Volume 29, Issue 3

Do international spillovers matter for long run neutrality?

Joaquim Pina
Universidade Nova de Lisboa

Abstract

This paper examines whether international spillovers matter for long run neutrality. Using as small open economy Canada, and U.S. for relevant foreign economy, we run three separate VAR systems, with none, some and all cross-border effects. We compare impulse responses and variance decompositions across the systems. We conclude that, for Canada, unless international spillovers are considered, one can mistakenly find that long run neutrality does not hold.

1   Introduction

The question concerning the long run effects of money on real economic activity has been the object of extensive investigation. The quantity theory of money and the belief that changes in money lead to a one-to-one change in prices in the long run were embedded in the earlier literature (e.g. Friedman 1970, Lucas 1980). Moreover, many empirical models of money within the vector autoregressive (VAR) literature assume long run monetary neutrality in their identification schemes (e.g. King, Plosser, Stock and Watson 1991, Galí 1992). However, these views about the long run effects of money have been challenged recently. On the theoretical side, Chari, Jones and Manuelli (1996) study the long run effects of money in endogenous growth models and suggest that neutrality may not hold, and the recent "fiscal theory of the price level" disputes the statement that prices are a monetary phenomenon (see, e.g., Christiano and Fitzgerald 2000, Gordon and Leeper 2006). On the empirical side, robust ways of testing long run monetary neutrality were suggested by Fisher and Seater (1993), King and Watson (1997) and Bernanke and Mihov (1998).

As discussed in the Nobel lecture of Lucas (1996), such a proposition matters for both theory and policy. Long run monetary neutrality has been an important building block for many theoretical models of money. On the other hand, the monetary authority would like to know if the growth rate of real economic activity can be influenced by money, or if money only leads to price responses.

Most of the empirical literature concentrated on U.S. and few papers test long run monetary neutrality in a small open economy. Moreover, although some work was done for various countries, e.g. Weber (1994) and Serletis and Koustas (1998), including for specific small open economies, e.g. Haug and Lucas (1997) and Koustas (1998) for Canada, none takes into account international spillovers. For a detailed discussion on testing long run neutrality see Bullard (1999), who also questions whether taking into account international effects, specially in small open economies, would change results found. This topic is of interest also because the real world is populated by many small open economies and increasingly integrated, sometimes explicitly as in the case of the European Union. Furthermore, because for small open economies foreign shocks are important sources of fluctuations, e.g. Cushman and Zha (1997), one should expect that international spillovers may matter for testing long run neutrality, and that the omission of this information could bias the results.

This paper asks whether international spillovers matter for long run monetary neutrality in a small open economy. To answer this question we use VARs and a flexible identification scheme, where both short run and long run transmission mechanisms are left free and where a robustness analysis over the space of decompositions appears as an essential part of the study. In doing this we follow Canova (1994), who suggests the use of more information than that simply contained in bivariate VAR, to rely less on unit root tests, known to have lower power in small samples, and we use flexible identification schemes, which do not impose zero restrictions *a priori*.

Typically, long run monetary neutrality is intended to mean that a permanent increase in the money stock does not have long run effects on output -only prices rise in proportion- and assumes in the experiment that the change in the money stock is unexpected[1]. We take

---

[1]In the literature, however, appears a puzzling negative relation between inflation and growth, theoret-

this characterization as benchmark, but we define long run monetary effects as the responses of output to a monetary policy shock at the eight years horizon, where a monetary shock is characterized by particular joint responses of money, interest, prices and output.

We choose Canada as a small open economy and U.S. for representative rest of the world economy. We run three different systems and examine, for each, the monetary policy reaction function, the impulse responses and the variance decompositions following a monetary policy shock. First, we run a VAR for each of the countries on home variables -interest, money, prices and output. Then we perform two experiments, starting by including only the bilateral exchange rate in the set of home variables, and run a VAR for each country on this five variables, and finally we run a single international VAR on all home and foreign variables. Our scope is to check whether the long run implications of monetary policy in the small open economy change when we allow for none, some and all sources of cross-border effects to be present.

We find that foreign variables are important for the identification of the Canadian monetary policy reaction function and in testing long run neutrality. Namely, when we do not include international variables, we may mistakenly find that neutrality does not hold for Canada. We also find that monetary policy shocks have a small effect on prices in the long run, which appear to be mainly affected by foreign sector shocks.

The rest of the paper is organized as follows. A characterization of monetary policy shocks is provided in section two together with the corresponding identification scheme. Section three describes the data. Results are in section four and section five concludes.

2 Identifying Monetary Policy Shocks

2.1 Characterization

First, we want to extract monetary policy shocks from the data. According to Christiano Eichenbaum and Evans (1997), a contractionary monetary policy shock should reduce money, produce a mild initial fall of prices, the nominal interest rate is expected to be initially higher, output to fall, real wages decline by a small amount and profits fall. Sims (1998) further indicates that responses of real variables to monetary shocks are small and that monetary policy has historically reacted to inflationary nonpolicy shocks by increasing the nominal interest by more than if there was a fixed money stock policy in place.

For an open economy monetary policy shocks can be identified as follows. From "standard" economic theory, e.g. Krugman and Obstfeld (1991), Schlagenhauf and Wrase (1995), we characterize a monetary policy shock by adding to the above characteristics the following: a home contractionary monetary policy shock should imply an exchange rate appreciation. In addition, depending on the degree of transmission and the relative size of countries, the foreign interest rate may also increase abroad and output and inflation abroad should fall. These are not features that can easily be recovered from the data (see, e.g. Eichenbaum and

---

ically and empirically documented. That is, if changes in money translate one-to-one into inflation and if inflation affects output, then money is not neutral! We keep this in mind, but its solution is beyond the current paper.

Evans 1995, where persistent deviations from the uncovered interest rate parity were found, and Scholl and Uhlig 2007, on monetary policy and exchange rates).

2.2   Identification in VAR

We estimate the reduced form VARs and identify a monetary shock using the sign restrictions approach, suggested by Canova and De Nicoló (2002). Notice that identification of VAR models is, in general, crucial for the results obtained and that great attention must be paid to the economics involved (see, e.g. Canova and Pina 2005 and Bernanke and Mihov 1998). The approach followed provides a theory guided exploration over the space of decompositions (see appendix 1 on the application of sign restrictions identification). In our case, we select among the possible decompositions by imposing the restriction that in response to a monetary shock the sign of the impulse response of the interest rate should be of the opposite sign of that of money -i.e., a liquidity effect- and that the responses of money and output should have the same sign. More specifically, we accept as "valid" decompositions those where the conditions imposed are verified for at least 72 of the 96 months used as horizon for the impulse response functions. In this way we allow, for example, for some initial sluggishness or late reversion to the initial level.

One may ask why we use an alternative scheme when there exist informative identification procedures as those proposed by King and Watson (1997) and Bernanke and Mihov (1998)[2]. These schemes are very informative, making an explicit link between propositions like the liquidity effects and long run neutrality and, in the latter paper, rooting the underlying specification to a model of bank reserves. However, both methodologies have problems. The first is problematic, from a statistical point of view because of the weak instruments problem (see Sarte 1997) and the heavy reliance on unit root testing (see Canova 1994), and because it may become complicated from the sensitivity analysis point of view since it requires a large set of experiments, and many hypothesis about parameter values. The second procedure requires the use of variables that map into/from the underlying "micro" markets, and this is hard to do when many variables and more than one country are involved. Moreover, this may be impossible to do when someone wants to identify nonmonetary shocks (see also Galí 1998).

To overcome these difficulties, we chose the sign restrictions approach which is an informative and easily implementable identification scheme. The sign restrictions approach was also suggested by Bernanke and Mihov (1998) as an alternative way to study long run neutrality.

3   Data and Specification

We use monthly data for U.S. and Canada from January 1960 to July 2007. The data includes the industrial production index as measure of real activity, the consumer price index, M1 as measure of money, the fed funds for U.S. and the treasury bill rate for Canada as measures of interest rates, and the bilateral exchange rate in Canadian dollars. The U.S.

---

[2]We discard the use of Fisher and Seater (1993) approach because it is less informative and because it relies heavily on getting unit root testing right, which is statistically difficult.

is intended to represent a "rest of the world" economy for Canada, which is treated as the small open economy. A detailed description of the data can be found in appendix 2.

All the variables appear to have a unit root according to ADF tests. No strong cointegration relation was found using Johansen tests. So that we specify a VAR in first differences. Seasonal dummy variables are introduced to eliminate seasonal fluctuations which remained in some series. In addition, we add a dummy variable for the fixed/stable exchange rate period, May1962 to May 1970. The late 1979 and early 1980 years specific period was taken out from the estimation sample, October 1979 to September 1982, following, e.g., Bernanke and Mihov (1998) and Galí et al. (2003). Finally, a dummy variable was introduced to capture September and October 2001 behavior.[3] We select the lag order with Akaike and Schwarz criteria and choose in both the four and five variables VAR 8 lags for U.S. and 7 lags for Canada and in the international VAR 7 lags.

4 The Results

We found many identifications satisfying the restrictions characterizing a monetary policy shock. For example, in the four variables system we selected four identifications for Canada and three for U.S., which are reported in Figure 1 (only point estimates). These identifications in the four variables system suggest, in particular for Canada, that there are two families of impulse responses. On the one side, the responses of the interest rate, prices, money and output are of similar magnitude, and on the other side, the responses of money and output are of smaller magnitude than those of the interest rate and prices. A possible interpretation for this result, could be that in the second set of identifications relative to the first, we are more likely to find that neutrality may hold and that prices would be more affected by the monetary shocks. However, after including error bands all impulse responses look alike. The bands we consider herein are 68 per cent error bands (16th and 84th percentiles) following Sims and Zha (1999).

In our analysis, we select a single representative identification for Canada and another for U.S. in each of the VAR systems considered. In the four variables system the identified monetary policy rule for Canada, taking into account the error bands, resembles a combination of partial accommodation and a Taylor rule, while for U.S. indicates an interest rate rule with mild (nonsignificant) weight on inflation (see Table I). For U.S. a similar pattern is observed in the five variables system, whereas for Canada the large error bands only allow to suggest that possibly an interest rate rule with mild weight on money and the exchange rate would be identified. In the international VAR, where it was harder to find many identifications and large error bands for U.S. and Canada monetary policy rules were common, we may indicate an interest rate rule for U.S. and a monetary policy rule for Canada that mainly weights foreign variables. These patterns for the monetary policy reaction functions correspond to relative weights of monetary policy shocks in explaining output and prices in the long run (see Table II), and are also featured in impulse responses (see Figure 2). When the policy rule puts weight on prices/exchange rate we obtain that monetary policy shocks

---

[3]Sims and Zha (2006) point out to either absence of time varying monetary policy rule or changes in line with well known regimes.

explain more of prices behavior and somehow less of output relative to when the policy rule is closer to an interest rate rule.

4.1 Monetary Policy Rule

The identified monetary policy reaction functions (see Table I) suggest, in general, that for a small open economy international spillovers matter. The marginal difference relative to the home VAR obtained from adding just the exchange rate is higher then the one obtained by adding the remaining set of foreign variables.

The policy reaction function for Canada, estimated using only home variables, suggests that the nominal interest rate is the main instrument, possibly with some weight given to money, inflation and output. When we introduce the exchange rate in the system, this latter variable and money are likely to be the most weighted ones. In the international VAR, where cross-border effects are fully considered, foreign variables, are, in general, the most weighted variables in the monetary policy reaction function. These results suggest that estimating closed economy VARs for small open economies may lead to a bias in the identified reaction function. Actually, the Canadian monetary authority followed until the end of 2006 a Monetary Conditions Indicator where the exchange rate had a large weight.

For U.S. this does not seem to be the case, at least when the foreign country is Canada, and that a pure interest rate rule is supported in the data, although a rule where the interest rate reacts to prices may be also consistent with data.

4.2 Long run Neutrality

We report the impulse responses and the variance decompositions to a domestic monetary policy shock, in Figure 2 and in Table II, respectively, using as long run an 8-years horizon.

Impulse responses suggest that monetary policy shocks are likely to be neutral in the long run. International spillovers seem to matter for testing long run neutrality, mostly for Canada and particularly when introducing the exchange rate versus the home system. Namely, only when international variables are included in the VAR we tend to find that neutrality holds, otherwise we may find that neutrality does not hold.

The variance decompositions support similar conclusions. While in the home four variables VAR for Canada one may conclude that long run neutrality does not hold, in the five variables and in the international VAR systems it holds.

A surprising finding is the relatively low importance of monetary policy for prices in the long run, which appear to be mainly driven by foreign shocks[4].

---

[4]To this finding we could add some alternative and complementary interpretations. For money to be neutral one must find that it does not affect neither output nor prices in the long run, since prices appear to be (negatively) related with output. Another explanation for the low importance of monetary policy shocks for prices rely on the idea that price movements may not be just a monetary phenomenon, that other factors may be important, in particular related with the "fiscal theory of the price level".

5   Conclusions

When evaluating long run neutrality in a small open economy the existing literature does not take into account international spillover effects. This paper asks whether the cross-border effects are important for long run neutrality in a small open economy, such as Canada.

To answer this question we run three systems, one with four home variables, to the second with add the exchange rate and in the third one we use all variables -home, foreign and the exchange rate. We identify a monetary policy using a sign restrictions approach and compare across systems the identified impulses responses and variance decomposition at the 8-year horizon.

Our analysis suggests that foreign variables are important to describe Canadian monetary policy reaction function and crucial in testing long run neutrality. In particular, we show that unless international spillovers are considered, one may mistakenly conclude that monetary policy shocks have long run effects on output. This is in contrast with the conclusions for neutrality in Canada of Haug and Lucas (1997) and Koustas (1998). However, this authors use bivariate frameworks and different measures of economic activity and of money, as well as a different frequency for the data and time period analyzed. We also find that in international frameworks domestic monetary policy shocks have a very small effect on prices in the long run which seem to be primarily driven by foreign shocks.

References

[1] Bernanke, B. and Mihov, I. (1998) "The Liquidity Effect and Long-Run Neutrality" *Carnegie Rochester Conference Series* 49, 149-194.

[2] Bullard, J. (1999) "Testing Long Run Monetary Neutrality Propositions: Lessons from the Recent Research" Federal Reserve Bank of St. Louis *Review* 81, 57-78.

[3] Canova, F. (1994) "Testing Long-Run Neutrality: Empirical Evidence for G7-Countries with Special Emphasis on Germany, A Comment", *Carnegie-Rochester Conference Series on Public Policy* 41, 119-125.

[4] Canova, F. and De Nicoló, G. (2002) "Monetary Disturbances Matter for Business Cycle Fluctuations in the G-7" *Journal of Monetary Economics* 49, 1131-1159.

[5] Canova, F. and Pina, J. P. (2005) "What VAR Tell us about DSGE Models?", in *New Trends in Macroeconomics* by C. Diebolt and C. Kyrtsou, Eds., Springer-Verlag, 89-123.

[6] Chari, V. V., Jones, L. and Manuelli, R. (1996) "Inflation, Growth, and Financial Intermediation" Federal Reserve Bank of St. Louis *Review* 78, 41-58.

[7] Christiano, L., Eichenbaum, M. and Evans, C. (1997) "Sticky Price and Limited Participation Models of Money: A Comparison" *European Economic Review* 41, 1201-1249.

[8] Christiano, L. and Fitzgerald, T. (2000) "Understanding the Fiscal Theory of the Price Level", *manuscript,* Northwestern University and Federal Reserve Bank of Cleveland.

[9] Cushman, D. and Zha, T. (1997) "Identifying Monetary Policy in a Small Open Economy under Flexible Exchange Rates" *Journal of Monetary Economics* 39, 433-448.

[10] Eichenbaum, M. and Evans, C. (1995) "Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates" *The Quarterly Journal of Economics* 110, 975-1009.

[11] Faust, J. (1998) "The Robustness of Identified VAR Conclusions About Money" *Carnegie Rochester Conference Series* 49, 207-244.

[12] Friedman, M. (1970) *Wincott Memorial Lecture*, London.

[13] Galí, J. (1992) "How Well Does The IS-LM Model Fit Postwar U.S. Data?" *The Quarterly Journal of Economics* 107, 709-738.

[14] Galí, J. (1998) Comment on "The Liquidity Effect and Long-Run Neutrality" *Carnegie Rochester Conference Series* 49, 195-206.

[15] Galí, J., López-Salido, D. and Vallés, J. (2003) "Technology shocks and monetary policy: assessing the Fed's performance" *Journal of Monetary Economics* 50, 723-743.

[16] Gordon, D. and Leeper, E. (2006) "The Price Level, the Quantity Theory of Money, and the Fiscal Theory of the Price Level" *Scottish Journal of Political Economy* 53, 4-27.

[17] Haug, A. and Lucas, R. F. (1997) "Long-Run Neutrality and Superneutrality in an ARIMA Framework: Comment" *The American Economic Review* 87, 756-759.

[18] King, R., Plosser, C., Stock, J. and Watson, M. (1991) "Stochastic Trends and Economic Fluctuations" *The American Economic Review* 81, 819-840.

[19] King, R. and Watson, M. (1997) "Testing Long-Run Neutrality" Federal Reserve Bank of Richmond *Economic Quarterly* 83, 69-101.

[20] Koustas, Z. (1998) "Canadian Evidence on Long-Run Neutrality Propositions" *Journal of Macroeconomics* 20, 397-411.

[21] Krugman, P. and Obstfeld, M. (1991) *International Economics, Theory and Policy*, Harper Collins.

[22] Lucas, R. E., Jr. (1980) "Two Illustrations of the Quantity Theory of Money" *The American Economic Review* 70, 1005-1014.

[23] Lucas, R. E., Jr. (1996) "Nobel Lecture: Monetary Neutrality" *Journal of Political Economy* 104, 661-682.

[24] Sarte, Pierre-Daniel (1997) "On the Identification of Structural Vector Autoregressions" Federal Reserve Bank of Richmond *Economic Quarterly* 83, 45-67.

[25] Serletis, A. and Koustas, Z., 1998, "International Evidence on the Neutrality of Money" *Journal of Money, Credit, and Banking* 30, 1-25.

[26] Sims, C. (1992) "Interpreting the Macroeconomic Time Series Facts: the Effects of Monetary Policy" *European Economic Review*, 36, 975-1000.

[27] Sims, C. (1998) Comment on G. Rudebusch's "Do measures of Monetary Policy in a VAR make sense?" *International Economic Review* 39, 933-941.

[28] Sims, C. and Zha, T. (1999) "Error Bands for Impulse Responses" *Econometrica* 67, 1113-1156.

[29] Sims, C. and Zha, T. (2006) "Were There Regime Switches in U.S. Monetary Policy?" *The American Economic Review* 96, 54-81.

[30] Schlagenhauf, D. and Wrase, J. (1995) "Exchange Rate Dynamics and International Effects of Monetary Shocks in Monetary, Equilibrium Models" *Journal of International Money and Finance* 14, 155-177.

[31] Scholl, A. and Uhlig, H. (2007) "New Evidence on the Puzzles: Results from Agnostic Identification on Monetary Policy and Exchange Rates", *manuscript*,Goethe University Frankfurt and Humboldt-UniversitÄat zu Berlin.

[32] Uhlig, H. (1998) Comment on "The Robustness of Identified VAR Conclusions About Money" *Carnegie Rochester Conference Series* 49, 245-264.

[33] Uhlig, H. (2005) "What are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure" *Journal of Monetary Economics* 52, 381-419..

[34] Weber, A. (1994) "Testing Long-Run Neutrality: Empirical Evidence for G7-Countries with Special Emphasis on Germany" *Carnegie-Rochester Conference Series on Public Policy* 41, 67-117.

6   Appendix 1: Applying sign restrictions approach

The reduced form unrestricted VAR (1) is estimated with OLS equation by equation,

$$z_t = B(L)z_{t-1} + u_t \tag{1}$$

where z_t is the vector of variables included, L is the lag operator, $B(L)$ a matrix polynomial and u_t has covariance matrix Σ_u.

We identify shocks by choosing an invertible A_0 matrix such that $A_0 A_0' = \Sigma_u$, where the covariance matrix of the structural shocks, ε_t, is the identity matrix and $u_t = A_0 \varepsilon_t$,

$$A_0^{-1} z_t = A(L)z_{t-1} + \varepsilon_t \tag{2}$$

and $A(L) = A_0^{-1} B(L)$. To find A_0, that is to identify the structural model (2), we do not impose *a priori* exclusion restrictions, neither in the short run nor in the long run as it is common in the literature. Instead we use an eigenvalue-eigenvector decomposition of Σ_u, $PDP' = \Sigma_u$, where P is the matrix of eigenvectors and D is a diagonal matrix containing the eigenvalues of Σ_u, and compute $A_0 = PD^{1/2}$. Next, with the computed A_0 we inspect the joint behavior of variables in response to a particular shock and check if it matches that imposed by economy theory; if there is not a match between estimated and theoretically predicted signs of responses to the monetary shock, then we go on and try an alternative decomposition, $\tilde{A}_0 = A_0 * Q$, where Q is an orthonormal matrix, $QQ' = I$ (for related identification schemes see Faust (1998) and Uhlig (2005). That is, we search for all decompositions which satisfy the restrictions imposed by economic theory and then choose those which are "reasonable".

The identification scheme adopted here has the property of leaving unrestricted both the short run and the long run relations among variables. Economic theory is used here to pin down the "required" joint behavior of the variables following a monetary policy shock. This machinery can be viewed as a road for systematically exploring the space of identifications.

To make the identification scheme operational we run the following algorithm, having as an example the closed economy VAR of the paper:

(i) Establish, from theory, that a monetary policy shock is characterized by impulse responses of real output, consumer prices and money that are all of the same sign and of opposite sign to that of the nominal interest rate for any 72 points/months of the 96 months-horizon of the impulse response functions;

(ii) Identify the structural VAR without imposing neither short neither long run zeros *a priori*, which can be done using an eigenvalue-engenvector decomposition of the innovations covariance matrix, Σ_u, $PDP' = \Sigma_u$, where P is the matrix of eigenvectors and D is a diagonal matrix with the eigenvalues;

(iii) The decomposition just done means that the $A_0 = PD^{1/2}$, a (possibly full) impact matrix of shocks, where $A_0 A_0' = \Sigma_u$; importantly, particularly for our paper, notice that the long run effects are left free;

(iv) Compare the signs of the estimated impulse response functions, obtained from (iii), against those established in step (i);

(v) if a match is found in (iv), stop and select A_0 computed in (ii); otherwise, select an alternative decomposition, $\tilde{A}_0$, using an orthonormal matrix Q, $\tilde{A}_0 = A_0 * Q$, where Q can

be the rotation matrix, which rotates two-columns by angle θ, e.g.

$$Q = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \cos(\theta) & -\sin(\theta) \\ 0 & 0 & \sin(\theta) & \cos(\theta) \end{bmatrix}$$

where, in the four variables system, means that (only) columns 3 and 4 of A_0 are rotated by an angle θ;

(vi) The signs of the impulse responses obtained with the chosen $\tilde{A}_0$ in (v), i.e., Q and θ, are compared against those established in (i); we repeat the latter two steps, (v) and (vi) until a match is found; notice that there are $n(n-1)/2$ alternative Q (for a given angle, θ), where n is the number of variables in the VAR and that θ can any over $[0, 2\pi]$ (searched with a finite grid)[5].

Among the recovered decompositions in our VAR systems note that we have eliminated the set of those that exhibited a price puzzle (see Sims 1992). The procedure employed actually delivered sets of decompositions, for the three VAR systems we run, which are not singletons (see the four variables system for Canada and U.S. in Figure 1).

---

[5]For the angle of rotation, θ, we consider a grid of 120 points over $[0, 2\pi]$. Alternative grids were tried without significant changes for the results.

To save on computational time we actually explored the $[0, \pi/2]$ interval because of the form of the orthonormal matrix and because of the trigonometric result $\cos(\theta + \pi/2) = \sin(\theta)$.

7   Appendix 2: Data description

Empirical identification of monetary policy usually bounds researchers to choose monthly periodicity, which is the one closest to its decision time interval in real world. This is also our choice.

Monthly observations, however, possess few long run information. This drawback is in turn minimized as we use a long time series span, from 1960:January to 2007:July.

Because we believe that bivariate systems leave too much useful information outside we choose as benchmark the four variables system[6].

The exact description of the data, with source code, follows:

- International Monetary Fund's International Financial Statistics on CD-ROM

    - *Treasury bill rate (percent per annum, averages,* Canada*), 156 60C..*
    - *Consumer prices (index number, base year: 2000, averages,* Canada*), 156 64...*
    - *Industrial production seasonally adjusted (index number, base year: 2000, averages,* Canada*), 156 66..C*
    - *Exchange rate index 2000=100 (index number, averages,* Canada*), 156 ..AHX*
    - *Federal funds rate (percent per annum, averages,* United States*), 111 60B..*
    - *Consumer prices (index number, base year: 2000, averages,* United States*), 111 64...*
    - *Industrial production seasonally adjusted (index number, base year: 2000, averages,* United States*), 111 66..C*

- OECD Main Economic Indicators on CD-ROM

    - *Monetary aggregate M1 SA (Quantum, seasonally adjusted,* Canada*), 446003DSA*
    - *Monetary aggregate M1 SA (Quantum, seasonally adjusted,* United States*), 426003DSA*

In order to keep definitions clear and homogeneous we retrieve most series from IFS statistics and only the monetary aggregates from OECD Main Economic Indicators, because in there we could find M1 seasonally adjusted on comparable basis.

The use of the treasury bill rate for Canada, instead of a call rate, is due to the choice for the longest possible time span. Both nominal interest rates were transformed to a monthly basis, and taken in decimals.

The exchange rate appears defined in Canadian dollars per USD, therefore when in it increases (decreases) it means a depreciation (appreciation).

All variables were log-transformed, hence when differencing we obtain (approximately) their growth rates.

---

[6]In bivariate systems we may be excluding relevant information, which may lead to a bias in the results. To this problem we could also add the interpretation problems deriving from an incorrect aggregation of structural shocks.

8   Tables

Table I - Monetary policy reaction function

Four variables home systems

Rotation	Angle	Monetary Policy Shock	△ Interest	Growth of Money	Inflation	Growth of Output
			Canada			
2 - 4	1.05	2	2720.705 [2614.404,2809.707]	−52.437 [-57.884,51.135]	−15.949 [-27.730,-2.325]	− 13.431 [-22.885,-1.630]
			U.S.			
3 - 4	0.84	4	2980.842 [2874.627,3071.437]	22.018 [-32.054,37.765]	−283.240 [-303.695,283.897]	− 22.178 [-32.917,9.583]

Notes: Rotation column exhibits the relevant rotated columns of the standardized eigenvalue-eigenvector matrix of decomposition; angle column indicates the angle of rotation measured in radians; monetary policy shock column points out the number of the selected shock; in brackets are the error band defined by the 16th and 84th percentiles.

Table I (continued) - Monetary policy reaction function

Five variables home systems

Rotation	Angle	Monetary Policy Shock	△ Interest	Growth of Money	Inflation	Growth of Output	Growth of Exchange rate
					Canada		
3 - 5	0.52	3	1588.112 [-1587.291,1650.434]	−73.147 [-90.941,89.691]	−7.649 [-16.723,8.368]	−2.215 [-20.220,15.202]	− 5.625 [-42.365,51.030]
					U.S.		
4 - 5	0.99	5	2443.697 [2348.365,2523.916]	16.352 [-43.577,39.690]	−309.328 [-336.138,332.218]	−14.969 [-33.969,19.172]	− 3.391 [-7.851,1.883]

Notes: Rotation column exhibits the relevant rotated columns of the standardized eigenvalue-eigenvector matrix of decomposition; angle column indicates the angle of rotation measured in radians; monetary policy shock column points out the number of the selected shock; in brackets are the error band defined by the 16th and 84th percentiles.

Table I (continued) - Monetary policy reaction function

Nine variables international system

Rotation	Angle	Monetary Policy Shock	△Rc	g.Mc	Infl.C	g.Yc	g.Exchange rate	△Rus	g.Mus	Infl.US	g.Yus
							Canada				
			0.061	0.719	−9.473	−14.538	0.5731	0.033	−132.743	−5.836	74.889
			[-0.543,	[-11.386,	[-51.994,	[-30.764,	[-11.855,	[-0.539,	[-165.414,	[-38.851,	[-126.455,
1 − 9		5	0.668]	12.929]	50.156]	31.968]	12.031]	0.599]	155.920]	37.923]	123.150]
and	0.73						U.S.				
4 − 5		1	−720.994	−0.947	−6.251	−64.169	7.868	3116.592	−1.639	8.437	−15.857
			[-970.293,	[-18.426,	[-22.566,	[-73.400,	[-22.440,	[-3230.070,	[-10.678,	[-17.627,	[-22.483,
			848.469]	15.018]	17.238]	-48.171]	37.084]	3277.914]	10.728]	27.227]	-7.534]

Notes: Rotation column exhibits the relevant rotated columns of the standardized eigenvalue-eigenvector matrix of decomposition; angle column indicates the angle of rotation measured in radians; monetary policy shock column points out the number of the selected shock; in brackets are the error band defined by the 16th and 84th percentiles.

Table II - Variance decomposition at 8-year horizon

| | CANADA | | | U. S. | |
	Output	Prices		Output	Prices
Monetary Policy Shock					
Four variables VAR	[2.3, 28.9]	[0.3, 6.3]		[0.3, 5.0]	[1.0, 91.2]
Five variables VAR	[0.6, 22.1]	[0.4, 9.9]		[0.2, 4.8]	[5.0, 90.3]
International VAR	[0.9, 12.5]	[0.6, 23.1]		[2.1, 19.1]	[0.3, 20.6]

Note: reported values, in brackets, are the 16th and 84th percentiles.
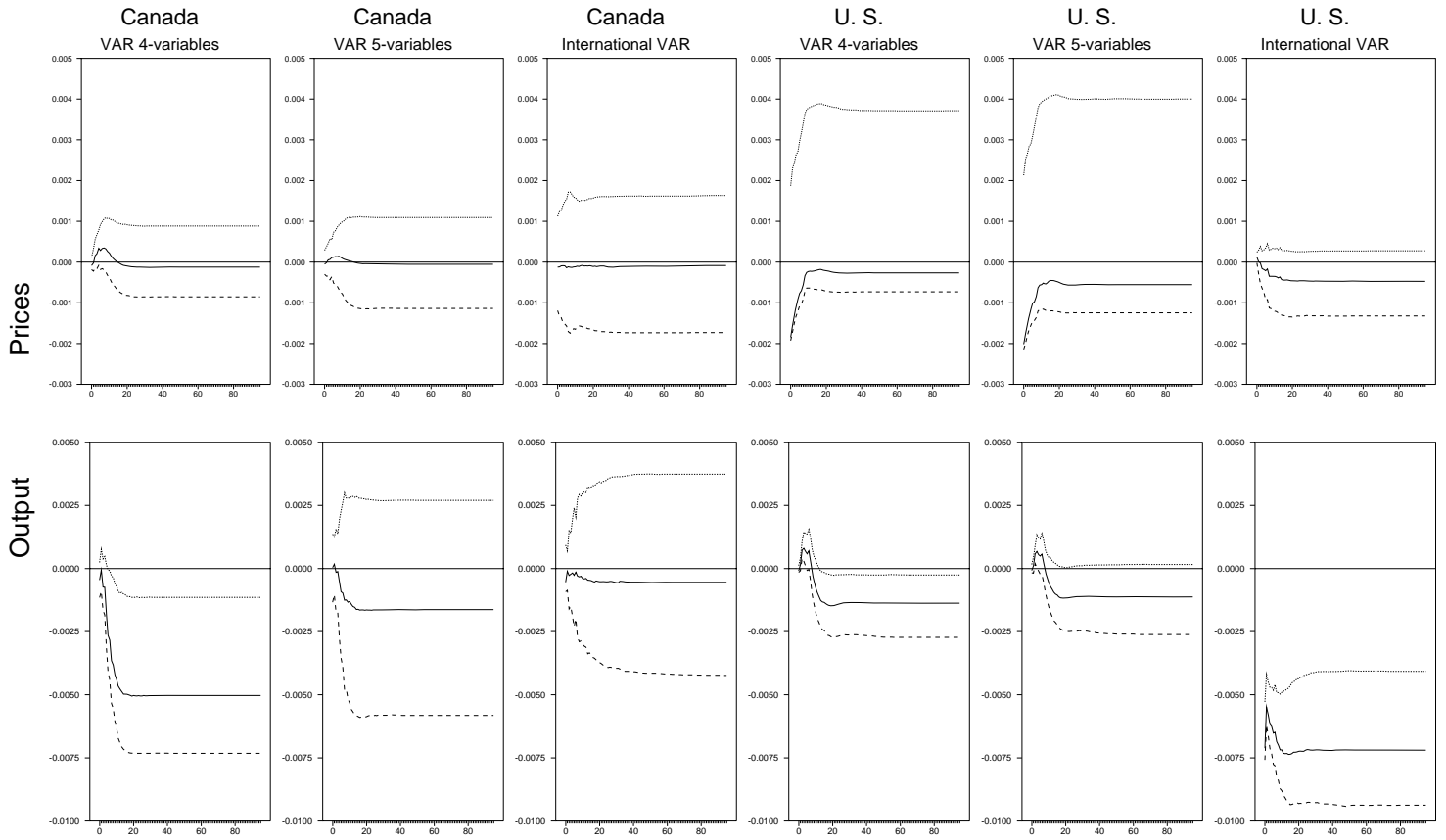
Figure 1

Impulse Responses to a Monetary Policy Shock - VAR 4-variables
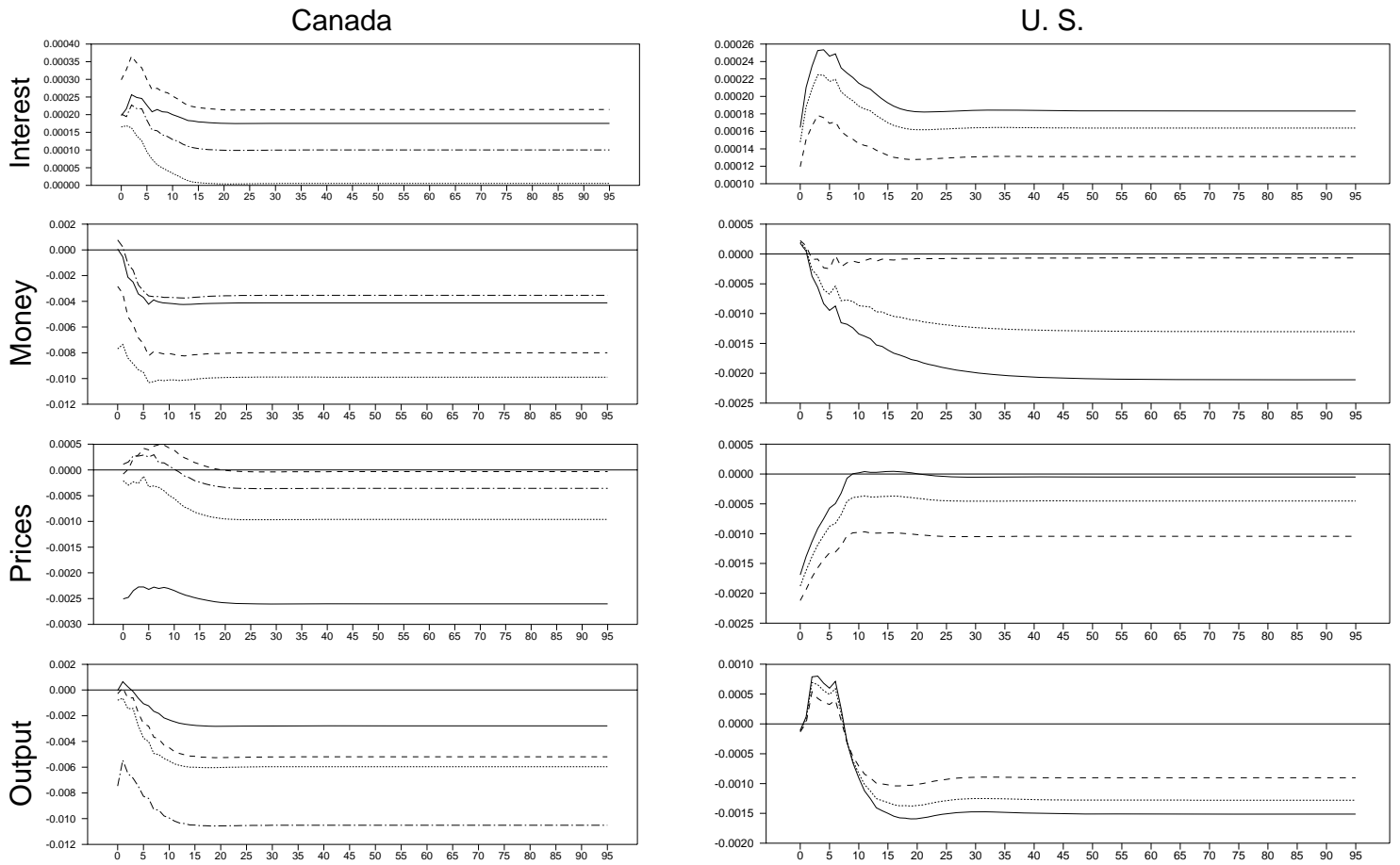
Note: Sample of selected impulse responses (point estimates)

Figure 2

Impulse Responses to a Monetary Policy Shock

Note: Solid line is impulse response; dashed lines are 68 per cent error bands