

Variations Across Canadian Regions in the Sensitivity to U.S. Monetary Policy

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Abstract This paper contributes to the research on regional economic responses to monetary policy shocks in two ways. First, rather than just model the Canadian economy at the national level, we examine the impact of monetary policy shocks across five separate Canadian regions. The second extension of the literature is our focus upon estimating the impact from both Canadian and U.S. monetary policy shocks upon regional Canadian economic activity. The findings are broadly consistent with results from previous research modeling the national Canadian economy, but noteworthy regional differences are observed. Eastern Canadian regions, defined as Ontario (ON), Quebec (QU), and Atlantic (AT), exhibit greater sensitivity to Canadian monetary policy shocks than do Western Canadian regions. We also find that U.S. monetary policy shocks have a discernable impact on Canadian regional economic activity, but the impact varies across regions. For the three Eastern Canadian regions ON, QU, and AT, there is a significant impact upon regional economic activity from a U.S. monetary policy shock, but not for the two Western Canadian regions Prairie (PR) and West (WE). Moreover, the impact on ON, QU, and AT from a fed funds shock is quite similar to the impact from a shock to the Canadian Bank Rate.

Keywords Vector autoregression · Impulse response function · Monetary policy · Canadian regional employment

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Introduction

Three potential channels have been identified in the literature by which regional variation in the response to monetary policy shocks can arise. These channels involve differences across regions in the percent of regional output coming from interest-rate sensitive sectors, the percent of regional output coming from small rather than large firms, and the percent of regional lending activity done by small rather than large banks (Carlino and DeFina 1998). Empirically, however, for U.S. regions it is only variations in the percent of regional output from interest rate-sensitive sectors that has been shown to correlate significantly, and, in the expected manner, with variations in regional income sensitivity to federal-reserve policy shocks (Carlino and DeFina 1999). Less work has been published testing for differences across Canadian regions in their responsiveness to monetary shocks, but *a priori* there are reasons to expect differences. In addition to Canadian regional variation in manufacturing output share, another potential channel through which monetary policy shocks may impact Canadian regional economic activity is *via* induced changes in the real exchange rate. Ontario and Quebec are both more manufacturing dependent and more export dependent than the other provinces.¹

We identify the regional impact from both Canadian and U.S. monetary policy shocks using a Vector Autoregressive (VAR) model with a structure well represented in the literature for identifying monetary policy shocks. The model includes national output data for the U.S. and Canada, monetary policy shocks for both U.S. and Canada, and Canadian regional economic activity variables for five Canadian regions: West (British Columbia and Alberta), Prairie (Saskatchewan and Manitoba), Ontario, Quebec, and Atlantic (New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island). Our findings match well with previous literature examining the impact on the Canadian economy at the national level from Canadian monetary policy shocks. We do find, however, differences across Canadian regions in their sensitivity to both Canadian and U.S. monetary policy shocks, as well as U.S. economic activity shocks.

Literature Review

There have been multiple studies done using VAR methodologies in order to identify the impact upon the Canadian national economy from monetary policy shocks. Armour et al. (1996) provide a useful introduction to the existing research. Their own work finds that the impact from Canadian monetary policy shock dissipates within 14 to 20 quarters. As seen in the results section, we also find considerable persistence in the impact of Canadian monetary policy upon Canadian national output. Other research has compared the national Canadian economy to other industrialized nations in terms of domestic output's sensitivity to domestic policy shocks. Both Kim (1999) and Fung and Kasumovich (1997) find that Canada's economy is less responsive to domestic monetary policy shocks than is the U.S. and

¹ See Brady and Novin (2001) for documentation of Canadian regional variation in importance of manufacturing and exports.

Germany. In addition, Fung and Kasumovich (1997) also find that France and the U.K. have more sensitivity to domestic monetary policy shocks than does Canada.

One possible reason for the above findings of a lesser impact within Canada from domestic monetary policy shocks is that Canada's high degree of integration with the much larger U.S. economy may lessen the effectiveness of its monetary policy. Multiple studies have documented the impact on national Canadian output, employment, or interest rates from U.S. based shocks. Burbridge and Harrison (1985) analyze monthly data from 1971 to 1983 and find Canadian interest rates and the nominal exchange rate impacted by U.S. interest rate shocks, and they find Canadian industrial production influenced by U.S. industrial production shocks. Schmitt-Grohé (1998) documents an impact upon Canadian investment, output, and labor hours from innovations to U.S. output from 1950 to 1991. Holman and Neumann (2002) use quarterly data from 1963 to 1996 and find that U.S. and Canadian monetary shocks have approximately the same impact upon Canadian Real GDP. Lange (2005) finds that U.S. monetary shocks have large persistent effects on Canadian long-term bond yields.

While the evidence of an impact from U.S. monetary and output shocks upon the Canadian national economy is well documented, the impact of U.S. shocks upon Canadian regions remains less thoroughly investigated. Racette and Raynald (1994) and Raynald (1988) use VARs to compare Canadian regional responses to exogenous changes in the U.S. economy, but they focus only on employment shocks rather than specifically examining the response to monetary policy. Debenedictus (1997) uses a VAR to analyze Canadian regional activity but focuses solely on British Columbia and only includes Canadian variables in the model. Georgopoulos (2001) examines Canadian regional employment responses to innovations in the spread between Canadian short-term and long-term interest rates but does not examine the response to U.S. interest rate shocks. Glaes et al. (2001) examine the Canadian regional effects of interest rate and exchange rate shocks but include no U.S. macro variables in the model. Another strand of literature germane to this paper is the work on sub national regional variation to monetary policy shocks. For the U.S., there have been multiple studies, and the most consistent finding is that regions with a larger share of output from manufacturing activity exhibit greater sensitivity to the monetary policy shocks.² This finding has been shown to hold in EU regions.³

Research particularly relevant to our study is Georgopoulos (2009), which similarly uses a VAR to examine regional differences in the responsiveness of Canadian employment to Canadian monetary policy, finding Newfoundland and Prince Edward Island to be the most responsive provinces to positive innovations in the Canadian Bank Rate. Our paper exhibits key differences from this earlier work. First, our interest is not only on comparing the responses of Canadian regional employment to Canadian monetary policy, but to U.S. monetary policy as well. Although Georgopoulos (2009) includes the U.S. Fed Funds rate in the VAR, the author does not report the impulse response functions of regional employment to

² See Toal (1977), Garrison and Chang (1979), Garrison and Kort (1983), and Carlino and Defina (1998, 1999)

³ See Arnold (2001), Arnold and Vrugt (2002), and Arnold and Vrugt (2004)

changes in this rate. In addition, Lastrapes (2005) points out that when comparing the responses of a cross-section of variables to a common aggregate shock, using separate VARs for each element in the cross-section, as in Carlino and Defina (1998) and Georgopoulos (2009), can yield misleading results because the identification of the aggregate shock will vary across the separate VARs. We address this issue by using regional rather than provincial employment and estimating a large VAR with all regions included, rather than separate VARs for each province.

In summary, this paper extends the research on both identifying the impact of monetary policy shocks upon the Canadian economy and assessing the importance of sub-national regional variation in the importance of monetary policy shocks. One contribution is assessing the degree of regional variation within Canada in the impact of domestic monetary policy shocks, and comparing the findings against the U.S. and European regional literature. As a small open-economy, Canada is much more representative of most of the world than is the U.S. economy, so it will be interesting to see if regional differences can persist within an economy much more open than the U.S. economy. In addition, we explicitly model and compare the importance of U.S. monetary policy shocks versus domestic Canadian monetary policy shocks across Canadian regions. Our analysis places more emphasis upon identifying rest-of-world shocks than has been done in the existing regional literature.

VAR Model and Identifying Restrictions

In this paper, we utilize a vector autoregression (VAR) to measure the dynamic response of Canadian regional employment to the Federal Funds Rate and the Canadian Bank Rate, as well as other shocks. We build on the existing literature by using a just identified VAR including both U.S. and Canadian macroeconomic variables as well as Canadian regional employment data to measure the extent to which there are differences in the dynamic response of Canadian regional employment to monetary policy shocks emanating from both the U.S. and Canada. The well known and widely used Choleski decomposition, as outlined by Christiano et al. (1996), is the identification strategy used in the model. This identification scheme imposes a recursive structure on the system and fully identifies the structural model from the reduced form. We choose variables pertaining to macroeconomic activity (Y), energy prices ($PENG$) the exchange rate (EX), regional employment (REG_i), and interest rates indicative of monetary policy (R).⁴ Explicitly,

$$Z_t = \left\{ PENG_U, Y_U, R_U, EX_U, PENG_C, Y_C, R_C, REG_{ON}, REG_{QC}, REG_{WE}, REG_{AT}, REG_{PR} \right\}$$

A U subscript denotes a United States macro variable, while a C subscript denotes a Canadian macro variable. The ordering of the variables implies the degree of exogeneity. In our model, we list all United States variables before any Canadian variables, implying that no Canadian variable can contemporaneously affect macro

⁴ Carlino and Defina (1998) and Carlino and Defina (1999) examine U.S. sub-national responses to monetary policy and also use interest rates to measure monetary policy and include energy prices to capture supply shocks.

variables pertaining to the United States. This ordering is due to the fact that the U.S. is a larger, more autonomous country which is less likely to respond contemporaneously to Canadian innovations than vice versa.⁵ Furthermore, the nominal exchange rate (in terms of Canadian dollars to U.S. dollars) is placed between the U.S. and Canadian macro variables, meaning that it cannot contemporaneously affect any U.S. variable but may contemporaneously affect Canadian variables.⁶ The last five variables in the system are the Canadian regional employment variables, and they are listed by order of average total employment over the sample size. The effect of this is to make larger regions more autonomous than smaller regions. The regions, in order of exogeneity, are: Ontario (ON), Quebec (QU), West (WE), Atlantic (AT), and Prairie (PR). This ordering imposes the restriction that Ontario employment cannot be contemporaneously affected by employment in any other region, that Quebec employment may be contemporaneously affected by Ontario employment, but not so by any other region's employment, and so on. Finally, note that within each macro sub-set, we list relative energy prices first, followed by real aggregate output and then by interest rates. This allows the interest rates pertaining to monetary policy to be affected contemporaneously by energy prices and output, but only allows the policy rates to affect the former variables with a one-period lag. A similar approach is used in Christiano et al. (1999) and it minimizes the potential contribution of the interest rates to the variances of the other variables listed before them as well as allows each interest rate equation in the VAR to be better thought of as a policy rule being followed by a Central Bank. As a final point, note that our approach does not restrict any of the system's dynamics; any variable may affect any other variable with as little as a one-month lag.

Data

We employ monthly data from January 1972 to April 2007.⁷ For our U.S. relative energy price measure, we employ the Producer Price Index (PPI) for fuel and related products deflated by the PPI for all commodities. To measure Canadian energy prices, we take the Canadian energy commodity price index and deflate by the Canadian Industrial Product Price Index. For aggregate output, we use U.S. Industrial Production and Canadian Real Gross Domestic Product.⁸ We include the nominal Canada/U.S. exchange rate to better capture linkages between the two economies, and the U.S. Effective Federal Funds Rate and the Canadian Bank Rate are our interest rates indicative of monetary policy. We utilize non-agricultural regional employment for the five regions set forth by the Canadian Central Bank (Atlantic, Ontario, Quebec, Prairie, and West) to capture Canadian regional economic activity. U.S. prices, U.S. Industrial Production, the nominal exchange rate, and the U.S. Fed Funds Rate are obtained from the St. Louis Fed's

⁵ See Holman and Neumann (2002).

⁶ Burbidge and Harrison (1985) perform a similar ordering strategy.

⁷ We end our sample in mid-2007 to exclude data observations generated during the credit crisis and subsequent economic downturn that began in the latter part of that year.

⁸ Canadian real GDP is reported monthly, whereas U.S. real GDP is reported quarterly, so we opted for monthly Industrial Production as our measure of U.S. output.

macroeconomic database, FRED2. Canadian prices, Canadian Real GDP, the Canadian Bank Rate, and Canadian Regional Employment are obtained from Statistics Canada. All data, besides the interest rates and exchange rates are measured in logarithms. Also, Augmented Dickey-Fuller tests were conducted to test for the presence of a unit root in each data series.⁹ In each case, we could not reject the null hypothesis of a unit root in levels, but we could reject the same null for the first differenced data, which implies that each of the data series are integrated of order one. Therefore, to achieve stationarity we take first differences of each data series in the VAR. All data but the interest rates and exchange rate is in percentage growth rates format.

Estimation and Results

We estimate the twelve-variable VAR described above to obtain the dynamic responses of interest. Each equation in the VAR includes a constant, trend term, seasonal dummy variables, and twelve lags of each variable. AIC and SBC tests of various lag lengths confirmed that twelve lags were optimal and Ljung-Box Q-tests on the residuals find no serial correlation.¹⁰

Figure 1 reports the orthogonalized cumulative impulse response functions of each variable to a one standard deviation (approximately 40 basis points) increase in the Canadian Bank Rate. The dashed lines above and below the impulse response functions were obtained from Monte-Carlo integration with 2,500 replications and represent one standard deviation bands around the point estimates. As expected, Fig. 1 shows that the increase in the Canadian Bank rate causes a statistically significant decrease in Canadian Real GDP. Furthermore, each of the five Canadian regions exhibits a decline in non-agricultural employment. Ontario and Quebec see a definitive statistically significant decline within 2 years after the rate increase, and the West region is very slightly statistically significant for 1 month, approximately 1 year after the shock. The response of Atlantic regional employment is negative but only slightly significant 27 months after the shock and then only temporarily so, while the regional employment response of the Prairie region is negative but always within one standard deviation from zero. These results indicate that small regional differences exist in the Canadian employment response to a positive shock in the Canadian Bank Rate, with the manufacturing hubs of Ontario and Quebec being slightly more interest sensitive than the other regions.

Closer examination of Fig. 1 reveals that Ontario's employment is the most sensitive to changes in the Canadian Bank Rate. It is approximately .25% lower 2 years after the shock and reaches a low of about .3% below baseline 38 months post-shock. Quebec exhibits a very similar employment response as Ontario to the innovation in the Canadian Bank Rate. The response of the West and Atlantic regions are not as pronounced, but similar nonetheless to Ontario and Quebec, particularly within the first 2 years after the shock. The response of the Prairie

⁹ Results of ADF tests are available upon request.

¹⁰ Results are available upon request.

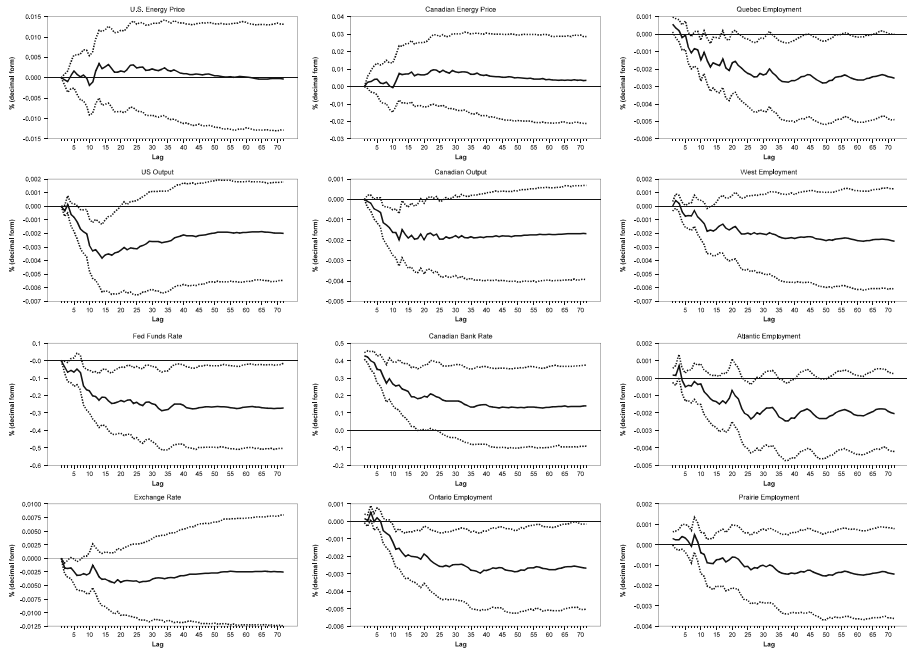


Fig. 1 Responses to Canadian bank rate shock

region’s employment is the least responsive to the interest rate shock at virtually all lags, never falling below about .13% of its pre-shock level.

Figure 2 reports the model’s orthogonalized cumulative impulse response functions to a one standard deviation (approximately 50 basis points) increase in the U.S. Fed Funds Rate. This increase in the Fed Funds rate leads to a negative and significant response to both U.S. Industrial Production and Canadian Real GDP, with a statistically significant positive response to the Canadian Bank Rate. The Fed Funds shock does appear to impact Canadian regional employment, though differences certainly exist. As with the Canadian Bank Rate shock, Ontario and Quebec both demonstrate statistically significant drops in employment, while the employment response in the West and Prairie regions is not statistically significant. The response of employment in the Atlantic region is negative but is not outside of one standard deviation from zero until about 2 years after the shock. As with the Canadian Bank Rate shock, Ontario and Quebec appear the most sensitive to changes in the Fed Funds Rate with respect to non-agricultural employment.

Further examination of Fig. 2 shows that 14 months after the interest rate shock, Quebec regional employment is almost .25% lower than its pre-shock level before leveling off just over .3% percent below steady-state. Ontario’s regional employment has the largest long-run response, at almost .35% below baseline, with the Atlantic region’s employment response being the next most responsive, with a long-run negative response of approximately .25%. Prairie and West are substantially less responsive than Ontario, Quebec, and Atlantic in their employment responses to the Fed funds rate increase. Prairie’s response is never greater than about .125% below baseline, and the response of employment in the West is essentially zero at most time horizons. It appears that with regards to changes in the Fed Funds rate, there exists a

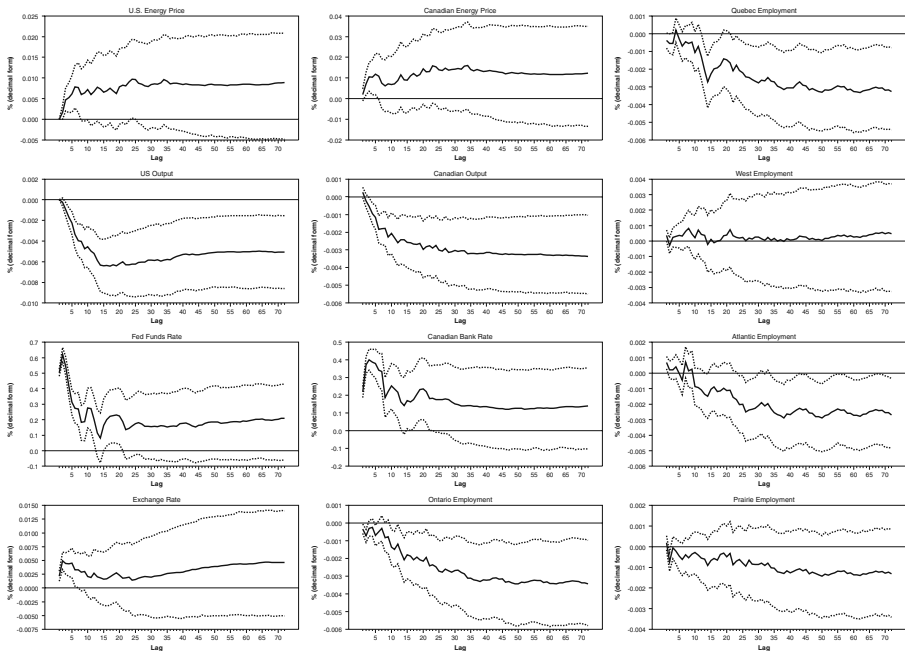


Fig. 2 Response to fed funds rate shock

clear distinction between the three core regions of Ontario, Quebec, and Atlantic, and the two non-core regions of the West and Prairie provinces. This is reinforced in Fig. 2, with Ontario, Quebec, and Atlantic being the only regions that display statistically significant negative employment responses to the positive Fed Funds shock.

Figure 3 provides each region’s employment response to both interest rate shocks. The solid line is the response to the Fed Funds rate while the dashed line is the response to the Canadian Bank Rate. Of particular note is that for Ontario, Quebec, Atlantic, and Prairie, the response to a Fed Funds shock very closely matches the response to a Canadian Bank Rate shock for most time horizons. The only region that has a noticeable difference in the employment response to the two interest rates is the West, which is particularly more responsive to the Canadian Bank Rate than to the Fed Funds Rate. With regards to the dynamic response of employment to monetary policy shocks, it appears that for every region in Canada other than the West, it makes little difference whether the interest rate shock comes from the U.S. or Canada.

As a check on the robustness of the model above, an alternative specification of the VAR model with two modifications was estimated. U.S. industrial production was replaced with three U.S. nonfarm employment variables: East Border employment, West Border employment, and Rest-of-U.S. employment.¹¹ This modification permits a broader measure of monthly U.S. economic activity than Industrial Production to be used, and it allows for a differential impact upon

¹¹ East (West) Border is total employment for U.S. states bordering Canada east (west) of Mississippi River. Rest-of-U.S. is total U.S. employment less (East Border+West Border employment).

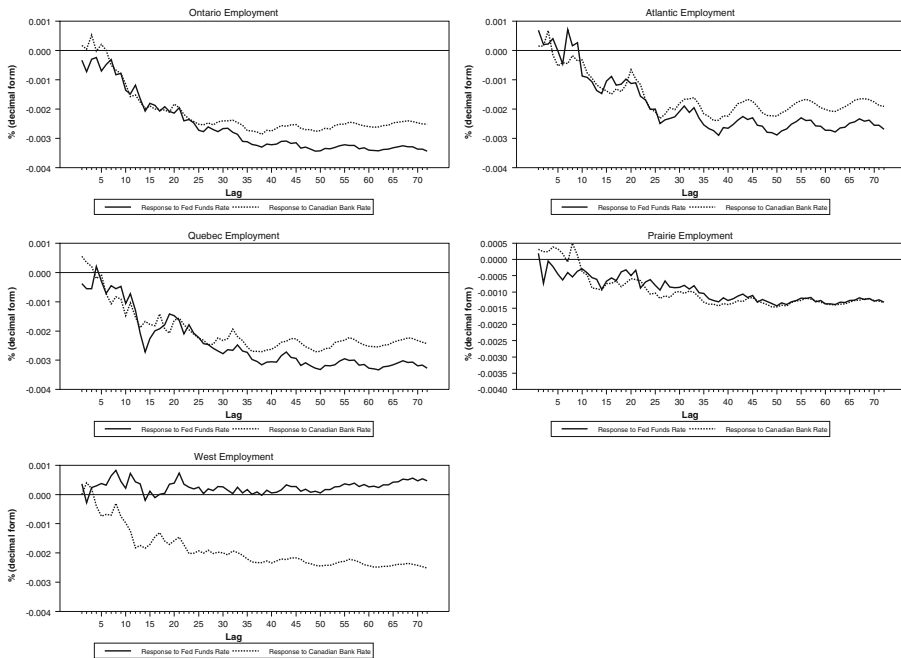


Fig. 3 Canadian regional employment responses to interest rate shocks

Canadian provinces from economic activity shocks in U.S. border regions. The regional impacts may well vary across provinces given that eastern Canada’s economy has deeper cross-border integration than western Canada due to the U.S.—Canada auto pact in particular and more generally due to the larger importance of manufacturing for Ontario and Quebec.¹²

This alternate model shows the same pattern across provinces from Fed Funds shocks as in the base model: Ontario and Quebec are the most sensitive to Fed Funds shocks, with the Atlantic region having a smaller impact, while the West region has no statistically significant impact from Fed Funds shocks. The one change from the base model is that the Prairie region now has a statistical significant impact, similar to the Atlantic region, from the Fed Funds shocks.¹³ Examining U.S. non monetary shocks, Canada’s regional employment responses to Canadian output and the three U.S. regional activity measures are summarized in Fig. 4. With the exception of Quebec, there is a positive impact on Canadian regional employment from a positive shock to employment in the adjacent cross-border states region (East Border for ON, QU, and AT; West Border for PR and WE). In contrast, positive shocks in the non adjacent cross-border states have a negative impact upon Canadian regions, suggesting that cross-border regional business cycles are more synchronized for adjacent cross-border regions.

¹² The authors thank a reviewer for pointing out these possibilities.

¹³ Results not shown due to space constraints, full results available from authors upon request. Also, a version of the model with a single All Border States region rather than East and West regions was estimated and the same impact from Fed Funds shock was found.

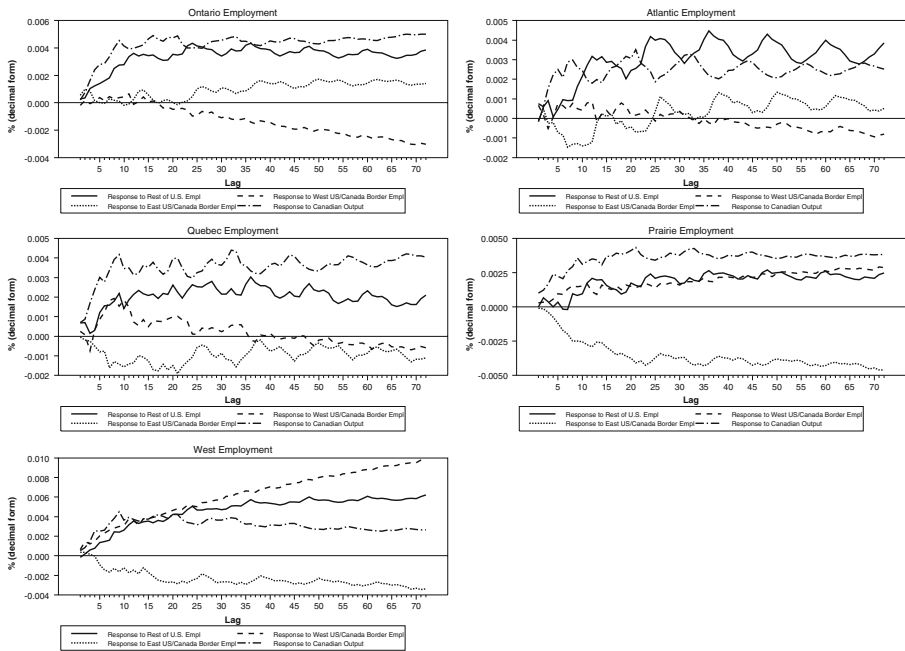


Fig. 4 Canadian regional employment responses to output shocks

As a final check on the robustness of these results, the identification strategy was varied by altering the order of the variables in the Choleski decomposition. Instead of first reporting all U.S. variables and then all Canadian variables, the ordering was done by macro variable with the U.S. variable listed first: {PENG_U, PENG_C, Y_U, Y_C, R_U, EX_{U/C}, R_C, REG_{ON}, REG_{QC}, REG_{WE}, REG_{AT}, REG_{PR}} where Y_U includes the three U.S.-based employment measures ordered as Rest-of-U.S., East Border, West Border. The findings on the impact from Fed Funds and U.S.-based economic activity shocks are substantively the same as already reported.¹⁴

Conclusion

This paper adds to the existing literature on Canadian-U.S. macroeconomic linkages by using a just identified VAR to estimate the dynamic response of Canadian regional employment to changes in both the Canadian Bank Rate and the U.S. Fed Funds Rate. We find regional differences in the employment response to Canadian Bank Rate shocks consistent with the existing literature on sub national regional variations to domestic monetary shocks. Each Canadian region, except for Prairie, has a negative and statistically significant employment response to positive innovations in the Canadian Bank Rate with Ontario and Quebec being more interest-sensitive than other regions. This is to be expected given that Ontario and Quebec are the primary provincial hubs of Canadian manufacturing activity. With

¹⁴ Results available upon request

respect to changes in the effective Fed Funds Rate, the Ontario, Quebec, and the Atlantic regions display statistically significant (negative) employment responses, with Ontario and Quebec once again displaying the most sensitivity, reflecting the tighter integration of these two regions with the U.S. economy through cross-border motor vehicle production and other manufacturing activity.

Of particular note is the finding that each Canadian region, other than the West, exhibits very similar responses to changes in the Fed Funds Rate as to changes in the Canadian Bank Rate. The West is the only Canadian region that appears to be decidedly more sensitive to Canadian monetary policy than U.S. monetary policy. We also find that positive economic activity shocks in adjacent cross-border U.S. states have a positive impact on Canadian regional employment for all regions but Quebec.

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