constructed from the Bank of Canada's staff economic projections. Bank of Canada staff produce four exhaustive projections each year, following the release of the quarterly national income and expenditure accounts, which are generally carried out around the end of March, June, September, and December.[15] These staff projections contain quarterly forecasts as well as historical (real-time) data of numerous macroeconomic aggregates. They are a material part of the analysis presented to the Governing Council every quarter in the weeks leading up to the publication of the Bank's Monetary Policy Report.[16] The quarterly staff projections are analogous to the

[14]Since February 1996, the target for the overnight rate is set as the mid-point of the operating band, and the Bank rate is equal to the upper limit of the band. Consequently, any change in the target rate translates into an equal change in the band and the Bank rate. These rates are published on the Bank of Canada website. See Appendix A for details.

[15]Note that for many years from 2005-on, Bank of Canada staff produced eight projections per year: the four just mentioned, and four updates released before the other four monetary policy announcement dates. When available, we use these additional forecasts.

[16]See Macklem (2002) for details about the information and analysis presented by the staff to the Governing Council. We highlight the fact that these are staff's estimates and thus may not be the same estimates provided in the MPR, the Bank of Canada publication containing detailed economic analysis

Greenbook forecasts prepared by the Federal Reserve Board staff; it is judgemental in the sense that the forecasts are based on different sources of information and economic models. Second, we construct the (real-time) unemployment rate series from digitised Statistics Canada archives (1978-2015) and hard copies of Bank of Canada Reviews for 1973-1977. Third, our series for the USD/CAD exchange rate is taken from Statistics Canada, and the U.S. FFR is taken from the Federal Reserve Board website. Appendix A.XX presents further details on the data series used in the first-stage regression.

The relevant inflation index varied over our sample. Up to March 1980 inclusively, we use total CPI inflation, while from April 1980 onward, we use core CPI inflation.[17] The earliest vintage of projection data where we have both GDP and inflation forecasts is 1974:Q1.

Before matching each monetary policy decisions ("meetings", for short) with the relevant set of real-time data and forecasts, we need to define what we mean exactly by "meeting". Since December 2001, defining a meeting is straightforward as the Bank announces monetary policy decisions eight times per year on fixed, announced dates. These "announcement dates" consequently become our meetings from 2001:12 to 2015:10, since the latest policy decision in our sample is October 21, 2015. Before 2001:12, the definition of meeting is less trivial as we cannot know with certainty when a meeting happened. Following Cloyne and Hürtgen (2016), we define as a meeting all dates where a change in our intended policy rate occurred; moreover, when a new set of forecast is released but there is not change in our intended policy rate, we do not treat the forecast release as a decision itself because we cannot be sure these are genuine monetary policy decisions.[18]

The next step involves assigning the relevant projection data to each meeting, since the regression in equation (2) is conducted on a meeting-by-meeting frequency. Note that we are facing the complication that we do not have a new projection for every monetary policy

and economic outlook and representing the view of the Governing Council, available every quarter since 2001.

[17]Since May 2001, core CPI inflation in Canada is known as CPIX, which excludes the eight most volatile components of the CPI and adjusts the remaining components for the effects of changes in indirect taxes. Before May 2001, core inflation was defined as CPI excluding food, energy, and the effects of changes in indirect taxes.

[18]We test the robustness of our results in Section 5 below by adding all those dates where we have a new forecast but no change in the intended policy rate. All our results remain robust to adding these additional observations.

decisions because there are more meetings than forecast releases. For all those meetings with no new projection, we follow Cloyne and Hürtgen (2016) and assign the latest available set of forecasts.[19] Note that since the introduction of the fixed announcement dates in December 2001, this is less of an issue because a new projection was prepared for most of the announcement dates (meetings), so matching a new projection with a meeting is straighforward.[20] Before this, we must be careful when assigning a set of forecasts to a given meeting in order to avoid endogeneity of forecasts to the policy change. Therefore, we use the projection prepared at the end of the quarter preceding the meeting date, ensuring that the forecasts do not include the effects of the subsequent policy change.[21] Table (1) provides examples of the data assignment to meetings. The first column lists the variables of interest (i.e. regressors) from equation (2), while the other columns show the data source and the time period forecasted (or the backdata, when using lagged data) for different meeting dates (shown in the top row).

The second block of columns, corresponding to the April 17 and May 22, 1980 meetings, provides a case where two consecutive meetings are assigned the same set of forecasts. Because these two meetings happen in 1980:Q2, we use the projection from March 1980 to get the values for real GDP growth ($\hat{y}^f_{m,t+j}$) and inflation ($\pi^f_{m,t+j}$). Moreover, we assign the relevant lags of unemployment rates, exchange rates and U.S. FFR available at the time of the meeting from our real-time data set.[22]

Lastly, we use all changes in our intended policy rate, apart those meetings occurring within the same four weeks during the March 1980 to May 1994 period (when meetings are occurring at a high frequency).[23] Overall, our data assignment allows us to have a sample

[19]Note that in equation (2) we control for developments between a given meeting and the last available projection by including of monthly lags of the unemployment rate and the interest rate two weeks before the meeting.

[20]For those announcement dates without a new projection, we keep assigning the latest projection data available.

[21]In Appendix C.X, we test the robustness of our results to two different first-stage specifications: (i) we take out the $t+2$ forecast from equation (2), and (ii), we add a third quarter of forecast ($t+3$) to equation (2). Our results are qualitatively similar for both specifications, although not including the second quarter of forecast matters more for the results.

[22]Note that the *change* in the USD/CAD exchange rate and in the U.S. FFR (i.e. $\Delta ER_{m-m_{-1}}, \Delta FFR_{m-m_{-1}}$ in equation (2)) between these two consecutive meetings (May 22 and April 17, 1980) are computed as follows: ($ER_{22May1980,t-d14} - ER_{17Apr1980,t-d14}$) and ($FFR_{22May1980,t-d14} - FRR_{17Apr1980,t-d14}$), respectively.

[23]During those years the Bank rate was changing more often than in the rest of the sample. See Appendix

Table 1: Assigning forecasts and economic variables to Bank rate decisions

	Meeting dates [Current quarter]									
	12/22/1976 [1976 Q4]		...	4/17/1980 [1980 Q2]		5/22/1980 [1980 Q2]		...	7/17/2001 [2001 Q3]	
Variables	Source	Forecast / Data		Source	Forecast / Data	Source	Forecast / Data		Source	Forecast / Data
$\hat{y}^f_{m,t-1}$	Sep-76 proj	1976Q3	...	March-80 proj	1980Q1	March-80 proj	1980Q1	...	June-01 proj	2001Q2
$\hat{y}^f_{m,t}$	Sep-76 proj	1976Q4	...	March-80 proj	1980Q2	March-80 proj	1980Q2	...	June-01 proj	2001Q3
$\hat{y}^f_{m,t+1}$	Sep-76 proj	1977Q1	...	March-80 proj	1980Q3	March-80 proj	1980Q3	...	June-01 proj	2001Q4
$\hat{y}^f_{m,t+2}$	Sep-76 proj	1977Q2	...	March-80 proj	1980Q4	March-80 proj	1980Q4	...	June-01 proj	2002Q1
$\pi^f_{m,t-1}$	Sep-76 proj	1976Q3	...	March-80 proj	1980Q1	March-80 proj	1980Q1	...	June-01 proj	2001Q2
...	...	...	...	...	...	...	...	...	...	...
u_{t-1}	Real-time data	Nov-76	...	Real-time data	Mar-80	Real-time data	Apr-80	...	Real-time data	Jun-01
u_{t-2}	Real-time data	Oct-76	...	Real-time data	Feb-80	Real-time data	Mar-80	...	Real-time data	May-01
...	...	...	...	...	...	...	...	...	...	...
ER_{t-d14}	Real-time data	12/8/76	...	Real-time data	4/3/80	Real-time data	5/8/80	...	Real-time data	7/3/01
FFR_{t-d14}	Real-time data	12/9/76	...	Real-time data	4/3/80	Real-time data	5/8/80	...	Real-time data	7/3/01
...	...	...	...	...	...	...	...	...	...	...

Notes: Assignment of forecasts and lagged real-time data to different meeting dates. The upper row corresponds to the exact date of the meeting, with (in brackets) the corresponding year and quarter the given meeting is happening in. The "Source" column refers to the specific Staff projection database which the real GDP growth and inflation real-time and forecasts data were prepared, while the lagged (real-time) unemployment rate, exchange rate, FFR and the policy rate are taken from Statistics Canada or Bank of Canada archives. The "Forecast/Data" column shows the year and quarter of the forecasts estimates (for real GDP growth and inflation), while it shows the specific date (month or day) for the other lagged real-time variables.

of meetings matched with projections data from 1974:M4 to 2015:M10. Our rich data-set is constructed in a similar fashion as in Cloyne and Hürtgen (2016); it contains a large number of observations (337 meetings) and should be useful for future research.[24]

A for details. Note that Cloyne and Hürtgen (2016) face the same kind of issue for the early 1980s sample and do not use changes in meetings occurring within the same two weeks instead of four weeks like we do. We test the robustness of our results in Section 5 to dropping changes within two weeks instead of four weeks for the specified period and find that both specifications yield similar results.

[24]For example, Champagne et al. (2016) use the same projection database to study the real-time properties of the Bank's staff output gap estimates.

3 The new measure of monetary policy shocks

3.1 Taking out the systematic component

We use our data-set of changes in the intended policy rate carefully matched (be meeting date) with the staff forecasts and real-time data to estimate the regression equation (2). As mentioned earlier, our preferred strategy critically departs from R&R and Cloyne and Hürtgen (2016) as we estimate equation (2) for the pre-IT and 1992-onward periods separately, such that our estimates account for the change in the monetary policy reaction function observed around the introduction of the inflation-targeting period. To show the importance of breaking our estimation in two parts, we also estimate equation (2) using the full sample (all 337 meetings). Table (2) reports the results of these estimations.

Examining the full-sample estimates (left column) suggests that monetary policy has been conducted in an acyclical fashion over the the past 40 years. For example, coefficients on real GDP growth level sum up to 0.27, while they sum to -0.24 for the revision to the forecast. Coefficients on inflation forecast levels and revisions to inflation forecasts are very low, at 0.04 and -0.02, respectively. Thus, a 1 percentage point increase in inflation from one forecast release to the next is associated with a mild increase in the policy rate of 0.02. Finally, a 1 percentage point fall in the unemployment rate translates into a small 0.06 percentage point increase in the policy rate. Monetary policy is also positively related to changes in the U.S. FFR and negatively related to movements in the USD/CAD exchange rate.

This acyclical behavior of monetary policy along with the responses to U.S. interest rates and exchange rates movements hide considerable heterogeneity once one breaks the first-stage estimation into two sub-samples. The second and third columns (the "IT-break estimation") show the regression estimates for the pre-IT (1974-1991) and IT-period (1992-2015), respectively.[25] Three results stand out: first, summing coefficients on real GDP and inflation for the pre-IT period yield procyclical estimates of -0.17 and -0.29 percentage points, respectively, and a countercyclical estimate of -0.18 for the unemployment rate. A very different picture emerge for the second sub-sample: summing the same coefficients

[25] A Chow test of parameter stability with a break date set to January 1992 yields a F-statistic of 2.26 with a associated p-value of 0.0007.

Table 2: Determinants of the change in the policy rate

	Full-sample estimation		IT-break estimation			
	1974-2015		Pre-IT		IT-period	
Variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Constant	0.166	(0.29)	1.954	(1.57)	-0.155	(0.30)
Initial Bank rate	-0.029	(0.03)	0.006	(0.08)	-0.053	(0.04)
U.S. FFR:						
level	0.045	(0.03)	0.046	(0.07)	0.013	(0.03)
change	0.292***	(0.07)	0.249***	(0.08)	0.164*	(0.09)
US/CAD exchange rate:						
level	0.071	(0.27)	-1.186	(1.69)	-0.013	(0.22)
change	-3.730***	(1.35)	-14.139***	(4.00)	-1.222	(1.08)
Forecasted output growth,						
Quarters ahead:						
-1	0.223	(0.14)	0.511**	(0.21)	0.130	(0.09)
0	-0.336	(0.22)	-0.389	(0.27)	-0.156	(0.23)
1	0.341	(0.24)	0.449*	(0.25)	0.300	(0.40)
2	0.039	(0.20)	0.070	(0.30)	0.138	(0.25)
Change in forecasted output growth,						
Quarters ahead:						
-1	-0.033	(0.12)	-0.260	(0.16)	-0.046	(0.10)
0	0.225	(0.19)	-0.059	(0.25)	0.363*	(0.20)
1	-0.143	(0.20)	0.076	(0.22)	-0.498*	(0.29)
2	-0.285	(0.24)	-0.572*	(0.34)	0.062	(0.18)
Forecasted inflation,						
Quarters ahead:						
-1	0.019	(0.13)	0.074	(0.21)	-0.008	(0.20)
0	-0.198	(0.20)	-0.052	(0.25)	-1.073	(0.72)
1	0.380**	(0.17)	0.185	(0.18)	1.790	(1.29)
2	-0.160	(0.13)	-0.353**	(0.15)	-0.419	(1.09)
Change in forecasted inflation:						
Quarters ahead:						
-1	-0.084	(0.18)	-0.146	(0.26)	-0.093	(0.19)
0	-0.012	(0.24)	-0.636	(0.44)	1.123*	(0.59)
1	-0.025	(0.28)	0.207	(0.35)	-1.060	(0.95)
2	0.100	(0.33)	0.430	(0.51)	0.415	(0.82)
Unemployment rate,						
Months:						
-1	-0.333*	(0.17)	-0.390*	(0.23)	-0.240	(0.21)
-2	0.256	(0.22)	0.339	(0.34)	0.093	(0.18)
-3	0.018	(0.15)	-0.128	(0.22)	0.129	(0.12)
Observations	337		146		191	
R-squared	0.388		0.537		0.309	

Notes: Robust standard errors in parentheses; stars indicate statistical significance (i.e. (***:p<0.01, **:p<0.05, *:p<0.1). Dependant variable: change in the intended policy rate, constructed as described in the text. "Full-sample estimation" refers to first-stage regression estimated over the full sample (1974:M4–2015:M10). "IT-break estimation" refers to first-stage regression estimated over two sub-samples separately (i.e. Pre-IT: 1974–1991, and IT-period: 1992–2015). A Chow test of parameter stability with a date break fixed to January 1992 (IT introduction) yields a F-statistic of 2.26 with an associated p-value of 0.0007.

yield estimates (in percentage points) of 0.29 or real GDP, 0.68 for inflation and -0.02 for the unemployment rate, implying strong countercylical monetary policy since 1992. Second, the pre-IT behavior of monetary policy can be explained by the response with respect to the U.S. rates and USD/CAD exchange rate: a one per cent increase in the U.S. FFR between two meetings translates into a 0.3 percentage point increase in the policy rate, while a one per cent decrease in the value of the exchange rate between two meetings implies a 0.15 percentage point increase in the policy rate. Third, the response of monetary policy toward these two variables changed dramatically since 1992: the response to changes in the FFR decreased by more than a third (0.18) and fell to almost zero with respect to exchange rate movements (0.01 percentage point). Since 1992, Canadian monetary policy has been responding fiercely to economic developments related to inflation and real GDP growth and much less to exchange rate movements.[26]

Overall, our full sample estimates are very weak and consequently do not compare with the first-stage estimates of R&R for the U.S. and Cloyne and Hürtgen (2016) for the U.K. However, our 1992-2015 estimation results are qualitatively similar as those for the U.S. and U.K., albeit not identical. Our estimates for the response of the policy rate to inflation are higher, as the Bank has been targeting inflation closely since 1992. Finally, the residual component of equation (2) from the "IT-break" estimation (ϵ_m) is our new measure of monetary policy shocks, orthogonal to the information set of policymakers.[27]

3.2 Analyzing the new shock series

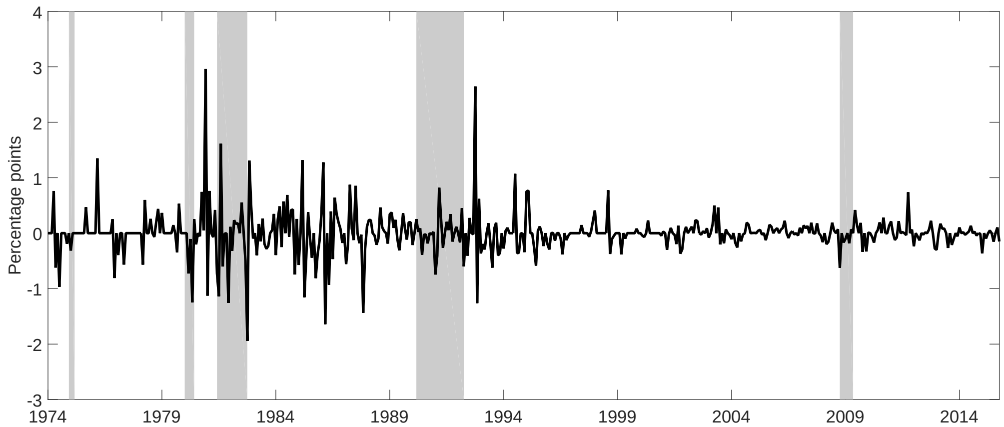
This residual series corresponds to specific meeting (i.e. policy decision) dates. To use these residuals for economic analysis, they must converted into a monthly series of monetary

[26] Another way to assess the relative importance for monetary policy decisions of the "foreign variables" (i.e. U.S. FFR and the USD/CAD exchange rate) in the first sub-sample and of the forecasts in the second sub-sample is to examine the changes in the R-squares of the regressions once we take these variables out (separately) of the regressions. For the pre-IT period, when we take out forecasts the R-square only falls from 0.54 to 0.47, while it drops dramatically to 0.24 when foreign variables are taken out but forecasts are kept in. For the IT period, when we take out forecasts the R-square drops sharply from 0.31 to 0.15, while it barely falls (0.28) when foreign variables are taken out but forecasts are kept in. In Section 5, we present further evidence of how foreign variables and forecasts matter when estimating the systematic component of monetary policy in Canada.

[27] Below we show that our results are robust to breaking the first-stage estimation in 1994 instead of 1992, when the operating bands for the overnight rate were introduced.

policy innovations. To do this, we follow R&R and assign each shock to the month in which the corresponding meeting occurred. If there is no meeting in a given month, we record the shock as zero for that month; if there are more than one meeting within the same month, we sum the shocks. Figure 3.2 presents our new monthly series of monetary policy shocks, which we denote μ_t as above.

Figure 1: New monthly monetary policy shocks series for Canada



Notes: Shaded grey bars represent recessions as determined by the C.D. Howe Institute.

As found by R&R for the U.S. Cloyne and Hürtgen (2016) for the U.K., our new series for Canada is more volatile in the first half of our sample, up to the end of the year 1992. This observation coincides nicely with the view that there was a regime change in 1992 (e.g. see Rowe and Yetman (2002) or Ragan (2005)), when the Bank of Canada began targeting inflation explicitly. Three other developments mentioned earlier also made the policy-making process more transparent during this sub-period: the introduction of operating bands around the overnight rate in 1994 (Lundrigan and Toll (1998)) leading to the explicit target for the overnight rate in 1996, as well as the introduction of fixed announcements dates in December 2001.[28] Note that our series is substantially more volatile in the early 1990s than the U.S. and U.K. series, likely due to the uncertain environment the Canadian economy was facing in those years.[29]

[28]As noted by Cloyne and Hürtgen (2016), larger shocks in the first part of the sample could also reflect that the level of the Bank rate was relatively higher than in the second part.

[29]This period was marked by different developments that clouded the economy with uncertainty. For

Many academics and other economic commentators have publicly debated the conduct of monetary policy by the Bank of Canada throughout the past decades. For example, in his in-depth analysis of the Bank's conduct of monetary policy between 1975 and 1980, Courchene (1981) argues that the Bank fell far short in the implementation of its policies to fight inflation and must bear the responsibility for the re-acceleration of inflation at the end of the 1970s. The Bank's price stability program announced by Governor John Crow in January 1988 was marked by wrenching economic and political turmoil (Laidler and Robson (1993)). Fortin (1996)) dubbed the early 1990s period 'The Great Canadian Slump', arguing that the Bank has been responsible for the weak levels of economic activity, while other academics and central bankers such as Racette and Raynauld (1994) and Freedman and Macklem (1998) argued otherwise. We can use our new measure of monetary policy shocks to shed light on these episodes as our series of monetary policy innovations yields a measure of the stance of monetary policy: i.e. periods with a sequence of positive innovations are ones in which the Bank raised the policy rate more than it would normally have given current and expected economic conditions. Figure 1 in Appendix B plots the exogenous Bank rate path (i.e. our new shock series, cumulated) along with the actual path of the Bank rate. First, we see that for most if the 1975–80 period, policy was looser than predicted by equation (2), consistent with the claims by Courchene (1981) that monetary policy was too loose given the high rate of inflation in the 1970s and its objective to reduce it significantly. Second, although the Bank rate increased precipitously between 1988 and 1990, the stance of monetary policy was roughly neutral during those years and was actually loose in the preceding years, consistent with the claims in Racette and Raynauld (1994). The stance of monetary policy became tighter for a short period between 1992 and 1993. Looking back, as the early 90s recession started in March 1990, it is more likely that the Bank's tightening actions held back somewhat the subsequent recovery but did not trigger the recession. Third, note that monetary policy has been generally loose between 1996 and 2005, and relatively tighter from 2006 onward. Interestingly, the alternate shock series

example, after five years of relative stability at around 4 per cent, inflation took off in 1988; the Bank rate was very high, coupled with historical high of the Canadian-U.S. 90-day treasury bill spreads; the USD/CAD exchange rate was very volatile and economic conditions started deteriorating in 1990, leading to the severe 1990–92 recession. There was also political uncertainty in the early 1990s: the aftermath of the Meech Lake Accord failure and the introduction of the new goods and services tax in January 1991.

estimated using the "full sample" as in R&R implies a very different path for the exogenous Bank rate (dashed red line). After following a similar pattern than our shock series between 1974 to 1989, it diverged markedly afterwards: it implies that monetary policy has been very tight for 10 years up to 1999, where it loosened precipitously afterward. Since 2007, this alternate shock measure implies that given current and expected future economic conditions, monetary policy has been –by far –at its loosest stance over the last 40 years.

3.3 Predictability of the new measure of monetary policy shocks

We follow Coibion (2012) and Cloyne and Hürtgen (2016) and test whether our new monthly measure monetary policy shocks is unpredictable from movements in ex-post revised data.[30] We perform a Granger-causality test by regressing our innovations series μ_t on a large set of lagged macroeconomic variables (x_{t-i}) including two of the most relevant measures of inflation for Canada (CPI, CPIX), two measures of output (real GDP, industrial production), the unemployment rate, commodity price inflation, the change in the Toronto Stock Exchange Index (TSX) and the change in money supply (M2):[31]

$$\mu_t = c + \sum_{i=1}^{I} \beta_i x_{t-i} + \upsilon_t \tag{3}$$

Under null hypothesis that our shock series μ_t is not predictable, the β_i are jointly equal to zero. Table 3 reports the F-statistics and P-values for the null hypothesis based on estimation of equation (3) for our new measure of monetary policy innovations ("New measure of shocks", right panel) along with the alternate shock series discussed above, estimated as in R&R using the full sample (left panel).

Two things stand out: first, the shock series estimated on the full sample shows many low P-values, implying some degree of predictability. For example, this alternate shock series is significantly predictable using either 3 or 6 lags of real GDP growth and 6 lags of the unemployment rate; it also has low P-values when equation (3) is estimated with CPIX,

[30] We also look whether our new measure is uncorrelated with other structural shocks, such as the U.S. and U.K. monetary policy shocks of R&R and Cloyne and Hürtgen (2016) (correlations of 0.03 and 0.06, respectively), as well as oil supply shocks (0.00) from Kilian (2009).

[31] See Appendix A for data details. Note that we have a monthly series for real GDP in Canada, which we will also use below when quantifying the macroeconomic effects of monetary policy shocks.

Table 3: Predictability of monetary policy innovation series

	Full sample shocks				New measure of shocks			
	I = 3 lags		I = 6 lags		I = 3 lags		I = 6 lags	
Variable	F-stats	P-values	F-stats	P-values	F-stats	P-values	F-stats	P-values
Monthly CPI inflation	1.33	0.26	1.14	0.34	0.76	0.51	0.98	0.44
Monthly CPIX inflation	0.85	0.47	1.68	0.12	0.24	0.87	1.12	0.35
Change in monthly real GDP	2.76	0.04	2.82	0.01	1.64	0.18	1.97	0.07
Change in monthly Ind. Prod.	1.73	0.16	0.95	0.46	1.23	0.30	0.62	0.71
Unemployment rate	0.39	0.76	2.05	0.06	0.05	0.98	1.22	0.29
Commodity price inflation	1.98	0.12	1.07	0.38	1.42	0.24	0.81	0.56
Nominal USD/CAD	0.58	0.63	0.89	0.49	0.14	0.94	0.71	0.64
Change in TSX	1.89	0.13	0.94	0.46	1.40	0.24	0.57	0.76
Money growth (M2)	0.17	0.91	0.14	0.99	0.16	0.92	0.33	0.92

Notes: Sample from 1974:4 to 2015:10. The table reports F-statistics and p-values for the null hypothesis that all coefficients (β_i) are equal to zero. The standard errors are corrected for the possible presence of serial correlation and heteroskedasticity using a Newey-West variance-covariance matrix. The "Full sample shocks" specification refers to first-stage regression is estimated over the full sample (1974-2015). "New measure of shocks" refers to our new series of monetary policy shocks, where the first-stage regression is estimated over two sub-samples separately (i.e. Pre-IT: 1974–1991, and IT-period: 1992–2015).

commodity price inflation, industrial production growth and the change in the TSX. Second, a sharp contrast emerge when one looks at our new measure of innovations (columns 5 to 8): for example, the P-values of real GDP are 4.5 times (3 lags) and 7 times (6 lags) larger using our new measure and 5 times larger for the unemployment rate. Overall, most P-value are very large for the new measure; this lack of predictability and stark contrast with the alternate full-sample shock series is another argument in favor of our preferred measure and suggest that our shock series is a suitable instrument to identify the macroeconomic effects of monetary policy in Canada.

4 The Macroeconomic Effects of Monetary Policy

The next step of our analysis is to use our new measure of monetary policy shocks to estimate the macroeconomic effects of monetary policy from 1974 to 2015. To do this, we follow Coibion (2012) and Cloyne and Hürtgen (2016) and use a parsimonious VAR with the following four variables: the log monthly real GDP (y_t), the log price level (p_t) based on the Consumer Price Index (CPI)[32], the log commodity prices (com_t) based on

[32] In Section 5, we consider two otehr measures of the price level: CPIX, which removes the eight most volatile components of CPI and CPIxMIC, which excludes mortgage interest costs from the CPI.

the Bank of Canada commodity index (BCPI), measured in Canadian dollars, and our new measure of monetary policy shocks. [33] Appendix C.1 shows the robustness of our results to larger specifications, such as adding the unemployment rate and the Bank rate. Note that our VAR includes monthly real GDP instead of industrial production; papers in the literature have used industrial production indexes because of its monthly availability and high correlation with real GDP. As industrial production is also available on a monthly basis in Canada, in Section 5 we assess whether industrial production react similarly to monetary policy shocks, which is an interesting contribution in itself. Data definitions can be found in Appendix A.

Specifically, the VAR we estimate is given by:

$$X_t = B(L)X_{t-1} + \epsilon_t \tag{4}$$

where *B(L)* is a lag polynomial with P lags. The vector of observables X_t is defined as: $[y_t, p_t, com_t, cum.shock_t]'$. Since VARs usually include the levels of macroeconomic variables as well as the level of interest rates, we follow R&R and Cloyne and Hürtgen (2016) and cumulate our new monetary policy shock series ($cum.shock_t = \sum_{i=1}^{t} \mu_i$) and order it last in the VAR, using Christiano et al. (1996)'s recursive identification strategy, i.e. monetary policy responds to, but do not affect the non-policy variables contemporaneously.[34] We follow Cloyne and Hürtgen (2016) and use P=*24* lags in the VAR; our sample has a monthly frequency t, starting in 1974:M4 and ending in 2015:M10. We also include in the VAR estimation a constant and a time trend.[35]

Figure 2 presents the impulse responses of real GDP, the price level, and the Bank

[33] While the wider literature on the effects of monetary policy tends to employ VARs, R&R use single regressions. Coibion (2012) finds that an important part of R&R's large effects of monetary policy is due to the contractionary impetus implied by the single regression approach and to the non-reserve borrowing period of Volcker (1979–82); when their shock series is used in a VAR instead, the effects become smaller and more robust to individual shocks episodes, such as the 1979–82 period. For sake of completeness, below (Section 5) we present single regression results and show that they are in line with our VAR results.

[34] On the one hand, because we estimate a monthly VAR, this assumption is less restrictive when compared with quarterly VARs. On the other hand, if we have correctly captured the information set that the policymakers used to form their decisions in our first-stage estimation, our shock series should be contemporaneously exogenous and thus the recursive assumption should not be essential for our results. We relax this assumption in Appendix C.3 and show that our results remain robust.

[35] Appendix C.3 shows that our robust are robust to different lag structures in the VAR, as well as to removing the constant and the trend.

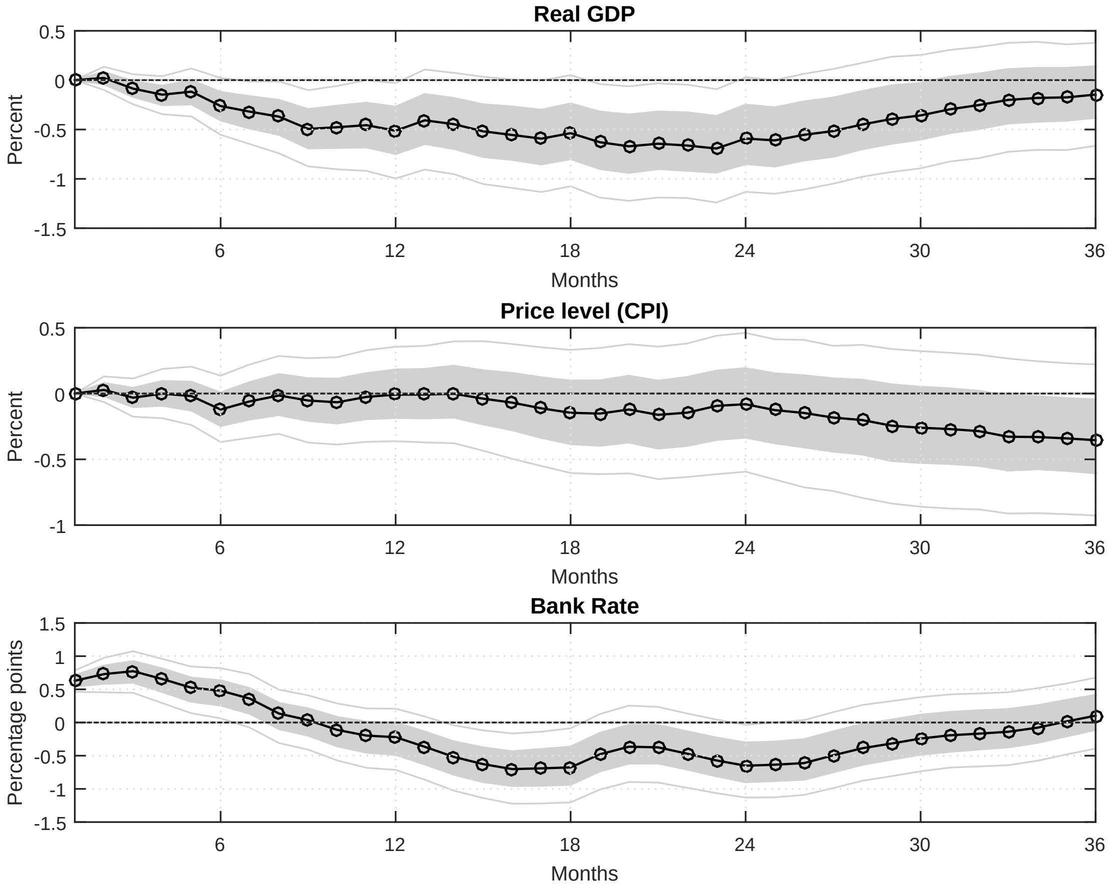
rate to a 100 basis points monetary policy innovation using our new measure of monetary policy shocks, together with 68 and 95 per cent bootstrapped confidence intervals using 2000 replications. Following this contractionary innovation to the policy rate, real GDP falls gradually to about -0.7 per cent between months 18 and 24. The shock effects then fade as GDP climbs back and ends at -0.1 per cent after three years. The GDP response is highly significant (95 per cent) for 18 months between months 6 and 24. The price level (CPI) is less responsive to the contractionary shock: it stays roughly flat for the first 15 months, where it then falls slowly to -0.4 per cent after three years. It is only in the last six months that the response is significant. The last panel of Figure 2 shows the increase in the Bank rate is short-lived:[36] the Bank rate increases on impact, starts falling in month four and turns negative throughout, ending at zero after three years.[37]

In the previous section, we discussed the importance of breaking the first-stage estimation into pre–1992 and 1992 onward sub-samples to identify our new measure of monetary policy shocks. A natural questions to ask is how different the responses of GDP and inflation to monetary policy shocks would be had we use the shock series estimated using the full sample in the first stage regression, as done in R&R and Cloyne and Hürtgen (2016)? To answer this, we estimate the same VAR as above but we substitute our new measure of shocks for the shocks estimated in the first stage using the full sample (not accounting for the IT-break). Figure 3 reproduces the main impulse responses (solid, circled line) from Figure 2 along with those from the full-sample shocks (dashed red line). Two things are worth nothing: first, the response of real GDP is similar for the first 18 months, but keeps going down afterward for the full-sample shocks, so much that the response falls out of the 95 per cent confidence bands of our main estimates in the last 8 months. After three years, real GDP is 1 per cent lower following the shock estimated using the full sample, while it ends at -0.1 per cent following our new shock series. The response of the price level (CPI) is also quite different using this alternate shock series. While our new shock series implies a flat response of CPI for 15 months before falling, the response of CPI shows a

[36] For this third panel, we add the Bank rate ordered last in the VAR.

[37] Coibion (2012) performs a sensitivity exercise to test if R&R's main results are robust to dropping a particular episode in their sample; he finds very different effects of monetary policy when one takes out the Volcker period. In Appendix D, we perform a similar sensitivity exercise and find that our results are robust to any specific episodes in our sample.

Figure 2: Macroeconomic Effects of Monetary Policy Shocks

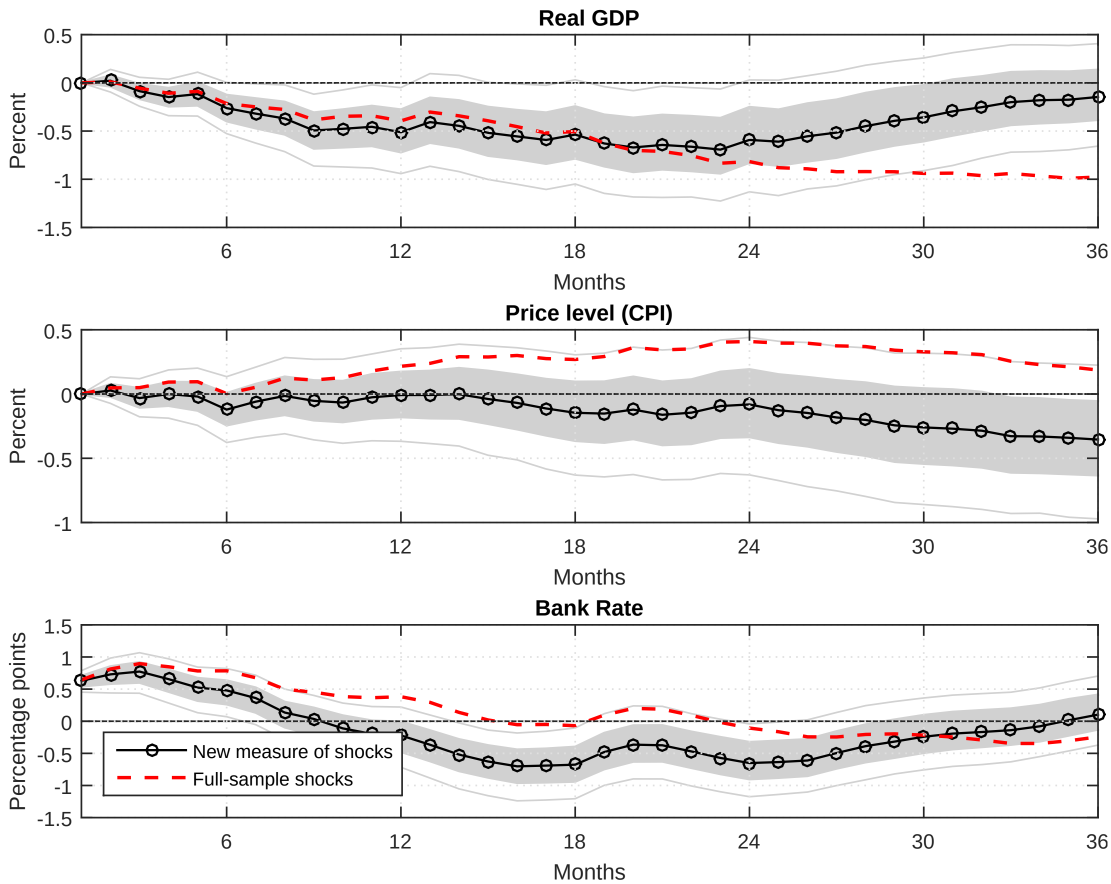


Notes: Impulse responses to a 100 basis point contractionary monetary policy innovation along with the corresponding 68 and 95 per cent confidence bands. The VAR includes log real GDP, log CPI, log BCPI and our new measure of monetary policy innovations. For the Bank rate response, the VAR includes the same variables and adding the Bank rate, ordered last. P=24. Sample: 1974:M4 to 2015:M10.

price puzzle: it is positive throughout with a peak near 0.5 per cent after two years. This alternate response of CPI lies largely outside the 68 per cent confidence bands of our main estimates, and for the last 18 months lies closely to the 95 per cent upper band.

Overall, these results show how accounting for the break in the monetary policy reaction function matters for our estimates of the effects of monetary policy. When one does not consider the break, the real GDP response is larger and more persistent and a small price puzzle emerge.

Figure 3: Macroeconomic Effects of Monetary Policy Shocks - New measure of monetary policy shocks vs. Full-sample shocks



Notes: Impulse responses to a 100 basis points contractionary monetary policy shock. "New measure of shocks" refers to our new measure of monetary policy shocks (solid black circled line) while "Full-sample shocks" refers to the shock series estimated in the first stage over the full 1974–2015 sample (dashed red line). The VARs include log real GDP, log CPI, log BCPI and the measure of monetary policy shocks. For the Bank rate response, the VARs include the same variables and adding the Bank rate, ordered last. P=24. Sample: 1974:M4 to 2015:M10.

4.1 The price puzzle

Sims (1992) first documented the observation that a monetary policy tightening is followed by an increase in the price level when measured in convential VARs employing observed interest rates and the recursive identification strategy of Christiano et al. (1996). Dubbed the "price puzzle", this observation has raised doubts about the validity of the recursive identification assumption and paved the way to a large literature that proposed various methods to resolve this puzzle, such as expanding the VAR with oil or commodity prices or to use factor-augmented VARs. R&R show that including the Greenbook forecasts into the central bank's information set remove the price puzzle for the U.S.

For Canada, we also find a large price puzzle when we replace in our VAR specification our exogenous shock series with the Bank rate as the policy instrument and use the standard recursive identification strategy (real GDP, CPI, and commodity prices remain in the VAR). Figure 4 shows the price level response to a one percentage point increase in the Bank rate in our VAR (dashed line) along with the analogous price response to our shock series. The response is large and positive through the first 3 years, and lies largely outside the 95 confidence bands of our main estimate. [38]

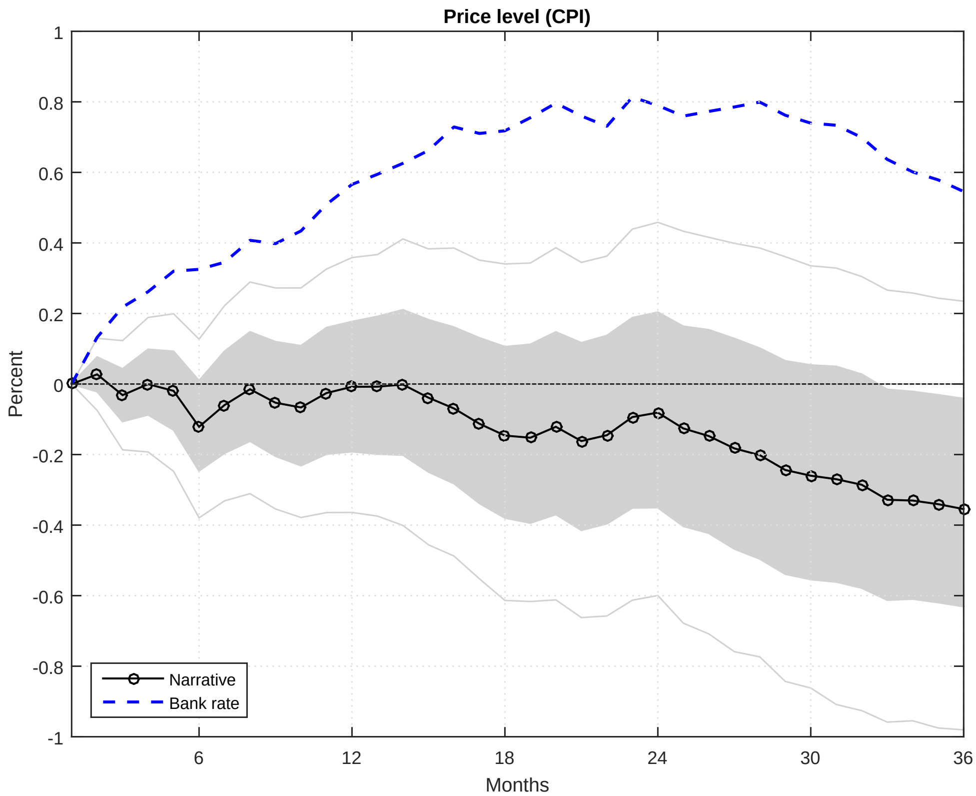
The findings of R&R and Cloyne and Hürtgen (2016) for the U.S. and U.K., respectively, document that the narrative identification strategy solves the price puzzle obtained using the conventional recursive VAR methodology for both countries. Our results show that these findings pertain to Canada, and thus the narrative identification approach can yield novel insights on the macroeconomic effects of monetary policy in a small-open economy.

4.2 Comparison with literature

Our paper is related to various areas of the empirical monetary policy literature. A first comparison of interest is to what extent our results are in line with the evidence of Coibion (2012) for the U.S. and Cloyne and Hürtgen (2016) for the U.K. Using a VAR similar to ours with the cumulative RR shock series, Coibion (2012) finds that the R&R shocks lead to a peak fall in industrial production close to 2 per cent and a peak decrease of the price level also of about 2 per cent in the U.S. Using a similar setting, Cloyne and Hürtgen (2016) find that a 1 per cent contractionary monetary policy shock in the U.K. leads to a peak decrease in industrial production somewhat smaller, at 0.5 per cent, and a peak fall of annual inflation of close to 1 per cent. Our peak real monthly GDP response at 0.7 per cent lies in between those estimates, while the peak response of the price level in Canada is smaller than in the U.S., at about 0.4 per cent. In the next section, we show that the

[38] In Appendix C.6, we plot this impulse price response along with the corresponding 68 and 95 confidence bands; the price puzzle is significant at 95 per cent for almost the three years. Note that if we add other variables in this VAR (such as the unemployment rate and the US/CAD nominal exchange rate), we also find a price puzzle.

Figure 4: VAR with the new narrative exogenous shocks vs. conventional, recursive VAR with Bank rate



Notes: Impulse responses to a 100 basis points contractionary monetary policy shock from VAR with our new measure of monetary policy shocks (solid black circled line) along with the corresponding 68 and 95 per cent confidence bands. The chart also shows a conventional VAR with the Bank rate instead of our shocks measure as the policy variable (dashed blue line). Both VARs contain log real GDP, log CPI, log BCPI and the monetary policy variable ordered last. P=24. Sample: 1974:M4 to 2015:M10.

response of industrial production is much larger (1.4 peak), implying that the real GDP response in the U.S. and U.K. might be somewhat smaller than the estimates for industrial production. In order to make our price level results comparable with Cloyne and Hürtgen (2016), in Appendix C.XX we show that a VAR with annual inflation rate produces a peak fall in inflation of 0.5 per cent in Canada, in line with our main estimate but somewhat smaller than in the U.K. In both cases, the dynamics of the responses of our real activity variable and price level are qualitatively very similar to the ones in the U.S. and the U.K.

There are a few papers for Canada on identifying the effects of monetary policy with VARs. Armour et al. (1996) use a standard VAR with the recursive assumption à la Christiano et al. (1996, 1999) and find small effects on output and prices (peak of -0.1 per cent).

Other papers argue that since Canada is a small open economy, VARs identified with the recursive assumption imply very strong assumptions on the contemporaneous relationship between exchange rates and monetary policy. In order to circumvent this problem, Cushman and Zha (1997) estimate a VAR with home and foreign parts, block exogeneity and non-recursive restrictions using data from 1973 to 1993, corresponding roughly to our pre-IT sub-period. They find that following a contractionary monetary policy, there is little movement in interest rates, but a strong reaction of the exchange rate. While there is a small price puzzle following the shock, the price level slowly decreases, reaching a peak impact after two years, where the price level levels off afterward. Quantitative comparisons with our paper are complicated by the fact that Cushman and Zha (1997) identify monetary policy shocks through changes in the money supply, and not interest rates. All in all, they find very small effects of monetary policy on output, prices and the trade balance. Applying a similar model, but to a more recent period following the introduction of inflation targeting, Bhuiyan (2012) finds that a 1 per cent increase in interest rates has peak impacts on output of about 0.2 per cent after six months and 0.5 per cent on the price level between one and two years after the shock. While the peak impact on prices is very similar to the one we obtain, the output response to our narrative shocks are substantially larger. Overall, our estimates of the effects of monetary policy shocks on output and inflation are higher than what has been found in previous studies for Canada.

5 Robustness and Additional Results

In the subsections below, we assess the robustness of our main results to: (1) estimating the effects of monetary policy shocks with single regressions (using local projections) instead of a VAR specification; (2) different measures of output and inflation in the VAR; (3) alternative first-stage specifications; (4) excluding forecasts and controls for the U.S.-CAD exchange rate and the U.S. FFR in the first-stage; (5) using quarterly data in the VAR; (6) the IT-period (1992-2015); (7) controlling for U.S. shocks from R&R and finally we estimate the effects of U.S. monetary policy shocks on Canadian variables and compare them with the effects from our new shocks measure.

5.1 Single Equation Results

In order to make our results as comparable as possible to previous literature, we have opted to use our shocks series within a standard VAR model. Nonetheless, single regression approaches such as Jordà (2005)'s local projections have increasingly been used to investigate the effects of economic shocks in general, and monetary policy shocks in particular.[39] Here, we examine the responses of GDP and inflation within this single equation model. Specifically, we estimate the local projection model:

$$x_{t+h} - x_t = c + \Phi_h(L) z_{t-1} + \beta_h \mu_t + \varepsilon_t \tag{5}$$

for $h = 0,1,2,...,36$. The variable of interest is x, $\Phi_h(L)$ is a polynomial lag operator, z_{t-1} is a vector of controls, and μ_t is our measure of monetary policy shocks.

Figure 5 shows the impulse responses to a 100 basis points contractionary monetary policy shock. Overall, the results are qualitatively similar to the ones obtained from the VAR model. A distinctive quantitative feature is that the responses of monthly GDP and inflation are stronger than the ones from the VAR model. Following the monetary policy shock, the price level falls by over 0.5 per cent after 36 months, whereas real GDP falls by 1.4 per cent. These larger responses with local projections is also found by Cloyne and Hürtgen (2016). These results are consistent with the more persistent response of the policy rate in the local projections model relative to the VAR.

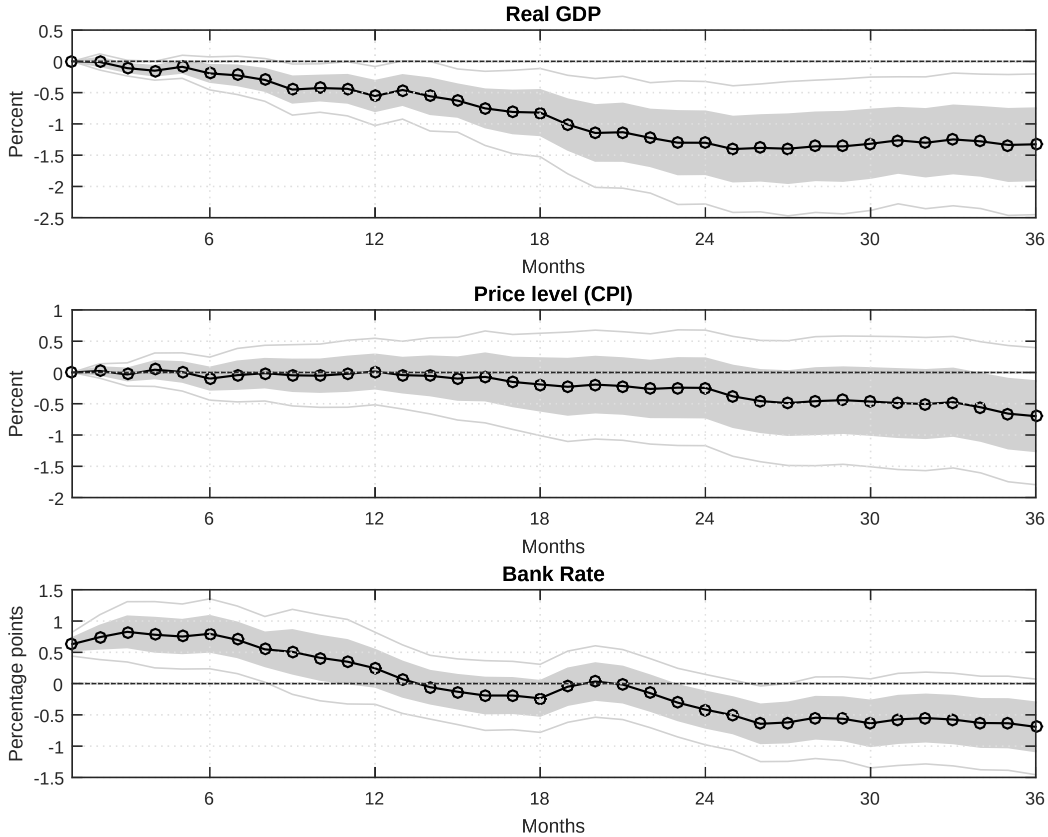
5.2 Different output and price measures

The vast majority of monetary VARs estimated at the monthly frequency use industrial production as the output measure due to data availability.[40] As we alluded earlier, a distinctive feature of the Canadian data is that a measure of real GDP is made available monthly by Statistics Canada. Additionally, two other important indicators of inflation in Canada are computed from (i) the core CPI (CPIX), which excludes the eight most volatile components of CPI, and (ii) CPI excluding mortgage interest costs (CPIxMIC).

[39]For recent examples, see Ramey (2016), Owyang et al. (2013), Auerbach and Gorodnichenko (2013), among many others.

[40]e.g. Christiano et al. (1996, 1999), R&R, Coibion (2012) and Cloyne and Hürtgen (2016).

Figure 5: Single equation approach

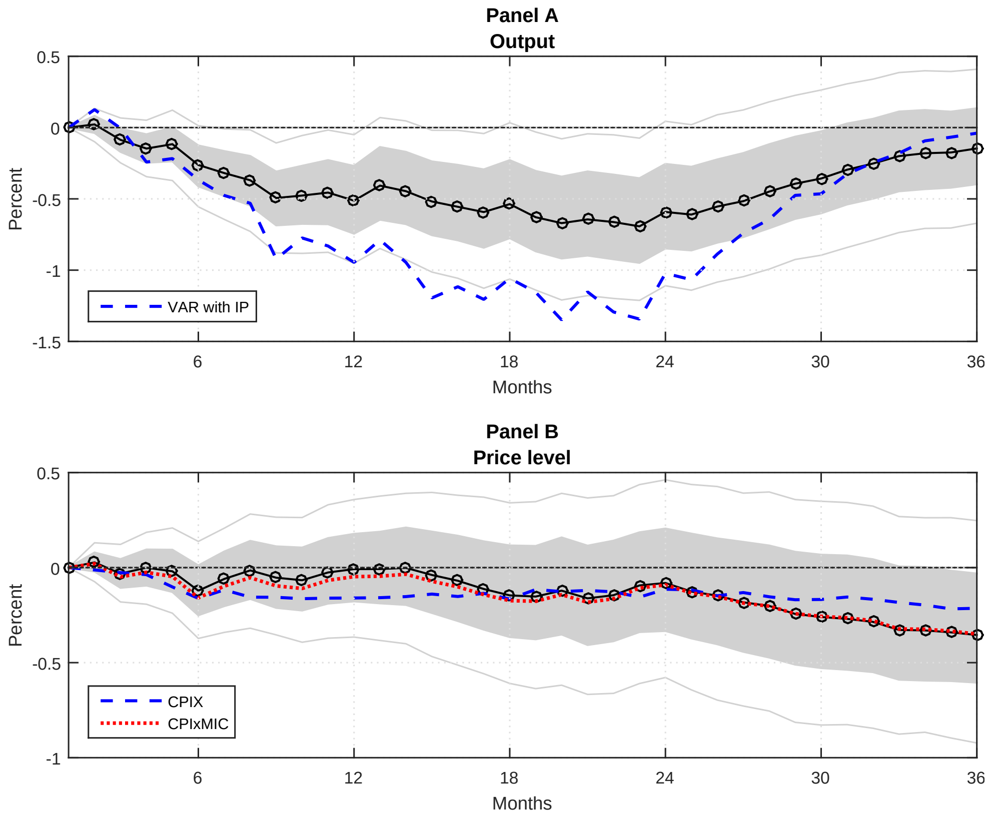


Notes: Impulse responses to a 100 basis points contractionary monetary policy innovation using local projections model with corresponding 68 and 95 per cent confidence intervals. The local projections model include (monthly) log real GDP, log CPI, log commodity prices and our new shock series. Sample: 1974:M4 to 2015:M10.

Figure 6 presents two robustness exercises: one where we substitute (in the VAR) our real monthly GDP measure for the industrial production index (panel A), and another where we substitute the CPI for the two alternate measures of the price level (Panel B).

Panel A shows that the peak response of industrial production to a monetary policy innovation is two times larger (-1.4 vs. -0.7) than real GDP and lies outside the 95 per cent interval for about 12 months. Interestingly, the timing of the peak responses are the same, and both responses end close to zero after 36 months. Panel B shows on the one hand, that the response of CPI and CPIX are qualitatively similar, with CPIX showing a somewhat stronger fall 6 to 18 months after the shock, but a mildly weaker one after 24 months; on the other hand, CPIxMIC lies almost exactly on top of the CPI measure.

Figure 6: Robustness to different measures of output and inflation



Notes: Impulse responses to a 100 basis points contractionary monetary policy shock from our baseline VAR (solid black circled line) with corresponding 68 and 95 per cent confidence bands. Panel A: Alternate VAR with (monthly) log industrial production, log CPI, log commodity prices, and our new measure of shocks (blue dashed line). Panel B: VAR with (monthly) log real GDP, log price measure, log commodity prices, and our shock series. Alternate price measures: CPIX (dashed blue line) and CPIxMIC (dotted red line). P=24. Sample: 1974:M4 to 2015:M10.

5.3 Alternative first-stage specifications

In this section, we examine the robustness of our baseline results to different first-stage specifications. First, as mentioned in Section 2, we consider meetings that are at least four weeks apart during the 1980s up to May 1994, where Bank rate changes occurred frequently. In Panel A of Figure 7, we test the robustness of our results by considering all meetings that are at least two weeks apart for that period (blue, dashed line), as done in Cloyne and Hürtgen (2016).[41] The responses of real monthly GDP and CPI inflation are both qualitatively similar to our main results, although the CPI response is slightly

[41] This increases the number of policy meetings (i.e. observations in our first-stage regression) to 549.

stronger.

Second, also in Panel A (red dotted line) we show the robustness of our results to breaking the first stage estimation in 1994, when the operating bands for the overnight rate were introduced. The response of real GDP is very similar to our main results for the first 18 months, and then decrease more to peak at 0.95 per cent between months 25 and 36. For CPI, again the first 18 months are almost exactly equal as our main results, and afterward the response remains weaker, although following a similar pattern.

Third, in Panel B we modify the set of first-stage regressors in two ways: one where we add a second lag of real-time GDP growth and inflation (blue dashed line), and one where the USD/CAD exchange rate enters the first-stage regression with only one week lag, instead of two (red dotted line). For both cases, impulse responses are very much in line with our main results.

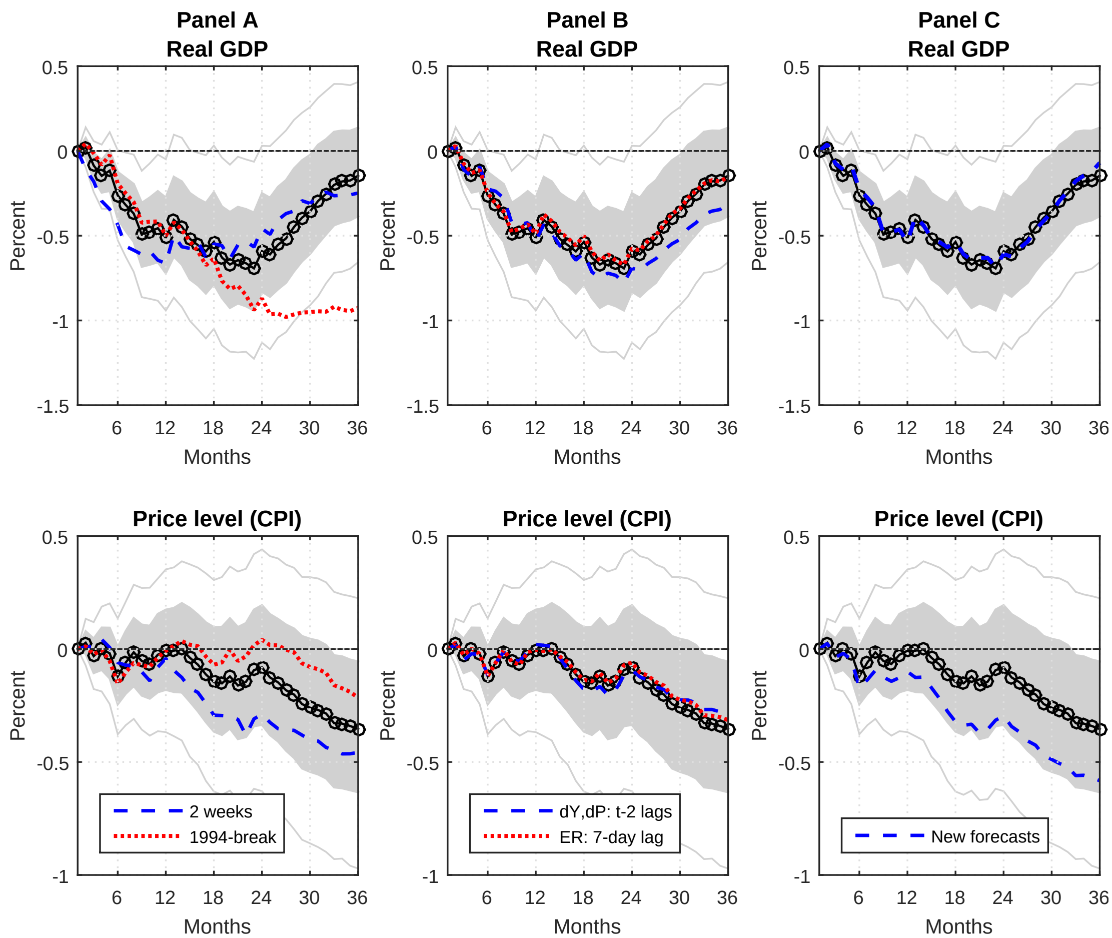
Finally, in Panel C we include additional observations when the intended policy rate was unchanged but a new set of forecasts was released.[42] The responses of real monthly GDP are virtually unchanged in this specification, whereas the response of CPI is stronger but within the 68 per cent confidence bands.

5.4 The importance of controlling for forecasts and foreign variables

In this section, we explore the importance of adding forecasts and the foreign variables to our first-stage specification. As we discussed earlier, in our first stage regression we critically depart from the narrative literature by (i) breaking the estimation in two sub-samples and (ii) including U.S. short-term interest rates and the CAD/USD exchange rate ("foreign variables"). In this section, we examine the importance of controlling for those foreign predictors as well as real GDP growth and inflation forecasts when identifying our monetary policy shock measure. Panel A of Figure 8 shows the response of real monthly GDP and inflation to monetary policy shocks when the first stage regression does not include forecasts of either GDP growth or inflation. This omission increases the GDP response slightly, but leads to a stronger inflation response. This is contrary to the evidence from the U.S.

[42]This adds 25 (XX confirm this XX) meetings to our first-stage regressions.

Figure 7: Robustness to different first-stage specifications



Notes: Impulse responses to a 100 basis points contractionary monetary policy shock using our new measure of shocks (solid black circled line) with corresponding 68 and 95 per cent confidence bands compared with shock series of different first-stage specifications. VARs include (monthly) log real GDP, log CPI, log commodity prices, and the alternate shock series. The alternate shocks series are estimated from different specifications of equation (2): Panel A - meetings are at least two weeks apart between 1980 and 1994 (dashed blue line), and breaking first-stage estimation in 1994 (dotted red line); Panel B - adding second lags of real-time inflation and GDP growth (dashed blue line) and including 7-day lag of the USD/CAD exchange rate (dotted red line) instead of 14-day lag; Panel C - includes all new forecasts counting as meetings, even if the intended policy rate did not change (dashed blue line). P=24. Sample: 1974:M4 to 2015:M10.

(R&R) and U.K. (Cloyne and Hürtgen (2016)) where the exclusion of forecasts leads to the well-known price puzzle. As discussed in Section 2.1, there is extensive narrative evidence, in addition to our own estimates, that the role played by the forecasts was very different before and after 1992, when inflation targeting began. In this sense, it is no surprise that the exclusion of the forecasts does not lead to a price puzzle.

In Panel B, we show the responses of real GDP growth and inflation to monetary policy shocks estimated with first stage regressions that omit the foreign predictors. In this case, we find a much weaker response of both real GDP and inflation to the monetary policy shocks, highlighting the importance of controlling for the foreign predictors in the policymakers' information set.

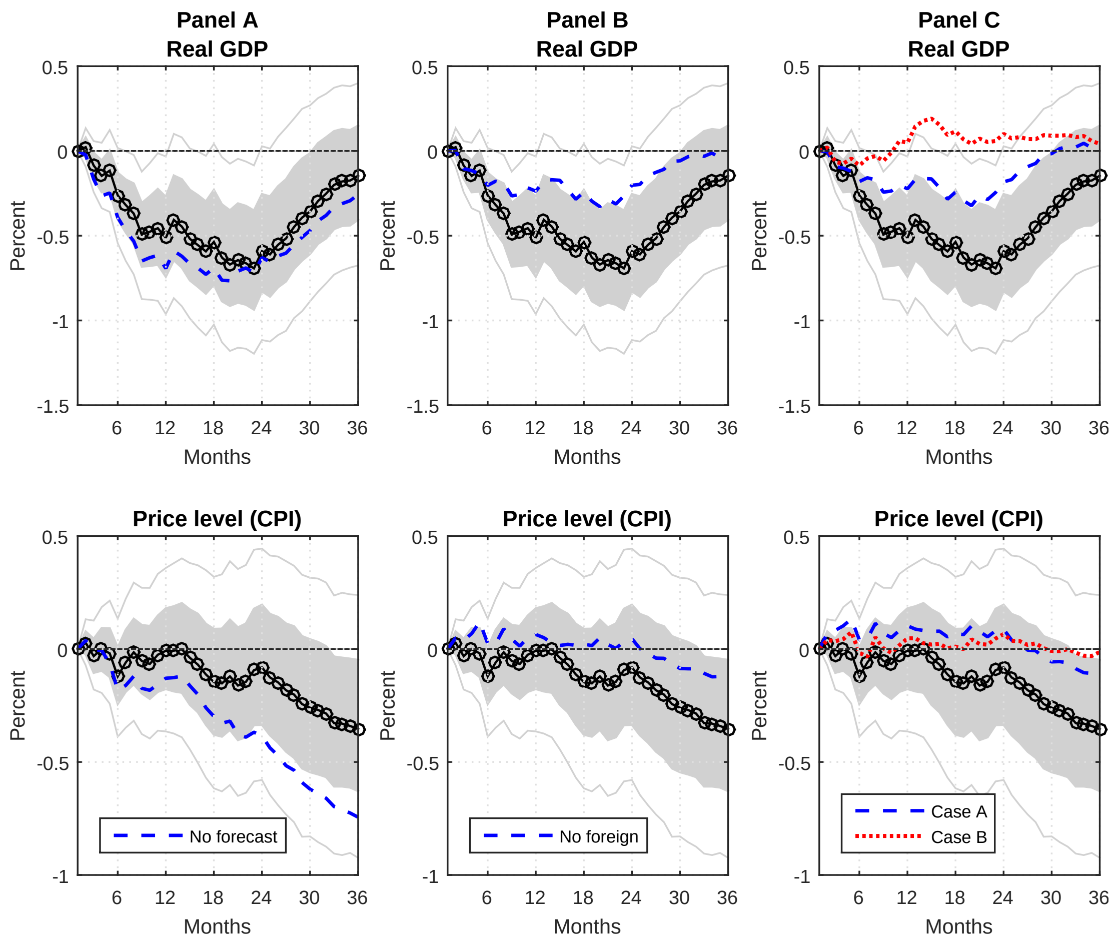
Finally, in Panel C we perform two different exercises. First (Case A, dashed blue line), we exclude the foreign variables of the first stage regression for the pre-IT sample (1974-91) and the forecasts for the IT sample (1992-2015). This leads to a even weaker response of real GDP and inflation stays basically flat around zero. At last, we exclude both foreign variables and forecasts, from both sub-samples (Case B, dotted red line). We find a positive real GDP response and a price puzzle for the price level for most of the horizons. These results highlight the importance of controlling for foreign predictors during our first sub-sample (1974 to 1991) and economic forecasts from the staff projections in latter part of our sample (1992 to 2015). Both are key to removing the price puzzle.

5.5 Quarterly VAR

As discussed earlier, the availability of a monthly GDP measure for Canada exempts us from having to use a monthly proxy for economic activity, like industrial production. Many papers, though, estimate VAR models at the quarterly series in order to investigate the impact of monetary policy shocks on GDP. For comparability, in this sub-section we estimate a quarterly VAR, summing up our monthly monetary policy shocks within the quarter, as in Cloyne and Hürtgen (2016). The responses of quarterly real GDP and CPI, shown in Panel B of Figure 9, are very similar to the monthly VAR ones. The peak impact (-0.7 per cent) on GDP occurs about eight quarters after the shock, and the impact dissipates after 12 quarters, as in the monthly VAR. CPI responds by falling very little during the first 8 quarters after the shock, and then accelerates to end -0.4 per cent lower after three years.[43]

[43] We can also use our new shocks measure to assess the effects of monetary policy on a range of other macroeconomic variables, such as consumption, investment, exports, hours worked, etc. Appendix C.XX shows the impulse responses of other quarterly macroeconomic aggregates to our shocks measure using the local projections method.

Figure 8: Robustness to excluding forecasts and foreign variables



Notes: Impulse responses to a 100 basis points contractionary monetary policy shock using our new measure of shocks (solid black circled line) with corresponding 68 and 95 per cent confidence bands compared with different first-stage specifications of equation (2). VARs include log (monthly) real GDP, log CPI, log commodity prices, and the shocks measure. Panel A: first-stage regression without nowcasts and forecasts (dashed blue line). Panel B: first-stage regression without foreign variables (dashed blue line). Panel C (Case A, dashed blue line): first-stage regression estimated without foreign variables for 1973-91 and without nowcasts and forecasts for 1992-2015. Panel C (Case B, dotted red line): first-stage regression estimated without both foreign variables and forecasts for both sub-samples. P=24. Sample: 1974:M4 to 2015:M10.

5.6 Inflation-targeting period

The Bank of Canada announced in 1991 a new inflation-targeting framework for monetary policy that officially began in January 1992. Following this announcement, inflation quickly converged to the target and has remained low and stable since. Likewise, between the early 1990s recession up to the Great Recession following the financial crisis, the volatility of GDP growth has been significantly lower relative to the previous two decades. The lower volatility of output and inflation during this period is also reflected in the estimated monetary policy shocks. As Figure 1 shows, our estimates of monetary policy shocks are visibly less variable after the introduction of inflation-targeting. Given this remarkable shift in the conduct of monetary policy, we now examine if the effects of monetary policy have remained stable through this period.

When examining the effects of monetary policy for the inflation-targeting period, we estimate our first-stage regression solely using data from 1992–2015. We then use our baseline VAR[44] to estimate the responses of real GDP and CPI during this period. Panel A of Figure 9 shows the results. Real GDP falls to a peak effect of -0.7 per cent following a 100 basis points monetary policy shock, although the response is more persistent than our full sample estimates, as the shock does not dissipate after 36 months. For the price level, we observe a small price puzzle between months 6 and 12 following the monetary policy shock, where then the price level falls by 40 basis points to end at -0.2 per cent, slightly lower than our main estimates. The CPI response is significant in the last 8 months.

Overall, our estimates suggest that monetary policy effects on GDP are quite similar before and after the introduction of inflation targeting.[45] Reflecting the smaller sample size, as well as the lower variability of our shock series, it is not surprising that confidence bands around these estimates are larger than for our full sample estimates.

5.7 The effects of U.S. monetary policy on Canadian variables

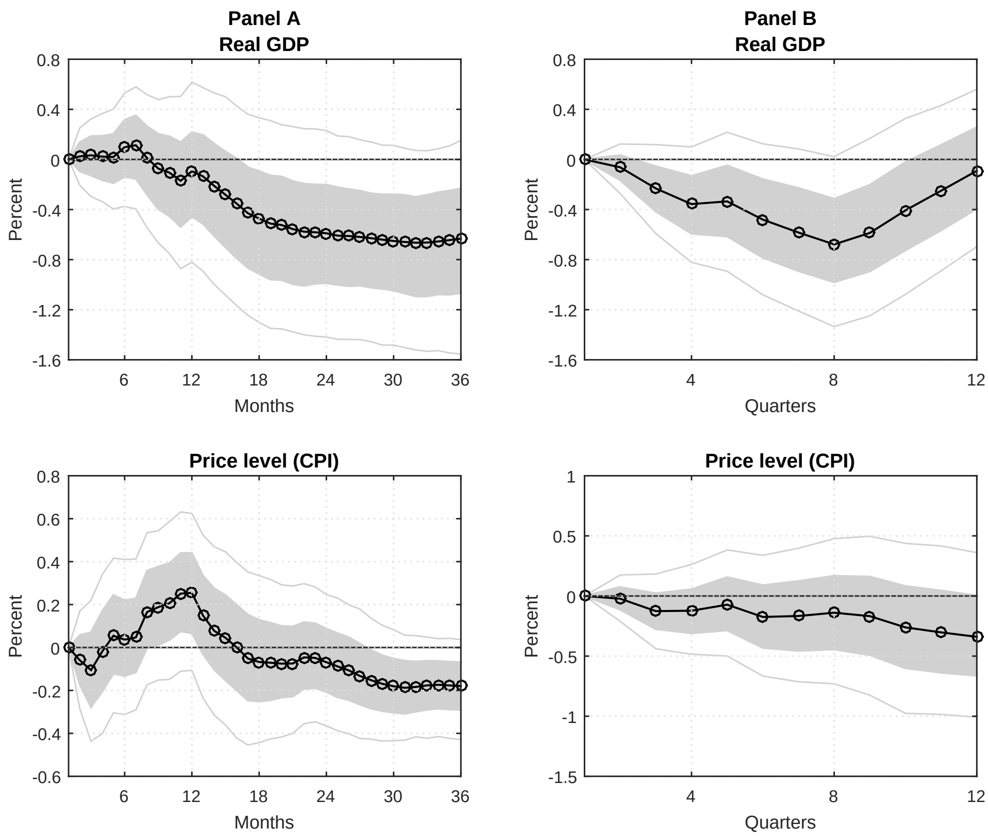
A large literature has examined the international transmission of monetary policy. Not surprisingly, given its size and importance in the international monetary system, a large share of this literature focus on the transmission of U.S. monetary policy to other developed or developing countries.[46] As discussed by Georgiadis (2016), in many countries spillovers from U.S. monetary policy generate output fluctuations that are larger than the domestic

[44]When examining the effects of monetary policy during the inflation-targeting period, we estimate our main VAR with only 12 lags, given the smaller sample.

[45]Similarly, Cloyne and Hürtgen (2016) also finds that the effects of monetary policy on output remained similar after the introduction of inflation-targeting in the U.K.

[46]See, for example, Ehrmann and Fratzscher (2009), Bluedorn and Bowdler (2011), Ehrmann and Fratzscher (2005), Bruno and Shin (2015), and Georgiadis (2016), among many others.

Figure 9: IT-period and Quarterly VAR



Notes: Impulse responses to a 100 basis points contractionary monetary policy shock (solid black circled line) with corresponding 68 and 95 per cent confidence bands. VARs include log real GDP, log CPI, log BCPI, and our new measure of shocks. Panel A: VAR estimated (monthly frequency) only for the Inflation Targeting period (1992 onward). Panel B: VAR estimated using quarterly data. P=12 for IT-period VAR and P=8 for quarterly VAR. Sample: 1992:M1 to 2015:M10 (IT period VAR) and 1974:Q2 to 2015Q3 for quarterly VAR.

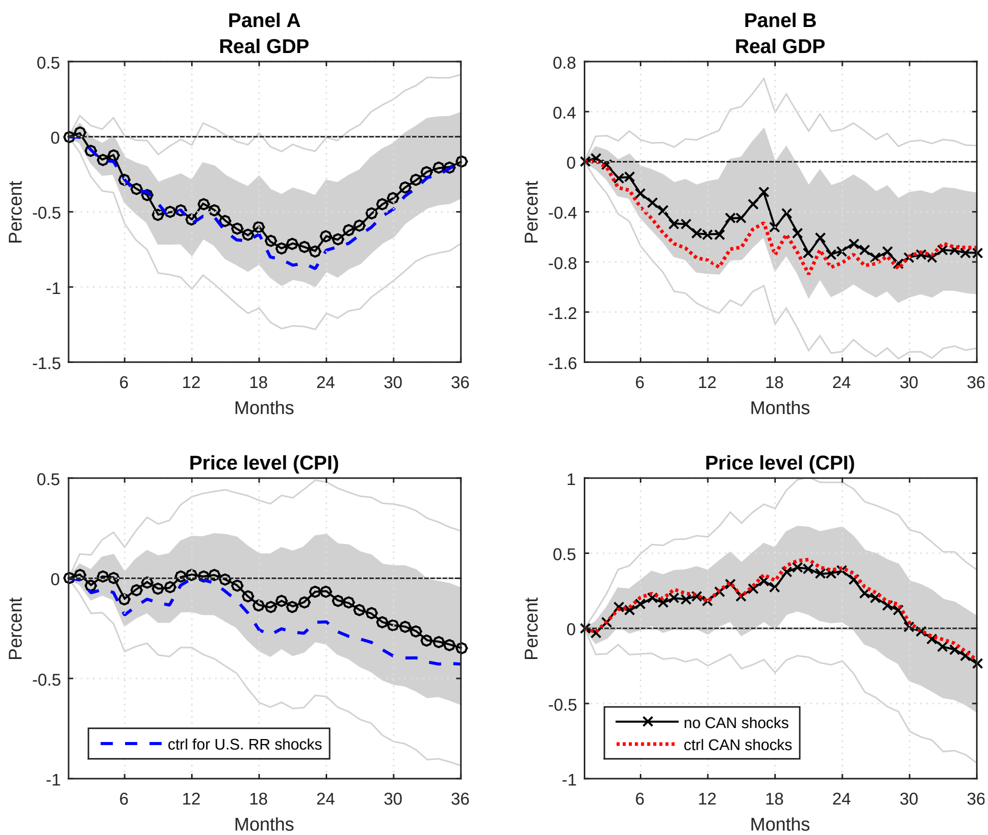
effects of U.S. monetary policy itself. Given Canada's size relative to the U.S. and its close commercial and financial ties, it is not surprising if U.S. monetary policy shocks would affect Canadian output and inflation.

In order to compare the magnitude of spillovers from U.S. monetary policy shocks in Canada with our main estimates, we augment the VAR in Section 4 with R&R monetary policy shocks updated to 2011.[47] We first note that our main results are very similar when we stop the VAR estimation in 2011; second, we verify the robustness of our results to the inclusion of R&R U.S. monetary policy shocks in the VAR. Third, we examine the response of Canadian real GDP and inflation to the U.S. shocks.

Figure 10 shows the results. Panel A shows that the inclusion of U.S. monetary policy shocks in the VAR is inconsequential to our baseline results. Real GDP responses are virtually unaffected, whereas the response of CPI is a bit stronger, but well within the 68 per cent confidence bands. More interestingly, Panel B shows the response of Canadian real GDP and CPI to a U.S. monetary policy shock. Following a 100 basis point U.S. contractionary shock, Canadian real GDP falls reaching a peak of approximately 0.8 per cent between 18 to 24 months. This is remarkably similar to the response to the domestic monetary policy shock, albeit much more persistent. Even after 36 months, the GDP response to the U.S. shock shows no sign of dissipating. The response of Canadian CPI to the U.S. shock is very different than from our Canadian shock measure: CPI slowly rises, with a peak effect of almost 0.5 per cent after 18 months. It then reverses its trajectory until the response turns negative after 30 months. As we show in the appendix, the depreciation of the Canadian dollar following the U.S. monetary policy shock explains the positive response of CPI for the first 18 months. When the exchange rate pass-through dissipates, the negative effects of the U.S. shock on domestic economic activity dominates and the CPI starts decreasing.

[47] We use Greenbook forecasts data from Yuriy Gorodnichenko's website and re-estimate the R&R shocks for the 1973 to 2011. Note that starting in 1969 (as in R&R) does not change our results.

Figure 10: The Spillover Effects of U.S. shocks



Notes: Impulse responses to a 100 basis points contractionary monetary policy shock (solid black circled line) with corresponding 68 and 95 per cent confidence bands. VAR includes log (monthly) real GDP, log CPI, log BCPI and the measure of monetary policy shocks. Panel A: VAR includes U.S. R&R monetary policy shocks, ordered before our measure of shocks (blue dashed line). Panel B: effects of U.S. monetary policy shocks on Canadian real GDP and CPI. We substitute in the VAR our new measure of shocks for the R&R shocks (solid black circled line); we also include our new measure of monetary policy innovations as a control, ordered (dotted red line).

6 Conclusion

Estimating the effects of monetary policy on the economy has been one of most studied question in all macroeconomics, and the estimates vary markedly across the literature. On the one hand, many papers identifying the exogenous component of monetary policy using different VAR models obtain modest responses of output and inflation to monetary policy shocks. On the other hand, using narrative methods, R&R estimate large effects of monetary policy shocks while Coibion (2012) suggests that the effects of monetary policy are likely to be medium-sized. On the international side, Cloyne and Hürtgen (2016) apply R&R's narrative approach to the U.K. and find similar effects as those for the U.S. of Coibion (2012).

We construct a new, rich data-set of real-time data and forecasts from the Bank of Canada staff projections going back to the early 1970s and employ the narrative strategy of R&R to identify a new measure of monetary policy shocks for Canada. Canada is an interesting case study as it is a textbook small-open economy, closely linked with the U.S. and has its own specific institutional details regarding the conduct of monetary policy. We find that a 100 basis points monetary policy innovation generates a peak decline of 0.7 and 0.4 per cent in real GDP and CPI, respectively, after two to three years. Whereas the response of GDP to this shock is of similar magnitude as the one for U.S. and the U.K, the peak decline of CPI in Canada is about half. Relative to previous Canadian studies using standard VAR approaches, our estimates are much larger. We also provide evidence that spillovers from U.S. monetary policy shocks lead to very similar drop in GDP and a rise in the price level.

We show that our new measure of monetary policy shocks crucially departs from R&R on two aspects: first, the monetary policy reaction function includes U.S. interest rates and the USD/CAD exchange rate; second, it accounts for the strong change in the Canadian monetary policy framework following the adoption of IT from 1992 onward. Before the introduction of IT in Canada, changes in the target policy rate are mostly explained by the USD/CAD exchange rate and U.S. interest rates, while they are more significantly centered around the staff forecasts for output and inflation since. If we do not account for these when identifying our new measure of shocks, a price puzzle emerges. Moreover, using a commonly-used recursive VAR with the Bank rate instead of our new measure of shocks leads again to a price puzzle, as found in the U.S. and the U.K.

Our results bring much needed evidence on the effects of monetary policy shocks in Canada, and contribute to the ongoing debate about the conduct of monetary policy and its effects on the economy. In doing so, we provide a new measure of monetary policy shocks for Canada and hope it will provide new, interesting avenues for future research.

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