

Study of the Unemployment Rate Response to Narrative Monetary Policy Shocks in Canada: A Local Projection Approach with Regional Differences and State-dependency Considered

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Abstract

This study explores the state-dependent effects of monetary policy shocks on the Canadian economy at two levels: national and provincial. The study employs the monetary policy shocks identified by Champagne and Sekkel (2018) by narrative approach. The impulse response framework used in the study is local projections (LPs), a widely applied linear regression-based alternative to the standard vector autoregression (VAR) framework. The state-dependency is modelled by both a dummy variable approach and a smooth transition approach. Two economic states are considered: expansion and recession. One major finding is noticeable differences exist across some Canadian provinces as well as between economic states in terms of unemployment response to monetary policy. Sensitivity analyses solidify the result.

Key words: impulse response, local projections, state-dependent, monetary policy shocks, unemployment rate, territorial, provincial, long horizon

I would like to formally express my deep gratitude to my Major Research Paper supervisor Professor Francesca Rondina. In my view, she has been the embodiment of academic excellence, supportive advisorship, and caring teachership throughout my master's studies at University of Ottawa.

1 Introduction

Canada is a large federation composed of ten provinces and territories, which together cover 9.985 million square kilometers, making it the second-largest country in the world by total area. The Canadian provinces and territories differ in many respects, from economic structure, to culture, to demographic structure. Hence, it is natural to raise the question of whether they respond to monetary policy actions differently. In addition, it has long been entertained as an idea that monetary policy actions are likely to have differential effects depending on the economic state (see Tenreyro and Thwaites, 2016; Thoma, 1994). Inspired by these two understandings, this study investigates how the combination of the two factors affects monetary policy effects. Specifically, this paper aims to empirically study if material differences exist in the response of unemployment rates to monetary policy across different regions and in different economic states in Canada.

There is little arguing against unemployment being a topic of perennial interest for economists. Employment, or unemployment, has long been utilized as the economic indicator in monetary policy response studies (see Georgopoulos, 2009; Potts and Yerger, 2010). It is hard to refute that the unemployment rate is affected by numerous factors which are regional in nature. To be more specific, the geographical location and natural resource endowment could largely influence the industry structure and local residents' behaviour, which in turn could affect unemployment rates under various circumstances. Apart from the geography and natural resources, local governments could also play a part in unemployment rate response heterogeneity, in view of the fact that Canada is a federation and the ten provincial governments have high autonomy in local economic matters. It is often the case that regional governments adopt different approaches in response to a nation-wide economic shock, likely giving rise to differential responses of certain macroeconomic variables at the regional level.

There is value in ascertaining whether monetary policy effects depend on the economic state. If the effects of monetary policy vary across business cycles, the government might need to adjust its policy actions according to the economic state. In view of the high stakes of monetary policy, it is desired that knowledge of monetary policy effects be as specific as possible. In fact, the literature offers empirical evidence (see Carlino and DeFina, 1998; Owyang and Wall, 2009) in support of the proposition that, in the U.S., the economy's response to monetary policy shocks does vary with the state of the economy. In light of the similarity and adjacency between Canada and the U.S., whether the monetary policy in Canada has state-dependent effects on the economy is a natural subject for investigation.

In addition to its potential practical significance, this study could potentially contribute to the deeper understanding of economic models, in the spirit of the Lucas program, which proposes to test the plausibility of structural economic models based on their responses to exogenous shocks (see Lucas, 1980). The details for leveraging impulse response analyses to deepen structural understanding of economies could be a good topic to be explored in subsequent studies. Last but not least, impulse response analyses are a widespread approach in economic studies. They have been

applied to numerous problems and multiple methods have been proposed to conduct them (see Ramey, 2016; Lütkepohl, 2005). This impulse response-based study offers an in-depth case study, to which other academic works could compare and contrast. Juxtaposition of works on similar problems or by related methods often generates insights that are hard to come by in standalone studies.

The method of my choice is local projections (see Jordà, 2005). Local projections (LPs) have been gaining increasing attention in academia since 2005 when they were proposed. It has become a popular practice, if not a standard one, to conduct both VARs and LPs in an impulse response study for comparative and confirmatory purposes (see Ramey, 2016). The pros and cons of VARs and LPs have been hotly debated. The up-to-date research of the economic community on comparisons between VAR-based impulse response and local projections will be discussed in section 2. In short, it is acknowledged by most academics that local projections are better in providing flexibility in modeling varying time horizons and state-dependency (see Ramey and Zubairy, 2018), as well as in providing robust inferences in comparison to VARs (see Montiel Olea and Plagborg-Møller, 2021).

In the context of the economic literature, this study differentiates itself from the existing literature in its attempts to investigate whether the state-dependent effects of the Canadian monetary policy shocks differ across regions. To the best of my knowledge, no such studies exist in the literature. Several existing studies attempt to quantify the effects of monetary policy shocks at a regional level (see Fortin-Gagnon et al., 2021). However, they do not take economic states into consideration. There are also studies focused on quantifying the effects of monetary policy in different economic states (see Tenreyro and Thwaites, 2016). Yet they do not investigate regional responses. Moreover, most works study the United States, not Canada. Hence, this study aims to fill the gap in the existing literature on the differential responses of the Canadian regional unemployment rate to monetary policy in different economic states. This paper adds to a small, yet growing, body of empirical literature on varying monetary policy effects.

The remainder of the paper is organized as follows. Section 2 provides a literature review on relevant studies and results. Section 3 delineates the framework and data applied in this study. Section 4 presents the empirical results and interpretations. Section 5 conducts the sensitivity analysis on the results. Section 6 concludes this study and suggests future research topics.

2 Literature Review

2.1 Regional Effects of Monetary Policy

Most of studies on regional monetary policy effects employ real variables. For instance, the U.S. studies typically use personal income and related proxies and Canadian studies normally use various measures of employment. Studies on Europe, Australia, and China are usually based on GDP or its proxies.

Most of the existing empirical studies on regional effects of monetary policy

focus on the United States and the European monetary union (EMU), in large part due to the high stakes of the heterogeneous effects of monetary policy for the U.S. and the EMU (see De Grauwe, 2011) and the large quantities of high quality data available in these two economies (see Cavallo and Ribba, 2015; Georgiadis, 2015). In addition to the U.S. and the EMU, there are studies on regional effects of monetary policy in several other countries, including Australia (see Fraser, Macdonald and Mullineux, 2014; Vespignani, 2015; Weber, 2006), Canada (see Georgopoulos, 2009; Potts and Yerger, 2010), China (see Cortes and Kong, 2007; Guo and Tajul, 2017, 2014), India (see Nachane, Ray and Ghosh, 2002), Indonesia (see Ridhwan et al., 2011), and Turkey (see Duran and Erdem, 2014). Dominguez-Torres and Hierro (2019) synthesize the empirical research of regional effects of monetary policy up to the year of 2018.

Most studies of the regional effects of monetary policy apply VARs. To the best of my knowledge, Calino and DeFina (1998; 1999; 1999) first apply the VAR framework to analysis of regional effects of monetary policy in investigating the effects of U.S. monetary policy in different geographical areas of the U.S. Gerlach and Semets (1995), as well as Kieler and Saarenheimo (1995; 1998) utilize the VAR framework to analyze differential monetary effects at the cross-national level. There are only a few studies (see Fortin-Gagnon et al., 2021) in the literature on using LPs to study the regional effects of monetary policy in Canada.

The empirical analyses generate ample evidence for the regional heterogeneity of monetary policy responses in a few countries. It should be noted that many results are not completely comparable across studies and geographies. This is because studies on different geographies employ different economic indicators and/or adopt different methodologies. Nevertheless, the comparable studies do supply strong converging evidence for both territorial and temporal heterogeneity of monetary policy responses in some monetary unions, such as the U.S. (see Carlino and DeFina, 1998; Carlino, DeFina et al., 1999; Crone et al., 2007; Owyang and Wall, 2009) and the EU (see Boeckx, Dossche and Peersman, 2017; Burriel and Galesi, 2018). Yet for most other monetary unions, robust and converging results are lacking.

As mentioned previously, the studies on monetary policy effects in Canada pale in comparison to those on the U.S. and the EMU in terms of quantity. Yet there is still robust, albeit sometimes conflicting, evidence for regional heterogeneity of monetary policy effects. For instance, Georgopoulos (2009) points out that the Canadian regions most affected by monetary policy are Newfoundland and Prince Edward Island, while Potts and Yerger (2010) rank Ontario and Quebec as the regions most responsive to monetary policy. Looking at the study details, the disagreement of ranking between studies might be due to the following reasons. One, different types of effects are measured and modeled, with some employing cumulative effects whilst others use non-cumulative effects. Two, different economic indicators are used in different studies, with some using employment while others use non-agricultural employment. It also should be noted that neither of these two studies consider possible differences in monetary policy effects in different economic states.

2.2 State-dependent Monetary Policy Effects

The empirical literature on state-dependency of monetary policy effects is small and notably none of it is on Canada. The paper closest to this study is Tenreyro and Thwaites (2016), in both method and result. Tenreyro and Thwaites' (2016) study directly parallels my research in using regime-switching LPs and narrative monetary shocks (see Romer and Romer, 2004) to investigate the effects of monetary policy on real economic variables in different economic states. The differences between their study and mine are that Tenreyro and Thwaites (2016) do not investigate effects of monetary policy at the regional level and their study is on the U.S. economy while mine is on Canada. Tenreyro and Thwaites (2016) present strong evidence for the asymmetric monetary policy effects in the U.S. Some other studies adopt different methods to reach similar results, pointing to monetary policy effects being more powerful in expansions than in recessions (see Thoma, 1994). There are also a few studies based on methods similar to mine and Tenreyro and Thwaites (2016) for purposes other than estimating the monetary policy effects. For example, Ramey and Zubairy (2018) adopt state-dependent LPs to study whether U.S. government spending multipliers change according to the economic state. Auerbach and Gorodnichenko (2012) apply regime-switching VARs to investigate the output responses to fiscal policy for different economic states.

A few studies attempt to theoretically explain the asymmetric effects of monetary policy. For example, Aastveit et al. (Aastveit, Natvik and Sola, 2013) argue that monetary policy shocks have significantly weaker effects when uncertainty is high. Vavra (2014) also maintains that recessions often come with high uncertainty, which in turn could be the reason that monetary policy is relatively ineffective during recessions.

2.3 Champagne and Sekkel's Shocks and Their Applications

The intensive research on macroeconomic shocks originated in the early 20th century, thanks to the works of Eugen Slutsky and Ragnar Frisch connecting shocks and economic fluctuations (see Ramey, 2016; Frisch, 1933). Since then, the literature on macroeconomic shocks quickly proliferated.

In the shock identification strand of literature, a well-established framework is narrative methods proposed by Romer and Romer (2004). The general idea is to construct shock series based on historical documents to exclude endogenous and anticipatory movements from the shock series. A number of subsequent studies follow Romer and Romer (2004) to implement the narrative approach to identify structural shocks in different scenarios. Among them are Champagne and Sekkel who estimate Canada's monetary policy shocks based on the Bank of Canada's staff projections (see Champagne and Sekkel, 2018), Murgia (2020) who estimates the Eurozone's monetary policy shocks, and Cloyne et al. (2016) who estimate the monetary policy shocks of the United Kingdom. This study adopts shocks identified by Champagne and Sekkel using narrative methods.

As discussed previously, the study that is the most relevant and comparable

to ours is Fortin-Gagnon et al. (2021), which takes advantage of Statistics Canada data and Champagne and Sekkel’s narrative-based shocks to explore the regional heterogeneity of monetary policy shocks in Canada. This study provides wide-ranging empirical evidence on the territorial heterogeneity of Canadian monetary policy effects on a large set of economic variables ranging from employment, to inflation, to housing starts. They investigate the sub-indicators under the general indicators, such as employment in various industries in addition to overall employment. In addition to regional differences and numerous economic variables studied, Fortin-Gagnon et al. (2021) also investigate temporal heterogeneity. They specifically estimate the impulse responses before and after the implementation of an inflation target. The results suggest the inflation target has a significant impact on monetary policy effects and considerable heterogeneity exists across economic variables and regions in Canada. It should be noted, however, that Fortin-Gagnon et al. (2021) do not consider possible differences in monetary policy effects in different economic states. Information regarding the data used in Fortin-Gagnon et al.’s study can be found in Section 4.1, where the data for this study are described.

3 Framework

I construct a state-dependent impulse response estimation framework based on the local projections approach (see Jordà, 2005). My framework estimates the impulse response of the unemployment rate to monetary policy at the regional level in Canada. The monetary policy shocks are identified by Champagne and Sekkel (2018). The macroeconomic variable measurements are from Statistics Canada. There are two variations for the state-dependency component applied in this study: a dummy variable approach and a smooth transition function approach. The dummy variable approach is inspired by the work of Ramey and Zubairy (2018), while the smooth transition function approach follows the work of Auerbach and Gorodnichenko (2012).

3.1 Baseline Local Projections

The baseline local projections model proposed by Jordà (2005) is as follows:

$$y_{t+h} = \alpha_h + \mathbf{b}'_{1,h} \mathbf{z}_{t-1} + \mathbf{b}'_{2,h} \mathbf{z}_{t-2} \dots + \mathbf{b}'_{p,h} \mathbf{z}_{t-p} + \beta_h d_t + \mu_{t+h}, \quad (1)$$

where y_{t+h} is the variable of interest, \mathbf{z}_{t-i} is a vector of control variables, d_t is the shock vector, h indicates the response horizon length and p is the control lag length. In this study, the variable of interest is the unemployment rate. Research (see Montiel Olea and Plagborg-Møller, 2021) suggests lags of the variable of interest should be included among the controls to augment LPs. I thus include 4 lags of the variable of interest as controls. Comparative implementations suggest more than 4 lags do not make noticeable differences. All LP models in this study are lag-augmented LPs with no other control variables besides lags of the variable of

interest. Following Champagne and Sekkel (2018), I also include 48 shock lags to control for measurement errors in the shock series, as explained in Section 3.4. Comparative applications show results differ as the shock lag changes until 48 and more than 48 shock lags do not change the results in material ways. Thus, all models in this study have 48 shock lags as controls.

3.2 State-dependent Regional Local Projections

The framework adopted in this study expands on the baseline LP (1) with two additions: state-dependency estimation and regional effect estimation. As mentioned before, there are two variations for state-dependency estimation. The dummy variable variation of the framework is as follows:

$$y_{t+h,k} = \mathbf{I}_{t-1}[\alpha_{A,h,k} + \Phi(L)_{A,h,k}z_{t-1,k} + \beta_{A,h,k}d_t] + (1 - \mathbf{I}_{t-1})[\alpha_{B,h,k} + \Phi(L)_{B,h,k}z_{t-1,k} + \beta_{B,h,k}d_t] + \mu_{t+h,k}, \quad (2)$$

where \mathbf{I}_{t-1} is a dummy variable representing the state of the economy, $\Phi(L)$ is polynomial lag operator, and k indicates the region, namely the Canadian provinces and territories. I define two states for the economy in this study, recession and expansion, where $\mathbf{I} = 0$ corresponds to an economy in the state of recession as indicated by A in the subscript of parameters, and $\mathbf{I} = 1$ in the state of expansion as indicated by B in the subscript of parameters.

The second state-dependency component, the smooth transition function variation of the framework is as follows:

$$y_{t+h,k} = \mathbf{F}(z_{t-1})[\alpha_{A,h,k} + \Phi(L)_{A,h,k}z_{t-1,k} + \beta_{A,h,k}d_t] + (1 - \mathbf{F}(z_{t-1}))[\alpha_{B,h,k} + \Phi(L)_{B,h,k}z_{t-1,k} + \beta_{B,h,k}d_t] + \mu_{t+h,k}, \quad (3)$$

where $\mathbf{F}(z_t)$ is a smooth transition function. In this study, I define it as the following logistic function:

$$\mathbf{F}(z_t) = \frac{e^{(-\gamma z_t)}}{1 + e^{(-\gamma z_t)}}, \quad (4)$$

where z_t is an index of choice, $\gamma > 0$ is a parameter. There is no consensus choice of index z . I follow Auerbach and Gorodnichenko (2012) to set z to be a seven-month moving average of output growth. The parameter γ is set by the modeler and it needs calibration. I calibrate it to be $\gamma = 1.5$ and define the economy to be in recession if $\mathbf{F}(z_t) > 0.8$ to align smooth transition function results with economic datings in the literature. Under this calibration, most of the identified recessions are also recessions dated in Cross and Bergevin (2012), as will be discussed in Section 5.

3.3 Rationale for Local Projections

The differences of impulse response estimation between local projections and the VAR are loosely parallel to direct forecasting and iterated forecasting (see Ramey, 2016). The VAR estimates impulse response functions (IRFs) by iterating forward with the parameters of one horizon estimated on the basis of the parameters in the previous horizon. In contrast, LPs directly estimate IRFs for each horizon. Hence the name, meaning shock effects being locally projected to a specific response period without going through all the periods between the shock period and the response period. In LPs, the estimation of the IRF for one horizon does not depend on the estimate of the IRF in the previous horizon. It has been long discussed and debated how to compare and select VAR and LP in impulse response analysis. Early literature in impulse response community suggests the LP is better than the VAR in that the LP is free from compounded mis-specification errors because it leapfrogs the interim periods, avoiding possible accumulation of errors along the course of computation (see Jordà, 2005). However, cutting-edge research suggests that LPs and VARs are conceptually identical and both frameworks generate the same impulse responses under certain conditions, including unrestricted lag structures (see Plagborg-Møller and Wolf, 2021). Olea and Plagborg-Møller (2021), on the other hand, point out that LPs hold several advantages over VARs including that LPs are more parsimonious and robust under certain conditions.

Between the two impulse response candidate frameworks, this study opts for LPs. In light of the general equivalence between VAR and LP approaches in impulse response analysis, there still appears to be reasons for gravitating toward one of the two under certain circumstances. In particular, the following reasons compel me to choose LPs over VARs in this study.

The LP approach, by construction of linear regression, allows easier and more flexible ways than the VAR approach does to model states or regimes (see Jordà, 2005; Ramey and Zubairy, 2018). As demonstrated above in subsection 3.2, an LP framework could be easily extended to model nonlinear state-dependency by introducing dummy variables or smooth transition functions. In contrast, A VAR framework does not readily provide such an easy way to model nonlinear state-dependency.

LPs are more parsimonious by design, which makes them more suited for investigating a large number of variables' responses without including too many variables in the model (see Champagne and Sekkel, 2018), in contrast to VARs. To be specific, LPs, being linear regressions, could have one variable of interest as the regressand in estimating the variable's response to identified shocks. Hence, LPs are also known as a single equation approach in the literature. Conversely, VARs need to simultaneously include a vector of variables in one model, even only one of them is of interest. In the cases where a large number of variables are to be estimated in VARs yet only a few of them are of interest, and/or we do not wish to assume a particular structural model incorporating all the variables, LP-based single equation models stand as the preferred option.

Finally, if the structural shock has already been identified, LPs provide an easy framework to incorporate them. If the structural shock has already been exogenously identified, LPs provide a more natural framework than a VAR to include the shock in the model. By construction, LPs have a distinctively defined regressor term for the shock on the right-hand side of the equation (see Adämmer, 2019) while VARs do not.

Altogether, in view of the fact that this study investigates model dependency based on exogenous shock series, LPs constitute a natural choice for modeling.

3.4 Rationale for Choosing Champagne and Sekkel Shocks

I utilize the monetary policy shocks identified by Champagne and Sekkel (2018) in the impulse response analysis of this study. The Champagne and Sekkel shocks are based on the narrative approach in method and Bank of Canada's staff projections for data.

The constructed monetary shocks are desired to be free of endogenous and anticipatory movements. Narrative methods are designed for this goal. In Romer and Romer (2004), the Federal Reserve's internal forecasts of inflation and real activity contain both endogenous and anticipatory movements. Thus, it makes sense to purge the intended monetary policy actions of Federal Reserve's internal forecasts to obtain "cleaner" monetary policy shocks, which should be unexpected by definition. Analogously, monetary policy shocks in other economies could be obtained by purging the intended monetary policy actions of systematic components of monetary policy, typically based on information from the central bank. In particular, Champagne and Sekkel (2018) apply the narrative approach to derive the Canadian monetary shock series by purging the explicit target interest rates published by the Bank of Canada from systematic components of the monetary policy reaction function, including the real output growth, inflation, and U.S. Federal Funds Rates as well as CAD/USD exchange rates. This study uses Champagne and Sekkel's shock series.

Building on Romer and Romer's narrative methods, Champagne and Sekkel make two critical modifications specific to the case of identifying the Canadian monetary policy shocks. One, Champagne and Sekkel control for the U.S. federal funds rate and the USD/CAD nominal exchange rate (see Champagne and Sekkel, 2018) in addition to the economic variables considered in Romer and Romer's narrative approach. These controls are based on the premise that the Canadian economy is subject to the influences of the U.S. monetary policy because it is a small open economy with deep economic ties with the U.S. Two, Champagne and Sekkel conduct shock identification on two subsamples over the periods divided by the introduction of an inflation target (IT) in 1991, instead of identifying shocks based on the whole period extending before and after the inflation target introduction. The premise is the introduction of the IT fundamentally altered the systematic component of the target policy rate, and thus altered shock identification. Both premises are reasonable in theory and practice, thus these two modifications of Champagne and Sekkel enhance the credibility of the identified shock series.

In addition, multiple studies apply Champagne and Sekkel’s shocks to a wide range of scenarios involving multiple economic variables with both VAR and LP methods (see Cantore, Ferroni and León-Ledesma, 2019; Champagne and Sekkel, 2018; Duprey and Ueberfeldt, 2020; Fortin-Gagnon et al., 2021; Jain and Sutherland, 2018; Kronick and Villarreal, 2019; Mugableh et al., 2019; Verstraete and Suchanek, 2018), with results consistent with economic theory and common sense to a great degree. The results are also internally consistent, meaning LPs and VAR arrive at largely consistent results. The generally consistent application results generated by various impulse response estimation methods and variables lend credibility to the validity of the monetary shocks constructed by Champagne and Sekkel.

Two caveats should be noted on Champagne and Sekkel’s shocks. First, the rationale behind narrative methods requires the premise that the monetary policy reaction function does not change over time, at least not in the economy during the time span of shock identification. This assumption in the U.S. case is challenged by multiple studies (see Boivin and Giannoni, 2006; Primiceri, 2005), which suggest a major change in U.S. monetary policy systematic components in the early 1980s. However, to the best of my knowledge, there is no strong evidence for Canadian monetary policy systematic components undergoing major changes, aside from the introduction of the IT, which has been accounted for in Champagne and Sekkel’s shocks. Second, as the intermediate results provided by Champagne and Sekkel (2018) suggest, measurement errors exist in shock series construction, which lead to undesired auto-correlation in shock series. Hence, shock lags are included as controls in LPs as stated in Section 3.1. This practice follows Champagne and Sekkel (2018) and Fortin-Gagnon et al. (2021), who include 48 lags of the shocks as controls in their LP implementations.

4 Empirical Analysis

4.1 Data

Data from three sources are used in the empirical component of this study. First, the macroeconomic data are from Statistics Canada. The variables and the vector names are provided in Table 1 in the Appendix. Second, the shock data are from the dataset provided by Julien Champagne and Rodrigo Sekkel (see Champagne and Sekkel, 2018). The reason for this choice is explained in subsection 3.4. Third, the economic state datings, namely expansions and recessions, are from the C.D. Howe Institute, which regularly publishes reports on the business cycle status of the economy (see C.D. Howe Institute, 2012*b*). At the C.D. Howe Institute, Cross and Bergevin (see Cross and Bergevin, 2012) provide a systematic dating of Canadian cycles since 1926 ¹.

In the empirical part of this study, I use a sample constructed from all three aforementioned datasets. The constructed sample consists of 12 variables. It in-

¹The Business Cycle Council of the C.D. Howe Institute also publish systematic datings of Canadian cycles in its annual meetings. However, there are no large differences between the Cross and Bergevin and Business Cycle Council economic datings.

cludes 418 monthly observations of Canadian GDP from 1981-01 to 2015-10 and 447 monthly observations of the unemployment rates at both the Canadian national level and the territorial level from 1977-09 to 2015-10, as shown in the notes of Table 2. The date ranges are determined by the intersection of date ranges of all sources of data since we need shocks, economic variables, and economic states to derive impulse response functions. The unemployment data is from Statistics Canada (see Statistics Canada, 2021*b*).

The local projection models of equation (1) in this study utilize the GDP data, and the unemployment rate of Canada at a national level as well as at regional level. Specifically, the regional unemployment rate data include data from the Canadian provinces from West to East, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Newfoundland and Labrador, Prince Edward Island. The Canadian real GDP data in logs are shown in Figure 16 in the Appendix.

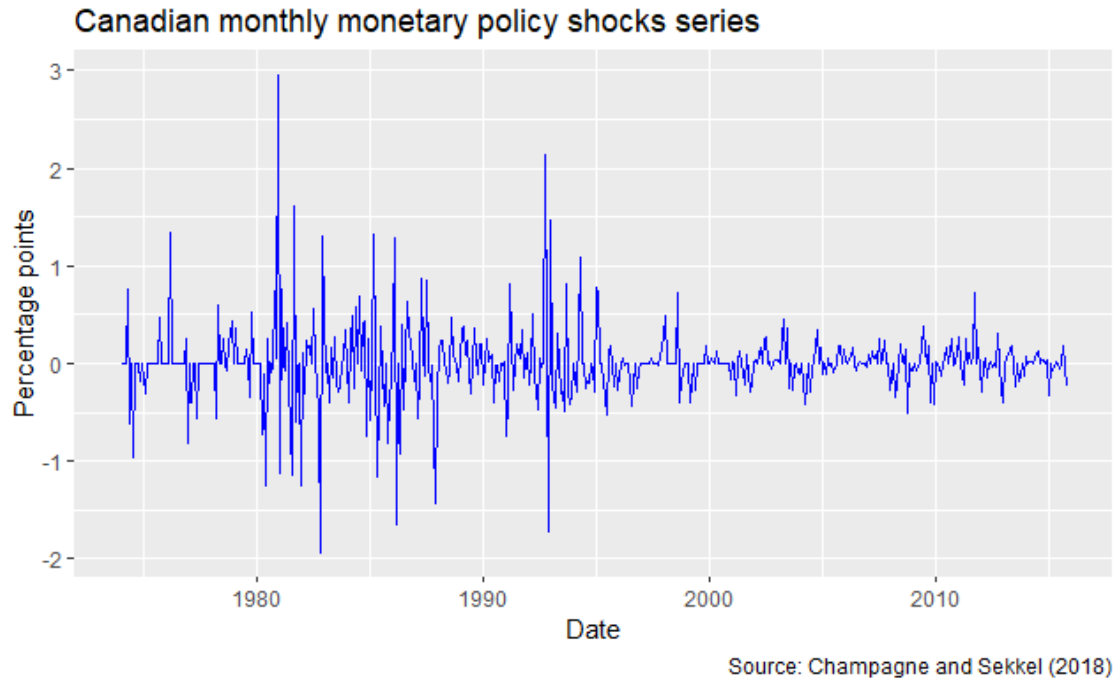
The unemployment rate data are constructed by Statistics Canada based on the data from the Labour Force Survey (LFS) (see Statistics Canada, 2021*a*), which is conducted on a monthly basis. The visualization of the Canada national unemployment data is displayed in Figure 17 in the Appendix. The visualization of the Canada regional unemployment data is in Figure 18 in the Appendix. Note from Figure 18 that the provinces differ in levels in terms of the unemployment rate yet they roughly move in the same trends, although regions seem to differ in the volatility of the unemployment change.

Summary statistics for the variables used are provided in Table 2 in the Appendix.

As mentioned previously, Champagne and Sekkel’s Canadian monetary policy shocks (see Champagne and Sekkel, 2018) are constructed via the narrative approach. Champagne and Sekkel’s narrative approach consist of two steps. First, they construct the Canadian policy rate series based on the Target for the Overnight Rate used and provided by the Bank of Canada. Second, a regression is applied to purge the policy rate from the systematic component of monetary policy. The regression has the change in the intended policy rate as the dependent variable and a set of independent variables that act the surrogate of the information set on which the policy-makers base the monetary policy. The error term in the regression hence reflects the unexpected change in monetary policy, which is the monetary policy shock. Figure 1 displays the plot of the shocks.

The visualization for Cross and Bergevin recessions (see Cross and Bergevin, 2012) is in Figure 19 in the Appendix. For comparative purposes, the visualization of the Canadian real GDP gap is also presented. Figure 20 presents the output gap in the Canadian economy estimated by two approaches, the extended multivariate filter (EMVF) and the integrated framework (IF). The data are from the Bank of Canada (see Bank of Canada, 2020).

Figure 1: Champagne and Sekkel Canadian monetary policy shock series



Notes: Champagne and Sekkel Canadian monetary policy shock series, 1974-1-1 to 2015-10-1.

By observation of Figure 20, it can be seen that C.D. Howe Institute does not simplistically equate negative output gaps to be recessions. Rather, they require multiple signs to be persistently present to recognize the economy to be recession (see C.D. Howe Institute, 2012a).

4.2 Programming Detail

The majority of coding is conducted in R language, with extensive use of the R package "lpirfs" developed by Philipp Adammer (2019) and various plotting functions.

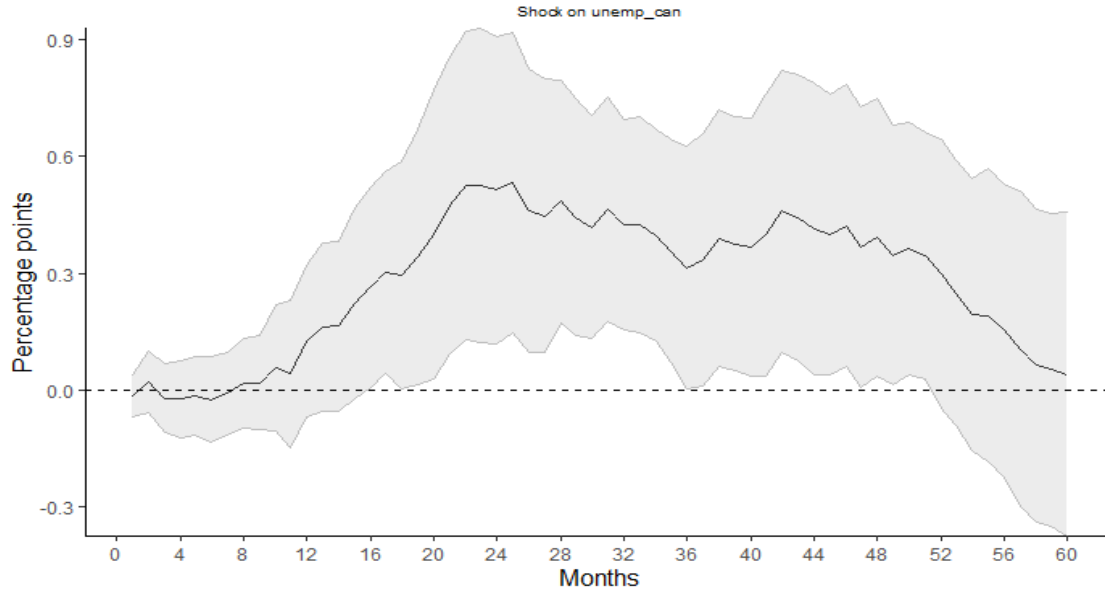
4.3 Empirical Results

The results presented in the remainder of the section are produced by LP models. The LP models are estimated by Ordinary Least Squares (OLS) and the standard errors are estimated by the Newey and West method (see Newey and West, 1987). As previously mentioned, all LP models used in this section are lag-augmented LP models as proposed by Olea and Plagborg-Moller (see Montiel Olea and Plagborg-Moller, 2021) with 4 lags of the variable of interest, and 48 shock lags as suggested by Champagne and Sekkel (see Champagne and Sekkel, 2018), as well as Fortin-Gagnon et al. (see Fortin-Gagnon et al., 2021). Note that all impulse response function plots characterize the responses of the variable of interest to a 100-basis-point contractionary monetary policy shock.

4.3.1 Nation-level Applications

I replicate the results of Champagne and Sekkel (see Champagne and Sekkel, 2018) regarding the effects of shocks on Canada's GDP and the Canadian unemployment rate. Since the main variable of interest is the unemployment rate, I put the unemployment rate results below and the GDP results can be found in Figure 22 in the Appendix.

Figure 2: Effects of monetary policy shocks on Canadian unemployment rates



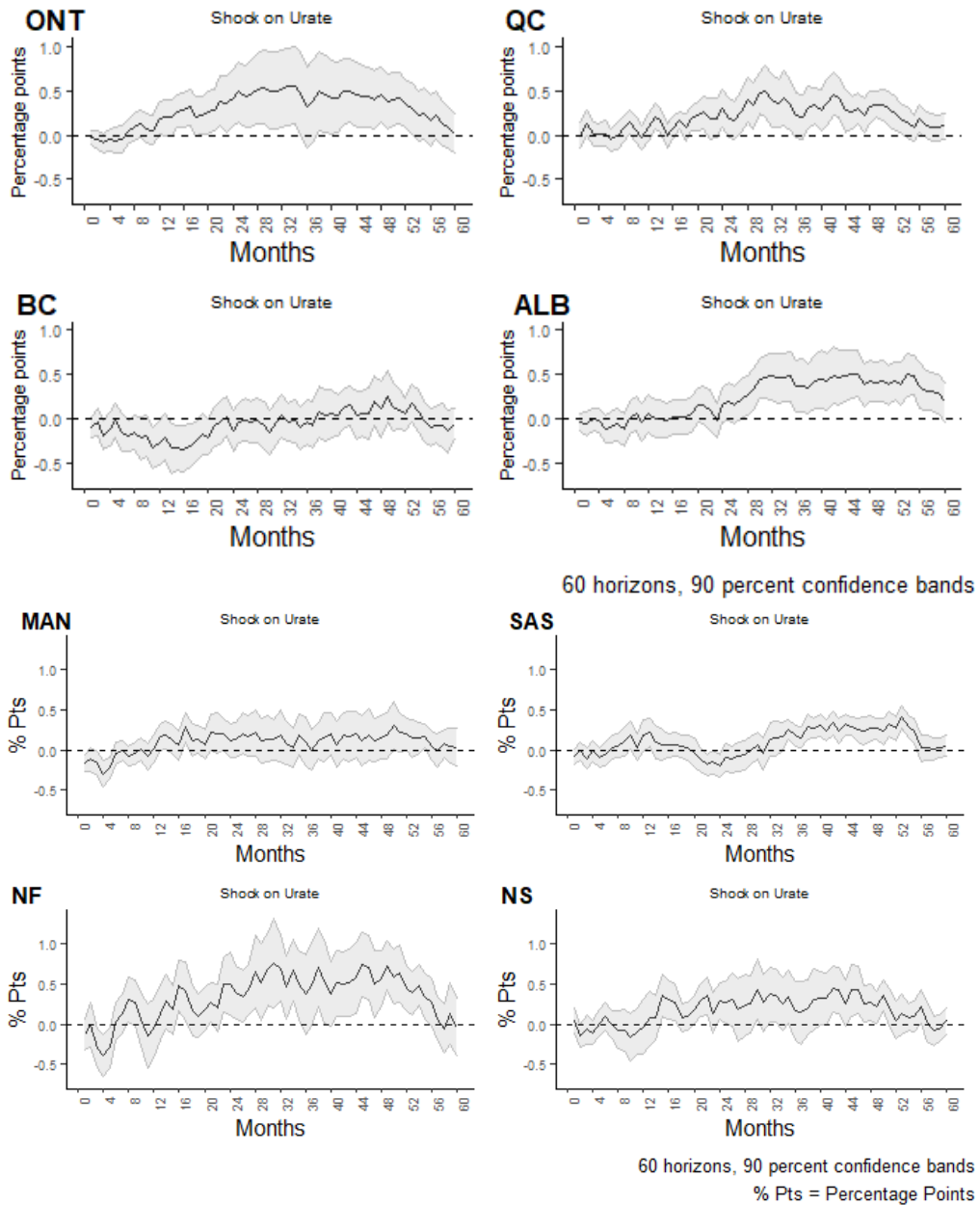
Notes: Impulse response of Canadian unemployment rate to a 100-basis-point contractionary monetary policy shock. 90 percent confidence bands.

In the above plot, the horizontal axis represents the time lags as of the occurrence of the shock and the vertical axis represents the change of the variable of interest in percentage point. The solid dark line traces out the point estimated response of the variable of interest to the shock at the time lags indicated by the horizontal axis. The shaded band surrounding the solid dark line stands for the 90% confidence interval of the estimate. Responses where the confidence interval incorporates the zero (the dashed line) imply no significant effect of the shock on the variable of interest at the time lag. Since all the shocks used in this study are contractionary money policy shocks, Figure 2 and Figure 22 are consistent with economic theory in that the unemployment rate rises and the real Canadian GDP declines in the wake of a contractionary monetary policy shock. The results also line up with Champagne and Sekkel's results (see Champagne and Sekkel, 2018). Notably, the results in Figure 2 and Figure 22 suggest considerable lags in the effects of monetary policy shocks on Canadian GDP and unemployment rate. The lags are up to 50 months after the occurrence of the shock. This agrees with the conventional understanding on the long-term effects of monetary policy actions.

4.3.2 Regional Applications

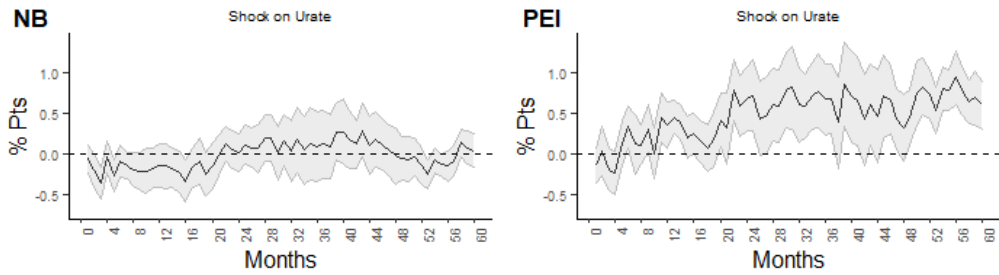
I apply local projections as in Equation (1) for different regions in Canada. To be exact, I apply local projections to quantify the effects of monetary policy shocks on the unemployment rate in the following 10 provinces: Ontario (ONT), Quebec (QC), British Columbia (BC), Alberta (ALB), Manitoba (MAN), Saskatchewan (SAS), Newfoundland and Labrador (NF), Nova Scotia (NS), New Brunswick (NB), and Prince Edward Island (PEI). The results are depicted by Figures 3 and 4.

Figure 3: Effects of monetary policy shocks on unemployment rate in 8 Canadian provinces



Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock.

Figure 4: Effects of monetary policy shocks on unemployment rate in 2 Canadian provinces



60 horizons, 90 percent confidence bands
 % Pts = Percentage Points

Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock.

It is worthy of note from Figure 3 and 4 that the unemployment response to monetary policy shocks differs noticeably from region to region. A few more specific interesting observations are as follows.

First, Ontario’s unemployment response to monetary policy shocks resembles that of Canada as a whole, whereas the unemployment responses of other regions bear little similarity to Canada’s. This is consistent with the fact that Ontario stands as the most economically significant sub-national division in Canada, accounting for over 38 percent of Canada’s GDP in 2019, as shown in Table 36-10-0402-02 of Statistics Canada (see Statistics Canada, 2021*c*). It makes sense that Ontario’s response mirrors the nation’s response. After all, a substantial part of the national response is Ontario’s response.

Second, in a similar vein, the second economically significant sub-national division Quebec with 19.92 percent of Canada’s GDP is also fairly similar to Canada as a whole in terms of the impulse response of the unemployment rate to monetary policy shocks.

Third, it is noteworthy that the BC results are the reverse of those of the other provinces. Specifically, BC’s unemployment rate decreases in response to the monetary policy shock, in contrast to the increases in the unemployment rate seen in other regions. This is also at odds with economic theory. However, this in-congruence could be due to the fact that BC’s response is not very precisely estimated and is insignificant for most periods.

Fourth, geographic proximity does not seem to correlate with unemployment response. In other words, neighbouring provinces could differ considerably in terms of the unemployment response to monetary policy shocks. For example, BC’s unemployment response is markedly different from that of the adjacent province Alberta, which in turn clearly differs from that of the contiguous Saskatchewan.

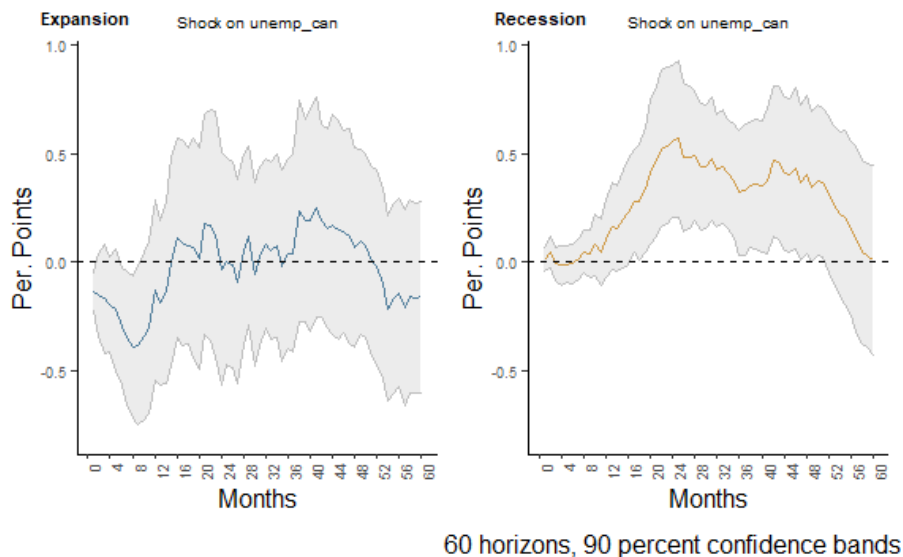
Lastly, the unemployment rate response of Alberta to shocks show particularly long lags. As the bottom right panel of Figure 3 illustrates, the unemployment rate in Alberta starts to noticeably rise 24 months after the shock and keeps at statistically significant levels until the 60th month in the wake of the shock.

4.3.3 State-dependent Applications

I implement state-dependent models as presented in Section 3.2. I consider two states for the Canadian economy: expansion and recession. I use states identified by Cross and Bergevin (see Cross and Bergevin, 2012) at the C.D. Howe institute. Figure 5 visualizes the response of the Canadian unemployment rate to monetary policy shocks by state. The visualization of the state-dependent real GDP responses is in Figure 21 in the Appendix.

Notably, in both cases, the responses to monetary policy shocks are more pronounced in the state of recession. As a matter of fact, the effects of both variables in expansion are statistically insignificant at all times. This lines up with the mainstream understanding of asymmetric effects of monetary policy (see Tenreyro and Thwaites, 2016).

Figure 5: Effects of monetary policy shocks on Canadian unemployment rates, by state

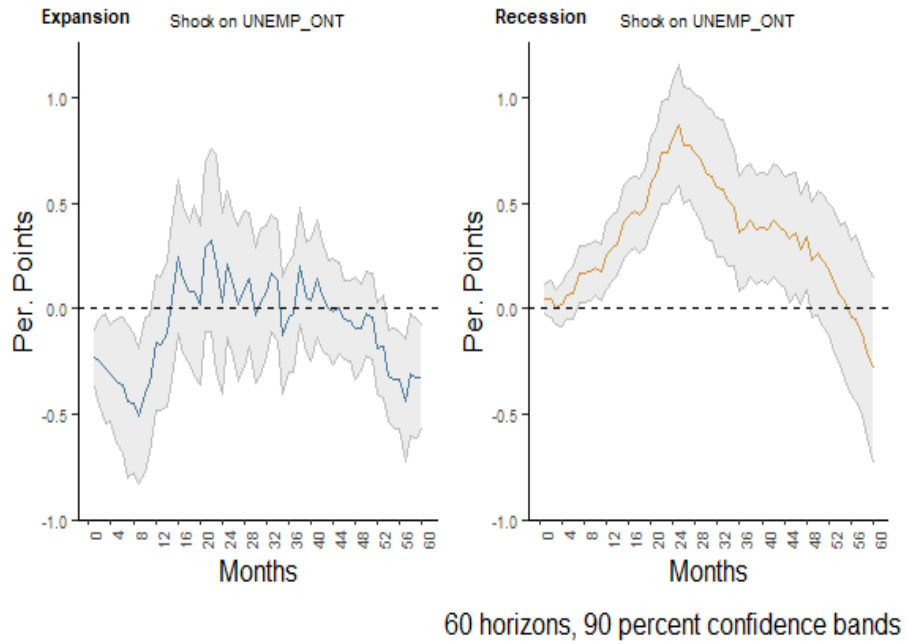


Notes: Impulse response of Canadian unemployment rate to a 100-basis-point contractionary monetary policy shock in recession and expansion, respectively.

I apply the dummy variable approach of state-dependent models as presented

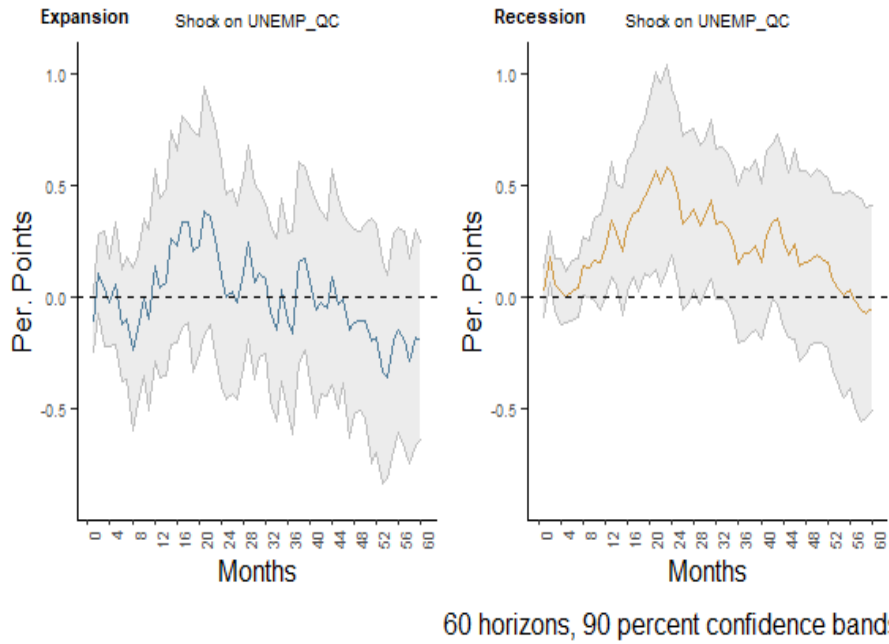
in Section 3.2 to each region in terms of unemployment response to monetary policy shocks. Below are the results for the four economically biggest regions in Canada, in descending order of their percentage of Canadian GDP. The results for the rest of Canadian regions are in the Appendix.

Figure 6: Effects of monetary policy shocks on unemployment rate in Ontario



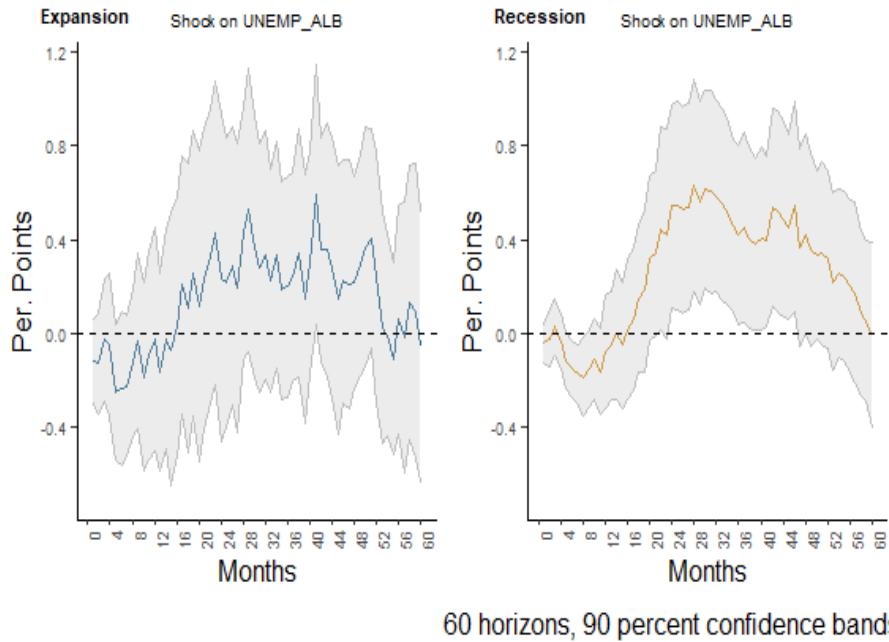
Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

Figure 7: Effects of monetary policy shocks on unemployment rate in Quebec



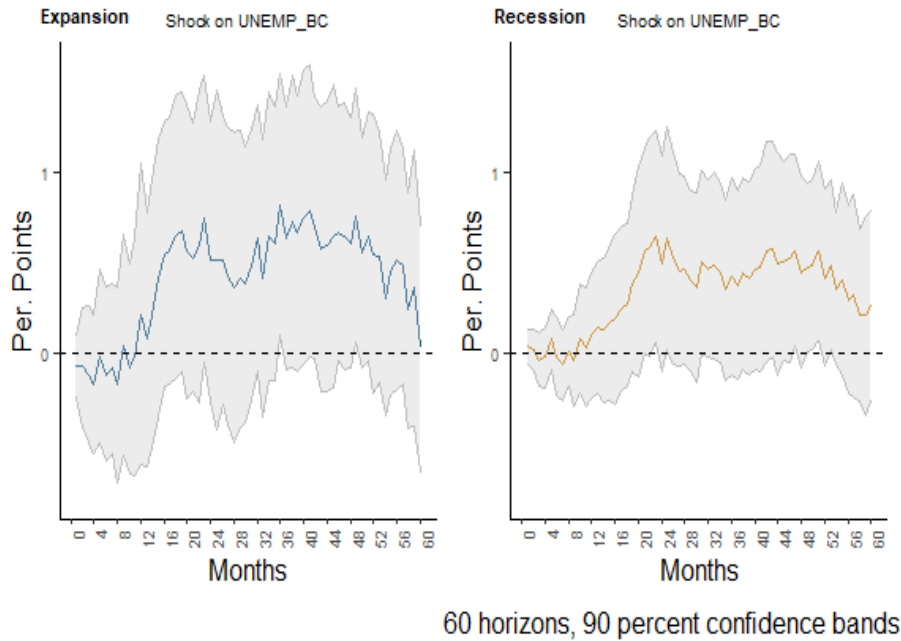
Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

Figure 8: Effects of monetary policy shocks on unemployment rate in Alberta



Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

Figure 9: Effects of monetary policy shocks on unemployment rate in British Columbia



Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

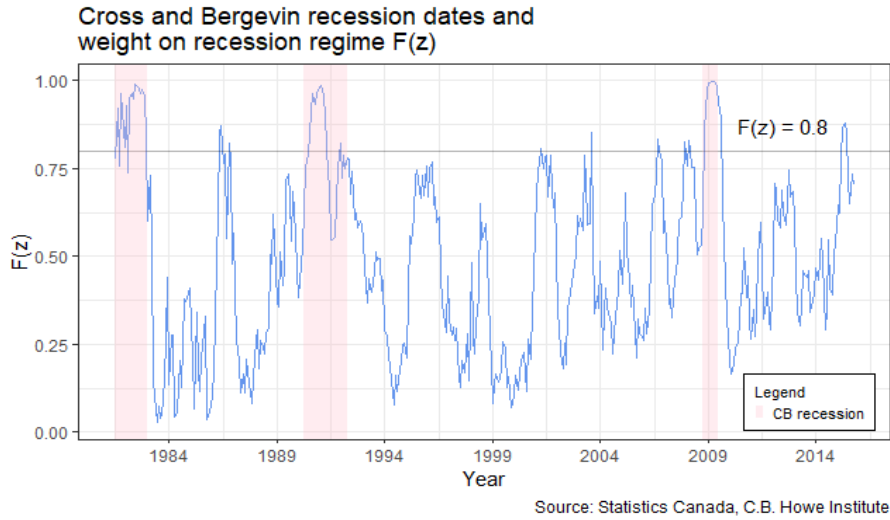
Two interesting results are noted. First, for the four major regions, the unemployment responses to shocks are noticeably stronger in recessions than in expansions. This lines up with the response patterns at the national level. There are few statistically significant responses in expansions for three of the four regions and only a few for Ontario. Yet all provinces, with the notable exception of BC, exhibit statistically significant responses in recessions, albeit for varying lengths.

Second, Ontario stands out as displaying particularly salient responses in recessions, in stark contrast to its mild to no responses during expansions. The responses of Ontario in recession are also considerably more pronounced in comparison to most other provinces.

5 Robustness Check

In Section 4.3.3, I implement state-dependent models with dummy variables as presented in Section 3.2. As a check, I implement the state-dependent models with smooth transition functions in this section. The recession regime weight is calculated based on Equation (4) in Section 3.2. As mentioned in Section 3.2, the index z is chosen to be a seven-month moving average of the output growth rate. Figure 10 compares the value of $\mathbf{F}(z)$ to recessions dated by Cross and Bergevin (see Cross and Bergevin, 2012). Notably, if a recession is defined as when $\mathbf{F}(z_t) > 0.8$ as by Auerbach and Gorodnichenko (2012), the smooth transition function recession weights are consistent with Cross and Bergvin recession dates.

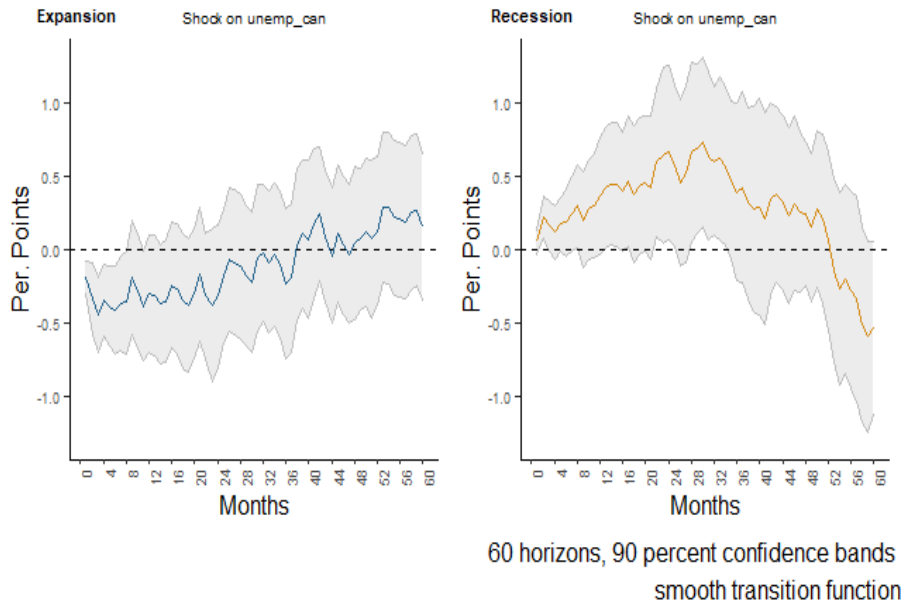
Figure 10: Weight on regime $F(z)$



Notes: $F(z)$ is calculated by Equation 4 based on a seven-month moving average of the output growth rate.

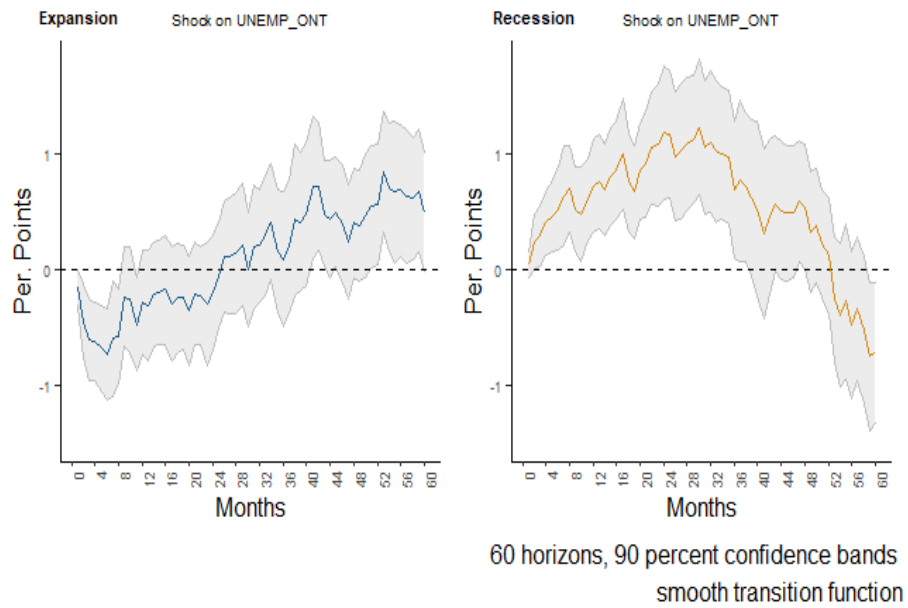
Below are the results with smooth transition functions for Canada and the four economically biggest regions in Canada. The results for other provinces are in the Appendix.

Figure 11: Effects of monetary policy shocks on unemployment rate in Canada



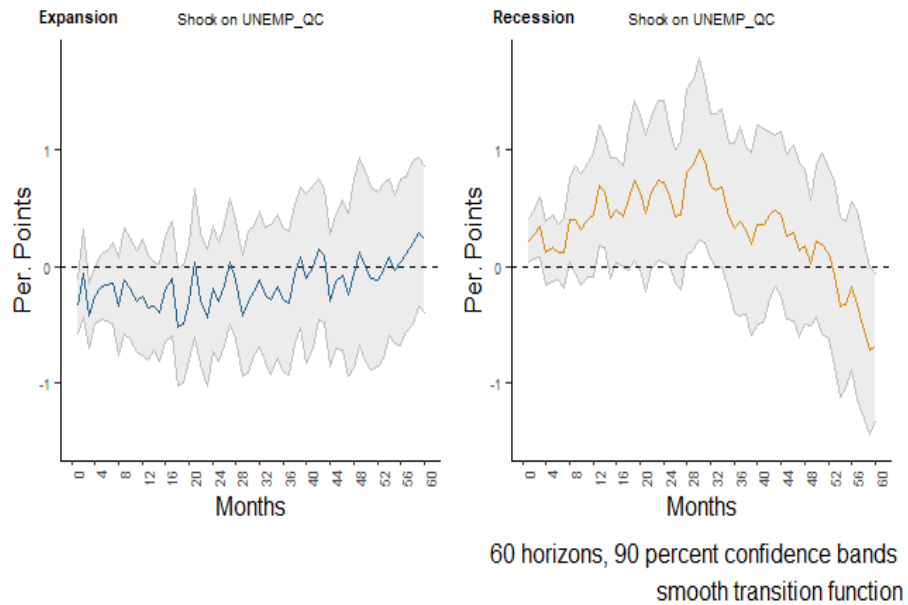
Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Figure 12: Effects of monetary policy shocks on unemployment rate in Ontario



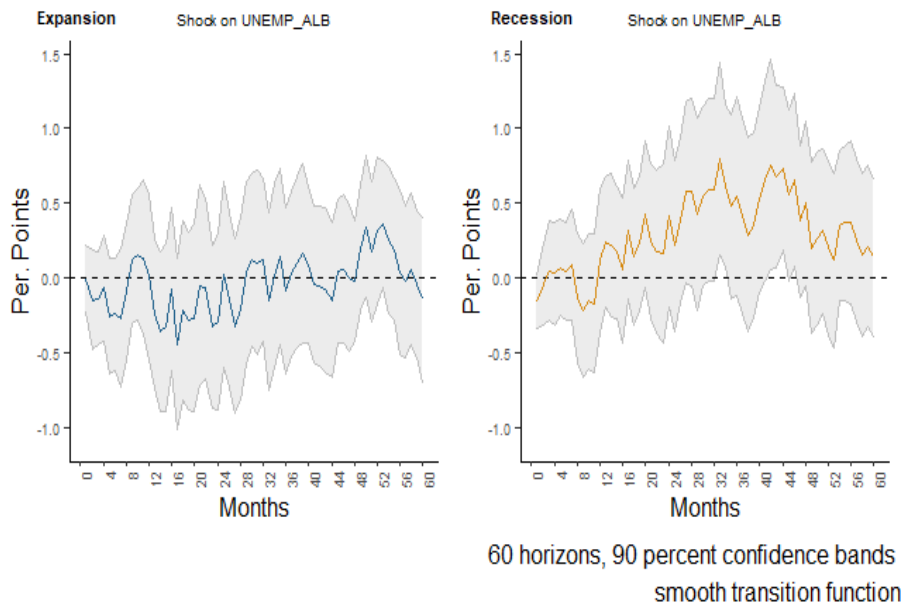
Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Figure 13: Effects of monetary policy shocks on unemployment rate in Quebec



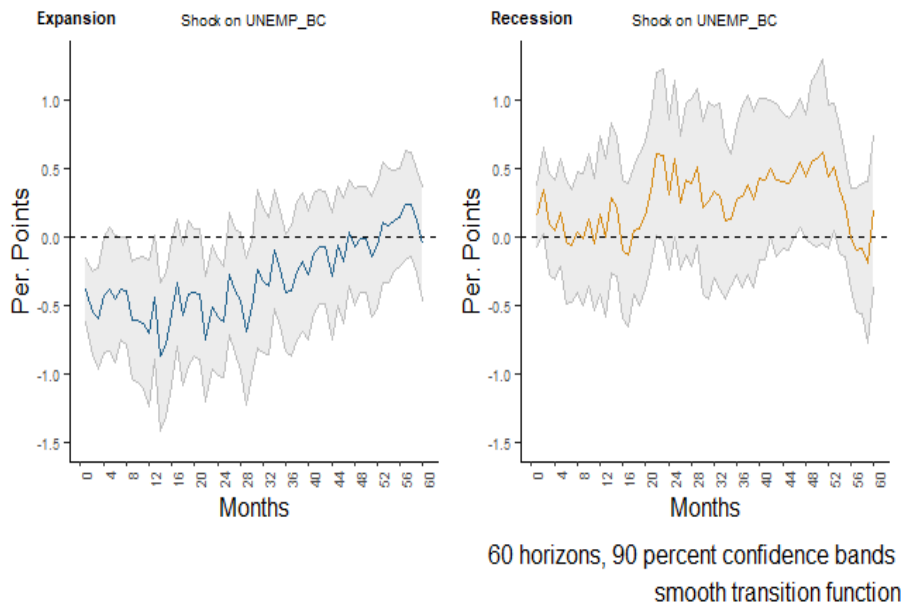
Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Figure 14: Effects of monetary policy shocks on unemployment rate in Alberta



Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Figure 15: Effects of monetary policy shocks on unemployment rate in British Columbia



Notes: Impulse response of regional unemployment rate to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Some of the notable observations are as follows. First, echoing the results in the dummy variable models, it is still the case that under the smooth transition approach most regions exhibit stronger responses to monetary policy shocks in recessions than in expansions, although the smooth transition approach and the dummy variable approach slightly differ in the results of Ontario and BC. To be more specific, the number of statistically significant responses in the expansion state in Ontario and BC is different under the smooth transition function approach and the dummy variable approach.

Second, also parallel to the dummy variable models, Ontario shows distinctively strong responses in recession states under the smooth transition approach, although Ontario's responses appear to be generally milder under the smooth transition approach than under the dummy variable approach.

Finally, it appears that overall dummy variable approach and smooth transition approach agree qualitatively in most cases. The general consistency of evidence from two approaches provides moderate confidence to the reliability of the results.

6 Conclusion

In this paper, I apply regime-dependent lag-augmented local projections models to quantify the response of the Canadian national and regional unemployment rate to monetary policy shocks. Quantitative evidence points to the existence of inter-province differences in terms of monetary policy effects on the unemployment rate. In addition, some provinces display noticeable differences in their reaction to monetary policy shocks between the states of the economy. In particular, Ontario shows considerably more salient responses to monetary policy shocks in recessions than in expansions. These findings provide strong evidence for the unique status of Ontario in Canada and constitute interesting starting points for future research.

I see many interesting research projects stemming from my paper, on both the theoretical and practical fronts. On the theoretical front, methods other than local projections could be implemented in comparison with local projections. The validity of assumptions is open to scrutiny in the context of specific datasets. The very foundation of local projections is linear regression, which is in and of itself a fountain of research problems despite its long history of research and application. On the practical front, many specific findings from this paper could be further studied. In-depth investigation could be launched into the reason for Ontario's salient response to monetary policy shocks in recession while Quebec's response is much less pronounced in spite of the geographic and economic closeness between these two provinces. Moreover, closer looks into the differences between responses in expansions and recessions are likely to generate useful and interesting insights. Above all, with some understanding of regional differential unemployment response to monetary policy shocks in mind, it is a good departure point for the study on what policy makers could or should do to foster economic prosperity and equity.

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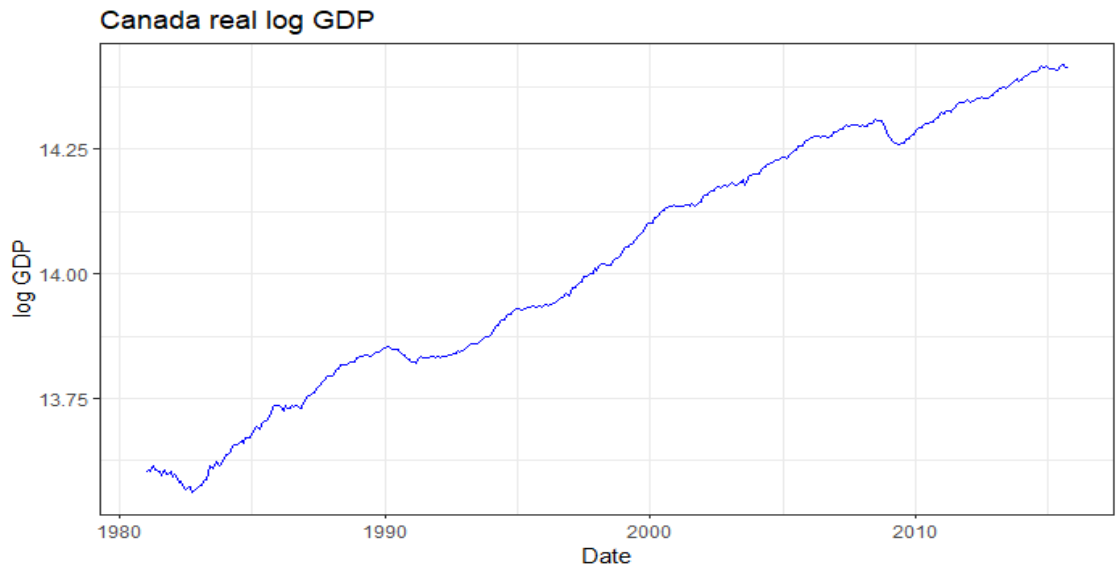
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APPENDIX

Figure 16: Canada real GDP in log



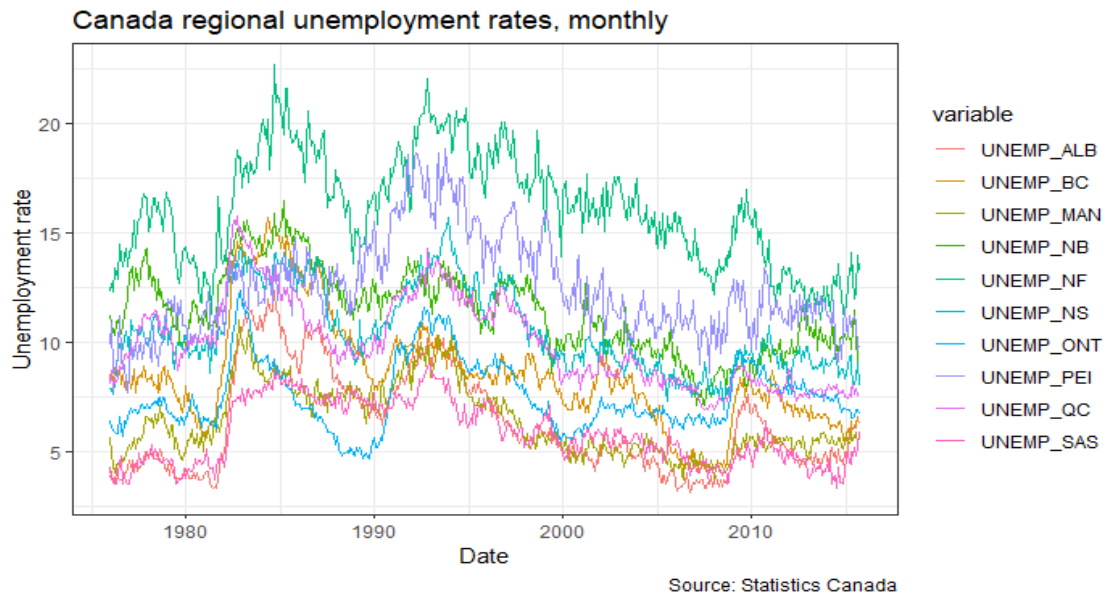
Source: Statistics Canada

Figure 17: Canada unemployment rate



Source: Statistics Canada

Figure 18: Canada regional unemployment rates



Notes: Not all Canadian provinces and territories are presented.

Figure 19: Cross and Bergevin recessions against unemployment rate

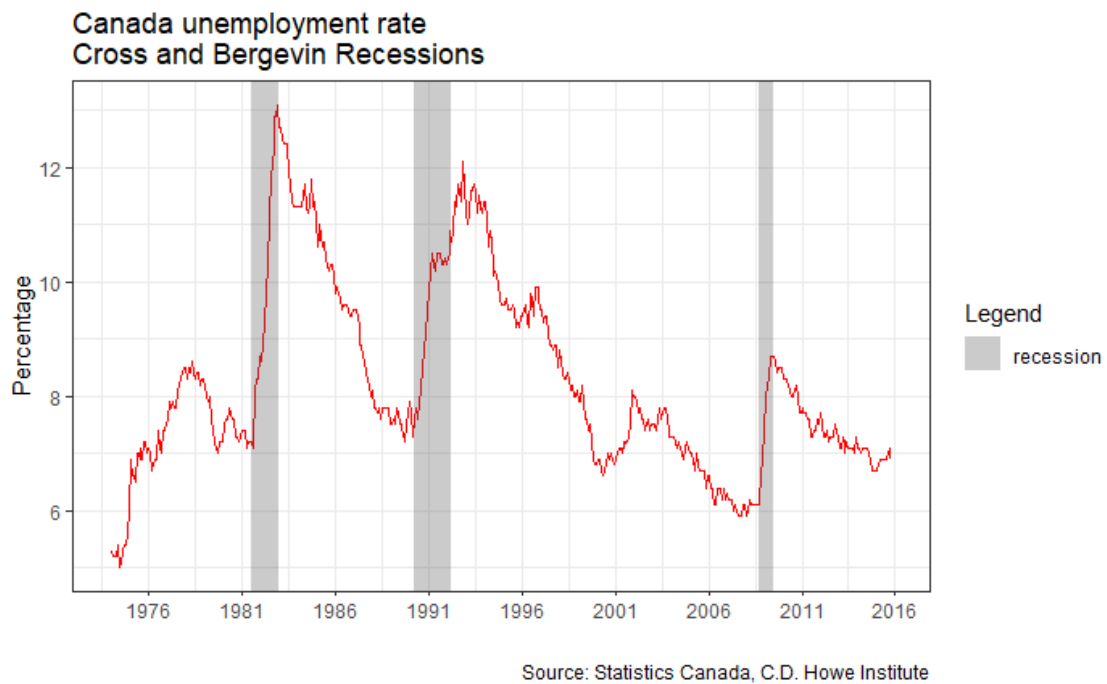
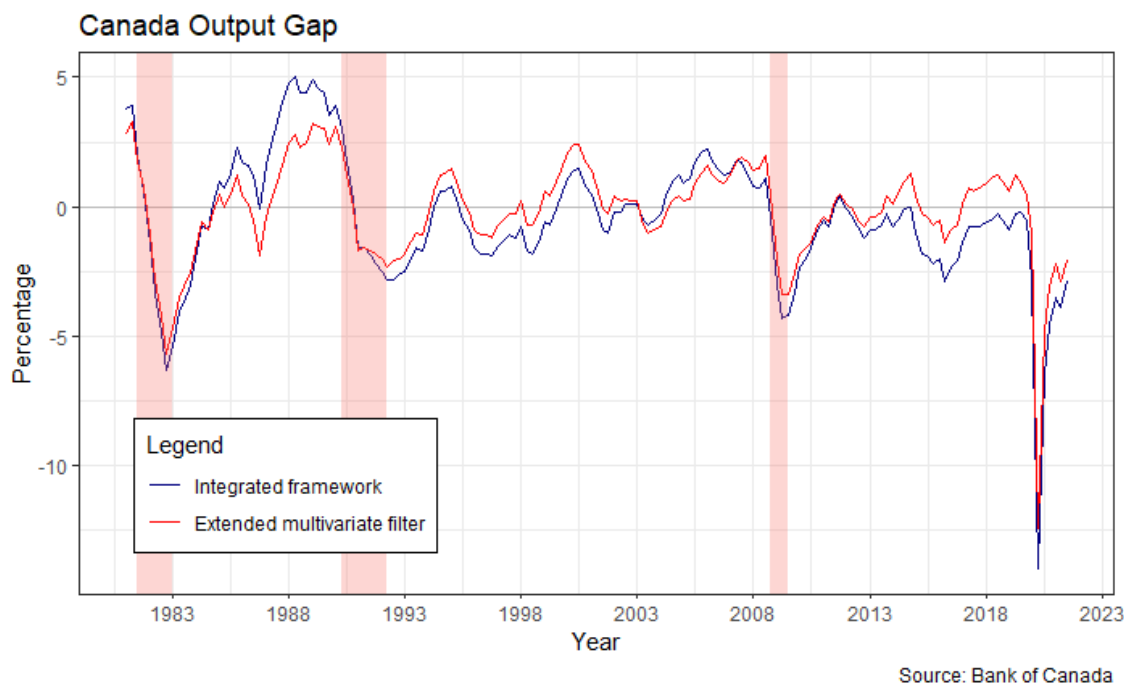
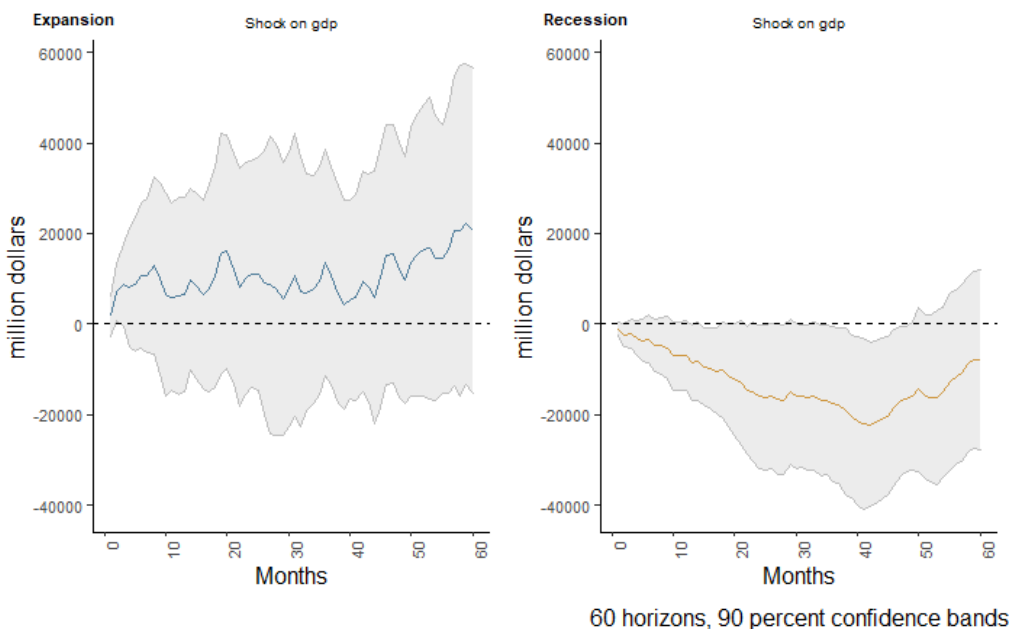


Figure 20: Canada Output Gap, 2 measurement approaches



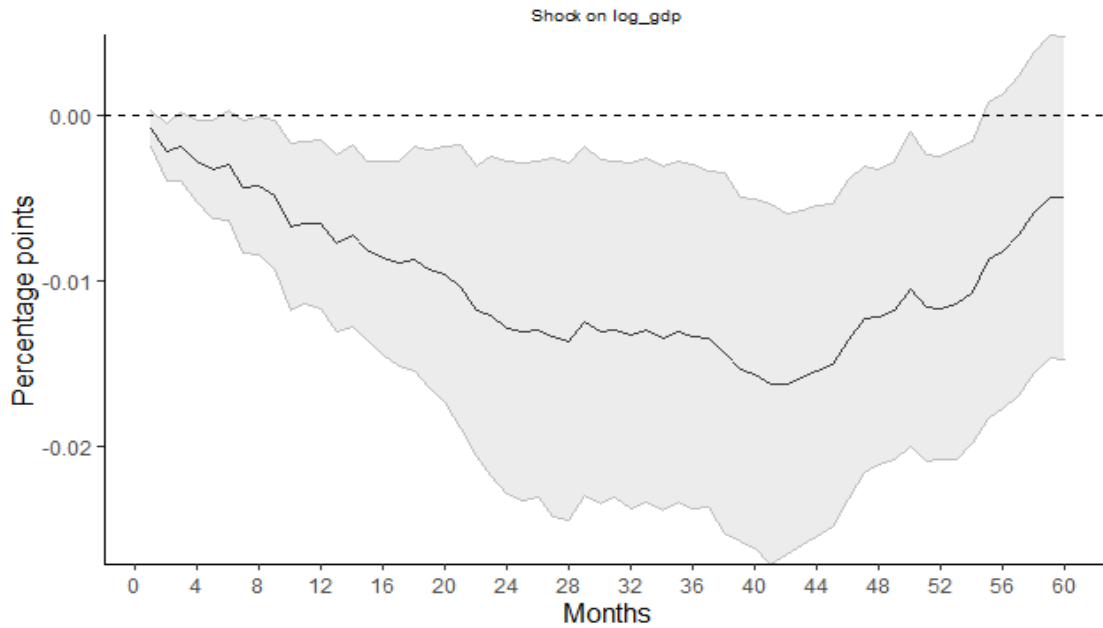
Notes: The bands are recessions dated by Cross and Bergevin.

Figure 21: Effects of monetary policy shocks on Canadian real GDP, by state



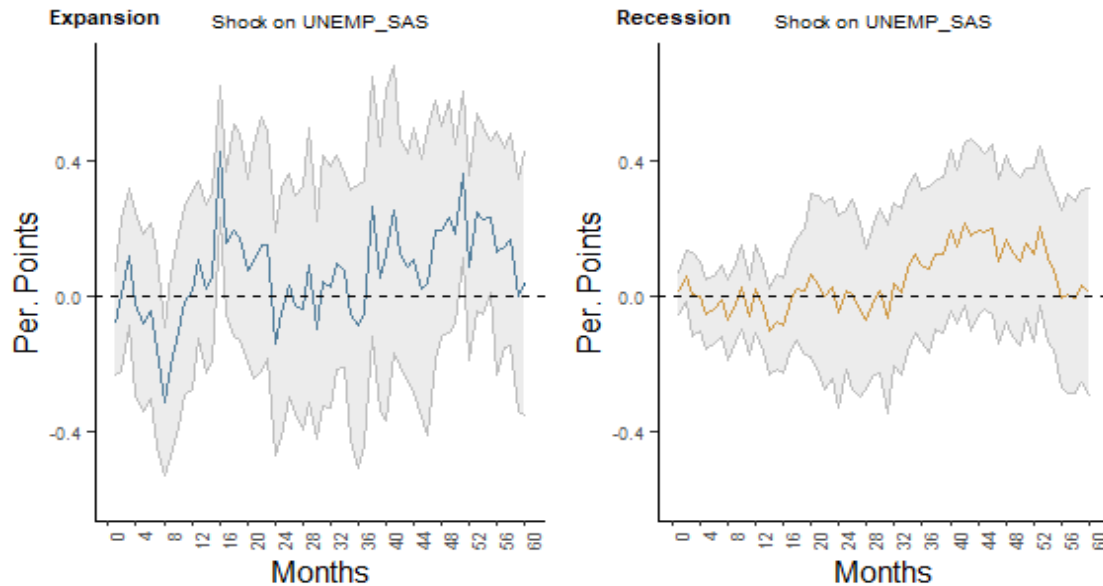
Notes: Impulse response of Canadian GDP to a 100-basis-point contractionary monetary policy shock in recession and expansion, respectively.

Figure 22: Effects of monetary policy shocks on Canadian real GDP



Notes: Impulse response of Canadian GDP to a 100-basis-point contractionary monetary policy shock. 90 percent confidence bands.

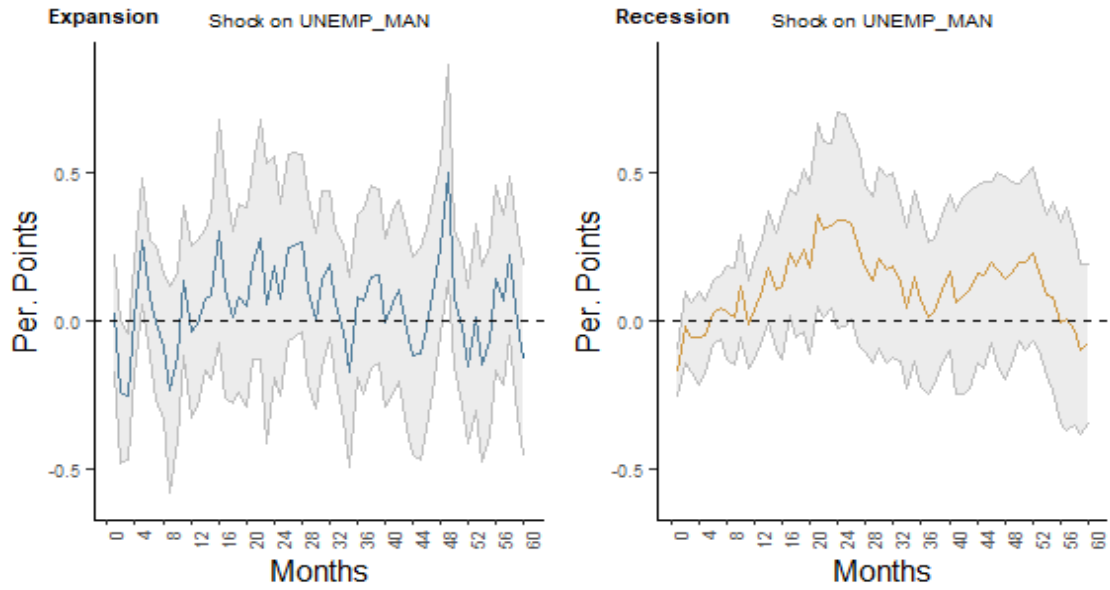
Figure 23: Effects of monetary policy shocks on unemployment rate in Saskatchewan



60 horizons, 90 percent confidence bands

Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

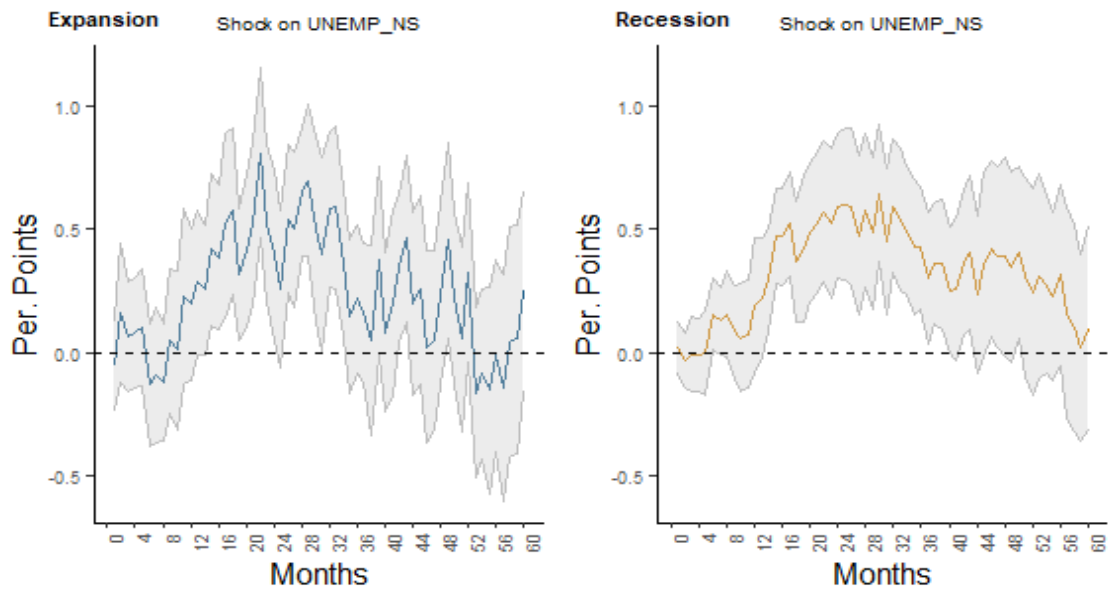
Figure 24: Effects of monetary policy shocks on unemployment rate in Manitoba



60 horizons, 90 percent confidence bands

Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

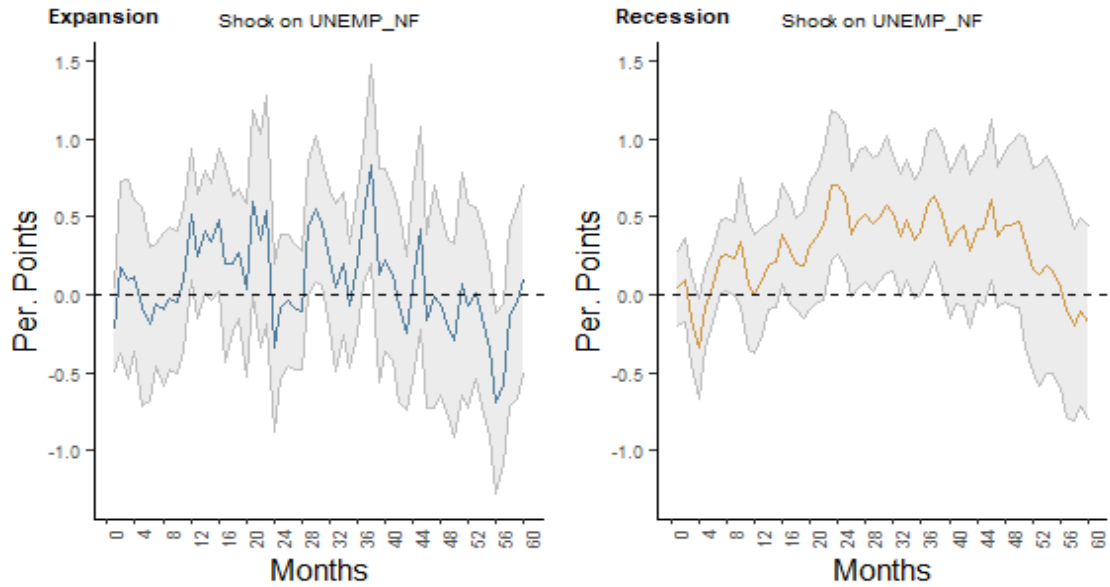
Figure 25: Effects of monetary policy shocks on unemployment rate in Nova Scotia



60 horizons, 90 percent confidence bands

Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

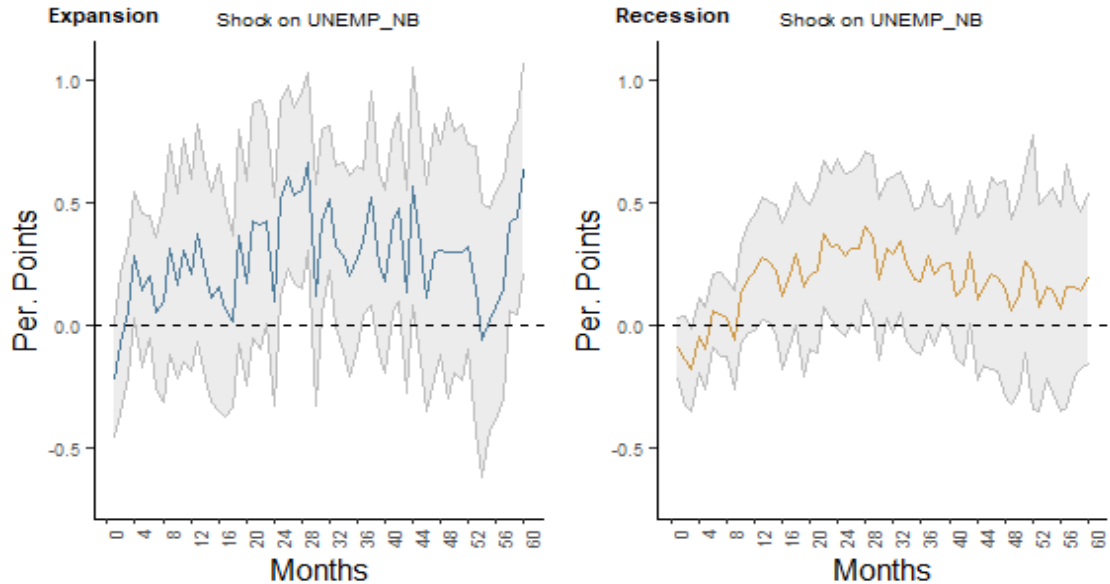
Figure 26: Effects of monetary policy shocks on unemployment rate in Newfoundland and Labrador



60 horizons, 90 percent confidence bands

Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

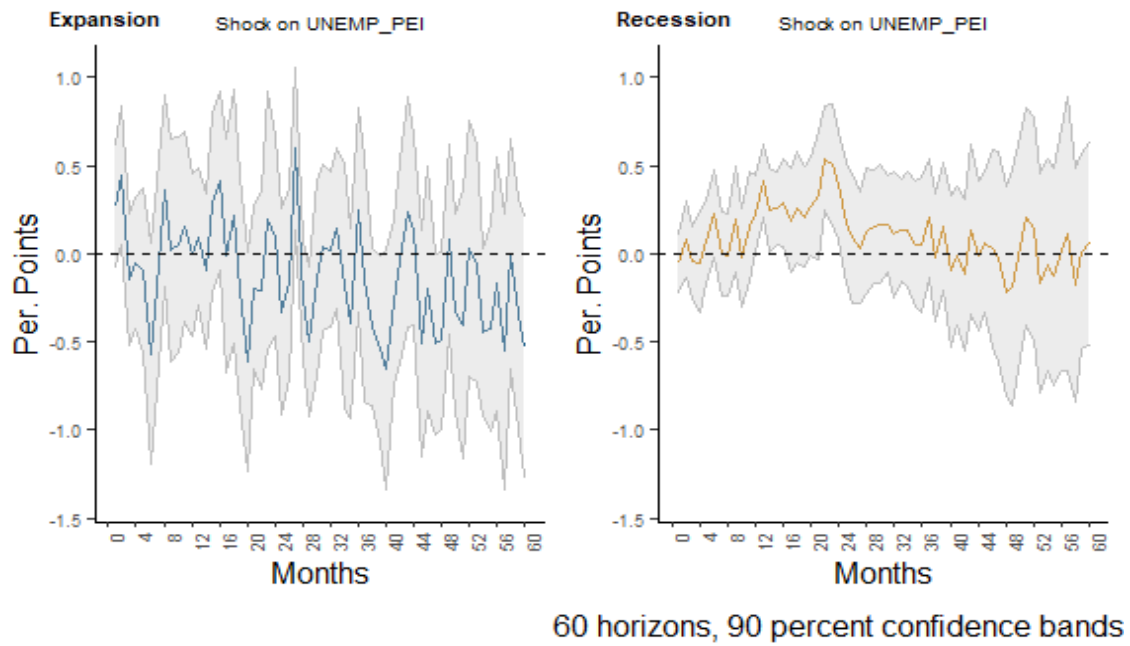
Figure 27: Effects of monetary policy shocks on unemployment rate in New Brunswick



60 horizons, 90 percent confidence bands

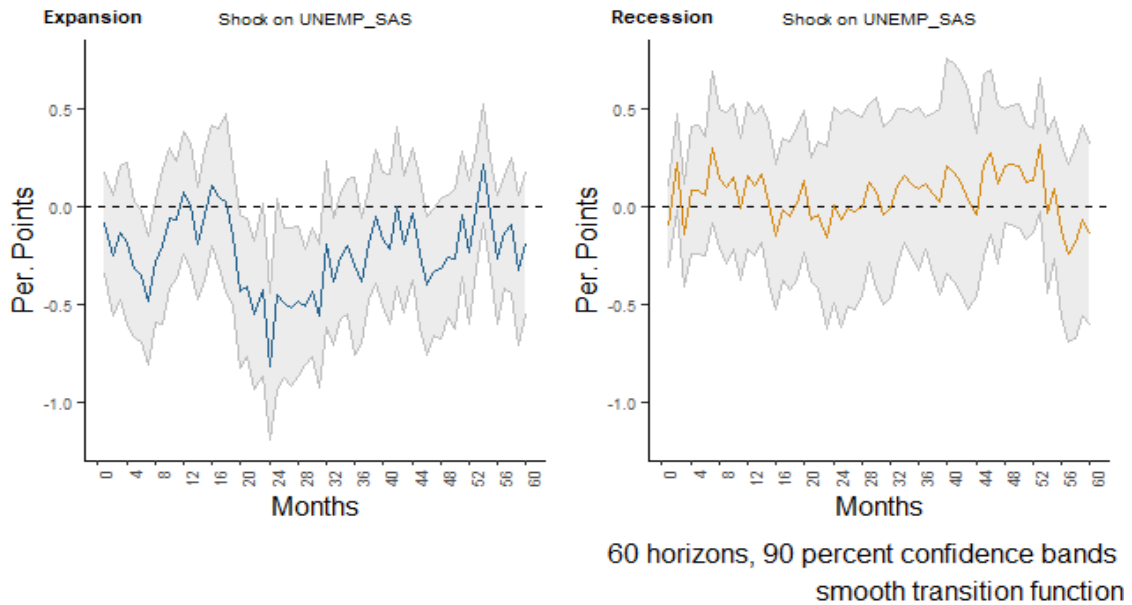
Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

Figure 28: Effects of monetary policy shocks on unemployment rate in Prince Edward Island



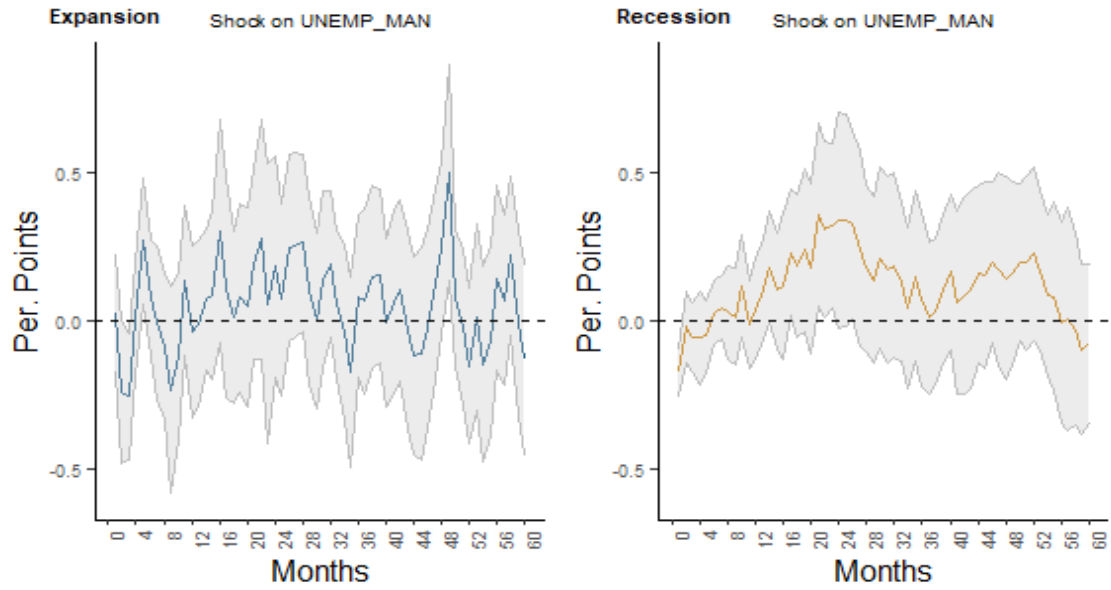
Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Dummy variable approach.

Figure 29: Effects of monetary policy shocks on unemployment rate in Saskatchewan



Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

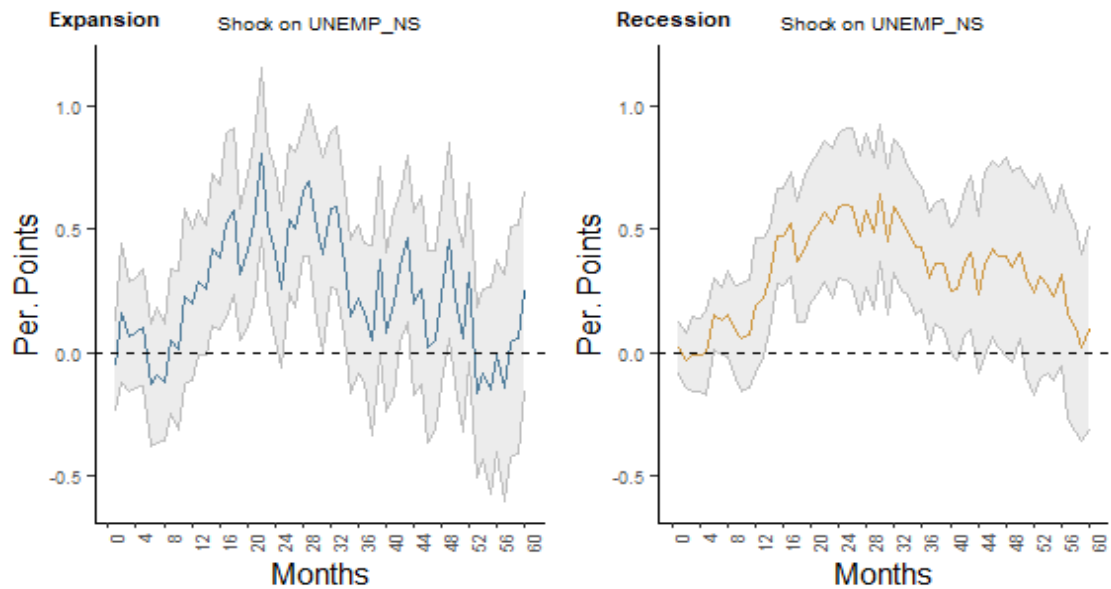
Figure 30: Effects of monetary policy shocks on unemployment rate in Manitoba



60 horizons, 90 percent confidence bands

Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

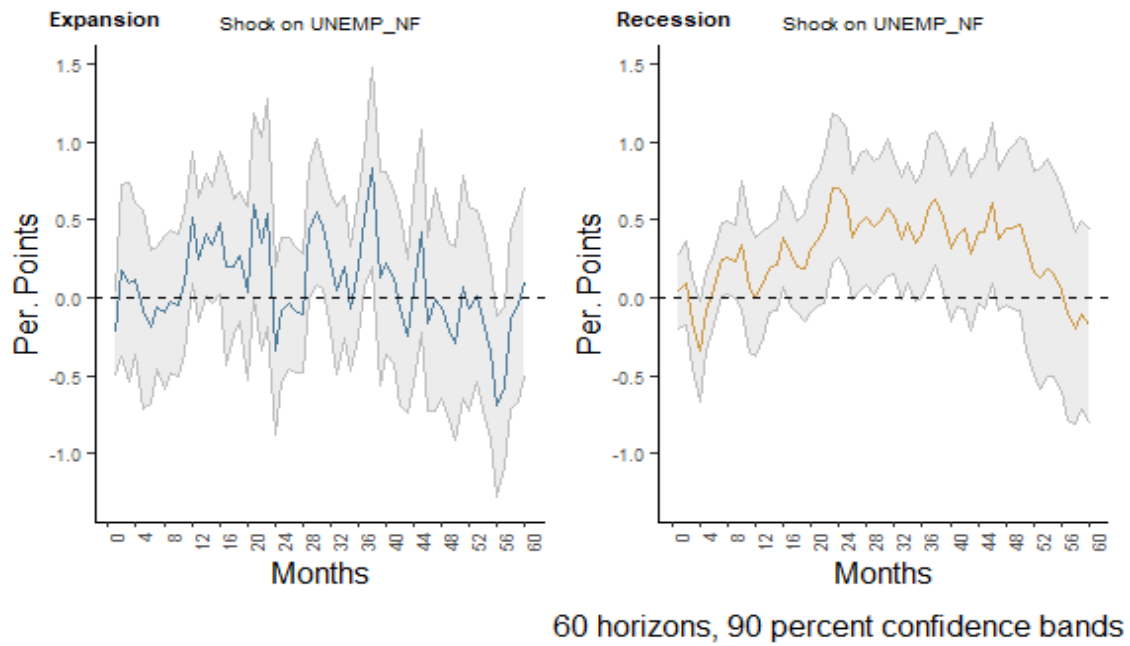
Figure 31: Effects of monetary policy shocks on unemployment rate in Nova Scotia



60 horizons, 90 percent confidence bands

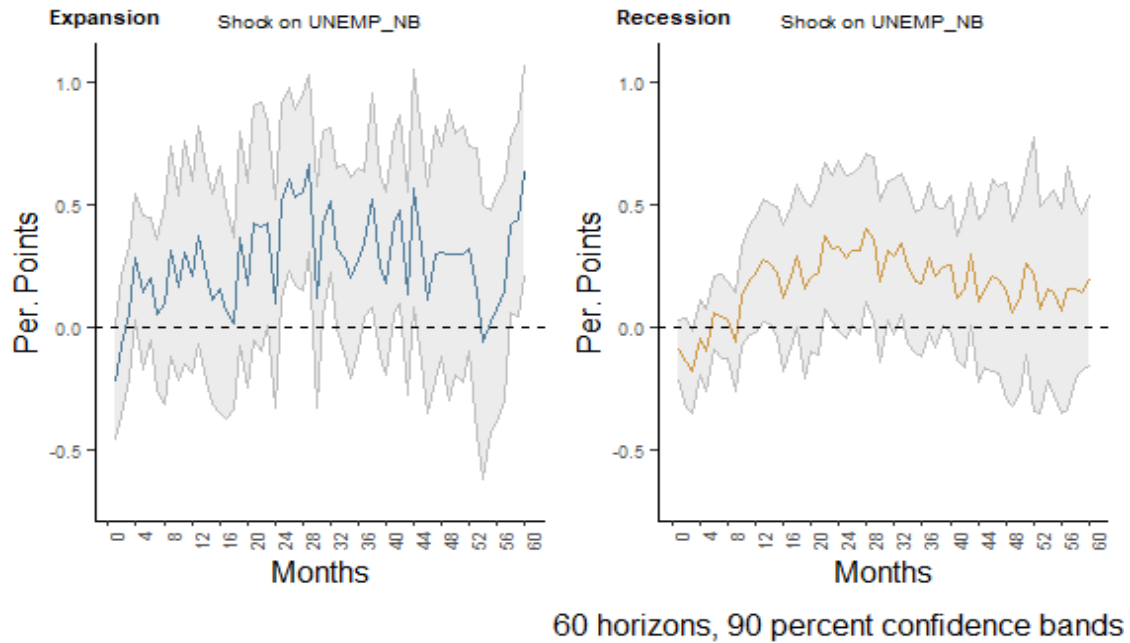
Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Figure 32: Effects of monetary policy shocks on unemployment rate in Newfoundland and Labrador



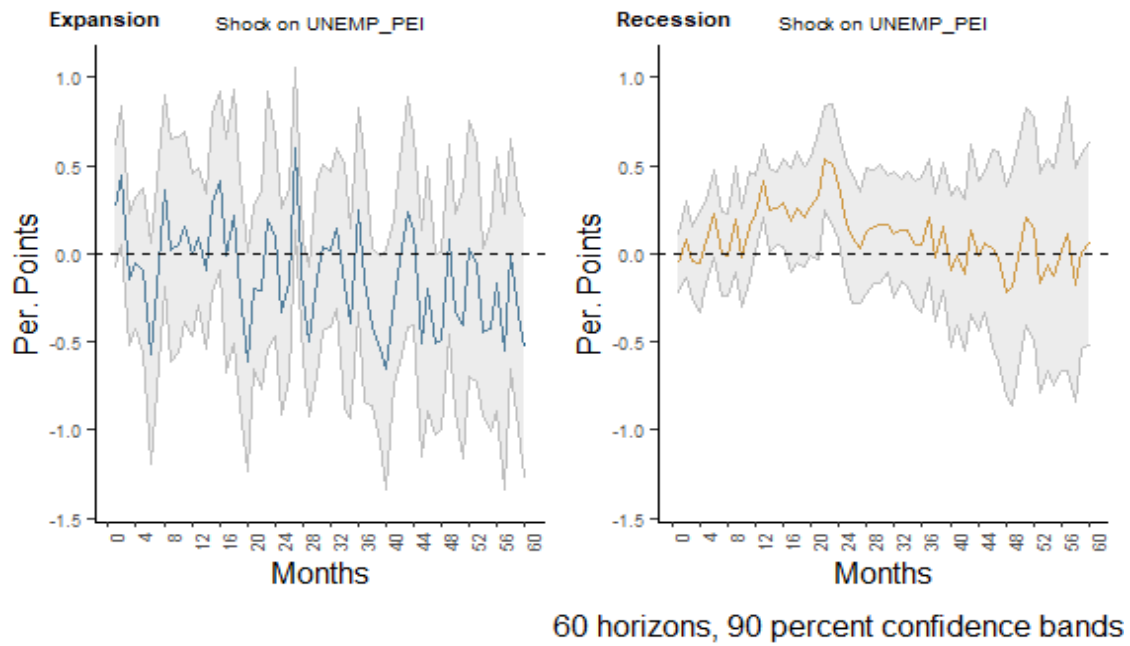
Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Figure 33: Effects of monetary policy shocks on unemployment rate in New Brunswick



Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Figure 34: Effects of monetary policy shocks on unemployment rate in Prince Edward Island



Notes: Unemployment responding to a 100-basis-point contractionary monetary policy shock. Smooth transition function approach.

Table 1: Variables used

| No | Variable | Region | Vector | Table |
|----|---------------------|--------|-----------|---------------|
| 1 | GDP | CAN | v41881478 | 36-10-0434-01 |
| 2 | Unemp. Rate, Canada | CAN | v2062815 | 14-10-0287-01 |
| 3 | Unemp. Rate, BC | BC | v2064705 | 14-10-0287-01 |
| 4 | Unemp. Rate, ONT | ONT | v2063949 | 14-10-0287-01 |
| 5 | Unemp. Rate, QC | QC | v2063760 | 14-10-0287-01 |
| 6 | Unemp. Rate, ALB | ALB | v2064516 | 14-10-0287-01 |
| 7 | Unemp. Rate, SAS | SAS | v2064327 | 14-10-0287-01 |
| 8 | Unemp. Rate, MAN | MAN | v2064138 | 14-10-0287-01 |
| 9 | Unemp. Rate, NB | NB | v2063571 | 14-10-0287-01 |
| 10 | Unemp. Rate, NF | NF | v2063004 | 14-10-0287-01 |
| 11 | Unemp. Rate, NS | NS | v2063382 | 14-10-0287-01 |
| 12 | Unemp. Rate, PEI | PEI | v2063193 | 14-10-0287-01 |

Notes: The vectors refer to the vectors defined by Statistics Canada.

Table 2: Descriptive statistics of variables used

| Variable | N | Mean | Median | Std. | Min/Max |
|---------------------|-----|---------|---------|-----------|----------------|
| GDP | 418 | 1274183 | 1225514 | 318759.5 | 774935/1828312 |
| log GDP | 418 | 14.03 | 14.02 | 0.2565496 | 13.56/14.42 |
| Unemp. Rate, Canada | 447 | 8.262 | 7.8 | 1.671796 | 5.000/13.100 |
| Unemp. Rate, BC | 447 | 8.579 | 8.300 | 2.538526 | 4.100/15.700 |
| Unemp. Rate, ONT | 447 | 7.543 | 7.100 | 1.564364 | 4.700/12.400 |
| Unemp. Rate, QC | 447 | 9.993 | 9.700 | 1.994922 | 6.900/15.800 |
| Unemp. Rate, ALB | 447 | 6.308 | 5.500 | 2.292647 | 3.100/12.400 |
| Unemp. Rate, SAS | 447 | 5.827 | 5.500 | 1.423726 | 3.300/9.000 |
| Unemp. Rate, MAN | 447 | 6.384 | 5.700 | 1.613993 | 3.700/11.000 |
| Unemp. Rate, NB | 447 | 11.39 | 11.30 | 1.920268 | 7.10/16.50 |
| Unemp. Rate, NF | 447 | 16.14 | 16.10 | 2.525898 | 11.00/22.70 |
| Unemp. Rate, NS | 447 | 10.53 | 10.00 | 1.899696 | 6.90/15.70 |
| Unemp. Rate, PEI | 447 | 12.49 | 11.90 | 2.230072 | 7.70/18.90 |

Notes: GDP is in million CAD. All unemployment rates are in percentage. GDP range: 1981-01-01 to 2015-10-01. National and provincial unemployment rate range: 1977-09-01 to 2015-10-01.