

EXAMINING THE GREAT MODERATION HYPOTHESIS FOR CANADA

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Abstract

A number of studies have documented a reduction in the volatility of the growth rate of US GDP since the mid-1980s. This reduction has been called “the great moderation.” In this paper I investigate the possibility of a great moderation in Canada and find evidence of a moderation beginning in the third quarter of 1981(1981:3). A decomposition of the variances and covariances of the components of GDP indicates that a fall in the variance of the interest-rate sensitive components accounts for the moderation. Using a structural VAR model, I find evidence of a reduction in the response of output and the inflation rate to monetary policy shocks after 1981:3. Counterfactual experiments demonstrate that monetary policy has not become less effective. The main finding is that more stable monetary policy accounts for the drop in volatility of output.

Keywords: the Great Moderation; structural VAR; monetary policy

Subject Terms: Gross Domestic Product; monetary policy

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1 Introduction

Over the past 20 years, the volatility of most macroeconomic data has declined in most industrialized countries, for example the G7 (Canada, Italy, German, France, Japan, the United Kingdom and the United States). This phenomenon has been well documented and the then Federal Reserve Board Governor Bernanke (2004) described the reduction in this volatility as “The Great Moderation.”¹

Reduced macroeconomic volatility has numerous consequences. Lower output volatility suggests less economic uncertainty confronting households and firms, and it appears to coincide with lower volatility of unemployment. Also lower output volatility appears associated with the less frequent and less severe recession. Lower inflation volatility reduces the uncertainty of long- term investment return and reduces the resources devoted to insuring against inflation shocks. Thus, lower inflation volatility may, in theory, improve the efficiency of investment.

In this paper I investigate whether Canada is also experiencing a “Great Moderation” similar to the US and, if so, when the moderation began. To identify the timing of the moderation I test for a structural break in the volatility of Canadian GDP. For robustness, I use two methods. The first test, proposed by Shimotsu (2006), distinguishes between long memory and structural breaks and

¹ On February 20, 2004, at the Eastern Economics Association Meetings, Bernanke described this phenomenon as “the great moderation”.

is well-suited to series, such as the GDP growth rate that may have long cyclical components. The second test, proposed by Inclan and Tiao (1994), identifies the timing of a structural break point. Both tests confirm the presence of a moderation for Canada and the second test dates the timing of the moderation as the third quarter of 1981 (1981:3).

It remains, however, an open question as to what has caused the “Great Moderation.” Using Canadian data, I investigate the contribution of monetary policy changes in explaining the moderation.

One notable difference between Canada and the U.S. is in the conduct of monetary policy. Unlike the U.S. Federal Reserve, the Bank of Canada began a policy of inflation targeting in 1991. Using US data, Boivin and Giannoni (2003) argue that changes in monetary policy help explain the moderation in the U.S. In term of Canadian data, I find that decomposing Canadian GDP into broad expenditure categories suggests that most of the moderation has been in consumption and investment – two interest-rate sensitive sectors. Thus, I next consider whether monetary policy in Canada explains the moderation using the structural vector autoregression proposed by Boivin and Giannori (2002). I find that monetary policy contributes to the moderation in output in Canada. However, in contrast to Boivin and Giannoni, I find the great moderation in Canada results largely from a reduction in the volatility of monetary policy shocks. It may be that a change in monetary policy has lead to fewer, or smaller, policy errors.

The rest of the paper is organized as follows: Section 2 is literature review.

Section 3 describes the data. Section 4 uses the two tests provided by Shimotsu (2006) to test long memory and structural breaks. In these tests I demonstrate that there exists structural breaks. Then I apply the test of the cumulative sums of squares of Inclán and Tiao (1994) to find the structural break. Section 5 decomposes output and examines the variances and covariances of the components. Section 6 presents the structural VAR model of Boivin and Giannoni(2003) , and uses counterfactual analysis to examine the effect of monetary policy. Section 7 concludes.

2 Literature Review

There have been numerous studies that have documented the evidence of a “Great Moderation” in U.S. GDP volatility. Kim and Nelson (1999), McConnell and Perez-Quiros(2000) , Blanchard and Simon(2001), Stock and Watson(2003) , Summer (2005), and Owyang, Piger and Wall(2007) have all found evidence to support a “Great Moderation” that began, approximately, in the mid-1980s. Despite unanimity in the presence, and approximate timing of the moderation, there remains uncertainty as to the cause. Five candidate explanations in the literature are: improvements in monetary policy, innovations in financial markets; good luck; changes in the external balance, and; changes in the composition of the labour force.

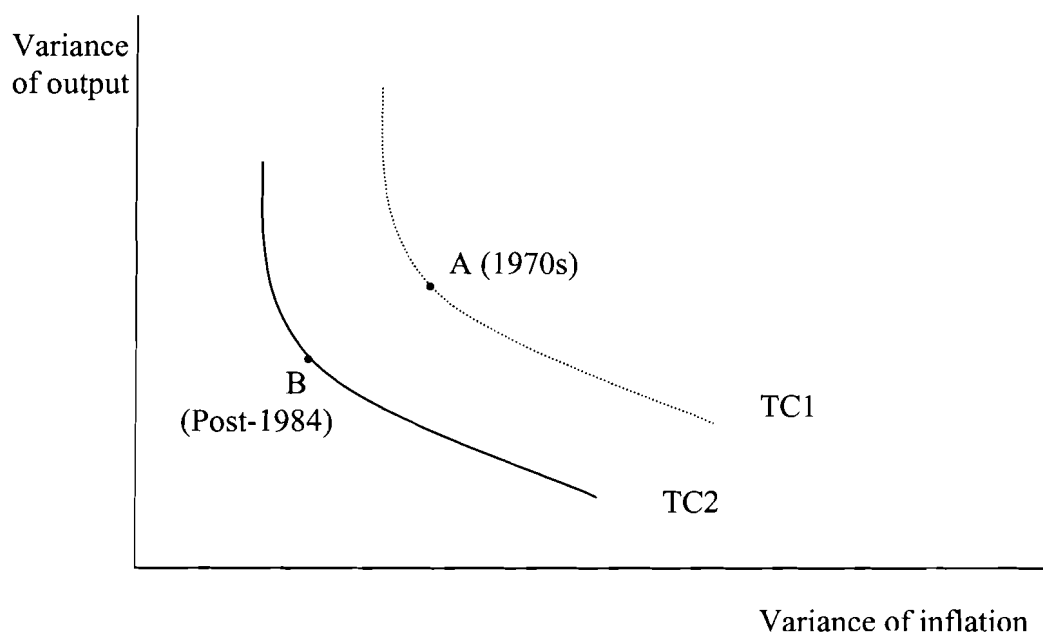
One view is that improvements in monetary policy, though not the only factor, have been an important source of the Great Moderation. For example, Boivin and Giannoni(2003) suggest changes in monetary policy have dampened economic fluctuations. Bernanke (2004) provides some support for the “improved-monetary-policy” explanation for the Great Moderation.² He argues that improvements in the effectiveness of monetary policy are the main reason for reaching the Taylor curve³ even in the absence of any change in the structure of the economy or in the underlying shocks. Improvements in the policy framework, in policy implementation, or in the policymakers' understanding of the economy

² Bernanke, the great moderation, remarks by Governor Ben S. Bernanke, at the meetings of the Easton Economics Association, Washington, DC, February 20, 2004.

³ John B. Taylor (1998). Graphically, the Taylor curve depicts the possible combinations of output volatility and inflation volatility from which monetary policymakers can choose in the long run.

could allow the economy to move from the inefficient point *A* to the efficient point *B*, where the volatility of both inflation and output are more moderate. Meanwhile, DeLong(1997), Romer and Romer(2002) also suggest that monetary policy during the late 1960s and the 1970s was unusually prone to creating higher volatility because of some misconceptions about policy, than in both earlier and later periods.

Figure 2.1: The Taylor curve



Note: from Bernanke (2004), the great moderation, Remarks by Governor Ben S. Bernanke, at the meetings of the Eastern Economic Association, Washington, DC. February 20, 2004.

To investigate the role of monetary policy changes more thoroughly, several authors try to show whether and how monetary policy contributes to the Great Moderation (see Clarida, Gali and Gertler, 1997, they estimate a forward-looking monetary policy reaction function for the postwar US economy before and after

Volcker's appointment as Fed Chairman in 1979, and show that the Volcker-Greenspan rule is stabilizing). Boivin and Giannoni (2002) demonstrate most of the reduced volatility is due to a change in the monetary transmission mechanism. Boivin and Giannoni (2003) also investigate the implications for the evolutions of monetary policy effectiveness using a structural vector autoregression (SVAR). Although the impulse response functions of output and inflation from their SVAR analysis appear less sensitive after the beginning of the moderation, they find that monetary policy has been more stabilizing since the mid-1980s as a contributor to the "Great Moderation", rather than becoming less effective. Using Markov Switching VAR model, Benoit (2007) also investigate the role of monetary policy in two related aspects of the great moderation: the mid 1980's decline of US output volatility and the decoupling of household investment expenditure from the business cycle. In contrast to Boivin and Giannoni(2002), Benoit finds that changes in the size of monetary policy shocks affect output volatility by affecting the correlation between GDP components and their volatility, rather than the changes in monetary transition mechanism. This conclusion is consistent with Leeper and Zha (2003) and Canova (2005), who also show that the monetary transition mechanism has changed little over the last 40 years. However, all studies provide evidence in common that monetary policy does account for a sizeable fraction of the "Great Moderation."

A second explanation for the "Great Moderation" has been that either a structure change or "Good Luck" has been the driving factor of output stabilization. Kahn et al.(2000) suggest that innovations to inventory

management have smoothed output; meanwhile the innovations in the financial market regulations during this period are demonstrated by Gertler and Lown(2000), Barth and Ramey(2001), as one possible cause behind of the decline of macroeconomic volatility . Stock and Watson (2003) simulate how the economy would have performed after 1984 if monetary policy had followed its pre-1979 pattern. Although inflation performance after 1984 would clearly have been worse if pre-1979 monetary policies had been used, Stock and Watson find that output volatility would have not been much different. They conclude that improved monetary policy does not account well for the reduction in output volatility since the mid-1980s. Instead, noting that the variance of the economic shocks implied by their models for the 1970s was much higher than the variance of shocks in the more recent period, they support the good-luck explanation of the “Great Moderation.” Similarly, Cogley and Sargent (2002) and Ahmed, Levin, and Wilson (2004) find a substantial reduction in the size and frequency of shocks in the recent period, which provide evidence to support the good-luck hypothesis. Ahmed et al. (2004) suggests that, the nature of the innovations themselves possibly have changed, for example, oil shocks become less frequent in this period. Jaimovich and Siu (2006) focus on the changes in the composition of the labour market, arguing that the aging of baby boomer has raised the average age of the working population, as a result, leading to a reduction in job-to-job transitions. Fogli and Perri (2006) examine the influence of the US external imbalance, assessing “how much of the observed

deterioration of the US net foreign asset position can be explained by the reduction in the volatility of the US shocks.”

3 Data

I use a sample of the growth rate of real GDP in Canada, y_t , where $y_t = 100 \times (\ln Y_t - \ln Y_{t-1})$, and $\ln Y_t$ equals the natural logarithm of real GDP from 1961:1 to 2007:2. The quarterly data of real GDP in 1992 price are from CANSIM. Due to the difference, I have 185 observations. The mean, variance and autocorrelation parameter of the growth rate is 3.02, 3.04 and 0.76 respectively in the whole sample.

To get a better sense of the GDP growth rate, Figure 3.1 below reports the growth rate, and Figure 3.2 reports the unconditional variance of the growth rate for the period from 1961:2 to 2007:2. A visual inspection of both figures suggests that there has been a reduction in the level of variance of GDP growth starting in the 1980s.

Figure 3.1: The GDP growth rate in Canada

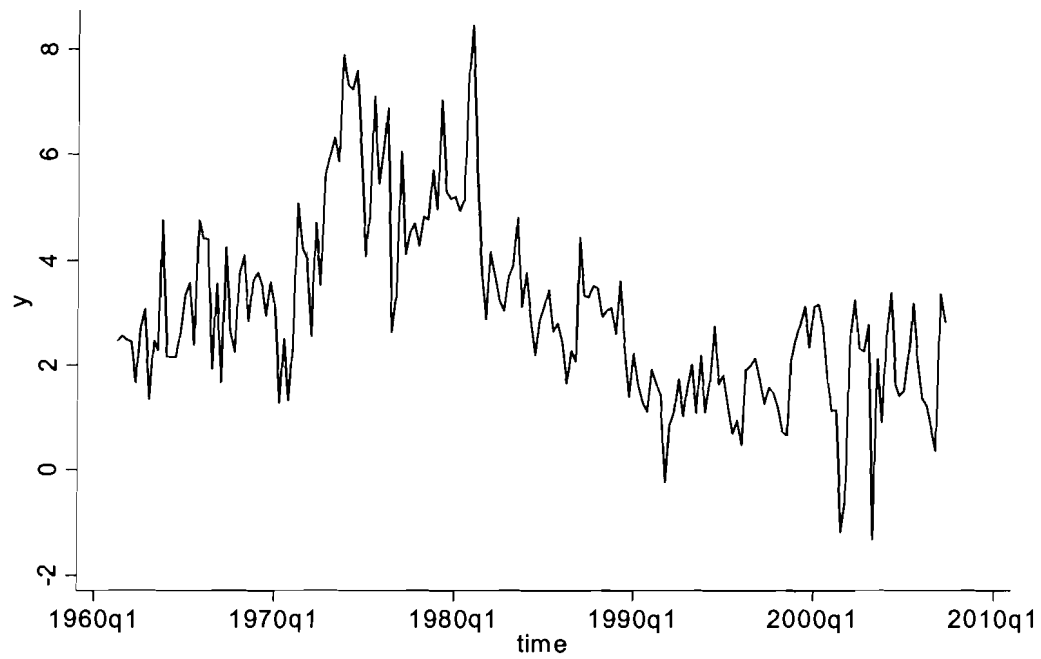
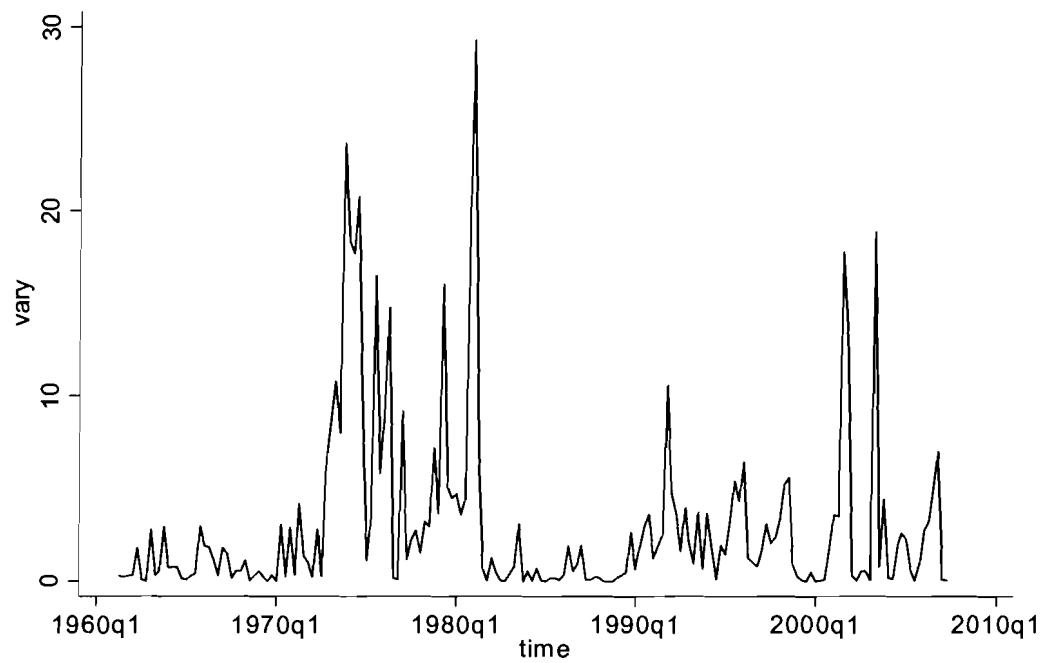


Figure 3.2: The unconditional variance of the GDP growth rate in Canada



4 Structural Break

Shimotsu (2006) proposes two tests to test structural breaks in time series data, based on the property of fractionally integrated $I(d)$ processes. These tests differentiate between a series with long memory and a series with a structural break. An $I(d)$ process for the growth rate of output supposes that $(1 - L)^d y_t = u_t$, where u_t is a covariance stationary process whose spectral density is bounded and bounded away from zero at the zero frequency. The intuition is that if a time series follows an $I(d)$ process, then each subsample of the time series also follows an $I(d)$ process with the same value for d , and if a time series follows an $I(d)$ process, then its d th differenced series follows an $I(0)$ process.

In the first test, the sample is split into b subsamples, the local whittle (Gaussian Semiparametric) estimator is used to estimate d for each subsample. The values of d are then used to compare with the estimate of d from the full sample. In the second test, the estimate of d is used to take the d th difference of the sample, then the KPSS test ((Kwiatkowski et al., 1992) and the Phillips-Perron test Z_τ (Phillips and Perron, 1988) are applied to the differenced data and its partial sum to test the constancy of the parameter of the data. Both tests are applicable to stationary and nonstationary $I(d)$ process and small samples.

My sample is still the growth rate of real GDP in Canada, y_t , from 1961:2 to 2007:2. The result is presented in Table 1:

Table 4.1: Estimation and test result with the GDP growth rate in Canada

m	\hat{d}	\bar{d}		W_c		Z_t	ηt
		b=2	b=4	b=2	b=4		
8	0.7525	0.4150	0.5238	0.0540	0.2220	-2.0301	0.0975
12	0.7517	0.5495	0.1576	0.8702	9.6423 *	-2.0250	0.0980
16	0.7521	0.5713	0.4663	3.3000	8.0376 *	-1.9682	0.1097
20	0.6395	0.4147	0.5017	1.2984	4.3485	-1.3450	0.2004
24	0.5845	0.4214	0.2225	1.7581	7.9219	-1.0497	0.2578
28	0.5588	0.4058	0.2116	2.1658	11.3670*	-0.9181	0.1097
32	0.5385	0.4017	0.3161	2.2623	11.5646*	-0.8029	0.3326
36	0.5538	0.4392	0.3646	1.7272	8.2723 *	-0.8712	0.3107

Note: * indicates rejection of the null at the 5% level. $\chi^2_{0.95}(1) = 3.84$,

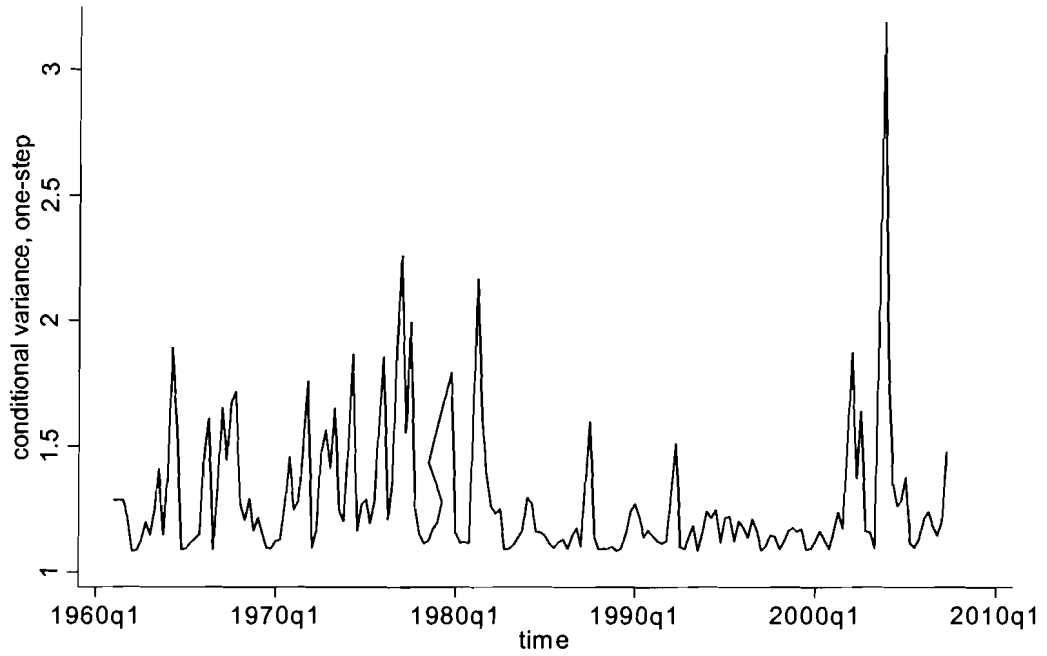
$\chi^2_{0.95}(3) = 7.82$. The null hypothesis $H_0 : d_0 = d_{0,1} = \dots = d_{0,b}$

Table 4.1 shows the estimates of the parameter of the whole sample \hat{d} and subsample \bar{d} , the value of adjusted Wald test W_c (Shimotsu, 2006)⁴, and the PP test Z_t and KPSS test ηt for various values of m [8, 36] and b {1, 2, 4}. The values of \hat{d} and \bar{d} are not very close when $m = 8, 12, 16, 24, 28, 32$ and 36 , also the adjusted Wald test can reject the null of constancy of d when $m = 12, 16, 28$ and 32 and 36 , although Z_t test and ηt test values are not beyond their critical values. Also, as m increases, d decreases. This suggests a possibility of a presence of structural breaks in the data.

⁴ Shimotsu (2006) introduced the adjusted Wald statistic with modification based on Huivich and Chen (2000).

To take a close look at the GDP growth rate volatility, figure 2 above reports the unconditional variance of the growth rate in Canada for the period from 1961:2 to 2007:2. Also most empirical papers exploited ARCH or GARCH model to capture the output growth rate volatility. Figure 3 reports the variance of the widely used ARCH (1) model which is $y_t = a + \alpha y_{t-1} + \varepsilon_t$, and $\text{var}(\varepsilon_t) = \sigma_t = b_0 + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2}$.

Figure 4.1: ARCH (1) variance



To detect the structural break, I apply the approach of centered cumulative sums of squares described by Inclan and Tiao(1994).

Let $C_k = \sum_{t=1}^k a_t^2$ be the cumulative sum of squares of a series of uncorrelated random variables $\{a_t\}$ with mean 0 and variance σ_t , $t = 1, 2, \dots, T$. Here $\{a_t\}$ is the AR (1) residuals subtracted their mean, T is number of

observations. Define $D_k = \frac{C_k}{C_T} - \frac{k}{T}$, $k = 1, 2, \dots, T$, with $D_0 = D_T = 0$ the centered cumulative sums of squares. If the series has homogeneous variance, the plot of D_k against k will fluctuate around 0. If there is a sudden change in its variance, then D_k will exceed some specific boundary with high probability. Based on this observation, Inclan and Tiao construct a statistic $\sqrt{T/2}D_k$ that behaves like a Brownian bridge under the null of variance homogeneity with an asymptotic critical value which is $(\sqrt{T/2}|D_k|)_{0.5}^* = 1.358$ when $n \rightarrow \infty$. Let k^* be the value of k at which maximized value of $\sqrt{T/2}|D_k|$ is attained. If this maximum value exceeds the predetermined boundary, then we can say there is a structural break at k^* .

Figure 4.2: Plot of statistic value and critical value

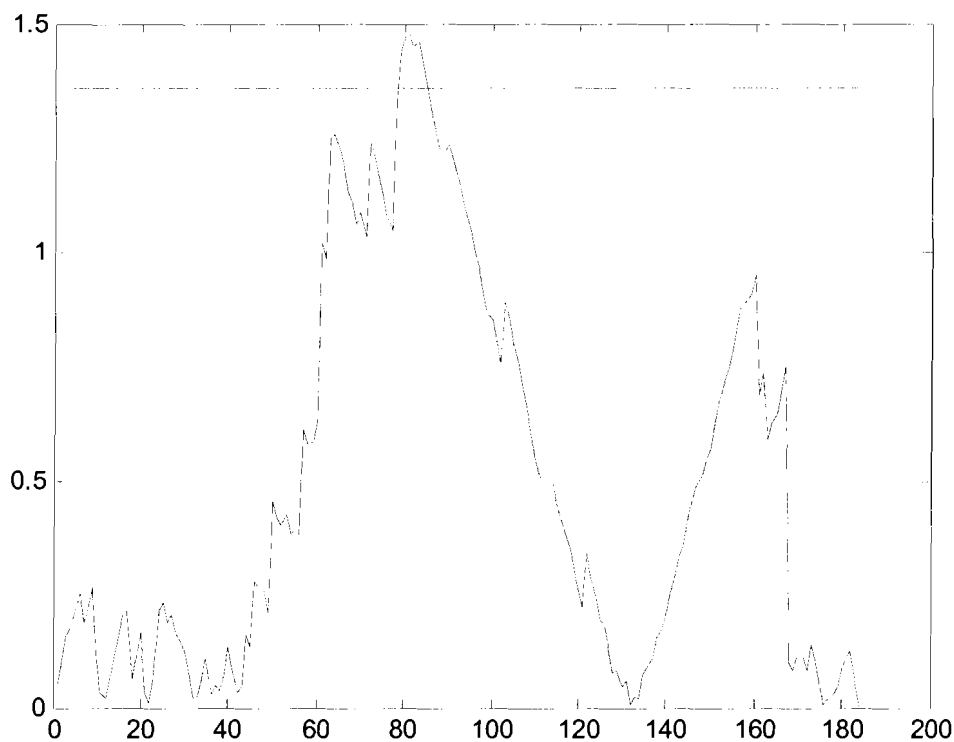


Figure 4.2 plots the value of $\sqrt{T/2}|D_k|$ and critical value of 1.358. Under this procedure I identified one structural break among all the observations, which happens at the 81st point. Since the period starts from 1961:2 because of the difference, we can conclude that the structural break is at 1981:3.

5 Variances and Covariances of GDP Components

Kahn (2002) reports that the change in the covariance of inventories, investment and sales. Recently Irvine and Schuh (2005) use a supply side decomposition of output to note that the decline of output volatility is largely due to a reduction of the co-movement of sectoral business cycles. Also Dynan (2006) shows that savings and incomes have become more correlated than they were before, which should provide some evidence that the improved completeness of financial instruments to the US households.

Since the changes in the variances and covariances of the components are suggestive of endogenous adjustments of GDP components, they may suggest a structural interpretation of the Great Moderation. Therefore I propose to show how the variances and covariance of GDP main components have changed over time.

Following the analysis reported by Benoit (2007), but not taking the weight into consideration, I opt for the simplest form of the variances and covariances changes over time. I focus on three main components of GDP: consumption, which includes durable goods, nondurable goods, semi-durable goods and services; investment, which includes investment in fixed capital, inventories and residential investment, and; net exports. As Benoit (2007) points out, “the variance and covariance involving net exports and government consumption had little impact on the post-1984 drop in the volatility of GDP growth”, so government consumption is not included here.

Table 5.1: Decomposition of the variances of main components of GDP

Quarterly growth rate and variances	1961:2-2007:2	1961:2-1981:3	1981:4-2007:2
GDP growth rate	3.04	2.95	1.25
Consumption	1.06	1.18	0.49
Durable goods	11.58	16.14	7.34
Nondurable goods	1.80	1.93	1.15
Semi-durable goods	2.60	3.38	1.33
Service	1.05	1.17	0.51
Investment	19.94	22.10	17.14
Investment in fixed capital and inventories	20.28	22.04	17.61
Residential investment	770.53	803.20	743.63
Net exports	11.35	11.47	10.13

Table 5.1 reports the variances of the main components of GDP in the whole sample and two subsamples respectively. As it shows, the Great Moderation is indeed remarkable. The variances of the GDP growth rate decreased from 2.95 in the pre-1981:3 subsample to 1.25 in the post-1981:3 subsample. The variances of both consumption and investment growth rate dropped substantially, especially the variance of consumption dropped by 57.8% in the second subsample. However the variance of net exports does not contribute much to the drop of volatility of the GDP growth rate. Figure 5, Figure 6 and Figure 7 also reflect the changes in the volatility of these components. Taking a closer look at the data indicates that the variances of some components of consumption and investment fell by even a larger magnitude, for instance, durable goods, semi-durable goods and investment in fixed capital and inventories. However, I do not investigate these disaggregated variances further in this paper.

Table 5.2: Decomposition of the covariances of main components of GDP

Quarterly growth rate and covariances	1961:2-2007:2	1961:2-1981:3	1981:4-2007:2
Consumption and Investment	0.66	0.04	0.44
consumption and net exports	0.89	0.96	0.09
Investment and net exports	0.56	-0.39	0.20
Components of Consumption			
Durable and non-goods	0.82	0.96	0.15
Durable and semi-goods	1.94	1.59	1.60
Durable and service	0.66	0.39	0.36
Nondurable and semi	0.75	0.71	0.19
goods			
Nondurable and service	0.46	0.35	0.05
Semi and service	0.76	1.17	0.25
Components of investment			
Investment in fixed			
Capital, inventories and	-3.24	-1.06	-6.28
Residential investment			

Table 5.2 reports the covariances of these components, which reveals the bilateral cross-sector correlation. The drop in the covariances after 1981 mainly comes from the fall in the correlation between durable goods and nondurable goods, semi-durable goods and nondurable goods, which is consistent with the result of Benoit (2007). The correlation between investment in fixed capital and inventories and residential investment becomes significantly negative, which contribute negatively to the variance of GDP growth rate.

Figure 5.1: The change in the GDP grow rate and consumption growth rate over time

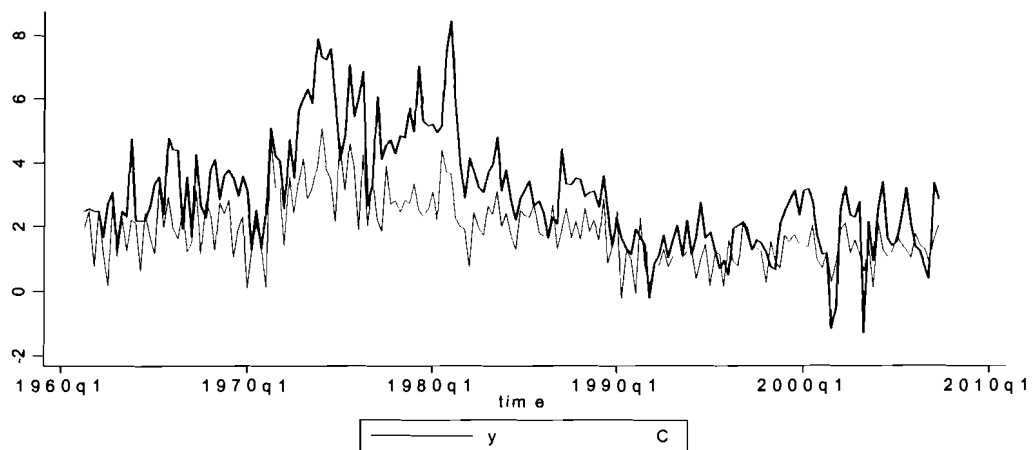


Figure 5.2: The change in the GDP growth rate and investment growth rate over time

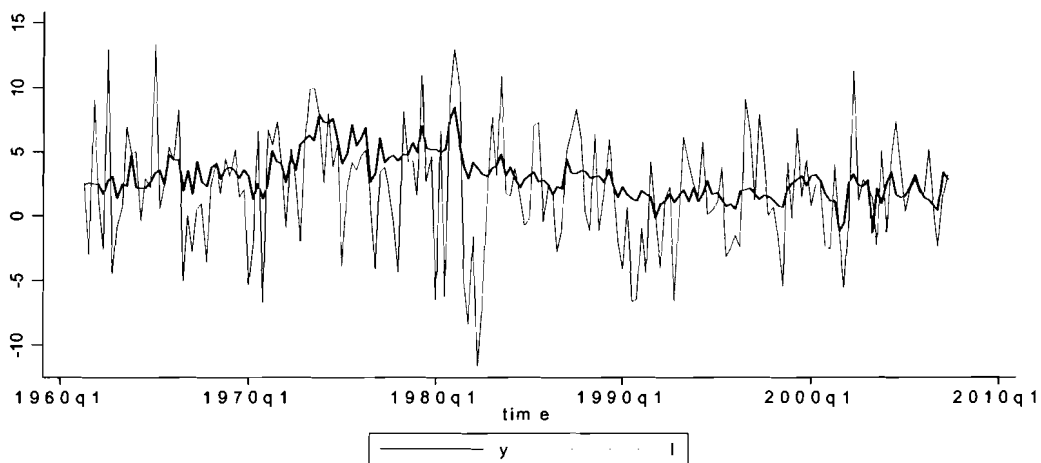
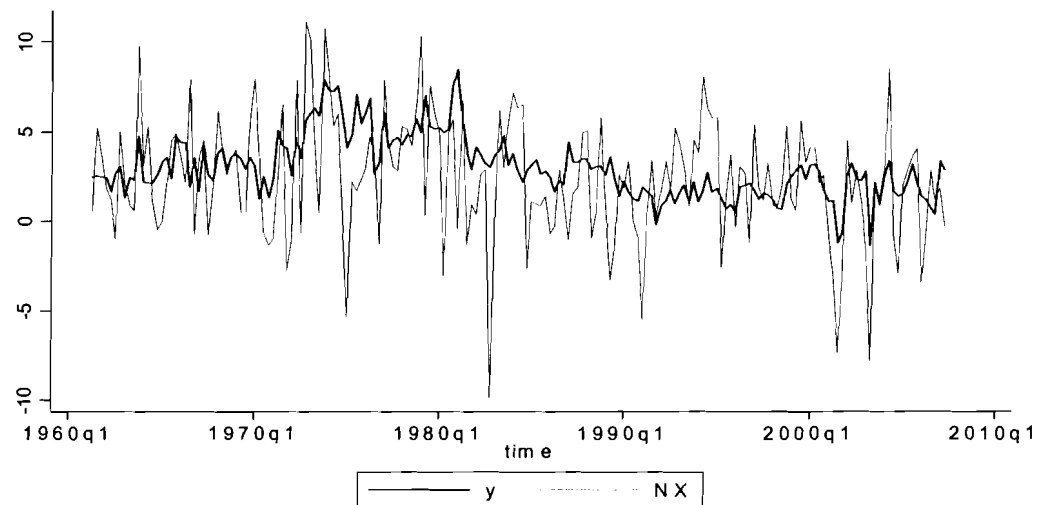


Figure 5.3: The changed in the GDP growth rate and net exports growth rate over time



The results suggest that the Great Moderation is due to these interest-rate sensitive expenditures, i.e., durable goods, semi-durable goods and investment. In other words, the more interest-rate sensitive expenditures account for a sizeable fraction of the output stabilization. We may surmise the evolution can be related to the impact of improved monetary policy or financial innovation on the demand of durable goods (Ramey and Vine, 2006)

In the following, I therefore propose to examine whether monetary policy accounts for the drop of output volatility.

6 A Structural VAR Model Evidence on the Source of the moderation

Some studies, for example, Evans and Kuttner (1998), apply the approach of reduced-form VAR model to estimate the changes in the variance-covariance matrix of shocks Σ_u . It is, however, not possible to determine without further assumptions about structural constraints whether this is due to changes in contemporaneous relationship among variables or whether it is caused by a change in the variance-covariance matrix of the fundamental shocks Σ_ε . In order to isolate properly the contribution of changes in the fundamental shocks from the structural policy, a structural VAR model is adopted.

Bernanke and Mihov (1998) argue that the federal funds rate has been the key policy instrument in the US over some periods. Following this finding, I use the Bank of Canada rate as the monetary policy instrument. Define the vector Y_t of endogenous variables as two components: $Y_t = [Z_t' R_t']$, where R_t represents the monetary policy instrument, and Z_t includes all other non-policy macroeconomic variables. In this paper the GDP growth rate and the inflation rate are included in Z_t . Under the recursive structure, the identified structural VAR can be written as:

$$Z_t = (B_0^{ZZ})^{-1} [b^Z + \sum_{i=1}^k B_i^{ZZ} Z_{t-i} - B_0^{ZR} R_t + \sum_{i=1}^k B_i^{ZR} R_{t-i} + \varepsilon_t^Z] \quad (1)$$

$$R_t = b^R - B_0^{RZ} Z_t + \sum_{i=1}^k B_i^{RZ} Z_{t-i} + \sum_{i=1}^k B_i^{RR} R_{t-i} + \varepsilon_t^R \quad (2)$$

Where $B_i = \begin{bmatrix} B_i^{ZZ} & B_i^{ZR} \\ B_i^{RZ} & B_i^{RR} \end{bmatrix}$ is the decomposition of the matrix B_i . The first equation

describes the evolution of the non-policy variables in response to changes in all contemporary and past endogenous variables as well as unforecast shocks ε_t^z .

The second one describes the monetary policy instrument in response to all the other nonpolicy variables, lagged term of the policy variables as well as unforecast shocks ε_t^R .

Following Boivin and Giannoni(2002), I assume that the policy variable has no contemporaneous effect on the other non-policy variables, that is, $B_0^{ZR} = 0$. All other variables have a contemporaneous effect on R_t .

6.1 Stability Test on the Underlying VAR

The stability of VAR parameters has been investigated in some of recent papers. Stock and Watson (1996) find wide-spread instability in the bivariate relationships among 76 macroeconomic variables. Boivin(1999) also concludes that there is compelling evidence of instability in monetary VARs.

To investigate the stability of the parameters in the Structural VAR in subsample 1(pre-1981:3) and subsample2(post-1981:3), I use the test provided by Lutkepohl(1993) and Hamilton(1994), who both show that if the modulus of each eigenvalue of the parameter value is strictly less than one, then the estimated VAR is stable. The results of test on both subsamples are provided below:

Table 6.1: Eigenvalue stability condition of pre-1981:3 subsample

Eigenvalue	Modulus
0.9689974	0.9689974
0.7037543	0.7037543
-0.06458151 + 0.2598647i	0.267769
-0.06458151 - 0.2598647i	0.267769
0.1285389	0.128539
-0.1182082	0.118208

Table 6.2: Eigenvalue stability condition of post-1981:3 subsample

Eigenvalue	Modulus
0.9093718	0.909372
0.5424513	0.542451
0.3038557	0.303856
0.09594087 + 0.2337723i	0.252694
0.09594087 - 0.2337723i	0.252694
-0.05007868	0.050079

As table 6.1 and table 6.2 report, all the eigenvalues lie inside the unit circle, thus we can conclude that the underlying VAR of the structural model satisfies the stability condition. Meanwhile it also gives the evidence that the structural break that I find is robust. As Boivin and Giannoni (2003) mention, if instability is detected, confidence intervals for the break data can be constructed. If the estimates of the VAR are stable for both subsamples, then this suggests that the structural break has been correctly identified.

6.2 Monetary Policy Shocks

Although the variance of monetary policy increased a little, from 0.72 to 0.78, which is consistent with the result of Boivin and Giannoni(2003) using 1980:1 as the structural break, the fraction of variance of output and inflation due to these shocks has decreased substantially since 1981:3. From Table 6, we can see 12 percent of output variance is attributable to monetary policy before 1981:3, while after that this contribution has fallen to around 2 percent. The contribution to the inflation rate of monetary policy shocks has dropped from 18 percent to 14 percent. This confirms that monetary shocks can help account for the stability of output and inflation since the beginning of the 1980s.

Some may argue that monetary policy does not matter much, since the contribution to output variance does not take a big percentage in both periods. However as Boivin and Giannoni(2003) argue “monetary policy is mostly characterized by the endogenous response to developments in the economy,..., even if monetary policy shocks were very small, monetary policy could still matter substantially for the determination of output and inflation.”

Table 6.3: Monetary policy shocks' contribution

	1961:2-1981:3	1981:4-2007:2
Variance of monetary policy shocks	0. 72	0.78
Contribution to output variance (percent)	12	1.89
Contribution to inflation variance(percent)	18	14

6.3 Split-Sample Estimates of Impulse Response to Monetary Policy Shocks

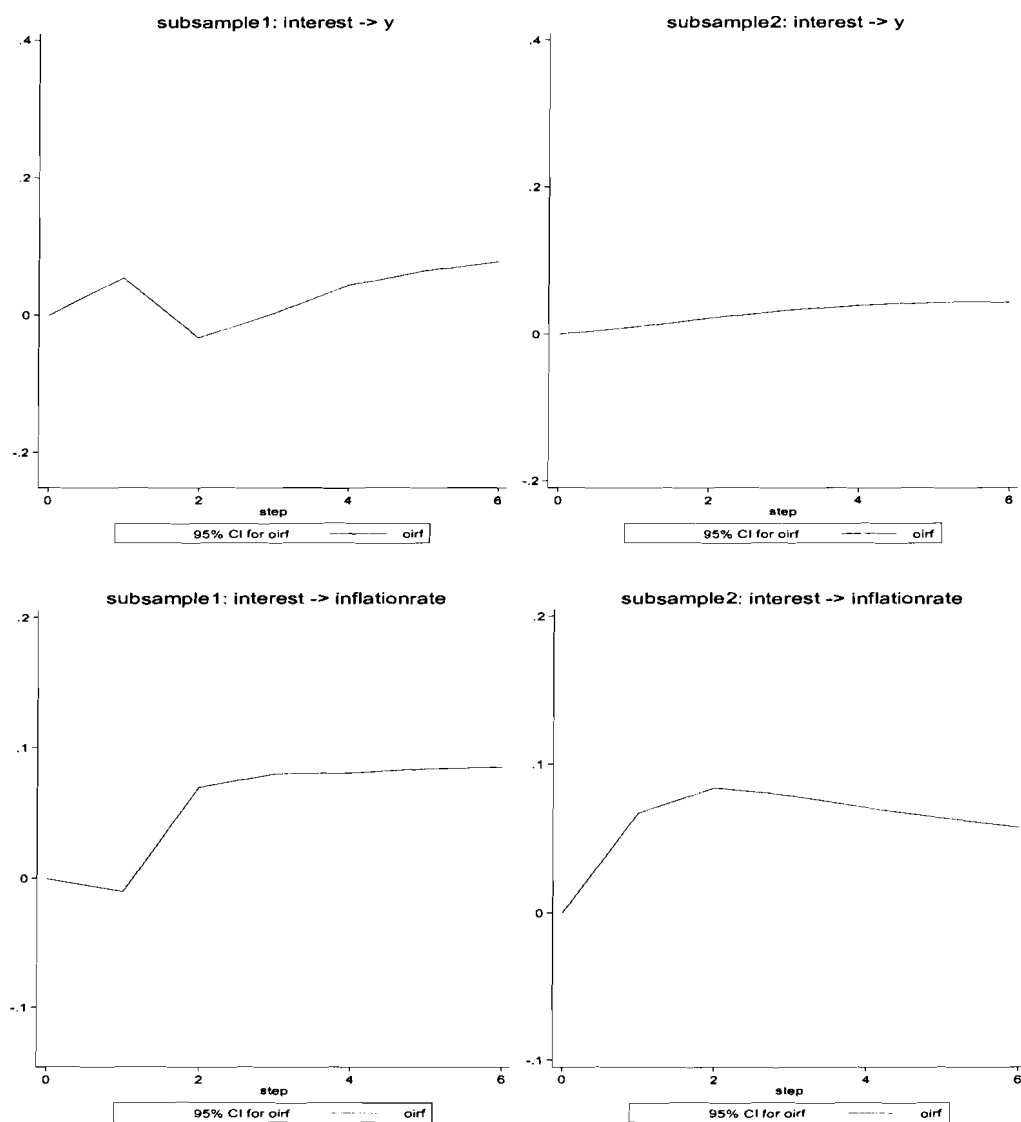
Given the evidence of the contribution of monetary policy shocks to the economy, we now turn to the response of the economy to monetary policy and the effect of monetary policy. Using the structural VAR model described above, I report the change of impulse response functions of the output growth rate, the inflation rate and the Bank of Canada rate to monetary policy. Figure 8 displays the comparison of the impulse response functions to an unexpected unit increase in the interest rate and the associated 95% confidence interval for pre-1981:3 subsample and post-1981:3 subsample. One key result from the comparison across two subsamples is that the response of output and inflation is less significant and persistent since the beginning of 1980s, particularly the response of output to monetary policy. Barth and Ramey (2001) have documented in the literature that the impact of monetary policy shocks was stronger in the first period. The other key result from comparison is that the response of inflation does not drop as substantially as in the US (Boivin and Giannoni, 2002). Table 7 shows that the inflation rate has a significant contemporaneous effect on the Bank of Canada rate, which to some extent appears to confirm the fact that monetary policy in the second period has followed inflation targets. Based on much flatter impulse response functions here, one possible interpretation is that monetary policy has become less effective. However, an alternative interpretation is that monetary policy is more effective to moderate the effects of exogenous disturbances since the beginning of 1980s, as a result, the estimated

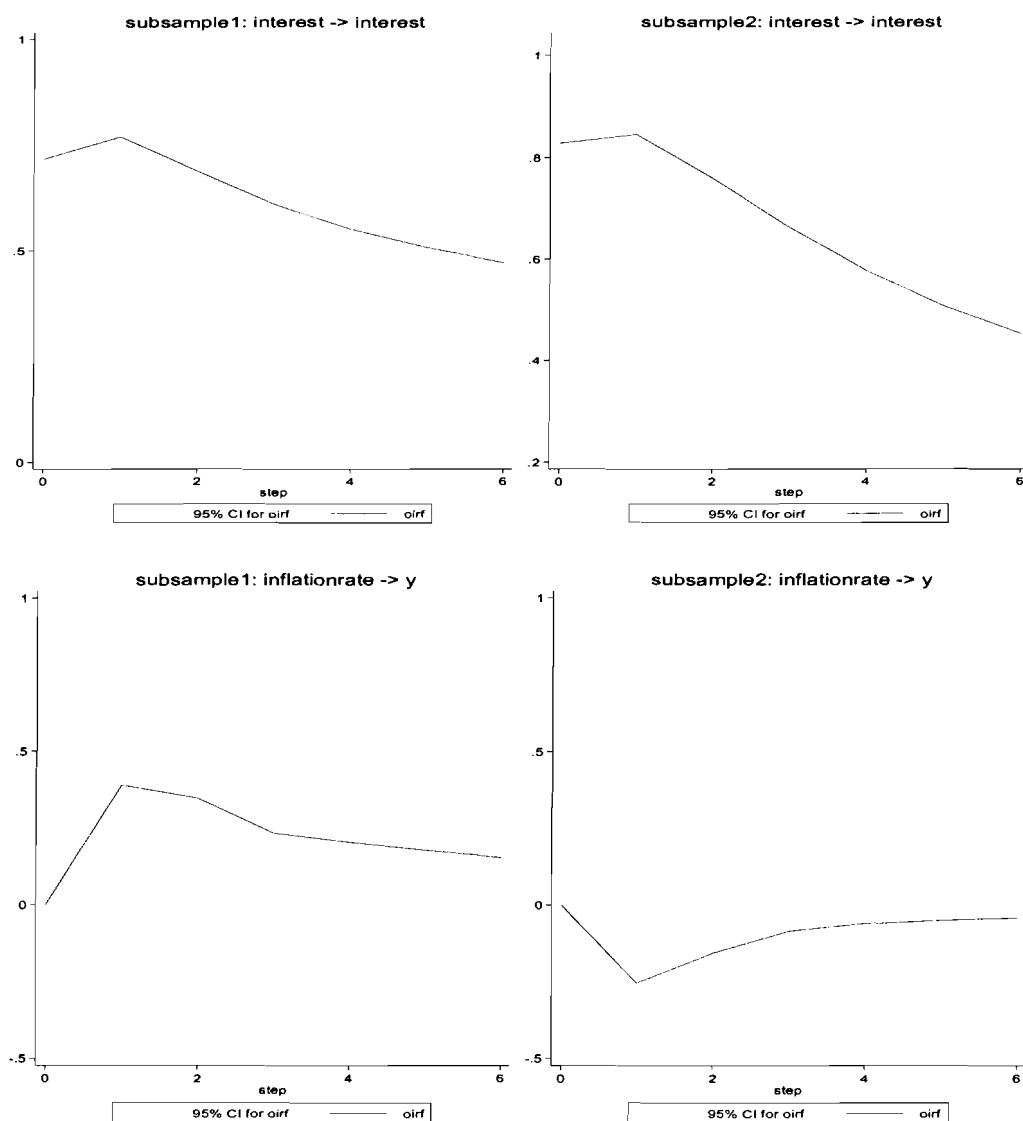
impulse response functions to monetary shocks also will display less or no response. In this case, as Boivin and Giannoni(2003) argue, the change in the response to monetary shocks would not reflect a reduction in the effectiveness of monetary policy ,but rather that its conduct has improved. In order to address this issue, the following section provides the counterfactual analysis with the same structural VARs to illustrate how the transmission mechanism of monetary policy has altered and what the impulse response will be in the same economy but with different policies.

Table 6.4 : Estimates of structural parameters

Parameters	Subsample 1	Subsample 2
B_0^{RZ} of output	-0.1140096 (0.073975)	0.0867285 (0.0890003)
B_0^{RZ} of inflation	-0.0716571 (0.1585241)	-0.2331671 (0.166977)

Figure 6.1: The impulse responses to a monetary policy shock across two subsamples





6.4 Counterfactual Analysis with Structural VARs

In this section, taking the same approach as Boivin and Giannoni (2002), I perform a counterfactual analysis on the structural VAR model described above to investigate the change in the effectiveness of monetary policy. Two questions will be addressed: 1) How does the size of monetary policy shock change in the

post-1981:3 economy but with pre-1981:3 monetary policy? 2) Do the impulse response functions of non-policy variables change as policy changes?

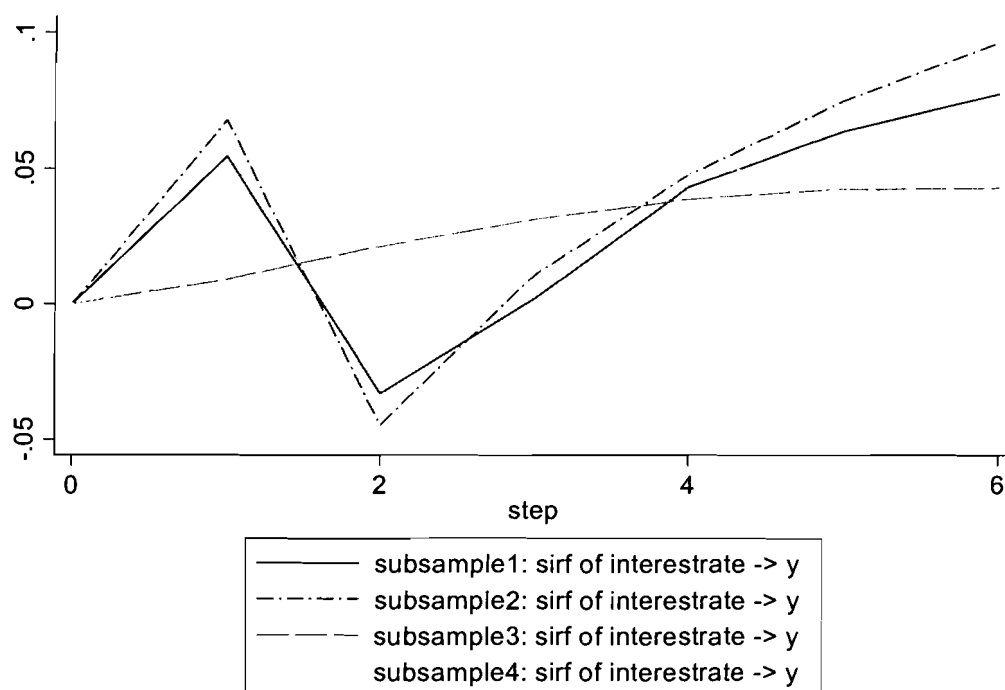
To simplify the question, let Φ_i represent the estimates of the parameters of monetary policy for period i and Ω_j represent the estimates of the remaining parameters for the rest of the economy, that is, the parameters for equation (1). A combination (Φ_i, Ω_j) characterizes the set of impulse response functions. For instance, (Φ_1, Ω_2) corresponds to the impulse response function in the post-1981:3 economy assuming the pre-1981:3 monetary policy is adopted. Here two counterfactual experiments that Boivin and Giannnnoni provide can be expressed as (Φ_1, Ω_2) and (Φ_2, Ω_1) . Figure 9 below displays the resulting impulse response functions to unit increase in the Bank of Canada rate in these two experiments.

Under such experiments, both Φ and Ω affect the impulse response functions, as demonstrated by the difference in the impulse response between these subsamples in Figure 7. Inspecting Figure 7 further, we note that fixing the estimated non-policy parameters of the economy Ω and allowing monetary policy Φ to change, the impulse responses of output and inflation fluctuate substantially, especially the impulse response of inflation in the second period. For instance, in the same economy of period 1, Φ_1 , but using the monetary policy for period 2, Ω_2 , we can see that output and inflation also become more responsive and sensitive than (Φ_2, Ω_2) , even than (Φ_2, Ω_1) . This suggests that monetary policy has not lost potency. In addition, this response of inflation to the

interest rate which is showed in the second panel in Figure 9 is much more pronounced in comparison to the response of output to inflation. As a consequence, this again confirms the conclusion that monetary policy is targeted on the inflation rate. However, apart from the change in the transmission mechanism of the monetary policy, there also exists the change in the economy. Fix the monetary policy parameters Ω and let the rest of the economy vary, we can observe the impulse response functions also change a lot especially associated with the pre-1981:3 monetary policy, which mentioned above is quite different from the result that Boivin and Giannoni (2002) get⁵.

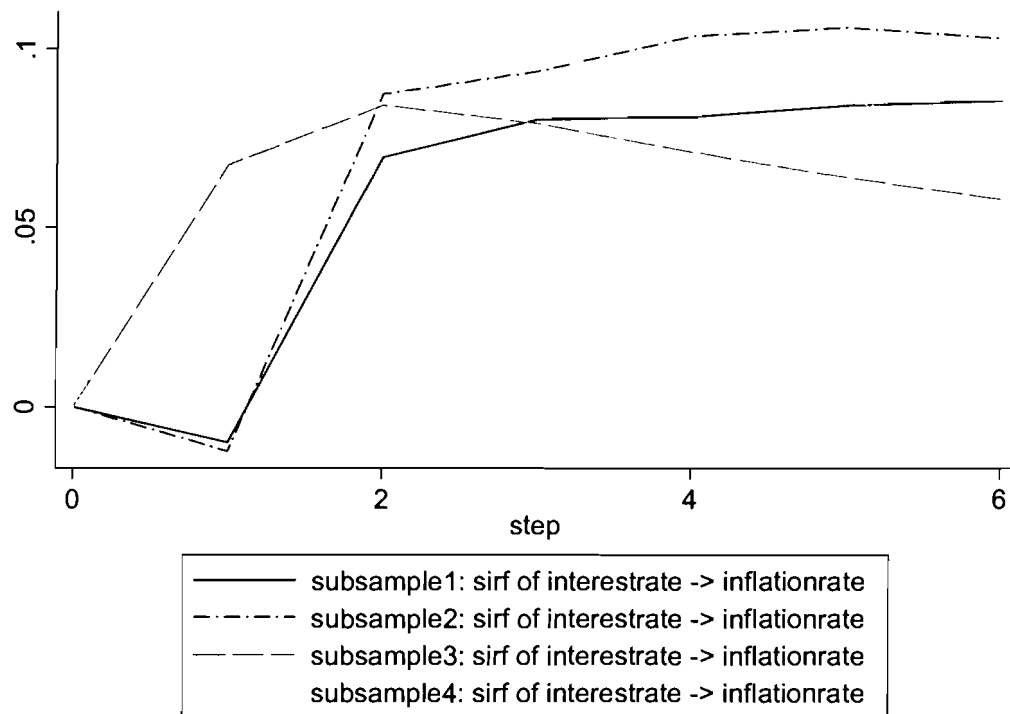
Figure 6.2: Structural-based counterfactual analysis: Pre-1981:3 sample versus post-1981:3 sample

The impulse response function of the output growth rate to the interest rate

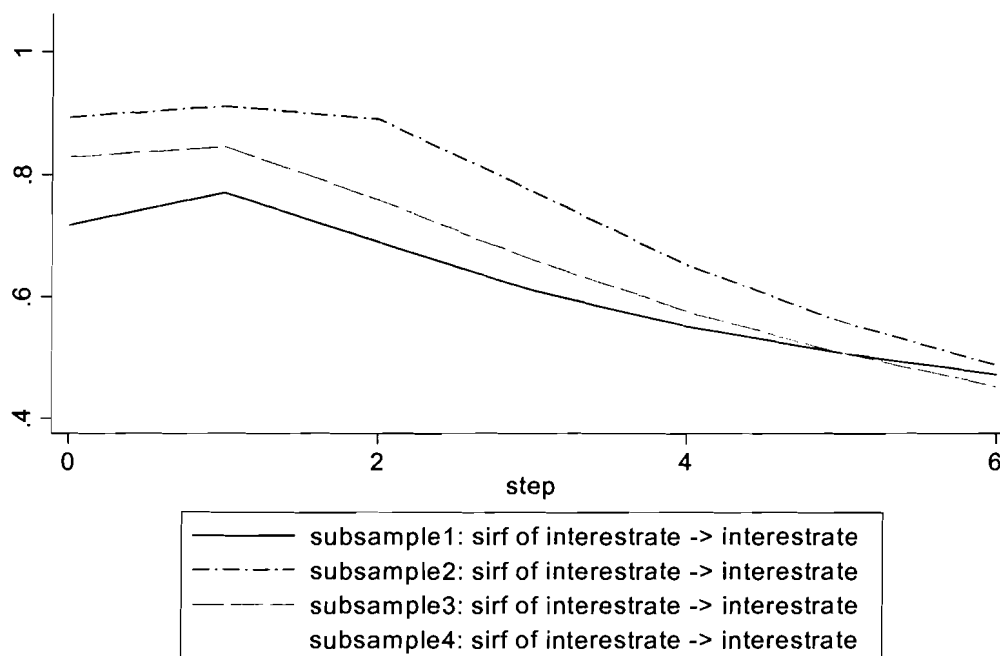


⁵ Boivin and Giannoni (2002) shows that fix the monetary policy, the economy does not change that much.

The impulse response function of the inflation rate to the interest rate



The impulse response function of the interest rate to the interest rate



Note: subsample1: pre-1981economy, pre-1981policy (Φ_1, Ω_1)

subsample2: pre-1981economy, post-1981policy (Φ_1, Ω_2)

subsample3: post-1981economy, post-1981policy (Φ_2, Ω_2)

subsample1: post-1981economy, pre-1981policy (Φ_2, Ω_1)

Therefore, it appears that monetary policy has not become less effective since the beginning of 1980s, though the change in the transmission mechanism of monetary policy in Canada should not be taken as the only main source of the stability of monetary policy. Also from the analysis above, I conclude that the nature of the economy itself, apart from the propagation mechanism of the monetary policy, has changed across these two periods.

Although the alteration of the propagation mechanism of monetary policy can not be interpreted as a dominant contributor to the moderation of the volatility of the economy growth in Canada, the size of monetary shock itself is deserving of comment. In the pre-1981:3 economies, the variance of monetary policy shocks using post-1981:3 policy is 0.6959, almost identical to the variance using the pre-1981:3 policy of 0.7188. However, in the post-1981:3 economy the variance of the monetary policy shocks using pre-1981:3 policy is higher than if the post-1981:3 policy had been used. These results suggest that the transmission mechanism for monetary policy may have changed over the two sub-samples, perhaps owing to a change in the structure of the economy itself. One might charitably conclude that this is due to more stable monetary policy since the beginning of 1980s.

Table 6.5: Variance of monetary policy shocks in counterfactual analysis

Variance of monetary policy shocks	Ω_1	Ω_2
Φ_1	0.7188	0.6959
Φ_2	0.9194	0.7795

In addition, from this counterfactual analysis, it appears that the economy itself also has changed apart from the propagation mechanism of monetary policy. Due to this reason, some economists argue various innovations in private sectors and financial markets might have allowed consumers to cushion themselves from the influence of fluctuations, for instance, Kahn, McConnell and Perez-Quiros(2002) argue that the innovation in inventory management accounts

for the Great Moderation after 1984. However, I will not attempt to extend this paper to other sources of the Great Moderation.

7 Conclusion

In this paper, I have showed that the volatility of the growth rate of output in Canada was reduced substantially after a structural break dated 1981:3. Canada has also experienced a Great Moderation similar to the US.

I decompose the output and the components of output and find that most of the components that reflect the significant drop in the volatility are interest- rate sensitive expenditures. Using a structural VAR, I show that the contribution of monetary policy shocks to the output fluctuation has been reduced, also the impulse responses of output and inflation to the interest rate appear much more stable. However, this does not imply that monetary policy became less effective in the past two decades. In the counterfactual analysis of structural VAR model, there is no evidence that monetary policy has lost some of its potency; on the contrary, the stability of monetary policy appears mainly due to fewer monetary policy mistakes. Although monetary policy was demonstrated that it can account for the Great Moderation in Canada, it is still unclear whether monetary policy changes are the dominant factor.

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