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Jérôme Creel
ESCP EUROPE & OFCE SCIENCES PO

Paul Hubert
OFCE, SCIENCES-PO

OFCE - Centre de recherche en économie de Sciences Po
69, quai d'Orsay - 75340 Paris Cedex 07 - Tél/ 01 44 18 54 00 - Fax/ 01 45 56 06 15
www.ofce.sciences-po.fr

Has Inflation Targeting Changed Monetary Policy Preferences?[*]

Jérôme Creel
ESCP Europe & OFCE Sciences Po[♣]

Paul Hubert
OFCE Sciences Po[♦]

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Abstract
The literature on inflation targeting has up to now focused on its impact on macroeconomic performance or private expectations. In contrast, this paper proposes to investigate empirically whether the institutional adoption of this framework has changed the policy preferences of the central banker. We test the hypothesis that inflation targeting has constituted a switch towards a greater focus on inflation. We use three complementary methods: a structural break analysis, time-varying parameters and Markov-Switching VAR which make possible to estimate linear or nonlinear, and forward or backward looking specifications, to account for heteroskedasticity without having to assume a date break ex ante. Our main result is that inflation targeting has not led to a stronger response to inflation. We infer that the inflation targeting *paradigm* should not be confounded with the inflation targeting *framework*.

Keywords: Monetary Policy; Inflation Targeting; Taylor Rule; Structural Break; Time-Varying coefficients, Markov-Switching VAR.

JEL classification: E52, E58.

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[♣] Email: jerome.creel@sciences-po.fr, ESCP Europe and OFCE/Sciences Po, 69, quai d'Orsay, 75340 Paris Cedex 07, France, tel. +33 1 44 18 54 56, fax. +33 1 44 18 54 78.
[♦] [Corresponding author] Email: paul.hubert@ofce.sciences-po.fr, OFCE/Sciences Po, 69, quai d'Orsay, 75340 Paris Cedex 07, France, tel. +33 1 44 18 54 27, fax. +33 1 44 18 54 78.

1. Introduction

The growing concern about the financial crisis originating on the subprime mortgage market has emphasized the role of monetary policy in either fuelling or dampening[1] the crisis but, in the meantime, it has blurred the debate over the adoption of inflation targeting (IT) in the US[2]. Such a debate had been raised after B. Bernanke's nomination as Fed's Governor, as a consequence of his long-standing position in favor of IT (see e.g. Bernanke et al., 1999). Walsh (2009), among others[3], recalls that the debate "*has centered on the view that IT places too much emphasis on inflation, potentially at the expense of other monetary policy goals*", a situation which is quite at odds with the definition that Bernanke et al. (1999) gave of IT. Indeed, the authors advocated a general framing of monetary policymaking, encompassing a numerical target on inflation, publication of internal forecasts, accountable policymakers, increased transparency and a flexible strategy[4].

Our contribution is to investigate whether the adoption of the inflation targeting framework has changed monetary policy preferences and more particularly the weight put on inflation. We focus on early adopters of IT among developed countries, which still operate under this framework and for which a sufficiently long sample of data is available. In this respect, the paper focuses on three of them: Canada, Sweden and the United Kingdom.

Empirical papers dedicated to the inflation targeting can be split into two main categories: the first one deals with the change in private expectations whereas the second is dedicated to inflation performance. Most contributions are cross-country studies involving a control group. Conclusions are mixed between these two categories. Evidence points to lower and better anchored inflation expectations with IT adoption, while there is no significant effect on inflation performance. Johnson (2002) produced evidence of lower expected inflation in IT countries and Levin et al. (2004) and Gurkaynak et al. (2006) showed that in comparison with non-IT countries, inflation targeters have been able to better anchor long-run inflation expectations: UK and Swedish inflation expectations have not been sensitive to economic events since IT adoption. Johnson (2002) and Levin et al. (2004) used data from the Consensus Forecasts, while Gurkaynak et al. (2006) extracted expected inflation from the difference between forward rates on indexed and non-indexed 10-year public bonds. Fregert and Jonung (2008) showed that long term wage agreements increased steeply right after IT had been adopted in Sweden, testifying for a decrease in inflation expectations. However, Ball and Sheridan (2003) found no evidence of a beneficial impact of IT on a country's economic performance[5] in comparison with non-IT countries, while Angeriz and Arestis (2007) do not find a significant break in the estimated evolution of inflation in the UK compared with the US and EMU and Genc (2009) assesses regime switches in four developed IT countries in a univariate model for inflation and finds no evidence of a structural break in the inflation levels. Cecchetti et al. (2002) conclude that the extent to which IT exerts a measurable influence on monetary policy is limited. Last, Lin and Ye (2007), using propensity score matching, conclude that IT has had no significant effects.

[1] See respectively e.g. Taylor (2009) and Bullard (2009).
[2] See e.g. McCallum (2007) and Hetzel (2007).
[3] See e.g. Friedman (2004) and Leijonhufvud (2007).
[4] Although the Fed has not adopted IT, it is sometimes suggested that it is an implicit targeter. This definition of the IT framework proves that the Fed is not even an informal targeter: there is neither a clear target on inflation on which the Fed communicates, nor transparency on future monetary policy strategy since staff forecasts are not made public until five years have passed.
[5] Economic performance was assessed using a very large scope of statistics: inflation, inflation variability and persistence, output growth and variability, long-term interest rates, and variability of short-run interest rates.

These papers are all confronted with the control group problem first enlightened by Gertler (2003) in this strand of the literature and magnified by the exceptional stability of world inflation during the last decade. Insofar as all countries in the world have seen inflation rates decrease, it is highly difficult in a comparative setting[6] to evidence a change either in inflation expectations or in inflation performance that could be solely attributed to a change in institutions.

These papers are also confronted with the self-selection problem of policy adoption: what may have led actually to low inflation in IT countries was their decision to aim specifically at lower inflation than in earlier (pre-IT) periods. Stated in the above-mentioned terms, the argument claims that good inflation performance may stem from a policy switch towards a greater focus on inflation, at the expense of other policy objectives. This stronger response to inflation, due to the central bank's official focus on and commitment to inflation has not been proved so far and depends on whether or not the behavior of central bankers has changed after the institutional adoption of IT.

Compared to the vast literature on the impact of IT on macroeconomic performance or private expectations, this paper investigates whether the institutional adoption of IT has modified the monetary policy preferences. To our knowledge, only few studies have been performed in this respect for countries having adopted IT. Seyfried and Bremmer (2003) find a break in the monetary policy reaction functions of six IT countries, and they conclude that IT central banks pay more attention to inflationary pressures (proxied by the output gap) than to current inflation (whose coefficient is never significant), while Baxa, Horvath and Vasicek (2009) find the response to inflation has become less aggressive after IT adoption. For the UK, Trecroci and Vassalli (2009) find higher response to inflation (but with a significantly negative interest rate smoothing parameter, inconsistent with central bank interest rate evolutions) and Assenmacher-Wesche (2006) low and non-significant response to inflation before IT, while Davradakis and Taylor (2006) find significant response to inflation only since IT adoption and when the latter is above the target.

We depart from these papers by the multiplicity of the estimation methods used in order to uncover the changes in policy preferences. We use estimation methods which allow us to have to assume neither potential break dates nor nature of the breaks: sudden switch or gradual evolution. We thus perform structural break *à la* Qu and Perron (2007), Time-Varying Parameters (TVP) and Markov-Switching Vector Autoregressive (MSVAR) estimations to test the three possibilities of changes: no switch at all in the preferences, a switch towards a higher focus on inflation, or the opposite. Without probability priors regarding these three possibilities, our standpoint is to "let the data speak". These methods contrast with split-sample approach which needs to suppose a structural break and a date for it. Last, TVP and MSVAR methods also contrast with simple tests of monetary rules that generally do not capture multiple shifts in variance because they do not make enough allowance for heteroskedasticity.

[6] All countries have experienced common macroeconomic evolution (for instance strong disinflation) and Lin and Ye (2007) themselves note that "*one can reasonably suspect that the low inflation (variability) might be caused by some common uncontrolled factors that affect both targeting and non-targeting countries*". For this reason, our focus is not on the inflation performance of IT versus non-IT countries, but solely on changes in monetary preferences within IT countries. Moreover, many authors (see e.g. Boivin (2006) or Sims and Zha (2006)) have shown for US, a non-IT country, that changes in the reaction function of the Federal Reserve happened when Volcker started his mandate and that the monetary preferences of the Fed have been stable since then (i.e. on our sample). Our own MSVAR checks on US data confirm this result. This suggests that evidence presented in this paper is not due to factors that would have also affected non-IT central banks.

Dealing with a change in the preferences of policymakers over time has given rise to an abundant literature since the seminal contribution of Clarida et al. (2000) where they showed that the response of the Fed to changes in inflation was higher during Chairmen Volcker and Greenspan's eras than during the preceding period. In this paper, an agnostic view has been endorsed as to which estimation method better fits our hypothesis: tests have been performed using the three empirical methods in order to assess changes - and their nature - in the conduct of monetary policy without making assumptions or imposing binding conditions on those changes, dates and nature of potential breaks.

We use a forward-looking Taylor (1993) type rule, which corresponds to the normative description of central banking to estimate both potential structural breaks with the Qu and Perron (2007)'s procedure when the date and number of breaks is unknown and Time-Varying Parameters (TVP) through a Kalman filter to capture shifts in policymakers' preferences. In the literature, TVP has been developed and used in various aspects. Canova (1993), Stock and Watson (1996), Cogley and Sargent (2001) and Primiceri (2005) estimate VARs with drifting coefficients, while Boivin (2006), Kim et al. (2005), and Kim and Nelson (2006) focus on forward-looking monetary rules in the US. Because of our focus on a change in the preferences of central bankers since IT adoption, we focus on the single equation approach in the vein of Boivin (2006).

We complement these approaches with the use of MSVAR as developed by Hamilton (1989, 1994) and Sims and Zha (2006). It permits to date breaks and assess whether a new regime appears or a previous one re-emerges. Our assessment of policy changes goes beyond earlier attempts to estimate the potential changes involved by IT adoption. To our knowledge, no study has been ever implemented in order to estimate regime shifts in IT countries with an MSVAR model. Assenmacher-Wesche (2006) used this method to estimate monetary policy reaction functions in the UK, USA and Germany and she did not devote much attention to inflation targeting *per se* in the UK, nor did she extend the empirical analysis to other IT countries. Ammer and Freeman (1995) had estimated a canonical VAR whose sample stopped just before inflation targets were first announced, and then, they compared actual values for GDP, inflation, and the real interest rate with the (out-of-sample) forecasted ones. They interpreted the differences between couples – actual and forecasted – of all variables as evidence of a change of regime. In contrast, using MSVAR can reveal a new regime rather than assume it. Moreover, the focus on the emergence of regimes rather than on the occurrence of pure breaks also enables to check the argument that anti-inflation policies had already existed before IT adoption. Last, identification of forward-looking monetary reaction functions is generally supposed to be fragile (see *e.g.* Sims and Zha, 2006). MSVAR models, with their backward looking estimations, nicely complement the more usual range of tests performed previously.

The main result is the following. In the three countries considered, the adoption of inflation targeting has not led to a greater focus on inflation. The consistency of results whatever the method is acknowledged. Moreover, there is no evidence of a higher response to output which may suggest increased concern about inflation if output is considered as a leading indicator of inflation. Two intertwined interpretations of our result are put forward, which are based on two supposed benefits of inflation targeting. First, IT -through central bank commitment to a target- is meant to help anchor private inflation expectations, which will enable a central bank to control inflation without pursuing aggressive action towards inflation variations. Second, the central bank's decision to lower inflation may have led to low and stable inflation and hence to a lower response to inflation. Last, the outcome of this paper suggests that the inflation targeting *paradigm* (which consists in strong response to inflation to reach low and stable inflation, that will produce in the end stable macroeconomic conditions) should not be confounded with the inflation targeting *framework* (which consists in a commitment to a numerical target, publication of forecasts and increased transparency). Indeed, countries who have adopted the IT *framework* have not over-emphasize inflation deviations from target like "inflation nutters" to take the words of King (1997), while the IT *paradigm* common to IT and non-IT central banks in the last decade has made emerge a consensus around the inflation target at a 2% level. The debate on IT adoption might therefore be centered on the level of the inflation target[7] rather than on the emphasis on inflation.

It is important to acknowledge that this paper does not assess the efficiency of monetary policy. Hence, our tests do not address the debate on the Great Moderation. The latter is usually associated with the great decline in output, employment and inflation volatility and attributed to more efficient monetary policy, increased globalization, better inventory policies and/or "good luck" (see Davis and Kahn, 2008, for a critical empirical review of these arguments)[8]. It remains that our results are not blurred by the debate around the Great Moderation. We do not investigate the reasons for the decline in inflation, but we rather focus on the relationship between the inflation rate and the policy instrument, without any judgment on its effectiveness over time. We focus on the changes in monetary policy preferences which have occurred since IT adoption and find no higher response to inflation.

The remainder of the paper is organized as follows. Section 2 deals with data. Section 3 focuses on the Qu and Perron (2007)'s structural break procedure. Section 4 displays TVP estimation. Robustness checks are discussed. In section 5, the regime-switching method is presented along with estimation outcomes and related robustness tests. Section 6 concludes.

2. Data

We concentrate on three industrialized IT countries, the biggest ones among those having adopted it at the earliest and making long time series at a high frequency available. Thus, if we focus on OECD countries that have adopted IT the earliest, we are left with 8 countries which have turned formally to an IT regime since the early 1990s: between New-Zealand, which adopted it in 1990, and Spain, in 1995, the six others were: Australia, Canada, Finland, Israel, Sweden and the UK. From this list, we decided to focus[9] on Canada, Sweden and the UK. IT was adopted in Canada in February 1991 and was in its completion form at the end of 1995 when the decelerating path of inflation was transformed in a fixed target range. The same process took place in the UK: an adoption in October 1992 and a completion in May 1997 that corresponds to the statute change of the Bank of England and its increased independence. In Sweden, IT was adopted in January 1993 with the objective to be fully applied in January 1995, and the inflation target has remained the same since IT adoption: no decelerating path of inflation occurred[10] during the implementation period.

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[7] See recently on this point Blanchard et al. (2010).

[8] Davis and Kahn (2008) use US micro data and conclude that improved supply-chain management (or better inventory controls) is the most prominent cause of the Great Moderation. They also show that no decline in uncertainty for the households can be associated with the Great Moderation.

[9] We dropped New-Zealand and Australia due to their multiple modifications of their IT framework, Israel as it is an emerging economy and Finland and Spain due to their accession to the eurozone.

[10] In Sweden and Canada, no change in the target has occurred since the completion of IT. In the UK, the target changed once: in December 2003, the target moved from 2.5% per year (for the RPIX) to 2% per year (for the CPI). It is generally admitted that because the RPIX and the CPI are not measured similarly, a 2% target for the CPI amounts to a 2.5% target for the RPIX (*cf.* King, 2004; Cukierman and Muscatelli, 2008). With respect to the motivations of our study, the fact that changes in targets have been almost nonexistent or scarce at least is

We focus on the period from 1987:1 to 2007:12 in order to rule out the disinflation period of the early 1980s during which most of central banks have fought against high inflation. We consider a period of stable inflation over which potential changes in monetary policy would be ever more striking. We therefore escape the usual criticism that better inflation performance under IT is concomitant with disinflation policies that started being implemented all over the industrialized world in the early 1980s. There has been a global focus on inflation since then and we may suppose IT adopters may have behaved as IT central banks prior to the official adoption. Focusing on a stable sample starting in 1987:1 enables to assess if the *institutional* adoption had an effect on central bankers' behavior and preferences.

Our concern being on monetary policy preferences, we focus on the three standard variables of the Taylor (1993) rule: the nominal short-run interest rate, the officially-targeted CPI index and the output gap. We use monthly data. The interest rate is the central bank reference rate as advertised by central banks themselves. The inflation rate is the measure of inflation targeted by central banks. For the UK, the series is extrapolated from RPIX, RPI and CPI-H, the harmonized index of consumer prices. In Canada, the series is the CPI excluding eight of the most volatile components; and for Sweden, UND1X, a core CPI index, is used. Interest rates and price indices come from central banks' statistical databases. The output gap measure comes from the OECD whereas unemployment rates, which are used to check the robustness of our outcomes in replacement of output gap measures, are national measures taken from Thomson Financial Datastream. Inflation rates are expressed as the first difference of the log of the price index and all variables are expressed in percent. Figure 1 represents these series. The grey bars represent the implementation period between the institutional adoption of IT and its completion in the final form. Series are stationary and unit root tests are provided in table A of the Appendix.

3. Has Monetary Policy Changed? A Structural Break analysis

The first step of our analysis is to assess whether monetary policy preferences have changed during the sample considered and to compare potential break dates with the IT adoption date. In order to test the hypothesis that the adoption of inflation targeting may have changed the coefficients in the monetary policy reaction function, we use the estimation procedure of Qu and Perron (2007), which enables the estimation of unknown break dates in a multivariate framework.

3.1 Method

We characterize the monetary policy preferences with a usual Taylor-type rule with a smoothing term as advocated by Woodford (2003) and responses to future inflation and output as in Clarida, Gali, Gertler (1998, 2000). This forward looking rule takes the form:

$$r_t = \alpha + \rho\ (L) \cdot r_{t-1} + \beta_\pi \cdot \pi_{t+h_\pi} + \beta_y \cdot y_{t+h_y} + \varepsilon_t \qquad (1)$$

where r_t is the central bank reference rate and $\pi_{t+h\pi}$ and y_{t+hy} are central bank's expectations of inflation and output gap, respectively at horizons h_π and h_y. Results displayed hereafter are always long-run responses to inflation and output gap, that is to say $\beta_\pi/(1\text{-}\rho)$ and $\beta_y/(1\text{-}\rho)$. For the sake of convenience, we use the notations β_π and β_y in all the tables.

The empirical model we use to characterize the monetary policy preferences is therefore forward looking. This raises two issues. First, in the absence of proper internal forecasts of

important in that it helps to escape finding a change of monetary regime that would ensue solely from a change in the target, and not from a change in the preferences in order to achieve it.

these central banks over a long time span[11], we suppose that they behave under rational expectations. The relatively recent use of dynamic stochastic general equilibrium models under rational expectations in these institutions reinforces this assumption[12]. In absence of real-time forecasts for those three central banks (compared to the Federal Reserve which makes its real-time forecasts available), inflation and output expectations of central banks in the monetary rule are therefore assumed to be realized values, in accordance with the assumption made in the literature when facing data availability constraints. Second, we may be faced with the endogeneity problem. To circumvent it, we rely on arguments from Boivin (2006). We can assume that endogeneity is regular throughout the whole period; then, it should not distort the changes in the policy parameters. Moreover, in order to assess that our findings are not blurred by endogeneity, we estimate changes in monetary policy using different positive forecasting horizons h_π and h_y in the forward looking rule and with the current values of inflation and output gap (h_π=h_y=0) which are not affected by contemporaneous policy shocks and then not subject to potential endogeneity issue. Since changes are similar between future realizations and current values, it suggests that evidence regarding the policy coefficients is unaltered by this endogeneity problem. Last, we assess the robustness of our analysis by complementing it with a MSVAR backward-looking estimation (see section 5 below).

The benchmark specification of the monetary policy rule comprises four lags of the interest rate and we suppose the central bank focuses on inflation and output gap three quarters ahead, hence $h_\pi = h_y = 9$. We apply the multivariate procedure of Qu and Perron (2007) which allows us to test for the presence of breaks in the coefficients and variance of error of the monetary policy reaction function. It first tests the null hypothesis of no breaks against an unknown number of breaks up to a maximum of *M*, and then identifies the exact number and the locations of the breaks using a sequential approach. The procedure is as follows. The supremum statistic SupLR is a Wald-type test statistic for structural change at *M* unknown break dates. Then a sequential F-type test is used to determine the number of breaks and their locations. The SupSEQ is designed to detect the presence of *j+1* breaks conditional on having found *j* breaks. The statistical rule is to reject *j* in favor of a model with *j+1* breaks if the overall minimal value of the sum of squared residuals (over all the subsamples where an additional break is included) is sufficiently smaller than the sum of squared residuals from the model with *j* breaks. The dates of the selected breaks are the ones associated with this overall minimum. The sequential test statistic is applied until the test fails to reject the null hypothesis of no additional structural break. The maximum number *M* of breaks needs to be specified as well as the minimum fraction of the sample in each regime in proportion of the total sample size. The latter has to be chosen large enough for tests to have approximately correct size and small enough for them to have decent power. Moreover, when the errors are autocorrelated and/or heteroskedastic, it has to be larger than when these features are absent. In order to balance these issues, we set the minimal length at 0.20 and *M* = 3.

3.2 Results

Table 1 summarizes the estimated break dates. The Qu and Perron (2007) multiple structural breaks test reveals breaks at the date 1991:9, 1995:10 and 2001:7 for Canada, when allowing for 3 breaks. The most important one is in 1995:10 with a confidence interval at 90% from 1994:8 to 1995:11. This date corresponds to the end of the implementation period of IT. In the United Kingdom, the three estimated breaks are 1992:8, 1996:8 and 2001:7 with the third

[11] Canada started publishing internal forecasts in mid-2000s, Sweden in late 1990s and the UK in mid-1990s.

[12] See the Bank of England Quarterly Model, ToTEM model at the Bank of Canada and RAMSES model of the Sveriges Riksbank.

being non significant. The most important break is in 1992:12 with a confidence interval from 1990:12 to 1993:1. The break estimated takes place two months after the formal adoption of IT by the Bank of England. In Sweden, two break dates are evidenced: 1992:7 and 1996:7, with the second being only significant at the 10% level. The most important break when considering only one is 1992:10 with a confidence interval from 1992:9 to 1992:11. This break predates from 2 months the formal adoption of IT.

A change in the monetary policy preferences therefore happens just around the formal adoption of the new framework in Sweden and the United Kingdom, while the change happens in the end of the implementation period in Canada. Thus, the structural break estimated for each country coincides with the adoption or implementation of IT.

3.3 Linear Estimates

We provide in table 1 the linear estimates of the two regimes determined before and after the break date. In Canada, the response to inflation β_π is non significant before and after, while the response to output β_y is significant and equals one before and is not significant afterwards. For Sweden, neither the response to inflation nor to output is significant before and after. In the UK, the response to inflation is high (β_π = 1.52) and significant before and non significant after, while the response to output is never significant. All in all, there is no evidence of a policy change towards a greater focus on inflation.

3.4 Alternative forecasting horizons

Table 2 summarizes the linear estimates of responses to inflation and output for alternative forecasting horizons from h=0 to h=12. Estimated break dates are similar to the ones of the benchmark case. For Canada, the linear responses to inflation are very unstable from one horizon to the other, being positive, null or negative, while the decrease in the response to output seems to be confirmed. For Sweden, both responses are unstable. In the UK, the pattern is stable: both responses are lower after the break, but coefficients are not significantly different before and after the break. The outcomes show the instability of linear estimation of coefficients of monetary rules and calls for an estimation method that is able to reveal a gradual change in monetary policy preferences.

4. How has Monetary Policy Changed? A Time-Varying analysis

The Time-Varying Parameters model is well fitted for revealing a potential gradual and permanent change in the strategy of policymakers after IT was adopted. Indeed, Boivin (2006), Canova and Gambetti (2008) and Koop et al. (2009), among others, show monetary policy may change smoothly. Compared to MSVAR, TVP models permit to uncover changes in parameters separately. This model is of course less suitable for detecting a simultaneous single discrete jump for all parameters compared to the structural break analysis but allows to assess the evolution of monetary policy parameters at different points of the sample.

4.1 Method

We estimate policy changes induced by inflation targeting through a forward looking Taylor-type (1993) rule augmented with time varying coefficients. A generally accepted characterization of the monetary policy conduct takes the following form:

$$\begin{aligned} r_t &= \alpha_t + \rho_t(L)\cdot r_{t-1} + \beta_{\pi t}\cdot \pi_{t+h_\pi} + \beta_{yt}\cdot y_{t+h_y} + \varepsilon_t \\ &= \Psi_t' Z_t + \varepsilon_t \end{aligned} \tag{2}$$

where r_t is the central bank reference rate and $\pi_{t+h\pi}$ and y_{t+hy} are central bank's expectations of inflation and output gap, respectively at horizons h_π and h_y. Every coefficient has a *t* subscript to denote its time varying characteristics. We use this policy rule to assess the conduct of monetary policy in inflation targeting countries and determine the extent to which monetary policy has changed with the adoption of this monetary framework.

The Time-Varying Parameter model assumes that all policy parameters in the measurement equation (the Taylor rule) follow a driftless random walk, called the transition equation:

$$\Psi_t = \Psi_{t-1} + \upsilon_t \quad with \ \upsilon_t \sim N(0, \sigma_\upsilon^2) \tag{3}$$

This transition equation is estimated[13] using the Kalman filter. Evolution of coefficients depends therefore on the value of the noise to variance ratio, which is the ratio between the variance of the transition equation and the variance of the measurement equation ($\sigma_\upsilon^2 / \sigma_\varepsilon^2$). A regression with fixed regressors would consist in fixing $\sigma_\upsilon^2 = 0$ in the transition equation, thus having a noise to variance ratio equal to 0. When parameters are time invariant, the estimation would then produce OLS results. This noise to variance ratio defining the variance of the transition equation can be estimated by Maximum Likelihood (ML). However, when this variance is small, the "pile-up" case arises: the estimate is biased in the direction of 0, because the ML has a large point mass at 0. Stock and Watson (1998) propose to estimate it through a median unbiased estimator.

To uncover the evolution of the coefficients across time, we quite simply rely on an agnostic view as regards the value of the noise to variance ratio, which we set equal to 0.01: it means that the variance of the transition equation is small in comparison with the variance of the measurement equation. This is in line with the idea that policymakers do not change their reaction function very frequently. Indeed, this ratio is not essential in itself as it sets the variability of the coefficients. The rationale for using this method is to uncover the changes and the direction of these changes in policy coefficients more than the variability of these coefficients. We show later that our results are not sensitive to more or less volatility of policy parameters with a large range of ratios.

Last, the TVP approach allows dealing with heteroskedasticity, as some authors among which Sims (2001), Sims and Zha (2002), Primiceri (2005) and Kim and Nelson (2006) argue that time-varying variance of the shocks is more important than time-varying coefficients in modeling the monetary policy rule.

4.2 Results

Figure 2 reports the evolution across time of the responses, respectively to inflation and to the output gap, of the central bank interest rate for the benchmark policy rule with four lags and $h_\pi = h_y = 9$. The response to inflation has clearly decreased in Canada and Sweden, while being stable and non significant in the UK. In the former countries, the response is statistically significant in the beginning of the sample and not afterwards. The response to output gap has risen from negative and significant values to non significant values after 1995 in Canada and Sweden. In the UK, the response is not significant all over the sample.

All in all, estimates for Canada and Sweden testify for a lower monetary reaction towards inflation over the sample, at the benefit of a higher reaction towards the output gap. Time-varying estimates for the three countries clearly reject the hypothesis of a stronger focus on inflation with the adoption of inflation targeting and show that the conduct of monetary policy has not changed in the direction usually admitted since the late 1980s or since IT adoption. The latter has not led so far to an increase of the policy response to inflation. Moreover, IT adoption did not lead to a clear decrease of the policy response to output.

[13] We used the *Captain* toolbox to perform the estimations, from CRES, Lancaster University, Lancaster, LA1 4YR, United Kingdom, http://www.es.lancs.ac.uk/cres/captain/.

4.3 Robustness

Figure 3 exhibits the time-varying responses to future inflation and output at various horizons. For Canada and Sweden, the response to inflation has decreased whatever the forecasting horizon, while the response to output gap has increased. The picture is less pronounced for the UK, where depending on the forecasting horizon, the evolution of the monetary policy reaction towards inflation is mixed. The response is stable at the 9-month forecasting horizon, while is decreasing at the current, 6-month and 12-month horizon and thus the downward trend is similar to Canada's or Sweden's. For the response to the output gap, the difference with the other two countries under study is sizeable: the responses to the output gap range between a limited decrease and stagnation. Globally, the evolution of policy coefficients is consistent across forecasting horizons (between positive horizons and current values which are not subject to potential endogeneity issue) to the extent that they reject the hypothesis that the conduct of monetary policy has focused more strongly on inflation since IT adoption.

In order to check whether our results are dependent on the value of the noise to variance ratio, we have estimated the same specifications of the forward looking monetary policy rule with a noise to variance equal to resp. 0.1 and 0.001. We report[14] in figure 4 the estimates obtained with a noise to variance ratio of 0.001, hence with a smaller variance in the random walk process of policy parameters than the variance of policy shocks. The responses to inflation and to the output gap have evolved consistently with baseline estimates. It is even noteworthy that the decrease of the policy response to inflation in the UK is clearer with this specification of the noise to variance ratio than in the previous context.

Rejection of the hypothesis of an increase of the response to inflation is consistent with the time-varying estimations of Baxa et al. (2009), which find low and decreasing responses to inflation in Canada, Sweden and the UK.

5. Complementary Analysis through Markov-Switching VAR

In order to complement the structural break analysis, we now assess whether the potential break in the policy coefficients gives rise to a new regime and whether there have been or there have not been occurrences of return to the previous regime. For this, we adopt the nonlinear stochastic dynamic simultaneous equations model of Assenmacher-Wesche (2006) and Sims and Zha (2006). The Markov-Switching method allows us to confirm the break underlined in section 3 and to assess the possibility of a return to the previous regime. This analysis departs from the rest of the paper as the procedure does not involve a forward-looking monetary rule, but a (backward-looking) 3-equation VAR with the same three variables: the central bank interest rate, the inflation rate and the output gap. We acknowledge that a backward looking specification is not much representative of the behavior of central bankers, but it avoids the potential endogeneity bias and enables to verify the robustness of our forward looking results.

5.1 Method

The Markov-Switching VAR, as proposed by Hamilton (1989, 1994), allows the structural coefficients and the covariance matrix to be dependent on an unobserved state variable S_t which is assumed to follow a 1st order Markov chain. The joint distribution of the shocks can

[14] Estimates of policy coefficients with a noise to variance ratio equal to 0.1 are available from the authors upon request and display similar evolutions of policy coefficients.

be non-constant across the sample periods. The general framework is described by the following equation:

$$\begin{cases} y_t = x_t \cdot \beta_{S_t} + u_t & t = 1,\ldots,T \\ u_t \left| S_t \sim N(0,\Sigma_{S_t}) \right. & S_t = \{1,\ldots,M\} \end{cases} \tag{4}$$

where y_t = $(y_{1,t},..,y_{p,t})$ is an 1 × n vector of endogenous variables, with n the number of variables of interest, x_t is an 1 × np vector of p lagged endogenous variables, S_t is an unobserved state, β_{St} is an np × 1 vector of parameters, T is the sample size and M the number of states (or regimes). The covariance matrix Σ_{S_t} takes the form:

$$\Sigma_{S_t} = \sigma_S^2(S_t) \cdot I_p \tag{5}$$

The transition probabilities matrix, noted P, is defined following Hamilton (1994):

$$P = \begin{pmatrix} p_{11} & \cdots & p_{M1} \\ p_{12} & \cdots & p_{M2} \\ \vdots & \cdots & \vdots \\ p_{1M} & \cdots & p_{MM} \end{pmatrix} \tag{6}$$

$$\text{with } \sum_{j=1}^{M} p_{kj} = 1 \text{ and } p_{kj} \geq 0, \ \ \forall k, j \in \{1...M\}.$$

Initial values of the vector of parameters are calculated. A conditional probability density function is defined according to the information set in *t-1*. The model is recursively estimated through the ML "EM" algorithm, starting from the unconditional density of y_t which is calculated by summing conditional densities over possible values for S_t. The ML estimates are finally obtained by maximizing the log-likelihood function and allows to attain the final matrix of parameters.

Our approach is very close to that of Assenmacher-Wesche (2006). First, the baseline equation of the model is free of restrictions. The *ad hoc* nature of restrictions is totally opposed to the seminal motivation of our methodology: since we do not know *ex ante* the possible changes of monetary policy effects implied by IT and because the empirical approach is data driven (*i.e.* we are looking for what data tell us about this framework setting aside any preconceived conclusions), it becomes obvious that we cannot impose any restrictions on parameters. Second, the use of Bayesian techniques, though it represents a great advancement in structural estimation, runs up against the same motivation. Indeed, the link between estimation and calibration is strong and depends on subjective priors, which we chose not to use. In the end, the nearest method to the Bayesian one is the Maximum Likelihood (ML)'s, which is free of calibration.

Our variables of interest introduced in the VAR are the central bank interest rate, the inflation rate and output gap. Four lags have been introduced in the VAR. We focus on a full changes specification, *i.e.* a specification with changes in coefficients as well as in disturbance terms. We can underline different regimes with different monetary policy coefficients and thus test whether monetary policy has actually changed. We have tested for two to three different states (or regimes); since results are consistent and robust, we only present the 2-state specification which fits well into the issue of whether during a relatively short sample (1987-2007), IT has constituted a regime with a stronger focus on inflation *per se*.

5.2 Results

Results are reported in figure 5: they show the implied state-probabilities over time[15] and the coefficients[16] of the interest equation which characterize each monetary regime: the degree of persistence ρ, the respective long run response of the interest rate to inflation β_π, and to the output gap (or the unemployment rate) β_y. By long run response, we mean coefficients of response divided by one minus the autoregressive terms. The degree of persistence ρ comes from the sum of the coefficients on the lagged interest rates.

Canada does not show any regime shift over the sample: regime 1 has been prominent since the beginning of the sample and is characterized by a response to inflation satisfying the Taylor principle in the long run, as well as by a relatively high response to the output gap (see table 3 for point estimates and standard errors and table 4 for matrices of transition probabilities). Canada only experiences a period of adaptation between announcement and completion of IT and this regime 2 shows weak responses to inflation and the output gap. It seems that the break evidenced in section 3 corresponds to the implementation period and that central bank's preferences have not changed with the adoption of IT. Moreover, the preference of monetary authorities between both policy objectives – inflation and the output gap – under regime 1 is not biased in favor of an excessive focus on inflation: the coefficient on the output gap is higher.

In the UK, the MSVAR estimation does not underline a precise break but rather a situation evolving slowly from regime 2 to regime 1. The response to inflation of the gradually-more-frequent regime 1 is lower than the one in regime 2. Hence, the gradual prominence of regime 1 goes hand in hand with a lower focus of the Bank of England on inflation deviations from target. This latter result may complement those reported in Assenmacher-Wesche (2006)[17]: she opposed "high inflation" and "low inflation" states, and showed that during the "low inflation" state, the Bank of England had a higher reactivity to inflation deviations and the output gap than under "high inflation", which stopped being dominant before the beginning of our own sample. Our analysis focuses exclusively on the "low inflation" sample and shows that the evolution of policy preferences has not led to a greater focus on inflation.

As a matter of fact, the adoption of IT in Sweden has constituted a regime shift: regimes 1 and 2 were intertwined before IT adoption. Regime 1 has almost fully disappeared since IT announcement in 1993. This is a clear-cut result for Sweden which confirms the break estimated in section 3. It corresponds to the usual assessment by Swedish central bankers that monetary policy has entered into a new era after "flexible inflation targeting" was adopted (see Svensson, 2009). The hypothesis of a higher response to inflation is also

[15] Figures depict at each date the average probability to stand in the corresponding regime over the last 6 months.

[16] Coefficients of response are "artificial long run responses" of the policy rate to both objectives of monetary policy, and they have been computed as in SZ (2006), using the same confidence interval at 68 percent. ρ, β_π , β_y, correspond respectively to the AR coefficient, the long run coefficient on inflation and the long run coefficient on either the output gap or the unemployment rate, in the interest rate equation. According to SZ, "(artificial long run responses) are neither an equilibrium outcome nor multivariate impulse responses, but are calculated from the policy reaction function *alone*, asking what would be the permanent response in (the policy rate) to a permanent increase in the level or rate of change of the variable in question, if all other variables remained constant".

[17] Results are in contrast with those reported by Cukierman and Muscatelli (2008). Their estimations tend to show that the UK has entered a regime of "inflation dominance" since 1993, after a regime of "recession avoidance" until 1990. Contrary to the present paper, Cukierman and Muscatelli (2008) impose prior restrictions on the monetary policy reaction function, strongly assuming that a standard new Keynesian framework fits the data.

challenged as regime 1 being dominant after IT adoption exhibits a lower response to inflation than regime 2, consistently with the evolution estimated in section 4.

These findings for the three countries suggest that IT adoption has not constituted a change in the monetary policy reaction function *in the direction of* a higher focus on inflation. Two arguments have been used in this respect. First, in Canada, there has been a break during the implementation period (confirming estimates of the section 3), but not the emergence of a new monetary policy regime. Second, there has been a switch, abrupt for Sweden and smooth for the UK, towards a new regime with a lower response to inflation than in the other regime. Though this can raise concerns about whether monetary policy has been more permissive or more efficient, it remains that reaction of central banks to inflation has been reduced since IT adoption or completion, showing that monetary policies have not changed in the way generally admitted.

5.3 Robustness

A comparison of the estimated monetary reaction functions with those reported in the literature shows that they are common (see table 5). The long run responses of the Canadian central bank rate towards inflation and the output gap are consistent with Muscatelli et al. (2002)'s; the coefficient on inflation has a negative sign in Seyfried and Bremmer (2003), though the coefficient on the output gap is relatively close to ours. The negative sign reported for the monetary reaction towards inflation in the UK is also found in Kuttner (2004) and Seyfried and Bremmer (2003), whereas Valente (2003) found that the Taylor principle was violated. The violation of the Taylor principle in Sweden is shared by Muscatelli et al. (2002), whereas the negative Swedish monetary reaction towards the output gap can also be found in Kuttner (2004) and Muscatelli et al. (2002).

In order to assess the robustness of baseline MSVAR results, we ran new estimations with unemployment data, rather than output gaps. Unemployment rate can be considered as a proxy for the output gap, via Okun's law; moreover, it is a good measure of real activity at a monthly frequency (see Orphanides and Wieland, 2008). One, four and three lags have been introduced respectively for Canada, Sweden and the UK according to the Schwarz information criterion.

Regimes probabilities are reported on figure 6. Under this alternative setting, Canadian outcomes are similar: the second regime has only occurred during the implementation period towards full completion of IT, and the monetary regime has always remained the same before IT announcement and after IT completion. It confirms that no regime shift in favor of a stronger focus on inflation happened in Canada between 1987 and 2007. The conclusion is also reinforced in the case of the UK: the gradual prominence of regime 1 (with a lower focus on inflation) across time is in accordance with TVP estimates. For Sweden, the regime shift after IT adoption is also confirmed and consistent with TVP and structural break estimates. Computed estimations of monetary reaction functions including the unemployment rate (see tables 3 and 6), first, confirm the initial results while, second, they improve initial outcomes in that all reported coefficients show the expected signs.

6. Concluding remarks

The three preceding sections have shown that the official adoption of IT has not led to stronger responses to inflation in the monetary reaction functions. Two intertwined mechanisms may explain this result. First, IT is meant to help anchor private inflation expectations, which will enable a central bank to control inflation without pursuing aggressive action towards inflation variations. Second, the central bank's decision to lower inflation may have led to low and stable inflation and hence to a lower response to inflation. We also note differences between the three countries: in Sweden and the UK, it appears that the response to inflation has decreased, while there is not a new monetary policy regime in Canada. One potential interpretation of this difference may stem from the communication policies of the central banks. Indeed, Ehrmann, Eijffinger, Fratzscher (2009) have evidenced the significant role of central bank communication in guiding private forecasts. While the Bank of England and the Riksbank have started to publish their internal macroeconomic forecasts in the 1990s, the Bank of Canada has only started to do so in the mid-2000s. Furthermore, the former two publish their own policy rate projections, while the third do not. This analysis is consistent with the findings of Hubert (2010) showing that the Bank of England's and Riksbank's inflation forecasts influence private inflation forecasts while those of the Bank of Canada do not. The better anchoring of private inflation expectations in the UK and Sweden may then have allowed central banks to reduce their response to inflation.

The central contribution of this paper is to provide an empirical assessment of the changes in monetary policy coefficients induced by the adoption of inflation targeting without assuming the date and the nature of potential breaks. Indeed, a vast literature deals with the macroeconomic impact of inflation targeting, but there is only few papers which assess whether the institutional adoption of inflation targeting has really changed the conduct of monetary policy. The analysis is carried out with structural break and time-varying parameters estimations of a forward-looking standard monetary policy rule and complemented with an estimation of a (backward-looking) Markov-switching VAR with a focus on the interest equation. The main result is the following. In Canada, Sweden and the UK, the adoption of inflation targeting has not led to a greater focus on inflation whatever we consider steep or gradual estimation procedures. These outcomes, linked to evidence on the stability of private expectations in IT countries, suggest that the inflation targeting framework does not constitute a binding commitment to inflation, but permits to implement a flexible strategy.

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Table 1 - Testing Structural Break in the Benchmark monetary rule - 4 lags & h=9 when allowing for a break in the regression coefficients and in the covariance matrix of errors

	CANADA		
Maximum number of breaks allowed†	3 breaks		
SupLR test: 0 vs. 1	128.67***		
SupSEQ test: 1 vs. 2	31.64***		
SupSEQ test: 2 vs. 3	27.80**		
Estimated break dates	1991:9	1995:10	2001:7
Estimated break date when 1 break allowed	**1995:10**		
90% interval confidence	1994:8	1995:11	
OLS estimates	inflation - βπ	output - βy	sigma resid.
Sample pre-break	0.49 (1.60)	1.00* (0.55)	0.48
Sample post-break	-1.63 (1.17)	0.32 (0.30)	0.25
	SWEDEN		
Maximum number of breaks allowed†	3 breaks		
SupLR test: 0 vs. 1	467.69***		
SupSEQ test: 1 vs. 2	25.31*		
SupSEQ test: 2 vs. 3	0		
Estimated break dates	1992:7	1996:7	2002:6
Estimated break date when 1 break allowed	**1992:10**		
90% interval confidence	1992:9	1992:11	
OLS estimates	inflation - βπ	output - βy	sigma resid.
Sample pre-break	0.75 (0.25)	-0.61 (0.18)	0.80
Sample post-break	1.13 (0.60)	-0.10 (0.40)	0.37
	UK		
Maximum number of breaks allowed†	3 breaks		
SupLR test: 0 vs. 1	173.86***		
SupSEQ test: 1 vs. 2	35.22***		
SupSEQ test: 2 vs. 3	21.45		
Estimated break dates	1992:8	1996:8	2001:7
Estimated break date when 1 break allowed	**1992:12**		
90% interval confidence	1990:12	1993:1	
OLS estimates	inflation - βπ	output - βy	sigma resid.
Sample pre-break	1.52* (0.85)	0.16 (0.75)	0.46
Sample post-break	1.07 (0.95)	-0.46 (0.60)	0.15

† Given the minimal length criteria of a regime (set at 20% of the total length of the sample) and the location of the breaks from the global optimization with 3 breaks there is no more place to insert additional breaks that satisfy the minimal length requirement. Numbers in parentheses are standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table 2 - OLS estimates for both subsamples

	CANADA - 1995:10		**SWEDEN - 1992:10**		**UK - 1992:12**	
	inflation - βπ	output - βy	inflation - βπ	output - βy	inflation - βπ	output - βy
			Benchmark - h=9			
Sample pre-break	0.49 (1.60)	1.00* (0.55)	0.75 (0.25)	-0.61 (0.18)	1.52* (0.85)	0.16 (0.75)
Sample post-break	-1.63 (1.17)	0.32 (0.30)	1.13 (0.60)	-0.10 (0.40)	1.07 (0.95)	-0.46 (0.60)
			h=0			
Sample pre-break	-0.24 (0.60)	1.08*** (0.29)	0.36 (0.54)	-0.59 (0.40)	0.37 (0.82)	1.18** (0.42)
Sample post-break	1.67* (0.91)	0.20 (0.21)	1.63*** (0.57)	0.08 (0.27)	0.14 (0.88)	-0.69 (0.52)
			h=6			
Sample pre-break	-2.01 (2.01)	2.21*** (0.71)	0.63* (0.32)	-0.60** (0.23)	1.25*** (0.42)	-0.06 (0.31)
Sample post-break	-2.18** (1.00)	0.32 (0.25)	1.42** (0.67)	0.11 (0.39)	0.10 (1.13)	-0.52 (0.69)
			h=12			
Sample pre-break	1.72 (1.26)	0.33 (0.45)	0.83*** (0.25)	-0.65*** (0.17)	2.09 (1.45)	0.10 (1.48)
Sample post-break	-2.74** (1.32)	0.37 (0.36)	0.85 (0.55)	-0.29 (0.40)	0.54 (0.95)	-0.88 (0.63)

Numbers in parentheses are standard errors. *,**,*** means respectively significant at 10%, 5% and 1%.

Table 3 - Individual Coefficients of the Interest Rate Equation

3-equation VAR with Output Gap

Canada

regime1		rate	inf.	gap
const	-0.01			
	(0.03)			
lag1		1.20*	-0.05*	0.17*
		(0.03)	(0.05)	(0.12)
lag2		-0.15*	0.19*	0.07
		(0.04)	(0.05)	(0.26)
lag3		-0.03	0.09*	-0.12
		(0.04)	(0.05)	(0.24)
lag4		-0.03*	0.00	-0.09
		(0.03)	(0.05)	(0.11)
sigma		0.02		
Σ coefficients		0.98	0.23	0.03
Long Run Responses			1.36	2.24

regime2		rate	inf.	gap
const	1.25*			
	(0.66)			
lag1		1.11*	5.53*	-0.95*
		(0.22)	(1.14)	(0.68)
lag2		-0.59*	-1.34*	0.15
		(0.52)	(0.81)	(0.53)
lag3		-1.78*	-0.50	1.63
		(0.70)	(0.79)	(1.63)
lag4		2.12*	-3.82*	-0.65
		(0.44)	(1.38)	(1.05)
sigma		0.15		
Σ coefficients		0.86	-0.14	0.18
Long Run Responses			-0.08	1.29

Sweden

regime1		rate	inf.	gap
const	0.05*			
	(0.02)			
lag1		1.47*	-0.08*	0.01
		(0.07)	(0.05)	(0.09)
lag2		-0.44*	0.14*	-0.15
		(0.07)	(0.04)	(0.17)
lag3		-0.04*	0.01	0.40*
		(0.03)	(0.05)	(0.26)
lag4		-0.01	-0.01	-0.26*
		(0.02)	(0.06)	(0.14)
sigma		0.02		
Σ coefficients		0.98	0.05	-0.01
Long Run Responses			0.21	-0.34

regime2		rate	inf.	gap
const	-0.21			
	(0.65)			
lag1		0.76*	0.74*	-0.15
		(0.12)	(0.37)	(0.62)
lag2		-0.06	0.60	1.69
		(0.13)	(0.65)	(2.28)
lag3		0.01	0.97*	-4.36*
		(0.17)	(0.71)	(3.56)
lag4		0.26*	-0.86*	2.76*
		(0.12)	(0.37)	(1.85)
sigma		0.40		
Σ coefficients		0.96	1.46	-0.06
Long Run Responses			2.43	-1.38

United Kingdom

regime1		rate	inf.	gap
const	0.01			
	(0.03)			
lag1		0.99*	-0.02	0.04
		(0.04)	(0.03)	(0.17)
lag2		0.02	0.01	0.06
		(0.06)	(0.02)	(0.36)
lag3		0.02	0.02	-0.20
		(0.06)	(0.03)	(0.32)
lag4		-0.05*	-0.04*	0.10
		(0.04)	(0.03)	(0.14)
sigma		0.01		
Σ coefficients		0.98	-0.03	0.00
Long Run Responses			-0.14	0.09

regime2		rate	inf.	gap
const	0.14*			
	(0.11)			
lag1		1.31*	0.15*	1.24*
		(0.11)	(0.10)	(0.34)
lag2		-0.24*	0.34*	-2.96*
		(0.19)	(0.10)	(0.69)
lag3		0.01	0.09*	2.85*
		(0.24)	(0.08)	(0.67)
lag4		-0.14	0.28*	-1.05*
		(0.14)	(0.09)	(0.35)
sigma		0.10		
Σ coefficients		0.94	0.85	0.08
Long Run Responses			1.14	1.29

3-equation VAR with Unemployment

Canada

regime1		rate	inf.	unemp.
const	0.47*			
	(0.09)			
lag1		0.97*	0.39*	-0.07*
		(0.00)	(0.09)	(0.01)
sigma		0.03		
Σ coefficients		0.97	0.39	-0.07
Long Run Responses			1.03	-2.40

regime2		rate	inf.	unemp.
const	2.55*			
	(1.52)			
lag1		0.70*	0.19	-0.04
		(0.07)	(0.24)	(0.12)
sigma		0.25		
Σ coefficients		0.69	0.19	-0.04
Long Run Responses			0.05	-0.12

Sweden

regime1		rate	inf.	unemp.
const	0.03			
	(0.05)			
lag1		1.50*	-0.04	-0.08*
		(0.06)	(0.07)	(0.06)
lag2		-0.51*	0.07*	0.08*
		(0.06)	(0.05)	(0.06)
sigma		0.03		
Σ coefficients		0.99	0.03	0.00
Long Run Responses			0.22	-0.06

regime2		rate	inf.	unemp.
const	1.08*			
	(0.67)			
lag1		0.86*	0.34*	1.04*
		(0.09)	(0.25)	(0.64)
lag2		0.02	0.64*	-1.13*
		(0.09)	(0.46)	(0.68)
sigma		0.57		
Σ coefficients		0.89	0.97	-0.09
Long Run Responses			0.68	-0.79

United Kingdom

regime1		rate	inf.	unemp.
const	0.05*			
	(0.03)			
lag1		1.01*	0.01	-0.26*
		(0.05)	(0.03)	(0.16)
lag2		0.07	0.02	0.09
		(0.07)	(0.02)	(0.26)
lag3		-0.08*	0.03	0.16
		(0.05)	(0.03)	(0.16)
sigma		0.01		
Σ coefficients		0.99	0.06	-0.01
Long Run Responses			0.53	-0.76

regime2		rate	inf.	unemp.
const	-0.12			
	(0.13)			
lag1		1.31*	-0.01	-0.67*
		(0.10)	(0.10)	(0.43)
lag2		-0.19*	0.25*	0.08
		(0.15)	(0.10)	(0.76)
lag3		-0.12*	0.17*	0.57*
		(0.09)	(0.09)	(0.41)
sigma		0.11		
Σ coefficients		1.00	0.42	-0.01
Long Run Responses			5.72	-3.08

Standard errors are in parentheses. * $p < 0.3$. The long run response for inf. is annualized to match the annual rate of interest.

Table 4 - Matrix of markovian transition probabilities P[i,j]

Canada	Sweden	UK
Output gap	Output gap	Output gap
0.93 0.73	0.90 0.39	0.68 0.49
0.07 0.27	0.10 0.61	0.32 0.51
Unemployment	Unemployment	Unemployment
0.95 0.40	0.93 0.27	0.73 0.38
0.05 0.60	0.07 0.73	0.27 0.62

Table 5 - Long Run Policy Responses

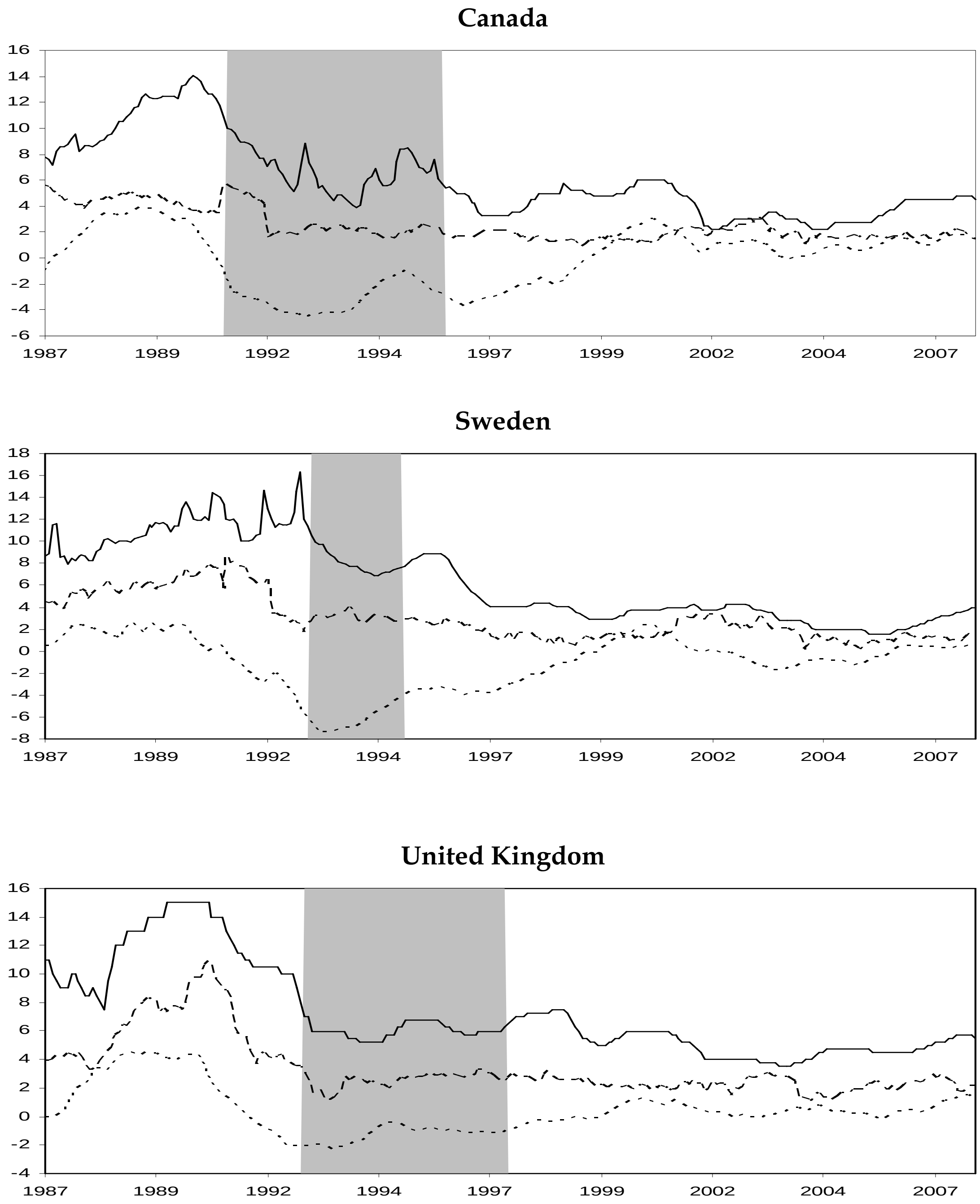
		Canada	Sweden	UK
Regime 1				
Responses of R to				
	inflation - β_π	1.36	0.21	-0.14
	output gap - β_y	2.24	-0.34	0.08
*Kuttner (2004)**				
Responses of R to				
	inflation forecast - β_π	na	1.97	-0.47
	output gap - β_y	na	-0.55	0.32
*Muscatelli et al. (2002)***				
Responses of R to				
	expected inflation - β_π	1.32	0.77	1.40
	output gap - β_y	1.41	ns	0.57
Seyfried and Bremmer (2003)				
Responses of R to				
	inflation - β_π	-0.12	na	-0.45
	output gap - β_y	1.45	na	0.37
Valente (2004)				
Responses of R to				
	inflation - β_π	na	na	0.69
	output gap - β_y	na	na	0.13

*: estimations including growth forecast (not reported)
**: estimations giving the lowest standard error and including other regressors (money growth, exchange rate, etc.: not reported)
ns: not significant; na: not available

Table 6 - Long Run Policy Responses - Unemployment

		Canada	Sweden	UK
Regime 1 Responses of R to				
	inflation - β_π	**1.03**	**0.21**	**0.52**
	unemp. - β_y	-2.40	-0.06	-0.76
Regime 2 Responses of R to				
	inflation - β_π	0.05	0.68	5.71
	unemp. - β_y	-0.12	-0.79	-3.07

Figure 1 –Data

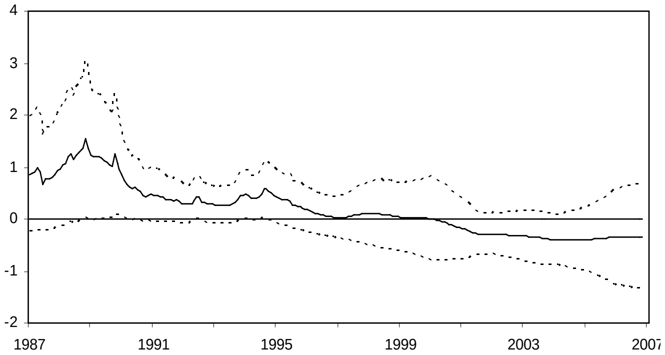


The implementation period between the adoption of IT and its completion in final form has been represented by a grey area. The solid line is the central bank reference interest rate, the dashed line is the inflation rate targeted by the central bank, and the dotted line is the output gap.

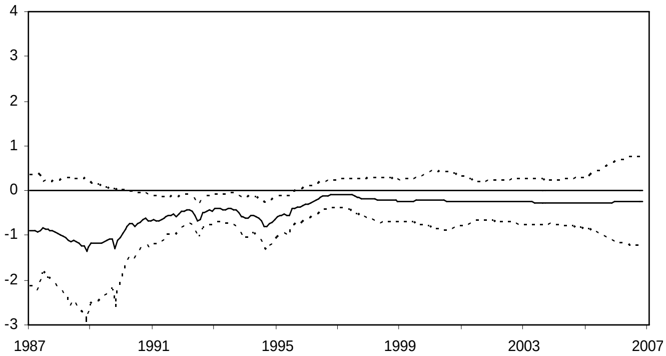
Figure 2 – Time-Varying Responses to Inflation and Output Gap with h_π = h_y = 9, a Noise-to-Variance ratio = 0.01 and 1 S.E. bands

Canada

Response to inflation

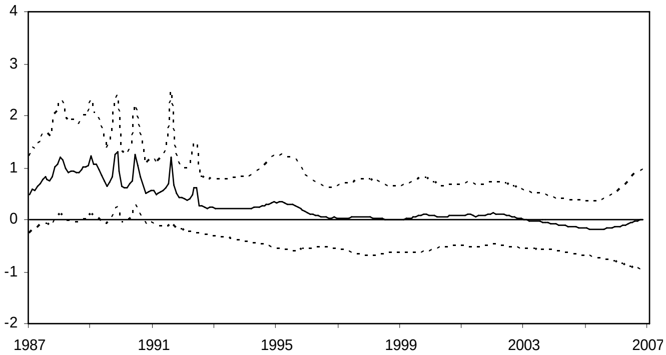


Response to output gap

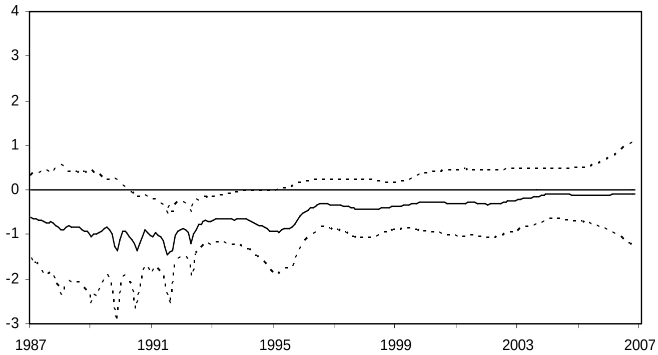


Sweden

Response to inflation

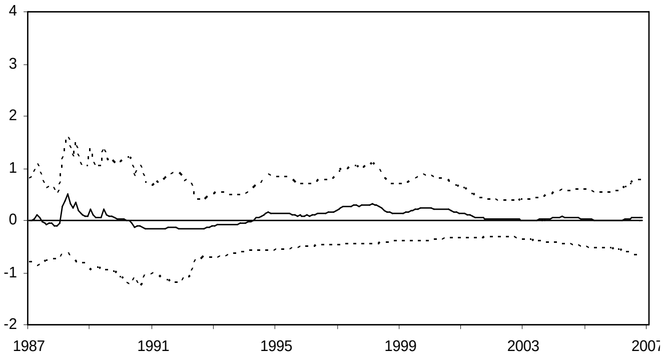


Response to output gap



United Kingdom

Response to inflation



Response to output gap

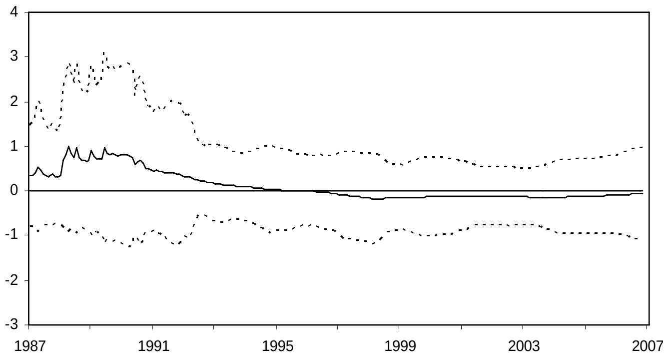
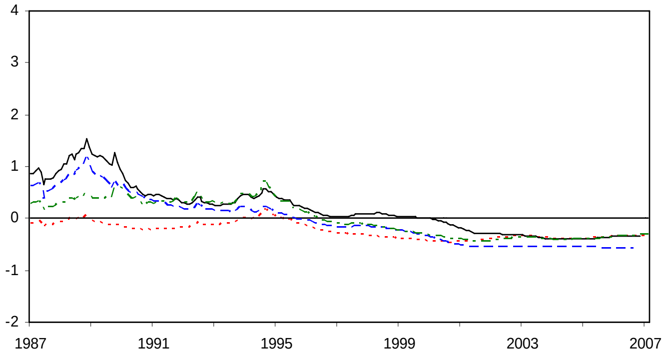


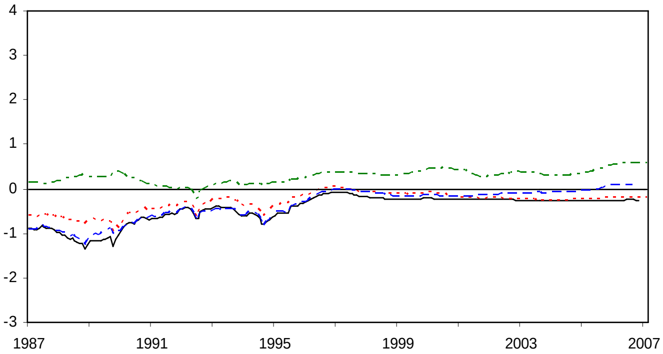
Figure 3 – Time-Varying Responses to Inflation and Output Gap with Alternative Forecasting Horizons h_π and h_y, and a Noise-to-Variance ratio = 0.01

Canada

Response to inflation

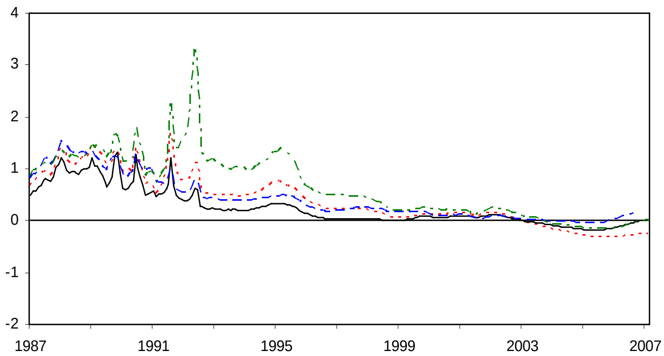


Response to output gap

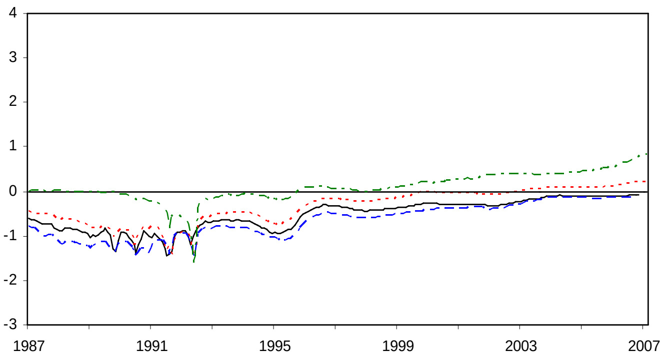


Sweden

Response to inflation

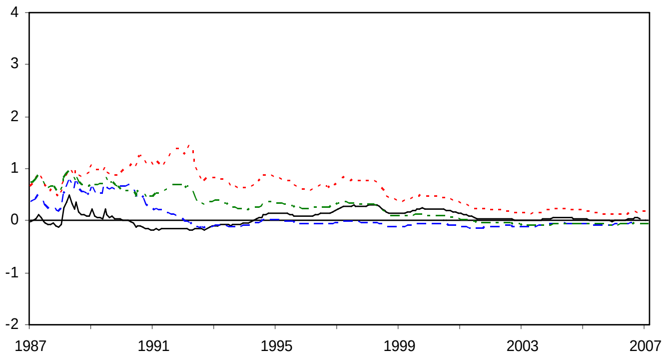


Response to output gap

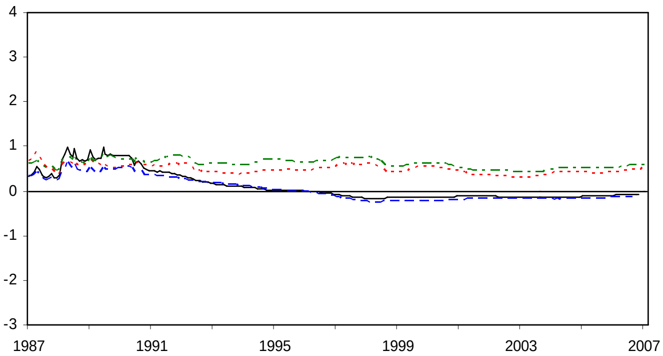


United Kingdom

Response to inflation

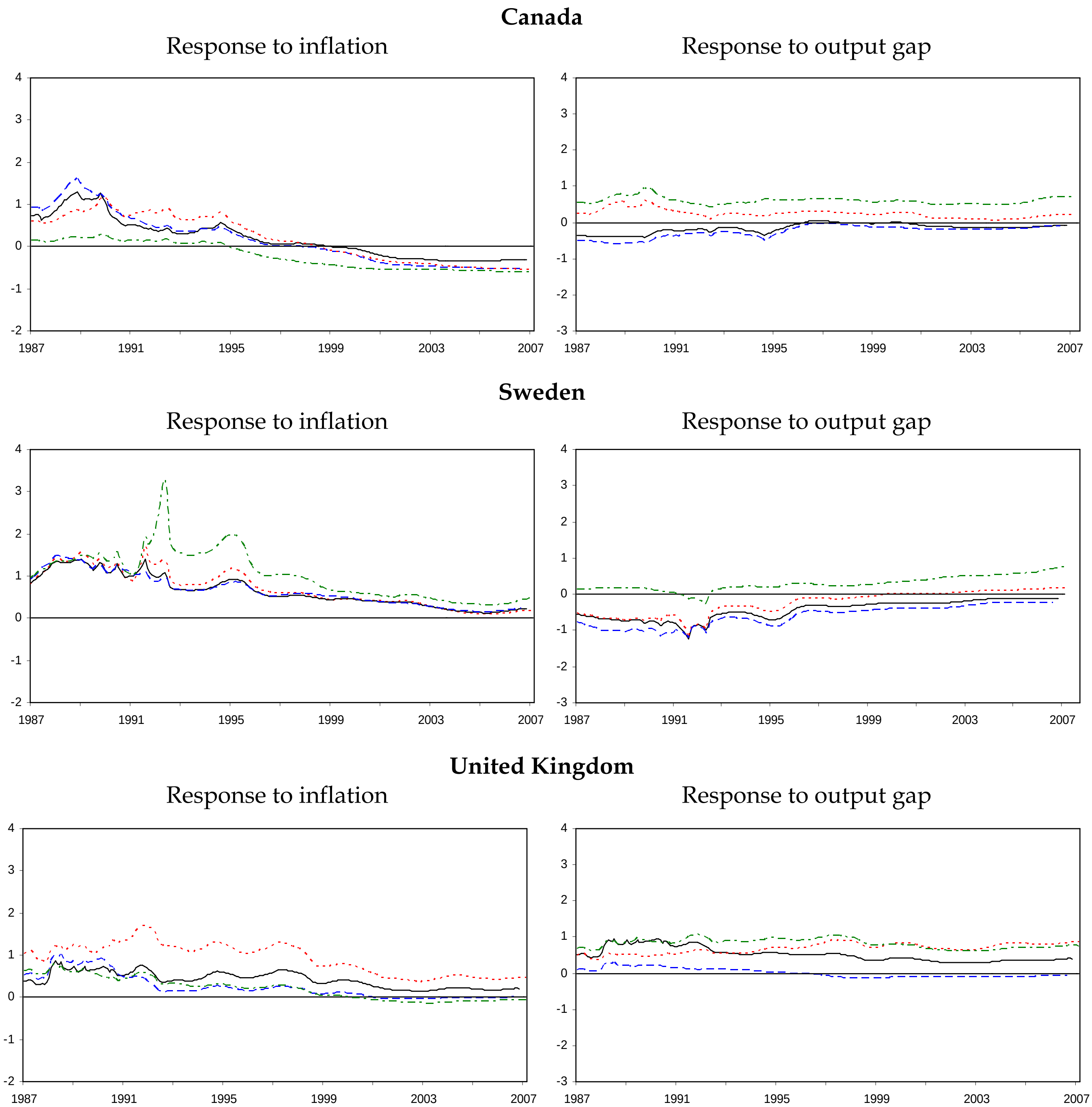


Response to output gap



The dot-dashed green line stands for [$h_\pi = h_y = 0$], the dotted red line for [$h_\pi = h_y = 6$], the solid black line for [$h_\pi = h_y = 9$] and the dashed blue line for [$h_\pi = h_y = 12$].

Figure 4 – Time-Varying Responses to Inflation and Output Gap with an Alternative Noise-to-Variance ratio = 0.001

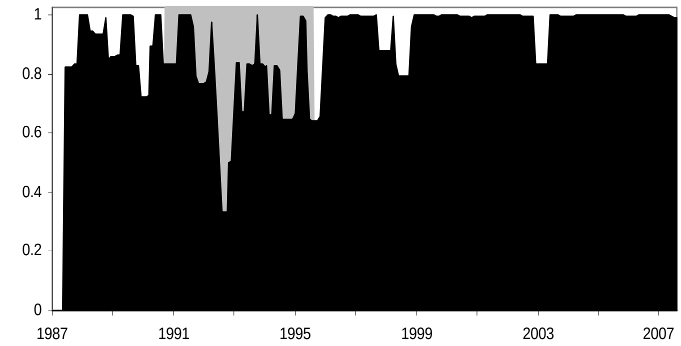


The dot-dashed green line stands for [$h_\pi = h_y = 0$], the dotted red line for [$h_\pi = h_y = 6$], the solid black line for [$h_\pi = h_y = 9$] and the dashed blue line for [$h_\pi = h_y = 12$].

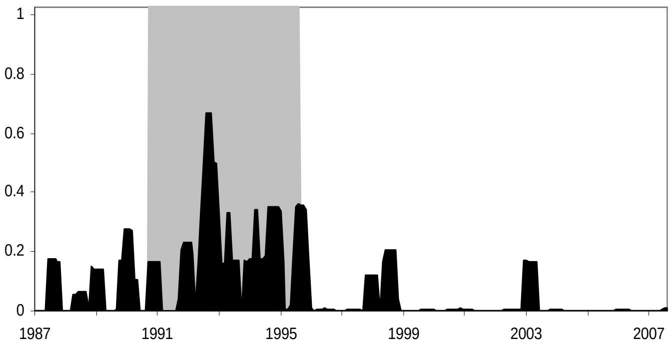
Figure 5 – Regimes' Probabilities over time
for 3-equation VAR with Output gap

Canada

Regime 1 - ρ = 0.98, β_π = 1.36, β_y = 2.24

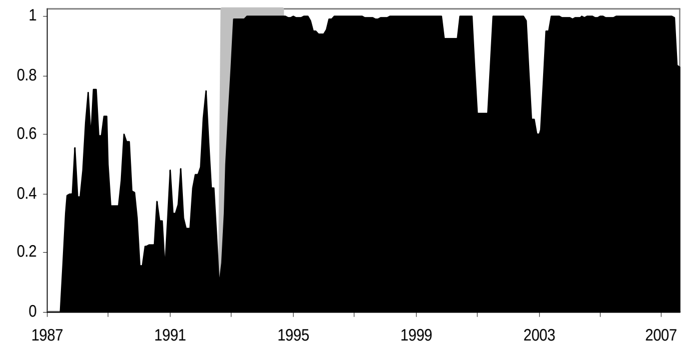


Regime 2 - ρ = 0.85, β_π = -0.08, β_y = 1.29

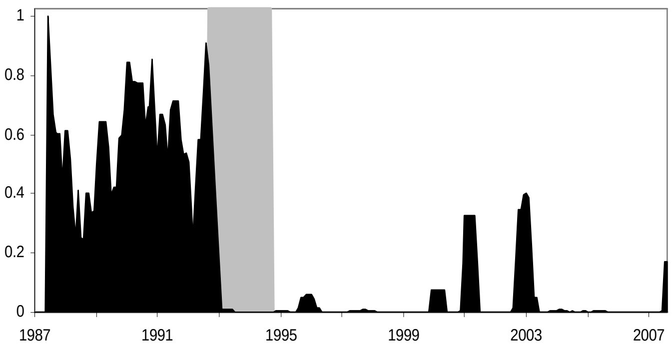


Sweden

Regime 1 - ρ = 0.98, β_π = 0.21, β_y = -0.34

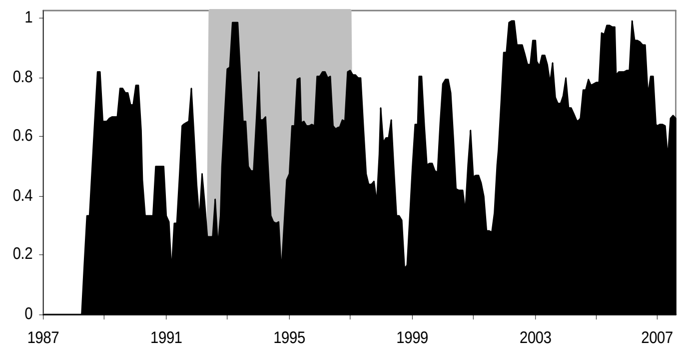


Regime 2 - ρ = 0.95, β_π = 2.43, β_y = -1.37



United Kingdom

Regime 1 - ρ = 0.98, β_π =-0.14, β_y = 0.08



Regime 2 - ρ = 0.94, β_π = 1.14, β_y = 1.29

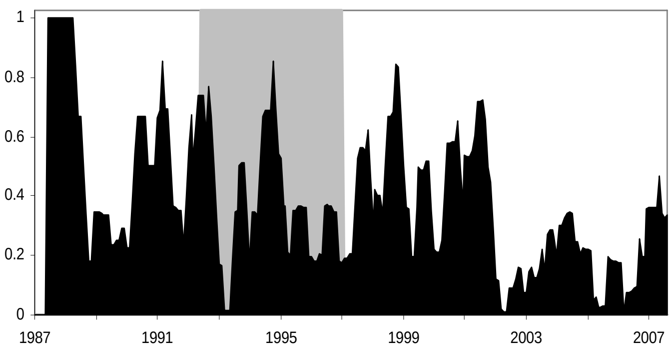
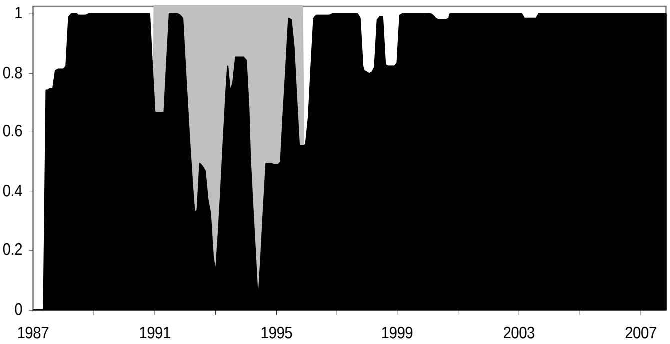


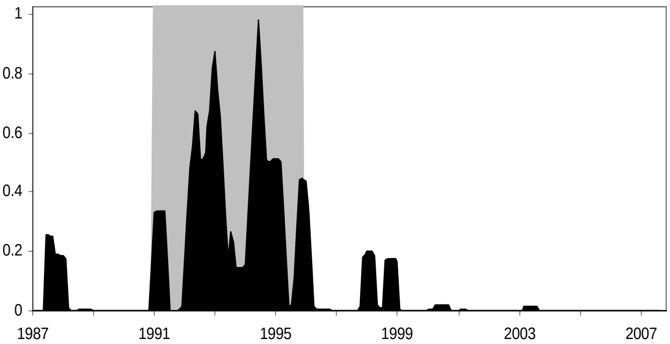
Figure 6 - Regimes' Probabilities over time
for 3-equation VAR with Unemployment

Canada

Regime 1 - $\rho = 0.97$, $\beta_{\pi} = 1.03$, $\beta_y = -2.40$

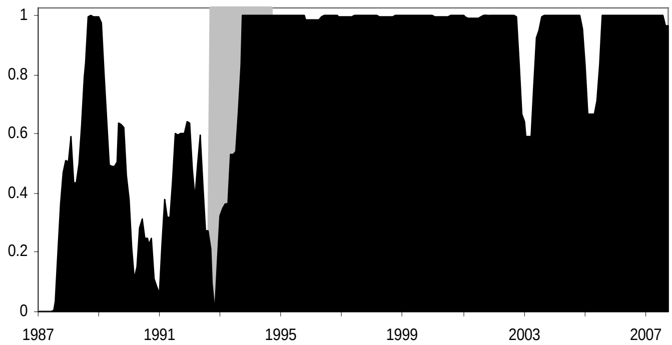


Regime 2 - $\rho = 0.69$, $\beta_{\pi} = 0.05$, $\beta_y = -0.12$

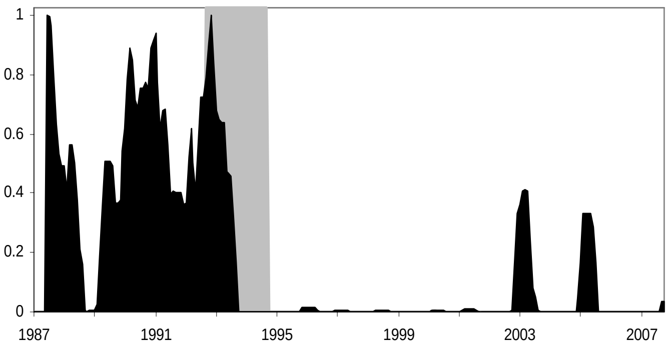


Sweden

Regime 1 - $\rho = 0.98$, $\beta_{\pi} = 0.21$, $\beta_y = -0.06$

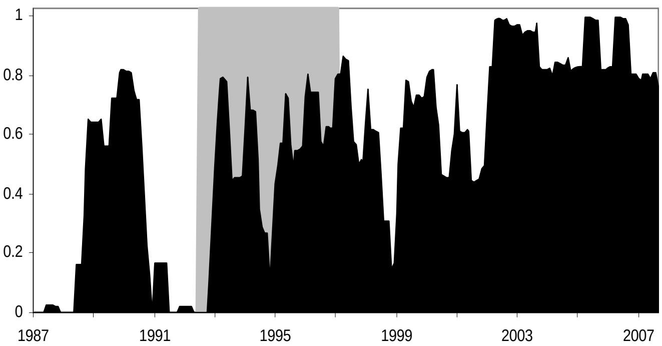


Regime 2 - $\rho = 0.88$, $\beta_{\pi} = 0.68$, $\beta_y = -0.79$

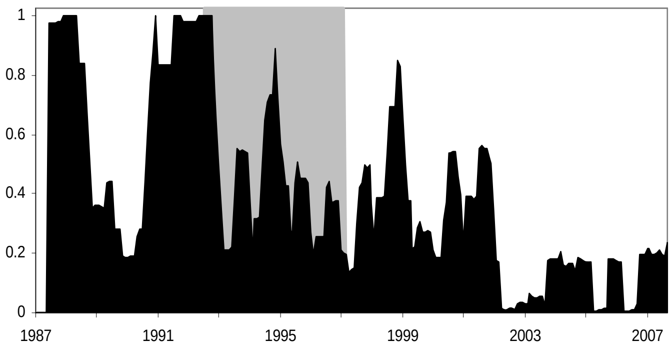


United Kingdom

Regime 1 - $\rho = 0.99$, $\beta_{\pi} = 0.52$, $\beta_y = -0.76$



Regime 2 - $\rho = 0.99$, $\beta_{\pi} = 5.71$, $\beta_y = -3.07$



Appendix

Table A - Stationary tests for Interest rate, Inflation Rate and Output Gap

Method	Statistic	Prob.
Canada		
Method	Statistic	Prob.
ADF - Fisher Chi-square	16.67	0.01
ADF - Choi Z-stat	-2.49	0.01
Sweden		
Method	Statistic	Prob.
ADF - Fisher Chi-square	11.66	0.07
ADF - Choi Z-stat	-1.78	0.04
United Kingdom		
Method	Statistic	Prob.
ADF - Fisher Chi-square	18.70	0.00
ADF - Choi Z-stat	-2.29	0.01

Tests are performed for individual roots on the whole sample with 252 observations and an automatic selection of lags based on SIC. The null hypothesis is the presence of an individual unit root process