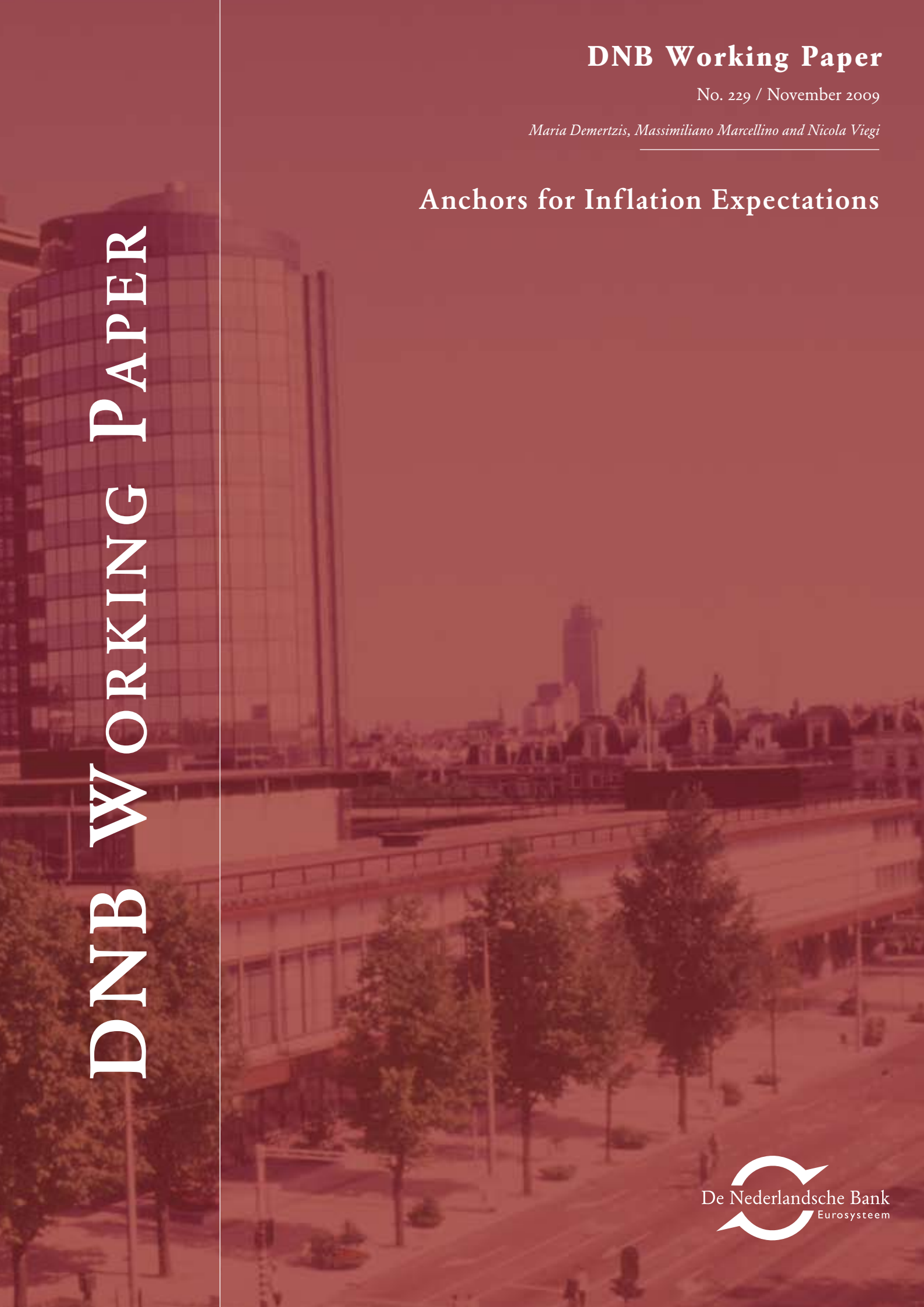
DNB WORKING PAPER

DNB Working Paper

No. 229 / November 2009

Maria Demertzis, Massimiliano Marcellino and Nicola Viegi

Anchors for Inflation Expectations



De Nederlandsche Bank
Eurosysteem

Anchors for Inflation Expectations

Maria Demertzis, Massimiliano Marcellino and Nicola Viegi *

* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

Working Paper No. 229/2009

November 2009

De Nederlandsche Bank NV
P.O. Box 98
1000 AB AMSTERDAM
The Netherlands

Anchors for Inflation Expectations*

Maria Demertzis†
De Nederlandsche Bank

Massimiliano Marcellino‡
European University Institute, Università Bocconi and CEPR

Nicola Viegi§
University of Cape Town and ERSA

November 2009

Abstract

We identify credible monetary policy with first, a disconnect between inflation and inflation expectations and second, the anchoring of the latter at the inflation target announced by the monetary authorities. We test empirically whether this is the case for a number of countries that have an explicit inflation target and therefore include the Euro Area. We find that for the last 10 year period, the two series are less dependent on each other and that announcing inflation targets help anchor expectations at the right level.

Keywords: Inflation Targets, Measures of Credibility
J.E.L codes: E52, E58

*Views expressed are our own and do not necessarily reflect those of any of the institutions we are affiliated with. We would like to thank Jesper Johansson, Richard Harrison, Nir Eilon and seminar participants at the DNB, Norges Bank and SUERF 2009.

†Corresponding author: m.demertzis@dnb.nl, Research Department, De Nederlandsche Bank, P.O. Box 98, 1000 AB, Amsterdam, the Netherlands, tel: +31 (20) 524 2016, fax: +31 (20) 524 2506, http://home.kpn.nl/m_demertzis/.

‡massimiliano.marcellino@eui.eu, European University Institute, Via della Piazzuola 43, Firenze 50133, Italy, tel: +39 055 4685 956, fax:+39 055 4685 902.

§nicola.viegi@uct.ac.za, School of Economics, University of Cape Town, Private Bag, Rondebosch, 7700, Cape Town, South Africa, tel: +27 (21) 650 2763, fax: +27 (21) 650 2854.

1 Introduction

Mishkin (2007) emphasizes the importance of a nominal anchor for inflation expectations. He argues that an institutional commitment to a nominal inflation[1] helps promote price stability and is a crucial element to successful management of inflation expectations. This is a key feature of the recent theory on optimal monetary policy, (Clarida, Gali, and Gertler, 1999; Woodford, 2003). The implication of commitment is that there appears a disconnect between inflation and inflation expectations. In inflation targeting countries, expectations thus aim to follow the anchor provided by the central bank (Demertzis and Viegi 2007, 2008) and inflation is only affected by the variability of shocks that hit it. Empirically, a number of studies have attempted to examine whether countries that have an explicit inflation target have managed to perform better. Levin et al (2004) argue that if expectations are better pinned down in an inflation targeting regime, then the relation between expectations (for different horizons) and current inflation is weaker. They find that indeed for inflation targeters the correlation between inflation and inflation expectations is a lot smaller, and inflation is a lot less persistent. Others have shown that a successful commitment to a nominal anchor has been found to produce not only more-stable inflation but also lower volatility of output fluctuations (Fatás et al 2007; Mishkin and Schmidt-Hebbel, 2002, 2007). Using the difference between far-ahead forward rates on nominal and inflation-indexed bonds as a measure of compensation for expected inflation and inflation risk at long horizons, Gürkaynak et al (2010) find evidence that a well-known and credible inflation target helps to anchor the private sector's perceptions of the distribution of long-run inflation outcomes.

We apply the methodology from Demertzis et al, (2008) to identify the degree to which inflation expectations have indeed been anchored and at what level, for a number of inflation targeting countries, including the Euro area (and Japan). For the countries for which sufficient data is available, we check how this degree of anchoring, and the target itself, have evolved over a given period. For the rest we provide an average estimate since 1999. In turn, we check how the implicit anchor derived from the analysis compares to the inflation target announced by the respective central banks. We find that for this period, inflation expectations were disconnected from inflation and have successfully stabilized at levels close or at the target followed by the Central Bank.

The paper is organized as follows. Section 2 presents a number of stylized facts about inflation and long term inflation expectations, for a set of inflation targeting countries as well as Japan. Section 3 defines the anchoring effect and measures the way it has evolved for Sweden, Israel and the Euro-zone, for which there is sufficient data. Section 4 then describes the econometric setup, which allows us to formulate a number of testable hypotheses on the extent of the anchoring effect. Section 5 presents the results and section 6 summarizes and concludes.

[1] Or commitment more generally, see Albanesi et al (2003) and Christiano and Gust, (2000).

2 Stylized facts

We start by describing a series of stylized facts on the relationship between inflation and long term inflation expectations for a number of OECD countries. We report stylized facts for several countries, many of which follow an explicit inflation targeting framework. Notice that the Euro-Area is not an inflation targeter, but it has an explicit inflation objective, which it communicates to the public.

2.1 Inflation and Inflation Expectations

It is fair to say that most of the IT countries had experienced periods of relative high and volatile inflation prior to the introduction of explicit targets but have also seen, on the whole, significant improvements in inflation around the time of introducing it (Bernanke et al, 1999). Figures 1-2 plot inflation and long-run inflation expectations from 1999 till today.[2] For the inflation targeter (IT) countries we also report the bands and the way they may have changed since 1990.

A number of countries have introduced the target at the bottom, or at relative low levels, of the downward trend (e.g. Sweden, UK, Switzerland). Others waited till inflation had stabilized at relatively low levels (Norway, Australia). Finally, a separate group have changed the inflation target bands progressively to bring inflation down (New Zealand, Canada), an approach that proved particularly popular in countries that were at the time facing relatively high levels of inflation (most Latin American countries, but also Central European countries but also Israel). For a number of countries we see that expectations are simply disconnected from the level of inflation and are focused on the mid-point (Canada and Sweden being the prime examples, followed by Australia and New Zealand). The UK is also very interesting, especially since agents were very quick to internalize the change of inflation measure targeted in December 2003[3]. But the Euro-zone and Norway, who only have an upper limit rather than a symmetric band around a target, also appear to fall into this category with that limit effectively acting as a ceiling for expectations.

[2] Data on inflation targeting bands is based primarily on Mishkin and Schmidt-Hebbel (2002), Levin, Natalucci and Piger (2004) and national Central Bank web sites. Series for inflation (quarterly, CPI y-o-y, 1990q1-2008q2) are taken from DATASTREAM. Data for expectations refer to Consensus Forecasts 10-year ahead inflation expectations (semi-annual). Euro area inflation expectations refer to 5-year ahead and for Israel we use capital market inflation expectations 10 years based on breakeven numbers (monthly based on daily data).

[3] The Bank of England has been targeting the RPIX till December 2003 at a level of 2.5%. After that it has switched to targeting CPI at the level of 2%. We thus present data for the first till December 2003 and the second after that. The remit given to the MPC by the Chancellor states that the target is a point target. We report bands however of $\pm 1\%$ to reflect that the Governor must write an open letter to the Chancellor explaining why inflation is away from the point target, what actions the MPC will take to return inflation to target and the horizon over which they intend to do so.

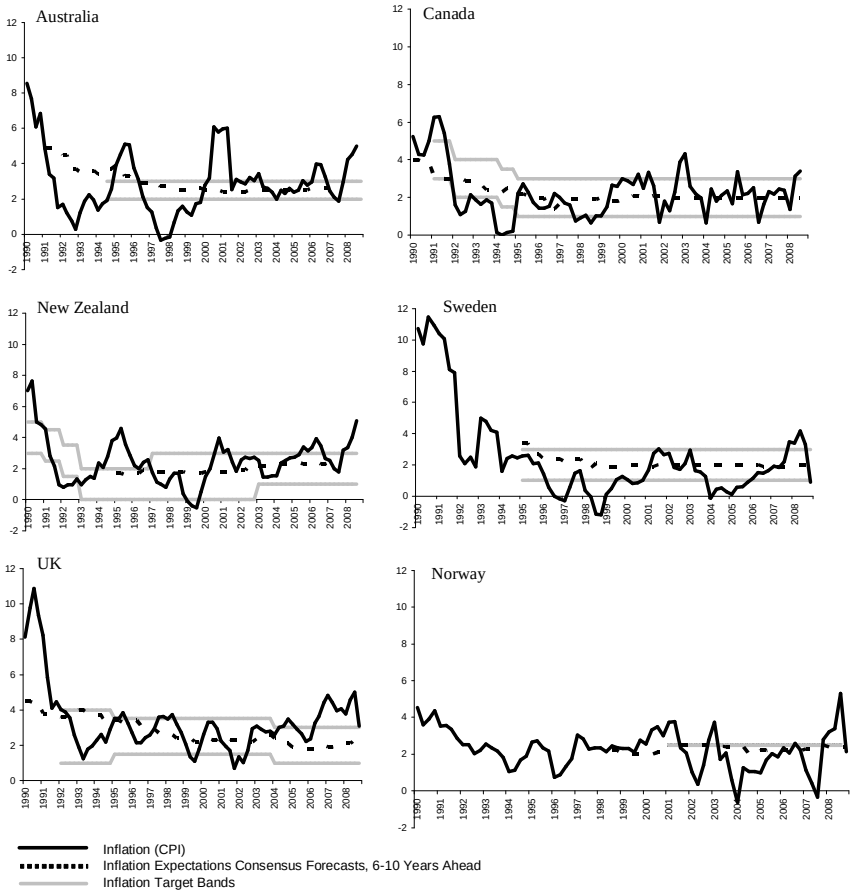


Figure 1: Inflation and inflation expectations

But there are also big differences in the way countries have implemented the inflation targeting regime.[4] For some countries, the target and bands around it have been seen, right from the start, as the long term objective. Countries like Australia, Sweden or Norway announced just the one band-width (and target). For others, there has been a certain degree of refining at the beginning, (see Canada, New Zealand and to a lesser extent the UK), eventually settling at a unique target and band-width after few adjustments. On the other hand, for

[4] Goodfriend (2007) mentions that ITers may differ in four respects: "...1) the announcement of an explicit numerical inflation target by the central bank, 2) patience in reversing an inflationary shock to minimize adverse effects on employment, 3) transparency of central bank concerns and intentions about the economy and interest rate policy, and 4) formal governance mechanisms designed to hold a central bank accountable for inflation outcomes".

a big number of countries, inflation targets and the bands around them were introduced progressively and were subject to changes in small and gradual steps. This is typical for countries that were on a disinflationary path and were using the regime very much as a means of building up credibility (see for example Israel,[5] but this is true for a number of others too, Mishkin and Schmidt-Hebbel 2002).

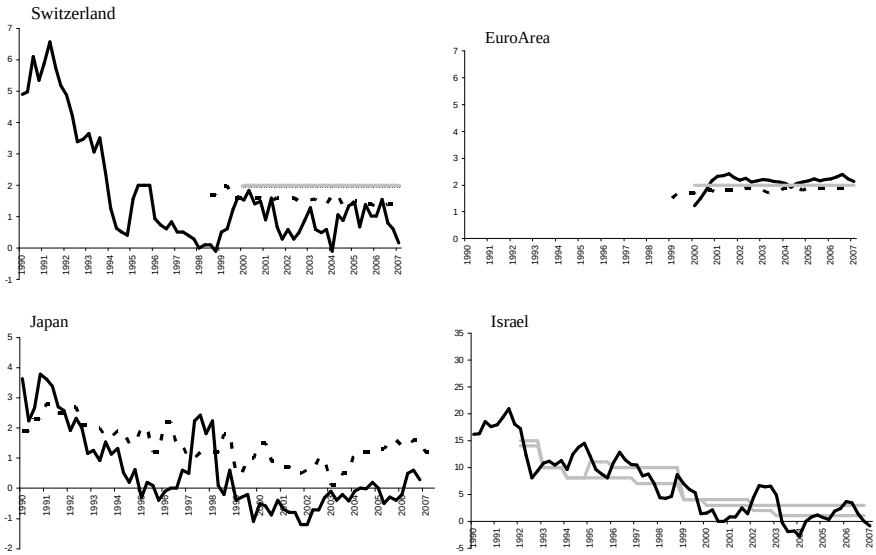


Figure 2: Inflation and inflation expectations

Observing the summary statistics in tables 1a-1c, inflation and inflation expectations have been relatively low for the periods reported. Data typically start in 1990, or as soon as inflation expectations are available.

Table 1a. Inflation and long run inflation expectations

	Australia		Canada		New Zealand	
	$Infl$	$Infl^e$	$Infl$	$Infl^e$	$Infl$	$Infl^e$
Mean	2.42	3.09	2.22	2.24	2.01	1.88
Median	2.37	2.70	2.11	2.00	1.99	1.80
Max	6.02	4.90	6.28	4.00	4.58	2.30
Min	-0.25	2.40	0.00	1.40	-0.40	1.60
St.Dev.	1.58	0.77	1.27	0.55	1.24	0.21
Persistence	0.58	0.80	0.51	0.70	0.33	1.05
Corr with Infl	-	-0.12		**0.48**	-	0.31
Sample	91s1-04s1		90s1-08s2		95s1-06s2	

[5] Data for inflation expectations is monthly as we explain further down, where we also plot it.

Table 1b. Inflation and long run inflation expectations

	Sweden		UK		Norway	
	$Infl$	$Infl^e$	$Infl$	$Infl^e$	$Infl$	$Infl^e$
Mean	1.34	2.10	3.32	2.79	2.09	2.28
Median	1.28	2.00	2.94	2.45	2.14	2.30
Max	4.18	3.40	9.80	4.50	3.78	2.50
Min	-1.19	1.80	0.69	1.80	0.36	2.00
St.Dev.	1.15	0.32	1.83	0.78	0.96	0.17
Persistence	0.66	0.35	0.63	0.76	0.21	0.65
Corr with Infl	-	0.10	-	**0.42**	-	-0.38
Sample	95s1-08s2		90s1-08s2		98s2-08s2	

Table 1c. Inflation and long run inflation expectations

	Switzerland		Euro-Area		Japan		Israel	
	$Infl$	$Infl^e$	$Infl$	$Infl^e_5$	$Infl$	$Infl^e$	$Infl$	$Infl^e$
Mean	1.06	1.53	2.22	1.89	0.55	1.43	2.05	2.84
Median	0.89	1.50	2.13	1.90	0.20	1.40	1.81	2.64
Max	2.91	2.00	3.94	2.00	3.80	2.80	6.94	5.81
Min	-0.10	1.30	0.88	1.80	-1.17	0.10	-2.74	1.57
St.Dev.	0.70	0.16	0.62	0.06	1.24	0.64	2.52	0.82
Persistence	0.02	0.29	-0.35	0.66	0.80	0.77		
Corr with Infl	-	-0.21	-	0.00	-	**0.69**		0.32
Sample	98s2-08s2		99s1-08s2		90s1-08s1		01m5-09m2	

In addition for most inflation targeters inflation expectations have correlations below 0.50 with inflation, and only for Canada and the UK are they statistically different that zero[6]. The Euro-area[7] also has expectations that are always below the 2 per cent mark and exhibit no correlation with inflation. For Japan, a non inflation targeter country without an announced objective, expectations are highly correlated with inflation, have equal persistence as actual inflation and, more importantly, are on average higher than actual inflation. In Israel, inflation expectations are on average higher than inflation but they are not significantly correlated with inflation.

[6] We examine the significance of the correlation coefficients between the variables in question by applying Fisher's transformation:

$$z = 0.5 \ln\left(\frac{1+\rho}{1-\rho}\right)$$

This statistic is approximately normally distributed, with mean zero and standard deviation $\sigma = (n-3)^{-\frac{1}{2}}$, where n is the sample size. The hypothesis tested is $H_0: \quad \rho = 0$ against the alternative $H_1: \quad \rho \neq 0$. Bold indicates significantly different from zero at the 5% level.

[7] From 1999-mid 2003 - EU two-year ahead inflation forecasts, 05/2003: Change in the inflation target from below 2% to an inflation rate of below, but close to, 2% over the medium term (www.ecb.int).

3 The Anchoring Effect

We measure the anchoring effect based on Demertzis et al (2008), who model inflation and inflation expectations in a general VAR framework.

$$\pi_t = a_0 + a(L)\,\pi_t + b(L)\,\pi_t^e + e_{1t}, \tag{1}$$
$$\pi_t^e = c_0 + c(L)\,\pi_t + d(L)\,\pi_t + e_{2t}. \tag{2}$$

The intuition behind this framework is that the two variables are intrinsically related, such that when the level of credibility is low, inflation will not reach its target because expectations will drive it away, and expectations themselves will not be anchored at the level the Central Bank wishes. The anchoring effect itself is based on Bomfin and Rudebusch (2000), who model this feature by assuming that long-run inflation expectations at time t are a weighted average of a constant π^* (which in their case is the current target) and last period's inflation rate.[8]

$$\pi_t^e = \lambda\pi^* + (1-\lambda)\,\pi_{t-1}. \tag{3}$$

Parameter λ then measures the degree to which expectations are anchored. If $\lambda = 1$, inflation expectations are perfectly anchored to the constant π^*. For inflation targeting regimes, it is possible to cross-check π^* against the inflation objective π^T communicated by Central Banks. Credible regimes will be those for which both $\lambda = 1$ and the anchor matches the objective of the central bank. Note that the notion of credibility applies to longer horizons, which are no longer affected by policy. That is why expectations considered in this context refer to the long-run (in our case the 5- or 10-year horizon). This definition does not necessarily preclude anchored expectations in the short-term, but the movement of expectations in the short-run is not necessarily evidence of lack of credibility. Taking (2) to the long run implies that the relationship between inflation and inflation expectations is:

$$\pi^e = \frac{c_0}{1-d(L)} + \frac{c(L)}{1-d(L)}\pi. \tag{4}$$

Matching coefficients between (4) and (3), we have that:

$$\lambda = 1 - \frac{c(L)}{1-d(L)}, \tag{5}$$
$$\pi^* = \frac{c_0}{(1-d(L))\,\lambda}. \tag{6}$$

Therefore, we have an empirical measure of the degree of the anchoring effect. For those countries that have an explicit inflation target we can also check

[8] A heuristic expectations formation (Brazier *et al* 2008), or monetary policy as an information game (Demertzis and Viegi, 2008), or expectations learning (e.g. Orphanides and Williams, 2005), all constitute examples of such an expectations process.

how close π^* is to π^T, the actual CB target, and thus identify a proxy for its credibility. Parameter, λ in (5) is not constrained to belong to the $[0,1]$ interval. If $c(L)$ takes a negative value, or in other words there is a negative relation between inflation and expectations, it is possible for λ to take values greater than one (from 5). This is never however, economically significant. Finally, estimating λ and π^* from (5) and (6) implies that the underlying equilibrium values for the two parameters are constant (see Argov et al, 2007). Alternatively, we can estimate a time varying VAR, (based on Stock and Watson 1996), which would then allow us to derive λ_t and π_t^* and show how they change over the whole period. We apply a Kalman filter and we do this for Sweden, Israel and the Euro-zone, for which there is sufficient data available.[9] For the remainder of countries, for which data is insufficient to perform a Kalman filter, we examine the stability of the relationship before estimating an average measure for λ and π^* across the whole period. We discuss this in sections 4 and 5.

3.1 Time-varying λ : Sweden, Israel and Euro area

To calculate a time-varying λ, we need to use data at a higher frequency. We use 5-year ahead inflation survey expectations for Sweden in quarterly frequency[10] (similarly for the euro area, based on Survey of Professional Forecasters data) and 10-year ahead Capital market expected inflation for Israel.[11] Based on the estimated parameters from the time-varying VAR (1 and 2), we calculate the time varying λ_t (from 5). For both series, the Kalman filter is calculate based on one quarter lag. The data for Sweden spans for the period from 1995Q3 till 2009Q1.

Figure 1 shows that the introduction of inflation targeting in Sweden in1995 occurred after inflation had come down from a level of over 10 per cent. The bands introduced in Sweden require that inflation remains between 1 and 3 per cent. At the point of the introduction, the degree of anchoring of expectations, λ, was above 0.6. Inflation remained below 2 per cent up till the early 2000, and despite the fact that it was sometimes below the lower bound, λ kept increasing. However, a similar violation of the lower band between 2004 and 2006 was met with a reduction in λ (albeit slow and small), which was sustained in the period after that, with a violation of the upper bound in 2008 and again a reversal in the latest period. The latest value estimated is around the level of 0.83. Although

[9] Finally, it is worth mentioning that our measure of credibility is precisely the one employed by King (1995), who analyzes the difference between long-run inflation expectations (derived from nominal and real yield curves) and inflation targets. It is also close to the expectational definitions in Johnson (1997a, 1997b) and Croushore and Koot (1994), which employ short-run inflation expectations from surveys.

[10] "TNS Prospera has been commissioned by Sveriges Riksbank to undertake a series of surveys, four times a year, aiming at mapping expectations of inflation, wage increase, GDP and future repo rates in Sweden among labour market parties, purchasing managers and money market players." http://www.prospera.se/. They are the weighted means of all groups interviewed.

[11] This market series is available on a daily basis but as the highest frequency for inflation available is monthly, we use the last date of the month as the monthly equivalent. We thank the Bank of Israel for providing us with the series.

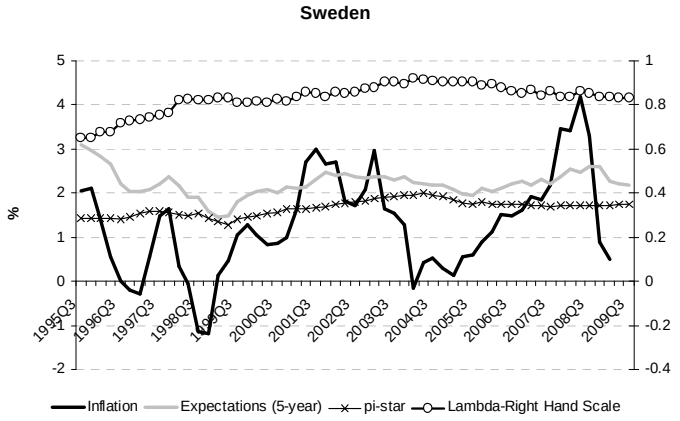


Figure 3: Time-varying λ.

expectations have been above 2 per cent for most of the period in figure 3, the implicit anchor π^* is approaching the level of two per cent, consistent with the mid-point of the bands.

Expectations data for Israel is monthly and spans from 2001m5 till 2009m2.

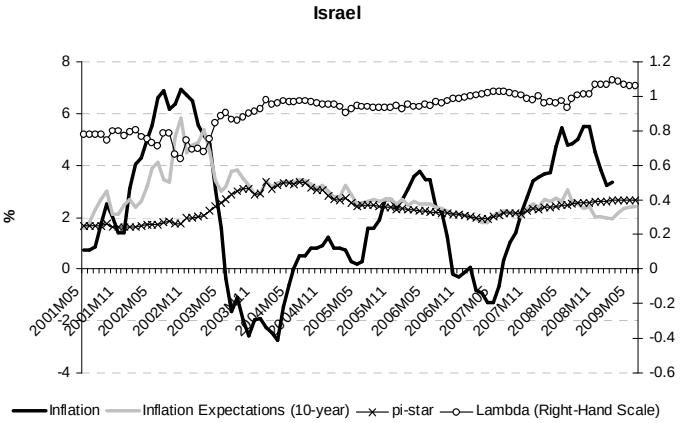


Figure 4: Time-varying λ.

As figure 2 illustrates, inflation targeting was introduced in 1992 and unlike Sweden was used very much as a way of entering a disinflationary path. Both the point target as well as the bands around the point target have changed substantially and have only stabilized in 2003. Figure 4 then illustrates the

estimates for the time varying λ from 2001. We observe that at the end of 2002 λ is starting to increase and stabilizes at the value of about one in 2003. Similar to Sweden, inflation in Israel has been repeatedly outside the bands set since 2001. The level of λ appears to have been affected for periods when inflation was outside the upper bound (e.g. 2008) but not when the it was outside the lower bound (e.g. 2003-2004).

As already explained mentioned, the results for the Euro area are based on the 5-year ahead inflation expectations of the Survey of Professional Forecasters.

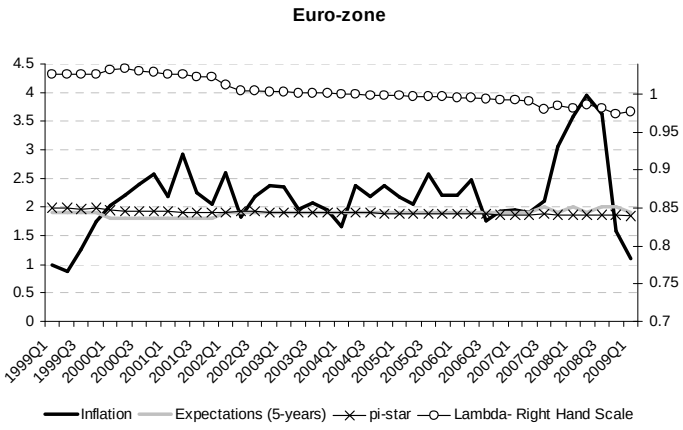


Figure 5: Time-varying λ.

We observe that expectations have been anchored at a level of 2 percent initially and then below 2 in the latter half of the period (in line with the change in the way the inflation objective was communicated). As Figure 5 shows, expectations appear to have stabilized at that level, and their anchoring degree ranges from about 1 to 0.97 at the end of the sample.

4 Testing for the anchoring effect

Based on data for the US, Demertzis et al (2008) argue that a credible monetary policy regime will be associated with a disconnect between inflation and inflation expectations dynamics. In what follows we summarize how this disconnect would manifest itself in the data in the form of 4 hypotheses.

4.1 A Conjecture

As shown above we model π_t and π_t^e in the context of a VAR set-up:

$$\begin{pmatrix} \pi_t \\ \pi_t^e \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \begin{pmatrix} a(L) & b(L) \\ c(L) & d(L) \end{pmatrix} \begin{pmatrix} \pi_{t-1} \\ \pi_{t-1}^e \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix}, \qquad (7)$$
$$\begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix} \sim i.i.d. \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{12} & \sigma_{22} \end{pmatrix} \right).$$

Conjecture 1 *A credible inflation expectations disconnect would imply that the following hypotheses are satisfied:*

H1: Expected inflation is not affected by lagged actual inflation, i.e., $c(L) = 0$.

H2: Expected inflation is anchored to a constant on average, i.e., $c(L) = 0$ and $d(L) = 0$.

H3: Actual inflation is not affected by expected inflation, i.e., $b(L) = 0$.

H4: The persistence of actual inflation should decrease, i.e., the sum of the coefficients of $a(L)$ should decrease with higher credibility.

H5: There should be no contemporaneous transmission of shocks from actual to expected inflation and vice versa, i.e., $\sigma_{12} = 0$.

Hypotheses H1-H3 can be tested with standard Wald tests. In particular, H1 and H3 correspond to Granger non causality of, respectively, actual inflation for expected inflation, and expected inflation for actual inflation. If there is evidence of some heteroskedasticity in the errors, a robust (HAC based) version of the Wald test is used. Hypothesis 4 and the second part of hypothesis 2, refer to the persistence of inflation and inflation expectations. The rationale behind this test is that the greater the credibility, the lower the persistence. Although not a formal test, we check the level of persistence for the whole data set (reported in tables 1a-1c) to the level of persistence for the shorter period since 1999 (reported below in tables 21-2c).Hypothesis 5 can be verified by checking the non-significance of the correlation between the VAR errors ($\text{cor}_{e_{1t},e_{2t}} = 0$), for example by applying a Fisher transform test (as in footnote 6).

5 Credible Monetary Policy?

We examine the period from 1999 till the recent past. This is an inflation targeting period for most countries[12] and matches also the introduction of the Euro. This is a period characterized by low and stable inflation across most of the world. We check whether this is also followed by a disconnect between inflation and inflation expectations. Tables 2a-c show how inflation and inflation expectations have evolved in this period.

[12] Note that Switzerland only adopted inflation targeting in 2000.

Table 2a. Inflation and long run inflation expectations

	Australia		Canada		New Zealand	
	$Infl$	$Infl^e$	$Infl$	$Infl^e$	$Infl$	$Infl^e$
Mean	3.13	2.48	2.28	2.00	2.33	2.09
Median	2.84	2.50	2.28	2.00	2.67	2.20
Max	6.02	2.60	3.80	2.10	3.98	2.50
Min	1.07	2.40	0.72	1.80	-0.40	1.70
St.Dev.	1.51	0.06	0.78	0.06	1.16	0.28
Persistence	0.45	0.46	-0.30	0.18	0.40	0.94
Corr with Infl	-	-0.43		-0.16	-	**0.46**
Sample	99s1-04s1		99s1-08s2		99s1-06s2	

Comparing tables 1a-c to 2a-c, we see that the average of inflation expectations has diminished. Inflation itself has remained in more or less the same levels as for the whole period but its persistence has significantly reduced (H4). At the same inflation expectations have reduced on average and the correlation with inflation has mostly reduced (except for New Zealand). Similarly, inflation expectations persistence is also lower for the latter period (second part of H2).

Table 2b. Inflation and long run inflation expectations

	Sweden		UK		Norway	
	$Infl$	$Infl^e$	$Infl$	$Infl^e$	$Infl$	$Infl^e$
Mean	1.57	1.97	2.86	2.18	2.08	2.28
Median	1.39	2.00	2.94	2.20	2.11	2.30
Max	4.18	2.00	4.58	2.60	3.78	2.50
Min	0.28	1.90	0.69	1.80	0.36	2.00
St.Dev.	1.04	0.05	1.10	0.23	0.98	0.18
Persistence	0.33	0.09	0.44	0.64	0.21	0.65
Corr with Infl	-	-0.21	-	**-0.42**	-	-0.38
Sample	99s1-08s2		99s1-08s2		99s1-08s2	

Table 2c. Inflation and long run inflation expectations

	Switzerland		Euro-Area (q)		Japan	
	$Infl$	$Infl^e$	$Infl$	$Infl^e_5$	$Infl$	$Infl^e$
Mean	1.12	1.52	2.19	1.89	-0.19	1.03
Median	0.95	1.50	2.18	1.90	-0.40	1.20
Max	2.91	2.00	3.94	2.00	2.00	1.60
Min	0.33	1.30	0.88	1.80	-1.17	0.10
St.Dev.	0.66	0.16	0.63	0.05	0.72	0.44
Persistence	-0.10	0.29	0.11	0.77	0.59	0.39
Corr with Infl	-	-0.13	-	0.08	-	**0.50**
Sample	99s1-08s2		99q1-09q1		99s1-08s1	

The descriptive statistics for Japan point to a movement in the right direction but there is still a significant contemporaneous correlation between inflation and expectations. Table 3 summarizes the test results for hypotheses H1,H3 and H5.

We see that there is no causality between the two variables in inflation targeting countries, with the exception of Australia, for which inflation still appears to affect the way expectations are formed. This is also the case for Israel.

Table 3. H1, H3, H5, (1999s1-2008s2)

	Dependent	*Excluded*	df	χ^2	(Pr)	cor_{e_1,e_2}
UK	π	π^e	1	0.45	(0.50)	-0.01
	π^e	π	1	0.05	(0.83)	
SW	π	π^e	1	3.71	(0.05)	-0.01
	π^e	π	1	3.48	(0.06)	
NZ	π	π^e	1	0.00	(0.97)	0.04
	π^e	π	1	0.45	(0.50)	
CA	π	π^e	1	0.38	(0.53)	-0.01
	π^e	π	1	3.56	(0.06)	
AU	π	π^e	1	1.95	(0.16)	0.00
	π^e	π	1	**12.24**	(0.00)	
NO	π	π^e	1	2.27	(0.13)	-0.01
	π^e	π	1	0.03	(0.86)	
Euro-Area	π	π^e	1	0.64	(0.42)	0.00
	π^e	π	1	1.65	(0.20)	
CH	π	π^e	1	1.89	(0.17)	-0.02
	π^e	π	1	0.26	(0.61)	
JP	π	π^e	1	0.14	(0.70)	**0.10**
	π^e	π	1	0.08	(0.78)	
Israel	π	π^e	6	16.5	(0.01)	**0.27**
	π^e	π	6	**2.51**	(0.86)	

Notes: Bold indicates significance at 5% level. Israel (monthly data), Euro-area, 5-year ahead

We also see that shocks do not contemporaneously transmit from one variable to the other, with the exception of Japan and Israel where this correlation (cor_{e_1,e_2}) is significant.[13] Tables 5 and 6 in appendix B report the same results for an extended period and demonstrates that there has indeed been an improvement in the latter period, in the sense of a greater disconnect between the two variables.

5.1 Credibility and the anchoring effect

The evidence presented above points to an increasingly weaker relation between inflation and long-term expectations for most of the countries in the sample. To the extent that the period from 1999 is characterized by such a disconnect, we can then estimate an average value for the anchoring effect, λ, and the anchor, π^*. We compare then the implicit anchor to the target or mid-value of the range announced by the respective central bank. A credible regime thus requires both a high λ, as well as an anchor that matches the inflation target announced.

[13] Errors estimated are heteroscedasticity consistent.

Table 4 shows the results for the countries in our sample, for the periods indicated in tables 2a-c.[14]

Table 4. Anchors and Credibility

Country	λ	π^*	π^T
UK	0.99	2.17	2.5
AU	1.0	2.5	2.5
NZ	0.87	2.23	2
NO	0.98	2.31	2.5
SW	0.98	1.98	2
CA	0.96	1.99	2
JP	0.64	1.9	N/A
CH	1.0	1.51	2
Euro Area	0.93	1.88	<2
Israel	1.0	2.85	2

The findings for the other countries indicate that for the respective periods examined, monetary policy has been well anchored (i.e., high λ). Among the countries examined, Japan is the only one where expectations appear to follow lagged actual inflation. For Australia, Sweden and Canada, we observe both a high level for the anchoring effect after the adoption of inflation targeting, as well as at the explicit numerical target announced by the bank. This is also true for the Euro area: the target is not so tightly specified ('below but close to 2 per cent') but we see that expectations are tied at about 1.88 per cent. Norway, the UK and Switzerland also benefit from high degrees of the anchoring effect, but then at a level lower than the announced target. It is worth noting that the Bank of England changed its inflation target from 2 to 2.5 per cent in December 2003 (see footnote 3). Israel observes also a high value for the degree of anchoring λ but at a level of inflation which is closer to the upper bound (of 3) rather than the mid-point of 2 per cent (consistent also with figure 4).

6 Conclusions

Critical to the decision on how to form expectations is the extent to which monetary policy is perceived to be credible. For inflation targeting countries this is straight-forward to check as inflation outcomes can be cross-checked against the inflation objectives announced. Well anchored expectations at the pre-announced level then make a strong case for credible and sustainable monetary policy in the long-run. Our analysis allows us also to check the extent to which inflation expectations are anchored to a certain level and identify what that level is. We find that monetary policy has, on the whole, been credible during that last ten-year period, and that the adoption of an inflation targeting regime has made an important difference for most of the countries. Japan remains the

[14] For completeness we also include the same calculations done for the whole periods available (Table 7 in appendix B).

only country in our sample, where expectations are not well anchored. Equally important in implementing this approach is the realization that credibility and the underlying anchor are not constant but are subject to changes as new data becomes available, an important reminder that credibility can be gained but it can also be lost.

APPENDIX

A A measure of credibility from a VAR(p)

The VAR(p) equations are:

$$\pi_t = a_0 + a_1\pi_{t-1} + ... + a_p\pi_{t-p} + b_1\pi^e_{t-1} + ... + b_p\pi^e_{t-p} + e_{1t}$$
$$\pi^e_t = c_0 + c_1\pi_{t-1} + ... + c_p\pi_{t-p} + d_1\pi^e_{t-1} + ... + d_p\pi^e_{t-p} + e_{2t}.$$

In the long run it is

$$\pi = a_0 + a_1\pi + ... + a_p\pi + b_1\pi^e + ... + +b_p\pi^e$$
$$\pi^e = c_0 + c_1\pi + ... + c_p\pi + d_1\pi^e + ... + d_p\pi^e,$$

and

$$\begin{aligned}
(1 - a_1 - ...a_p)\,\pi &= a_0 + (b_1 + ...b_p)\,\pi^e \\
\pi &= \frac{a_0}{1 - a_1 - ... - a_p} + \frac{b_1 + ... + b_p}{1 - a_1 - ... - a_p}\pi^e \qquad \text{and} \\
(1 - d_1 - ...d_p)\,\pi^e &= c_0 + (c_1 + ...c_p)\,\pi \\
\pi^e &= \frac{c_0}{1 - d_1 - ... - d_p} + \frac{c_1 + ... + c_p}{1 - d_1 - ... - d_p}\pi.
\end{aligned}$$

It follows that

$$\begin{aligned}
\lambda\pi^* &= \frac{c_0}{1 - d_1 - ... - d_p} \\
1 - \lambda &= \frac{c_1 + ... + c_p}{1 - d_1 - ... - d_p}.
\end{aligned}$$

The non-linear restrictions to be imposed on the VAR coefficients to ensure that $\lambda \in [0, 1]$ can be derived as for the VAR(1) case. For example, for the VAR(2) case, it is

$$\pi^e_t = c_0 + c_1\pi_{t-1} + c_2\pi_{t-2} + d_1\pi^e_{t-1} + d_2\pi^e_{t-2} + e_{2t},$$

and

$$\begin{aligned}
\lambda &= 1 - \frac{c_1 + c_2}{1 - d_1 - d_2} \\
\pi^* &= \frac{c_0}{(1 - d_1 - d_2)\,\lambda}.
\end{aligned}$$

Therefore

$$\pi^e_t = c_0 + [(1 - \lambda)\,(1 - d_1 - d_2) - c_2]\,\pi_{t-1} + c_2\pi_{t-2} + d_1\pi^e_{t-1} + d_2\pi^e_{t-2} + e_{2t}.$$

B Additional Tables

Table 5. H1, H3, H5 (various dates)

	Dependent	*Excluded*	df	χ^2	(Pr)	cor_{e_1,e_2}
UK (1989s2 2007s1)	π	π^e	2	**8.01**	(0.02)	-0.10
	π^e	π	2	0.34	(0.84)	
UK (1997s1-2007s1)	π	π^e	2	2.12	(0.34)	0.18
	π^e	π	2	3.14	(0.21)	
SW (1995s1-2007s1)	π	π^e	2	3.08	(0.21)	0.31
	π^e	π	2	1.51	(0.47)	
NZ (1995s1-2007s1)	π	π^e	1	0.55	(0.46)	**0.51**
	π^e	π	1	0.01	(0.93)	
CA (1989s2-2007s1)	π	π^e	1	**4.35**	(0.03)	**-0.37**
	π^e	π	1	0.97	(0.33)	
CA (1991s1-2007s1)	π	π^e	1	1.99	(0.16)	**-0.48**
	π^e	π	1	0.97	(0.32)	
AU (1989s2-2007s1)	π	π^e	1	0.90	(0.34)	0.11
	π^e	π	1	0.18	(0.66)	
NO (1998s2-2007s1)	π	π^e	1	**6.17**	(0.01)	0.03
	π^e	π	1	0.58	(0.45)	
NO (2001s1 2007s1)	π	π^e	1	1.85	(0.17)	0.17
	π^e	π	1	1.25	(0.26)	

Notes: Bold indicates significance at 5% level.

Table 6. Granger Causality (H1, H3, H5)

	Dependent	*Excluded*	df	χ^2	(Pr)	cor_{e_1,e_2}
Euro (1999s1-2007s1)	π	π^e	1	2.20	(0.14)	0.16
	π^e	π	1	0.09	(0.77)	
JP (1990s1-2007s1)	π	π^e	4	**9.80**	(0.04)	0.16
	π^e	π	4	7.32	(0.12)	
CH (1998s2-2007s1)	π	π^e	1	**6.94**	(0.01)	-0.21
	π^e	π	1	1.24	(0.27)	
CH (2000s1-2007s1)	π	π^e	1	2.79	(0.09)	0.22
	π^e	π	1	0.05	(0.83)	

Notes: Bold indicates significance at 5% level.

Table 7. Anchors and Credibility (Full Samples)

Country	Sample	λ	π^*	π^T	Notes	se_λ
UK	90s2-07s1	1	2.5	2.5		0.18
UK	97s1-07s1	0.87	2.39	2.5		0.07
AU	91s1-07s1	1.07	2.5	2.5	restriction $\lambda = 1$ not rejected	0.18
NZ	95s2-04s1	0.99	2.2	2		0.24
NO	98s2-07s1	0.88	2.30	-		0.21
NO	01s1-07s1	0.91	2.39	2.5		0.10
SW	95s2-07s1	1.02	1.98	2	restriction $\lambda = 1$ not rejected	0.04
CA	89s2-07s1	0.88	1.98	2	Full Sample	0.10
CA	94s2-07s1	0.98	1.97	2	IT Sample	0.07
JP	89s2-07s1	0.64	1.9	N/A		0.10
CH	00s1-07s1	0.98	1.5	2		0.07
EU	99s2-07s1	0.97	1.83	<2		0.08
EU_SPF(2)	99q1-07q4	0.96	1.83	<2		0.00
EU_SPF(5)	99q1-07q4	0.94	1.89	<2		0.00

References

[1] Albanesi, S. V.V. Chari and L.J. Christiano, 2003. Expectation Traps and Monetary Policy, The Review of Economic Studies, Vol. 70, 715-741.

[2] Argov, E. N. Epstein, P. Karam, D. Laxton and D. Rose, 2007. Endogenous Monetary Policy Credibility in a Small Macro Model of Israel, IMF Working Paper, 207.

[3] Bernanke, B.S., T. Laubach, F.S. Mishkin and A. Posen, 1999. *Inflation Targeting: Lessons from International Experience*, Princeton: Princeton University Press.

[4] Bomfin, A and G. Rudebusch, 2000. Opportunistic and Deliberate Disinflation Under Imperfect Credibility, Journal of Money Credit and Banking, 32, November, 707-721.

[5] Brazier, A., R. Harrison, M. King and T. Yates, 2006. The Dangers of Inflating Expectations of Macroeconomic Stability: Heuristic Switching in an Overlapping Generations Monetary Model, Bank of England, Working Paper, no. 303, August.

[6] Christiano, L.J. and C. Gust, 2000. The expectations trap hypothesis, Economic Perspectives, Federal Reserve Bank of Chicago, issue Q II, 21-39.

[7] Clarida, R., J. Gali and M. Gertler, 1999. The Science of Monetary Policy: A New Keynesian Perspective, Journal of Economic Literature, vol. 37, 4, 1661-1707.

[8] Croushore, D.C. and R.S. Koot 1994. A Measure of Federal Reserve Credibility, Journal of Policy Modelling, 16, 215-31.

[9] Demertzis, M. and N. Viegi, 2007. Inflation Targeting: A Framework for Communication, DNB Working Paper, No. 142.

[10] Demertzis, M. and N. Viegi, 2008. Inflation Targets as Focal Points, International Journal of Central Banking, Vol. 4, No. 1, March, 55-87.

[11] Demertzis, M., M. Marcellino and N. Viegi, 2008. A Credibility Measure: Tracking US Monetary Developments, CEPR Working Paper, No. 7036.

[12] Fatas, Mihov and Rose, 2007. Quantitative Goals for Monetary Policy, Journal of Money Credit and Banking, Vol 39, No. 5, 1163-1176.

[13] Goodfriend, M. and King, R. 2005. The incredible Volker disinflation, Journal of Monetary Economics, 52, 981-1015.

[14] Goodfriend, M. 2007. How the World Achieved Consensus on Monetary Policy, The Journal of Economic Perspectives, Vol. 21, No. 4, 47-68.

[15] Gürkaynak, R., A.T. Levin and E.T. Swanson, 2010. Does Inflation Targeting Anchor Long-Run Inflation Expectations? Evidence from Long-Term Bond Yields in the US, UK and Sweden, Journal of the European Economic Association, forthcoming

[16] Johnson, D., 1998. The Credibility of Monetary Policy: International Evidence Based on Surveys of Expected Inflation Price Stability, in Macklem, T. (ed), Price Stability, Inflation Targets and Monetary Policy, Proceedings of a Conference Bank of Canada, 1997, 361-395.

[17] Johnson, D.R., 2002. The effect of inflation targeting on the behavior of expected inflation: evidence from an 11 country panel, Journal of Monetary Economics 49, 1521-1538.

[18] King, M., 1995. Credibility and Monetary Policy: Theory and Evidence, Bank of England Quarterly Bulletin, February.

[19] Levin, A.T., F.M. Natalucci and J.M. Piger, 2004. The Macroeconomic Effects of Inflation Targeting, Federal Reserve Bank of St. Louis Review, vol. 86(4), 51-80.

[20] Mishkin, F.S., 2007. Will Monetary Policy Become more of a Science?, NBER, Working Paper, No. 13566, October.

[21] Mishkin, F. S. and K. Schmidt-Hebbel, 2002. One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know? in Norman Loayza and Raimundo Soto, (eds), *Inflation Targeting: Design, Performance, Challenges*, Central Bank of Chile, Santiago, 117-219.

[22] Mishkin, F.S., and K. Schmidt-Hebbel, eds. 2007. Does Inflation Targeting Matter? in *Monetary Policy Under Inflation Targeting*, Santiago: Central Bank of Chile, 291-372.

[23] Orphanides, A. and Williams, J.C., 2005. Expectations, learning and monetary policy, Journal of Economic Dynamics and Control, 29(11), 1807-1808.

[24] Perrier, P and R. Amano, 2000. Credibility and Monetary Policy, Bank of Canada Review, Spring, 11-17.

[25] Stock, J.H. and M.W. Watson, 1996. Evidence on structural instability in macroeconomic time series relations, Journal of Business and Economic Statistics 14, 1, 11-30.

[26] Woodford, M., 2003, *Interest and Prices*, Princeton University Press.

Previous DNB Working Papers in 2009

No. 198 **Peter ter Berg**, Unification of the Fréchet and Weibull Distribution
No. 199 **Ronald Heijmans**, Simulations in the Dutch interbank payment system: A sensitivity analysis
No 200 **Itai Agur**, What Institutional Structure for the Lender of Last Resort?
No 201 **Iman van Lelyveld, Franka Liedorp and Manuel Kampman**, An empirical assessment of reinsurance risk
No. 202 **Kerstin Bernoth and Andreas Pick**, Forecasting the fragility of the banking and insurance sector
No. 203 **Maria Demertzis**, The 'Wisdom of the Crowds' and Public Policy
No. 204 **Wouter den Haan and Vincent Sterk**, The comovement between household loans and real activity
No. 205 **Gus Garita and Chen Zhou**, Can Open Capital Markets Help Avoid Currency Crises?
No. 206 **Frederick van der Ploeg and Steven Poelhekke**, The Volatility Curse: Revisiting the Paradox of Plenty
No. 207 **M. Hashem Pesaran and Adreas Pick**, Forecasting Random Walks under Drift Instability
No. 208 **Zsolt Darvas**, Monetary Transmission in three Central European Economies: Evidence from Time-Varying Coefficient Vector Autoregressions
No. 209 **Steven Poelhekke**, Human Capital and Employment Growth in German Metropolitan Areas: New Evidence
No. 210 **Vincent Sterk**, Credit Frictions and the Comovement between Durable and Non-durable Consumption
No. 211 **Jan de Dreu and Jacob Bikker**, Pension fund sophistication and investment policy
No. 212 **Jakob de Haan and David-Jan Jansen**, The communication policy of the European Central Bank: An overview of the first decade
No. 213 **Itai Agur**, Regulatory Competition and Bank Risk Taking
No. 214 **John Lewis**, Fiscal policy in Central and Eastern Europe with real time data: Cyclicality, inertia and the role of EU accession
No. 215 **Jacob Bikker**, An extended gravity model with substitution applied to international trade
No. 216 **Arie Kapteyn and Federica Teppa**, Subjective Measures of Risk Aversion, Fixed Costs, and Portfolio Choice
No. 217 **Mark Mink and Jochen Mierau**, Measuring Stock Market Contagion with an Application to the Sub-prime Crisis
No. 218 **Michael Biggs, Thomas Mayer and Andreas Pick**, Credit and economic recovery
No. 219 **Chen Zhou**, Dependence structure of risk factors and diversification effects
No. 220 **W.L. Heeringa and A.L. Bovenberg**, Stabilizing pay-as-you-go pension schemes in the face of rising longevity and falling fertility: an application to the Netherlands
No. 221 **Nicole Jonker and Anneke Kosse**, The impact of survey design on research outcomes: A case study of seven pilots measuring cash usage in the Netherlands
No. 222 **Gabriele Galati, Steven Poelhekke and Chen Zhou**, Did the crisis affect inflation expectations?
No. 223 **Jacob Bikker, Dirk Broeders, David Hollanders and Eduard Ponds**, Pension funds' asset allocation and participants age: a test of the life-cycle model
No. 224 **Stijn Claessens and Neeltje van Horen,** Being a Foreigner among Domestic Banks: Asset or Liability?
No. 225 **Jacob Bikker, Sherrill Shaffer and Laura Spierdijk**, Assessing Competition with the Panzar-Rosse Model: The Role of Scale, Costs, and Equilibrium
No. 226 **Jan Marc Berk and Beata K. Bierut**, Communication in a monetary policy committee: a note
No. 227 **Dirk Broeders, An Chen and Birgit Koos**, An institutional evaluation of pension funds and life insurance companies
No. 228 **Michael Hurd, Maarten van Rooij and Joachim Winter**, Stock market expectations of Dutch households