Has the Persistence of Household Inflation Expectations Changed in Australia After Inflation Targeting?

by

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Abstract

This essay studies the dynamics of persistence of households' inflation expectation in 1975-2008 based on Australian survey data. In particular, this essay investigates whether the persistence of expectations has changed after the introduction of the inflation targeting scheme in 1993 and, if so, how these changes occur. A univariate autoregressive model is used to estimate the persistence parameter (the sum of the coefficients on the lagged dependent variables). Average levels of expected inflation, as well as actual inflation, have been substantially reduced and generally maintained at a low level since targeting. While the estimated persistence of expected inflation seems to have been falling gradually since adoption, there is little evidence to suggest that the inflation targeting scheme has significantly reduced persistence.

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1 Introduction

To my best knowledge, almost all the papers that study persistence look at the actual consumer price inflation, very few pay attention to persistence of expected consumer price inflation. As Cecchetti and Debelle (2004) suggest, a study on the dynamics of persistence of inflation expectations rather than actual inflation may reveal more information about the effects of changes in monetary stance.

This essay examines how the persistence of expected consumer price inflation has changed as a result of the introduction of the inflation targeting scheme in 1993 in Australia. Inflation expectations provide useful information for assessing monetary policy. One of the primary goals of inflation targeting, as part of a monetary policy framework, is to keep inflation expectations well anchored. This implies that, if the targeting policy is credible, inflation expectations (especially long-term expectations) should be relatively less responsive to one-time shocks than they would otherwise be without the target in place. Data shows that the average level of expected inflation has dropped remarkably since the early 1990s. A simple univariate autoregressive model is employed to estimate the persistence of inflation expectations based on the survey data. Results from moving-window rolling regressions suggest little evidence, however, that persistence has been significantly reduced since the introduction of the targeting policy. The essay concludes that the monetary policy in Australia has been successful in lowering the actual inflation as well as the public's expectation of inflation in the past two decades. However, persistence of inflation expectation has remained relatively stable despite the introduction of the explicit target and it is therefore not clear whether the target has been fully credible.

Inflation expectations play an important role in economic activity. They not only determine the aggregate price level, but they can also be self-fulfilling to some extent. They affect decisions of households, firms and policy-makers in terms of consumption, investment, asset allocation, wage bargaining and price setting. Through such decisions, inflation expectations feed through and shape inflation itself. For example,

if inflation is expected to be persistently higher, workers will take that into account when negotiating wages with firms to ensure that they receive a real wage increase. Firms face higher cost of labor input and are under pressure to raise selling prices, which in turn pushes up inflation. Inflation expectations therefore greatly influence the central bank's ability to achieve price stability.

High inflation distorts decision-making and hinders economic growth. One of the primary roles of monetary policy is to serve as an effective instrument to ensure medium-term price stability. There are various approaches such as exchange-rate pegging, monetary targeting and inflation targeting. The main reasons, as set out in Brash (2002), that many adopt inflation targeting are the following: (a) to find some credible anchor for monetary policy (especially when an exchange-rate target is proved impossible to maintain or a monetary target is proved both difficult to achieve and is less closely connected to the inflation rate than the central bank has hoped for); (b) to give the central bank independence, as well as to balance independence with accountability;[1] (c) to reduce the costs of disinflation by anchoring the inflation expectations of both financial markets and households.

In the late 1980s and early 1990s, many central banks around the world started adopting inflation targeting which aimed to keep inflation expectations anchored. The term "anchor" refers to relative insensitiveness to new data. For example, if the public does not change their long-run expectation much in response to a short period of higher than expected inflation, then expectations are well anchored. Well anchored inflation expectations have implications for the performance of inflation and the overall economy. Mishkin (2007) points out that if inflation expectations respond less to variations in economic activity, then inflation itself will become relatively more insensitive to the level of activity. If inflation expectations are well anchored, a shock, such as a one-time increase in fuel or food prices, is unlikely to lead to a permanent

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[1]Mishkin (2007) adds that inflation targeting increases the accountability of the central bank and its policy transparency. The explicit inflation target helps the public assess the central bank's commitment to price stability

increase in inflation. Instead, the one-time shock will only lead to a change in relative prices.

King (1995) defines credibility as the public belief that the government will actually carry out its plans for future policy actions contingent upon events. A future monetary policy is credible if the central bank has the incentive to implement this policy when the time comes. Ammer and Freeman (1995) discuss the likely effect of policy announcements on private expectations. They state that explicit targets make monetary policy more transparent and help agents to make decisions that will lead to more efficient macroeconomic outcomes.

Such a policy may not reduce uncertainty for private agents unless they believe that it will be implemented. Accurate anticipation of anti-inflation policy by agents could lower the cost of inflation reduction by cutting potential welfare loss associated with suboptimal decisions induced by misperceptions of the policy. The effectiveness of an anti-inflation policy may thus depend crucially upon the credibility of announced policy goals. Taylor (1982), on the other hand, contends that the credibility of monetary policy should also depend on its effectiveness. In order for monetary policy to be credible, it must be possible for agents to perceive the central bank's policy stance as desirable and effective. If inflation reduction is perceived as a costly procedure for a central bank, credibility requires that the benefits of implementing an anti-inflation policy outweigh the costs. Rodrik (1989) adds that a well-intended and clear policy statement by a competent central banker may still lack credibility. This could occur if the anti-inflation policy is incompatible with other government policies such as announced large budget deficits. Alesina and Summers (1990) examine the relationship between central bank independence and success in inflation fighting. They find that increased central bank independence has become a key element to the success of some inflation-targeting regimes.

The remainder of the essay is organized as follows. Section 2 surveys the literature and provides empirical evidence on the subject. Section 3 outlines how inflation

expectations may be measured and distinguishes the difference between consumer and "expert" expectations. Section 4 describes the data, selects appropriate econometric methods to estimate persistence of inflation expectations in Australia, and provides interpretation of the results. Section 5 concludes and provides suggestions for future research.

2   Literature review and empirical evidence

Persistence of inflation measures how quickly inflation reverts to its initial level, or how long a changed level of inflation lasts as a result of a shock. A common practice in empirical research is to estimate a univariate autoregressive (AR) model and to measure persistence as the sum of the estimated AR coefficients. Andrews and Chen (1994) advocate this sum of the coefficients on lagged dependent variables as the best scalar measure of persistence, instead of other popular approaches such as the largest autoregressive root and the half-life measure. The sum of the coefficients is commonly known in the literature as the persistence parameter. If the persistence parameter is close to unity, then shocks to inflation have long-lasting effects on inflation. On the other hand, if the sum of the coefficients is well below unity, then a shock to inflation has only a temporary effect on inflation.

There has been lively debate and mounting empirical research on the inflation process over the past two decades, though the results have often been inconclusive. Researchers employ various techniques and econometric methodologies to uncover the dynamics of inflation persistence in order to analyze the effectiveness of monetary policy. O'Reilly and Whelan (2005) find that inflation persistence was high (i.e. close to one) in the Euro-area since 1970 and unchanged over time. They apply the Andrews-Quandt sup-F statistic, which is the maximum of a sequence of traditional Chow tests at all potential breakpoints. This tests for structural breaks with unknown breakpoints, for the GDP price inflation series. However, they neglect to apply this method to the consumer price inflation series. Instead, they test for parameter stabil-

ity with the non-seasonally adjusted consumer price inflation series, which they argue may exhibit instabilities due to changing seasonal patterns. Their rolling regression results, nevertheless, show that the consumer price inflation persistence has been relatively stable over the post-1970 period, while allowing for changes in the mean of inflation over different sub-samples. This finding is opposed to the expectation that there would be large declines in the coefficient estimates due to changes in monetary policy regimes that were more favourable to inflation fighting in the Euro-area since 1970.

Dopke et al. (2005) estimate persistence of inflation, as well as inflation expectations, in four major EU economies. They find high persistence with the median unbiased estimates of the largest autoregressive root close to one. However, they fail to consider possible structural breaks in the data. Perron (1989) points out that an analysis that does not allow for structural breaks in the intercept or trend may result in spuriously high estimates of the persistence parameter. The study of inflation dynamics for 12 industrial countries over 1984-2003 in Levin and Piger (2003) is a good example.[2] The study finds strong evidence for a break in the intercept in a univariate AR model in the late 1980s or early 1990s, using both classical and Bayesian econometric methods. Without allowing for possible breaks, Levin and Piger report a persistence parameter for the U.S. GDP price inflation of 0.92 from the first quarter of 1984 to the last quarter of 2003. Once a structural break is allowed for, persistence drops to 0.36. Benati and Kapetanios (2002) test for multiple structural breaks at unknown points and find structural breaks in 23 inflation series from 18 countries plus the Euro-zone. The breaks appear to broadly coincide with major macroeconomic events such as the breakdown of Bretton Woods, the Volcker disinflation in the U.S. and the introduction of inflation targeting in some countries. The authors conclude that, in general, inflation is not a highly persistent process.

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[2]Levin and Piger (2003) analyze four different inflation measures: the GDP price inflation, the personal consumption expenditure price inflation, the consumer price inflation and the core consumer price inflation.

In contrast, Cecchetti and Debelle (2004) show that persistence of consumer price inflation in 17 countries has been declining over time after allowing for changes in the mean of inflation. However, their results are based on the sum of the coefficients of AR(1) and AR(12). Their reasoning is that the former is the simplest measure and the latter factors in the monthly series features, while others select the models by using information criteria.[3] While the effect of lag order selection on the model estimate is unclear, they acknowledge that the results and measures of inflation persistence depend crucially on the sample period over which they are calculated. They show that estimates in the post-1990 period exhibit a very low level of persistence in most countries studied.

Hondroyiannis and Lazaretou (2004) estimate inflation persistence in Greece from 1975 to 2003. They observe that inflation persistence was high during the inflationary period (1975-1991) and the first six years of the disinflationary period (1992-2003). The authors test for structural breaks with unknown break points by experimenting with a number of possible dates using the Chow test, and they find a break in the first quarter of 1991. They also use the test developed by Bai and Perron (1998, 2003) and rolling regressions to test for multiple breaks. The results are consistent with the experiment that uses the Chow test. The estimated correlations between inflation and policy stance measures reveal that there was a delay in the inflation response to changes in monetary policy under the sample period, and this delay seems to have remained stable over time. The paper concludes that inflation persistence started to fall in 1997 when inflation expectations seem to have been stabilized. Thus, monetary policy in Greece was effective at reducing inflation.

There is evidence that reductions in inflation persistence are more often found in inflation targeting countries than non-targeting countries. DeBelle and Wilkinson (2002) report that the inflation process in Australia has become more anchored since the targeting, suggesting that the Australian economy has become more resilient to

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[3]For the Australian and New Zealand series which are quarterly, Cecchetti and Debelle use AR(4) instead of AR(12).

temporary price level shocks. They assume some proportion of inflation expectations is formed in a backward-looking manner and the rest is anchored at a so-called perceived inflation target.[4] They find that persistence has also declined considerably in the U.K., Canada and New Zealand in the 1990s, but little evidence of lower persistence is found for the U.S. data. Their results support the Kuttner and Posen (1999) hypothesis that the adoption of inflation targeting has increased the capacity of the central bank to manage inflation, by reducing the propagation of inflation shocks. Kuttner and Posen also find declining persistence of inflation in Canada, the U.K. and New Zealand in the period after inflation targeting was introduced. They argue that this reduction in persistence may reflect the success of the inflation targeting regime in enhancing public trust of the central bank's commitment. Gurkaynak et al. (2006) examine the sensitivity of inflation expectations to macroeconomic data releases and monetary policy announcements. They compare results for the U.K., Sweden (inflation-targeters) and the U.S. (non-inflation-targeter). Their findings support the view that a well-known and credible inflation target helps anchor private sector inflation expectations. They use the difference between forward rates on nominal and inflation-indexed bonds as an estimate for inflation expectations. They find that the U.S. data is highly responsive to economic news, whereas such sensitivity was absent in the U.K. when the central bank became independent in 1997. The Swedish data was shown to be insensitive to economic news.

Empirical evidence on inflation persistence dynamics in non-inflation targeting countries is mixed, though the focus is mainly on the U.S. data. In addition to Levin and Piger's (2003) results, Taylor (2000) finds that the inflation process in the U.S. was less autocorrelated in the 1980s and 1990s than it was in the 1970s. Taylor argues that inflation persistence may have been brought down by the low level of inflation. Kozicki and Tinsley (2002) report that there has been a change in the intercept and that inflation persistence was lower in the 1990s. Stock (2002), Stock and Watson

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[4]The authors argue that indicators of forward-looking inflation expectations in Australia are quite poor and a simple model of past inflation and an anchored inflation rate fits the data well.

(2003) and Pivetta and Reis (2007) find high persistence but no evidence of a change in inflation persistence. Kim et al. (2004) find one structural break in inflation data in late 1979, which gives rise to lower persistence. However, their approach allows for only one break in the sample period.

3   Measures of inflation expectations

Inflation expectations are not directly observable. Instead, they can be inferred with certain methods, directly and indirectly. The most common methods are expectation surveys and market-based measures via inflation-linked financial securities. The former asks agents about their expectations, and thus is a direct measure; the latter infers expectations from observable market behaviour that are embodied in the prices of financial securities, and is therefore indirect.

3.1   Survey measure

Surveys of inflation forecasts provide a source of direct information on expectations. Respondents are asked in which direction they think inflation will change and by how much.[5] There are two broad categories of surveys of inflation expectations in the private sector: short-term (i.e. one to two years ahead) and longer-term. Short-term expectations are helpful when assessing possible reaction of agents to different price shocks, for instance, the risk of second-round effects of an oil price shock. Longer-term expectations are useful for assessing monetary policy credibility. If the policy is credible, longer-term expectations should be less affected by shocks as agents believe that the central bank is committed to achieve price stability at a specified inflation target.

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[5]In some surveys, respondents are not asked to put a precise figure to the average inflation rate they anticipate, but simply to indicate whether they think the inflation will be higher, lower, or stay unchanged. These types of surveys are qualitative and provide information only on the anticipated direction of change in prices. Other surveys ask respondents for an inflation figure without explicitly specifying the "consumer price inflation" (e.g. the Marketscope Survey of Household Inflation Expectations sponsored by the Reserve Bank of New Zealand).

While surveys provide direct measures of inflation expectations, they have certain drawbacks. For example, surveys of forecasts are infrequent and expensive. Surveys take time to compile and are only available on a periodic basis. Many consumer inflation expectation surveys are conducted on a monthly or quarterly basis, while surveys of professional forecasters are quite often conducted annually or semi-annually. Due to its untimely nature, only information at the time of the survey is recorded and this information does not get updated until the next survey. Survey samples are often limited to the general public, economists and commentators who may not be representative or have a significant impact on economic outcomes. Also, survey respondents may not have the incentives to report their views accurately (i.e. talk is cheap). It is not clear if survey data actually represent the true expectations. Ranchhod (2003) examines the relationship between surveyed inflation expectations and actual inflation in New Zealand. The study reports that, while survey data may be inaccurate in forecasting inflation, it still provides useful directional information regarding short-term inflationary pressures.

3.2 Expectations: general public versus experts

Agents with different degrees of knowledge about the economy are likely to have different opinions. Quite often, surveys of inflation expectations are conducted separately among consumers and professional economists (the "experts"). Some have studied responses from the two groups and argue that the difference is due to the fact that not all consumers are picking up on what the experts are predicting. For instance, Carrol (2003) argues that because of the costs of acquiring and processing information, only a fraction of households follow the latest inflation commentaries in news reports and update their expectations. The fraction of households who adopt expert views is estimated to be around one quarter in the U.S., based on the University of Michigan Inflation Expectation survey data, while three quarters maintain their own view. The paper concludes that the fact that consumers only occasionally read these

reports generates "stickiness" in aggregate expectations. Dopke et al. (2005) apply Carroll's (2003) model to European data and find that most European households adjust rather sluggishly to new information, and that they use information processed by experts rather than just relying on past information. Brischetto and de Brouwer (1999) conduct a cross-sectional study based on the Australian consumer inflation expectations survey data. They find that people who are older, better educated or in an occupation that requires developed information-processing skills have lower inflation expectations and more accurate forecasts. However, evidence of how consumers' expectations compare to those of the experts' is not presented in their paper. Inflation expectations of households are more responsive to actual inflation than the experts'. Tuffley (2007) finds that expert views have some influence on consumer expectations based on New Zealand data. Gramlich (1983) compares the mean expectations of the economists from Calson (1977), which is based on the Livingston survey, and that of the households in the Michigan the survey. He finds that inflation expectations appear to be more biased and inefficient for economists than for households. He also observes that both economists' and households' views are strongly influenced by current inflation, past inflation and money supply growth rates. In addition, variables such as the budget deficit, a Republican president and wage control seem to affect households' expectations but not those of economists.

3.3 Market-based measures

Financial market-based measures usually refer to the spread between the yield on a conventional nominal bond and on an inflation-indexed bond of the same maturity. This spread is also known as the break-even inflation rate, as it is the inflation rate at which the expected real (i.e. inflation-adjusted) return on the two bonds is to be the same if both are held until maturity. Inflation-indexed bonds are bonds with a principal value and coupon payments that are linked to a price index. Inflation expectations determine the expected real value of a fixed stream of income, as well

as the price of a conventional bond. For example, higher than expected inflation would reduce the real income stream and thus lead to a lower conventional bond price. Financial market participants incorporate their expectations of inflation into the price they pay today for future nominal fixed-income securities. It is the real return that investors are ultimately concerned with. Therefore, break-even inflation rates provide useful information about financial market participants' average long-term inflation expectations.

However, break-even inflation rates may not be precise because of the incorporation of inflation risk and liquidity premia. The former places an upward bias on the break-even inflation rate as investors require a positive premium to compensate for inflation uncertainty. The latter introduces a downward bias as inflation-indexed bonds are usually less liquid than conventional nominal bonds. Moreover, break-even inflation is subject to institutional distortions such as taxes and changes in regulations that affect investors' tax liabilities.

4 Econometric analysis

In this section, I analyze the persistence of inflation expectations based on the Australian household inflationary expectations survey data by using a number of econometric techniques. Section 4.1 provides some background information about Australia's experience with adopting inflation targeting, followed by a description of the data in section 4.2. Section 4.3 performs econometric estimates and interprets the results.

4.1 Background

Unlike in certain other countries, the Australian targeting scheme was implemented only after inflation had been reduced. In 1993, the Reserve Bank of Australia (RBA) officially adopted an inflation target with the objective of keeping underlying inflation between 2 and 3 per cent, on average, over the course of the business cycle (Grenville

1997). Debelle and Stevens (2005) claim that the "2-3" objective is an acceptable long-run average rate of inflation and that "an average rate of inflation that has a '2' in front of the decimal place is regarded as a success". The average inflation rate in Australia was roughly 12 per cent in the 1970s, then fell to 8.4 per cent in the 1980s, and further reduced to just over 3 per cent in the first half of the 1990s. As Figure 1 shows, starting in 1990, the inflation rate began a downward trend that continued until 1993, and has mostly remained within its target range since 2002. In recent years, inflation has increasingly been observed to be stabilizing within the target range, although near the upper bound of the range. Annual real GDP growth in Figure 1 provides a cyclical context for the Australian economy. Australia was hard hit by the sharp economic downturn initiated by the "Black Monday" stock market crash in October 1987.

Figure 1: Inflation and real GDP in Australia
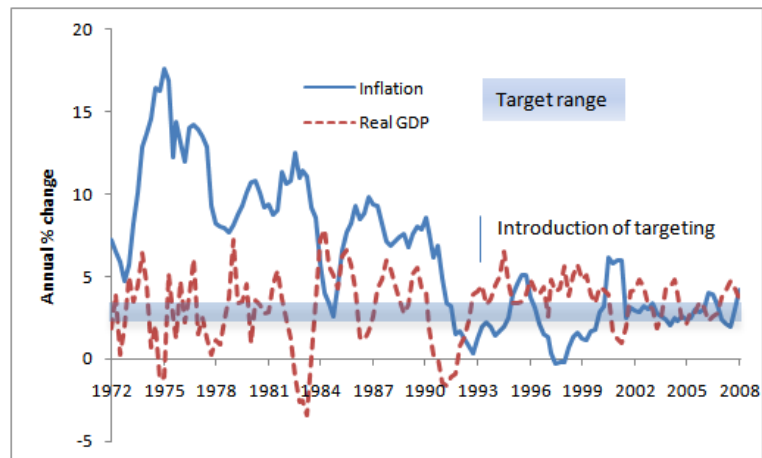
Source: Australian Bureau of Statistics

4.2 The data

This essay uses the median inflation expectation data from the Melbourne Institute of Applied Economic and Social Research Surveys of Consumer Inflationary Expectations. Median inflation expectation data was first recorded in September 1975; the

Table 1: Descriptive statistics

|	Expected inflation		Actual inflation		Forecast errors	
	Before	After	Before	After	Before	After
Mean	9.3	3.1	8.2	2.6	-1	-0.4
Std. Dev.	1.8	0.7	3.3	1.5	2.1	1.3
Minimum	4.7	1.6	0.3	-0.3	-5.7	-2.6
Maximum	13.9	4.6	14.4	6.1	3.9	3.1

Note:
1. "Before" refers to the period 1975Q4-1992Q4 (before targeting) and "after" refers to 1993Q1-2008Q1 (after targeting)
2. Forecast errors = actual inflation - median expected inflation

survey was conducted quarterly until June 1993 when it shifted to a monthly basis. It is a stratified random sample of just under 5,000 households, with about 1,200 responding to the survey. The survey is conducted in the first half of each month. It is designed to represent the average householder's expected rate of consumer price changes over the coming 12 months. Consumers are asked about whether and by how much they believe prices will go up or down, or whether prices will stay the same. The Melbourne Institute converts qualitative responses into quantitative ones, as 15-20 per cent of respondents decline to provide an actual figure. Survey responses are also adjusted for gender, age and location to correct possible sampling bias by weighting responses according to the census data.

There have been dramatic falls in the average levels, as well as volatility, of both expected and actual inflation after the introduction of targeting in 1993 (see Table 1). The right panel in Figure 2 compares forecast errors to the difference between households' expectations and the inflation target. The median expectation was very close to the target between 1993 and the first half of 1999. From the second half of 1999, inflation expectations seemed to be trending upwards, exceeding the target by an average of 0.8 per cent up until mid-2005, and an average of 1.4 per cent between mid-2005 and early 2008. Forecast errors, which measure how far away expectations are from the actual figures, were mainly negative over the sample period. This is

Figure 2: Inflation expectations and forecast errors
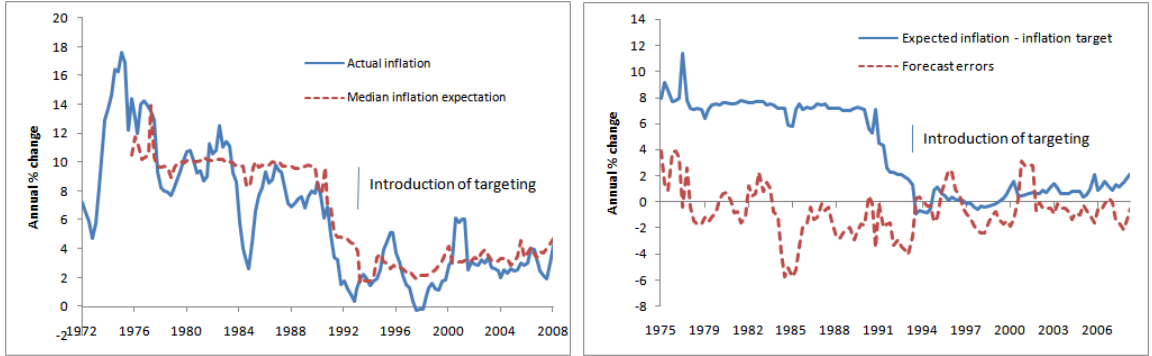
Source: Australian Bureau of Statistics, Melbourne Institute of Applied Economic and Social Research

especially true for the decade between 1983 and 1992 when households over-predicted inflation by almost 2 per cent on average. Panels in Figure 3 plot expected inflation against selected macroeconomic variables. The brief recession in Australia that lasted from September 1990 to September 1991 explains the dramatic falls at the beginning of the 1990s.[6]

4.3   Econometric estimation

To estimate the persistence parameter, I follow the approach set out in O'Reilly and Whelan (2005) and Levin and Piger (2003). Consider a univariate autoregressive process for an inflation series:

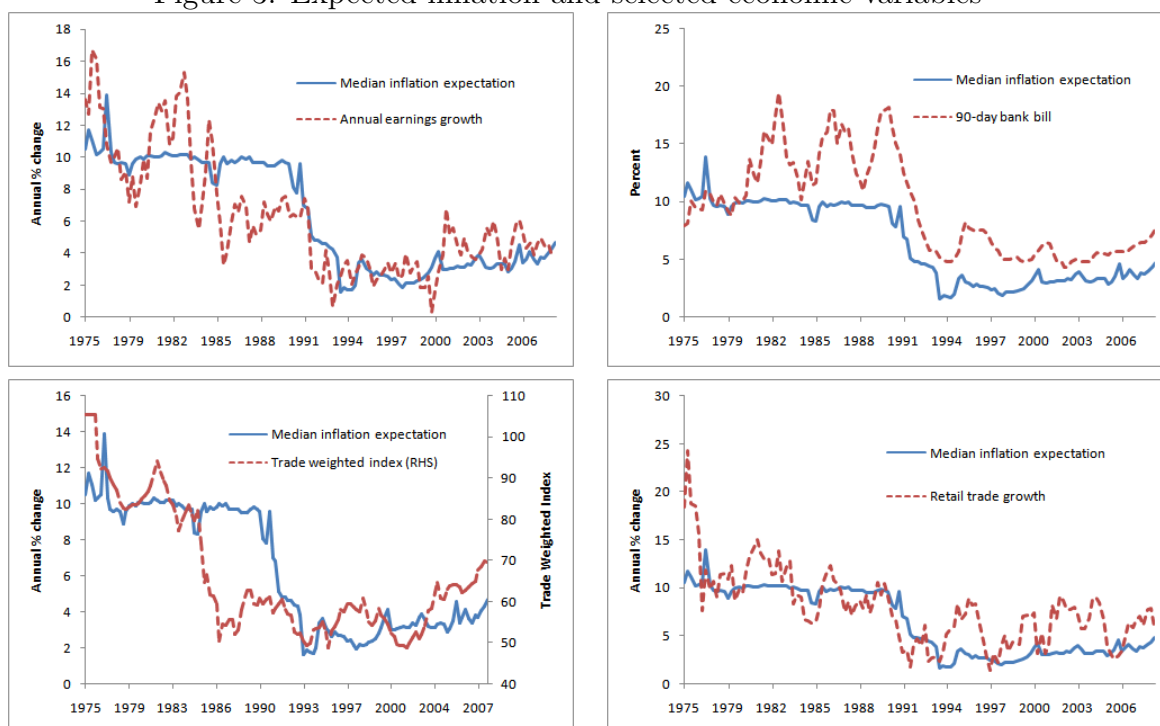$$\pi_t = \mu + \sum_{j=1}^{K} \alpha_j \pi_{t-j} + \epsilon_t \tag{1}$$

where ϵ_t is a serially uncorrelated but possibly heteroskedastic random error term. An equivalent expression of equation (1):

$$\pi_t = \mu + \rho \pi_{t-1} + \sum_{j=1}^{K-1} \varphi_j \Delta \pi_{t-j} + \epsilon_t \tag{2}$$

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[6]Rather surprisingly, Brischetto and de Brouwer (1999) find that macroeconomic variables such as the output gap, import price inflation, changes in the exchange rates and wage growth have no systematic effect on households' inflation expectations. Actual inflation and monetary policy (e.g. interest rates) are instead found to be the key direct macroeconomic influences behind the expectations.

Figure 3: Expected inflation and selected economic variables

The persistence parameter is $\rho \equiv \sum \alpha_j$ and the higher-order dynamic parameters φ_j are transformations of the AR coefficients in Equation (1). Equation (2) reflects the reduced-form Phillips curves. The AR lag order K can be chosen based on a given information criterion. This essay uses the Bayesian Information Criterion (BIC) as it is parsimonious with the number of lags to include. As it turns out, the optimal number of lags to include is 2 for both expected and actual inflation regressions.

I first estimate persistence for the full sample. Results are summarized in Table 2. In the period from the fourth quarter of 1975 to the first quarter of 2008, the persistence parameters for both expected and actual inflation are close to one before targeting. The persistence parameter for the actual inflation series is similar to that in Levin and Piger (2005) where it was estimated to be 1.02 in Australia from 1984 to 2003.[7]

To see how persistence of inflation expectations has changed after targeting, I

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[7]95th percentiles from the Hansen (1999) grid bootstrap procedure applied to the AR model.

Table 2: Full sample estimation

	π^e	π
Coefficient estimate of lag 1	0.778*	1.172*
Coefficient estimate of lag 2	0.195*	−0.224*
Persistence parameter	0.973	0.948
Adjusted R^2	0.956	0.935

consider the introduction of inflation targeting in 1993 as a shift towards a more aggressive anti-inflation approach and hence a breakpoint date in the inflation series. While the timing of a shift in the mean inflation is difficult to link directly to changes in monetary policy, Cecchetti and Debelle (2004) find some evidence of a simultaneous decline in the mean of price components that coincides with a change in the policy framework in some countries.

Table 3: Split sample estimation

|	π^e(before)	π^e(after)	π(before)	π(after)
Coefficient estimate of lag 1	0.712*	0.883*	1.208*	1.036*
Coefficient estimate of lag 2	0.265*	−0.145*	−0.261*	−0.239*
Persistence parameter	0.977	0.738	0.889	0.712
Adjusted R^2	0.795	0.569	0.889	0.712
Observations	67	61	67	61

* Significant at 5%

Note: π^e stands for expected inflation and π stands for actual inflation. "Before" refers to the period 1975Q4-1992Q4 (before targeting) and "after" refers to 1993Q1-2008Q1 (after targeting)

I calculate the persistence parameters before and after the introduction of targeting, for both the expected and actual inflation series. Table 3 reports the least-squares estimates. The coefficient estimates for both inflation expectation lags are significant at 5 per cent level before and after targeting. Expectations appear to have become less persistent, as the sum of the lag coefficients decreased from 0.977 before targeting to 0.738 after targeting. Given that the policy change is assumed to be *a priori* knowledge of the known breakpoint date, I apply the Chow test for differences in the estimated coefficients from the two subsamples (i.e. the sample is split into two at

the date of targeting adoption). The results turn out to be consistent with the null hypothesis that there is no structural break and the estimates are not statistically different (see test results in Table 4). Of course, the timing of a structural change in the inflation series does not have to coincide precisely with the formal adoption of the targeting scheme.

Figure 4: Autocorrelations of inflation
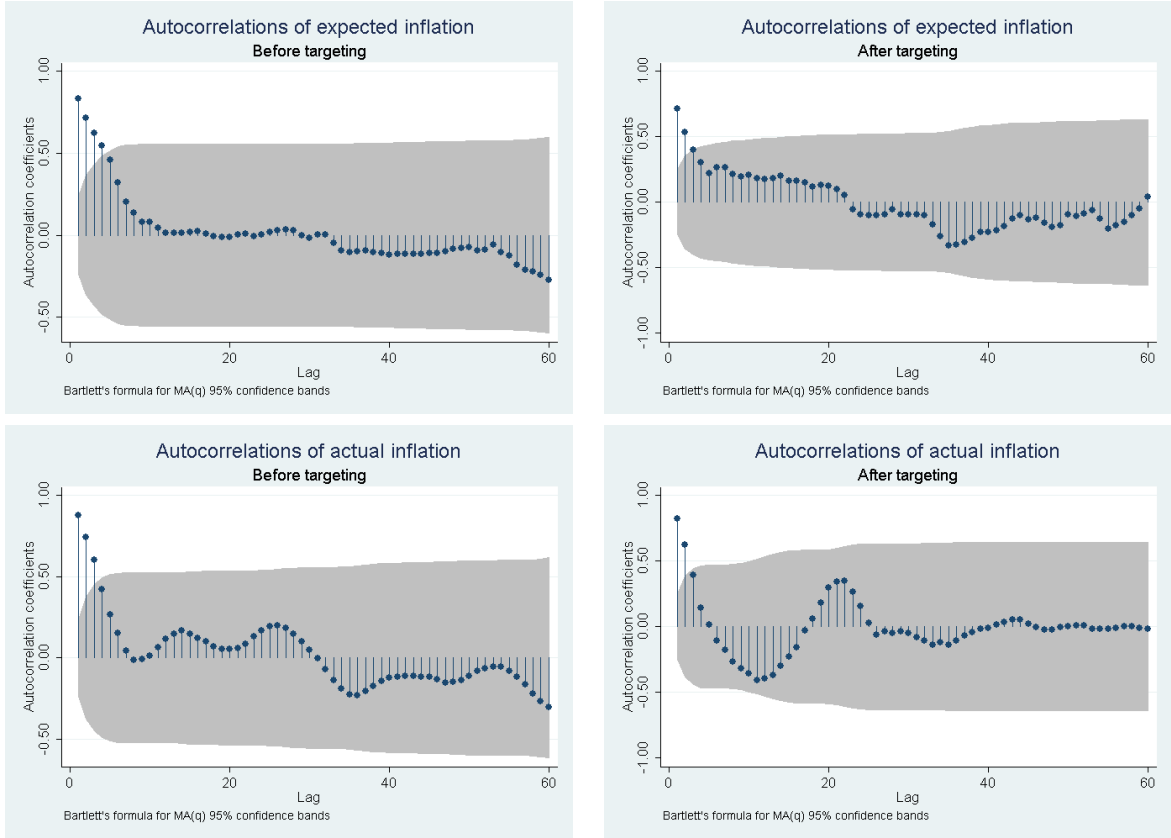
To test for breaks in the absence of *a priori* knowledge, I use the following methods. First, I run moving-window rolling regressions to generate sequences of coefficient estimates from each estimated period (with overlapping sub-samples). One question is how to determine the window size for the rolling regressions. Smaller sample sizes, for example a span of 8 years, offer the advantage of better flexibility in detecting structural breaks over time. However, they usually involve higher volatility in parameter estimates and wider confidence intervals. Larger sample sizes, for example

Figure 5: Rolling regressions for expected and actual inflation
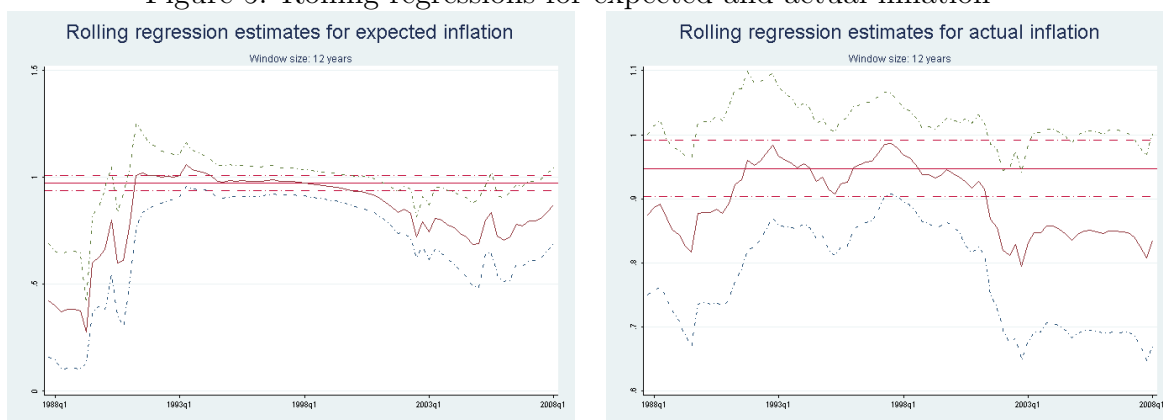
16 years, give more precise estimates but could be too long to capture changes in the behaviour of inflation expectations in response to changes in monetary policy regime over time. For this essay I opt for a window size of 12 years. Results of 8-year and 16-year rolling regressions are presented in the Appendix. Persistence of expected inflation starts to decline around 1998 but seems to rise steadily from 2006. The rise appears to be more gradual when the window size is extended to 16 years, and sharper when the data window size is shortened to 8 years. The jump in expected inflation persistence in the earlier stage of the sample period is apparent regardless of the data window size.

While the rolling regressions are able to show if persistence has changed, they are not very precise for indicating the exact timing of the change in the persistence. Therefore, I apply the sequential estimation methodology of Zivot-Andrews (1992), which tests the unit root as well as indicates the timing of the break. The main limitation of the Zivot-Andrews (1992) test is that it allows for only one break. I then apply the Clemente, Montanes and Reyes (1998) test which allow for up to two breaks in order to check for multiple breakpoints.[8] Finally I compare the two previous tests and use the Chow test to confirm the significance of the breaks.

Table 4 shows that, for the expected inflation series, there is stronger evidence for

[8]Cecchetti and Debelle (2004) suggest that normally one mean break is sufficient for inflation series.

Table 4: Tests for structural breaks

	π^e	π
Chow test with targeting adoption as a known breakpoint		
Chow test F-statistic (null: no break)	1.8	1.2
Critical F(k, n-2k)	2.7	2.7
Zivot-Andrews (1992) test		
Minimum t-statistic date	-6.451 at 1990Q4	-6.031 at 1991Q1
Critical values Zivot-Andrews (5%)	-4.8	-4.8
Chow test F-statistic (null: no break)	15.6	4.3
Critical $F(k, n-2k)$	2.7	2.7
Clemente, Montanes and Reyes (1998) test		
p-value at optimal breakpoint 1	0.000 at 1977Q2	0.000 at 1982Q4
Chow test F-statistic (null: no break)	-	-
Critical $F(k, n-2k)$	-	-
p-value at optimal breakpoint 2	0.000 at 1990Q2	0.000 at 1990Q3
Chow test F-statistic (null: no break)	8.6	4.0
Critical $F(k, n-2k)$	2.7	2.7
Conclusion	**Break at 1990Q4**	**Break at 1991Q1**

Notes:
1. Lag order selection in the Zivot-Andrews (1992) test is based on BIC and the maximum number of lags included is eight. The test allows for one break in the intercept.
2. Here the Clemente, Montanes and Reyes (1998) test uses an innovative outliers model which allows for a gradual shift in the mean. An additive model, which captures a sudden change in a series, is also tested and does not change the results significantly.

an intercept break in the fourth quarter of 1990 detected by the Zivot-Andrews (1992) than in the second quarter as indicated by the Clemente, Montanes and Reyes (1998) test. The rolling estimates suggest that expected inflation persistence increased from about 0.43 to over 0.7 around the break. The previously assumed shift in the intercept at the introduction of targeting turns out to be insignificant. For the actual inflation series, the break is detected in the first quarter of 1991. The timing of the breaks is within the economic slowdown period from September 1990 to September 1991 in Australia, after the 1987 stock market crash. This result is also consistent with the finding of Levin and Piger (2005), who provide evidence of an intercept break in the first quarter of 1991 in the Australian consumer price inflation series, based on the

Bayesian model.[9]

Figure 6: Rolling regressions for forecast errors
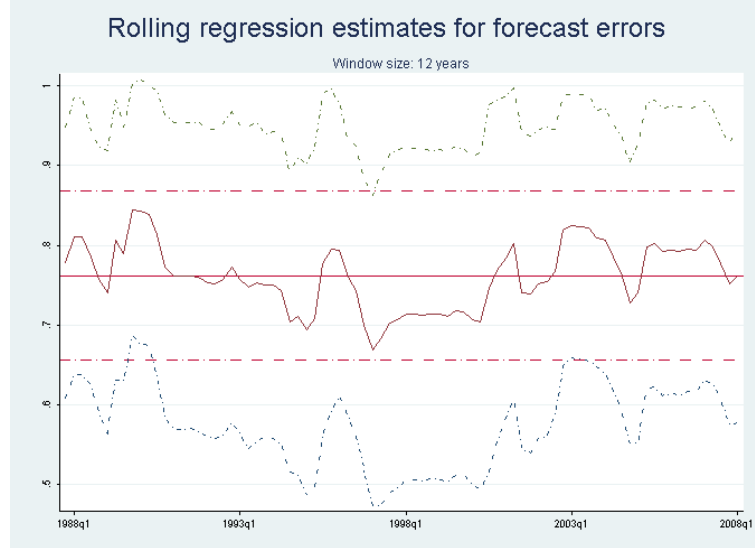
Another question follows, if households' inflationary expectations before targeting are as persistent after targeting, what does this mean for forecast errors? If households adjust their views about future inflation after observing the target, have the forecast errors become more or less persistent? And if there is a change in the persistence of the forecast errors, where is it? Again, I look for breaks in the rolling estimates for the forecast errors with a window size of 12 years. Persistence of forecast errors fluctuates around 0.77 but there is no indication of sudden tendency to increase or decrease over the sample period. When the window size is reduced to 8 years, there is a sharp decrease in the third quarter of 1992. However, it is insignificant at 5% level based on the Chow test statistic. This result implies that households' forecast errors have remained moderately persistent over the sample period and there is no evidence of significant revision in those errors.

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[9]Levin and Piger (2005) also employ the Quandt (1960) test statistic as an alternative to test for a break in the intercept at an unknown break date by selecting the maximum Chow test statistic obtained from checking all possible breakpoint candidates. They obtain the asymptotic p-value for the Quandt statistic from the "fixed-regressor" bootstrap procedure in Hansen (2000). The Quandt test results are consistent with the ones given by the Bayes factor.

4.4 Interpretation of the results

Putting all the results together, it appears that the introduction of targeting in Australia has substantially reduced the levels of both expected and actual inflation and maintained them at low levels. However, there is no evidence found on significant falls in households' inflation expectation persistence over the sample period, despite the clear change in the central bank's monetary policy regime. The timing of the structural break does not coincide with the adoption of the target. Instead, the break is found to be just before the introduction of the targeting scheme. One feasible explanation is that the Reserve Bank of Australia could have had an implicit target before the explicit target was announced. If the monetary policy was credible before the announcement, the public would not have changed their views when the explicit target was introduced since the effectiveness of the target would have already been incorporated into the public's expectations. The level of persistence in the expected inflation shot up markedly during the recession in Australia in 1990-91. It has remained high even through the latter half of the 1990s, when monetary policy was highly anti-inflationary. It is possible that the dramatic falls in inflation in the early 1990s were induced by a combination of events and policies, instead of monetary policy alone.

The results support the backward-looking model of expectations over rational expectations, given the general stability in the parameter estimates. This finding is consistent with O'Reilly and Whelan (2005) based on the Euro-area data. It also agrees with Estrella and Fuhrer's (2003) conclusion for the U.S. data; they state that backward-looking models tend to be more stable over time than models featuring rational expectations. Similarly, Lanne et al. (2008) find strong evidence that households form their expectations by adopting historical inflation rather than forward-looking news reports as suggested in Carroll (2003). Conversely, a cross-sectional study of the Australian data in Brischetto and de Brouwer (1999) concludes that households do not use all available information, such as past inflation and exchange

rate movements, when forming their expectations. Their expectations, however, do appear to be directly affected by monetary policy.

5 Conclusion

In this essay, I have examined the persistence of households' inflation expectations in the period 1975-2008 based on survey data in Australia. I follow the approach in O'Reilly and Whelan (2005) and Levin and Piger (2003) to estimate the persistence parameter, which is the sum of the autoregressive lag coefficients for inflation series. I find that the persistence of expected inflation in Australia has been high since the late 1980s, but has followed a gradual downward trend in the post-targeting period. There is no evidence, however, on statistically significant reductions in the persistence of inflation expectations after targeting was implemented. The persistence of households' forecast errors is also found to be relatively stable over time. While the monetary policy in Australia has maintained low inflation for the past 15 years, the question of whether the target has been fully credible (in terms of reducing persistence of inflation expectations) requires further testing.

To make the analysis in this essay richer, it would be helpful to obtain further data. For example, having the percentage of respondents who expect inflation to fall inside the Reserve Bank of Australia's target range would be useful as an alternative way to measure credibility.[10] Also, the Australian inflation-indexed bond yield data could be used as an additional way to estimate inflation expectations and could be compared with the survey data. To refine the econometric techniques used in this essay, it should be acknowledged that while the window sizes in rolling regressions conform to some of the research in the literature, they are still somewhat arbitrary. Rolling regressions do not entirely rule out the possibility that a shift occurred in a specific subsample, especially when shifts are frequent. An alternative way to test for

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[10]This data is available at the Melbourne Institute, but comes at a cost.

breaks with unknown breakpoints is the Quandt-Andews (1960) test.[11] To enrich the estimation process for the persistence parameter, it would be more desirable to compute the median-unbiased estimate using Hansen's (1999) grid-bootstrap procedure. When the persistence parameter is closer to unity, the standard asymptotic distributions for OLS coefficients and t-statistics based on finite samples in autoregressive models are poor approximations of their true finite-sample distributions. Hansen's (1999) biased-adjusted point estimates and confidence intervals correct for the finite-sample biases.

Along with Australia's adoption of inflation targeting, countries such as Canada, New Zealand and the U.K. are well known as pioneers in formally adopting explicit inflation targets. While data availability may impose potential difficulties on running econometric tests, there has been no work done thus far on measuring the persistence of expected inflation for these countries. This gap suggests a potential extension of this essay for future research.

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[11]This test is available in the software Eviews version 6.

References

Alesina, Alberto, and Lawrence Summers (1990) 'Central Bank Independence and Macroeconomic Performance: Some Comparative Evidence.' Discussion Paper 1496, Harvard Institute of Economic Research

Ammer, John, and Richard Freeman (1995) 'Inflation Targeting in the 1990s: The Experiences of New Zealand, Canada, and the United Kingdom.' *Journal of Economics and Business* 47(2), 165–192

Bai, Jushan, and Pierre Perron (1998) 'Estimating and Testing Linear Models with Multiple Structural Changes.' *Econometrica* 66(1), 47–78

—— (2003) 'Computation and Analysis of Multiple Structural Change Models.' *Journal of Applied Econometrics* 18(1), 1–22

Bank of Canada (1991) 'Targets for reducing inflation: Announcements and background material.' *Bank of Canada Review*

Benati, Luca, and George Kapetanios, eds (2002) *Structural Breaks in Inflation Dynamics* University of Washington

Brash, Donald (2002) 'Inflation Targeting: New Zealand's Experience Over 14 Years.' *The North American Journal of Economics and Finance* 13(2), 99–112

Brischetto, Andrea, and Gordon de Brouwer (1999) 'Householders' Inflation Expectations.' Research Discussion Paper 1999-03, Reserve Bank of Australia

Carlson, John (1977) 'A Study of Price Forecasts.' *Annals of Economic and Social Measurement* 6(1), 27–56

Carroll, Christopher (2003) 'Macroeconomic expectations of households and professional forecasters.' *Quarterly Journal of Economics* 118(1), 269–298

Cecchetti, Stephen, and Guy Debelle (2006) 'Has the Inflation Process Changed.' *Economic Policy* 21(46), 311–352

Debelle, Guy, and Glenn Stevens (1995) 'Monetary Policy Goals for Inflation in Australia.' Research Discussion Paper 9503, Reserve Bank of Australia

Debelle, Guy, and Jenny Wilkinson (2002) 'Inflation targeting and the inflation process: Some lessons from an open economy.' Research Discussion Paper 2002-01, Reserve Bank of Australia

Dodge, David (2002) 'Inflation Targeting in Canada: Experience and Lessons.' *The North American Journal of Economics and Finance* 13(2), 113–124

Dopke, Jorg, Dovern Jonas Fritsche Ulrich, and Jirka Slacalek (2005) 'European Inflation Expectations Dynamics.' Discussion Paper Series 37, Bundesbank

Estrella, Arturo, and Jeffery Fuhrer (2003) 'Monetary Policy Shifts and the Stability of Monetary Policy Models.' *Review of Economics and Statistics* 85(1), 94–104

Gramlich, Edward (1983) 'Models of Inflation Expectations Formation: A Comparison of Households and Economist Forecasts.' *Journal of Money, Credit and Banking* 15(2), 155–173

Gurkaynak, Refet, Levin Andrew, and Eric Swanson (2006) 'Does Inflation Targeting Anchor Long-Run Inflation Expectations? Evidence from Long-Term Bond Yields in the U.S., U.K. and Sweden.' Discussion Paper 5808, Centre for Economic Policy Research

Hondroyiannis, George, and Sophia Lazaretou (2004) 'Inflation Persistence During Periods of Structural Change: an Assessment Using Greek Data.' Working Paper 370, European Central Bank

Kim, Chang-Jin, Nelson Charles, and Jeremy Piger (2004) 'The Less Volatile U.S. Economy: a Bayesian Investigation of Timing, Breadth, and Potential Explanations.' *Journal of Business and Economics Statistics* 22(1), 80–93

King, Mervyn (1995) 'Credibility and Monetary Policy: Theory and Evidence.' *Scottish Journal of Political Economy* 42(1), 1–19

Kozicki, Sharon, and Peter Tinsley (2002) 'Alternative Sources of the Lag Dynamics of Inflation.' Working Paper 02-12, Federal Reserve Bank of Kansas City

Kuttner, Kenneth, and Adam Posen (1999) 'Does Talk Matter After All? Inflation Targeting and Central Bank Behavior.' Staff Report 88, Federal Reserve Bank of New York

Lanne, Markku, Luoma Arto, and Jani Luoto (2008) 'A Naive Sticky Information Model of Households' Inflation Expectations.' Unpublished

Levin, Andrew, and Jeremy Piger (2002) 'Is Inflation Persistence Intrinsic in Industrial Economics.' Working Paper 2002-023, Federal Reserve Bank of Saint Louis

Mishkin, Frederic (2007) 'Inflation Dynamics.' Working Paper 13147, National Bureau of Economic Research

O'Reilly, Gerard, and Karl Whelan (2005) 'Has Euro-area Inflation Persistence Changed Over Time.' *Review of Economics and Statistics* 87(4), 709–720

Perron, Pierre (1989) 'The Great Crash, the Oil-price Shock, and the Unit-root Hypothesis.' *Econometrica* 57(6), 1361–1401

Pivetta, Frederic, and Ricardo Reis (2007) 'The Persistence of Inflation in the United States.' *Journal of Economic Dynamics and Control* 31(4), 1326–1358

Ranchhod, Satish (2003) 'The relationship between inflation expectations survey data and inflation.' *Reserve Bank of New Zealand Bulletin*

Reddell, Michael, and Ben Watt (1997) 'Some perspectives on inflation-indexed bonds.' *Reserve Bank of New Zealand Bulletin* 60(4), 322–331

Scholtes, Cedric (2002) 'On Market-Based Measures of Inflation Expectations.' Quarterly Bulletin, Bank of England

Stock, James, and Mark Watson (2003) *Has the business cycle changed and why?* (MIT Press, Cambridge)

＿＿ (2007) 'Why has u.s. inflation become harder to forecast?' *Journal of Money, Credit, and Banking* 39(1), 3–34

Taylor, John (1982) 'Establishing credibility: A rational expectations viewpoint.' *American Economic Review* 72(2), 81–85

Tuffley, Nick (2007) 'New zealand inflation expectations: Their drivers and significance.' Occasional Paper, Westpac Institutional Bank

6 Appendix

Figure 7: Rolling regression estimates: window sizes 8 and 16 years