

Centre interuniversitaire de recherche
en économie quantitative

CIREQ

Cahier 16-2009

*DO INFLATION-TARGETING CENTRAL BANKS
IMPLICITLY TARGET THE PRICE LEVEL?*

Francisco J. RUGE-MURCIA



Le **Centre interuniversitaire de recherche en économie quantitative (CIREQ)** regroupe des chercheurs dans les domaines de l'économétrie, la théorie de la décision, la macroéconomie et les marchés financiers, la microéconomie appliquée et l'économie expérimentale ainsi que l'économie de l'environnement et des ressources naturelles. Ils proviennent principalement des universités de Montréal, McGill et Concordia. Le CIREQ offre un milieu dynamique de recherche en économie quantitative grâce au grand nombre d'activités qu'il organise (séminaires, ateliers, colloques) et de collaborateurs qu'il reçoit chaque année.

*The **Center for Interuniversity Research in Quantitative Economics (CIREQ)** regroups researchers in the fields of econometrics, decision theory, macroeconomics and financial markets, applied microeconomics and experimental economics, and environmental and natural resources economics. They come mainly from the Université de Montréal, McGill University and Concordia University. CIREQ offers a dynamic environment of research in quantitative economics thanks to the large number of activities that it organizes (seminars, workshops, conferences) and to the visitors it receives every year.*

Cahier 16-2009

DO INFLATION-TARGETING CENTRAL BANKS IMPLICITLY TARGET THE PRICE LEVEL?

Francisco J. RUGE-MURCIA

Ce cahier a également été publié par le Département de sciences économiques de l'Université de Montréal sous le numéro (2009-15).

This working paper was also published by the Department of Economics of the University of Montreal under number (2009-15).

Dépôt légal - Bibliothèque nationale du Canada, 2009, ISSN 0821-4441

Dépôt légal - Bibliothèque et Archives nationales du Québec, 2009

ISBN-13 : 978-2-89382-587-8

Do Inflation-Targeting Central Banks Implicitly Target the Price Level?*

Francisco J. Ruge-Murcia[†]

December 2009

Abstract

This paper reports graphical and statistical evidence that the inflation targeting regimes in Canada and the UK—but not in Australia, New Zealand, or Sweden—actually resemble price-level targeting. In particular, the price level closely tracks the path implied by the inflation target, and the time-series predictions of the “by-gones-are-by-gones” version of inflation targeting are rejected by the data in favor of those implied by price-level targeting. These results indicate heterogeneity in the actual application of inflation targeting across countries and, for Canada and the UK, imply that the characterization of inflation targeting as a policy where shocks are accommodated is at odds with the data. Moreover, up to extent that their current policies already resemble price-level targeting, the welfare gains of replacing inflation with (explicit) price-level targeting are likely to be small.

JEL Classification: E3, E5

Keywords: Inflation-targeting; price-level targeting; unit-root tests.

*This paper was inspired by a comment by Angelo Melino during the Bank of Canada Economic Conference held in Ottawa in November 2009, and it was written while I was visiting the International Department of the Bank of Canada. I thank the International Department for its hospitality and the Social Sciences and Humanities Research Council for financial support. The views expressed here are those of the author and should not be attributed to neither the Bank of Canada nor to its staff. The data used in this analysis are available at my Web page, www.cireq.umontreal.ca/personnel/ruge.html.

[†]Département de sciences économiques and CIREQ, University of Montréal, C.P. 6128, succursale Centre-ville, Montréal (Québec) H3C 3J7, Canada. E-mail: francisco.ruge-murcia@umontreal.ca.

1. The Debate

A current and important debate in monetary policy concerns the relative advantages of price-level targeting compared with inflation targeting. Under inflation targeting, the central bank announces a specific quantitative target for the inflation rate and directs monetary policy towards that goal. The announcement specifies the measure of inflation to be targeted, whether the target is a single value or a range, and the horizon at which the target applies. Among the countries that currently use inflation targeting are Australia, Canada, New Zealand, Sweden, and the United Kingdom. Under price-level targeting, the central bank targets the path of a measure of the price level (for example, a price index). The path may involve an upward trend implying a positive, but presumably low, inflation rate. A policy similar to price-level targeting was used in Sweden in the 1930s. The debate is of practical importance because some central banks that have successfully targeted the inflation rate in recent years are currently studying the possibility of adopting price-level targets instead.¹

An obvious difference between inflation and price-level targeting is that the former targets the rate of growth of the price level while the latter targets the price level itself. This means that under price-level targeting, an increase in the price level that is larger than allowed by the stated policy has to be offset in subsequent periods. In theory, inflation targeting imposes no such an obligation on the central bank and hence, temporary shocks that impinge on the price level may be accommodated. Put differently, under inflation targeting “bygones are bygones.” A simple characterization of both policies is plotted in Columns 1 and 2 of Figure 1. (Column 3 will be discussed later.) The top panels plot the path of the targeted variable, whether inflation or the price level. The lower panels plot the implied paths for the price level (in the case of inflation targeting) or the inflation rate (in the case of price-level targeting). In this illustration, the inflation target is 2 per cent and the price level target involves a growth trend of 2 per cent.

Consider first inflation targeting in Column 1. Imagine that a temporary shock takes inflation from 2 per cent in period 1 to, say, 3 per cent in period 2 (Panel A). Then, in period 3, the central bank steers inflation back to the targeted value of 2 per cent and manages to keep it at precisely this value thereafter. This inflation-targeting policy would be considered successful in that inflation was returned to its target and the (asymptotic) mean of inflation is the target value. The path for the price level implied by this policy (Panel B) shows that the price index grows by 3 per cent between periods 1 and 2 and by 2 per cent thereafter. Notice that the temporary shock

¹For example, in the *Renewal of the Inflation-Control Target: Background Information* issued in November 2006, the Bank of Canada announces its intention to research the potential costs and benefits of replacing the current inflation-targeting policy with a price-level targeting regime.

has a permanent effect on the price level: since the central bank accommodates the shock, bygones are bygones indeed.

Consider now the same shock but under a price-level targeting policy. In Column 2 (see Panel C), the price level grows by 3 per cent between periods 1 and 2, and the price index is, therefore, higher than the value targeted for that period. In order to return to the desired path, the central bank must set monetary policy so that the price level grows by only 1 per cent from period 2 to 3, and by 2 per cent thereafter. This price-level targeting policy would be considered successful in that the price index was returned to its targeted path. In this case, the temporary shock does not have a permanent effect on the price level. In Panel D, note that after an inflation rate of 3 per cent in period 1, the policy induces an inflation rate of only 1 per cent in period 3 and of 2 per cent thereafter.

Finally, let us consider a slightly different characterization of inflation targeting. In Column 3 (see Panel E), following the temporary shock that takes inflation to 3 per cent in period 2, the central bank sets monetary policy so that inflation is 1 per cent in period 3, and 2 per cent thereafter. This inflation targeting policy would be considered successful in that inflation was returned to its target and the mean of inflation is the target value. In some sense this version of inflation targeting may be regarded as more successful than the one in Column 1 because average inflation is the target value in the short-run, rather than only asymptotically. Comparing Columns 2 and 3, it is clear that this policy delivers a price-level path that is identical to that obtained under price-level targeting. In particular, temporary shocks have no permanent effect on the price level. Hence, there is an observational equivalence between inflation and price-level targeting. In this figure, the observational equivalence arises from the purposeful policy action of the inflation-targeting central bank, which seeks to deliver average inflation rates close to the targeted rate in the short-run. In principle, this equivalence may also arise as a result of symmetric shocks that take inflation sometimes above, sometimes below, its target.

Earlier literature finds that optimal monetary policy under commitment involves a stationary price level. This is so in New Keynesian models (see Woodford, 1999, and Clarida, Gali, and Gertler, 1999) and in models with rational inattention (Ball, Mankiw, and Reis, 2005). Since price-level targeting induces stationarity in the price level while inflation targeting does not, this is a powerful argument in favor of the former policy. In models where commitment is not possible, price-level targeting has a number of desirable implications which are welfare improving compared with inflation targeting. Most of these implications stem from the fact that forward-looking agents incorporate the future price-level path into their current actions. Svensson (1999) shows that price-level targeting reduces the variance of inflation and eliminates any average inflation bias.

Vestin (2006) finds that even if social preferences concern inflation, welfare is increased by delegating monetary policy to a central banker with an explicit price-targeting objective. Eggertsson and Woodford (2003) and Wolman (2005) find that price-level targeting is helpful in overcoming distortions in the neighborhood of the zero lower bound on nominal interest rates, and Amano, Ambler, and Ireland (2007) show that the optimal level of wage indexation is lower under price-level targeting and the resulting real wage flexibility is welfare improving. On the other hand, in a setup where some of the agents are backward looking, price-level targeting is not optimal and may be dominated by a policy that allows some price-level drift (Steinsson, 2003).

This paper contributes to the literature by looking at the data. Simple plots show that the inflation-targeting regimes in Canada and the UK—but in Australia, New Zealand, or Sweden—actually look like price-level targeting in that the price level closely tracks the path implied by the inflation target. Thus, while Canada and the UK look like Column 3 in Figure 1, the other countries look like Column 1. The time-series predictions for the price level of the “by-gones-are-by-gones” interpretation of inflation targeting are formalized and statistically tested against those of price-level targeting. For Canada and the UK, but not for the other countries, the data rejects the predictions of inflation targeting in favor of those of price-level targeting. These results suggest that there is heterogeneity in the actual application of inflation targeting across countries and, in particular, that the regimes in Canada and the UK are not of the form typically modelled in the literature. For these two countries, up to the extent that their central banks pursue policies that already resemble price-level targeting, the welfare gains of replacing inflation with (explicit) price-level targeting are likely to be small.

2. A Look at the Data

2.1 Five Inflation-Targeting Countries

The empirical analysis is based on price level indices from Australia, Canada, New Zealand, Sweden, and the United Kingdom. In order to motivate the choice of indices and sample periods used in the analysis, I briefly review the specific institutional arrangements in each country.

In Australia, the Reserve Bank of Australia (RBA) has had an inflation target since early 1993.² Since 1996 the policy has been formalized in a *Statement on the Conduct of Monetary Policy* jointly issued by the Government and the RBA. The *Statement* was renewed in July 2003 and September 2006. The target is a range of 2 to 3 per cent on average “over the cycle,” and initially applied

²Bernanke, Laubach, Mishkin and Posen (1999, p. 220) date the beginning of inflation targeting in Australia as September 1994 when Governor Fraser stated that “[an] underlying inflation of 2 to 3 per cent is a reasonable goal for monetary policy.” The conclusions reported here are robust to using either date.

to the growth rate of an “underlying” Consumer Price Index (CPI) that excluded volatile items (for example, petrol, vegetables, and fruits), public-sectors goods, and mortgage interests (see Bernanke *et al.*, 1999, p. 225). Starting in September 1998, the Australian Bureau of Statistics removed interest charges from the CPI, and soon after the Federal Treasurer and the RBA agreed that applying the target to the CPI was consistent with the intent of the original *Statement* (see *Reserve Bank Bulletin*, October 1998, pp. 1-5). Thus, for Australia, I use the All Groups CPI taken from the Web site of the RBA (www.rba.gov.au) for the period 1993:Q1 to 2009:Q3.

In Canada, the Bank of Canada announced “inflation-reduction” targets in February 1991. These targets initially envisaged a reduction in the annual inflation rate to 3 per cent by the end of 1992, 2.5 per cent by mid-1994, and 2 per cent by the end of 1995. As in Australia, the inflation targeting policy is formalized in a *Joint Statement* issued by the Government and the central bank. Since January 1996, the inflation target is 2 per cent with a tolerance range of plus or minus 1 percentage points. The target is defined in terms of the Consumer Price Index but a “core” CPI, which excludes food and energy prices and is adjusted for the effects of indirect tax changes, is used as the operational guide for the policy (see the *Joint Statement* released in February 1998). More recent *Statements* issued in May 2001 and November 2006 do not make this distinction between indices, reaffirm that the target applies to CPI inflation, and, in fact, do not mention the core CPI at all.³ Thus, for Canada, I use the CPI taken from the Web site of Statistics Canada (www.statcan.gc.ca) for the period 1996:M1 to 2009:M9, but I examine the robustness of the results to using the core CPI (taken from the same source). As in Sweden (see below), the sample excludes the transition period to the new inflation targeting policy (in this case, the period of inflation-reduction targets between February 1991 and December 1995).

In New Zealand, the first *Policy Target Agreement (PTA)* between the Ministry of Finance and the Reserve Bank of New Zealand (RBNZ) was issued in March 1990 and specified a target range of 0 to 2 per cent for a (new) Consumer Price Index where housing costs were to be measured as imputed rents rather than as actual expenditures. However, a few months later, the *PTA* of December 1990 re-specified the target in terms of the All Groups CPI. Successive *Target Agreements* have modified the target range and inflation measure. In particular, the *PTA* of December 1996 increased the width of the range to between 0 and 3 per cent, the *PTA* of December 1997 specified the target in terms of the All Groups CPI excluding credit services (CPIX), and that of December 1999 in terms of the All Groups CPI, again. Finally, the *PTA* of September 2002 adjusted the target to between 1 and 3 per cent. Thus, for New Zealand, I use the All Groups CPI taken from

³On the other hand, the background information on the renewal of the inflation targets (see the press releases on 18 May 2001 and 27 November 2006 available at www.bankofcanada.ca/en/press/index.html) still refers to the core CPI as the operational guide to policy.

the Web site of the Reserve Bank of New Zealand (www.rbnz.govt.nz) for the period 1991:Q1 to 2009:Q3. The sample excludes the period between 1990:Q2 and 1990:Q4 because I was unable to find the price index used to compute the inflation measure to be targeted under the *PTA* of March 1990. Part of the problem is that this index was not among those traditionally produced by Statistics New Zealand and, in fact, the *PTA* explicitly instructed the RBNZ to produce it. However, since the *PTA* of December of the same year redefined the target in terms of the CPI, which is readily available, and the sample is reduced by only three observations, it seems unlikely that results are affected by the way I have treated the missing observations.

In Sweden, the inflation target was announced in January 1993 but the policy was to take effect only from January 1995 onwards. The target is 2 per cent, with a tolerance range of 1 percentage point above and below, and applies to the annual change in the Consumer Price Index with no exclusions. Thus, for Sweden, I use the CPI taken from the Web site of Statistics Sweden (www.scb.se) for the period 1995:M1 to 2009:M9 for Sweden. The sample excludes the transition period to the new inflation targeting policy, that is, the period from January 1993 to December 1994 where the (future) targeting policy was known but not yet in effect.

Finally, in the United Kingdom, an inflation target range of 1 to 4 per cent was announced by the Chancellor in October 1992 and applied (until 2003) to the Retail Price Index excluding mortgage interest payments (RPIX). Starting in June 1995 the target was interpreted as the midpoint of the above range, with thresholds of plus or minus 1.5 percentage points after May 1997 (see Bernanke *et al.* 1999, p. 154 and 146, respectively). In December 2003, the target was adjusted to 2 per cent and applied thereafter to the Consumer Price Index. If inflation goes below 1 per cent or above 3 per cent, the Governor of the Bank of England must write an open letter to the Chancellor explaining why and proposing corrective policies to take inflation back to the target. Thus, for the United Kingdom, I use the RPIX for the period 1992:M10 to 2003:M12 spliced with the appropriately re-scaled CPI for the period 2004:M1 to 2009:M9. As a shorthand, I refer to this index as the RPIX-CPI. These indices were taken from the Web site of the UK National Statistics (www.statistics.gov.uk). I examine the robustness of the results by using the RPI (taken from the same source), rather than the RPIX, in the first part of the sample.

Finally, note that since targets apply to seasonally-unadjusted inflation in all countries, the price indices used here are seasonally unadjusted as well.

2.2 Graphical Analysis

Figures 2 through 6 plot the inflation rates, price indices, and targets for Australia, Canada, New Zealand the United Kingdom and Sweden, respectively. In each figure, the upper panel plots the

inflation rate and target, and the bottom panel plots the log of the price index used to compute that inflation rate and the price-level path implied by the announced inflation target. The inflation rate is the annual percentage growth in the price index, that is

$$\pi_t = 100(\log(P_t) - \log(P_{t-12})), \quad (1)$$

where π_t is the inflation rate and P_t is the price index. The price-level path implied by the inflation target is

$$\log(P_{s+t}^*) = (t/12) \log(1 + \pi^*/100) \log(P_s), \quad (2)$$

where π^* is the inflation target and s denotes the period when the inflation targeting policy started. In the cases where the data is available at the quarterly frequency (as in Australia and New Zealand) and/or the inflation target varies during the sample, definitions (1) and (2) are adjusted accordingly. In the case of Australia and New Zealand, where the inflation target is a range, I use the mid-point of the range as the empirical counterpart of π^* .

The remarkable observation that follows from Figures 3 and 6 is that the inflation-targeting regimes in Canada and the UK look very much like price-level targeting. (To some extent this is also true for Australia in Figure 2, but statistical results reported in Section 2.3 set Australia aside from Canada and the UK.) Under the standard view of how inflation targeting works in practice, the central bank accommodates shocks to the price level (bygones are bygones) and, consequently, they have a permanent effect. This implies that the price level should drift away from the path implied by the inflation target, as illustrated in Column 1 of Figure 1. Instead what these figures show is that the price index used to construct the targeted inflation rate tracks very closely the path implied by the target, just as one would expect to see in a price-level targeting regime. This is the real-life analog of the observational equivalence between inflation and price-level targeting illustrated in Columns 2 and 3 of Figure 1.⁴ In contrast, the cases of New Zealand (Figure 4) and Sweden (Figure 5) resemble more the standard view of inflation targeting where the price level drifts away from the path implied by the inflation target as a result of permanent shocks. This is the real-life analog of the inflation targeting policy in Column 1 of Figure 1.

In order to examine the robustness of the results for Canada and the United Kingdom to the price index used, I constructed figures using the core CPI for Canada (Figure 7) and the RPI for the UK (Figure 8). Figure 7 shows that results for Canada are not robust to using the core CPI,

⁴In the case of Canada, plots like Figure 3 (give or take some observations) are also reported by Kamenik, Kiem, Klyuev and Laxton (2008) and Parkin (2009), and discussed by Dodge (2005). Dodge suggests that this observation is due to symmetric shocks and unlikely to persist in the future. Kamenik *et al.* estimate a reduced-form model by Bayesian methods and conclude that there is a low probability that symmetric shocks account for Figure 3. Parkin carefully examines language used in successive *Statements* and detects a (perhaps) “unconscious” move to price-level targeting (p. 9). I am indebted to Bob Amano for bringing these references to my attention.

rather than the CPI. This is not surprising because the core CPI excludes items that account for 16 per cent of the CPI and in the presence of trends in relative prices both indexes would have different trends.⁵ In any case, even a central bank that explicitly targets the price level would be unable to target two different price indices with different trends using only one policy instrument. Figure 8 shows that results for the UK appear robust to using the RPI, rather than the RPIX, in the first part of the sample. The mortgage interest payments that are excluded from the RPI have a weight of only 5 per cent and so, compared with the Canadian case, is more likely that both indices share a common trend. However, we will see below that statistical results for the UK are not completely robust to using the RPI.

2.3 Unit-Root Tests

The interpretation of inflation targeting as a policy where by-gones are by-gones generates two specific and testable predictions about the price level. First, since shocks have a permanent effect, the price level should have a unit root. Second, since subtracting a deterministic trend from a unit root process does not render the resulting series stationary, then it must be the case that the deviation of the price index from the (deterministic) trend implied by the inflation target should have a unit root as well. Put differently, this must be so because the permanence of the shocks would make the price index wander arbitrarily away from such a deterministic path. In contrast, price-level targeting generates two alternative predictions for the price level. First, since price level deviations from the targeted path must be offset in future periods, the price level should follow a covariance stationary process around a deterministic trend and, second, the deviations should follow a stationary process around a constant (zero).

The natural way to empirically evaluate these implications is by means of unit root tests. Table 1 report results of Augmented Dickey-Fuller (ADF) unit root tests for the log of the price level and for the deviation of the price level from the path implied by the inflation target. In the former case, the hypothesis is that the price level follows a unit root process with drift, and the (estimated) alternative is a covariance-stationary autoregression with a deterministic trend and a constant term. For the latter case, the hypothesis is that the price level deviation from the path implied by the target follows a unit root process, and the (estimated) alternative is a covariance-stationary autoregression with a constant term (but not trend). Just to emphasize, the two hypotheses are what inflation targeting predicts about the price level and the alternatives are what price-level

⁵The core CPI excludes eight components from the CPI. These components are fruits, vegetables, gasoline, fuel oil, natural gas, mortgage interest, inter-city transportation and tobacco products. The weights of these components in the 2005 basket are 1.25 (fruit, fruit preparations and nuts), 1.11 (vegetables and vegetable preparations), 4.49 (gasoline), 0.41 (fuel oil and other fuels), 1.35 (natural gas), 5.16 (mortgage interest costs), 1.09 (inter-city transportation) and 1.33 (tobacco products and smokers' supplies).

targeting predicts. The level of augmentation of the ADF test (that is, the number of lagged first differences in the OLS regression) was selected using recursive t -tests, but using the Modified Information Criterion (MIC) proposed by Ng and Perron (2001) delivers basically the same results and supports the same conclusions. Finally, in order to assess the robustness of the results to the test procedure, I also report results using the Phillips-Perron (PP) unit-root test.

For Canada and the United Kingdom, both null hypotheses are rejected in favor of the alternatives when the price level is measured using the price indices used to construct the targeted inflation rate, namely the CPI and the RPIX-CPI. Notice, however, that in the case of the UK results are not always robust to the test procedure used. In particular, the hypotheses are always rejected by the PP, but not by the ADF, tests. One possible reason for this is that the change in the inflation target in the UK from 2.5 to 2 per cent in December 2003 induces a break in the deterministic trend, which, as it is well-known, biases the ADF test in favor of the null hypothesis (see Perron, 1989). In order to inspect this possibility, I ran all tests on the RPIX for the restricted sample from 1992:M10 to 2003:M12 where target was 2.5 per cent throughout. Notice that for this subsample, the hypotheses are rejected in all cases. Finally, notice that results are not robust to using other price indices (the core CPI for Canada and the RPI for the UK) whose inflation rates are not targeted by the central banks. However, as was noted above, price-level targeting only generates predictions concerning the index that is implicitly or explicitly targeted and is silent about indices that have different trends as a result of persistent movements in relative prices.

In summary, these statistical results support two conclusions regarding the inflation-targeting regimes in Canada and the United Kingdom. First, their policies do not appear to be of the by-gones-are-by-gones variety usually modeled in the literature. Instead, second, the actual application of inflation targeting in these two countries induces statistical properties in the price level that are essentially those implied by a price-level targeting regime.

In principle, it is possible that the observational equivalence between inflation and price-level targeting is the result of symmetric shocks. That is, that the central bank follows a by-gones-are-by-gones inflation targeting policy but symmetric shocks take inflation sometimes above, sometimes below, the target and deliver something like of Figures 3 and 6. However, I now argue that the statistical results reported in Table 1 do not support this interpretation. The reason is simply that in this scenario the price level and its deviation from the implied path would still have a unit root. Hence, the rejections reported in Table 1 cast doubt on the view that the observed paths of the price levels in Canada and the UK are solely the result of “luck.” Instead, a most likely explanation is that the actual application of the inflation targeting policy itself accounts for the empirical observations reported here.

Finally, in the cases of Australia, New Zealand and Sweden, one cannot reject the null hypotheses. Thus, in these countries, the price level and its deviation from the implied path appear to be well described by a unit root process.⁶ Except for Australia, these results were already anticipated by the Figures reported in Section 2.2. Hence, the statistical properties of the price levels in these countries are consistent with the view that inflation target allows shocks to have permanent effects on the price level.

3. Conclusions

This paper contributes to the ongoing debate about inflation *versus* price-level targeting by looking at the data. Simple graphs show that the inflation-targeting regimes in Canada and the UK (but not for Australia, New Zealand, or Sweden) look very much like price-level targeting. The analysis is pursued further statistically by characterizing the time-series predictions of the standard view of inflation targeting as a policy where shocks are accommodated and have, therefore, a permanent effect on the price level. Unit-root tests show that for Canada and the UK (but not in Australia, New Zealand, and Sweden) those predictions are rejected in favor of alternatives consistent with price-level targeting. A possible explanation for these results is the manner in which the policy is actually carried out in these countries. Thus, the view incorporated in theoretical models that inflation targeting central banks systematically accommodate shocks to the price level is at odds with the data from Canada and the UK, though it may be good representation for other countries. In case of these two countries, up to the extent that their central banks pursue policies that closely resemble price-level targeting, the welfare gains of replacing the current inflation-targeting regimes with price-level targeting with the same drift are likely to be small.

It is not completely obvious what accounts for the strikingly different results for Canada and the UK on one hand, and Australia, New Zealand and Sweden on the other. As argued above, the nature of the shocks received by these countries is unlikely to account for these results. A more plausible explanation are differences in the manner in which the inflation-targeting policy itself is applied in these countries. A suggestive observation, Sweden notwithstanding, is that Canada and the UK define their inflation targets as a numerical value (with upper and lower bounds), while Australia and New Zealand define their targets as a range only. However, additional research is required to examine this explanation more rigorously.

⁶It may be argued that results for Australia and New Zealand reflect low test power because their data is only available at the quarterly frequency and, hence, the number of observations is smaller than that of the other countries. However, Shiller and Perron (1985) show that the power of unit root tests depends on the span of the data and not on the frequency at which the data is sampled. The span for all five countries in the sample is approximately the same.

Table 1. Unit Root Tests

Price Index	Variable					
	Log of the Price Level		Deviation from Implied Path			
	ADF	PP	With Intercept		No Intercept	
ADF			PP	ADF	PP	
Australia						
CPI	-1.956	-1.970	-1.214	-1.208	-1.158	-1.161
Canada						
CPI	-3.531*	-3.175[†]	-2.984*	-2.714[†]	-2.991*	-2.719*
Core CPI	-2.921	-2.944	-1.945	-1.718	0.103	0.153
New Zealand						
CPI	-1.109	-1.091	-0.198	-0.006	—	—
Sweden						
CPI	-1.841	-2.173	-2.006	-1.386	—	—
UK						
RPIX-CPI	-3.479*	-3.718*	-2.353	-2.940*	-1.472	-2.513*
RPI-CPI	-2.734	-3.021	-2.108	-2.619[†]	-2.260*	-2.145*
RPIX	-3.268[†]	-3.752*	-3.281*	-3.781*	-1.867[†]	-2.545*
RPI	-2.086	-2.887	-2.280	-2.747[†]	-2.298*	-2.592*

Notes: ADF and PP stand for Augmented Dickey-Fuller and Phillips-Perron, respectively. The level of augmentation of the ADF test was selected using the recursive application of t -tests. The truncation lag of the PP test is three in all cases. For the log of the price index, the alternative is a covariance-stationary autoregression with a constant term and a deterministic trend. For the deviation of the implied path, the alternative is a covariance-stationary autoregression with a constant term. The superscripts * and [†] denote the rejection of the null hypothesis of a unit root at the five and ten per cent levels, respectively.

References

- [1] Amano, R., Ambler, S., Ireland, P., 2007. Price-Level Targeting, Wage Indexation and Welfare. Bank of Canada, Manuscript.
- [2] Ball, L., Mankiw, N. G., Reis, R., 2005. Monetary Policy for Inattentive Economies. *Journal of Monetary Economics* 52, 703-725
- [3] Bernanke, B., Laubach, T., Kishkin, F., Posen, A., 1999. *Inflation Targeting*. Princeton University Press, Princeton.
- [4] Clarida, R., Gali, J., Gertler, M., 1999. The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature* 37, 1661-1707.
- [5] Dodge, D., 2005. *Our Approach to Monetary Policy: Inflation Targeting*. Remarks to the Regina Chamber of Commerce. Available at www.bankofcanada.ca/en/speeches/spgen05.html
- [6] Eggertsson, G., Woodford, M., 2003. The Zero Bound on Interest Rates and Optimal Monetary Policy. *Brookings Papers on Economic Activity*, 139-211
- [7] Kamenik, O., Kiem, H., Klyuev, V., Laxton, D., 2008. *Why is Canada's Price Level So Predictable?* IMF Working Paper WP/08/25.
- [8] Ng, S., Perron, P., 2001. Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power. *Econometrica* 69, 1519-1554.
- [9] Parkin, M., 2009. *What is the Ideal Monetary Policy Regime*. C.D. Howe Institute Commentary No. 279.
- [10] Perron, P., 1989. The Great Crash, the Oil Price Shock and the Unit Root Hypothesis. *Econometrica* 57, 1361-1401.
- [11] Shiller, R. J., Perron, P., 1985. Testing the Random Walk Hypothesis: Power versus Frequency of Observation. *Economics Letters* 18, 381-386.
- [12] Steinsson, J., 2003. Optimal Monetary Policy in an Economy with Inflation Persistence. *Journal of Monetary Economics* 50, 1425-1456.
- [13] Svensson, L. E. O., 1999. Price-Level Targeting versus Inflation Targeting: A Free Lunch? *Journal of Money, Credit and Banking* 31, 277-295.

- [14] Vestin, D., 2006. Price-Level versus Inflation Targeting. *Journal of Monetary Economics* 53, 1361-1376.
- [15] Woodford, M., 1999. Optimal Monetary Policy Inertia. NBER Working Paper No. 7161.
- [16] Wolman, A. L., 2005. Real Implications of the Zero Bound on Nominal Interest Rates. *Journal of Money, Credit and Banking* 37, 273-296.

Figure 1: Inflation versus Price-Level Targeting

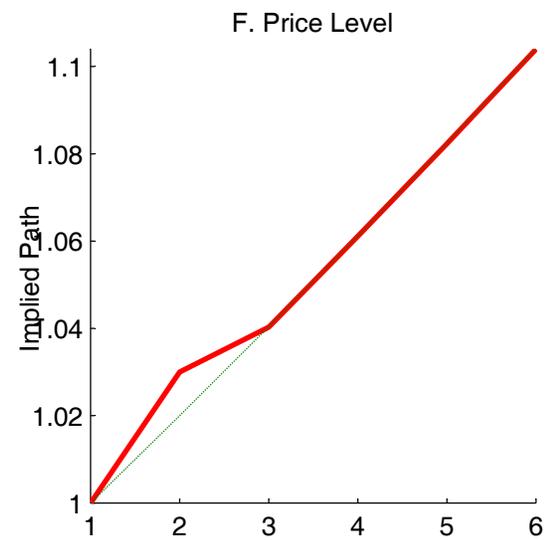
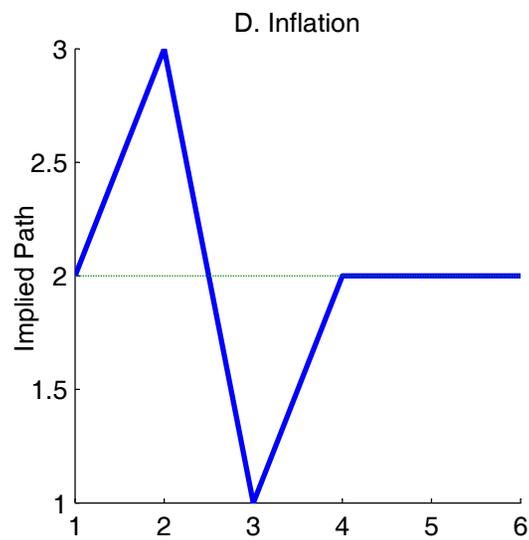
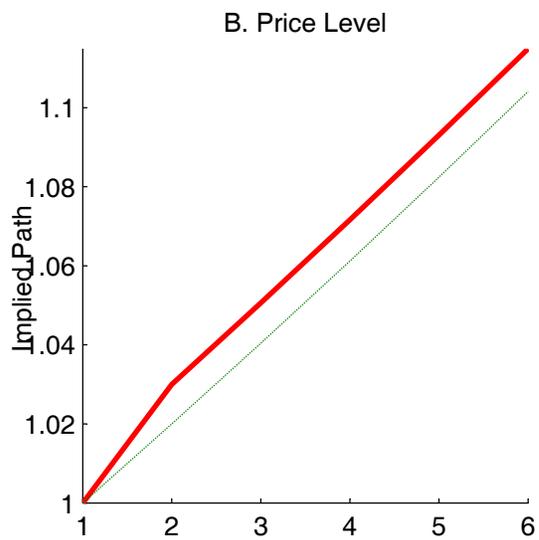
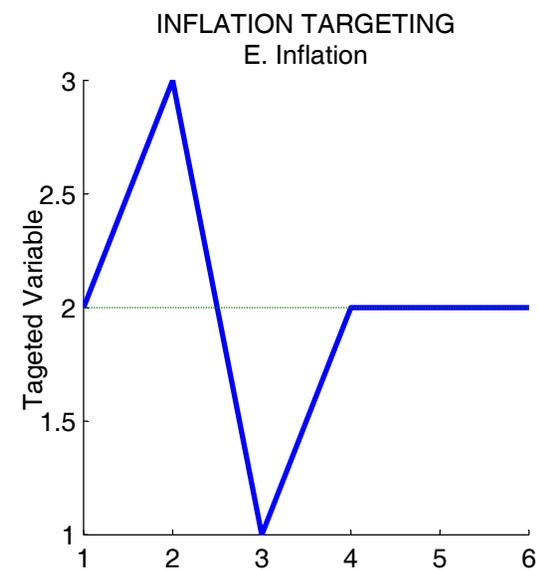
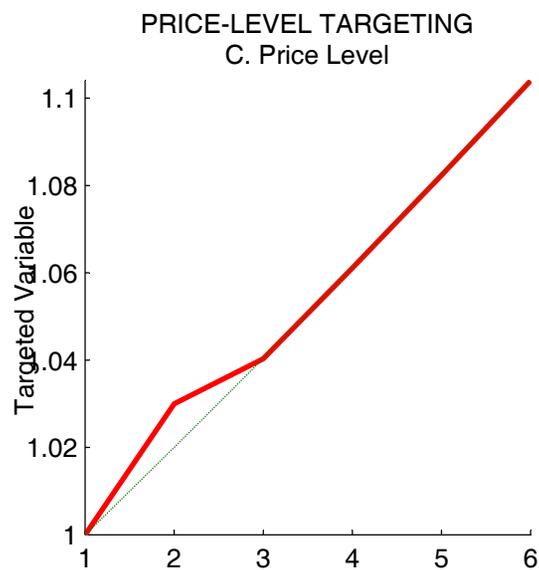
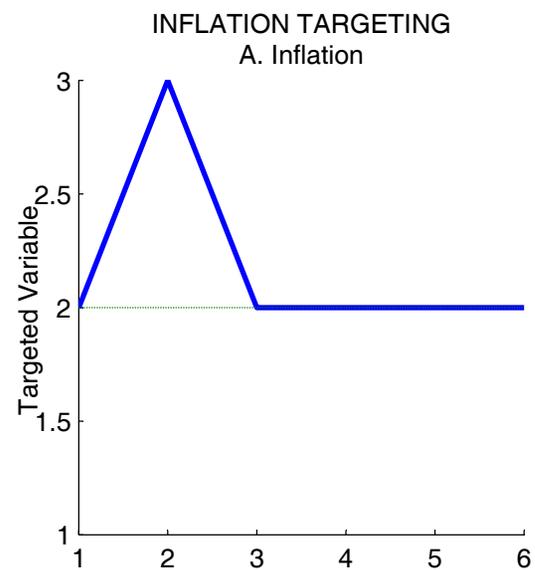


Figure 2: Australia (All Groups CPI)

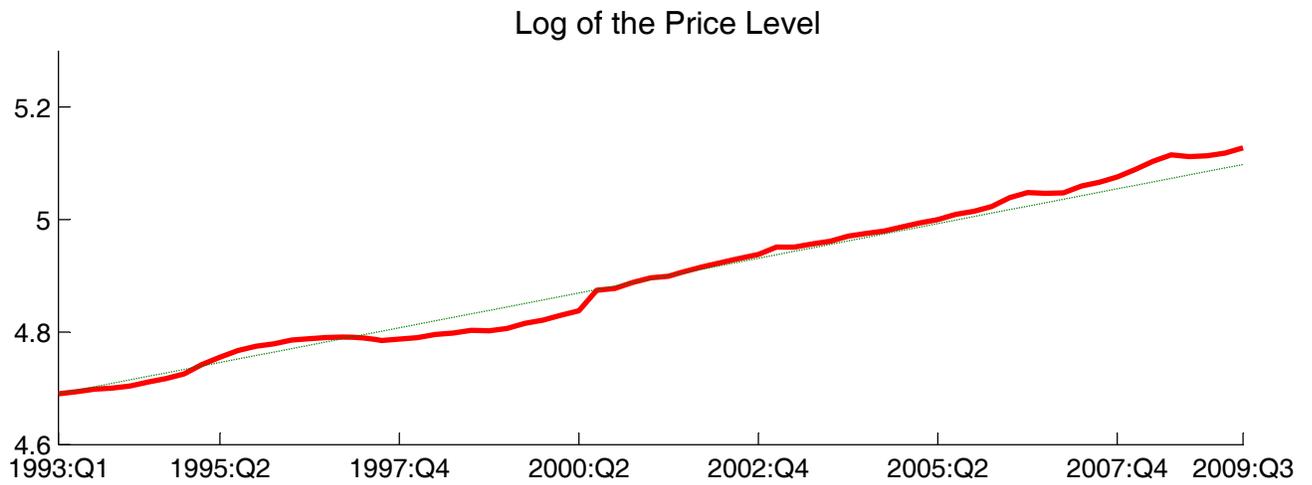
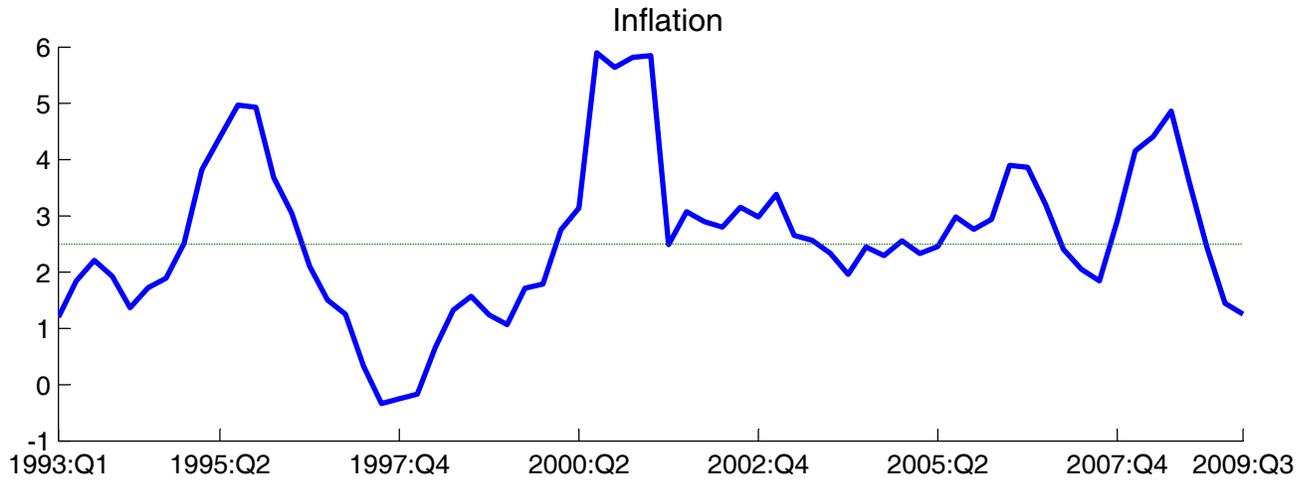


Figure 3: Canada (CPI)

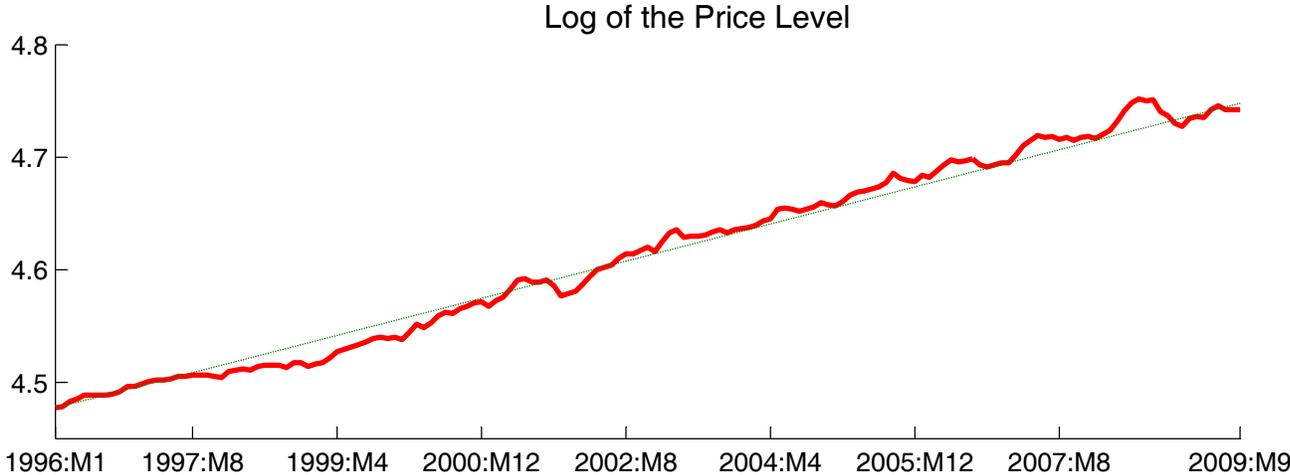
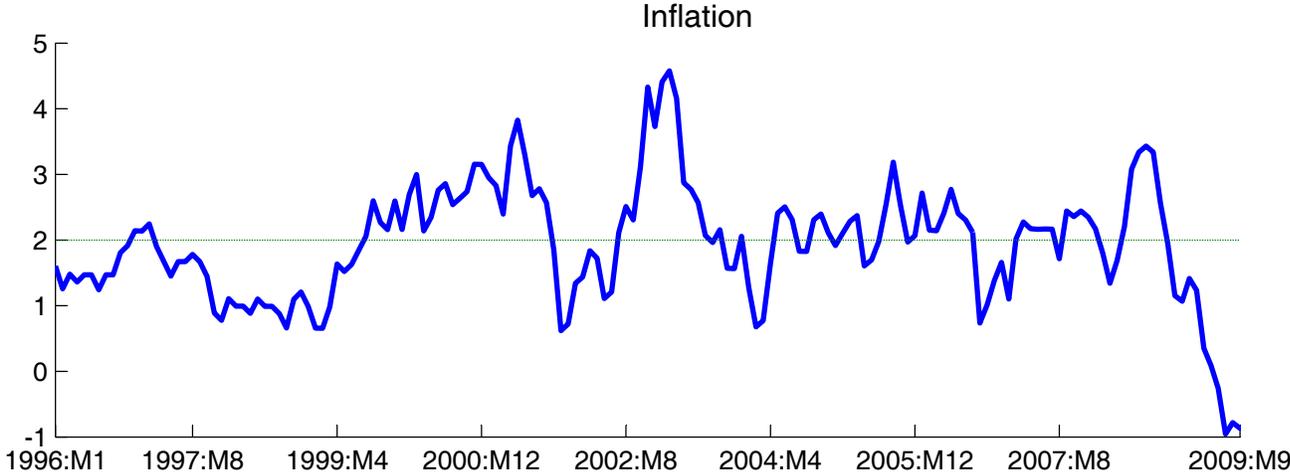


Figure 4: New Zealand (All Groups CPI)

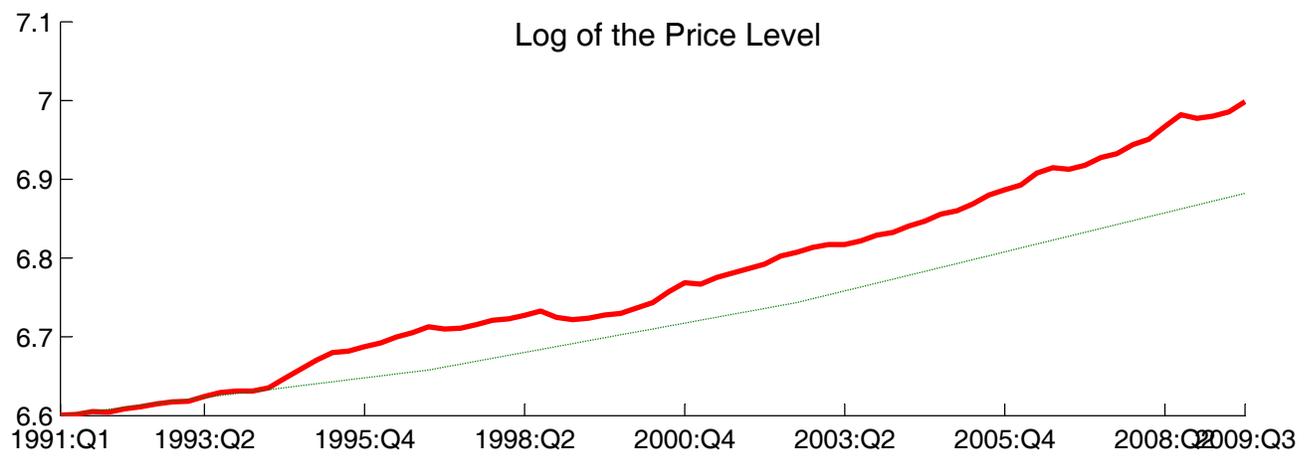
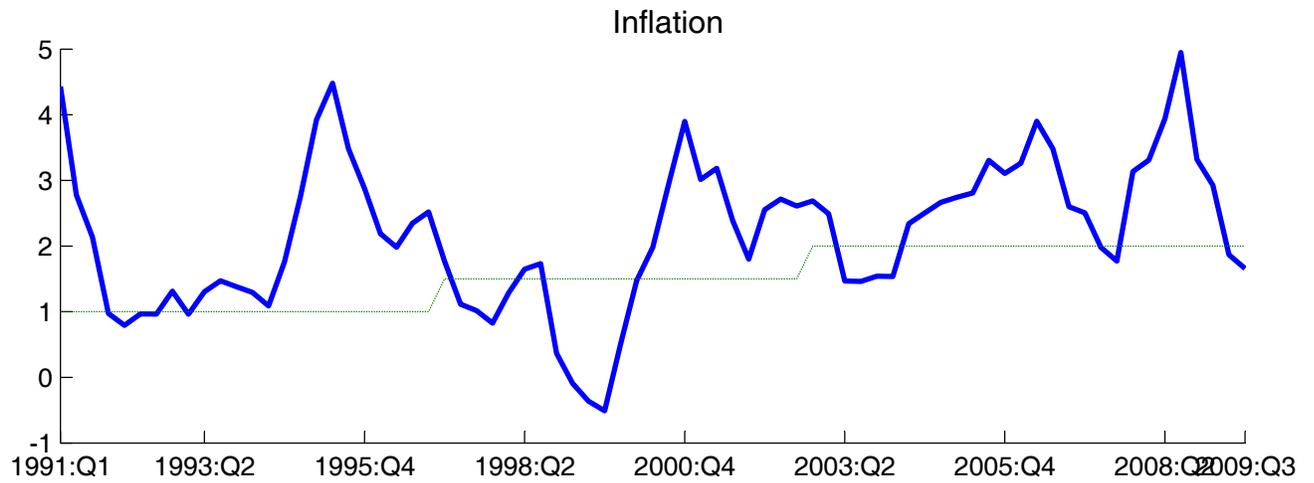


Figure 5: Sweden (CPI)

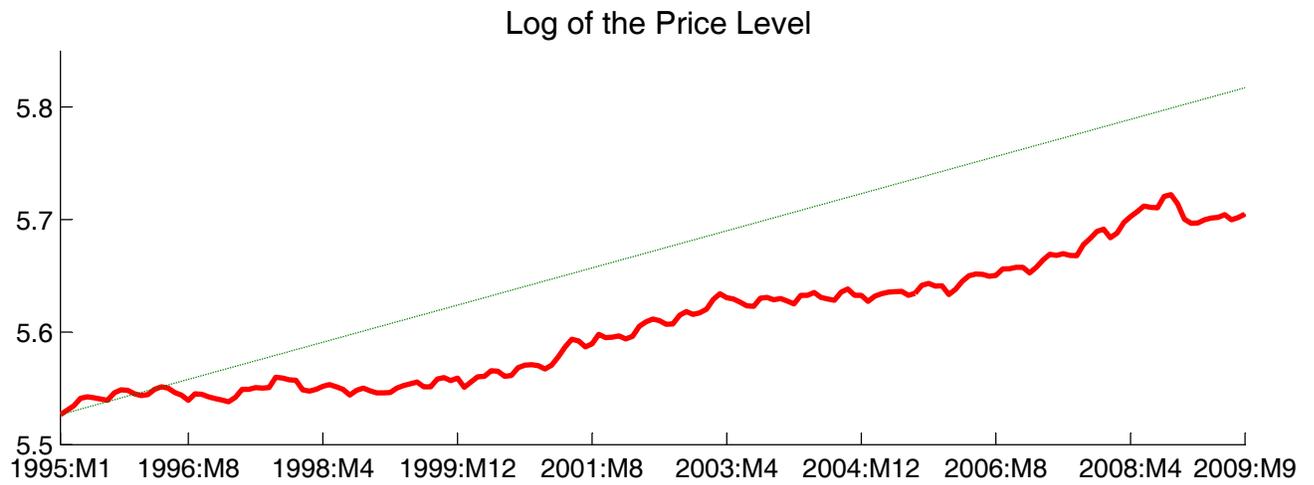
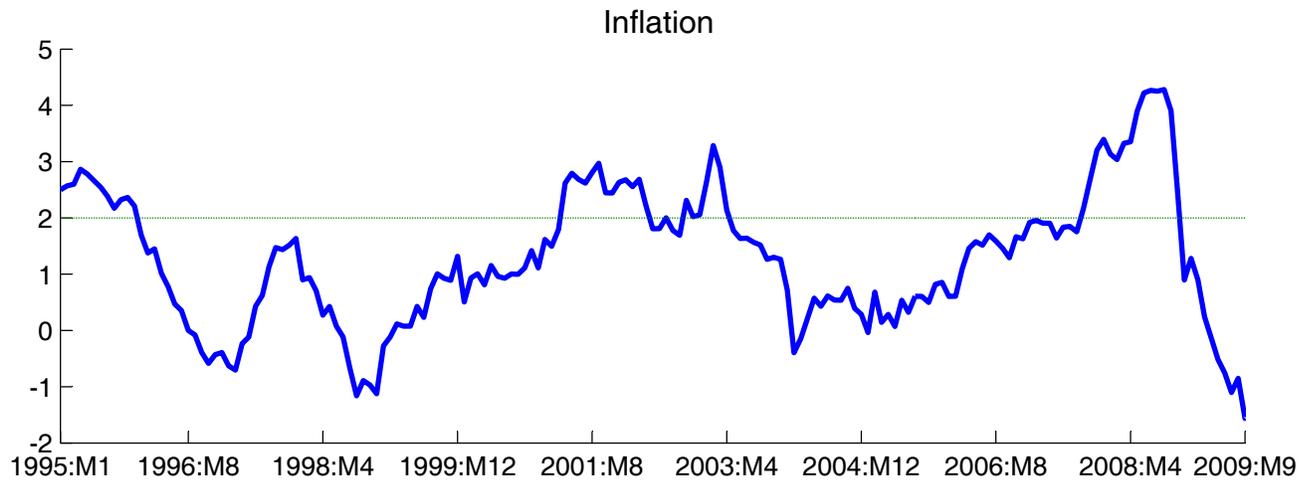


Figure 6: United Kingdom (RPIX-CPI)

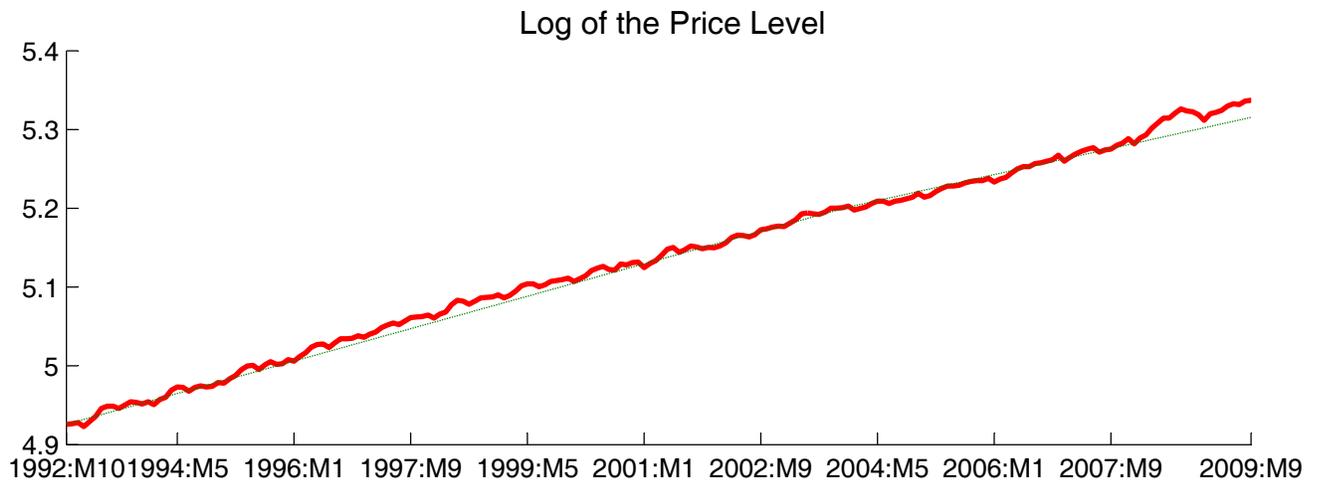
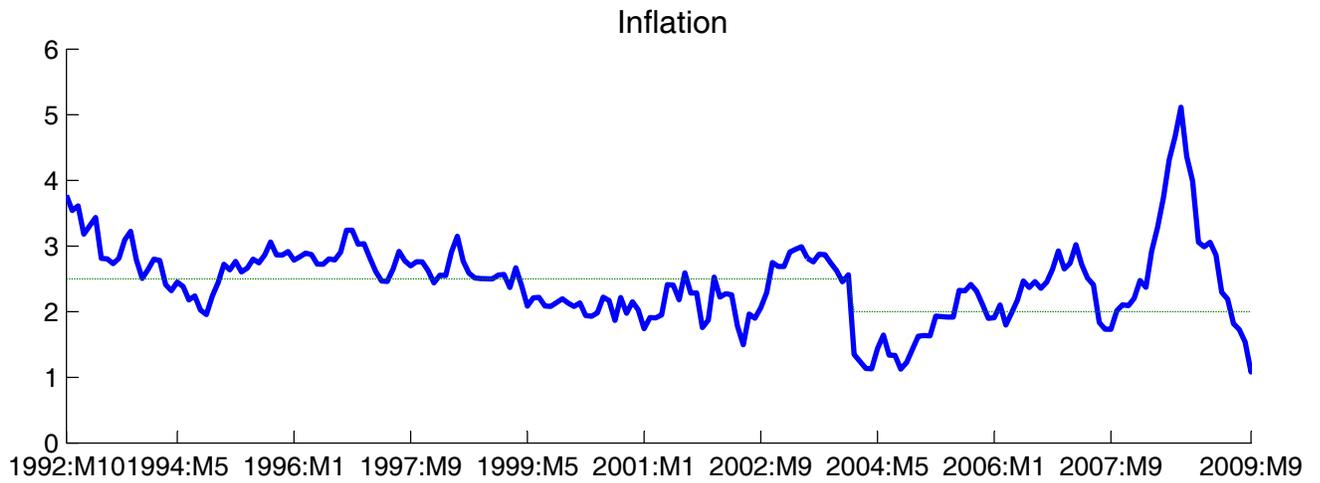


Figure 7: Canada (Core CPI)

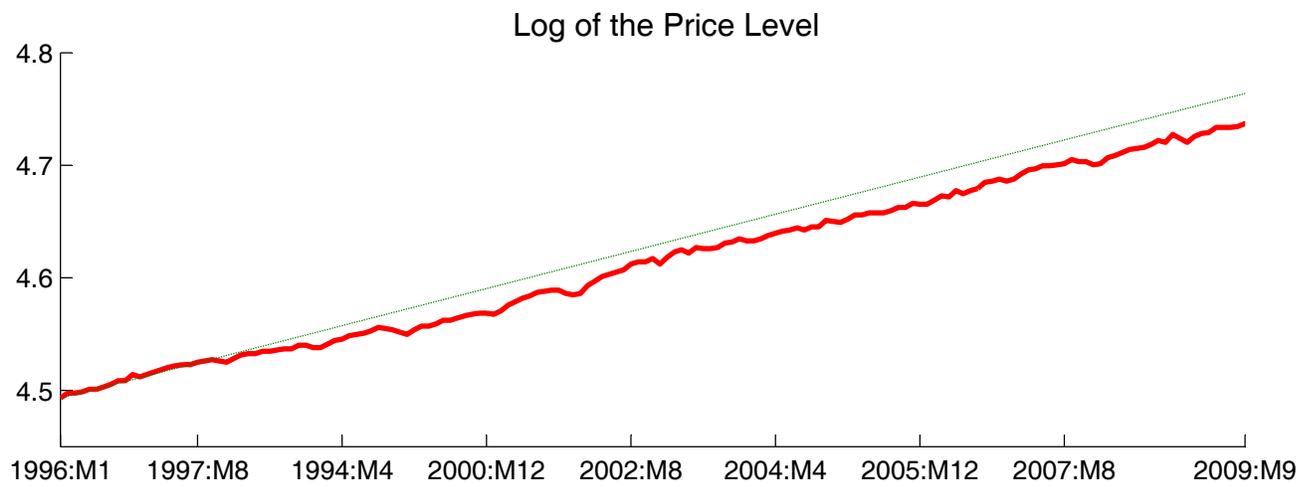
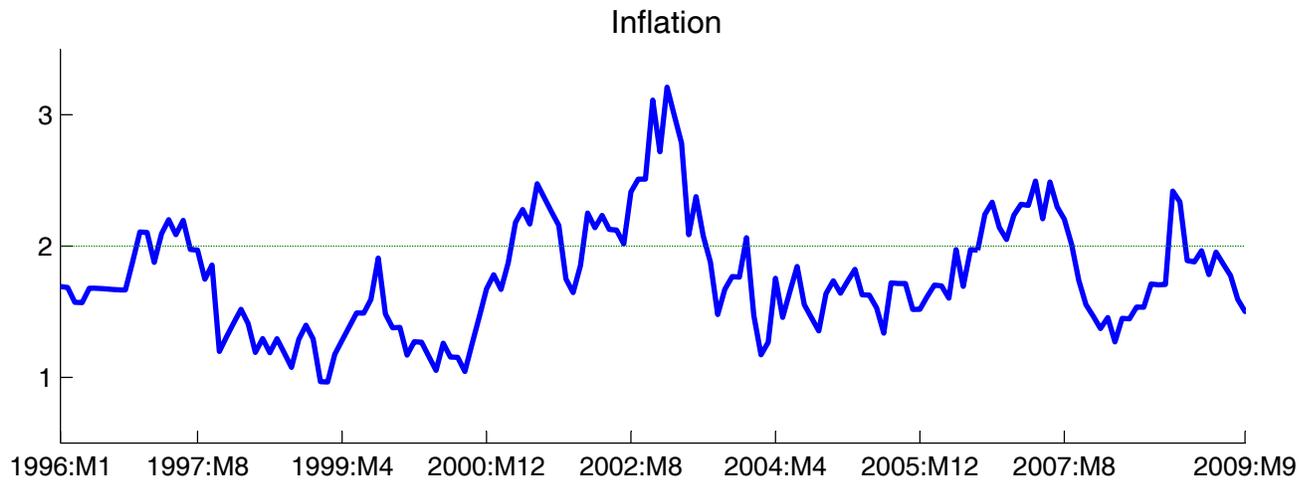


Figure 8: United Kingdom (RPI-CPI)

