INSTITUT C.D. HOWE INSTITUTE

COMMENTARY
NO. 506

Faulty Transmissions: How Demographics Affect Monetary Policy in Canada

An aging population has acted as a drag on monetary policy effectiveness in Canada. If further population aging continues to reduce the effectiveness of monetary policy, this could eventually undermine Canada's inflation-targeting regime.

Steve Ambler and Jeremy Kronick

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Commentary No. 506
March 2018
Monetary Policy

$12.00
ISBN 978-1-987983-58-6
ISSN 0824-8001 (print);
ISSN 1703-0765 (online)

The Study In Brief

Over the past decade, inflation in many countries has been tepid, despite rock-bottom interest rates and different forms of unconventional stimulative monetary policy, including quantitative easing. For its part, Canada has averaged 1.5 percent inflation over this period, below the 2 percent target. This *Commentary* asks what role demographics, in particular an aging population, has on monetary policy effectiveness, looked at through the lens of its impact on inflation and unemployment.

This *Commentary* first evaluates the impact of Canadian monetary policy effectiveness on economic variables from the mid-1980s onward and then looks at the impact of an aging population on this effectiveness in the years since the Bank of Canada became an inflation-targeting central bank. We improve on previous work on Canadian monetary policy effectiveness by using monetary policy shocks that remove the puzzling results found in standard empirical setups. Furthermore, since the old-age dependency ratio changes only slowly over time, we use a panel data set that gives us the necessary variation. This allows us to estimate the impact of aging in Canada more precisely.

Results are ambiguous on monetary policy's effectiveness over the last 30 years. In part, this could be due to the fact that inflation expectations have become better anchored at the 2 percent target. This would mean that even if the Bank has to work harder to affect inflation, inflation is at least more stable in the face of real economic shocks.

Our follow-up question – and, really, the central question of this *Commentary* – is what is the impact of demographics on this record of monetary policy effectiveness? What we find is that Canada's aging population has acted as a drag on and is likely a leading cause of the systematic undershooting of inflation we have seen since the financial crisis. We also find that the interest rate and credit channels help explain this result. Specifically, an aging population that takes on less debt is less sensitive to changes in the interest rate.

This means that meeting the Bank of Canada's inflation target will require more significant changes to the overnight rate target and, in the case of expansionary monetary policy, will be made more difficult by a lower neutral rate of interest, which may result in a quicker move to unconventional monetary policy. The results in this *Commentary* should help the Bank of Canada adjust its analysis accordingly.

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Inflation targeting, a monetary approach aimed at achieving stable inflation and stable economic growth, can trace its origins as far back as Keynes' *Tract on Monetary Reform* (1923).

However, no country formally embraced inflation targeting until New Zealand in 1990. Canada followed suit the next year, and since then many other countries, both developed and developing, have adopted this path to secure and stable economic growth. Indeed, inflation targeting has been very successful for these some 30 nations when measured by several different metrics, including lower volatility of both inflation and real GDP, as well as lower unemployment rates (see, for example, Parkin 2016).

Meanwhile, the need to tackle high inflation has lessened since the 2007/08 global economic crisis. In fact, over the past decade, inflation has been tepid, despite rock-bottom interest rates and different forms of unconventional stimulative monetary policy, including quantitative easing. For its part, Canada has averaged 1.5 percent inflation over this period, below the 2 percent target. This *Commentary* asks what role demographics, in particular an aging population, has on monetary policy effectiveness, looked at through the lens of its impact on inflation and unemployment.

The economic context of inflation targeting has changed gradually over the past 25 years. Most notably, real and nominal interest rates have slowly decreased, with a sudden fall at the onset of the Great Recession.[1] Furthermore, the long-run neutral interest rate – the central bank policy rate consistent with output at its potential and inflation at target – is now lower than it was before the crisis. A lower neutral rate has important consequences, since it increases the probability that negative shocks will push a central bank's policy rate to its lower bound, leaving less room to lower policy rates to stimulate demand.[2]

Additionally, the relationship between the level of economic activity and inflation has weakened gradually over the past 30 years. In academic circles, this trend is often referred to as a flattening of the Phillips Curve (Phillips 1958), which posits an inverse relationship between inflation and unemployment. The implications of this phenomenon are mixed. On the one hand, if long-run inflation expectations are tied to an inflation target, imbalances between demand and supply are less likely to move inflation from the target. On the other hand, the flattening of the Phillips Curve can also mean that central banks, in order to affect inflation rates, must affect aggregate demand and output even more than before.[3]

What does all this have to do with an aging population? As populations age and workers approach retirement, savings rates tend to increase,

The authors thank Rosalie Wyonch, John Crow, Pierre Duguay, Paul Jenkins, David R. Johnson, David Laidler, David Longworth, Angelo Melino, John D. Murray, Angela Redish, Pierre Siklos and anonymous reviewers for comments on an earlier draft. The authors retain responsibility for any errors and the views expressed.

1 Ambler and Alexander (2015) review the reasons for the decline in real interest rates.

2 See Ambler (2016) for an analysis of the monetary policy challenges posed by low interest rates.

3 Carney (2017) notes that economies have become more open and the nature of international trade has changed since the financial crisis, with global value chains boosting trade in intermediary goods and inflation becoming a much more globalized phenomenon.

pushing down long-term interest rates. In Canada, the overall median age in 1971 was 26.2 and has since steadily risen, reaching 40.6 in 2017.[4] Additionally, for the first time there are now more Canadians over 65 than under 15 (Robson 2017). An aging population usually means a reduction in the ratio of the labour force to total population. Offsetting this trend has been a tendency of individuals to postpone retirement beyond the age of 65 as life expectancies increase.

Changing demographics can also impact the effectiveness of monetary policy because interest rate changes produce different reactions among different age cohorts. For example, as populations age, they typically have less debt, making them less sensitive to changes in interest rates, but have more assets, including a higher proportion of fixed-income assets, making them more sensitive to such changes. These two opposite effects call for an empirical analysis.[5]

In this *Commentary*, we use a new data set identifying monetary policy shocks (Champagne and Sekkel 2017) and quarterly macroeconomic data on Canadian provinces, as well as for Canada as a whole, to estimate the changing effectiveness of monetary policy over the Q2/1985 to Q4/2015 period. We find that the effectiveness of monetary policy has not unambiguously increased or decreased over time when measured by its impact on inflation and unemployment. We would have expected this effectiveness to have increased since 1991 when the Bank of Canada began inflation targeting.

Our follow-up question – and, really, the central question of this *Commentary* – is what is the impact of demographics on this record of monetary policy effectiveness? We test the theory that demographics has played an important role in slowing down monetary policy's impact on key macroeconomic variables. Data availability forces us to study the shorter Q1/1992 to Q4/2015 time period. However, in some ways this is positive, as it focuses the analysis on the period since the Bank of Canada became an inflation targeter.

Our primary finding is that demographic change has reduced the effectiveness of monetary policy, consistent with the results of other studies (see Boivin et al. 2010). As monetary policy has been expansionary for the bulk of the period under analysis, the implication is that because of aging lower interest rates have slowed the typical increase in spending, leading to subdued inflation and lower economic growth.[6] Therefore, demographics represents a plausible explanation for why inflation has not reached higher levels post-economic crisis, despite considerable monetary policy stimulus.

What this all means is that hitting the inflation target will require more significant changes to the overnight rate target. In times requiring expansionary monetary policy, this will be made more difficult by a lower neutral interest rate and may result in the Bank having to resort to unconventional monetary policy more quickly. The findings in this *Commentary* should help the Bank of Canada adjust its models accordingly.

4 See CANSIM Table 051-0001.

5 Juselius and Takats (2015) find that demographics accounts for one-third of the variation in inflation across a set of countries over the 1955-2010 time period. Interestingly, they find a U-shaped pattern, implying that higher inflation is more likely in populations with more dependents (i.e., more young and old). They also show that monetary policy has both reinforced this relationship and mitigated it at different points over the course of their sample period.

6 In a globalized world where credit comes from different jurisdictions, different debt levels matter as domestic debtors are not simply offset by domestic creditors.

Channels for Monetary Policy Effectiveness

In this section we look at the three primary monetary policy transmission channels discussed by Imam (2015): the interest rate channel, the credit channel and the wealth channel.[7] These channels represent the mechanisms through which an aging population impacts monetary policy effectiveness.

The interest rate channel follows from the life-cycle hypothesis (Modigliani 1966). The essential idea is that households accumulate debt as they go through the early stages of adulthood but are able to pay off this debt as they age and end up creditors by the time they hit life's later stages. For this reason, younger households are more sensitive to changes in interest rates than older ones since they need more credit. In this case, monetary policy has a reduced impact on an aging population.

In many ways the credit channel is related to the interest rate channel. As households age, they have higher net worths and possess significantly more collateral. It is, therefore, cheaper for them to borrow. This is known as having a lower external finance premium. The smaller this finance premium, the less sensitive households are to monetary policy.[8] In contrast, young adults have a higher external risk premium. Once again, the implication is that monetary policy has a reduced impact on an aging population.

While the interest rate and credit channels have the same impact – aging leads to less effective monetary policy – the wealth channel has the opposite impact. As societies age, the population tends to own more assets and have greater net worth. The more assets one has, the more sensitive one's wealth is to interest-rate changes. This is exacerbated by the fact that these assets tend to be fixed-income products and are by their very nature interest-rate sensitive. Therefore, we expect monetary policy to generate larger real economy effects through the wealth channel.

In addition to assessing the net change in Canadian monetary policy effectiveness – and an aging population's role – we evaluate the impact of interest rate and credit channels. Lack of reliable data unfortunately prevents an evaluation of the wealth channel.

The Changing Effectiveness of Monetary Policy

The empirical methodology used in this *Commentary* is based on Imam (2015). We describe the methodology in detail in a companion working paper that is available online (Kronick and Ambler 2017). Imam uses a panel of different countries to exploit cross-country population variations to identify the impact of demographic changes. We use a panel of Canadian provinces to do the same for Canada. Canada's provinces can be viewed as part of a currency union: our methodology is also similar to that of Georgiadis (2015), who uses a panel of Euro-area countries to identify the impact of different economic structures on the three monetary transmission mechanisms.

Our first research stage involves using quarterly data to determine how monetary policy effectiveness has evolved from Q2/1985 to Q4/2015. One major change from the work in Imam is how we identify exogenous monetary policy shocks. Imam's results for Canada show a significant delay in price drops following a contractionary monetary policy shock. This so-

7 See also Mishkin (1996) for a general discussion of monetary policy's transmission channels.

8 We note that the elasticity of consumption with respect to the external finance premium is based partly on the interest-rate level. Additionally, the external finance premium itself may differ based on the interest rate. However, all else equal, younger households face a higher premium, making them more sensitive to policy-rate changes.

called "price puzzle", in which monetary policy shocks are identified using innovations in policy rates in a vector autoregression setup, is consistent with other studies (see Kim and Roubini 2000).

One approach that eliminates the "price puzzle" from the results is the narrative approach (pioneered by Romer and Romer 2004). In the US context, this approach uses minutes of Federal Open Market Committee (FOMC) meetings in order to generate a time series of intended changes to the Federal Funds Rate (FFR). Using the minutes was necessary since the FOMC did not always explicitly target the FFR. In Canada, meanwhile, the analysis is easier for this period as we have always used an explicit inflation target and can thus see the intended rate change simply by evaluating how the overnight rate target differs from one Bank of Canada announcement to the next.

The Bank's intended rate change is partly a reaction to changing economic conditions. We define a monetary policy shock to be that part of a rate change that cannot be predicted on the basis of an estimated reaction function, which estimates the systematic reaction of the Bank's policy rate to a series of economic indicators. We go into greater detail in our working paper, but suffice it to say that the Bank's reaction function, according to Champagne and Sekkel (2017), consists of:

- one- and two-quarter ahead forecasts of real output growth and inflation;
- the now-cast and the real-time one-quarter lag of these variables;
- revisions to the forecasts relative to the previous round of forecasts;
- the intended policy rate two weeks before a Bank announcement; and
- the unemployment rates over the previous three months.

Champagne and Sekkel's major departure from the Romer and Romer reaction function is that they also control for lagged levels and changes of the FFR and the lagged USD/CAD dollar nominal exchange rate.

Importantly, to control for the major change in the Bank of Canada's monetary policy framework, the authors break their subsample in two: 1974–1991 and 1992–2015.[9]

Once we have assessed the monetary policy shock series, we can move to the system of equations mentioned earlier (i.e., inflation, unemployment and the Bank of Canada's policy rate) and replace the bank rate with this new series. Generally, variables in structural vector autoregressions are non-stationary (have non-constant means over time), so the shock series – which is stationary – is cumulated in order to make it consistent with the other series.

We depart from Champagne and Sekkel by placing the shock-variable impact ahead of inflation and unemployment. We do this because if the shock is identified properly, and the Bank follows its own mandate of targeting inflation in the medium term, there should be no contemporaneous impact of inflation and unemployment on the shock series.[10]

We also depart from the authors in the choice of variables that impact the monetary policy shock variable contemporaneously. Like Champagne and Sekkel, we place the Bank of Canada's commodity price index first. However, we also add FFR ahead of the shock. We do this because, while the reaction

9 If we assume the market understands this reaction function, regressing the actual change in the policy rate on these variables leaves a set of residuals, which represents the true set of exogenous monetary policy shocks. They are spliced together, given the splitting of the sample into subsamples.

10 Champagne and Sekkel use this method as a robustness check and find no change to the results.

function incorporates lagged FFR, we believe there are contemporaneous quarterly impacts of US monetary policy on the Bank of Canada's monetary policy decisions.

As mentioned, we study the period from Q2/1985 to Q4/2015, and all variables are measured in percentages. The coefficients relating unemployment and inflation to Canadian monetary policy are allowed to vary systematically over time, making the model a time-varying coefficient structural vector autoregression.[11] This methodology is critical when one is interested in evaluating slow-moving, smooth and long-term economic variables such as demographics, as we do in the second stage.

This stage-one analysis, performed on Canada and all its provinces, provides us with our dependent variables for stage two. These dependent variables can be thought of as a time series of monetary policy effectiveness measured by either the maximum or the cumulative values of inflation and unemployment following a monetary policy shock.[12]

Box 1: Structural Vector Autoregression Model

A time-varying structural vector autoregression (SVAR) model, in which we allow for contemporaneous effects of independent variables on dependent variables, takes on the following generalized form:

$$y_t = X_t' A_t + B_t u_t$$

where y_t is a vector containing the Bank of Canada's commodity price index, the US Federal Funds rate, the monetary policy shock series, as well as Canadian or provincial inflation and Canadian or provincial unemployment; X_t contains contemporaneous and lagged values of the variables contained in y_t as described above; A_t is the corresponding vector of coefficients; B_t is a vector of coefficients that embodies our assumptions for identification; and u_t is a vector of structural shocks.

Placing the shock variable before inflation and unemployment (but after the FFR and commodity price index) reflects the belief that contemporaneous levels of the commodity price index and FFR impact monetary policy decisions, but that otherwise the shock has been fully identified.

Results

We detail the individual provincial results for stage one in the companion working paper but for brevity we focus here on the aggregate Canadian results. The Canadian results are summarized graphically in Figure A1 of Appendix A below. In each graph, the lower left-hand axis measures the number of periods (quarters) after the monetary policy shock.

Two aspects of the results stand out. As we go through these results the reader should keep in mind that a greater fall (rise) in inflation (unemployment) across time indicates increasing monetary policy effectiveness following a contractionary monetary policy shock. The results are also symmetric if one prefers thinking of an expansionary monetary policy shock.

That said, the results for inflation tell a mixed story for monetary policy effectiveness over the past 30 years. If we examine the maximum fall in

11 We use Bayesian estimation techniques, so officially it is a time-varying coefficient Bayesian vector autoregression. See the online companion paper for the technical details.

12 We do not include monetary aggregates. While we are sympathetic to their importance to monetary policy, their addition would add more required estimated coefficients, and the literature has largely moved away from using them in identification.

inflation over this period, there has been a slight uptick from -0.366 percent to -0.344 percent, implying mildly less effectiveness. Looking at cumulative inflation tells the opposite story. There is a slight fall from beginning to end, -4.20 percent to -4.27 percent. However, in both cases, there is substantial movement in both directions over the period under investigation so it is hard to glean a conclusion one way or the other.

This result is consistent with the fact that inflation-targeting central banks have been successful by many metrics on the one hand, including lower variability of inflation and lower inflation levels, but that, on the other hand, firmer expectations have made it more difficult for policy changes to have the same impact on inflation.

Unfortunately, when focusing on Canada's low-growth, post-crisis economy, monetary policy has lost some of its effectiveness, using either maximum or cumulative changes in inflation. This confirms the results other studies have found for a wide range of countries. (See, for example, Borio and Hofmann 2017).

The second panel of Figure A1 shows the response of unemployment to a monetary policy shock. In this case there is an uptick in effectiveness during the early years (peaking at 2.95 percent for cumulative unemployment and 0.36 percent maximum unemployment, both in Q4 1992), a subsequent fall lasting approximately three years, before essentially being flat from the mid-1990s on, including through the crisis and after. This is consistent with the idea that there has been a breakdown in the relationship between inflation and the real economy.

To summarize, whether monetary policy has become more effective or not (as measured by maximum or cumulative changes to inflation/unemployment) is unclear. However, while this is an important question to continue to evaluate, the primary question we answer in this *Commentary* is what role demographic change has played on monetary policy's impact on key macroeconomic variables.

The Impact of Demographics

To look at this question, we use a dynamic, ordinary least squares (OLS) panel regression analysis.[13] We take our measures of monetary policy effectiveness by province from the previous section as dependent variables in a series of regressions. We test our results on four different dependent variables: maximum inflation, maximum unemployment, cumulative inflation and cumulative unemployment.

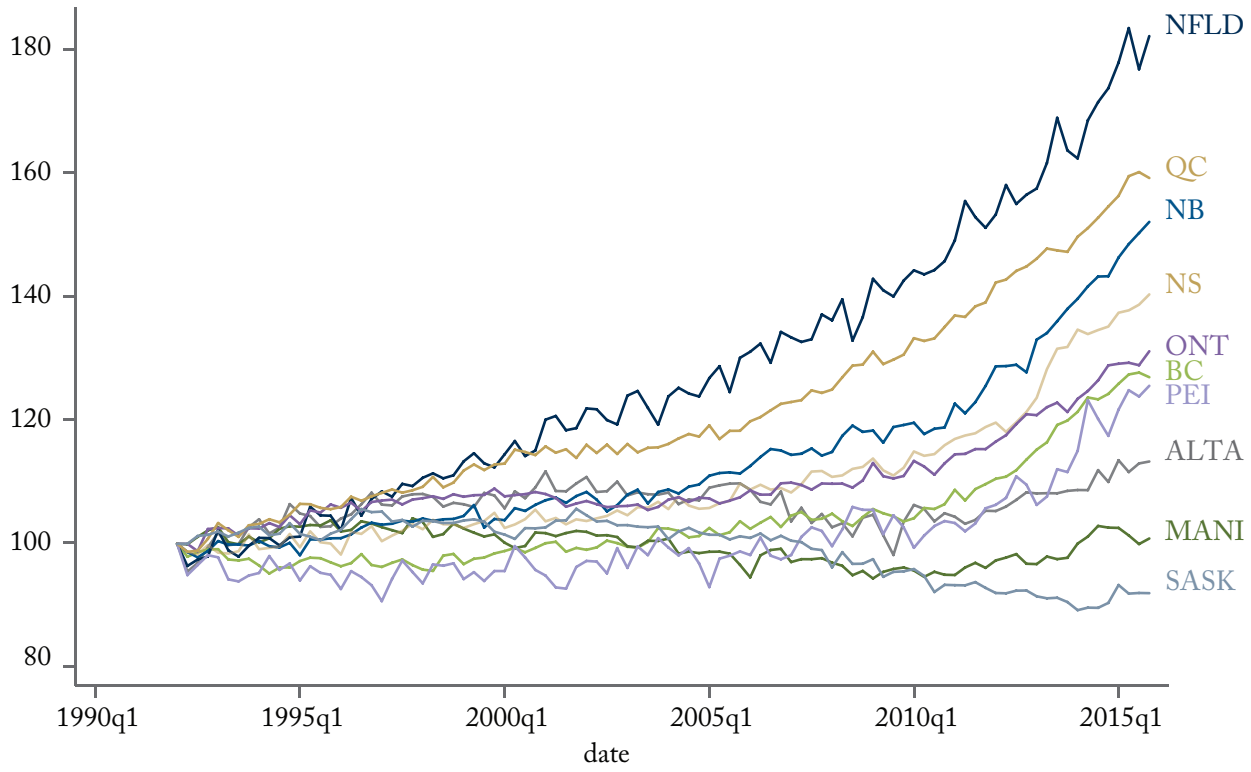
For a positive monetary policy shock (increase in the overnight rate), maximum inflation will be the largest (negative) change in inflation when we calculate the impulse-response function. A positive shock to the overnight rate leads to an increase in unemployment, so the maximum response in the case of unemployment is the largest (positive) change in the unemployment rate when we calculate the impulse-response function. The cumulative effects are calculated by summing the responses of either inflation or unemployment to the policy shock over time. For notational purposes, we label this variable as $effect^{j}_{it}$ where i represents the different provinces in the panel, t is time and j separates when we are looking at inflation versus when we are looking at unemployment (and, for that matter, maximum vs. cumulative).[14]

The explanatory variables we use in our panel regression, similar to Imam (2015), are the old-age dependency ratio, manufacturing output relative to total output, a measure of the economy's openness to the rest of the world and a measure

13 More on dynamic OLS can be found in our accompanying working paper.

14 See Appendix B for the full formal regression.

Figure 1: Provincial Old Age Ratios (indexed to 100 in 1992q1)



Source: CANSIM Table 282 0087 and authors' calculations.

of the importance of private-sector credit. We are interested primarily in the effects of demographic change, but we use the other variables in the regressions as controls in order to avoid biased results from omitted variables. Imam also includes the share of smaller firms to total firms within an economy, which we are unable to do as a result of data availability at the provincial level.

The use of the old-age dependency ratio as our demographic variable reflects an assumption that the behaviour of different age cohorts is relatively constant over time. We checked this assumption by analyzing data on the cross-cohort behaviour of assets and debts in Canada in 1999, 2005, 2012 and 2016. In all four years, debt peaked at 35–44 while assets peaked at 55–64. Our interpretation is that age-distribution change matters. In other words, what is important is the changing relative sizes of different cohorts over time.

As the purpose of this *Commentary* is to determine aging's impact on monetary policy effectiveness, we should drill down further on this measure of changing demographics. We use CANSIM Table 282 0087 and subtract those aged 15–64 from those aged 15 and over to arrive at the population aged over 65. We divide this number by those aged 15–64 to get the old-age dependency ratio (similar to Imam 2015 at this point). In simple

Box 2: Data Adjustments

To begin, we needed to generate quarterly provincial GDP values since the lowest available frequency is annual. To do so, we interpolated[1] annual provincial GDP and trade data using quarterly Canadian GDP.[2] We used these quarterly provincial GDP results to generate the other control variables.

First, we generated the intensity of the manufacturing variable. Using quarterly data from CANSIM Table 304 0015, we focused on manufacturing sales by province, dividing by province-specific consumer price indices to generate real series. To determine the manufacturing intensity, we divided real manufacturing sales by real GDP, creating the variable mfg_{it}.

For openness, we used provincial export and import data to/from other countries from CANSIM Table 384 0038. By adding exports and imports, we created a measure of real total trade that we divide by real GDP to create our openness measure, $open_{it}$.

Lastly, we needed a measure for private credit. This is important as credit levels have soared due to cheap credit, which in theory should cause more sensitivity to monetary policy. We note, though, that debt-service ratios in Canada have remained fairly flat over the period under analysis (Kronick 2017).

In any event, while a complete private credit story by province is difficult to obtain, provincial asset and liability data are available from chartered banks in CANSIM Table 176 0074. As chartered banks make up the bulk of the lending in the economy, we believe we have an appropriate proxy measure.

We include the following in private credit: 1) non-mortgage loans to individuals for non-business purposes (total personal loans); 2) non-mortgage loans to individuals and others for business purposes (total loans to Canadian resident non-financial business); 3) residential mortgages; 4) non-residential mortgages; 5) customers' liabilities under acceptances. We again divided this private credit data by real GDP by province to create the final control variable, $credit_{it}$.

1 We interpolate using the Denton method (Bloem et al. 2001).

2 See our companion paper (Kronick and Ambler 2017) for technical details. We test the effectiveness of this method by comparing actual quarterly Canadian total trade to an estimated interpolated quarterly Canada total trade. The correlation results are very high, giving us confidence that our interpolation method produces reliable measures of quarterly provincial GDP and total trade.

terms, this ratio represents the number of elderly relative to the working-age population.

The problem with this variable as described is that it arbitrarily sets 65 as "old." There are, however, reasons to use this cutoff. For example, the retirement age in Canada is 65, but one way to reduce the arbitrariness is by subtracting from the "old" total those aged 65 or older who remain in the labour force.[15]

As Figure 1 shows, this new "old age" ratio has steadily increased on balance over the period under analysis across all provinces except for Saskatchewan, while Quebec and the Atlantic provinces have experienced particularly large increases. Figure 1 is

15 We use the labour force survey from CANSIM table 282 0087.

Table 1: Impact of Macroeconomic Variables on Monetary Policy Effectiveness

A 1-Percent Increase in …	… Results in the Following Percent Change in the Effect of an Increase in the Policy Rate on … Cumulative Inflation	Cumulative Unemployment	Maximum Inflation	Maximum Unemployment
Old Age Population	-0.029	-0.059 (**)	0.003 (**)	-0.006 (***)
Manufacturing	0.092(***)	0.218 (***)	0.008 (***)	0.0141 (***)
Private Credit	-0.039(***)	-0.015(***)	-0.002 (***)	-0.0001
Openness	0.002	-0.008 (*)	0.0004	-0.0001

Notes:

*Marginal significance at the 10% level (p<0.10).

**Marginal significance at the 5% level (p<0.05).

***Marginal significance at the 1% level (p<0.01).

Source: Authors' calculations based on the Q1/1992 – Q4/2015 period.

an index that normalizes all of the series to 100 at the start of the sample. In the regressions, we use the dependency ratios without normalization.

Primary Results

The estimated monetary policy effectiveness equation is provided in Appendix B along with our basic formal panel regression results.[16]

Table 1 shows a simplified version of our results. Due to data availability, we estimate the equation using a sample period of Q1/1992 to Q4/2015. The monetary shock that we model in stage one is a one-percentage point increase in the Bank's policy rate, which has a negative effect on inflation and a positive effect on unemployment. This means that a positive (negative) sign in the table means that the relevant variable reduces (increases) the effectiveness of the policy change on inflation and increases (reduces) its effect on unemployment.

The results for all four dependent variables are broadly consistent with Imam (2015) in direction and significance, though with smaller magnitudes. The key result for our purposes is that an aging population apparently reduces the effectiveness of monetary policy on both inflation and unemployment, with the effect stronger on unemployment. The results are consistent for

16 The accompanying working paper (Kronick and Ambler 2017) contains full details on pre-regression stationarity tests.

unemployment whether we use cumulative or maximum as the dependent variable. With inflation, the effect is only statistically significant when we look at maximum inflation. The more mixed results for inflation are consistent with the anchored inflation expectations that have become more widespread since the Bank of Canada became an inflation-targeting central bank.

We also note that, while the standard 1 percent increase in old age is an appropriate way of analyzing the question at hand, perhaps more interesting given the slow moving nature of demographics, is the impact of the entire increase in our ageing population on the effectiveness of monetary policy over the period we study.

In Canada as a whole, the old age dependency ratio increased 33.8 percent from Q1 1992 to Q4 2015. Therefore, monetary policy effectiveness, as judged by maximum inflation, fell by 0.115 (33.8× 0.00341), or approximately 12 basis points. So if the average maximum fall in inflation from a contractionary monetary policy shock was 0.40 percentage points across panels over the period of our analysis, it would have fallen 0.52 percentage points if not for an ageing population.

Given the insignificance of an aging population on cumulative inflation we do not perform a similar analysis on this variable.

Looking at unemployment, multiplying 33.8 by the coefficients on cumulative and maximum unemployment gives us -1.994 and -0.204 respectively. Therefore, an expansionary monetary policy shock at the beginning of our sample that lowered the unemployment rate by 1.994 percentage points would have no impact today. Similarly, if the peak decrease in the unemployment rate from a monetary policy shock in 1992 had been 0.204 percentage points, it would be zero now.

Control Variables

What about our control variables? We find that an economy with a higher concentration of manufacturing causes greater unemployment sensitivity in response to monetary policy shocks. This is consistent with the idea that the manufacturing sector tends to be more interest-rate sensitive (see, for example, Carlino and Defina 1998). This result does not hold for inflation sensitivity: nevertheless it is consistent with Imam.

The results also indicate that a more open economy has no significant impact on monetary policy effectiveness. Even in the one case where there is some weak impact, the magnitude is so small we consider it negligible. The insignificance can be explained by two opposing considerations. On the one hand, an increase in interest rates will cause an appreciating exchange rate, which for a more open economy should lead to a greater fall in inflation and a larger increase in unemployment. However, increased global trade integration might actually weaken the linkages between monetary policy and key macroeconomic variables (Poloz 2016). In large part, this is because domestic inflation is affected more by global demand and supply than changes in domestic behaviour. For example, China's ascension in the global market and the global trade collapse during the Great Recession demonstrate significant international macroeconomic events that have had ripple effects domestically. The challenge is to figure out how inflation responds in this more recent environment and how central banks should react.

Finally, the coefficients on private credit tell a somewhat mixed story. For the regressions with inflation as dependent variables we regularly get significant and negative coefficients. This is consistent with the idea that the availability of more credit in the Canadian economy leads to increased sensitivity to changes in the interest rate, which then have a greater impact on spending and inflation.

For unemployment, the results are either insignificant or indicate a mildly less sensitive real economy. One possible explanation for this counterintuitive result is that we have experienced mostly expansionary monetary policy over our time period, and the more credit constrained individuals

become, the less space they have in their budgets to borrow and spend when interest rates are lowered. If that occurs, there is less of an increase in real output and less of a drop in unemployment. One would then expect lower inflation as a result. However, if spending decreased in sectors of the economy that experienced above-average inflation over our period (such as housing), it would be possible for the impact of monetary policy on inflation to grow while its impact on unemployment decreased.

Overall, though, the key takeaway from the primary results is that an aging Canadian population has acted as a drag on monetary policy effectiveness. Below we will look at the transmission mechanism(s) that are responsible for these results, but this demographic drag is what we want the readers to focus on when we discuss policy implications for the Bank of Canada in a later section.[17]

The Transmission Mechanism

The next logical question, once we know that aging acts like a drag on monetary policy effectiveness, is why does it do so? What is happening in the economy that causes this phenomenon? To answer these questions, we use empirical regression techniques to test the importance of the interest rate and credit channels. Unfortunately, we do not have access to wealth data at the provincial level. While wealth data are available at the national level, cross-sectional and time-series variation in the data are needed in order to properly evaluate the impact of the old-age dependency variable, which changes very slowly over time.

We use two techniques to test the impact of the interest rate and credit channels. Since they are so closely linked, we test them together. The first technique involves removing the private credit control variable from the primary regression. The second technique involves interacting the private credit variable with the old-age variable.

The results in Table 2 show the results for the variable removal technique. For inflation, removing private credit leads to the appearance of old age having a positive impact on monetary policy effectiveness. This is precisely what we would expect since an increase in credit on its own, not accounting for aging, should cause an increase in monetary policy effectiveness as higher debt loads mean more sensitivity to interest rate movements. In turn, increased credit boosts household spending and, therefore, inflation. What this then implies is that, if not for aging, monetary policy would have been more effective through its impact on credit.

For unemployment, we also see an impact from the removal of private credit, though this time we see a mild decrease in effectiveness as a result of old age. This is consistent with the discussion above on the role credit appears to be playing on the real economy – it magnifies the reduction in the effectiveness of monetary policy that comes from an aging population.

Table 3, which shows results for the variable interaction technique, is trickier to understand. The way to interpret the role of old age here is to add its coefficient to the interaction coefficient and multiply by some value of private credit (in our case, we take the mean). When one does that, one gets coefficients matching the primary results across the board. What is relevant is the fact that, with the exception of the cumulative inflation regression, the interaction terms are significant in all cases, highlighting the link between credit and old age. The insignificance of the interaction coefficient in the cumulative inflation regression is consistent with the insignificance of old age for this

17 For robustness checks, we experimented, among other things, with different leads and lags in our panel regression, as well as the removal of some outlier periods in some of our control variables. The results did not change materially from our base-case regression (see companion paper Kronick and Ambler 2017).

Table 2: Transmission Mechanism – Removal Technique

A 1-Percent Increase in …	… Results in the Following Percent Change in the Effect of an Increase in the Policy Rate on … Cumulative Inflation	Cumulative Unemployment	Maximum Inflation	Maximum Unemployment
Old Age Population	-0.089 (***)	-0.082 (***)	-0.0003	-0.006(***)
Manufacturing	-0.051 (***)	0.202 (***)	0.005 (***)	0.014 (***)
Openness	0.010 (***)	-0.005	0.001 (***)	-0.0001

Note:

* Marginal significance at the 10% level (p<0.10).

** Marginal significance at the 5% level (p<0.05).

*** Marginal significance at the 1% level (p<0.01).

Source: Authors' calculations based on the Q1/1992 – Q4/2015 period.

Table 3: Transmission Mechanism – Interaction Technique

A 1-Percent Increase in …	… Results in the Following Percent Change in the Effect of an Increase in the Policy Rate on … Cumulative Inflation	Cumulative Unemployment	Maximum Inflation	Maximum Unemployment
Old Age Population	-0.034	-0.391(***)	0.013(***)	-0.033(***)
Manufacturing	0.093 (***)	0.238 (***)	0.007 (***)	0.016 (***)
Private Credit	-0.039(***)	-0.156 (***)	0.002 (*)	-0.012 (***)
Openness	0.002	-0.008 (**)	0.0004 (*)	-0.0001
Interaction	-0.0001	0.008 (***)	-0.0002(***)	-0.0006(***)

Note:

* Marginal significance at the 10% level (p<0.10).

** Marginal significance at the 5% level (p<0.05).

*** Marginal significance at the 1% level (p<0.01).

Source: Authors' calculations based on the Q1 1992 – Q4 2015 period.

same regression in our primary specification. The bottom line is that these results are further evidence that the interest rate and credit channels play an important role as transmission mechanisms.

Policy Implications and Conclusions

Our results show that the inflation-targeting policy framework in Canada is in reasonably good shape, but is not perfect. A lower neutral interest rate means the Bank of Canada starts from a lower neutral position, meaning less room to decrease rates before hitting the zero (or small negative) lower bound. Future crises and/or recessions will, therefore, put the Bank in the position of having to resort to unconventional monetary policies sooner. If further population aging reduces the effectiveness of monetary policy, this could eventually undermine Canada's inflation-targeting regime.[18]

This *Commentary* first evaluated the impact of Canadian monetary policy effectiveness on economic variables from the mid-1980s onward and then looked at the impact of an aging population on this effectiveness in the years since the Bank of Canada became an inflation-targeting central bank. We improve on previous empirical work on Canadian monetary policy effectiveness by using a shock series that removes the price puzzle found in standard structural vector autoregression setups. Furthermore, since the old-age dependency ratio changes only slowly over time, we use a panel data set that gives us both time-series and cross-sectional variations. This allows us to estimate the impact of aging more precisely.

The data are not conclusive concerning whether monetary policy has become more or less effective over the last 30 years. In part this could be due to the fact that inflation expectations have become better anchored at the 2 percent target. This would mean that even if the Bank has to work harder to affect inflation, inflation is more stable in the face of real economic shocks.

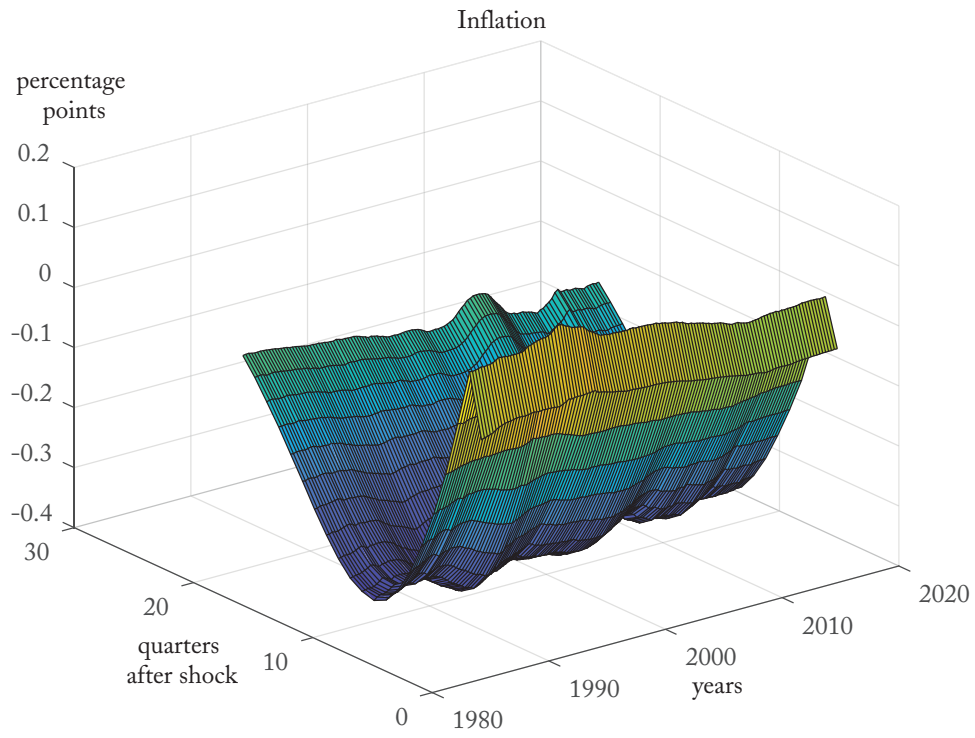
Nevertheless, our main focus was the role aging played in monetary policy effectiveness. What we find is that Canada's aging population has acted as a drag on and is likely a leading cause of the systematic undershooting of inflation we have seen since the financial crisis. We also find that the interest rate and credit channels help explain this result. Specifically, an aging population that takes on less debt is less sensitive to changes in the interest rate.

This means that meeting the Bank of Canada's inflation target will require more significant changes to the overnight rate target and, in the case of expansionary monetary policy, will be made more difficult by a lower neutral rate of interest, which may result in a quicker move to unconventional monetary policy. The results in this *Commentary* should help the Bank of Canada adjust its analysis accordingly.

18 We acknowledge that fiscal policy and immigration policy can also affect the impact of population aging, as one reviewer suggested, but our focus here is on monetary policy.

APPENDIX A

Figure A1: Response of Inflation, Unemployment, and Policy Rate – Canada



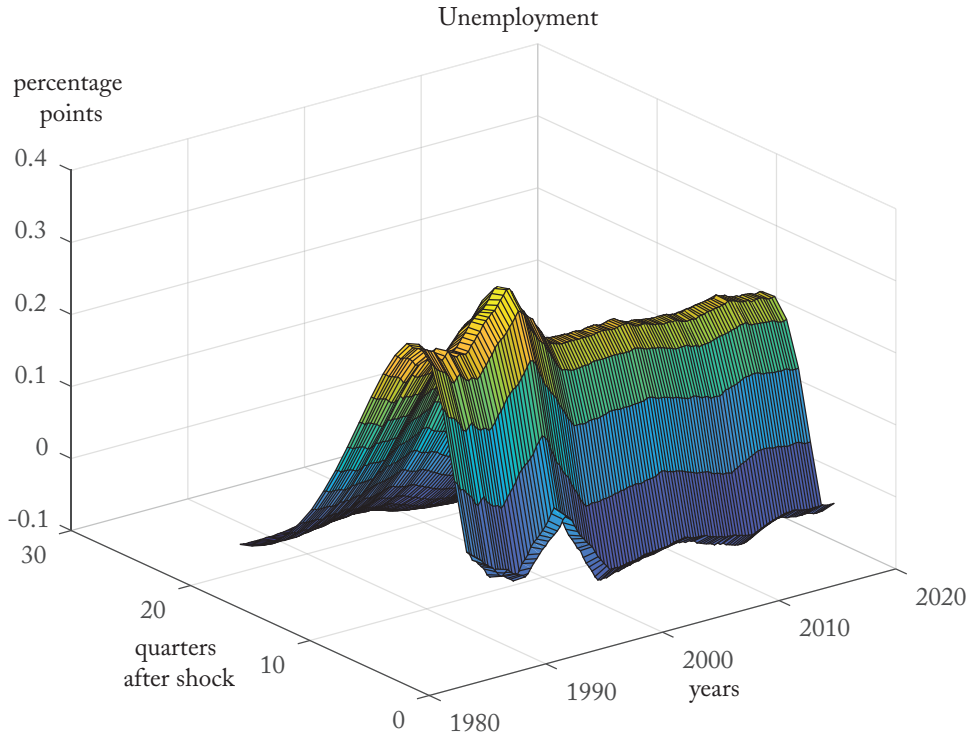
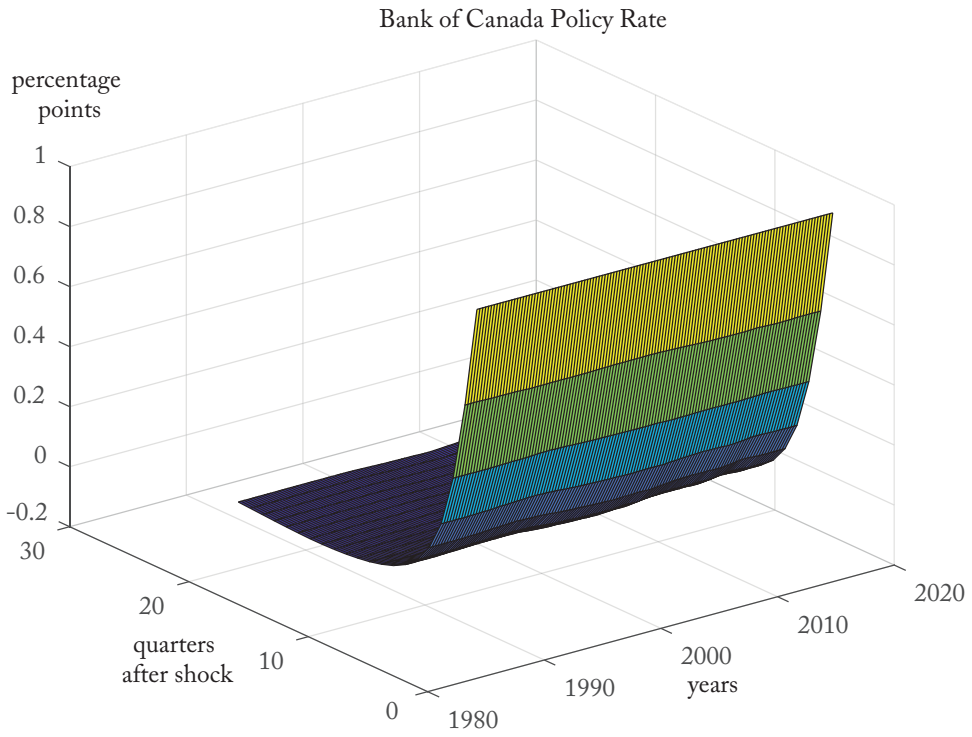


Figure A1: Continued



Note: The right axis is time, the left axis is the horizon following the monetary policy shock and the vertical axis is the impact of the shock, measured in percentage points. The analysis covers the Q2/1985 – Q1/2016 period.
Source: Authors' calculations.

APPENDIX B

We estimate the following equation:

$$effect^{j}_{it} = \alpha_0 + \alpha_1 age_{it} + \alpha_2 mfg_{it} + \alpha_3 credit_{it} + \alpha_4 open_{it} + \eta_{it}$$

where the $effect^{j}_{it}$ is the effectiveness of monetary policy for j equal to either cum_inf (cumulative inflation), cum_unemp (cumulative unemployment), max_inf (maximum inflation) or max_unemp (maximum unemployment) and where the i,t subscripts indicate the i^{th} province and t^{th} time period. Age_{it} is the old-age dependency ratio, mfg_{it} is manufacturing intensity, $credit_{it}$ is our proxy for private sector credit and $open_{it}$ is our measure of openness to trade. Finally, η_{it} is a random error term.

The results of the regression are given in Table B1 below.

In the table, one asterisk indicates marginal significance at the 10% level (p<0.10), two asterisks indicate marginal significance at the 5% level (p<0.05) and three asterisks indicate marginal significance at the 1% level (p<0.01). The results are discussed in detail in the text. The analysis covers the Q1/1992 – Q4/2015 period.

Table B1: Regression Results

	cum_inf	cum_unemp	max_inf	max_unemp
age	-0.029 (-1.31)	-0.059 (**) (-2.06)	0.003 (**) (2.00)	-0.006 (***) (-2.64)
mfg	0.092(***) (5.53)	0.218 (***) (10.10)	0.008 (***) (6.08)	0.0141 (***) (8.17)
build	-0.039(***) (-13.63)	-0.015(***) (-4.10)	-0.002 (***) (-10.81)	-0.0001 (-0.35)
open	0.002 (0.52)	-0.008 (*) (-1.94)	0.0004 (1.55)	-0.0001 (-0.38)

Note:

* Marginal significance at the 10% level (p<0.10).

** Marginal significance at the 5% level (p<0.05).

*** Marginal significance at the 1% level (p<0.01).

Source: Authors calculations based on the Q1 1992 – Q4 2015 period.

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