Has the Adoption of Inflation Targeting Represented a Regime Switch?
Empirical evidence from Canada, Sweden and the UK

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Abstract. Empirical evidence on inflation targeting (IT) outcomes has been mixed so far, mainly because most of the assessments have been based on a control group methodology in a period where differences between IT and non-IT countries were insignificant. In this paper, we study IT impact over time and whether its adoption has constituted a regime switch within the country using a Markov-Switching VAR technique. We assess, based on two different specifications, the two main features of IT: the preference for inflation in the monetary reaction function and the communication and transparency issues to anchor expectations. Our results contribute to the literature by showing first, at the policy level, that IT has not constituted a regime switch in favour of inflation; second, at the environment level, that a switch clearly appears for countries that have provided, through forecasts’ communication, means for the public to anchor expectations. Our results are visible on a stable sample, after inflation has been tamed, and robust to a comparison with a non-IT country: the US. Last, counterfactuals suggest this framework provides higher monetary policy leeway.

Keywords. Monetary policy; Inflation targeting; MSVAR; Regime-Switching; Counterfactuals; UK; Canada; Sweden.

JEL classification. E52, E58.

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1. Introduction

Since 1990, a growing number of countries have adopted explicit inflation targeting (IT) around the world and many assessments have been performed, but empirical evidence has been mixed so far. One reason for this relatively poor evidence has been that in a world where inflation has declined substantially since the early 1980s, it is rather difficult to emphasize the country-specific impact of IT.

The principal objective of this paper is to shed new light on the debate surrounding the impact of inflation targeting (IT) from a new standpoint: the use of regime-switching method (Markov-Switching VAR, hereafter MSVAR). Our paper has been motivated by three issues that this method can tackle. The first two of them concern the evaluation of IT characteristics, while the third is methodological.

First, this regime-switching method allows us to assess consequences of the adoption of this framework in terms of policy preferences, as IT is generally supposed to focus solely on inflation. Our first test focuses on changes in coefficients in order to assess potential modification of monetary policy reaction function. Second, IT implies forecasts’ communication and transparency involvement in order to anchor public expectations (Gurkaynak, Levin and Swanson, 2006). Then, according to economic theory, anchoring expectations contributes to economic stability. Our second test with MSVAR therefore highlights, by keeping coefficients constant, changes in the monetary environment. Third, the reason why empirical literature has been mixed so far is mainly that most of the articles focused on a control group method during a period where differences between IT and non-IT countries were insignificant. In contrast, our starting point has been to focus on individual countries to study changes over time that may have been implied by the adoption of IT.

In this respect, we assess IT adoption in three developed countries: Canada, Sweden and the UK through the multivariate Markov-Switching VAR model methodology, in the vein of Hamilton (1994) and Sims and Zha (2006). Contrary to the latter, no subjective priors are introduced in the model and the number of endogenous variables is reduced. The framework is close to the New Keynesian type. Two types of model are investigated: one with full changes, i.e. changes in coefficients and in intercept and variance; and the other where changes across “regimes” are only due to intercept and variance.

Our results contribute to the literature in many ways. First, they suggest that IT adoption has not constituted the change in the monetary reaction function which is generally admitted in the literature. No changes have occurred in Canada and the UK, while the adoption of IT in Sweden has produced a switch to a regime which has been less focused on inflation. Second, a switch in the monetary environment is clearly visible for both countries – Sweden and the UK – that have fully enhanced transparency thanks to forecasts’ communication. Moreover, this switch has been accompanied by a reduction of uncertainty. It suggests that IT success depends on communication to the public in order to anchor expectations. Less clear-cut results concerning Canada are from this point of view of interest: they confirm the latter interpretation. Last, IT seems to offer more policy leeway. The reason might stem from the successful anchoring of expectations.

The remainder of the paper is organised as follows. Section 2 deals with preliminary issues: empirical evidence on IT countries is reviewed, and the choice of the three countries and the underlying model are discussed. In section 3, the regime-switching method is presented.
Section 4 displays and comments results. Robustness checks and counterfactuals are performed. Section 5 summarises our main conclusions.

2. Preliminary issues

2.1. Does inflation targeting matter?

A great deal of attention has been paid to IT in the recent literature devoted to monetary policy\(^1\). As such, this strand has advocated a general framing of monetary policymaking, encompassing clear targets, accountable policymakers and a flexible strategy. In the words of its promoters, e.g. Bernanke et al. (1999), inflation targeting should be viewed as a “framework” rather than as a prescription of adopting mechanical rules like the Taylor rule\(^2\).

The essence of IT lies somewhere between rules and discretion, and has been labelled: “constrained discretion”. In the words of his promoters: “Inflation targeting is a framework for monetary policy characterized by the public announcement of official quantitative targets (...) for the inflation rate (...); by explicit acknowledgment that low, stable inflation is monetary policy’s primary long-run goal; (...) (by) vigorous efforts to communicate with the public about the plans and objectives of the monetary authorities, and (...) mechanisms that strengthen the central bank’s accountability for attaining those objectives.” (Bernanke et al., 1999, p.4). Later on, they add: “By imposing a conceptual framework and its inherent discipline on the central bank, but without eliminating all flexibility, IT combines some of the advantages traditionally ascribed to rules (discipline, stability) with those ascribed to discretion (flexibility)” (Bernanke et al., 1999, p.4, words in bold added).

The IT framework can be related to discipline in that it anchors expectations thanks to the publicly announced inflation target range. 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. But it permits some flexibility: deviations from the target do not incur a loss of credibility and reputation provided the reasons for the deviations are explained to the public. This flexibility gives some leeway to monetary policy and gives IT framework a specific feature that the Taylor rule cannot fully retain.

In the recent past, some OECD countries turned formally to an IT regime (see table 6.1 in Ball and Sheridan, 2003): between New-Zealand, which adopted it in 1990, and Spain, which did in 1995, five others did like Canada, Sweden and the UK. These institutional regime shifts raised questions on their direct incidence on the optimality of implemented monetary policy, e.g., have (expected) interest and inflation rates been lower than in non IT countries?

Johnson (2002) and Ball and Sheridan (2003) made important contributions to the assessment of the effects of IT on the countries which adopted it, developing cross-country studies with a control group. Their conclusion were mixed: whereas Johnson produced evidence of lower expected inflation in IT countries after the announcement of targeting, Ball and Sheridan

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\(^1\) A critical presentation can be found in Kuttner (2004).

\(^2\) Beyond its potential mechanical feature, the Taylor rule poses two main problems. First, it may produce indeterminacies, either related to the price level (Woodford, 2001), or to the equilibrium trajectories (Benhabib et al., 2001). Second, Qin and Enders (2008) concluded that the out-of-sample forecasting performance of a US Taylor rule were better than a univariate AR model before 1979, but not after although the first assessment by Taylor (1993) pointed to its accuracy between the mid-1980s and early 1990s. The relevance of the Taylor rule for anchoring monetary expectations is at stake.
found no evidence of a beneficial impact of IT on a country’s economic performance in comparison with non-IT countries. Economic performance was assessed using a very large scope of indicators: inflation, inflation variability, inflation persistence, output growth, output variability, long-term interest rates, and variability of short-run interest rates.

These latter results raised many doubts on the empirical validity of the methodology of adopting a control group. These doubts can be summarized by the following comments by Gertler (2003): “(Ball and Sheridan) make two main arguments:

1. The existing evidence in favour of inflation targeting is open to identification problems.
2. After taking into account this identification problem, the evidence suggests that inflation targeting has been irrelevant.

(...) The essence of the authors’ argument is that the endogeneity of inflation targeting makes the existing evidence difficult to interpret. I will argue that this same endogeneity problem potentially clouds the interpretation of their empirical tests. In particular, to the extent that there is not much exogenous variation in the choice to adopt inflation targeting, it may be very difficult to identify the effects, particularly in a small sample. (...) (Many of the nontargeters (if not just about all) (...) adopted monetary policies that were very similar in practice to formal inflation targeting. This lack of sharpness in the classification scheme further complicates the task of disentangling the contribution of inflation targeting.”

Despite this criticism, other empirical papers using a cross-country study have recently validated Ball and Sheridan (2003)’s early results. For instance, Angeriz and Arestis (2007) do not find a significant break in the estimated evolution of inflation in the UK after the adoption of inflation targeting. Comparing with a control group made of the US and EMU shows that central banks which do not pursue IT strategy have performed “at least as well” as the UK. According to the authors, this is not surprising since “in the UK, IT was introduced after inflation had been tamed.”

Using a more sophisticated methodology, Cecchetti et al. (2002) conclude that the extent to which IT exerts a measurable influence on monetary policy is limited. They quantify the monetary transmission mechanism of EU countries using a structural autoregression approach; then, they compute the revealed preferences of each national central bank in terms of the trade off between inflation and output variability to gauge differences among targeters and non-targeters. They conclude that differences are minimal.

These different papers are all confronted with the control group problem first enlightened by Gertler (2003) in this strand of the literature and magnified by exceptional stability of world inflation rates during last decade. They are also confronted with the self-selection problem of policy adoption (Lin and Ye, 2007): what may have led actually to lower inflation in IT countries was their decision to aim specifically at lower inflation than in earlier (pre-IT) periods.

Lin and Ye (2007) produce a statistical assessment of the possible effects of inflation targeting strategy on inflation, inflation variability, long-term interest rates and the income velocity of money using propensity score matching methods. They claim to address the self-selection problem of disentangling between IT and non-IT countries. Their dataset incorporates seven IT countries (Australia, Canada, Finland, New Zealand, Spain, Sweden, and the UK) and fifteen industrial non-IT countries. They conclude that IT has had no significant effects. Whereas propensity score matching is of particular interest in micro
empirics, the reliability of this method applied to macroeconomic data remains questionable: matching aggregates is confusing, the control group problem remains, and the use of annual data seems to stand in opposition with the need for a very large dataset with this method.

A new strand of the literature making use of Markov-Switching VAR (MSVAR) has developed and permits to date breaks and new regimes while letting data speak. It enables to circumvent the control group problem and to reveal the different regimes which have occurred in these IT countries. Moreover, the choice of regimes rather than pure breaks enables to check the argument that anti-inflation policies had already existed in the past, either shortly before IT adoption or hand-in-hand with the “Great Moderation” process, i.e. exogenously to IT adoption.

Unlike earlier attempts (see Ammer and Freeman, 1995), sufficiently-long samples since IT adoption will eventually produce the occurrence of a new regime. Ammer and Freeman 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 difference between both variables – actual and forecasted – as evidence of a change of regime. In contrast, using MSVAR technique can reveal a new regime rather than assume it.

Last, the MSVAR permits to go further than only checking for a change in regime that would only occur at the level of the monetary reaction function. First, tests of these functions generally do not capture multiple shifts in variance because they do not make enough allowance for heteroskedasticity. Second, identification of forward-looking monetary reaction functions is generally fragile. Third, inflation-targeting is not about interest rate rules but it is a practical framework which promotes the optimality of constrained discretion for monetary policy.

### 2.2. Selected countries

In the following, we concentrate on three industrialized IT countries, the biggest ones among those having adopted it the earliest: Canada, Sweden and the UK. The reasons for the choice of these three countries have been twofold. First, the choice has been driven by the need of homogeneity among them; a minimum set of similarities is required to perform a sensible international comparison. But, second, a minimum set of differences is also required in that it enables to assess the robustness of IT country-performances: despite differences, the fact that IT performances may be comparable would be an answer to the papers which state that monetary institutional design cannot explain a change in policy outcomes and that these changes come fully from external factors, like the exchange rate or the world disinflation era of the early 1980s to 1990s, i.e. the so-called “Great Moderation” (see infra).

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3 Heckman et al. (1997) and Heckman et al. (1998) showed that data quality and information content are a crucial ingredient to any reliable estimation strategy. Such aggregates like inflation, broad money growth and government fiscal balance, may hide high differences, e.g. seemingly comparable fiscal balance may stem from different variations in cyclically-adjusted and automatic components, therefore indicating different fiscal stances.

4 All countries have experienced common macroeconomic evolution (for instance strong disinflation) and the authors 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”.


6 These first two remarks are developed in section 2 of Sims and Zha (2006).
Among the similarities between these three countries, one finds that they are in a flexible *de jure* exchange rate regime, though they can be considered to follow a *de facto* peg regime: Sweden and the UK are mimicking the ERM II, except during financial turmoil; and Canada looks like having a peg with fluctuation bands *vis-à-vis* the US dollar. Moreover, they are part of trade agreements which make competitiveness a crucial growth factor: Sweden and the UK are European Union members, hence part of the EU Single Market. As for Canada, it is part of the North American Free Trade Area.

Among the differences, one finds economic structures and the respective degrees of openness. Canada benefits from abundant natural resources, whereas the UK has a prominent part of its economy that is driven by the tertiary sector. Sweden stands halfway between those two, with industrial activities and services taking a prominent share of overall activity. Moreover, the size of the UK economy is paramount in comparison with Canada and even more so in comparison with Sweden. In 2007, Canada’s GDP, expressed in volume and in PPP figure, represented 58% of UK’s; and Sweden’s only 16%, based upon OECD data. As for the degree of openness, which may have an impact on imported inflation, it was similar for Canada and the UK in 2007 (total imports were worth 34% of GDP), but Sweden was much higher (67%). Last, at the monetary policy framework level, as communication is one of the pillars of IT, we can note Canada has only started to make its forecasts available to the public after 2003, while the UK and Sweden publish numerical forecasts since the adoption of IT.

IT has been adopted in Canada in February 1991 and has been 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 has taken 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 independence declaration. In Sweden, IT has been adopted in January 1993 with the objective to be fully applied in January 1995. Contrary to the other countries, the inflation target has remained the same since the beginning of the IT regime and no decelerating path of inflation occurred.

### 2.3. Data and the underlying model

We use monthly data, from 1971:1 to 2006:12 for the UK and Canada and from 1987:1 to 2007:12 for Sweden. The interest rate is the central bank reference rate as advertised by central banks themselves. The inflation rate expressed in month-over-month growth rate is the measure of inflation targeted by central banks. For the UK, the series is extrapolated from RPIX, RPI and CPI-H, the harmonised index of consumer prices. In Canada, the series is the CPI excluding eight of the most volatile components; and for Sweden, UND1X is used. In the latter two countries, the targeted measure corresponds to core inflation. The output gap measure is the interpolated monthly measure of the OECD. The inflation variables are expressed in first difference of the price index and all variables in the VAR and MSVAR are expressed in percent.

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7 On most figures, the transition period between the adoption of IT and its completion in final form has been represented by a grey area.

8 We extend the Sweden sample until 2007 although data will certainly be adjusted, because the MSVAR methodology needs long time series and this particular sample starts only in 1987.

9 Despite an empirical agnostic approach (see *infra*), the use of a computed measure like the output gap will permit to interpret the results in terms of the new Keynesian framework (see also *infra*).
Models with three to six variables have been tested; they have always included the central bank interest rate, the inflation rate (either CPI, GDP deflator or core CPI), and the output gap, and they have been extended to real GDP, M2, energy prices and/or exchange rate.

Contrary to Sims and Zha (SZ, 2006) who always include a monetary aggregate, commodity prices and the unemployment rate, we have finally focused on a smaller structural model comprising only three endogenous variables: the output gap, the nominal short-run interest rate and the officially-targeted CPI index. The focus on core inflation in Canada and Sweden, in line with their central banks’ objectives and in countries which are highly opened to international trade, challenges the possible drawback of an analysis undertaken in a closed economy framework because imported inflation plays a relative minor role in core inflation.

Residuals of the canonical VAR model extended to include M2 are reported in Appendix A. They help to legitimate the three-variable-only VAR. Two results emerge. First, adding M2 has no noteworthy effects on the residuals of the interest rate, the output gap and the inflation rate. Second, multiple shifts in variance have occurred in the three countries and point to the use of a more sophisticated methodology like MSVAR.

Disregarding M2, as it does not seem to improve the fit, has two additional advantages. First, it saves some degrees of freedom, MSVARs being pretty much “data-consuming”: the number of parameters to estimate depends on the number of variables, lags and states and can quickly be explosive. Second, no ad hoc restrictions are needed to separate money demand and supply, or to make sure that money demand (supply) reacts negatively (positively) to the interest rate.

The three endogenous variables fit also relatively well in the new Keynesian framework which has developed at the same time as the IT literature. However, the underlying model cannot retain all the specificities of the new framework (see Walsh, 2003, for a presentation), which can be described by:

\[ x_t = E_t x_{t+1} - \frac{1}{\sigma} (i_t - E_t \pi_{t+1}) + u_t \]
\[ \pi_t = \beta E_t \pi_{t+1} + \kappa x_t + e_t \]
\[ i_t = E_t \pi_{t+1} + \alpha (E_t \pi_{t+1} - \pi^T_t) + \rho x_t \]

where \( x \) is the output gap, \( i \) the nominal short-run interest rate, \( \pi \) is the inflation rate, \( E \) is the expectation operator, \( \sigma \) is the marginal utility of consumption, \( \pi^T \) is the inflation target, and \( u \) and \( e \) are disturbances. The first equation is the demand side of the economy, representing a linear approximation to the representative household’s Euler condition for optimal consumption (hence, the expectational IS curve); the second equation gives inflation whose adjustment is derived under the assumption of monopolistic competition, with individual firms adjusting prices in a staggered, overlapping fashion; the third equation involves monetary policy represented by a rule for setting the nominal interest rate.

Within a VAR representation, the above 3-equation model would be based on a reduced-form which would make impossible to distinguish regimes shifts from one structural equation to the

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10 Exception is the UK as far as the inflation rate is concerned: the fit with M2 is worse than without this variable.
11 With \( n \) variables, \( p \) lags and \( m \) states, there are \( m \times (n \times (n \times p + 1) + (n \times (n - 1)/2) \) parameters for the VAR plus \( m \times (m - 1) \) elements in the transition probabilities matrix.
other. Thus, we adopt the nonlinear stochastic dynamic simultaneous equations model of SZ (2006). Moreover, lags are included and the empirical model will depart from a pure new Keynesian model which predicts nearly no persistence, except that coming from shocks $u_t$, $e_t$ or the inflation target $\pi_t$. The fact that the general framework is close to the new Keynesian fully coherent framework will permit to interpret on economic grounds the different results deriving from the estimated model.

3. The MSVAR Methodology

3.1. The Multivariate Markov-Switching Model

The Markov-Switching VAR, as proposed by Hamilton (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 1$st$ order Markov chain. The joint distribution of the shocks can be non-constant across our sample periods.

The general framework is described by the following equation:

$$\begin{align*}
y_t &= x_t \cdot \beta_S + u_t \quad t = 1, \ldots, T \\
u_t \cdot S_t &\sim N(0, \Sigma_{S_t}) \\
S_t &= \{1, \ldots, M\}
\end{align*}$$

(1)

where $y_t = (y_{1,t}, \ldots, y_{p,t})$ is an $1 \times n$ vector of endogenous variables, with $n$ the number of variables of interest, $x_t$ is an $1 \times np$ vector of $p$ lagged endogenous variables, $S_t$ is an unobserved state, $\beta$ is an $np \times 1$ vector of parameters, $T$ is the sample size and $M$ the number of states (or regimes). This baseline equation of the model is free of restrictions.

The covariance matrix $\Sigma_{S_t}$ takes the form:

$$\Sigma_{S_t} = \sigma^2_{S_t} \cdot I_p$$

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

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

12 The 1$st$ and 3$rd$ equations of the system under a reduced-form involve the disturbance on inflation.
13 See Gali et al. (2001) for an empirical characterisation of “hybrid Phillips curve”, where inertial processes are introduced in the new Keynesian setting.
14 See Hamilton (1994, chapter 22) for more in-depth details.
15 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), we do not impose restrictions on parameters. The ad hoc nature of restrictions is opposed to the seminal motivation of our methodology. The use of Bayesian techniques, though it represents a great advancement in structural estimation, run 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 Bayesian one is the Maximum Likelihood’s, which is free of calibration as our approach needs.
with \( \sum_{j=1}^{M} p_{kj} = 1 \) and \( p_{kj} \geq 0, \ \forall k, j \in \{1...M\} \).

Two models are tested:

\[
y_t = (1_n, y_{t-1}, ..., y_{t-p}) \cdot \beta_{S_t} + u_t \\
y_t = 1_n \cdot \beta_{S_t} + (y_{t-1}, ..., y_{t-p}) \cdot \delta + u_t
\]

and can be written as:

\[
y_t = x_t \cdot \beta_{S_t} + z \cdot \delta + u_t \\
\text{(2)}
\]

\( M \) different models are then simultaneously estimated such as:

\[
(1_p \otimes y_t) = x_t \cdot (\beta_1 | \cdots | \beta_M) + (1_p \otimes z_t) \cdot \delta + (u_t' | \cdots | u_t^M)
\]

and leads for a given regime \( S_t = j \) to:

\[
\begin{cases} 
  y_t = x_t \cdot \beta_j + z_t \cdot \delta + u_t \\
  u_t | S_t = j \sim N(0, \Sigma_j)
\end{cases}
\]

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 Maximum likelihood “EM” algorithm, starting from the unconditional density of \( y_t \) which is calculated by summing conditional densities over possible values for \( S_t \). The maximum likelihood estimates are finally obtained by maximizing the log-likelihood function and allows to attain the final matrix of parameters.

### 3.2. Specifications

Based on Hamilton (1989, 2004)’s method and SZ (2006)’s work, various specifications were considered in which the numbers of regimes and lags were allowed to vary. We considered specifications in which coefficients and residual variance switch and specifications in which only intercept and variance switch. In light of some SZ’s findings, we have not tried “particularly ill-fitting models” like those with a single regime or those in which regime changes are constrained to never occur again.

With the 3-variable VAR (see *supra*), we allowed for 2, 3 or 4 regimes to occur. SZ (2006) have analysed a 4-state specification, but their 4\(^{th}\) regime was very rare and always occurred during geopolitical crises: Tehran’s hostages in 1980, the beginning of the 1\(^{st}\) Irak war in 1991, and 9/11. The three countries under study were not engaged in comparable events and with comparable intensity to US, so that a 4\(^{th}\) regime does not seem necessary. We then decided to concentrate on 2 and 3 regimes to assess robustness of our estimations and get different degrees of precision of regimes concerned.

Concerning the sample period, we focus on 2 samples, a long one from 1971 to 2006 and a short one, from 1987 to 2006, to assess the adoption of IT on different period and in particular after inflation has been tamed, on a stable sample.

The Schwarz criterion for the 3-variable VAR specification gave the following numbers of lags: \( p = 3 \) for Canada, 4 for Sweden and 5 for the UK.
4. Regime Switches

4.1. Full Changes

In this section, we present the key results of the 3-equation specification with changes in coefficients and variances. This pattern is of interest because it follows the widespread idea that monetary policy has changed significantly since the late 1970s\(^{16}\). It may then capture the main characteristics of this conventional wisdom and may also describe the policy change ensuing from IT adoption.

Figure 1 depicts the implied state-probabilities\(^{17}\) over time produced by this model for Canada and the UK for a 3 states specification on the long sample (1971-2006). Concerning Canada, Regime 1 did not prevail before the beginning of the 1980s, dominated the end of this decade and has been the main regime since roughly the middle of the 1990s. Regime 2 dominated the 1970s and has appeared sporadically since then, whereas Regime 3 occurred almost exclusively between 1979 and 1982. Regime 1 seems to fit best during IT period, but occurred before that period, while Regime 2 also occurred under IT. Regime 3 almost disappeared with completion of IT. Concerning the UK, Regime 1 prevailed since the beginning of the sample, with a probability of occurrence rising over time. Regime 2 occurred during almost the whole sample but did not ever significantly; whereas Regime 3 took place in the 1970s, and progressively lost influence during the 1980s to finally disappear at the beginning of the 1990s. Thus, the adoption of IT does not seem to have corresponded to a regime switch, but more to the continuation of the main ‘old regime’. The disappearance of Regime 3, the second most prominent over the full sample, corresponds to the date of adoption of IT.

In both cases, a regime appears to end with IT, but IT periods are shared between 2 regimes (Canada) and/or characterized by a regime that already occurred significantly before (Canada and the UK). This result is robust if 2 states are assumed (figure 2).

Figures 3 and 4 display the implied state probabilities on a shorter sample, going from 1987 to 2006 for Canada and the UK and to 2007 for Sweden, respectively with 3 and 2 states. For Canada and the UK, the previous result is again confirmed with no change of regime coinciding with the adoption of IT. More particularly for the UK, indecision between first and second regime seems to suggest that an intermediary regime has taken place during the whole period. For Sweden, the picture is different: with 3 states, 2 regimes share the IT period, with coefficients particularly similar and in the 2 states estimation, it seems obvious that the adoption of IT has constituted a regime switch. More surprising is the fact that the coefficient of response of the central bank reference rate to inflation\(^{18}\) is superior and quite high: 2.43 in the regime preceding IT (Regime 2) than in the IT one: 0.21 (Regime 1).

These findings tend to prove that IT adoption has not constituted a monetary policy reaction function change per se, contrary to the above-mentioned conventional wisdom, except in Sweden, where this switch still goes against conventional wisdom of an inflation focus. However, the methodology reveals that adopting IT in the 3 countries clearly meant that a pre-existing regime was taken to an end.

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\(^{16}\) See, e.g. Clarida et al. (2000).

\(^{17}\) Figures depict at each date the average probability to stand in the corresponding regime over the last 6 months.

\(^{18}\) See infra for details about artificial long run responses.
These mixed results require to extend the analysis to the intercept and variance only specification where coefficients are kept fixed on the whole period. This setting allows to shed light more precisely on the variation of the non-coefficients changes. It is noteworthy that this specification has been shown to correspond to the best-fit model of SZ (2006) with US data.

4.2. Intercept and Variance only

4.2.1 Regimes Probabilities

Contrary to the previous section, coefficients are assumed to be the same across regimes, and we now focus on whether the change of monetary policy framework has induced changes in disturbances terms.

Figure 5 shows the probabilities across time on the long sample, with 3 states. For Canada, Regime 1 occurs steadily after 1996 and thus it seems to emerge significantly with the completion of IT, while Regime 2 and even more notably Regime 3 appear to vanish gradually during the same period. The state probabilities are respectively 0.33, 0.54 and 0.13 on the whole sample. The picture is clearer in the UK case where two regimes (1\textsuperscript{st} and 3\textsuperscript{rd}) disappear with the development of IT but, contrary to Canada, the regime that characterizes IT has occurred from the beginning of the sample. The state probabilities are 0.05, 0.75 and 0.20.

Figure 6, with 2 states estimations, confirms the previous estimations. On a long sample, with the possibility of only 2 states, it is straightforward that IT has led to the dominance of an already existing regime. Nevertheless, it remains to be noted that uncertainty around this regime has been null after the adoption of IT; hence, it better fits IT-period than pre-IT-period.

Robust estimations over a sample characterised by a stable economic environment will rule out the usual criticism that IT was performed after inflation had been tamed. The short sample begins after the high inflation then disinflation periods; it also begins after the literature usually dates the most significant change in monetary policy in OECD countries\textsuperscript{19}. Detection of a regime switch over this “stable sample” can be interpreted as a robust characterisation of an IT regime beyond inflation outcomes: as such, IT regime is also characterised by output outcomes and the policy rate. In the following, we try to assess if IT constitutes a regime switch on a short and stable sample.

Figure 7 displays the probabilities of occurrence of 3 states on the short sample. For the UK and Sweden, the results are quite straightforward: Regime 1 occurred quite steadily since the adoption of IT. Figure 7 for the UK shows a break occurring simultaneously with the adoption of IT which was already distinguishable on Figures 5 and 6. For Canada however, regimes are still intertwined on the whole sample. The clearest outcome for Canada is the very low probability of occurrence of regime 3 after IT had been adopted.

On figure 8, we also report results from intercept and variance only specification with 2 rather than 3 regimes on the short sample. Results for the UK and Sweden are consistent with a 3-

\textsuperscript{19} For instance, Clarida and al. (2000) use 1979 (the beginning of the Volcker mandate) or 1982 (after “Volcker disinflation”) as thresholds for subsamples.
state specification (figure 7), and confirm the robustness of our conclusions for these two countries: IT has constituted a regime switch. For Canada, figure 7 displayed a somewhat artificial distinction between regimes 1 and 2: regimes 1 and 2 on Figure 7 merged in Regime 2 of the specification of figure 8. Contrary to the UK and Swedish cases, the IT framework in Canada seems to have been in the continuity of the Great Moderation and its adoption has not constituted a clear regime switch.

4.2.2 Regimes’ Characteristics

Matching regimes with IT period requires more than chronological coincidence. Attributing the regime switch to IT adoption can be handled along the following procedure. One can check that the regime which matches IT chronologically does it also in terms of the properties which are attributed to it. The IT framework assumes that the monetary policy regime can mix discipline and flexibility and can reduce overall variability (see supra and Kuttner, 2004). Discipline, in the vein of Barro and Gordon (1983), should refrain central banks (or government in their seminal framework) from using their instruments, hence taming their ‘inflation bias’. Consequently, deviations of variables from their steady-state values would be minimal. Policy flexibility after a shock, insofar as it cushions the shock and helps variables converge towards the steady-state, produces the same effect. All in all, IT should produce lower uncertainty regarding inflation and output.

Within a setting where coefficients remain constant, the reducing-uncertainty property of IT can be captured by the values of the constant terms and the variance in the inflation and output gap equations. Restraining to variance only may hide sharp moves in inflation or output gap that would appear in the constant term.

The values of the constant terms and the variance which are reported for the three countries in table 1 gives straightforward results. Indeed, it is very clear that regimes which have been considered so far to correspond to IT are effectively those for which uncertainty has been the smallest: Regime 1 for Sweden and the UK.

In Sweden and the UK, a regime is therefore distinctly attributable to the IT framework: shortly before the end of 1992, a regime appeared and it has been exclusive ever since. The lower uncertainty property of IT regime is confirmed by intercepts and variance outcomes in the specification with only 2 states (table 2).

The case of Canada is less clear-cut: with a 2-state specification, a lower variance and intercept is obtained under regime 2 which encompassed the whole time period. The first regime occurred only during the transition period to IT adoption. Therefore, none of the two regimes can be attributed to IT. It is noteworthy that this first regime is similar to regime 3 within the 3-state specification (see supra). Comparing the 3-state specification with the 2-state specification, it can be asserted that the regime whose properties are closest to an IT regime is merged with the regime which occurred before IT was adopted. Tables 3 and 4 confirm this conclusion. Comparing the four specifications for Canada, we conclude that the adoption of IT has not constituted a clear break with the preceding regime (as shown by both specifications with 2 states), but that nevertheless a slightly perceptible change seems to occur after IT has reached its final form (as suggested by both specification with 3 states). As noted before, the absence of the publication of forecasts may have played a role in the stabilization of expectations and then in the success of the implementation of IT. In addition, the strong
link of Canada’s economy with the US’ may explain the common features with the US and the weak evidence for a switch.

The IT period has thus corresponded to a specific regime for both countries that fully adopted the transparency requirements, along which uncertainty has been minimised. Finally, results suggest the following conclusions: IT has produced a macroeconomic regime switch and IT has worked in these two countries, the UK and Sweden, in the sense that policy outcomes have been improved.

4.2.3 Robustness analysis

In this section, we provide some evidence on the relevance of our model and specifications. Table 3 reports “artificial long run responses” of the policy rate to both objectives of monetary policy, as presented by SZ20. We annualise inflation variable to match the annual rate of interest and the output gap. Estimates of responses of the interest rate to macro variables are in line with monetary practice and with the usual weights attributed to or estimated for central banks’ objectives in the literature. The revealed relative high preference for inflation vis-à-vis the output gap by the Sveriges Riksbank is comparable to results reported by Muscatelli et al. (2002) and Kuttner (2004). However, the former conclude to the underreaction of the Bank to inflation whereas the latter conclude to a very tough reaction. The under reaction of the policy rate to inflation and the relative lower inflation preference by the Bank of England in comparison with the Sveriges Riksbank is similar to Muscatelli et al. (2002)’s estimates (over their subsample 1980-1999), or to Clarida et al. (1998). Results for Canada are also comparable to Muscatelli et al. (2002) over the subsample 1975-1999. Thus, figures obtained for the long run policy responses suggest that the underlying model is relevant.

Investigation of consistency of intercept-and-variance-only specification is pursued with estimates of the model’s impulse dynamic responses as shown in Figure 9. Shocks are identified through a Cholesky decomposition of innovations where variables have been ordered as: policy rate, price index and output gap. We assume that monetary policy does not react immediately to monthly released data on inflation and output gap. The shapes of responses are very similar to those usually obtained in canonical or structural VAR: without any forward variable, like commodity prices, a monetary policy shock produces a “price puzzle” and a lower output gap, except in Sweden where the immediate, though temporary, price decline is concomitant with a significant positive, though temporary, response of the output gap. Consistency of all these responses with usual impulse response functions confirms that the model and specification are appropriate.

4.2.4 Comparison with the US

One may ask whether the changes underlined previously have been common to a non-IT country. In this respect, we have chosen the US as a benchmark because of its clear difference in terms of monetary policy framework vis-à-vis IT countries. Indeed, the Federal Reserve publishes its forecasts with a 5-year lag compared to IT central banks for which transparency

20 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”.
and communication issues are essential. Moreover, the objective of economic growth is more pronounced in the Fed statutes, whereas IT central banks focus primarily on inflation.

Over a long horizon (1971-2006) and with 3 regimes, figure 10 shows that a regime (the second one) has become prominent, although not exclusive, after 1988. Contrary to what happened in IT countries, this prominent regime cannot be chronologically associated with a specific change in the institutional monetary framework. Over the short sample which is generally associated from beginning to end with the “Great Moderation era”, two regimes are intertwined and one cannot draw conclusions on the superiority of one regime over the other. Table 4 reports intercepts and variance of specification 2 with 2 regimes in the US case. Regime 1 reveals better performance than regime 2 in terms of lower intercept in the CPI equation and variance. However, as both regimes are intertwined, it testifies for their instability. One conclusion arises: regime switches in IT countries have not been shared by a non-IT country like the US.

At this stage, three results are worth summarizing: first, for two countries out of three – Sweden and the UK –, a regime switch after IT adoption is clearly visible on a sample which is characterised by a relatively stable macroeconomic environment. In the case of Canada, the switch is only slightly perceptible. Second, a comparison with the US has revealed differences which emphasize the specific outcomes of IT countries.

### 4.3. Counterfactuals

In order to investigate IT outcomes beyond inflation, i.e. the sacrifice ratio of achieving low inflation and the level of the policy rate, counterfactuals are set up. We focus on the intercept and variance specification (hence, coefficients are constant) and therefore escape the Lucas critique. We can then assess how and the extent to which the optimal path of the policy rate, the inflation rate and the output gap have changed over time.

In this exercise, coefficients are the same across regimes, and the differences among them stem from the intercepts and variances, that we choose to set them at values of the IT regime (or the dominant regime during IT in the case of Canada). To obtain the path of the policy instrument as it would have evolved, had IT been adopted at the beginning of the sample, we simulate the policy equation without the disturbance term. With this optimal simulated rule, we compute the corresponding inflation rate and output gap over the full sample. These counterfactuals do not provide assessment of the stance of monetary policy across time per se, but they suggest levels of the variables and the macroeconomic effect of the IT framework.

Results are reported on Figure 11. In the following, we compare the situation where IT regime would have always dominated the other two regimes with the actual evolution of the different endogenous variables. Interest rates would have been relatively low earlier, then they would have been higher: since 1996 in Sweden, 2000 in the UK and 2001 in Canada. We interpret this latter result as a higher monetary leeway enabling to face a negative shock with a sharp fall in the interest rate. This interpretation is confirmed by the evolution of the price index: in the three countries, disinflation would have occurred earlier, but inflation rates would have been higher after 1983, though to a lesser extent in Canada. Thus the scope for achieving low real interest rates would have been higher in the recent history. Fluctuations in the inflation

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Data were taken from the website of the Federal Reserve Board, except the output gap whose source is the OECD.
rate would have been smoother in Sweden and the UK; but it would have remained broadly similar in Canada. The evolution of the output gap in the three countries would have been broadly similar under IT regime and the results do not point to an increase in the sacrifice ratio under IT regime. It is noteworthy that changes in Canada are small in comparison with Sweden and the UK, if the dominant regime during the IT period is applied throughout the whole sample.

5. Conclusion

The MSVAR method has revealed that the adoption of inflation targeting has not given rise to a focus on inflation only. Canada and the UK have not experienced changes in the coefficients of the monetary policy rule; and Sweden has moved to a regime with a lower response to inflation under IT. However, a pronounced change is clearly visible for countries – Sweden and the UK – that have fully enhanced transparency by communicating forecasts to the public and then succeeded to anchor expectations. The comparison with Canada that does not publish its forecasts may explain the major difference with the two other countries since IT is aimed at better anchoring expectations and requires communication to be at the forefront.

Finally, a counterfactual exercise has shown that IT could give more monetary leeway, \textit{i.e.} central banks under an IT regime could achieve a lower real interest rate, to be compared with situation where the \textit{same} central banks were not actually under IT regime. In the face of a negative shock, this potentially low real interest rate can be viewed as a further gain associated with the adoption of IT, while this paper shows that this framework does not imply to solely focus on inflation.

The return of worldwide inflation over the recent years challenges the optimality of monetary policies: central bankers are relatively deprived of means in the face of externally-driven inflation, as it is the case in most OECD countries. If the price shocks are concomitant with a slower growth process, the monetary leeway that IT has been shown to provide may be viewed as an incentive for new countries to adopt IT in order to anchor expectations.

References


Figure 1
Full changes specification probabilities - 3 states - Long Sample
Figure 2
Full changes specification probabilities - 2 states - Long Sample

Canada
Regime 1

Regime 2

UK
Regime 1

Regime 2
Figure 3
Full changes specification probabilities - 3 states - Short Sample

Canada
Regime 1

Regime 2

Regime 3

UK
Regime 1

Regime 2

Regime 3

Sweden
Regime 1

Regime 2

Regime 3
Figure 4
Full changes specification probabilities - 2 states - Short Sample

Canada
Regime 1

Regime 2

UK
Regime 1

Regime 2

Sweden
Regime 1

Regime 2
Figure 5
Variances only specification probabilities – 3 states – Long Sample

Canada
Regime 1

Regime 2

Regime 3

UK
Regime 1

Regime 2

Regime 3
Figure 6
Variance only specification probabilities - 2 states – Long Sample

Canada
Regime 1

Regime 2

UK
Regime 1

Regime 2
Figure 7
Variance only specification probabilities - 3 states – Short Sample
Figure 8
Variance only specification probabilities - 2 states – Short Sample

Canada
Regime 1

UK
Regime 1

Sweden
Regime 1
Figure 9
Impulse Response Function, Intercept and Variances Only Model, Long sample (except: Sweden), 3 states

Canada

UK

Note: First line reports central bank rate shock, second line CPI shock and third line output gap shock.
Sweden

Response of Rate

Response of CPI

Response of Gap
Figure 10
Variances only specification probabilities - US

US - 3 states - Full sample

Regime 1

Regime 2

Regime 3

US - 2 states - Short sample

Regime 1

Regime 2
Figure 11
Actual (black thin line) versus Counterfactual (red thick line)

<table>
<thead>
<tr>
<th>Country</th>
<th>Central Bank Rate</th>
<th>CPI</th>
<th>Output Gap</th>
</tr>
</thead>
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<td><img src="image1" alt="Canada Central Bank Rate" /></td>
<td><img src="image2" alt="Canada CPI" /></td>
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<td><img src="image4" alt="UK Central Bank Rate" /></td>
<td><img src="image5" alt="UK CPI" /></td>
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<tr>
<td>Sweden</td>
<td><img src="image7" alt="Sweden Central Bank Rate" /></td>
<td><img src="image8" alt="Sweden CPI" /></td>
<td><img src="image9" alt="Sweden Output Gap" /></td>
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### Table 1. Intercepts and variance in specification 2 - 3 states - short sample

<table>
<thead>
<tr>
<th></th>
<th>Regime 1</th>
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<th></th>
<th>Regime 3</th>
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<tr>
<td></td>
<td>Intercept</td>
<td>Variance</td>
<td>Intercept</td>
<td>Variance</td>
<td>Intercept</td>
<td>Variance</td>
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<tr>
<td>CANADA</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CPI Equation</td>
<td>0.104700***</td>
<td>(0.027687)</td>
<td>0.087920***</td>
<td>(0.022543)</td>
<td>0.177222</td>
<td>(0.129125)</td>
</tr>
<tr>
<td>Gap Equation</td>
<td>0.002437</td>
<td>(0.025252)</td>
<td>0.008983</td>
<td>(0.021446)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPI Equation</td>
<td>-0.133035***</td>
<td>(0.035411)</td>
<td>-0.811609***</td>
<td>(0.050815)</td>
<td>-0.442344***</td>
<td>(0.101815)</td>
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<tr>
<td>Gap Equation</td>
<td>0.011208</td>
<td>(0.026774)</td>
<td>0.023691</td>
<td>(0.039421)</td>
<td></td>
<td></td>
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<tr>
<td>SWEDEN</td>
<td></td>
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<tr>
<td>CPI Equation</td>
<td>0.006919</td>
<td>(0.018877)</td>
<td>0.063408</td>
<td>(0.063326)</td>
<td>0.047167</td>
<td>(0.425872)</td>
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<tr>
<td>Gap Equation</td>
<td>0.021899</td>
<td>(0.018797)</td>
<td>0.001512</td>
<td>(0.055976)</td>
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### Table 2. Intercepts and variance in specification 2 - 2 states - short sample

<table>
<thead>
<tr>
<th></th>
<th>Regime 1</th>
<th></th>
<th>Regime 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>Variance</td>
<td>Intercept</td>
<td>Variance</td>
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<tr>
<td>CANADA</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>CPI Equation</td>
<td>0.174092</td>
<td>(0.111872)</td>
<td>0.356594***</td>
<td>(0.068475)</td>
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<td>Gap Equation</td>
<td>0.002066</td>
<td>(0.226008)</td>
<td>0.006904</td>
<td>(0.030491)</td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CPI Equation</td>
<td>0.234469***</td>
<td>(0.050196)</td>
<td>1.070491***</td>
<td>(0.146753)</td>
</tr>
<tr>
<td>Gap Equation</td>
<td>0.003676</td>
<td>(0.045831)</td>
<td>-0.018360</td>
<td>(0.128010)</td>
</tr>
<tr>
<td>SWEDEN</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>CPI Equation</td>
<td>0.013598</td>
<td>(0.025301)</td>
<td>0.127047</td>
<td>(0.147289)</td>
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<tr>
<td>Gap Equation</td>
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<td>(0.021241)</td>
<td>-0.004862</td>
<td>(0.130172)</td>
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</table>
Table 3.  
Long Run Policy Responses, short sample, 2 states

<table>
<thead>
<tr>
<th></th>
<th>Canada</th>
<th>UK</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responses of R to</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>inflation</td>
<td>1.18</td>
<td>0.56</td>
<td>0.81</td>
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<td>output gap</td>
<td>1.59</td>
<td>0.41</td>
<td>0.27</td>
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Table 4. Intercepts and variance in specification 2 - 2 states - short sample

<table>
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<tr>
<th>USA</th>
<th>Regime 1 (Post-93)</th>
<th>Regime 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI Equation</td>
<td>intercept</td>
<td>intercept</td>
</tr>
<tr>
<td></td>
<td>variance</td>
<td>variance</td>
</tr>
<tr>
<td>USA</td>
<td>0.074574***</td>
<td>0.136363***</td>
</tr>
<tr>
<td></td>
<td>(0.022270)</td>
<td>(0.032859)</td>
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<tr>
<td>Gap Equation</td>
<td>0.026762</td>
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<tr>
<td></td>
<td>(0.000655)</td>
<td>(0.002286)</td>
</tr>
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<td></td>
<td>(0.022809)</td>
<td>(0.036063)</td>
</tr>
</tbody>
</table>
Appendix A – Canonical VAR residuals

Canada - Canonical VAR without M2

Canada - Canonical VAR with M2

Sweden - Canonical VAR without M2

Sweden - Canonical VAR with M2

UK - Canonical VAR without M2

UK - Canonical VAR with M2