The adoption of Inflation Targeting in Canada: SVAR identification using changes in policy

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EXTENDED ABSTRACT: The objective of his paper is to study the effects of the adoption of Inflation Targeting in Canada using a small SVAR (Structural Vector Autoregression) model of the economy. More specifically, the analysis focuses on two main research questions. First, I study the extent to which the impact of monetary policy shocks on inflation and output growth has changed after the introduction of the Inflation Targeting policy. Second, I examine the changes in the reaction of monetary policy, measured by the target overnight interest rate, to inflation and output shocks. These questions are addressed by studying the impulse responses obtained from a small SVAR model of the Canadian economy, estimated taking into account the break in the data that happened with the introduction of Inflation Targeting in the early 1990s. The SVAR model is identified using a combination of sign restrictions and assumptions on the changes in the policy related parameters and standard deviations of the structural shocks of the economy. In more detail, I assume that the policy change might have affected the contemporaneous relationships between the variables of interest because of the different policy response or because of changes in expectations. In addition, I assume that the introduction of inflation targeting might have affected the volatility of the monetary policy shocks (because of the change in policy), but not the volatility of the other structural shocks in the model.

In the baseline scenario, I use data from 1981 to 2008 to estimate the SVAR model of interest. However, I also perform an additional exercise in which I extend the analysis to incorporate a second break in the data, corresponding to the recent financial crisis. In this exercise, I use data from 1981 to 2015, and I consider two breaks, one represented by the adoption of Inflation Targeting and one occurring at the beginning of the financial crisis. The impact of the Inflation Targeting policy on the volatilities of the shocks and on the contemporaneous relationships between the variables of interest is assumed to be the same as described above, while the recent financial crisis is assumed to have potentially altered the volatility of all the underlying

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structural shocks of the economy.

Preliminary findings show modest changes in the transmission of monetary policy shocks after the adoption of the Inflation Targeting regime.

**Keywords:** VAR identification, inflation targeting, monetary policy, structural breaks.

**JEL Classification:** C32, E52, E58

1 Introduction

This paper is concerned with the analysis of monetary policy in a structural VAR model of the Canadian economy. I implement a relatively new approach to the identification of structural VAR models, which exploits breaks in the data to identify the parameters of the structural VAR model of interest. This approach was originally proposed by Rigobon (2003) and Lanne and Lütkepohl (2008).

The specific break that I am going to employ is the adoption of the Inflation Targeting regime in Canada in February 1991, which constituted an explicit change in the way in which monetary policy was conducted. I will use this change in policy to help identify a small structural VAR model of the Canadian economy, with the purpose of answering two main sets of questions. The first one is methodological, and it refers to the extent to which the parameters of the SVAR model of interest can be precisely identified using this approach. The second one is policy-oriented, and it concerns with the analysis of the changes in the role of monetary policy following the policy change. More specifically, do monetary policy shocks have a different impact after the adoption of the Inflation Targeting regime? And is the response of the interest rate (policy instrument) to structural shocks different after the adoption of Inflation Targeting?

This work contributes to two strands of the literature in Economics. First, it offers an implementation of the methodological advances on the identification of SVAR models using structural changes in the economy. The initial contributions in this area focused on structural changes originating from shifts in the volatility of the underlying shocks of the economy (Rigobon, 2003; Lanne and Lütkepohl, 2008), but recently Bacchiocchi and Fanelli (2015) extended this approach to more general breaks in the data. To my knowledge, there is no previous work that applies this identification methodology to a VAR model of the Canadian economy. This paper also contributes to the literature studying the Macroeconomic effects of Inflation Targeting, in particular to the strand focusing on the analysis of the impact of this policy in empirical models of the economy (Petursson, 2005; Reschreiter, 2011; Miller et al., 2012). Previous works analyzing this issue in the context of the Canadian economy have found mixed results. Honda (2000) finds no clear effects arising from...
the introduction of Inflation Targeting in Canada; Ftiti and Essaadi (2008) and Ragan (2010), on the other hand, estimate positive stabilizing effects; finally, Miles (2008) finds that the adoption of this policy had the negative consequence of increasing inflation volatility.

1.1 The Model

Consider the reduced-form VAR

\[ Y_t = b + B_1 Y_{t-1} + \ldots + B_q Y_{t-q} + u_t \]  

where \( Y_t \) is a \( k \)-dimensional vector of endogenous variables, \( b \) is a \( k \times 1 \) vector of intercepts, \( B_1, \ldots, B_q \) are \( k \times k \) matrices of parameters, and \( u_t \) is a \( k \times 1 \) vector of reduced-form innovations with \( E(u_t u_{t-j}') = 0 \) for \( j \neq 0 \) and \( E(u_t u_t') = \Omega \).

From the reduced-form VAR, we want to obtain the structural VAR:

\[ Y_t = b + B_1 Y_{t-1} + \ldots + B_q Y_{t-q} + C\varepsilon_t \]  

where \( C \) is a \( k \times k \) matrix of parameters, and \( \varepsilon_t \) is a vector of structural innovations with \( E(\varepsilon_t \varepsilon_{t-j}') = 0 \) for \( j \neq 0 \) and \( E(\varepsilon_t \varepsilon_t') = I \). The structural innovations are related to the reduced-form innovations by the following relationship \( u_t = C\varepsilon_t \), and by construction, \( C \) satisfies: \( CC' = \Omega \). Notice that we can decompose the matrix \( C \) as \( C = A^{-1}\Sigma \), where \( \Sigma \) is diagonal and represents the standard deviation of the structural shocks, while the matrix \( A \) has ones in the main diagonal, and denotes the contemporaneous relationships between the variables in \( Y_t \).

The standard problem in the identification of SVAR models is that there are several possible matrices \( C \) for which \( CC' = \Omega \). In more detail, there are \( k^2 \) parameters in \( C \), while the covariance matrix \( \Omega \) only provides \( k(k+1)/2 \) unique elements. This implies that in order to be able to fully identify the matrix \( C \) we will need additional \( k(k-1)/2 \) restrictions in the form of equations or assumptions on the elements of \( C \). The VAR literature has proposed several different ways to define these additional restrictions, for instance assumptions on the short run and long run relationships between the endogenous variables of the model, or restrictions on the sign of the impact of the shocks of interest. This paper employs a recent approach to SVAR identification which is based on structural changes in the model. As previously mentioned, this approach was introduced by Rigobon (2003) and Lanne and Lütkepohl (2008). Consider a standard reduced-form VAR model, and assume that there is a break in the data (policy changes, major events,...). If \( T_1 \) is the break date, the model can be
written as:

\[ Y_t = b + B_1 Y_{t-1} + \ldots + B_q Y_{t-q} + u_t \]

with \( E(u_t u_t') = \Omega_1 \) for \( t \leq T_1 \) and \( E(u_t u_t') = \Omega_2 \) for \( t > T_1 \). Notice that only the covariance matrix of the reduced-form innovations is assumed to change, while the VAR coefficients remain invariant.

Under some conditions, Lanne and Lütkepohl (2008) show that it is possible to write: \( CC' = \Omega_1 \) and \( C\Lambda C' = \Omega_2 \), where \( \Lambda \) is a diagonal matrix. The number of parameters to be estimated is \( k^2 \) (from \( C \)) plus \( k \) (from \( \Lambda \)), which gives a total of \( 2 \lfloor k(k+1)/2 \rfloor \) parameters. This is exactly the number of restrictions that we obtain from \( \Omega_1 \) and \( \Omega_2 \), so the model is exactly identified if the elements of \( \Lambda \) are different from each other. This framework has the interpretation of allowing for a change in the volatility of the structural shocks of the model, captured by the matrix \( \Lambda \). Indeed, the matrix \( C \) is assumed to change from \( C_1 = A^{-1}\Sigma \) for \( t \leq T_1 \) to \( C_2 = A^{-1}\Sigma \Lambda^{1/2} \) for \( t > T_1 \); this change can be interpreted as a shift in the standard deviation of the structural shocks from \( \Sigma \) to \( \Sigma \Lambda^{1/2} \).

Bacchiocchi and Fanelli (2014) extend the framework of Lanne and Lütkepohl (2008) to incorporate more general changes in the elements of the covariance matrix \( \Omega \). More specifically, they assume that this covariance matrix will change from \( CC' = \Omega_1 \) for \( t \leq T_1 \) to \( (C + \Lambda)(C + \Lambda)' = \Omega_2 \) for \( t > T_1 \). In this case, the matrix \( \Lambda \) will have zero and non-zero elements, so based on these restrictions, the model could be under-identified, exactly identified, or over-identified. Given our previous discussion about the number of parameters to be identified and number of restrictions obtained from the reduced-form covariance matrix, it is straightforward to see that in the framework of Bacchiocchi and Fanelli (2015) there will be no identification improvements unless some of the parameters in \( C \) remain unchanged after the break in the data (i.e., some of the elements of \( \Lambda \) are zero).

In this paper I will implement the approach of Bacchiocchi and Fanelli (2015) and I will focus on changes in parameters that can be interpreted as changes in the policy response to the structural shocks of the model. The model that I obtain is under-identified; for this reason, I will impose additional restrictions based on the sign of the response of the endogenous variables of interest to the structural shocks of the model.

### 1.2 Empirical Analysis

I consider a small VAR model of the Canadian economy, which includes 3 variables: inflation, a measure of real activity, and the interest rate. This choice follows previous contributions in the VAR monetary literature, for instance Primiceri (2005) and Cogley and Sargent (2001 and 2005). More specifically, inflation is measured as the percentage change in the \textit{CPI All Items in Canada}, real activity is measured by the \textit{Unemployment Rate Aged 15 and Over: All Persons for Canada}, and the interest rate is the \textit{3-Month or 90-day Rates and}
Yields: Interbank Rates for Canada. Robustness exercises performed using the Industrial Production index instead of the Unemployment rate and the Overnight Rate instead of the short term Interbank Rate give very similar results.

The data is monthly and goes from January 1981 to December 2008. The structural break date is set on February 1991, which corresponds to the official adoption of the Inflation Targeting regime in Canada.

I analyze 3 different scenarios, in which I identify the SVAR model of interest using an alternative set of restrictions on the matrix $C$. In the first one (which I will call the ”Benchmark” scenario), I identify the SVAR model using a Cholesky decomposition of the matrix $C$. This approach corresponds to imposing a restriction on the order in which the variables affect each other in the model. More specifically, I compute $C_1 = \text{chol}(\Omega_1)$ for $t \leq T_1$ and $C_2 = \text{chol}(\Omega_2)$ for $t > T_1$. The matrices $C_1$ and $C_2$ are unique and lower triangular by construction, so the model is exactly identified. In the second scenario (which I will call ”Exercise 1”), I study the case in which the adoption of Inflation Targeting is assumed to change the volatility of the structural shocks, but not the other parameters of the model. So, in this case I compute $CC' = \Omega_1$ for $t \leq T_1$ and $CAC' = \Omega_2$ for $t > T_1$. As mentioned before, if the elements of the diagonal matrix $\Lambda$ are different from each other, this model is exactly identified as well. Finally, in the third scenario (which I will call ”Exercise 2”) I implement the model as in Bacchiocchi and Fanelli (2015) and I identify the SVAR model of interest using zero restrictions on the matrix $\Lambda$ in addition to sign restrictions on the impact of the structural shocks.

**Benchmark case - Ordering restrictions**

The specific order of the variables that I choose follows the literature on the analysis of monetary policy in a VAR model of the economy (for instance, Primiceri, 2005). The vector $Y_t$ is defined as: $Y_t = [\pi_t \ u_t \ i_t]'$, meaning that the variables are ordered as: inflation rate, unemployment rate, interest rate. This ordering assumes that prices are determined first in the economy, followed by unemployment and the interest rate. The interest rate is typically interpreted as the measure of monetary policy, so the assumption is that monetary policy reacts last, after all the other variables are set. In other words, the monetary authorities are assumed to be able to observe current inflation and unemployment before setting a value for the interest rate.

Figures 1-3 report the responses of the variables of interest to an inflation shock, unemployment shock, and Monetary policy shock respectively.

**Exercise 1 - Changes in volatility, Lanne and Lütkepohl**

The model in this case is identified as explained above, with $CC' = \Omega_1$ for $t \leq T_1$ and $CAC' = \Omega_2$ for $t > T_1$. 
Figures 4-6 report the responses of the variables of interest to an inflation shock, unemployment shock, and Monetary policy shock respectively.

Exercise 2 - Changes in volatility and contemporaneous relationships

In this case, the model is such that: \( CC' = \Omega_1 \) for \( t \leq T_1 \) and \( (C + \Lambda) (C + \Lambda)' = \Omega_2 \) for \( t > T_1 \). The specific assumptions that I make to identify the model are: 1. that the policy reaction to all shocks in the economy might have changed (i.e. \( \Lambda[1 : 3, 3] \) are nonzero); 2. that the impact of the monetary policy shocks on the economy might have changed (i.e. \( \Lambda[3, 1 : 2] \) are nonzero). These restrictions are not enough to be able to exactly identify all the structural parameters of the models, and the SVAR is still under-identified. For this reason, the identification of the monetary policy shocks is supported by the addition of sign restrictions. More specifically, I assume that a monetary policy shock will cause a non-negative change in the interest rate, a non-positive change in the inflation rate, and a non-negative change in the unemployment rate. These restrictions are imposed for one quarter (three months), and they are applied to both \( C \) and \( (C + \Lambda) \).

In addition to monetary policy shocks, I identify structural shocks to inflation using alternative assumptions. The first one is that the volatility of the inflation shocks and its impact on the unemployment rate remain unchanged after the adoption of Inflation Targeting, while the response of monetary policy to these type of shocks is allowed to change. The alternative definition that I implement is that the volatility of the inflation shocks remains unchanged after Inflation Targeting is introduced, but their impact on unemployment and the response of monetary policy is allowed to change.

In this exercise, I focus on the changes in the impact of monetary policy shocks, and in the changes in the response of the interest rate to the structural shocks to inflation. Figure 7 reports the responses of the variables of interest to a Monetary policy shock, while Figure 8 reports the responses to an inflation shock, using the first definition stated above (but the alternative definition produces very similar results). I find that while monetary policy shocks are well (enough) identified, the structural shocks to inflation (and the response of monetary policy to these shocks) are not, which implies that the restrictions that I impose are too loose.

2 Summary of Results

In general, the Figures show that unless strong restrictions are imposed (as in the Benchmark case or in Exercise 1), the small SVAR model of the Canadian economy under analysis in this paper is not very well identified.

When the model is well identified, I find no relevant changes between before and after the adoption of Inflation Targeting either in the impact of monetary policy shocks nor in the response of the interest rate.
(policy variable) to inflation and unemployment shocks. Why is this the case? One possibility is that the time period considered (January 1981 to December 2008) is a relatively "quiet" period, in which no major Monetary policy interventions were required. This implies that, in practice, the adoption of a different policy approach might not have determined any important changes in the policies that were implemented during this period.

**Extension (in progress)**

I also currently working on an additional exercise in which I extend the analysis to incorporate a second break in the data, corresponding to the recent financial crisis. In this exercise, I use data from 1981 to 2015, and I consider two breaks, one represented by the adoption of Inflation Targeting and one occurring at the beginning of the financial crisis. The impact of the Inflation Targeting policy on the volatilities of the shocks and on the contemporaneous relationships between the variables of interest is assumed to be the same as described above, while the recent financial crisis is assumed to have potentially altered the volatility of all the underlying structural shocks of the economy. Preliminary findings show that, as for the main analysis, the transmission of monetary policy shocks in the economy after the adoption of the Inflation Targeting regime remains roughly unchanged.
References


Figures

Figure 1: Shocks to Inflation - Cholesky

![Figure 1: Shocks to Inflation - Cholesky](image)

Figure 2: Shocks to Unemployment - Cholesky

![Figure 2: Shocks to Unemployment - Cholesky](image)
Figure 3: Monetary Policy shocks - Cholesky

Figure 4: Shocks to inflation - Lanne and Lütkepohl
Figure 5: Shocks to Unemployment - Lanne and Lütkepohl

Figure 6: Monetary Policy shocks - Lanne and Lütkepohl
Figure 7: Monetary Policy shocks - Bacchiocchi and Fanelli

Figure 8: Shocks to inflation - Bacchiocchi and Fanelli