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25 Years of Inflation Targeting in Australia: Are There Better Alternatives for the next 25 Years?

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Keywords

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JEL Classification

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25 Years of Inflation Targeting in Australia: Are There Better Alternatives for the next 25 Years[1]?

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26 April 2018

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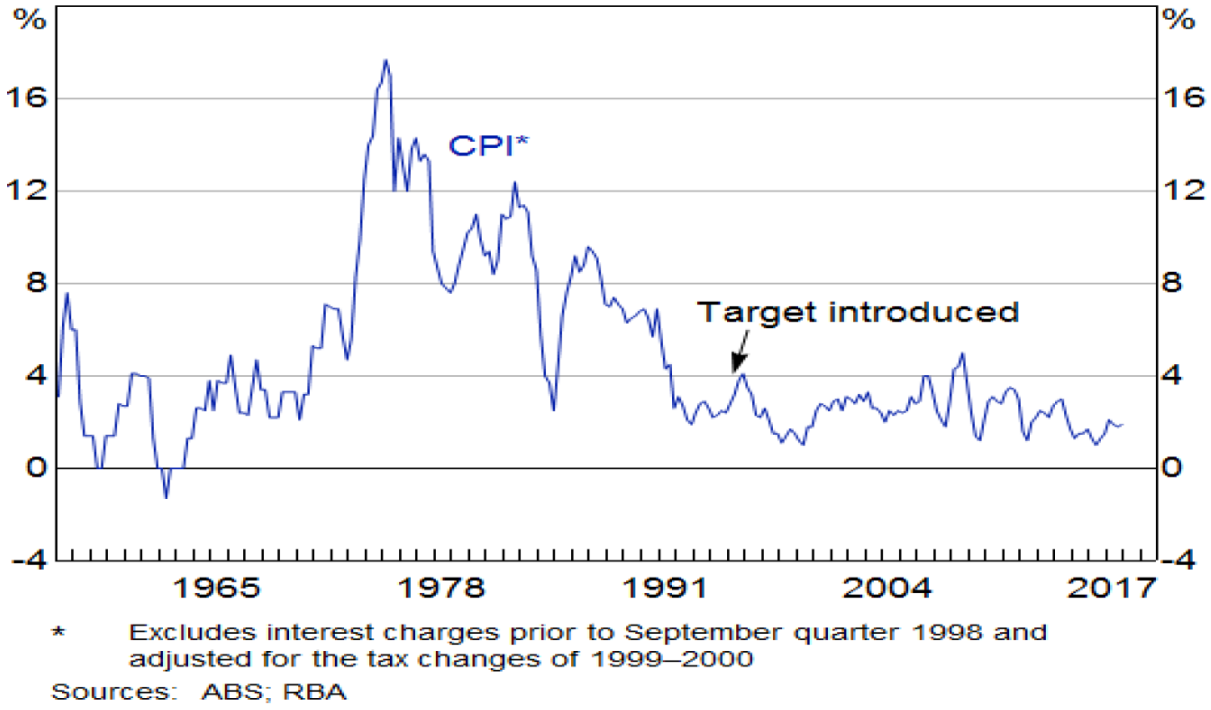
1. Introduction

The core mandates of the Reserve Bank of Australia (RBA hereafter) are promoting price stability, employment, economic prosperity and the welfare of the Australian people. However, the way in which monetary policy has been conducted, in order to achieve these goals, has undergone evolutionary changes over the past 35 years. Most notable was the switching from money targeting that prevailed throughout the 1980s, to a "checklist" approach and finally to inflation targeting beginning around 1993. Under the inflation targeting framework, the RBA's price stability objective is defined as achieving a *medium-term average inflation rate* of 2 to 3 percent over the cycle – which allows some policy space for short-run considerations of output and employment fluctuations. While the introduction of inflation targeting has witnessed a substantial containment in inflationary pressure, with year-ended inflation averaging under 3 percent since 1993[4] (Figure 1), the theoretical debate about the desirability of inflation targeting as an optimal monetary policy regime remains active. The debate has been less focused on whether inflation targeting has tamed inflation, but more focused on whether its side effects (e.g. sacrificing output stability for price stability, weak anchoring of expectations, etc.) are more pronounced compared to outcomes under alternative monetary policy regimes.

Figure 1. Evolution of CPI Inflation (1965-2017)



[4] Inflation targeting in Australia began around 1993

In discussing the possible future role for inflation targeting in Australia, this paper begins with a summary of the alternative monetary frameworks that have been proposed in the economics literature over many decades. Section 3 addresses the major issues that are important for the relevance of each monetary framework with a particular focus on the Australian context. Section 4 explores the nature of historical shocks experienced during the inflation targeting period in Australia and then conjectures the likely nature of future shocks in the domestic and global economies over the coming decades. A summary and policy implications are outlined in section 5.

2. Alternative Monetary Frameworks

Stanley Fischer (1995) observed that the search for an optimal monetary policy framework is an unending one. This is reflected in the RBA's monetary policy framework undergoing evolutionary changes over the years. From the failure of money targeting in the 1980s to the introduction of inflation targeting in the early 1990s, changes to the conduct of monetary policy have been mostly dictated by the prevailing macroeconomic fundamentals. In this section, we place the current inflation targeting regime in the broader context of alternative monetary regimes in the literature. The goal is to provide a summary analysis on how changing macroeconomic fundamentals can require rethinking the monetary policy framework over time.

2.1 Inflation targeting

In its strictest form, an inflation targeting regime is concerned with achieving and maintaining *low* and *stable inflation*, with a base drift, without consideration for controlling deviations in the output level. That is, all shocks that affect price stability— whether temporarily or permanently—are accommodated by changes to the policy rates as summarized by equation (1).

$$i_t = i_{t-1} + \alpha\,(\pi_{t,t+n} - \bar{\pi}\ ) \qquad (1)$$

where the nominal interest rate i set in period t is a function of the rate from $t-1$ and α measures how the central bank responds to shocks that cause forecast inflation ($\pi_{t,t+n}$) to deviate from the inflation target ($\bar{\pi}$).

However, in practice, as per the mandate of most central banks, some considerations are given to output stabilization in the conduct of monetary policy, under what is termed *flexible inflation targeting*. Under such a regime, the central bank has an objective function given in (2)

$$L_t = \frac{1}{2}[(\pi_t - \bar{\pi})^2 + \lambda y_t^2] \qquad (2)$$

where π_t is inflation in period *t*, $\bar{\pi}$ is the central bank's inflation target and $\lambda \geq 0$ is the weight on the output gap (y_t) stabilization. That is, instead of responding to all shocks that affect inflation, a flexible inflation targeting central bank distinguishes between temporary and permanent shocks in balancing the price stabilization objective with the output stabilization goal (Fischer, 1996; King, 1997; Bernanke 2015).

Equations (1) and (2) imply that the accuracy of the forecasts of inflation and potential output are critical in achieving optimal monetary policy outcomes—in the form of strongly anchored expectations and policy credibility. Indeed, most central bank models of inflation forecasting include an estimate of the output gap as a critical element in the forecast of future inflation. However, there is strong evidence that central banks' forecasts, particularly in measuring the output gap, are subject to large errors. The less well central banks can forecast the output gap, the more policy credibility is undermined (Orphanides, 2001; Beckworth and Hendrickson, 2016). A variant of the flexible inflation target regime is the set of rules proposed by Henderson and McKibbin (1993) and applied to the U.S. Fed policy behavior by Taylor (1993). As indicated by equation (3), the monetary policy reaction function under a Henderson-McKibbin-Taylor (HMT) type rule is expressed as:

$$i_t = i_{t-1} + \alpha\,(\pi_t - \bar{\pi}\ \ ) + \beta\,(Y_t - \bar{Y}_t) \qquad (3)$$

where α and β represent the respective weights on price or inflation stability and output stability[5]. Under the assumption of sticky nominal wages, these parameters can be derived, as the case in Taylor (1993) for the U.S. Fed covering the period 1984-1992. In addition to price and output stability, other macroeconomic indicators such as exchange rates can be included in the HMT-type rules using a general equilibrium modelling framework. An example is the approach in the G-Cubed model (McKibbin and Wilcoxen, 2013).

[5] The output term can also be written in terms of output growth relative to target. This alternative is the specification used in the G-Cubed model because average trend output growth is easier to measure than the level of potential output at each point in the future. McKibbin and Wilcoxen (2013)

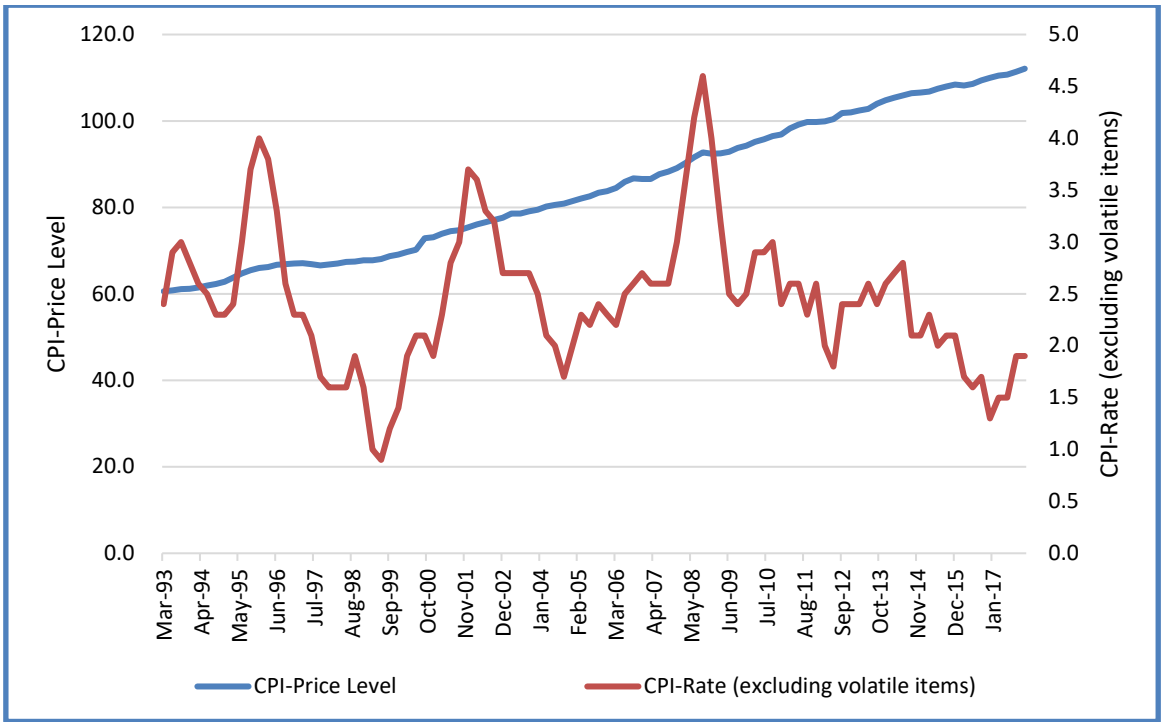
2.2 Price level targeting

The foremost objective of monetary policy, achieving and maintaining price stability, is usually interpreted as maintaining low and stable rate of inflation (Svensson, 1999). For the RBA, "*low and stable*" is defined as maintaining an average CPI inflation rate of 2 to 3 percent over the cycle. But it could also mean maintaining a *stable price level*, instead of its rate of increase—the inflation rate.

Under price level targeting, the goal of monetary policy is to maintain stability in the *price level*, with the price level maintained along a desired path by compensating lower past inflation with higher current inflation and vice versa. That is, under price level targeting, bygones are *not* bygones, making it an effective regime in anchoring expectations. However, the effectiveness of a price level target as a monetary policy anchor is crucially dependent upon whether economic agents are rational—that is, they fully understand the history dependent nature of central bank's policy response (Amano et al., 2011). However, recent findings by Woodford (2013) and Honkapohja and Mitra (2018) show that under the assumption that agents are not fully rational or have imperfect knowledge about the history-dependent nature of policy, price level targeting is still superior to inflation targeting.

As illustrated in Figure 2, while the RBA has maintained the average CPI inflation rate within policy range since 1993, the price level has been rising. However, by aiming for above-average inflation when the price level is below its desired target and vice versa, both the price level and inflation can be adequately anchored (Gasper et al. 2007).

Figure 2. Quarterly CPI and CPI Inflation 1993Q1-2017Q4



Data Source: RBA

By letting bygones be bygones—as is the case under inflation targeting—the price level becomes non-trend stationary with a base drift, potentially increasing the variance of output indefinitely. As Svensson (1999) has shown, assuming agents are rational, and the central bank has perfect control over inflation, then the monetary policy loss function under price level targeting can be written as

$$L_t = \frac{1}{2}[(P_t - P_t^*)^2 + \lambda(y_t - y_t^*)^2] \qquad (4)$$

where P_t and P_t^* are the price level and socially optimal price level respectively, while y_t and y_t^* are output and potential output and $\lambda \geq 0$ is the weight placed on output stabilization. Contrary to the argument that a price level targeting regime creates high output variability by not letting *some* (temporary) bygones be bygones, the strong anchoring of expectations and promotion of policy credibility cannot be overemphasized. Similar to arguments by Evans (2012) and Williams (2017), Bernanke (2017) points out that with the strong anchoring of expectations that can be achieved under price level targeting, monetary policy can be effective under a *binding* zero lower bound (ZLB) on interest rates by introducing a *temporary* price level target.

According to the temporary price-level target argument, instead of creating policy space by increasing the inflation target—which is inefficient (Eggertsson and Woodford, 2003)—or making a complete regime change to price level targeting—which could create high policy uncertainty—the optimal approach is the introduction of a *temporary* price level target evoked during periods of binding ZLB and communicated with clear Odyssean-type forward guidance.

2.3 Nominal income targeting

Nominal income targeting has long been advanced in the literature as a suitable policy rule[6]. Indeed, before the wide spread adoption of inflation targeting by central banks in the 1990s, various forms of nominal income targeting were seen to be a better alternative than inflation targeting under a range of assumptions. Unlike flexible inflation targeting (or price level targeting), that addresses the symptoms (price stability) of output volatility, the objective of monetary policy under nominal income targeting is the stabilization of some measure of total nominal income. A policy rule targeting a specific *level* of nominal income can be expressed as:

$$i_t = i_{t-1} + \alpha \left(PY_{t,t+n} - \overline{PY}_{t+n} \right) \qquad (5)$$

with PY_t representing nominal income level in period and $\overline{PY}_t$ the targeted level. McCallum (2015) argues that in order to overcome the time-inconsistency problem, nominal income targeting should be based on the growth rate of nominal income (g_t) instead of its level as expressed in equation (6):

$$i_t = i_{t-1} + \alpha \left(g_{t,t+n} - \bar{g}_{t+n} \right) \qquad (6)$$

Apart from the fact that there need not be a *divine coincidence* to simultaneously achieve price and output stability (Blanchard and Gali, 2007) under nominal income targeting, a central bank following the nominal income targeting regime does not need to have real-time knowledge of potential output—a source of serious policy errors under inflation targeting. A nominal income target can be achieved with a range of outcomes for inflation and real output. For example, inflation could be above that desired by equation (1) and real output growth below that desired in equation (1) but the nominal income target could still be achieved ex post.

[6] See Henderson & McKibbin (1993), Sumner (2014), Woodford (2012), Beckworth & Hendrickson (2016)

A second advantage of nominal income targeting is that productivity shocks that create divergent paths for price and output need not be accommodated by sacrificing output stability for price stability (Rogoff, 1985; Henderson and McKibbin, 1993). Third, in the event of extreme crisis when real interest rates may need to fall sharply to stabilize falling output, a nominal income target automatically allows expected inflation to rise well above the long run inflation goal. The sharper the fall in expected output, the larger the capacity for the central bank to drive higher expected inflation without abandoning the nominal income target. With falling real output, the inflation upper bound is automatically relaxed. In a very transparent way, the extent to which inflation can rise is restricted to a band that is determined by the amount real GDP changes for a given shock. Thus, there is still a credible band for expected inflation but the upper and lower inflation rates vary with the extent of economic shocks. This can be interpreted as a transparent rule that implements the idea of "inflation targeting over the cycle". This can be contrasted with a central bank following an inflation target. With a hard upper bound of 3%, a well anchored expected inflation rate is unlikely to rise above 3% unless a central bank announced a special circumstance. In the case of extreme negative supply shocks nominal income targeting enables the real interest rate to fall more quickly (if expected inflation can rise) and further than under a flexible inflation target.

A further consideration is that in a time of large private and public debts, a key part of financial stability is to ensure nominal GDP grows at a reasonable rate. Sustainable growth of nominal GDP is more important than low inflation in a highly leveraged world.

There are a number of additional considerations regarding the form of nominal income rules. Apart from level versus growth rate issues, a key question is whether a nominal gross domestic product (GDP) rather than a nominal gross national product (GNP) rule is more appropriate. In a closed economy the two would be the same. However, in an open economy, GDP is a measure of production location whereas GNP is a measure of what income is generated. In countries with large swings in terms of trade, GNP varies far more than GDP over time.

2.4 Financial stability

In addition to the conventional goals of promoting price stability and output stability as required by the mandates of most central banks, there has been an active debate on whether central banks should also worry about financial stability. An early contribution to this debate was Borio and Lowe (2002). The global financial crisis accentuated the debate and by 2010 it was a key issue in the debate about the role of monetary policy in Australia[7]. Evidence in the literature remains mixed on which policy rule can optimally incorporate financial stability as an objective of monetary policy, with Woodford (2012) arguing for a Taylor-type rule and Sheedy (2014) recommending a nominal income rule.

Using the weighted sum of asset prices and household debt in relation to an equilibrium level as proxy for financial stability risks (see Disyatat, 2010; Woodford, 2012), an additional mandate[8] incorporating financial stability can be described by a loss function of the form:

$$L_t = \frac{1}{2}\mathrm{E}_0 \sum_{t}^{\infty} \beta^t \left[\pi_t^2 + \lambda_y y_t^2 + \lambda_\Omega \Omega_t^2\right] \qquad (7)$$

where $\lambda_y \geq 0$ and $\lambda_\Omega \geq 0$ are the weights on output stability and financial stability, Ω_t is a measure of financial risks and $0 < \beta < 1$ is a discount factor. In this ternary framework, flexible inflation targeting is still the standard rule with an invariant long-run price level, but addressing financial stability risks are included as a mandate of monetary policy, not to be only tackled through regulatory policies.

2.5 Other monetary regimes

In addition to the above policy rules, there are a number of alternative proposals for monetary regimes. A fixed exchange rate regime is popular in countries with central banks that don't have sufficient credibility to follow independent monetary policies. The fixed exchange rate regime effectively imposes on the domestic central bank, the monetary regime of the country to which the exchange rate is pegged. Other variations include pegging the commodity price index or other definitions of the inflation or price level targets.

[7] This was a major focus in the paper by Cagliarini, Kent and Stevens (2010) on fifty years of inflation targeting.
[8] In the monetary literature this is referred to as a "ternary" mandate.

These have been comprehensively evaluated by Frankel (2011) in focussing on specific problems in emerging countries and countries subject to large variations in their terms of trade due to commodity price fluctuations.

In the Australian context, with the apparent success of inflation targeting over the past 25 years, the debate in 2018 is between the narratives on the continuation of flexible inflation targeting or switching to a more clearly identified nominal income target. The key issues to be carefully considered in making such a switch are analyzed in the next section.

3. Key Issues in the choice of the monetary regime

On the debate regarding the appropriate monetary regime for Australia, there are a number of critical issues that need to be considered. Included are several critical questions such as:

- How well does each regime handle shocks?
- Can the target of monetary policy be credibly measured and clearly understood?
- How transparent is the regime when exceptions to the basic policy rule are required";
- Are price expectations anchored by the monetary regime?

Each of these issues are considered in turn below.

3.1 How does the monetary regime handle shocks?

One of the more important issues in the choice of a monetary regime is how well each regime handles different types of shocks. This question goes back to the work of Poole (1970) on money demand versus goods demand shocks and supply shocks and extended by Henderson and Mckibbin (1993) to consider, money demand shocks, aggregate demand shocks, supply shocks, and changes in country risk.

The standard result in the theoretical literature and the large modelling literature (summarized in Bryant et al (1993)) is that inflation targeting and nominal income targeting handle money demand shocks well because both would neutralize the monetary shocks before they emanate from the money market. Both regimes handle demand shocks equally well since a rise in demand implies a rise in inflation as well as a rise in nominal income. Under both regimes, a rise in the interest rate would automatically dampen the effects of demand shocks on output and inflation.

The exact extent of policy change and therefore the trade-off between output and inflation would be different under each regime and which regime performs best depend on the parameters of the particular model. Thus in practice, the relative performance is an empirical question. Because of the constantly changing nature of money velocity, a fixed money rule does not handle demand shocks well, causing many countries to abandon monetary targeting during the 1970s.

The type of shocks which are not handled well by strict inflation targeting are aggregate supply shocks, such as a surprise fall in productivity or the occurrence of an earthquake. In the face of a negative supply shock, an inflation targeting central bank would see prices rising and output falling. In response to rising prices, monetary policy would be tightened and therefore the output fall would be accentuated. A flexible inflation targeting central bank, if it knew the nature of the supply shock, could argue that policy did not need to be tightened and therefore the response would be tempered. A nominal income targeting central bank would see price rising and output falling and nominal income approximately unchanged (the outcome would depend on output and price elasticities).

To the extent that some supply shocks are unobserved, there is an advantage of nominal income targeting over inflation targeting, and even over flexible inflation targeting in the form of weakened policy credibility. While a flexible inflation targeting central bank may have to signal special circumstances under which certain supply shocks would not be accommodated (if they are considered temporary), a nominal income targeting central bank on the other hand does not have to make such distinction. To the extent that the distinction between shocks that can be accommodated and those that cannot be accommodated is not correctly done due to the lack of real-time knowledge by the central bank, a nominal income target can be argued to promote stronger policy credibility than a flexible inflation target.

3.2 Can the target be credibly measured and clearly understood?

Whatever target a central bank adopts as the anchor for monetary policy, effective communication is crucial for the formation of expectations by private agents. Crucial to such communication are two key issues. First, can the selected target be *credibly* measured by the central bank? Second, is the target *clearly* understood by economic agents?

3.2.1 Measurement

For all monetary policy rules, the question of how credibly the central bank can measure the target is a key concern, particularly for indicators whose measurement in real time cannot be done with precision. There is strong empirical evidence that there is unlikely to be a *divine coincidence*[9] in the conduct of monetary policy, especially when there are real wage rigidities (Blanchard and Gali, 2007) or supply shocks (Kim, 2016).

That is, when there are divergent paths for price and output, central banks that aim to achieve both price and output stability—via *flexible* inflation targeting or price level targeting—are faced with a strong trade off. A key input into such flexible monetary policy reaction or loss functions is an estimate of the output gap. However, as the economy's potential output is not observed in real time, the use of preliminary estimates of the output gap is the norm. Apart from the lack of uniformity in measurement and large *ex post* revisions of preliminary estimates, the unreliability of output gap data for policy purposes is largely underpinned by the constant changes in the end-point in trend output as the true nature of the economy changes with hindsight (Orphanides and Norden, 2002). The lack of a reliable output gap measure is the "Achilles Heel" of inflation targeting as currently practiced.

As no publicly available historical output gap series is available for Australia, most empirical analyzes on the issue follow an econometric approach (see Gruen and Stone, 2002). For nominal income targeting on the other hand, such real-time knowledge burden from output gap measurement is not placed on the central bank. That is, for a monetary policy regime based on nominal income target (as opposed to inflation or price level target), the real-time knowledge problem on the central bank is for forecasting nominal income, instead of the output gap.

[9] achievement and maintenance of price stability does not guarantee output stability, with a strong trade-off in achieving both objectives

3.2.2 Understanding

Monetary policy is considered credible if the expectations of economic agents are firmly anchored. But such anchoring of expectations depends on how clearly and easily the policy or target can be understood. A nominal income target outperforms other policy rules on this count. First, unlike a flexible inflation target for which both price stability and output stability goals are communicated, only a nominal growth target is communicated for a nominal income targeting regime (McCallum 2011; Sumner, 2011)[10]. Second, with volatile items, particularly oil and food prices, excluded in measuring *underlying inflation*—the measure of inflation accommodated by most inflation-targeting central banks, including the RBA, persistent disconnect between headline and underlying inflation may weaken policy credibility, particularly in an environment characterized by persistent supply shocks that drive a wedge between underlying and headline inflation. Such distinction between underlying and headline inflation that affects policy credibility needs not be made under nominal income targeting.

Another issue relating to measurement is the extent of revision of data over time. Compared with inflation statistics, nominal GDP statistics are published with long time lags and subject to revisions over time. However, as there is evidence that errors from nominal income growth forecast are stationary, the impact of growth data revisions on target credibility may not a major concern compared with errors in measuring the output gap. However, it may be feasible, by using big data, to generate daily information on a large part of nominal expenditure. Whether good proxies for nominal income growth in real time may be developed is an area where future research could focus.

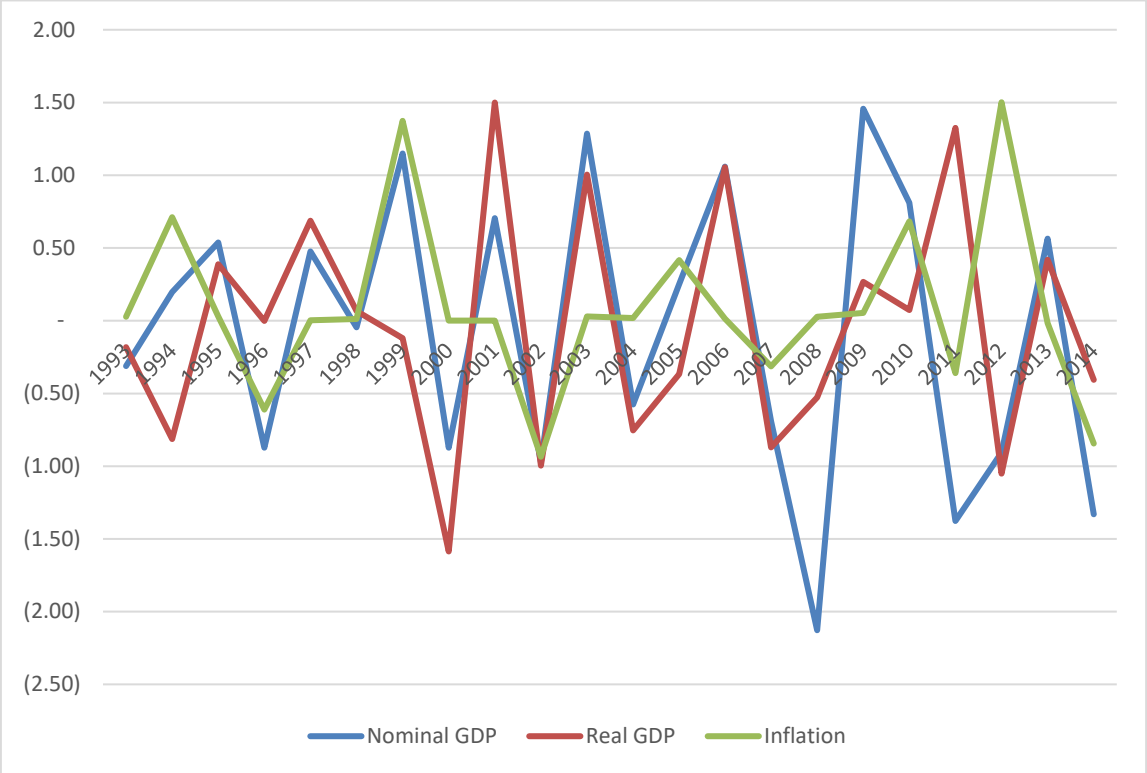
3.3 How forecastable are the Different Targets

Figure 3 shows the forecast errors made by the OECD in forecasting annual nominal GDP growth, real GDP growth and CPI inflation for Australia from 1993 until 2014. The forecast errors are also stationary when tested for a unit root. They also appear to be of a similar magnitude. The results are similar for errors made by the Australian Treasury in forecasting nominal GDP and inflation over the decade 2007-2017 (Table 1). For the period 2007-2012, the errors made in the May forecasts for 1-year nominal GDP and inflation are of similar

[10] Nothing prevents the central bank from announcing the underlying inflation and real growth goals – indeed this would enhance understanding the of the policy.

magnitude as measured by the root mean square error (RMSE). For the succeeding period (2012-2017), the RMSE for the May 1-year ahead nominal GDP forecast is almost twice that of inflation for the same period, although the December 1-year forecast for nominal GDP performance is better than the inflation forecast performance. However, over the entire 10-year period, there appears to be little difference between the Treasury's forecast performance for both CPI inflation and nominal GDP.

Figure 3: OECD's Forecast Errors for Nominal GDP Growth, Real GDP growth and CPI inflation



Source: OECD and authors' calculations

Table 1. Root-Mean Square Errors of Australian Treasury's forecasts of Nominal GDP and CPI Inflation (2007-2017)

	Nominal GDP		CPI Inflation	
Period	May Forecast for next FY	December forecast for next FY	May Forecast for next FY	December forecast for next FY
2007-08—2011-12	1.38	0.89	1.18	1.10
2012-13—2016-17	1.52	0.74	0.87	0.70
2007—2017	1.45	0.82	1.04	0.92

Note: The root mean squared error (RMSE) is calculated by squaring the forecast errors, averaging them over the indicated periods and taking the square root of the result. Forecast error at each horizon is computed as actual (outturn) less forecast.
Source: Australian Treasury and authors' calculations

3.4 Are Inflation Expectations Firmly Anchored in Australia?

It is often argued that a focus on inflation by central banks, is the best way to anchor inflation expectation. It is worth exploring if this is correct. The key measure of how credibly a central bank has performed under inflation targeting is to test for any decoupling between the inflation expectations of private agents and the central bank's inflation target or forecast (king, 2005). The best explanation of this concept is the statement by Blinder (2000) that "a central bank is credible if people believe that it will do what it says". Under a credible flexible inflation targeting regime, short-term deviations from target are allowed without fear of weakening policy credibility, provided economic agents are confident that the target will be achieved over the cycle.

That is, while the goal is the firm anchoring of long-term inflation expectations, short and medium-term expectations can be anchored through forward guidance—more likely so if the forward guidance is *"Odyssean"*, rather than *"Delphic"*, in nature[11]. However, as wage and price-setting behaviours are more contingent on short and medium-term expectations than longer-term ones, persistent flexibility in postponing target achievement may drive de-anchoring of inflation expectations.

[11] See Bernanke (2017).

We explore several aspects of the anchoring of inflation expectations in Australia. We follow the work by Demertzis et al (2008) on the U.S. economy and Łyziak and Paloviita (2016) on the inflation expectations in the Eurozone, First, we test how long-term expectations are influenced by actual inflation. Second, we examine the dependence of long-term expectations on short-term expectations. We base this inflation expectations on a mix of financial market data and different surveys of expectations. An alternative approach using survey data is proposed by Carvalho et al (2017) using data for a range of countries but not including Australia. Further work could use this approach to test the conclusion from our analysis.

An inflation targeting central bank minimizes the following loss function (8) subject to the Lucas supply function (9)

$$L_t = \frac{1}{2}\mathbb{E}[(\pi_t - \bar{\pi})^2 + \lambda y_t^2] \qquad (8)$$

$$y_t = \pi_t - \pi_t^e + \xi_t \qquad (9)$$

where ξ_t is a zero-mean and constant variance supply shock. The optimization of (8) can be written as

$$\pi_t|\xi_t = \frac{1}{2}[\bar{\pi} + \pi^e - \xi_t] \qquad (10)$$

where π_t is period's *t* inflation outcome that is conditional on ξ_t and π_t^e is private agents' expectations. Under a credible monetary policy regime, private agents' expectations are firmly anchored ($\pi^* = \pi^e$). This means that from equation (10),

$$\pi_t|\xi_t = \bar{\pi} - \frac{1}{2}\xi_t \qquad (11)$$

$$\mathbb{E}(\pi) = \bar{\pi} \qquad (12)$$

Assuming that long-run inflation expectation, π_t^e, at any given time is a function of the weighted average of the inflation target (π^*) and one period lagged inflation rate (π_{t-1}) as in (13),

$$\pi_t^e = \lambda_t\bar{\pi} + (1 - \lambda_t)\pi_{t-1} \qquad (13)$$

Then, λ_t ($\in [0,1]$) denotes how firmly inflation expectations are anchored. Therefore, at one extreme is full credibility ($\lambda_t = 1$) where expectations are exactly anchored at target. At the other extreme is the case of no policy credibility ($\lambda_t = 0$) with complete de-anchoring of expectations. Therefore, if the argument that inflation targeting has successfully tamed inflation in a credible manner is true, then there must be a disconnect between inflation and inflation expectations in the historical data.

To test this hypothesis, we follow the approach by Demertzis et al (2008) as summarized by the vector autoregressive (VAR) model below

$$\begin{pmatrix} \pi_t \\ \pi_t^e \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \begin{pmatrix} a(L) & b(L) \\ c(L) & d(L) \end{pmatrix} \begin{pmatrix} \pi_{t-1} \\ \pi_{t-1}^e \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}, \qquad (14)$$

$$\begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \sim i.i.d.\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{11} & \sigma_{21} \\ \sigma_{12} & \sigma_{22} \end{pmatrix} \right)$$

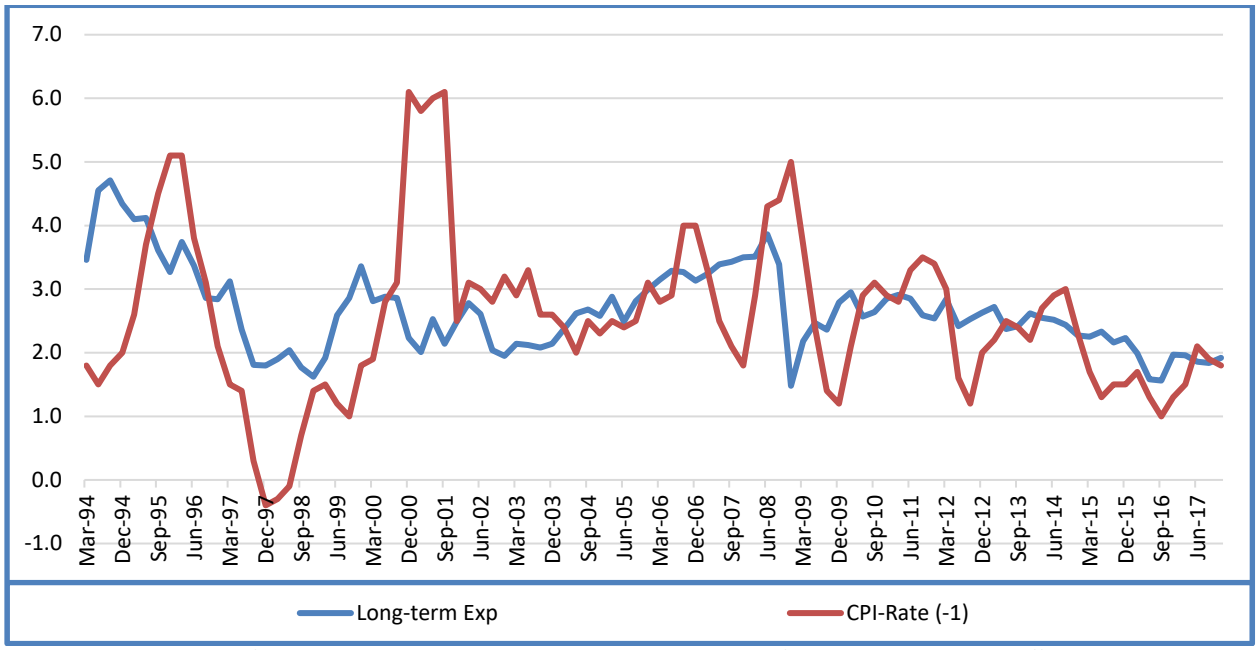
where π_t and π_{t-1} are the actual CPI and one quarter lagged CPI rates respectively and π_t^e is expected (medium or long-term) expected inflations. Under the conditions that actual lagged inflation has no effect on inflation expectations (medium and long-term) and vice versa, as well the lack of any contemporaneous shock transmission from actual inflation to expected inflation (vice versa), then impulse response functions (IRFs) generated from Equation (14) must show no reaction dynamics. Similar to Gillitzer and Simon (2015), we split the sample into two regimes with different inflation dynamics: the era before inflation targeting (1986Q3-1993Q4) and the inflation-targeting era (1994Q1-2017Q4).

Inflation expectations data are those based on RBA's statistics. Short-term expectations are represented by the business inflation expectations 3-month ahead data series (1989Q3-2017Q4) while medium-term expectations are represented by the Union Officials' 2-year ahead data series (1997Q2-2017Q4). We use the break-even 10-year inflation rate as a proxy for longer-term inflation expectations (1989Q3-2017Q4)

3.4.1 Pre-Inflation Targeting Era: Was Monetary Policy Credibility Low?

The primary goal of adopting inflation targeting was to improve the credibility of monetary policy. From figure 4, both CPI inflation and long-term inflation expectations[12] have been on the downward trend throughout the decades leading to inflation targeting.

Figure 4. Australia: Inflation and Long-term Inflation Expectations (1986-1993)

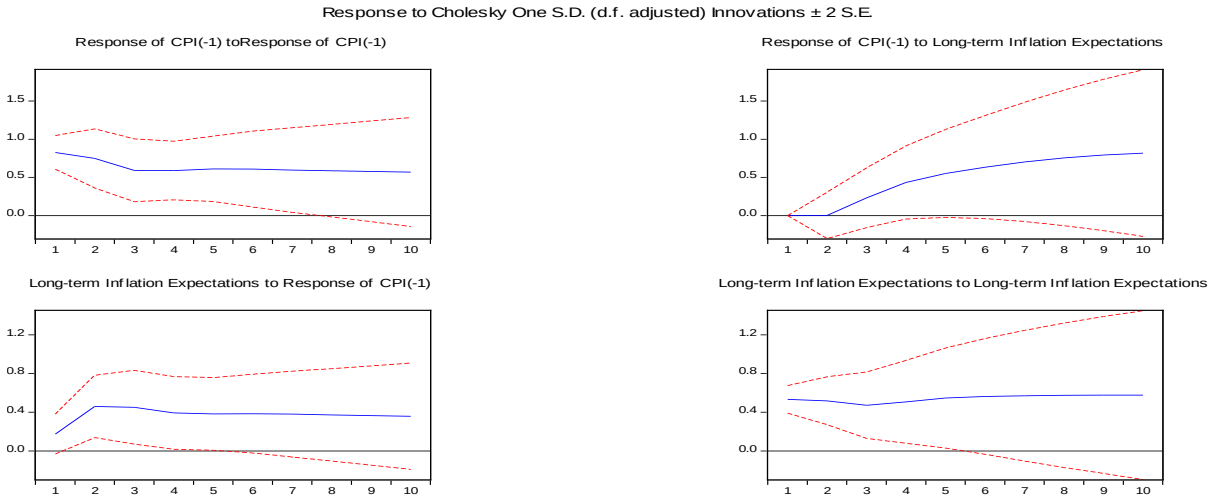


Source: RBA. Long-term Inflation Expectations are represented by the average annual inflation rate implied by the difference between 10-year nominal bond yield and 10-year inflation indexed bond yield as computed by the RBA

To test monetary policy credibility during the Pre-inflation targeting era, we examine the sensitivity of long-term inflation expectations to actual inflation dynamics (lagged one quarter) using the VAR model in Equation (14) with two lags (determined by information criteria). Empirical diagnostic checks show, among other things, that the model was correctly specified, with serially uncorrelated and homoscedastic errors. The impulse responses are provided in Figure 5. The results show that the formation of long-term expectations was sensitive to actual inflation dynamics during the period, indicating weak anchoring and poor credibility.

Figure 5: Long-term Inflation Expectations (1986Q3-1993Q4)

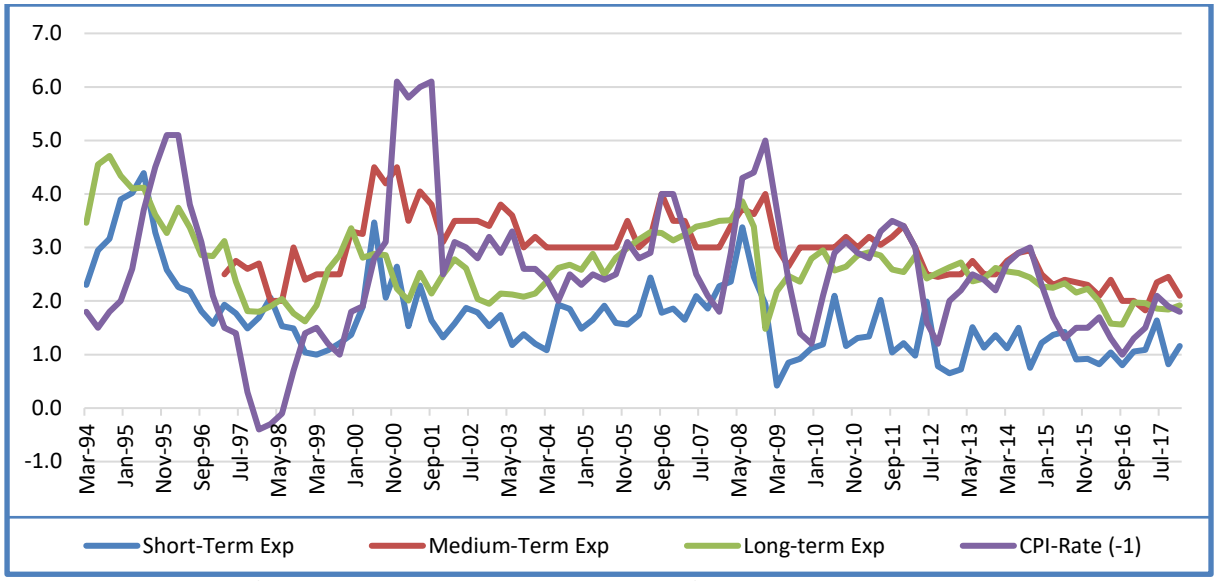
[12] Long-term Inflation Expectations are represented by the average annual inflation rate implied by the difference between 10-year nominal bond yield and 10-year inflation indexed bond yield as computed by the RBA



3.4.2 Inflation Targeting Era: Have Expectations Been Credibly Anchored?

Figure 6 shows inflation and expectations dynamics during the inflation targeting era. As more data on expectations are available for the inflation-targeting era, we examine not just how actual inflation affects long-term inflation and vice versa, also how long-term expectations are influenced by short-term expectations. Under strong anchoring, both actual inflation and short-term inflation expectations[13] should not influence long-term expectations and vice versa.

Figure 6. Australia: Inflation and Inflation Expectations (1994-2017)



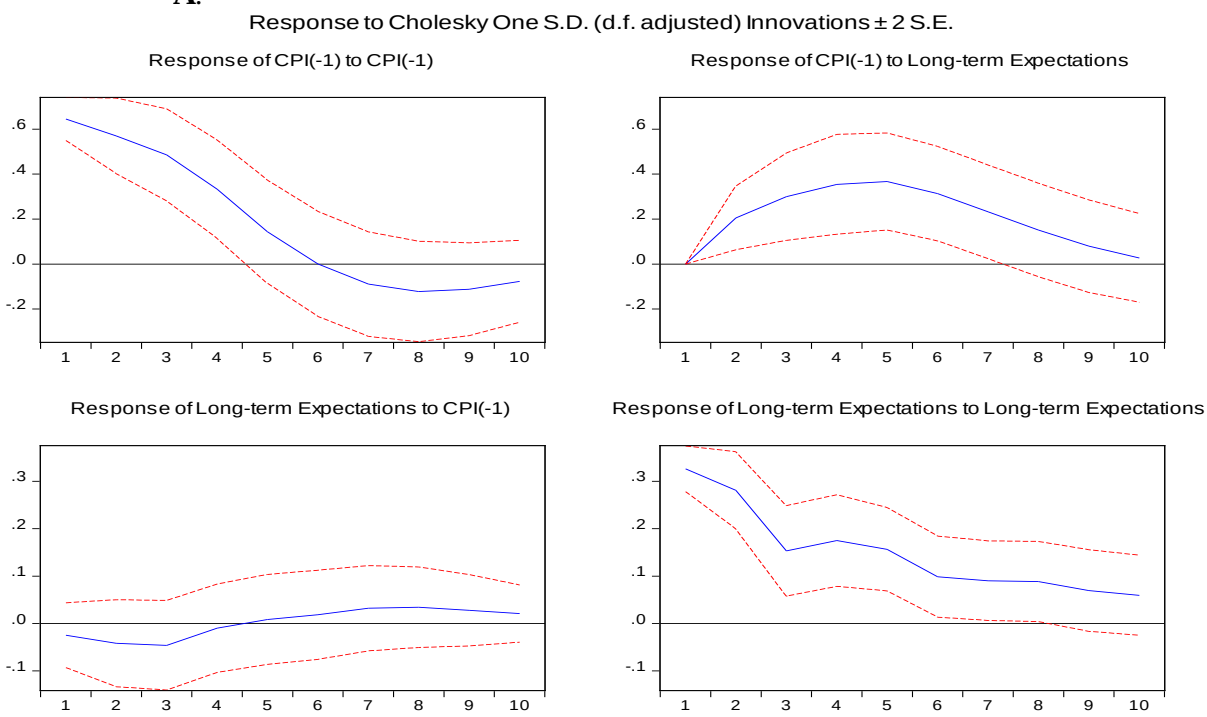
Source: RBA. Short-term Inflation Expectations are represented by Business inflation expectations – 3-months ahead as compiled by the National Australian Bank. Medium-term Inflation Expectations are represented by Union officials' inflation expectations – 2-year ahead

[13] Survey of Business inflation expectations – 3-months ahead as compiled by the National Australian Bank

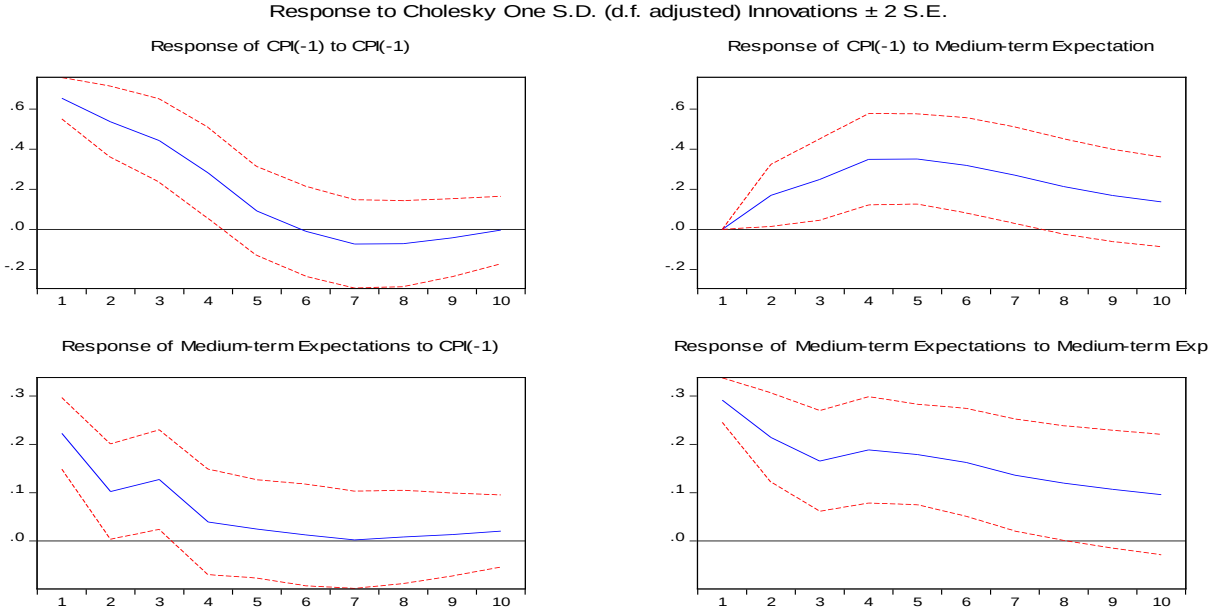
As shown in Figure 7 (A), actual inflation and long-term inflation expectations exhibit strong level of contemporaneous response to shocks emanating from either directions, indicative of incomplete anchoring of expectations. However, there is a return of inflation expectations to baseline after 4 quarters which indicates stronger anchoring over time. Section B also shows similar dynamics between CPI and medium-term expectations.

Figure 7: Inflation and Expectation Dynamics (1994-2017)

A.



B.



3.4.3 Did the Global Financial Crisis Affect the Anchoring of Expectations in Australia?

To account for the possibility of changes in de-anchoring risks over time during the global financial crisis[14] (GFC), we split the sample into two: before the GFC (data available for 1989Q3 to 2008Q2) and after the GFC (2008Q3 to 2017Q4) using a crisis dummy, d^{fc}, which equals 0 for the period before the GFC and 1 otherwise. Following Ehrmann (2015) and Łyziak and Paloviita (2016), we estimate the following equation (15):

$$\pi^{e}_{t|t+n} = (1 - d^{fc})\left[\alpha_{pre} + \beta_{pre-GFC}\pi_{t-1}\right] + d^{fc}\left[\alpha_{post} + \beta_{post-GFC}\pi_{t-1}\right] + \varepsilon_t \quad (15)$$

where $\pi^{e}_{t|t+n}$ denotes the average medium-term inflation expectations or long-term inflation expectations. π_{t-1} is one quarter lagged inflation rate and ε_t is white noise. From the results provided in Table 2 below, there is further evidence that inflation expectations are not strongly anchored in the short term, with the GFC having no real noticeable effects on such dynamics. While both pre-GFC and post-GFC coefficients are statistically significant, the pre-GFC coefficients are slightly larger.

Table 2: Pre-GFC and Post-GFC Inflation and Expectations Dynamics

Dependent Variable	$\beta_{Pre-GFC}$	$\beta_{Post-GFC}$	R^2 Adj.
Dependence of Medium Expectations on CPI (-1) Inflation			
Medium-Term Expectations	0.364*** (7.22)	0.240*** (4.70)	0.657
Dependence of Long and Medium Expectations on Short-term Expectations			
Long-term Expectations	1.164*** (3.61)	1.037*** (2.64)	0.562
Medium-Term Expectations	0.566*** (5.23)	0.424*** (3.31)	0.365

Source: RBA and authors' calculations.
Note: CPI(-1) refers to actual CPI inflation rate lagged one quarter. Estimation done using OLS with Newey-West HAC standard errors. T-statistics are indicated in parentheses. *** indicates statistical significance at 99 percent

[14] We consider September 2008 (2008Q3) onwards as the post-GFC period.

4. Empirical Evidence on Shocks

4.1 Nature of Historical Shocks

As outlined in section 3, the various monetary regimes handle shocks to the economy in different ways. Faced with demand shocks, an inflation targeting central bank can appropriately tighten the monetary policy stance, simultaneously containing inflationary pressure and slowing down output growth. Therefore, with demand shocks, there can be a *divine coincidence*[15], such that an inflation-targeting central bank faces no trade-off between achieving the price and output stability objectives. However, in the case of supply shocks that create divergent paths for price and output, such divine coincidence disappears, creating a stark trade-off between achieving price stability and output stability (see Blanchard and Gali, 2007 and Kim 2016). Historically there are number of studies of the Australian economy that have attempted to evaluate whether shock historically have been demand or supply shocks. A brief overview of empirical evidence on the nature of shocks (demand versus supply) that characterized Australia's business cycle over the years is provided below.

Empirical evidence on the nature of shocks (supply versus demand) underpinning Australia's business cycle is mixed. Using a SVAR model developed for the Australian economy covering the period 1980-1998, Dungey and Pagan (2000) provide evidence that demand shocks are the dominant driver of business cycle activities over the period, with limited influence from monetary policy. Buncic and Melecky (2008) reach similar conclusions. According to their findings, domestic demand shocks were the key driver of variations in Australia's potential output during the period 1981-2005, with limited influence from supply shocks. But the opposite is true for inflation, with aggregate supply shocks being the major determining factor. However, in a study analyzing key features of Australia's business cycles covering the period 1959-2000, Cashin and Ouliaris (2001) find strong empirical evidence demonstrating persistent countercyclical relationship between output and prices over the entire period, indicative of the dominance of supply shocks in explaining fluctuations in output.

[15] Divine coincidence occurs when the stabilization of both inflation and output can both be achieved with a single monetary instrument.

Similar findings, that supply shocks were the dominant drivers of Australia's macroeconomic fluctuations, were reached by Backus and Kehoe (1992) covering different periods spinning 1861-1985 and Fisher et al (1996) for the period 1959-1995. Recent evidence also remains mixed, although demand shocks are largely believed to be the major driver of the fluctuations in output relative to supply shocks. Using quarterly data covering 1992 to 2013, Rees et al (2015) find that while demand shocks (consumption preferences and expenditures) are relatively more pronounced in influencing output fluctuations and particularly strong in driving variations in consumption, aggregate supply shocks (markup shocks in the non-traded, non-resource and import sectors) are the major driver of the fluctuations in inflation.

4.2 Likely Future Shocks

While the debate on the performance of monetary policy regimes usually focuses on how regimes would have performed historically[16] it is also useful to be forward thinking in the likely nature of future shocks to the global and Australian economies. There are three main areas where future shocks can be anticipated. The first is climate change and climate policy responses. The second is the emergence of a fourth industrial revolution or a new Renaissance due to the rapid adoption of new technologies such as artificial intelligence. The third is the growth of larger emerging economies into the world economy following the experience of China.

4.2.1 Climate Change and Policy Responses

In a recent paper, McKibbin, Morris, Wilcoxen and Panton (2017) explored the interdependence between the choice of climate policy regimes and the choice of monetary regimes. They argue that while climate policy and monetary policy have been considered and pursued separately as two distinct policy regimes, the joint interaction of both policies in influencing macroeconomic fluctuations must be the concern for macroeconomic stabilization policy moving forward. That is, while optimal monetary policy outcomes can be achieved when the traditional goals (price stability and output stability) are met, the climate policy objective of promoting low carbon emissions cannot be achieved without consequences for price and output stability under alternative monetary policy and climate policy regimes.

[16] This was the basis of the Brookings model comparison project that created the "Taylor Rule". See Bryant et al. (1993)

There are several issued raised by the authors. The first is that increasing climate shocks will likely imply greater output volatility from supply side shocks due to climate related disruption. This greater volatility in the real economy also implies that estimating the output gap is likely to become increasingly difficult. Thus, an inflation targeting regime based on output gap forecasting is likely to be more difficult to implement. As mentioned above, a nominal income targeting regime does not rely on the output gap estimation and may be better at anchoring inflation expectations within a band.

The second problem is related to the nature of the likely climate policy response. A cap and trade carbon emissions trading framework targets the level of emissions over time through a market determined carbon price that stabilizes or reduces emissions. The deeper the carbon target, the higher and the more volatile the carbon price. The carbon price feeds directly into the price of energy and therefore into the inflation rate in the economy. Over time the carbon price is likely to have a trend increase given the nature of the carbon reduction targets adopted by countries, including Australia under the Paris Accords. Thus, an inflation targeting regime would need to adjust for both change in trend inflation due to the carbon price and well as volatility in inflation due to volatility in carbon prices. The second effect is less problematic if the climate policy is implemented as a carbon tax because the carbon price (equal to the tax) is known. There would still be a trend change in the underlying inflation rate which needs to be considered in the monetary regime.

The extent to which the issues raised by climate change are important will depend on a number of highly uncertain events: the nature of future climate disruption; the extent to which Australia takes on a deep cut emissions target and the nature of the actual climate policy that is eventually implemented in Australia. McKibbin et al (2017) conclude that consideration of climate change should be thought of as an increasing importance of supply side shocks which are better handled by nominal income targeting than inflation targeting.

4.2.2 The rise of artificial intelligence

There is a large and growing literature on the impact of artificial intelligence on economic activity[17]. While some analysts and policymakers are more optimistic about the potential benefits from artificial intelligence, ranging from enhanced real-time forecasting capabilities, spotting bubbles, and uncovering complex macro-financial links (Lagarde, 2017), some are more concerned about how such changes to the nature of the economy could make real-time forecasting and understanding of macroeconomic fundamentals more complicated than ever before. Saniee et al (2017) suggest that the world could be on a verge of a fourth industrial revolution underpinned by the rapid advancement in technology. This would make forecasts of potential growth and the output gap highly uncertain. Currently, there is a huge mismatch between low growth and productivity statistics on one hand and high expectations of improvement in productivity due to rapid advancement in technology on another.

The real problem could be due to two issues. Either there is a problem with how the effects of new technologies on economic growth and productivity are measured by economists (Feldstein, 2017) or we are yet to clearly understand the lag from the introduction of new technologies to the realization of their impacts on output and productivity (Brynjolfsson et al, 2017). In either case, as new technologies make the structure of the economy more complex, measuring the underlying fundamentals, particularly concepts like “potential output” will become even more challenging. An alternative view is offered by Bob Gordon (2016) who argues that productivity growth will remain weak for many years. Such uncertainty over productivity growth will make projection of potential growth very difficult.

In such an environment where central banks cannot account for surprise increases in productivity, then inflation would be surprisingly low for long period. The credibility and effectiveness of monetary policy in such an environment will be contingent upon the nature of the monetary policy framework in place. Suppose productivity growth rises more sharply than expected. Inflation targeting central banks would continue to see inflation below their inflation target because monetary policy would be too tight relative to that possible in a strongly growing world. They would need to continually relax monetary policy to attemopt to raise inflation to the target. Over time failure tio achieve this would undermine the credibility of the inflation

[17] For example see Acemoglu and Restrepo (2015), Benzel et al (2015),Bostrom (2014), Brynjolfsson and McAfee(2014), Kavuri (2018) and Kavuri and McKibbin (2017).

target. Under a nominal income target, suppose the target of the RBA is 6% per year calculated assuming 3% potential growth and 3% inflation.

If growth was surprisingly strong because of higher-than-expected productivity growth, output growth may turn out to be 4% and inflation at 2%. The nominal income target can still be met without affecting the credibility of the central bank. The difference would be that inflation would be lower than desired. If this is sustained then the central bank could announce a higher future nominal income target adjusting to the new reality of higher real growth.

4.2.3 Continued emergence of developing countries into the global economy

The accession to the WTO in 2000 and the implementation of structural reforms by Chinese authorities since then have positioned China as a major economy, transforming the global economy through millions of workers, producers and consumers entering global production and consumption networks. The importance of the China boom for the Australian economy from 2001 to 2016 is explored in Dungey et al (2014) and Dungey et al (2017).

An emerging country boom would impact Australia in a similar way to the China boom of the 2000s. Strong external demand, high Australian nominal income growth and an appreciating exchange rate which would lower import prices. It might also lead to a lowering on Australian country risk as investment in Australia is seem as a high return activity given Australia production structure and trade links into emerging economies. This would raise domestic prices but reduce import prices. It would also increase asset prices in Australia. An inflation targeting central bank would face what the Reserve Bank faced from 2000. Thus, a flexible inflation target and a nominal income growth target would both perform well as long as the shock was clearly understood and enunciated within the inflation target framework.

5. Summary and Implications

The past 25 years of inflation targeting has coincided with an impressive performance of the Australian economy. The flexible inflation targeting regime followed by the RBA has clearly outperformed the alternative monetary frameworks (i.e. fixed exchange rates; a fixed monetary rule; a checklist of intermediate targets) that had been implemented in earlier decades. However, as Australia positions itself as a competitive economy in a rapidly changing global economy, it is worth asking whether there is likely to be a better approach for monetary policy moving forward.

There has certainly been a long and rigorous debate that other monetary regimes can outperform inflation targeting in theory. Both flexible inflation targeting and the normal income targeting have appealing characteristics in theory. Flexible inflation targeting has worked well, although it could be argued that this is mostly because the nature of the shocks in the Australian economy which has largely been domestic and foreign demand shocks. The key issues moving forward is what will be nature of future shocks hitting the Australian economy. In recent years, productivity shocks have become more important. This has seen the ability of central banks including the RBA to forecast inflation and to achieve the inflation target to be less successful. We show in this paper that inflationary expectations appear not to be as well anchored in the Australian economy as would be expected given the existence of the inflation targeting framework.

Looking to the future the importance of supply shocks being driven by climate policy, climate shocks and other productivity shocks generated by technological disruption as well as a structural transformation of the global economy appear likely to be increasingly important. This suggests an important evolution of the monetary framework may be to shift from the current flexible inflation targeting regime to a more explicit nominal income growth targeting framework. The key research questions that need further analysis are: how forecastable is nominal income growth relative to inflation?; and what precise definition of nominal income is most appropriate given the ultimate objectives of policy (nominal GDP, nominal GNP, domestic demand netting out terms of trade shocks - or some other measure that is available at high frequency (e.g. big data on spending)). Also, the issue of the growth of income versus the level of income is an open research question with many of the same issues to be faced as the choice between inflation targeting versus price level targeting.

It would be a mistake to argue that there is no need to change the monetary regime because the existing monetary regime in Australia has been successful. Monetary regimes have evolved for centuries and when they have changed it has usually been because of a crisis - the collapse of Bretton Woods or the recession that Australia didn't need to have in 1991. It is better to have a policy regime change in an evolutionary way backed by theoretical and empirical research (much the same as has been experience of flexible inflation targeting in Australia since 1993) than to wait for a breakdown in the existing regime. The difference between inflation targeting over the cycle and a nominal growth target is an incremental move from a less transparent to a more transparent policy rule that has a number of attractive features particularly under the type of supply side shocks that are likely over coming decades.

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