INSTITUT C.D. HOWE INSTITUTE

COMMENTARY
NO. 627

Lessons from the Yield Curve: Evaluating Monetary Policy in Different Interest Rate Environments

The impact monetary policy has on the economy, the so-called monetary transmission mechanism, involves more than just changes in the overnight rate. What works, when?

Thorsten Koeppl and Jeremy Kronick

The C.D. Howe Institute's Commitment to Quality, Independence and Nonpartisanship

The C.D. Howe Institute's reputation for quality, integrity and nonpartisanship is its chief asset.

Its books, Commentaries and E-Briefs undergo a rigorous two-stage review by internal staff, and by outside academics and independent experts. The Institute publishes only studies that meet its standards for analytical soundness, factual accuracy and policy relevance. It subjects its review and publication process to an annual audit by external experts.

As a registered Canadian charity, the C.D. Howe Institute accepts donations to further its mission from individuals, private and public organizations, and charitable foundations. It accepts no donation that stipulates a predetermined result or otherwise inhibits the independence of its staff and authors. The Institute requires that its authors disclose any actual or potential conflicts of interest of which they are aware. Institute staff members are subject to a strict conflict of interest policy.

C.D. Howe Institute staff and authors provide policy research and commentary on a non-exclusive basis. No Institute publication or statement will endorse any political party, elected official or candidate for elected office. The views expressed are those of the authors. The Institute does not take corporate positions on policy matters.

Daniel Schwanen
Vice President, Research

About The Authors

Thorsten Koeppl
is Fellow-in-Residence, C.D. Howe Institute, and a Professor and RBC Fellow in the Department of Economics at Queen's University,

Jeremy Kronick
is Director, Monetary and Financial Services Research, at the C.D. Howe Institute.

Commentary No. 627
August 2022

$12.00
ISBN 978-1-989483-91-6
ISSN 0824-8001 (print);
ISSN 1703-0765 (online)

The Study In Brief

For much of the past two decades, interest rates have fallen in Canada (and elsewhere). At the time of writing, however, with inflation well above the Bank of Canada's 2 percent target, we are headed in the opposite direction. Where we will land over the long haul is unclear. However, it is vital that central banks have a clear understanding of whether the monetary policy transmission mechanism – i.e., how monetary policy affects the economy – changes based on the underlying interest rate environment. This paper answers the question by comparing a novel approach to identifying monetary policy shocks – one that takes into consideration the impact of unconventional monetary policy like quantitative easing and forward guidance – with more traditional approaches focused only on unexpected moves in the Bank of Canada's primary policy tool, the overnight rate.

The first step in our analysis is to separate what we call a more normal interest rate environment from a low interest rate environment. We restrict attention to those years when the Bank pursued inflation targeting to hold constant the monetary policy regime. We use a simple approach that looks at periods when the real interest rate – the Bank of Canada's bank rate less inflation – is negative. As it turns out, the real interest rate was never negative from the beginning of our sample, January 1992, to September 2002, but was negative over half the time from October 2002 to the end of our sample, February 2020.

Our second step is to identify monetary policy shocks. Most of the existing literature identifies monetary policy shocks using only large, unexpected changes in the overnight rate. But, in low interest rate periods, the Bank goes beyond the use of the overnight rate, using unconventional tools such as forward guidance and quantitative easing, both of which make use of interest rates with longer duration. Rather than a single statistic to summarize the impact of a policy announcement, we follow Inoue and Rossi (2021) and create a more comprehensive monetary policy shock vector that makes use of the entire yield curve.

Thirdly, we reduce a series of financial and macroeconomic variables to so-called factors. Each factor can be interpreted as representing a well-known monetary policy transmission mechanism. We find four, which we label: monetary aggregates, real economy, asset markets, and changes in credit intermediation.

Lastly, we use local projections, a statistical technique, which allows us to estimate the impact of monetary policy on each factor.

Our findings are as follows:

- The impact of monetary policy on the economy differs across the two interest rate periods studied. In particular, the magnitude of how factors react to monetary policy is larger in the low interest rate environment.
- Our four factors all play a distinct role in how monetary policy effectiveness changes, with the credit, asset, and real economy channels playing a more significant role in the low interest rate environment. This points to private demand and financial market conditions having become more important at the expense of the monetary channel, which plays a more significant role in normal interest rate periods.
- The more comprehensive shock series, which focuses on the entire yield curve, has had a larger effect on the economy compared with the more traditional shock series. This evidence suggests that unconventional monetary policy can be successfully used to create additional stimulus at the lower bound of the overnight rate, if needed.

As today's interest rates have increased sharply, our results suggest that the impact of monetary policy on the economy will differ in this environment relative to the decade after the financial crisis where interest rates were persistently near the lower bound. For example, money conditions, whether cash, bank deposits, or the broader supply of money, may play a more important role in the world we face today. Ultimately, understanding how the interest rate environment influences the effectiveness of monetary policy will determine how successful monetary policy will be in bringing inflation back to target. The Bank must adjust its models, putting more weight on some variables, like monetary conditions, and less on others, in order to better gauge monetary policy's likely impact on inflation.

Policy Area: Monetary Policy.
Related Topics: Banking, Credit and Payments, Central Banking, Inflation and Inflation Control.
To cite this document: Koeppl, Thorsten, and Jeremy Kronick. 2022. *Lessons from the Yield Curve: Evaluating Monetary Policy in Different Interest Rate Environments.* Commentary 627. Toronto: C.D. Howe Institute.

C.D. Howe Institute Commentary© is a periodic analysis of, and commentary on, current public policy issues. James Fleming edited the manuscript; Yang Zhao prepared it for publication. As with all Institute publications, the views expressed here are those of the authors and do not necessarily reflect the opinions of the Institute's members or Board of Directors. Quotation with appropriate credit is permissible.

To order this publication please contact: the C.D. Howe Institute, 67 Yonge St., Suite 300, Toronto, Ontario M5E 1J8. The full text of this publication is also available on the Institute's website at www.cdhowe.org.

Canada has been in a low interest rate environment for much of the last two decades. Such an environment is characterized by a low (real) "neutral rate" that is close to 0 percent. The neutral rate is the interest rate at which the economy performs up to its potential with inflation sustainably at the Bank's 2 percent target.[1]

With a lower neutral rate, the Bank of Canada has less ability to provide necessary stimulus in an economic downturn, as the overnight rate will hit its so-called lower bound more frequently. Indeed, the overnight rate has hit 0.25 percent – the lower bound according to the Bank of Canada – twice in the last 15 years: once in the Great Recession and once during the current pandemic.

The current run of higher inflation will lead to higher interest rates for a period of time, and the rate environment we will find ourselves in after prices have settled is open for debate. Regardless, what central bankers must look to understand is whether the monetary policy transmission mechanism, and, therefore, its effectiveness, changes based on the prevailing interest rate environment.

In this paper, we shed light on this question by comparing whether monetary policy's transmission mechanism has fundamentally changed over the last two decades, between the higher (or more normal) interest rate environment that preceded it, and the lower interest rate environment that characterized it. That will help us gauge monetary policy's impact no matter which interest rate environment defines the next number of years.

There are different reasons to believe that monetary policy works differently when the neutral rate is close to the lower bound on interest rates.

First, since the Bank is constrained by the lower bound, conventional monetary policy – i.e., lowering the overnight rate to stimulate the economy in a downturn – is no longer possible. The central bank must then turn to alternative, unconventional monetary policy tools to stimulate the economy. These include:

1) Forward guidance, where the Bank conditionally commits to low interest rates in the future;
2) Quantitative easing, where the Bank purchases government debt to lower longer-term interest rates; and
3) Credit easing, where the Bank purchases private debt to push down borrowing rates more broadly in financial markets.[2]

For helpful comments on an earlier draft, the authors thank Charles DeLand, William Robson, Jeannine Bailliu, Steve Ambler, John Crow, Pierre Duguay, Paul Jenkins, David Laidler, Angelo Melino, John Murray, Gregor Smith, Mark Zelmer, anonymous reviewers and members of the Monetary Policy Initiative of the C.D. Howe Institute. The authors retain responsibility for any errors and the views expressed.

1 There are many explanations for this downward trend in neutral rates such as an aging population, slower productivity growth and/or a larger premium for safe assets.

2 How effective these policies have been in leading central banks toward their ultimate goal of getting inflation back to target has been debated since their original use during the 2007-09 financial crisis (see, for example, Bernanke 2020). One tool, a negative overnight policy rate, has not yet been tried in Canada, and the Bank of Canada – despite its own research, which puts the effective lower bound at -50 basis points (see, for example, Witmer and Yang 2016) – has been quite clear during the recent pandemic that it does not see it as a valid policy option.

Key Concept Explainer

Monetary Policy Shocks:

Traditional: The focus is on the overnight rate and whether the Bank moves it more than is expected. A common methodology for identifying monetary policy shocks is to first estimate where the Bank of Canada can be expected to set its policy rate – the overnight rate – in response to a series of important economic indicators such as forecasts of real output growth and inflation. If the actual, announced change in the overnight rate by the Bank of Canada differs from this estimate, the difference is considered a monetary policy shock.

Novel: While the traditional methodology is sound, the use of only the overnight rate might be problematic since different central bank announcements may also affect other, longer-term interest rates. This is most relevant in the context of unconventional monetary policy where policy actions are aimed at moving short-term and longer term interest rates alike – i.e., the entire yield curve – to affect aggregate demand in the economy, and, therefore, inflation.

We derive a novel series of monetary policy shocks for Canada using the methodology introduced by Inoue and Rossi (2021) to estimate such a series for the US. The idea is to identify monetary policy shocks by how much the entire term structure of the yield curve changes in response to central bank announcements.

Second, financial intermediation changes in a low interest rate environment. When the Bank of Canada lowers the overnight rate, financial institutions typically lower both the deposit rate they pay out and the lending rate they charge, in order to maintain their profit spread. However, banks tend to shy away from charging negative deposit rates especially for retail customers. Consequently, as the overnight rate approaches its lower bound lending rates are unlikely to be lowered as much, meaning conventional monetary policy will have a more muted effect through the lending channel (i.e., loan demand does not increase by as much).[3] As profit margins get squeezed for traditional financial intermediaries, the search for yield also tends to favor more risky shadow banking activities, typically involving lending outside the traditional banking sector.

Third, at low interest rates, asset prices are naturally higher. This can have benefits since higher asset prices make people feel wealthier and they are more likely to spend. However, it can also lead households and businesses to take on too much debt. When interest rates increase again, periods of de-leveraging can lead to longer periods of reduced consumption spending, lower growth, and lower

3 There is ample empirical evidence and theoretical research that has documented less interest rate pass-through when interest rates are low. See the list of references at the end of this *Commentary* for recent contributions to this topic.

inflation[4] negating the benefits from stimulating demand through monetary policy in the medium run.

Our approach in empirically documenting changes in the monetary policy transmission is as follows. We first identify a break in the data on interest rates to separate a normal interest rate environment from a lower interest rate environment. We find that the first instance when our real interest rate (calculated using the Bank of Canada's bank rate – a nominal interest rate – and subtracting contemporaneous inflation) becomes negative is October 2002. From January 1992, where our data series starts, to September 2002, there were no instances of negative real interest rates. Between October 2002 and February 2020, which we choose as the end point for our data given the wild swings in some key macroeconomic variables during the pandemic, there were 110 months – or 53 percent of the time – where real interest rates were negative. Hence, we use September 2002 as our break point between a normal and low interest rate environment.

Next, we identify monetary policy shocks. As we have argued, in a low interest rate environment, central banks will have to turn to unconventional monetary policy more often. Many of the existing methods for determining monetary policy shocks focus only on conventional monetary policy; i.e., changes in the overnight policy rate.

To address this issue, we construct a novel monetary policy shock series for Canada following the methodology of Inoue and Rossi (2021). This methodology associates shifts in the entire yield curve around announcement events creating a more comprehensive monetary policy shock. This approach is attractive, since, in addition to conventional monetary policy, it can also capture unconventional monetary policy. Furthermore, looking at the entire yield curve, we can also break down monetary policy shocks into different components such as shifting the entire yield curve up or down, changing its slope, and/or its curvature. Each of these components are relevant to understanding the effects of unconventional monetary policy.

Having derived our novel monetary policy shock series, we then need to find a set of variables – in addition to inflation and real GDP – that can capture changes in the way such shocks influence the economy. We resort here to factor analysis, which takes financial and macroeconomic data and extracts common movements in the form of a much smaller number of variables – so-called factors. Ideally, we can interpret these factors as capturing aspects that are important to monetary policy transmission.

We identify four factors that summarize our data set.

(i) The first one summarizes variables related to monetary aggregates – which measure everything from cash and chequing and savings deposits to Canada Savings bonds, net mutual fund contributions and more – and can be thought of as a stand-in for classic effects of monetary policy that change such aggregates.

(ii) The second one is linked to real variables that reflect consumption, investment and housing. Hence, we can think of this factor as representing monetary policy's direct, real effects.

(iii and iv) Our last two factors are related to asset and credit markets. One of them combines prices and quantities of asset classes, while the other expresses the relative importance of traditional, bank-based intermediation vs. non-bank credit channels. These two factors thus reflect financial channels through which monetary policy is transmitted to the broader economy.

4 See for example Guerreri et al. (2020).

The final step in our analysis is to use local projections[5] (a statistical method) to estimate how these factors – and, hence, parts of the economy – respond to a monetary policy shock. We can then compare the results across the two interest rate environments to determine what changes there are to the transmission mechanism and effectiveness of monetary policy.

Our main findings can be summarized as follows:

1) The impact of monetary policy on the economy differs across the two interest rate environments. Surprisingly, given the low inflation that characterized much of the period after the Great Financial Crisis, we find larger magnitudes for the economy's response to a monetary policy shock when interest rates are low.
2) Our four factors all play a distinct role in how effective monetary policy is across interest rate environments. The credit, asset, and real economy channels plays a significant role in the low interest rate environment, pointing to the importance of private demand and financial market conditions, while there is indication that the monetary channel plays a more significant role in normal interest rate periods.
3) Using the inflation and real GDP responses to our novel shock series, we find that unconventional policy as expressed as a parallel shift in the yield curve has comparable effects on the economy to a conventional shock that affects only the overnight rate. This gives us some reason to believe that unconventional policy measures can have a significant impact on the economy.
4) Comparing our new shock series with the Champagne and Sekkel (2018) series of traditional monetary policy shocks, we find two differences. First, the impact of a shock on the economy is estimated to be much smaller than with our new series. Second, in the low interest rate environment, responses to monetary policy shocks are equally or less significant compared to our new series. This indicates that it matters what shock series one uses to measure the impact of monetary policy, with our novel series having the advantage of being more comprehensive.

Our results thus suggest that the interest rate environment matters for the impact that monetary policy can have on the economy. But, we also find that one needs to look carefully at how one constructs monetary policy shocks from the data.[6] Current high inflation may have been in part a misjudgment of the impact of quantitative easing, and with interest rates rising to compensate, our results suggest it will lead to a different monetary policy transmission environment than any we have seen over the last decade.

As interest rates increase, our results suggest the effect on economic activity – the so-called transmission mechanism – will change. For example, money conditions, whether cash, bank deposits, or the broader supply of money, appear to play a more important role when interest rates are high. Ultimately, understanding how the interest rate environment influences the effectiveness of monetary policy will determine how successful monetary policy will be in bringing inflation back to target. The Bank must adjust its models, putting more weight on some variables, like monetary conditions, and less on others, in order to better gauge monetary policy's likely impact on inflation.

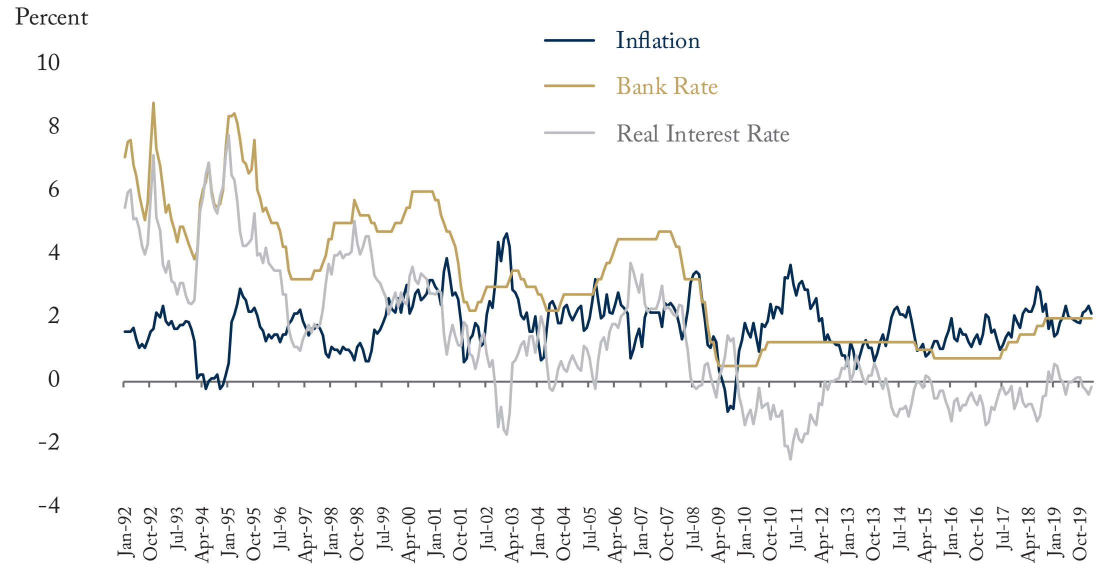
Interest Rate Environment

Throughout our analysis, we use monthly data from the inflation-targeting period, beginning in January 1992 and ending in February 2020, just before the beginning of the pandemic. As a first step, we need to define upfront what we mean by a low interest

5 See Jorda (2005), for more details on this method.

6 Research at the Bank of Canada has taken on this topic over the last few years (in addition to Champagne and Sekkel 2018, see, more recently, Zhang 2021).

Figure 1: Bank Rate, Inflation, Real Interest Rate, January 1992 – February 2020



Source: Authors' compilation.

rate environment relative to a normal interest rate environment. Our approach is not to rely on a formal test for a breakpoint in the data, but to employ a simple heuristic. We look at whether the level of the "real interest rate" has been commonly above or below zero.

To calculate this measure, we start with the Bank of Canada's Bank Rate and subtract headline inflation (year over year). This measure has a unique property over our time horizon. From January 1992 to September 2002, there was not one instance of this real interest rate dropping below zero (Figure 1). However, the first negative real interest rate occurred in October 2002, and from then until the end of our sample, more than half the time the real interest rate was negative. As a result, the October 2002 to February 2020 period represents our low interest rate environment.

With that in mind, our analysis now proceeds in three steps. We first identify monetary policy shocks that proxy for policy actions by the Bank of Canada. Next, we describe the transmission mechanism by extracting factors that summarize important elements in this mechanism. Finally, we evaluate whether monetary policy shocks affect inflation, real GDP, and these factors – and, hence, the transmission mechanism – differently based on interest rate environment.

Monetary Policy Shock Series

The first step is to generate a time series of comprehensive (exogenous) monetary policy shocks.

Much of the literature geared at creating such monetary policy shocks focuses on changes in the overnight rate that cannot be easily explained by a typical central bank reaction function. For example, Champagne and Sekkel (2018), using what's called the narrative approach first seen in Romer and Romer (2004), estimate their version of the Bank of Canada reaction function, which is the authors' best guess at how the Bank of Canada reacts to a series of important indicators.[7] If the reaction function suggests a certain level for the overnight rate, and the Bank of Canada announces a different overnight rate, the difference between the two is the exogenous monetary policy shock.

While their results are consistent with economic theory, one potential issue with such an approach is that it may not fully capture the impact of monetary policy, which works through the entirety of the yield curve; i.e., on interest rates at different maturities than the overnight rate.

Our dataset ends in February 2020 – in large part because of the significant volatility in key macroeconomic variables – so that unconventional monetary policy actions during the pandemic are not covered. Notwithstanding, the Bank engaged in forward guidance during the financial crisis, and communication from the Bank over time has provided more indications to markets as to what direction monetary policy is headed. Thus, we expect that monetary policy shocks impact longer-term interest rates in addition to short-term interest rates. Hence, it is important to have a monetary policy shock series that takes the entire yield curve into consideration rather than only the overnight rate.

A recent paper by Inoue and Rossi (2021) develops such a series of monetary policy shocks for the US. We follow their methodology and derive such a series for Canada. The idea is to identify monetary policy shocks through shifts in a few variables that summarize the entire term structure of the government yield curve around central bank announcements.[8]

First, we gather data on the entire yield curve from the 1-month treasury bill to the long-term government bond. Second, we extract three factors that describe movements in the yield curve.[9] The first one is the slope factor, which can be thought of as capturing changes to the overnight rate; the second one is a level factor, which can be thought of as a parallel shift of the yield curve where a central bank attempts to impact all interest rates simultaneously; and the third one is a curvature factor, which can be thought of as a more medium-run impact of monetary policy. Finally, we calculate the difference between each of these factors before and after a central bank announcement.[10] This methodology identifies monetary policy shocks using higher frequency data and, in principle, covers both conventional and more unconventional central bank actions. We believe our shock series is the first of its kind for Canada.

Evaluating the Transmission Mechanism across Two Different Periods

Having constructed this shock vector, we can evaluate what impact monetary policy has on certain macroeconomic variables, and whether these effects differ based on the interest rate environment we are in, as defined earlier. But with so many

7 These indicators include one- and two-quarter ahead forecasts of real output growth and inflation, the nowcast and real-time one-quarter lag of these variables, revisions to the forecasts relative to previous rounds of forecasts, the intended policy rate two weeks before a Bank announcement, the unemployment rate over the previous three months, lagged changes of the federal funds rate, and the lagged USD/CAD dollar nominal exchange rate.

8 For more detailed information on how to create the time series of shocks, see Appendix A.

9 To do so, we use the Nelson and Siegel (1987) model.

10 We follow Champagne and Sekkel (2018) for their determination of announcement dates before the Bank engaged in their current practice of eight formal announcements each year. If there was more than one announcement in a given month, we summed up these differences. More generally, one could derive a finer series of announcement dates that corresponds not only to fixed announcement dates, but also other major policy announcements by the Bank of Canada.

macroeconomic and financial variables to choose from, how to decide?

One must begin with inflation as, at the end of the day, the Bank's goal is to target low and stable inflation. Similarly, real GDP provides a comprehensive picture of the impact monetary policy has on the economy. For the transmission mechanism, we have to drill deeper. One approach is to use factor analysis[11] where we extract a small set of common, unobserved factors that summarize and proxy for a large number of observable variables. Hence, we can use a large dataset, but condense it to a much smaller set of variables that we can interpret as capturing a particular effect related to monetary policy.[12]

The final step in our analysis is to use local projections (see Jorda 2005 and Box 1 for more) to test the effect of monetary policy on our set of macroeconomic and financial factors over both the normal and low interest rate periods.

Inflation/Real GDP Results

Above all else, the Bank of Canada's job is to target inflation. So, first and foremost we want to see whether inflation responds differently in the normal versus low interest rate environments using both our Inoue and Rossi shock (slope and level), as well as the Champagne and Sekkel shock. We use the same 25 basis point shock in all exercises.

To carry out the comparison in a robust way, we look at different monetary policy shock series. We use our new monetary policy shock series, and look at two particular types of shocks. The first one considers a decrease in the slope of the yield curve, which is equivalent to a cut of 25 basis points (bps) in the policy rate. This corresponds to a proxy for a conventional monetary policy shock. The second one considers a downward shift in the level of the yield curve by 25 bps (i.e., all interest rates across the yield curve fall by 25 basis points). While it is possible to interpret this as the persistency of the monetary policy shock, we believe it also appropriate to think of it as a stylized proxy for an unconventional monetary policy shock that works through announcement effects (e.g., forward guidance) and/or asset purchases (e.g., quantitative easing).[13] Lastly, we look at the Champagne and Sekkel shock.

As we see in Figure 2, in response to an expansionary monetary policy shock, the results are largely what we'd expect, with a lag before we see inflation increase (we go out to 48 months as is standard in much of the macroeconomics literature). But, we do see some notable differences. First, with a conventional monetary policy shock (i.e., the slope), using either Inoue and Rossi or Champagne and Sekkel, we see a more significant increase in the low interest rate environment. This might sound contrary to some of the discussion that monetary policy has become less effective in the post-GFC world, but it might indicate that a 25 basis point move means a lot more when interest rates are near the lower bound then when they are not. The second difference is the magnitude of the response following the Inoue and Rossi shock is much larger than following the Champagne and Sekkel shock. As we are about to see, this theme appears again in the real GDP results and when looking at the factors.

We run the same exercise with real GDP, and largely get the expected result: an increase with a lag following a monetary policy shock. We see similar differences as with inflation: more significance in the low interest rate environment, and a larger magnitude

11 See Bernanke et al. (2005) for the first application of such analysis to monetary policy.

12 See Appendix B for more details.

13 Using the Inoue and Rossi (2021) approach, we could even look at specific policy events and determine their impact on our four factors. However, we have opted for a less granular approach so that we can interpret our results in a more standard way.

Box 1: Local Projections

Macroeconomic variables often react simultaneously to underlying economic conditions or shocks. As a result, it is difficult to argue that changes in a variable X cause changes in variable Y. One popular approach to dealing with this problem is the use of vector autoregressions, where a series of regressions of all variables are carried out simultaneously. Decisions on how to order the variables within your vector of variables – or putting specific restrictions on how the variables move together contemporaneously – allows one to identify how specific shocks move all these variables together.

We do not rely on such structural vector autoregressions (SVAR) to identify the effects of a monetary policy shock, but instead use local projections. Local projections have two benefits over using SVARs. First, results in local projections are less sensitive to the number of lags used. And second, one has more flexibility in the number of controls that one can use.

To study the effects of monetary policy, we employ the following specification for our local projections

$$f_{n,t+h} = \delta_{0,n}^h + \Theta_{12,h}^{(1)}\Delta\beta_{1,t}^d + \Theta_{12,h}^{(2)}\Delta\beta_{2,t}^d + \Theta_{12,h}^{(3)}\Delta\beta_{3,t}^d + \delta_{1,n}^h rgdp_{t-i} + \delta_{2,n}^h comm_{t-i} + \delta_{3,n}^h R_{t-i} + \delta_{4,n}^h \pi_{t-i} + \delta_{5,n}^h f_{n,t-1} + \epsilon_{n,t+h}^h \quad (1)$$

where f_n are the different factors, indexed by n. This equation expresses how current and future values of our factors respond to a monetary policy shock as expressed by $\Delta\beta_{1,t}^d$, $\Delta\beta_{2,t}^d$, and $\Delta\beta_{3,t}^d$ (the level, slope, and curvature effect). For the Champagne and Sekkel shock, we replace these three $\Delta\beta_{1,t}^d$ shocks with a single shock variable. As controls, we include three lags of real GDP, commodity price inflation, the Bank Rate, and inflation, as well as one lag of the factor itself. Finally, note that the index $t + h$ represents the different horizons h for which we calculate the impulse response function. In our analysis, $h = 0,1,2,....,24$, representing a period of 2 years, which falls within the 6-8 quarter horizon the Bank of Canada expects its monetary policy to work through the economy.

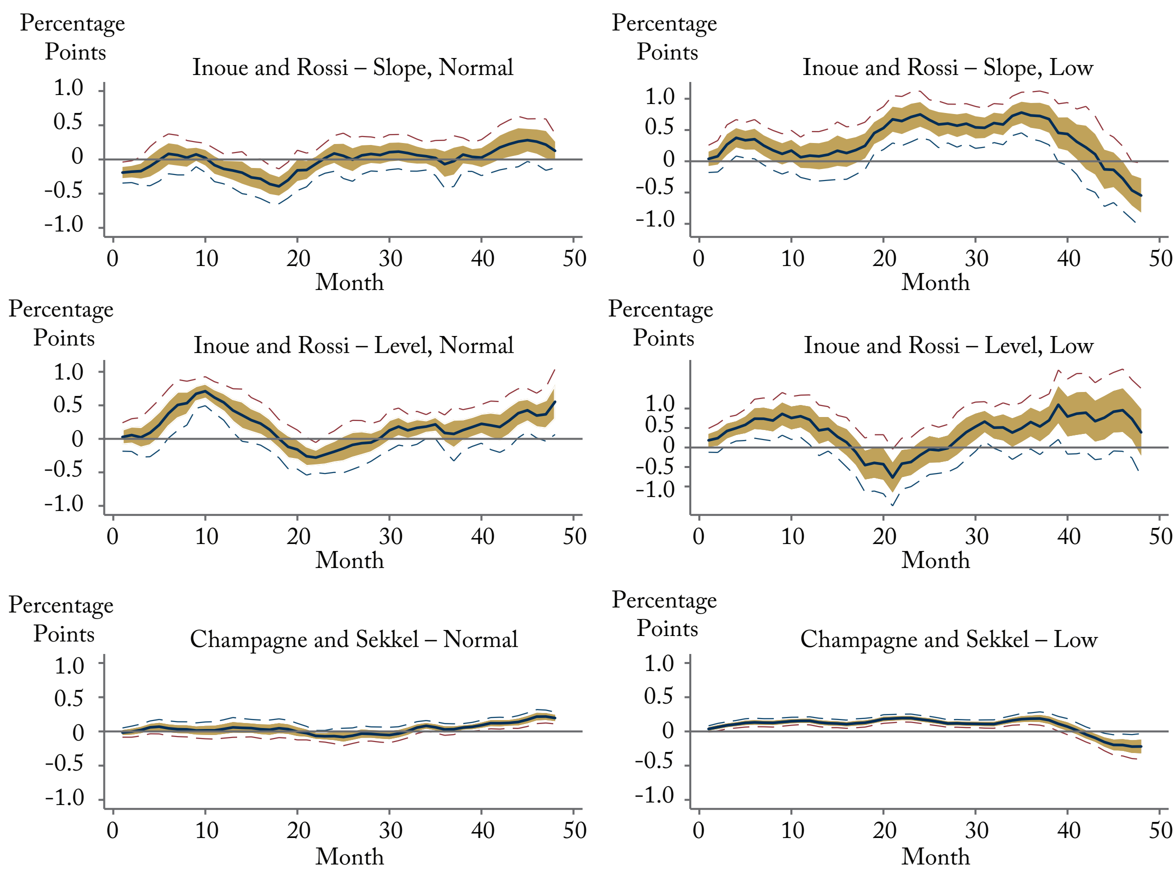
For the local projections where inflation and real GDP are the dependent variable, we use a slightly different set of controls to ensure no price puzzles (i.e., inflation moving the opposite direction expected following a particular monetary policy shock). Specifically, we remove the factor lag and use lags 1-12 on whichever of inflation/real GDP is the dependent variable:

$$\pi_{t+h} = \delta_0^h + \Theta_{12,h}^{(1)}\Delta\beta_{1,t}^d + \Theta_{12,h}^{(2)}\Delta\beta_{2,t}^d + \Theta_{12,h}^{(3)}\Delta\beta_{3,t}^d + \delta_{1,n}^h rgdp_{t-i} + \delta_{2,n}^h comm_{t-i} + \delta_{3,n}^h R_{t-i} + \delta_{4,n}^h \pi_{t-j} + \epsilon_{n,t+h}^h \quad (2)$$

$$rgdp_{t+h} = \delta_0^h + \Theta_{12,h}^{(1)}\Delta\beta_{1,t}^d + \Theta_{12,h}^{(2)}\Delta\beta_{2,t}^d + \Theta_{12,h}^{(3)}\Delta\beta_{3,t}^d + \delta_{1,n}^h rgdp_{t-j} + \delta_{2,n}^h comm_{t-i} + \delta_{3,n}^h R_{t-i} + \delta_{4,n}^h \pi_{t-i} + \epsilon_{n,t+h}^h \quad (3)$$

where $i = 1,2,3$ and $j = 1,2,\ldots 12$.

Figure 2: Shock Series Impact on Inflation



Note: Gold shaded areas represent one standard deviation confidence intervals while dashed lines represent two standard deviation confidence intervals. The scale of some subgraphs may differ.

Source: Authors' compilation.

effect following the Inoue and Rossi shock compared with the Champagne and Sekkel shock.

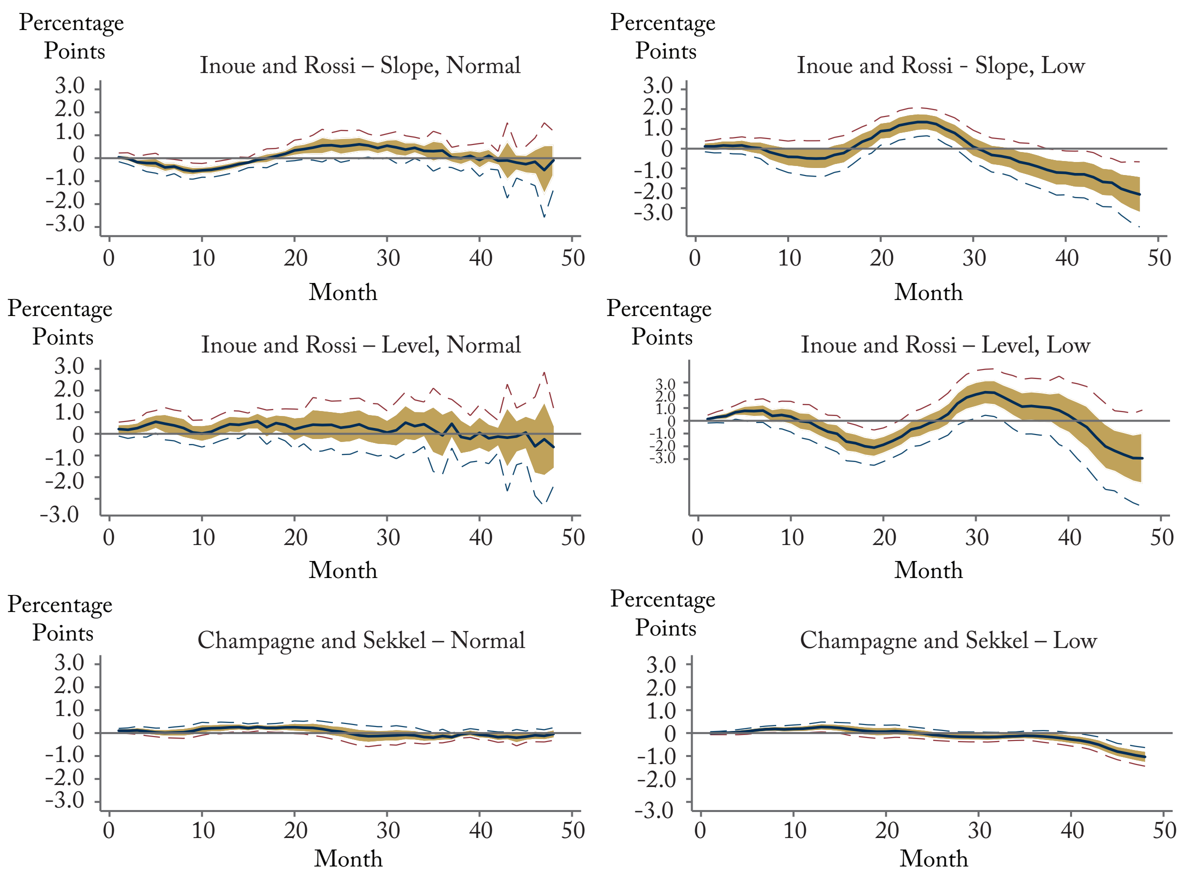
We note that the fact that we see an increase in inflation and real GDP, albeit with a relatively long lag for the latter, to the level factor is important, since it gives us confidence that monetary policy can still be effective when interest rates are low and monetary policy has to resort to unconventional tools.

The Four Factors

As indicated above, the next step in our analysis is to take a large dataset of macroeconomic and financial variables and reduce it to a small number of factors that can represent traditional monetary policy effects.

The full set of variables and sources can be found in Appendix B, but, as an overview, the variables consist of:

Figure 3: Shock Series Impact on Real GDP



Note: Gold shaded areas represent one standard deviation confidence intervals while dashed lines represent two standard deviation confidence intervals. The scale of some subgraphs may differ.

Source: Authors' compilation.

- credit variables from both banks and non-banks that include consumer credit, mortgage credit, business credit, non-residential mortgage credit, and bankers' acceptances;
- asset variables including equity markets (TSX), mutual funds, life insurance and pensions, and housing;
- real variables including retail and manufacturing sales, trade data (exports and imports) and housing starts;
- employment and earnings data; and
- monetary aggregates including both narrow and broad money.

Our analysis produces four factors.[14] Although all the variables feed into each of the four factors, we find that each of them can be given an economic interpretation.

We call the first one a "money factor" as it is mainly associated with changes in monetary aggregates. As such, this factor proxies for the traditional channel through which monetary policy works. An increase in the factor improves monetary conditions – or, liquidity – as it is associated with an increase in monetary aggregates.

The second factor broadly captures the real side of the economy. Hence, we label it "real factor." It comprises changes in retail and manufacturing sales and employment. On top of that, it incorporates changes to housing markets such as housing starts. Thus, an increase in the factor reflects an increase in aggregate demand.

The third factor is an "asset factor" as it summarizes mainly asset market data. Changes in the factor are harder to interpret as it comprises both prices, e.g. TSX, and quantities of financial markets, e.g. market value of mutual funds. An increase in the factor means that – on average – prices and/or investment in these asset classes have increased.

Our final factor reflects credit intermediation. This "credit factor" is interesting as it mainly expresses changes in flows of credit – either through the traditional banking sector or the non-bank sector. In particular, when the factor decreases it signifies more credit through banks and less through financial markets and alternative lenders. When the factor increases, it means substitution of credit away from banks to non-banks. As such, this factor is well suited to reflect changes in the willingness of banks to lend, which are then compensated for by non-traditional lenders.

Factor Results

We now test how our monetary policy shock series affects our four factors (using local projections). Our results are framed in terms of impulse response functions that express how these factors react to monetary policy – and, thus, shed light on the transmission of monetary policy. A key part of our analysis is to describe how these reactions differ across the two time periods.

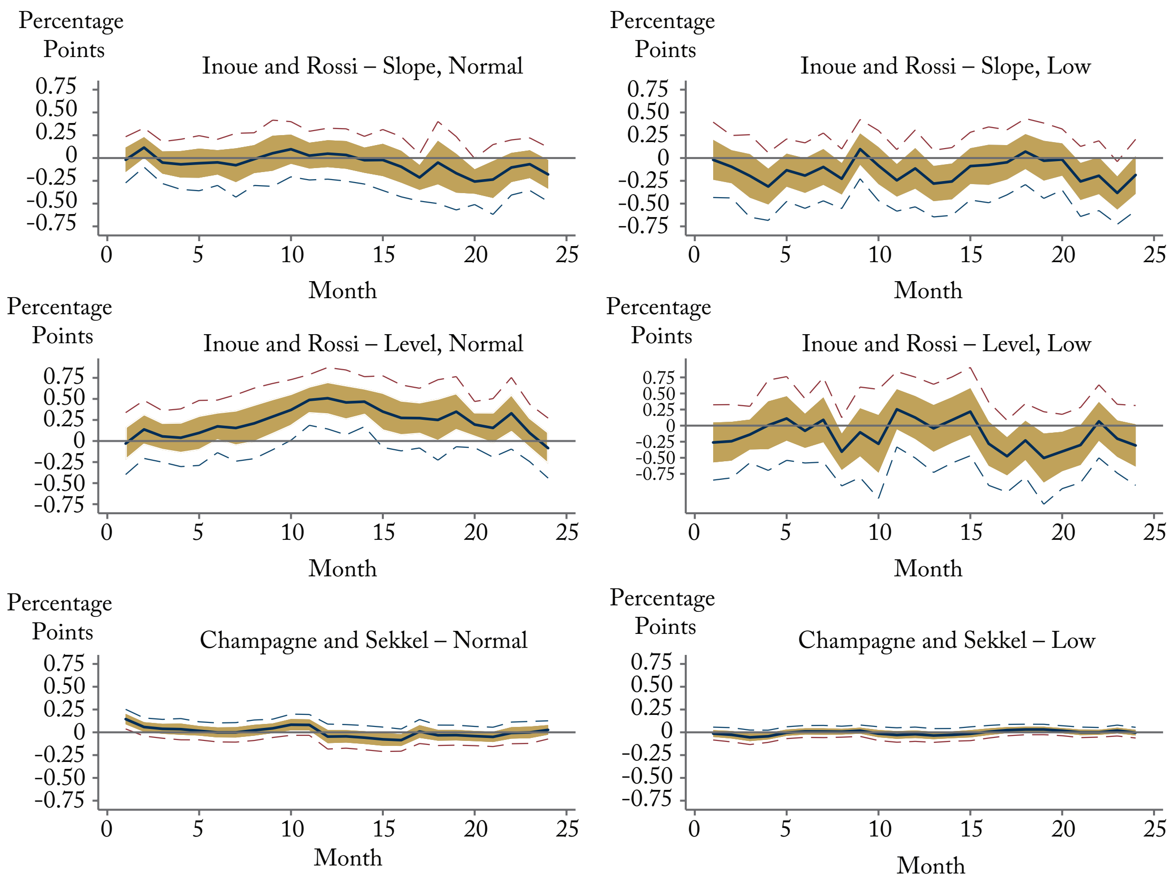
As above, we compare results from our Inoue and Rossi (2021) shock series, using slope and level shocks, with an analysis using the more traditional Champagne and Sekkel (2018) shock series. While we use the full sample ending in February 2020 for the Inoue and Rossi (2021) shock, data availability constrains our time period to October 2015 for the Champagne and Sekkel (2018) shock.[15] Unlike above, but consistent with monetary policy's traditional 6-8 quarter lag to get inflation back to target, we focus on the reaction of the factors on a shorter 24 month or two-year period.

When looking at the monetary factor (Figure 4), in the normal interest rate period, there is some evidence that it reacts significantly positive, with a lag, to expansionary monetary policy. In the low

14 Full results of this factor analysis can be found in Appendix B.

15 We run a number of robustness checks. We evaluate whether the factors remain the same regardless of whether we do the factor analysis over the entire period (as we do in our primary set of results) or derive factors for the two different interest periods separately. Importantly, we find no substantive differences in the factors, justifying our interpretation of the results as changes in monetary policy transmission. We also looked into whether the results for the Inoue and Rossi shock change if we trim the sample at the end of October 2015 (the end of our data availability for the Champagne and Sekkel shock series), but did not find any material difference in our results. Other robustness checks included comparing our monetary factor to an actual monetary aggregate (M2++) to see if the results compare, and controlling for the Great Financial Crisis by using a dummy variable for that period. The results did not materially change in either case. All robustness check results are available upon request.

Figure 4: Monetary Aggregate Factor Impulse Response Function



Note: Gold shaded areas represent one standard deviation confidence intervals while dashed lines represent two standard deviation confidence intervals. The scale of some subgraphs may differ.

Source: Authors' compilation.

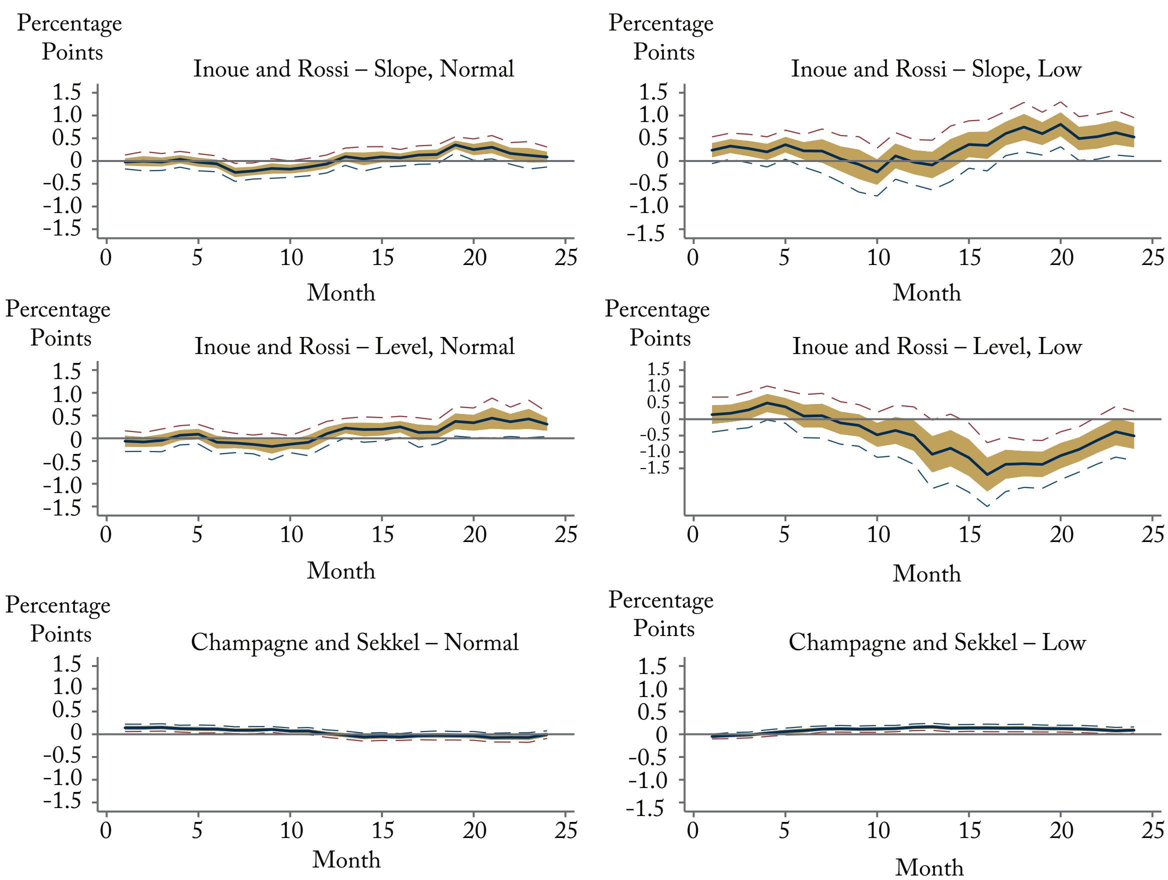
interest rate environment, however, this effect disappears entirely. The size of the responses, however, depend on what shock series one uses. There are negligible responses with the Champagne and Sekkel shock, but, as we saw earlier, much larger ones with the Inoue and Rossi shock (in particular the level shock).

These results provides evidence that the importance of monetary aggregates in the transmission mechanism has declined during the low interest rate environment, but may return in a more normal interest rate environment.[16]

Turning to the real factor (Figure 5), there are some clear differences across interest rate

16 With interest rates on the rise, and inflation unsettled, there is evidence of monetary aggregates mattering again (see, for example, Papadia and Cadamuro 2021 and Ambler and Kronick 2022).

Figure 5: Real Factor Impulse Response Function



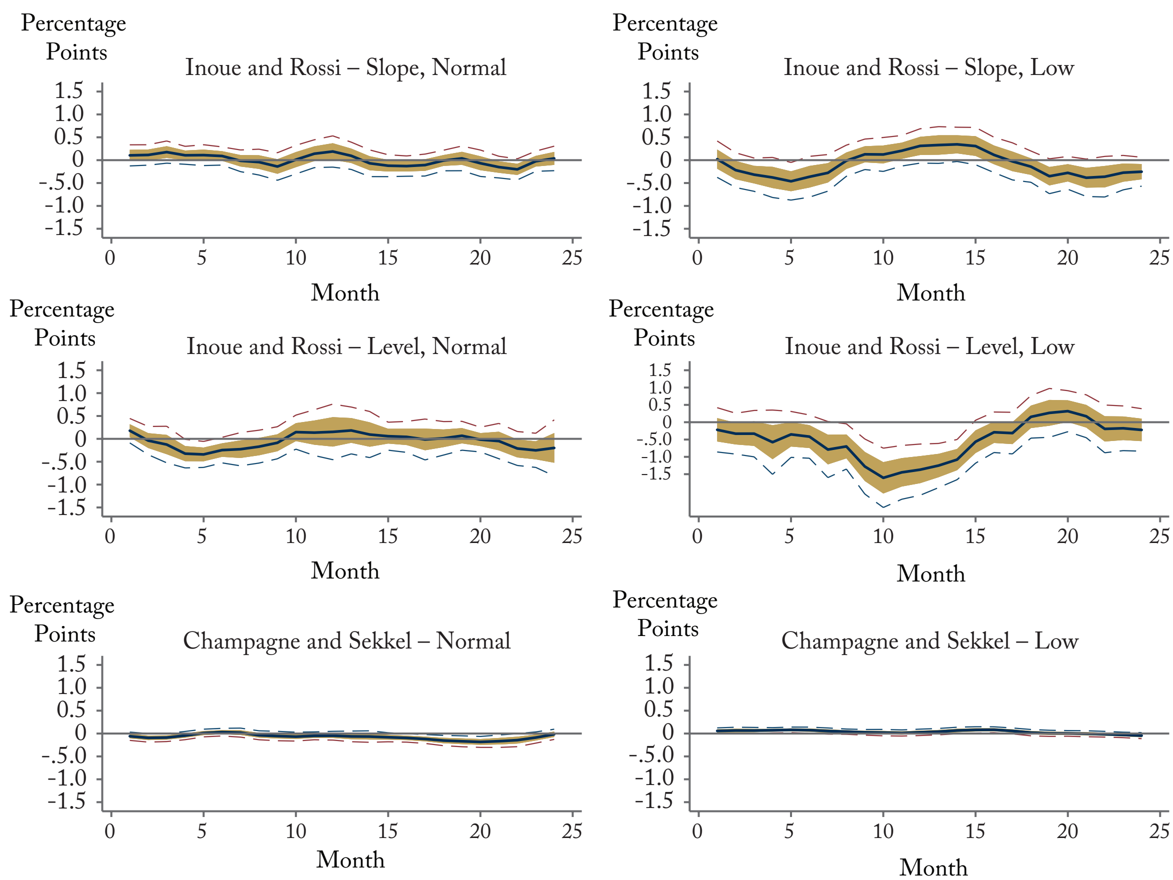
Note: Gold shaded areas represent one standard deviation confidence intervals while dashed lines represent two standard deviation confidence intervals. The scale of some subgraphs may differ.

Source: Authors' compilation.

environments and between shocks. When using the Inoue and Rossi shock, the impact of monetary policy on the real economy has become more significant and stronger (in absolute value) in the low interest rate period. Using the Champagne and Sekkel shock series, while the magnitudes/significance are similar across interest rate environments, the peaks differ, with an earlier peak in the normal interest rate environment. We again note, as with the monetary factor, the size of the impulse responses under Champagne and Sekkel are much smaller.

Recall that the real factor mainly represents aggregate consumption, employment and the housing market, which are strongly positively correlated with GDP. Comparing the first 24 months of the real GDP results in Figure 3, we see a similar pattern to what we see here for the Inoue and Rossi slope shock and the Champagne and Sekkel shock. What this says is that the

Figure 6: Asset Factor Impulse Response Function



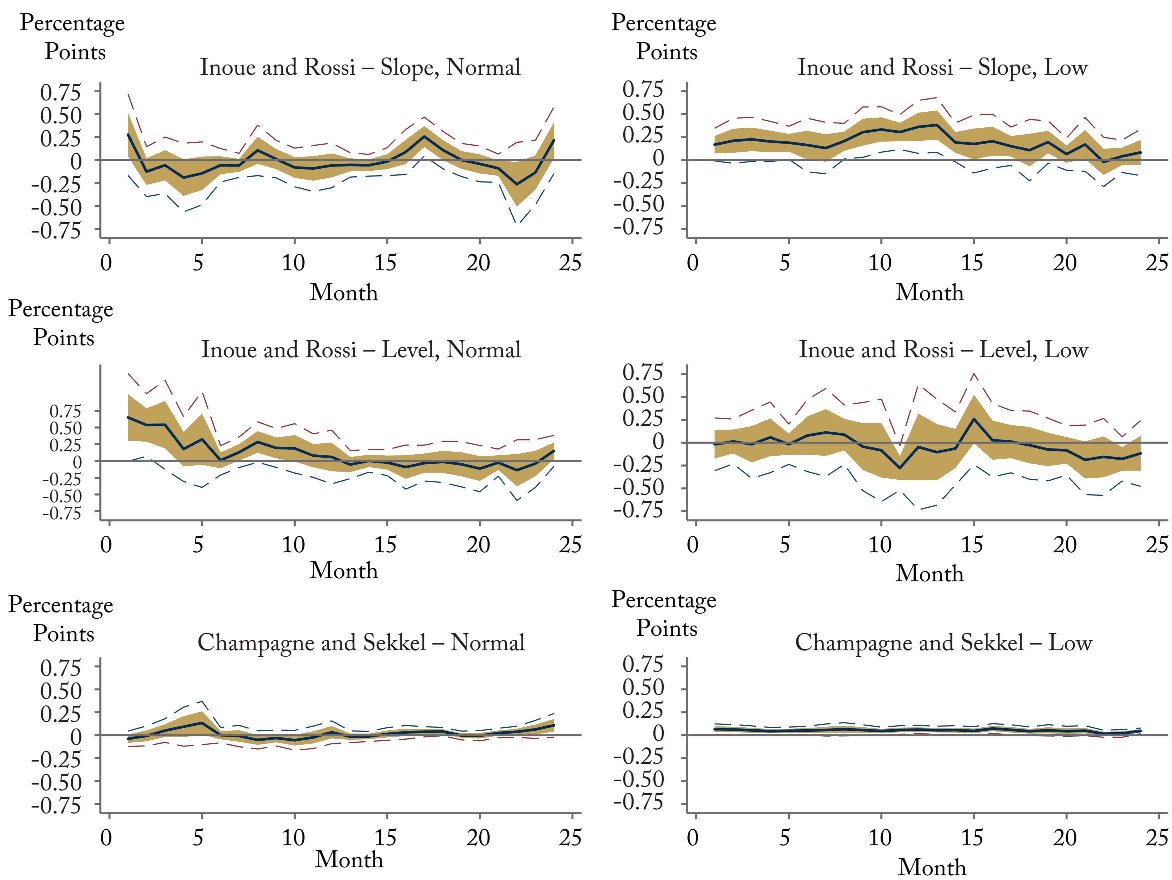
Note: Gold shaded areas represent one standard deviation confidence intervals while dashed lines represent two standard deviation confidence intervals. The scale of some subgraphs may differ.

Source: Authors' compilation.

economy tends to respond sluggishly but positively to expansionary monetary policy, more noticeably in the low interest rate environment, with the magnitude again larger in the case of our new Inoue and Rossi shock.

The response of the asset factor (Figure 6) is interesting. Once again, for the low interest rate period (using the Inoue and Rossi shocks), the results are significant and larger in magnitude (in absolute terms) compared with the normal interest rate period. More importantly, however, an expansionary shock – through the slope or a shift in the yield curve – leads first to a significant fall in the factor before showing a positive response in the longer run, though with very little, if any, significance. In the normal interest rate period, we see a similar fall using the Champagne and Sekkel shock, though, as with other factors, with a much smaller magnitude. However, in the low interest rate period, we see an increase (still smaller magnitude) in the factor, in particular over that first year, that we do not see using either Inoue and Rossi shock.

Figure 7: Credit Factor Impulse Response Function



Note: Gold shaded areas represent one standard deviation confidence intervals while dashed lines represent two standard deviation confidence intervals. The scale of some subgraphs may differ.

Source: Authors' compilation.

Finally, for the credit factor, the normal interest rate environment has very little significance, regardless of shock, while in the low interest rate environment, we see a positive and significant effect using either the slope effect from Inoue and Rossi or the Champagne and Sekkel shock.

This finding is interesting in that lower interest rates may force a reallocation of funding away from banks to non-banks or shadow banks as investors seek higher yields through riskier investments. Since our credit factor really expresses the composition of intermediated credit, there is some evidence that such changes in intermediation would take place in a low interest rate environment in response to expansionary monetary policy.

Based on these factor impulse response functions, the following important insights thus emerge for evaluating the transmission of a monetary policy shock when comparing the two interest rate regimes.

1) The shock series matters. In general, the economy responds more strongly to monetary policy when using an Inoue and Rossi shock compared with a Champagne and Sekkel shock. This is true particularly in the low interest rate environment.

2) Monetary policy still generates significant responses when interest rates are low. There may be a problem of cutting the policy rate significantly or shifting the yield curve down further, but to the degree that this is still feasible, monetary policy has a significant impact on the economy.
3) Unconventional policy measures, to the extent they are successful at shifting interest rate simultaneously, can substitute for interest rate cuts. Using the Inoue and Rossi shock series, shifts in the yield curve have qualitatively and quantitatively similar impacts to interest rate cuts – in particular when looking and inflation and real GDP.
4) The credit, asset, and real economy channel plays a significant role in the low interest rate environment, pointing to the importance of private demand and financial market conditions.
5) Monetary conditions seem to matter more in a normal interest rate environment, which is important in the current context where interest rates are set to rise further. Hence, tighter monetary policy could lead to slower growth in the monetary aggregates, thereby tightening liquidity.

Conclusion

Does the monetary policy transmission mechanism change based on the prevailing interest rate environment? The popular narrative is that monetary policy loses its power in a low interest rate environment, especially when called upon to provide stimulus to the economy. Our findings suggest however, that this is not the case. Indeed relying on a novel monetary policy shock, we see its effects when interest rates are low might even be larger for a given sized shock. To the contrary, as we look ahead to a period of higher interest rates, we see some factors such as monetary conditions may take on a greater role again.

This has stark implications. Central banks need to take into account the prevailing interest rate environment. For example, when interest rates are low, central banks can resort to unconventional policies, which – based on our results – are likely to yield a quantitatively similar effect to plain interest rate cuts. Hence, unconventional policy actions should be a focus for central banks that face the lower bound, but need to engage in further stimulus. Similarly, as interest rates rise again, the emphasis is likely to shift to different transmission channels for monetary policy. For example, our results indicate that central banks need to reconsider the role of monetary aggregates at higher interest rates.

We derived all of these insights by constructing a new monetary policy shock series. Hence, more thought needs to be put into characterizing such shocks in order to better understand how monetary policy affects the economy. Our analysis makes a start in this direction, but more work needs to follow in these footsteps.

Appendix A – Inoue and Rossi Shock

This appendix describes in detail how we created the monetary policy shock time series based on the methodology of Inoue and Rossi (2021).

A common method to identifying monetary policy shocks is the so-called narrative approach of Romer and Romer (2004). This approach estimates changes to the overnight rate that are intended by a central bank based on historical records and then isolates the part of those changes that are not explained by the central bank's information set. Key to the approach is the use of the announcement dates and looking at changes around those announcements in determining the exogenous monetary policy shock.

The difference in the approach taken by Inoue and Rossi (2021) is to not only use changes in the overnight rate, but to use the entire spectrum of the yield curve for government debt.

Inoue and Rossi (2021) follow the framework of Nelson and Siegel (1987) where the yield curve at any point in time can be summarized by a time-varying parameter vector ($\beta_{1,t}$, $\beta_{2,t}$, $\beta_{3,t}$), which represents the level (increases or decreases all yields independent of their maturity), slope, and curvature factors. More precisely, the model for a given maturity at a point in time can then be written as:

$$y_t(\tau) = \beta_{1,t} + \beta_{2,t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) + \beta_{3,t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) \text{ (A1)}$$

where $y_t(\tau)$ is the interest rate at time t at some maturity τ. The idea behind the tuning parameter λ is to set it such that it maximizes the loading on the curvature factor (see Diebold and Li 2006, for more details). We use Inoue and Rossi's value of $\lambda = 0.0609$ throughout and estimate the values of vector β at each point in time based on actual yield curve data.

Based on our estimates, we calculate how the vector β changes around a fixed Bank of Canada announcement date:

$$\Delta\beta_{j,t}^{d} \equiv d_t \Delta\beta_{j,t} \text{ (A2)}$$

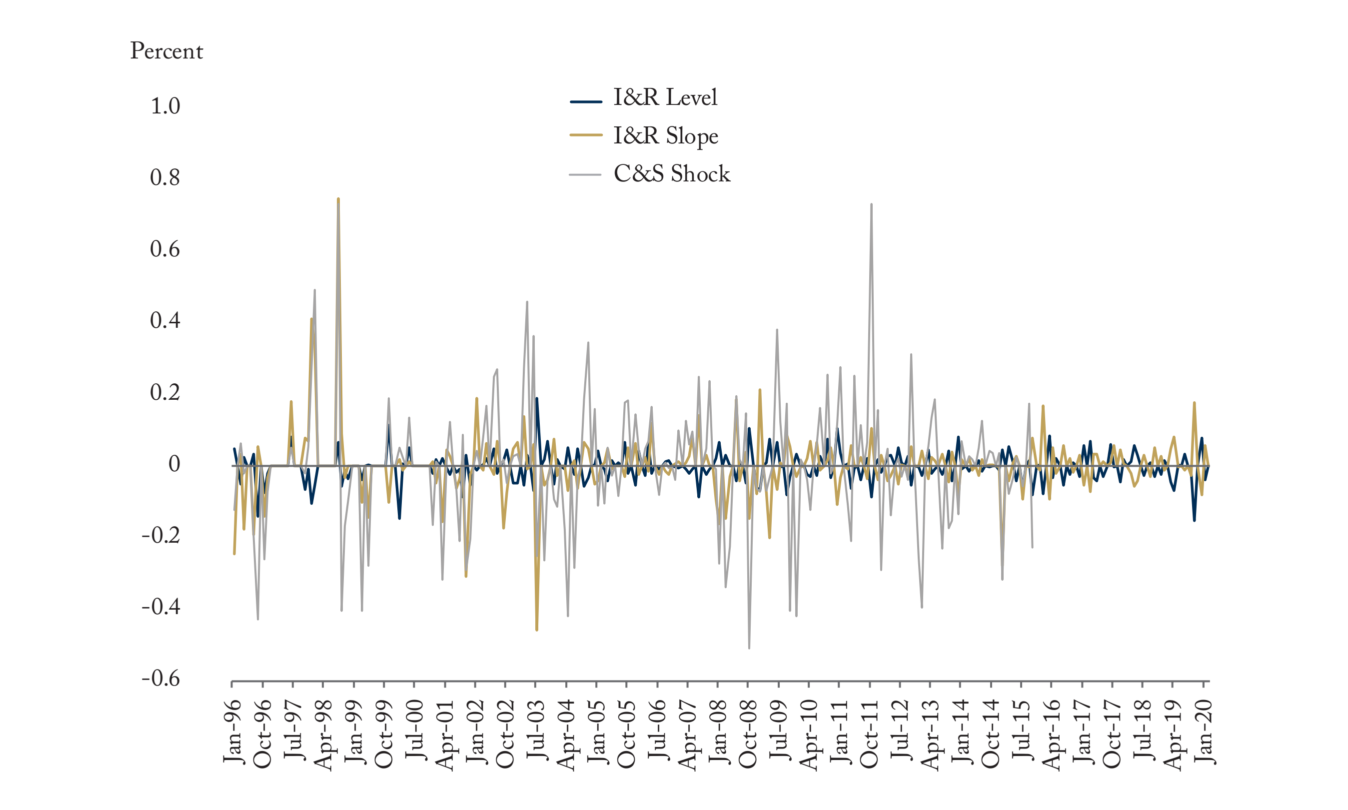
where $\Delta\beta_{j,t}$ is the daily change in each of three components $\beta_{1,t}$, $\beta_{2,t}$, $\beta_{3,t}$ and d_t is a dummy variable that is 1 if there is a Bank of Canada announcement date and a zero otherwise.

We then translate these results into the monthly frequency we use for our local projections. In a month where there is only one announcement, we simply use the $\Delta\beta_{j,t}$ for that one announcement. If there are multiple announcements, we sum up the different $\Delta\beta_{j,t}$ for each relevant t. As pointed out in Box 1, we run the following local projections regression

$$f_{n,t+h} = \delta_{0,n}^{h} + \Theta_{12,h}^{(1)}\Delta\beta_{1,t}^{d} + \Theta_{12,h}^{(2)}\Delta\beta_{2,t}^{d} + \Theta_{12,h}^{(3)}\Delta\beta_{3,t}^{d} + \delta_{1,n}^{h} rgdp_{t-i} + \delta_{2,n}^{h} comm_{t-i} + \delta_{3,n}^{h} R_{t-i} + \delta_{4,n}^{h}\pi_{t-i} + \delta_{5,n}^{h} f_{n,t-1} + \epsilon_{n,t+h}^{h} \text{ (A3)}$$

where f_n are the different factors, indexed by n. This equation expresses how current and future values of our four factors respond to a monetary policy shock as expressed by $\Delta\beta_{1,t}^{d}$, $\Delta\beta_{2,t}^{d}$, and $\Delta\beta_{3,t}^{d}$, (the level, slope, and curvature effect). One can add up the coefficients Θ to obtain the overall impact of a monetary policy shock as reflected in the movement of the yield curve. For the Champagne and Sekkel shock, we replace these three $\Delta\beta_{1,t}^{d}$ shocks with a single shock variable. As controls, we include three lags of real GDP, commodity price inflation, the Bank Rate, and inflation, as well as one lag of the factor itself.

Figure A1: Monetary Policy Shock Series Comparison



Note: I&R Level is the Inoue and Rossi level factor, I&R Slope is the Inoue and Rossi slope factor, and C&S is the Champagne and Sekkel shock.

Source: Authors' compilation.

Since our focus in the paper is on the slope and level factor portion of the Inoue and Rossi shock, and a comparison to the Champagne and Sekkel shock, we graph those three here for the interested reader (for the 2 percent inflation-targeting era starting in January 1996, Figure A1).

Appendix B – Factor Analysis

We run the Factor Augmented Local Projections (FALP) in two stages. In Stage 1, the focus of this appendix, we gather the relevant variables and run a factor analysis. In this setup, the observables are related to the factors in the following way

$X_t = \Lambda F_t + u_t$ (B1)

where X_t are the observables, F_t are the underlying factors, and Λ is the matrix of factor loadings. We are interested in using as much macroeconomic and financial data as we can. We, therefore, run our factor model (equation B1) and let the factor analysis determine how many relevant factors to use.[17] In all cases, our variables are in growth rates, and are all stationary.

We collect data on both household and business loans coming from both banks and non-banks. Specifically, we have consumer credit, residential mortgage credit, business credit, and non-residential mortgage credit from both banks and non-banks. We also have bankers' acceptance data from banks. All data come from the Bank of Canada.

We also collect data on monetary aggregates, both narrow and broad money. Specifically, we have data on M1+(gross), M1++(gross), and M2++(gross), all from the Bank of Canada.

We have real economy data on seasonally adjusted retail trade sales deflated by CPI, and seasonally adjusted real manufacturing sales. We also use the Canadian-Dollar Effective Exchange Rate Index as well as exports, imports, current account goods balance, and investment balance. For labour market data, we include weekly earnings from the Survey of Employment, Payroll and Hours, employment and unemployment rates (for both sexes and the age group 15 years and over). These variables are from Statistics Canada with some series accessed through Stephen Gordon's Project Link, which creates longer macro datasets of Canadian variables than is available directly through Statistics Canada.

Lastly, we collect asset related data. We use variables related to financial assets such as the new housing price index, the TSX Composite Index, both from Statistics Canada, CMHC housing starts data from Statistics Canada, as well as unlisted shares, mutual funds, and life insurance and pensions from Statistics Canada's National Balance Sheet Accounts.

Because yield curve data do not factor into the Champagne and Sekkel shock, we include it as part of our factor analysis when creating the factors for this version of our local projections work. We gather treasury bill data at a 1 month, 2 month, 3 month, 6 month, and 1 year frequency, and Government of Canada bond data at a 2 year, 3 year, 5 year, 7 year, 10 year, and long-term frequency. All data come from Statistics Canada.

Four factors have eigenvalues above one following the version without the yield curve data, and six for the version with yield curve data. Table B.1 has the factor loadings of these four factors for the Inoue and Rossi analysis, while Table B.2 has the factor loadings for the six factors for the Champagne and Sekkel analysis.

17 We take 1 for the eigenvalue as the cutoff for determining how many relevant factors there are. We confirm this strategy using a scree plot where relevant factors are ones that sit above the line of best fit.

Table B1: Factor Loadings for Inoue and Rossi Analysis

	Factor 1	Factor 2	Factor 3	Factor 4
banks_cons credit_gr	.0560905	.045801	-.00115	-.0628332
nonbanks_cons credit_gr	-.0176774	.1807352	.169683	.3384547
banks_mort credit_gr	-.0005358	.2042898	.0793176	-.5144607
nonbanks_mort credit_gr	.0093996	-.0704536	-.0753581	.7444587
banks_bus credit_gr	.0973165	.0732373	-.2568843	-.1387642
nonbanks_bus credit_gr	-.0397463	.1269899	-.1314895	.3826681
banks_bus non-res mort credit_gr	.0651646	.0579024	-.0504558	-.6172913
nonbanks_bus non-res mort credit_gr	.0508243	-.0402455	-.2179215	.4872815
bankersacceptance_bus credit_gr	.0106647	.057124	.1047963	.2416101
new housing price index_gr	.1185599	.3939367	-.0295214	.2441751
tsx_gr	-.1390451	.0034998	.6132731	.1178017
unlisted shares_gr	.0758505	-.0231683	.3078449	-.0189246
mutual funds_gr	.0157313	.0141223	.803161	-.1119951
life insurance/pension_gr	-.0093186	.0326476	.7426178	-.0543263
housing starts_gr	.0388615	.5249722	-.0411664	.0320143
retail trade_gr	-.0907781	.7180205	.0596126	-.0699512
mfg trade_gr	-.309105	.6135522	.0769121	-.1172605
xr_gr	.289545	.0137496	-.2449377	-.1758175
exports_gr	.0033041	.3371296	-.0044405	-.1159403
imports_gr	-.0890915	.3206738	.1338917	-.0247999
m2plus2_gr	.7152996	-.1221287	.0300827	.0200552
m1plus2_gr	.8548857	-.1290689	-.0602675	.0509393
m1plus_gr	.8652017	.0305805	.0021598	-.072608
earnings_gr	.0737037	.0572187	.0369562	-.0021901
employment_gr	-.0777529	.5344951	-.0806431	-.1015136
unemployment_gr	.1498776	-.4410214	.0371933	.0326498

Source: Authors' compilation.

Factor 1 puts the greatest weight on the monetary aggregate variables. Factor 2 loads on variables related to real economy factors, in particular retail trade sales and manufacturing sales. The factor also loads quite strongly on housing starts and the house price index as well as employment. Factor 3 has a lot of emphasis on asset factors like the stock market, mutual funds, and life insurance and pensions. Lastly, for factor 4, there is a lot of weight on our credit variables (in absolute terms). In relative terms, the factor loads positively on credit intermediated by non-banks and negatively on credit through banks.

Table B2: Factor Loadings for Champagne and Sekkel Analysis

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
banks_cons credit_gr	.0973214	-.0482573	.044224	.0368456	-.016062	-.0334464
nonbanks_cons credit_gr	-.0400451	-.0167941	-.0098278	.162767	.3447731	.1579874
banks_mort credit_gr	.0577003	-.0087664	-.0146397	.2242374	-.4989848	.0849024
nonbanks_mort credit_gr	-.0400539	.0022478	.0359039	-.0550553	.778609	-.0724187
banks_bus credit_gr	-.0241226	.1625725	.1150351	.077408	-.1671312	-.2426609
nonbanks_bus credit_gr	.0599454	.0328465	-.0449269	.1156456	.3844738	-.1072845
banks_bus non-res mort credit_gr	.0359382	-.0226144	.065775	.0740921	-.6187719	-.0461517
nonbanks_bus non-res mort credit_gr	-.0557744	.0009448	.0420234	-.0262469	.501014	-.1514303
bankersacceptance_bus credit_gr	-.0426965	-.0419626	.0650048	.0842793	.232368	.0921407
bond_2yr_gr	.8003908	.5000232	-.022246	.0461277	-.0181222	.0427361
bond_3yr_gr	.8676365	.3865878	-.0160035	.0610809	-.0029295	.0279487
bond_5yr_gr	.9479733	.2705902	-.0010089	.010418	-.0091451	.034381
bond_7yr_gr	.9571858	.2190648	.0242151	.0076159	-.0120741	.0048855
bond_10yr_gr	.96681	.1003648	.0244662	.0043398	-.0165705	-.032653
bond_long term_gr	.8904506	.0285536	.0413968	.0075543	-.0029494	-.115212
tbill_1m_gr	.1536415	.8983728	-.0300548	.0252362	.0020827	-.0105987
tbill_2m_gr	.2347801	.9500746	-.0211241	.0295135	.0226597	-.0169076
tbill_3m_gr	.2971506	.9391464	-.0172464	.0366368	.0170751	-.0191425
tbill_6m_gr	.4690116	.8465549	-.0263958	.0580145	-.0259081	-.0217872
tbill_1y_gr	.6283288	.7073865	-.0270743	.0805388	-.0389414	.0021201
new housing price index_gr	.0060481	.0323146	.0917273	.3956929	.2901225	-.0426655
tsx_gr	-.0306674	-.0474196	-.1342056	.0066329	.1208143	.6318115
unlisted shares_gr	-.0080057	.146366	.1376657	-.0446527	.0100651	.2301139
mutual funds_gr	.029161	-.0336243	.0299503	.0026077	-.1141122	.8178073
life insurance/pension_gr	-.0908557	-.0120516	-.0022492	.0436369	-.0544513	.7475568
housing starts_gr	.0104273	.078748	.033368	.5293853	.0300509	-.0156401
retail trade_gr	.1201972	.1689524	-.1081222	.7086732	-.0644803	.0460211
mfg trade_gr	-.0479368	.1629654	-.2992215	.6061973	-.1322922	.0979662
xr_gr	-.1038627	.0753996	.2998613	.0155102	-.2200674	-.2840209
exports_gr	.035088	.0838896	-.0577501	.3374066	-.0950122	.0159495
imports_gr	-.0045076	.1836324	-.1332024	.2900822	.0063258	.1598413
m2plus2_gr	-.0435721	-.0692465	.7109203	-.1276531	.0230663	.0146181
m1plus2_gr	.0278894	-.0787911	.8394573	-.1345668	.0740508	-.0633396
m1plus_gr	.0637713	.0055792	.8661104	.0099794	-.067735	.02413
earnings_gr	-.0142667	-.0151418	.0949298	.0610929	-.0135898	.0436945
employment_gr	.1544793	-.0035534	-.1012611	.5630173	-.0826929	-.0796184
unemployment_gr	-.1240227	.0050466	.1612336	-.4560207	.0211414	.0288586

Source: Authors' compilation.

Factors 3 through 6 match the results found for the Inoue and Rossi analysis (though with a different ordering). The additional two factors, factors 1 and 2 are yield curve factors dealing with both the long end (factor 1) and the short end (factor 2) of the curve.

REFERENCES

Ambler, S., and Kronick, J. 2018. *Navigating Turbulence: Canadian Monetary Policy since 2004*. Toronto: Renouf Publishers for C.D. Howe Institute.

____________. 2022. *Money Talks: The Old, New Tool for Predicting Inflation*. Toronto: C.D. Howe Commentary 623. July.

Bernanke, B. 2020. "The New Tools of Monetary Policy." *American Economic Review* 10(4): 943-83.

Bernanke, B., Boivin, J., and Eliasz, P. 2005. "Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach." *Quarterly Journal of Economics*, 120(1): 387-422.

Borio, C., and Gambacorta, L. 2017. "Monetary Policy and Bank Lending in a Low Interest Rate Environment: Diminishing Effectiveness?" BIS Working Paper No. 612, February.

Brunnermeier, M., and Koby, J. 2019. "The Reversal Rate of Interest." Mimeo, Princeton University.

Champagne, J., and Sekkel, R. 2018. "Changes in monetary regimes and the identification of monetary policy shocks: Narrative evidence from Canada." *Journal of Monetary Economics*, 99, pp. 72-87.

Eggertson, G., Juelsrud, R., Summers, L., and Wold, E. 2019. "Negative Nominal Interest Rates and the Bank Lending Channel." Working Paper 25416, National Bureau of Economic Research.

Eisenschmidt, J., and Smets, F. 2018. "Negative Interest Rates: Lessons from the Euro Area." Mimeo.

Ergungor, O.E. 2016. "Recession Probabilities."Federal Reserve Bank of Cleveland Economic Commentary, No. 2016-09, August.

Erikson, H., and Vestin, D. 2019. "Pass-through at mildly negative policy rates: The Swedish case." VOXEU.

deGroot, O. and Haas, A. 2020. "The Negative Interest Rate Policy Experiment." CESifo Forum 21(1):7-12.

Guerrieri, V., G. Lorenzoni, and Prato M. 2020. "Schumpeter Lecture 2019: Slow Household Delveraging." *Journal of the European Economic Association,* Volume 18, Issue 6, December, Pages 2755–2775

Heider, F., Saidi F., and Schepens, G. 2018. "Life below zero: bank lending under negative policy rates."Working Paper 2173, European Central Bank.

Inoue, A., and Rossi, B. 2021. "A new approach to measuring economic policy shocks, with an application to conventional and unconventional monetary policy." *Quantitative Economics*, 12:1085-1138.

Jorda, O. 2005. "Estimation and inference of impulse responses by local projections", *American Economic Review* 95:161-182.

Lewis, J., and Linzer, D. 2005. "Estimating regression models in which the dependent variable is based on estimates." *Political Analysis* 13: 345–364.

Nationalbank, Danmarks. 2020. "Positive Pass-Through from Negative Rates." Analysis, No. 5.

Papadia, Francesco, and Leonardo Cadamuro. 2021. "Does Money Growth Tell Us Anything About Inflation?" Working Paper 11/2021, Bruegel. https://www.bruegel.org/2021/11/does-money-growth-tell-us-anything-about-inflation/

Repullo, R. 2020. "The Reversal Interest Rate – A Critical Review." Mimeo.

Romer, C. and Romer, D. 2004. "A New Measure of Monetary Shocks: Derivation and Implications." *American Economic Review*, 94(4): 1055-1084.

Ulate, M. 2021. "Going Negative at the Zero Lower Bound: The Effects of Negative Nominal Interest Rates." *American Economic Review* 111(1): 1-41.

Witmer, J., and Yang, J. 2016. "Estimating Canada's Effective Lower Bound." *Bank of Canada Review Spring*, 3–14.

Zhang, X. 2021. "A New Measure of Monetary Policy Shocks." Bank of Canada Staff Working Paper 2021-29, June.

Recent C.D. Howe Institute Publications

August 2022	Mahboubi, Parisa. *The Knowledge Gap: Canada Faces a Shortage in Digital and STEM Skills.* C.D. Howe Institute Commentary 626.
August 2022	Robson, William B.P., and Mawakina Bafale. *Decapitalization: Weak Business Investment Threatens Canadian Prosperity.* C.D. Howe Institute Commentary 625.
August 2022	Ciuriak, Dan. "At What Cost? The Economic and Human Costs of Russia's Invasion of Ukraine." C.D. Howe Institute Working Paper.
July 2022	Lester, John. "Tax Support for R&D and Intellectual Property: Time for Some Bold Moves." C.D. Howe Institute E-Brief.
July 2022	Mahboubi, Parisa, and Amira Higazy. *Lives Put on Hold: The Impact of the COVID-19 Pandemic on Canada's Youth.* C.D. Howe Institute Commentary 624.
July 2022	Ambler, Steve, and Jeremy Kronick. *Money Talks: The Old, New Tool for Predicting Inflation.* C.D. Howe Institute Commentary 623.
June 2022	Hodgson, Glen. "Climate Risk and Canadian Banks: Is More Capital Required?" C.D. Howe Institute E-Brief.
May 2022	Nikolakakis, Angelo. "High Stakes Ahead: Canada and the Global Minimum Tax for Multinationals." C.D. Howe Institute E-Brief.
May 2022	Baldwin, Bob. "The Evolving Wealth of Canadians: Who Is Better Fixed for Retirement? Who is Not?" C.D. Howe Institute E-Brief.
May 2022	Grootendorst, Paul, Javad Moradpour, Michael Schunk, and Robert Van Exan. *Home Remedies: How Should Canada Acquire Vaccines for the Next Pandemic?* C.D. Howe Institute Commentary 622.
April 2022	Blomqvist, Åke. *Going Dutch: Choice, Competition and Equity in Healthcare.* C.D. Howe Institute Commentary 621.

Support the Institute

For more information on supporting the C.D. Howe Institute's vital policy work, through charitable giving or membership, please go to www.cdhowe.org or call 416-865-1904. Learn more about the Institute's activities and how to make a donation at the same time. You will receive a tax receipt for your gift.

A Reputation for Independent, Nonpartisan Research

The C.D. Howe Institute's reputation for independent, reasoned and relevant public policy research of the highest quality is its chief asset, and underpins the credibility and effectiveness of its work. Independence and nonpartisanship are core Institute values that inform its approach to research, guide the actions of its professional staff and limit the types of financial contributions that the Institute will accept.

For our full Independence and Nonpartisanship Policy go to www.cdhowe.org.

C.D. HOWE
INSTITUTE

67 Yonge Street, Suite 300,
Toronto, Ontario
M5E 1J8

Canadian Publication Mail Sales
Product Agreement #40008848