Twenty-five Years of Inflation Targeting in Australia: Are There Better Alternatives for the Next Twenty-five Years?

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1. Introduction

This paper surveys alternative monetary frameworks and evaluates whether the current inflation-targeting framework, followed by the Reserve Bank of Australia (RBA) for the past 25 years, is likely to be the most appropriate framework for the next 25 years. While flexible inflation targeting has appeared to work well in Australia in the past decades, the nature of future shocks suggests that some form of nominal income targeting is worth considering as an evolutionary change to Australia's framework for monetary policy.

The core mandates of the RBA are promoting price stability, employment and the economic prosperity and 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 per cent over the cycle for consumer price inflation (CPI) – 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 per cent since 1993 (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, and more 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.

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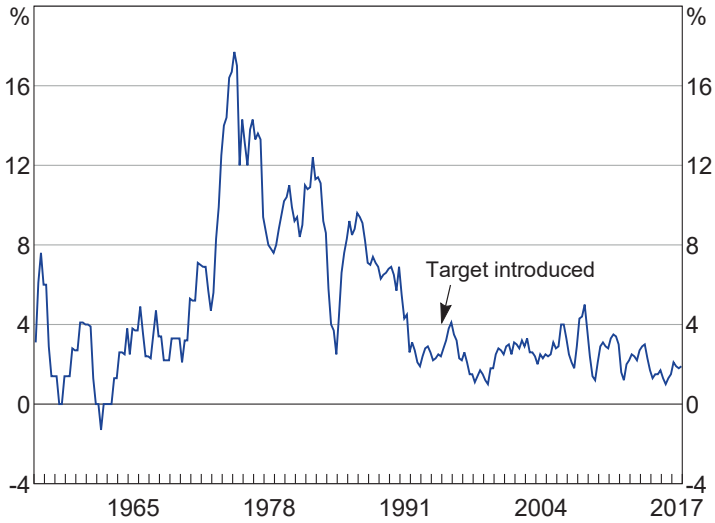
Figure 1. Evolution of CPI Inflation



Note: Excludes interest charges prior to September quarter 1998 and adjusted for the tax changes of 1999–2000
Sources: ABS; RBA

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 of 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 summarised by Equation (1):

$$i_t = i_{t-1} + \alpha\left(\pi_{t,t+n} - \overline{\pi}\right) \tag{1}$$

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

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

$$L_t = \frac{1}{2}\left[\left(\pi_t - \overline{\pi}\right)^2 + \lambda y_t^2\right] \tag{2}$$

where π_t is inflation in period t, $\overline{\pi}$ is the central bank's inflation target and $\lambda \geq 0$ is the weight given to output gap (y_t) stabilisation. 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 stabilisation objective with the output stabilisation goal (Fischer 1995; 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 inflation forecasting models 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 2018). A variant of the flexible inflation-targeting regime is the set of rules proposed by Henderson and McKibbin (1993) and applied to the US Federal Reserve policy behaviour by Taylor (1993). As indicated by Equation (3), the monetary policy reaction function under a Henderson-McKibbin-Taylor (HMT)-type rule is expressed as:

$$i_t = i_{t-1} + \alpha\left(\pi_t - \overline{\pi}\right) + \gamma\left(Y_t - \overline{Y}_t\right) \tag{3}$$

where α and γ represent the respective weights on price or inflation stability and output stability and Y_t is output.[1] Under the assumption of sticky nominal wages, these parameters can be derived, as was the case in Taylor (1993) for the US Federal Reserve covering the period 1984–1992. In addition to price and output stability, other macroeconomic indicators such as exchange rates can be included in HMT-type rules using a general equilibrium modelling framework. An example is the approach in the G-Cubed model (McKibbin and Wilcoxen 2013).

1 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).

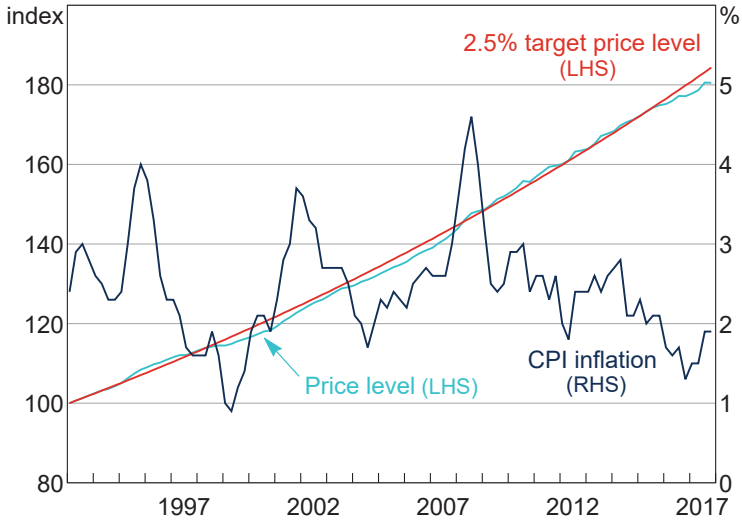
2.2 Price level targeting

The foremost objective of monetary policy, achieving and maintaining price stability, is usually interpreted as maintaining a 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 per cent 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, whether they fully understand the history-dependent nature of a central bank's policy response (Amano, Engle-Warnick and Shukayev 2011). Notwithstanding this, 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, the core CPI inflation rate has largely averaged below 2.5 per cent – the midpoint of the RBA's 2 to 3 per cent target range – since the introduction of inflation targeting in 1993. As periods of below-target inflation are not offset by above-target inflation under inflation targeting, the core price level remains slightly lower during most of the inflation-targeting era than it would have been had inflation been targeted at 2.5 per cent per annum with no bygones being bygones.

Figure 2. Quarterly CPI and CPI Inflation
Excluding volatiles



Notes: The 2.5 % target price level is the price level had inflation (excluding volatiles) been targeted at exactly 2.5 % throughout the entire period; levels are indexed at March 1993 = 100
Sources: ABS; Authors' calculations; 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 that the central bank has perfect control over inflation, then the monetary policy loss function under price level targeting can be written as:

$$L_t = \frac{1}{2}\left[\left(P_t - P_t^*\right)^2 + \lambda\left(Y_t - Y_t^*\right)^2\right] \tag{4}$$

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 stabilisation. 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 overemphasised. 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 invoked during periods when the ZLB is binding 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.[2] Indeed, before the widespread 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 of output volatility (price volatility), the objective of monetary policy under nominal income targeting is the stabilisation of some measure of total nominal income. A policy rule targeting a specific *level* of nominal income can be expressed as:

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

with $PY_{t,t+n}$ representing the nominal income level in period $t+n$, forecast in period t, and $\overline{PY}_{t+n}$ 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):

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

Apart from the fact that there need not be a *divine coincidence* to simultaneously achieve price and output stability (Blanchard and Galí 2007) under nominal income targeting, a central bank following the nominal income-targeting regime does not need to have real-time knowledge

2 See Henderson and McKibbin (1993), Woodford (2012), Sumner (2014) and Beckworth and Hendrickson (2018).

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 (3) and real output growth below that desired in Equation (3) but the nominal income target could still be achieved *ex post*.

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 an extreme crisis when real interest rates may need to fall sharply to stabilise 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 gross domestic product (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 per cent, a well-anchored expected inflation rate is unlikely to rise above 3 per cent unless a central bank announces 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 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 the 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 was Borio and Lowe (2002) and the global financial crisis (GFC) accentuated the debate. By 2010 it was a key issue in the debate about the role of monetary policy in Australia.[3] Evidence in the literature remains mixed on which policy rule can optimally incorporate financial stability

3 This was a major focus in the paper by Cagliarini, Kent and Stevens (2010) on 50 years of monetary policy.

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 a proxy for financial stability risks (see Disyatat (2010); Woodford (2012)), an additional mandate incorporating financial stability can be described by a loss function of the form:[4]

$$L_t = \frac{1}{2} E_0 \sum_t^{\infty} \beta^t \left[\pi_t^2 + \lambda_y y_t^2 + \lambda_\Omega \Omega_t^2 \right] \tag{7}$$

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 is included as a mandate of monetary policy, not one 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. These have been comprehensively evaluated by Frankel (2011) in the context of the specific problems faced by emerging economies, and economies 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 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 analysed in the next section.

3. Key Issues in the Choice of the Monetary Regime

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

1. How well does each monetary regime handle shocks?
2. Can the target of monetary policy be credibly measured and clearly understood?
3. How forecastable are the different targets?
4. Are price expectations anchored by the monetary regime?

Each of these issues are considered in turn below.

4 In the monetary literature this is referred to as a 'ternary' mandate.

3.1 How well does each 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 (summarised in Bryant, Hooper and Mann (1993)) is that inflation targeting and nominal income targeting handle money demand shocks well because both would neutralise 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 depends 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 that 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 prices 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 a distinction. To the extent that the distinction between shocks that can be accommodated and those that cannot be accommodated is not correctly made 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 of monetary policy 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 *divine coincidences* in the conduct of monetary policy, especially when there are real wage rigidities (Blanchard and Galí 2007) or supply shocks (Kim 2016).[5]

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 of trend output as the true nature of the economy changes with hindsight (Orphanides and van Norden 2002). The lack of a reliable output gap measure is the 'Achilles heel' of inflation targeting as currently practised.

As no publicly available historical output gap series is available for Australia, most empirical analyses on the issue follow an econometric approach (see Gruen, Robinson and Stone (2002)). For nominal income targeting, 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 a nominal income target (as opposed to an inflation or a price level target), the real-time knowledge problem faced by the central bank is of forecasting nominal income, instead of the output gap.

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 are subject to revisions over time. However, as there is evidence that errors from nominal income growth forecasts are stationary, the effect of growth data revisions on target credibility may not be a major concern compared with errors in measuring the output gap. Furthermore, 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.

5 Achievement and maintenance of price stability does not guarantee output stability, with a strong trade-off in achieving both objectives.

3.2.2 Understanding

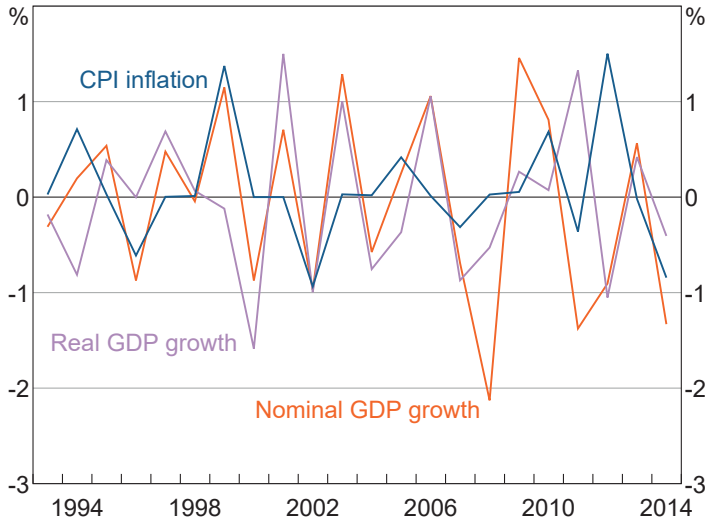
Monetary policy is considered credible if the expectations of economic agents are firmly anchored. But such anchoring of expectations depends on how clearly and easily the policy or target can be understood. A nominal income target outperforms other policy rules on this count. First, unlike a flexible 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).[6] Second, with volatile items, particularly oil and food prices, excluded from *underlying inflation* – the measure of inflation accommodated by most inflation-targeting central banks, including the RBA – the persistent disconnect between headline and underlying inflation may weaken policy credibility, particularly in an environment characterised by persistent supply shocks that drive a wedge between underlying and headline inflation. No such distinction between underlying and headline inflation needs to be made under nominal income targeting.

3.3 How forecastable are the different targets

Figure 3 shows the forecast errors made by the Organisation for Economic Co-operation and Development (OECD) in forecasting annual nominal GDP growth, real GDP growth and CPI inflation for Australia from 1993 until 2014. The forecast errors are 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 2007/08–2016/17 (Table 1). For the period 2007/08–2011/12, the errors made in the May forecasts for one-year-ahead nominal GDP and CPI inflation are of similar magnitude as measured by the root mean squared error (RMSE). For the succeeding period (2012/13–2016/17), the RMSE for the May one-year-ahead nominal GDP forecast is almost twice that of inflation for the same period, although the December one-year-ahead forecast for nominal GDP performance is better than the inflation forecast performance. However, over the entire ten-year period, there appears to be little difference between the Treasury's forecast performance for both CPI inflation and nominal GDP.

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

Figure 3: OECD Forecast Errors



Sources: Authors' calculations; OECD

Table 1: Root Mean Squared Errors of Australian Treasury's Forecasts of Nominal GDP and CPI Inflation

Forecast for next financial year

Period	Nominal GDP		CPI inflation	
	May	December	May	December
2007/08–2011/12	1.38	0.89	1.18	1.10
2012/13–2016/17	1.52	0.74	0.87	0.70
2007/08–2016/17	1.45	0.82	1.04	0.92

Notes: The RMSE is calculated by squaring the forecast errors, averaging them over the indicated periods and taking the square root of the result; the forecast error at each horizon is computed as actual (out-turn) less forecast

Sources: Australian Treasury; Authors' calculations

3.4 Are price expectations anchored by the monetary regime?

It is often argued that a focus on inflation by central banks is the best way to anchor inflation expectations. 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, p 1422) that '[a] central bank is credible if people believe it will do what it says'. Under a credible flexible inflation-targeting regime, short-term deviations from the 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 (see Bernanke (2017)). 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 a de-anchoring of inflation expectations.

We explore several aspects of the anchoring of inflation expectations in Australia. We follow the work by Demertzis, Marcellino and Viegi (2008) on the US economy and Łyziak and Paloviita (2016) on the inflation expectations in the euro area. 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 these 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 minimises the following loss function (8) subject to the Lucas supply function (9):

$$L_t = \frac{1}{2}\mathbb{E}\left[\left(\pi_t - \overline{\pi}\right)^2 + \lambda y_t^2\right] \tag{8}$$

$$y_t = \pi_t - \pi_t^e + \xi_t \tag{9}$$

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

$$\pi_t \middle| \xi_t = \frac{1}{2}\left[\overline{\pi} + \pi^e - \xi_t\right] \tag{10}$$

where π_t is the inflation outcome in period t, which 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 ($\overline{\pi} = \pi^e$). This means that from Equation (10):

$$\pi_t \middle| \xi_t = \overline{\pi} - \frac{1}{2}\xi_t \tag{11}$$

$$\mathbb{E}(\pi) = \overline{\pi} \tag{12}$$

Assuming that long-run inflation expectations, π_t^e, at any given time is a function of the weighted average of the inflation target ($\overline{\pi}$) and one-period lagged inflation rate (π_{t-1}) as in Equation (13):

$$\pi_t^e = \rho_t \overline{\pi} + (1 - \rho_t)\pi_{t-1} \tag{13}$$

Then, $\rho_t \left(\in [0,1]\right)$ denotes how firmly inflation expectations are anchored. Therefore, at one extreme is full credibility ($\rho_t = 1$) where expectations are exactly anchored at target. At the other extreme is the case of no policy credibility ($\rho_t = 0$) 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 summarised by the vector autoregressive (VAR) model below:

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

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

where π_t and π_{t-1} are the actual CPI inflation and one-quarter lagged CPI inflation rates, respectively, and π_t^e is medium- or long-term inflation expectations. 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 (and 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 (1986:Q3–1993:Q4) and the inflation-targeting era (1994:Q1–2017:Q4).

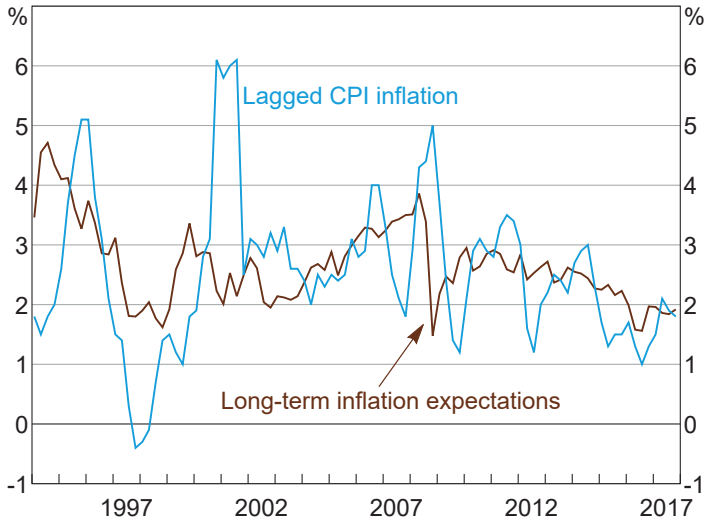
Inflation expectations data are those based on the RBA's statistical tables. Short-term expectations are represented by the business inflation expectations 3-months ahead data series (1989:Q3–2017:Q4), while medium-term expectations are represented by the union officials' 2-year ahead data series (1997:Q2–2017:Q4). We use the break-even 10-year inflation rate as a proxy for longer-term inflation expectations (1989:Q3–2017:Q4).

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. As shown in Figure 4, both CPI inflation and long-term inflation expectations have been on a downward trend throughout the decades leading to inflation targeting.

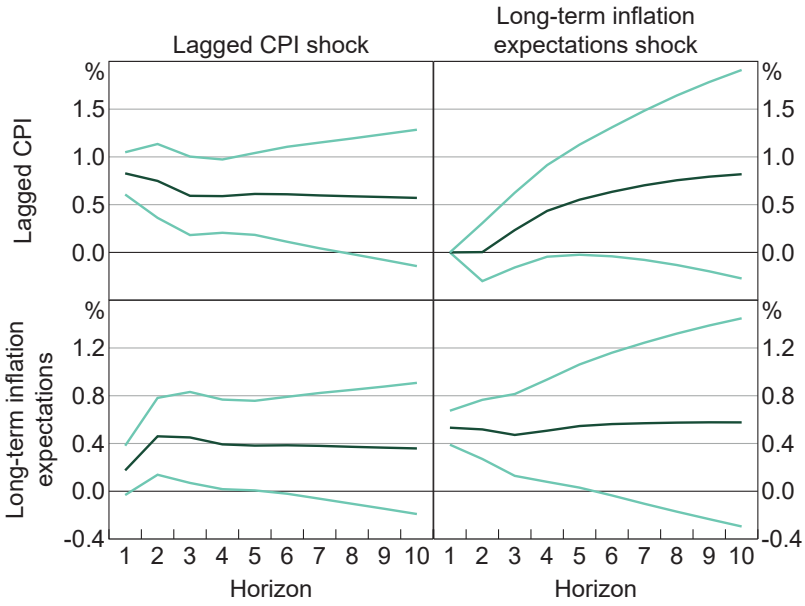
To test monetary policy credibility during the pre-inflation-targeting era, we examine the sensitivity of long-term inflation expectations to actual inflation dynamics (lagged one quarter) using the VAR model in Equation (14) with two lags (determined by information criteria). Empirical diagnostic checks show, among other things, that the model was correctly specified, with serially uncorrelated and homoskedastic 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 4: Inflation and Long-term Inflation Expectations



Note: Long-term inflation expectations are represented by the average annual inflation rate implied by the difference between the 10-year nominal bond yield and the 10-year inflation-indexed bond yield, as compiled by the RBA
Sources: RBA; Yieldbroker

Figure 5: IRFs – CPI and Long-term Inflation Expectations
1986:Q3–1993:Q4

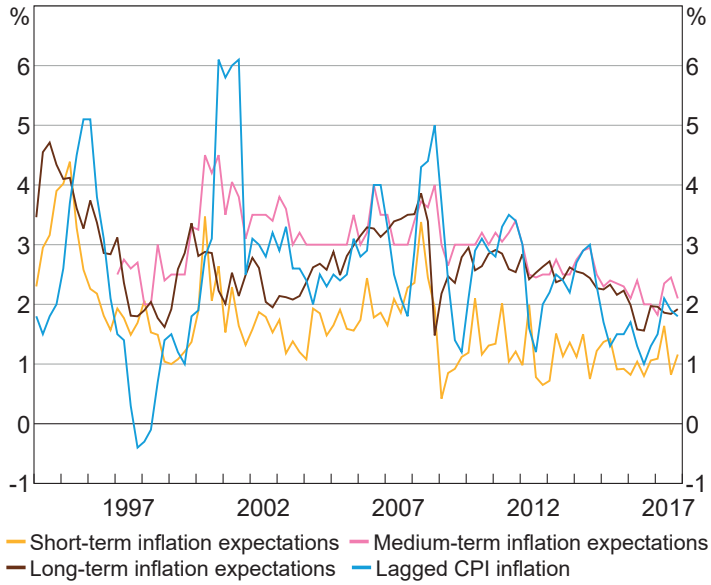


Note: Response to Cholesky one standard deviation (degrees of freedom adjusted) innovations with ±2 standard errors
Sources: Authors' calculations; RBA

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, but also how long-term expectations are influenced by short-term expectations. Under strong anchoring, both actual inflation and short-term inflation expectations should not influence long-term expectations and vice versa.[7]

Figure 6: Inflation and Inflation Expectations



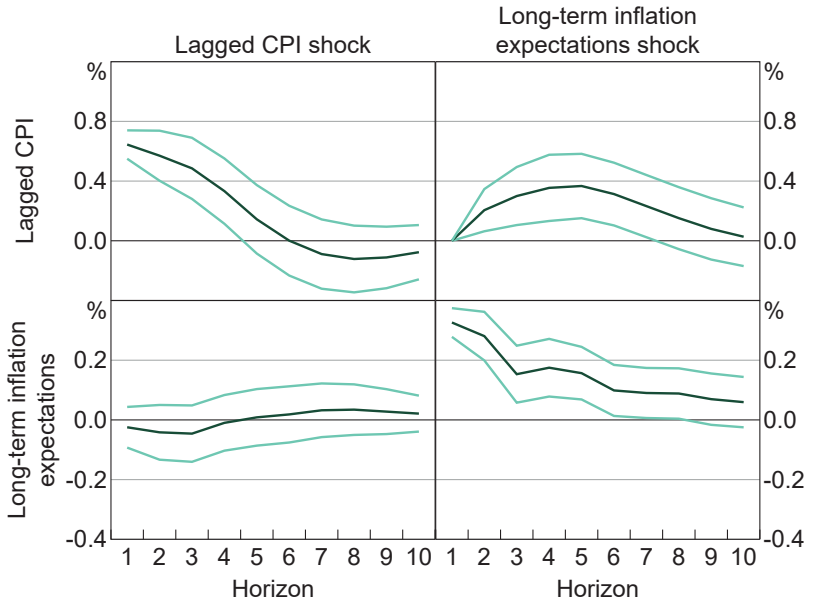
Notes: Short-term inflation expectations are represented by business inflation expectations – 3-months ahead as compiled by the National Australia Bank (NAB); medium-term inflation expectations are represented by union officials' inflation expectations – 2-years ahead; long-term inflation expectations, see notes to Figure 4

Sources: ABS; Australian Council of Trade Unions; Employment Research Australia; NAB; RBA; Workplace Research Centre; Yieldbroker

As shown in Figure 7, actual inflation and long-term inflation expectations exhibit strong contemporaneous responses to shocks emanating from either direction, indicative of incomplete anchoring of expectations. However, there is a return of inflation expectations to baseline after eight quarters which indicates stronger anchoring over time. Figure 8 also shows similar dynamics between CPI inflation and medium-term expectations.

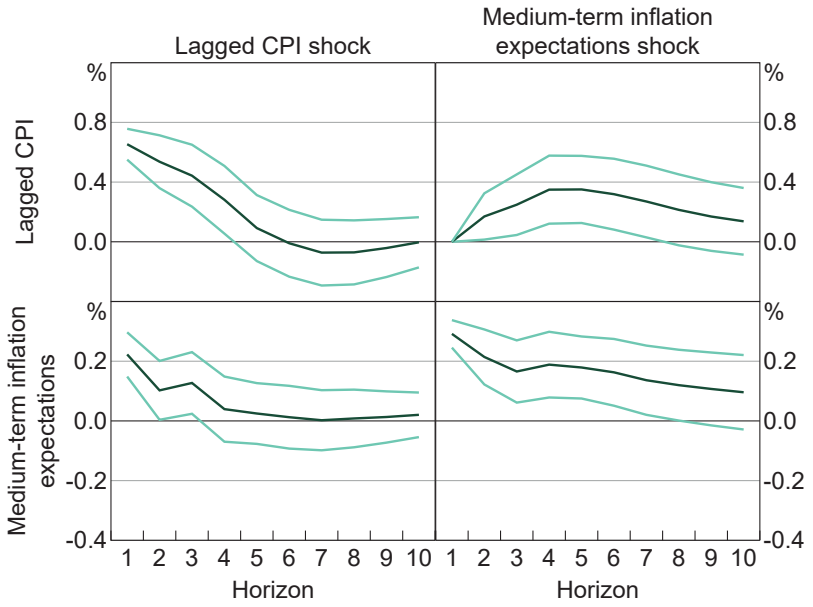
7 We use Quarterly Business Survey inflation expectations – 3-months ahead as compiled by the National Australia Bank as a measure of short-term inflation expectations.

Figure 7: IRFs – CPI and Long-term Inflation Expectations
1994:Q1–2017:Q4



Note: Response to Cholesky one standard deviation (degrees of freedom adjusted) innovations with ±2 standard errors
Sources: Authors' calculations; RBA

Figure 8: IRFs – CPI and Medium-term Inflation Expectations
1994:Q1–2017:Q4



Note: Response to Cholesky one standard deviation (degrees of freedom adjusted) innovations with ±2 standard errors
Sources: Authors' calculations; RBA

3.4.3 Did the GFC affect the anchoring of expectations in Australia?

To account for the possibility of changes in de-anchoring risks over time during the GFC, we split the sample into two: before the GFC (data available for 1989:Q3 to 2008:Q2) and after the GFC (2008:Q3 to 2017:Q4), using a crisis dummy, d^{GFC}, 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:

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

where $\pi^{e}_{t|t+n}$ denotes the average medium-term 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, 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	$\psi_{pre\text{-}GFC}$	$\psi_{post\text{-}GFC}$	Adjusted R^2
Dependence of medium expectations on π_{t-1}			
Medium-term expectations	0.364***	0.240***	
	(7.22)	(4.70)	0.657
Dependence of long and medium expectations on short-term expectations			
Long-term expectations	1.164***	1.037***	
	(3.61)	(2.64)	0.562
Medium-term expectations	0.566***	0.424***	
	(5.23)	(3.31)	0.365

Notes: π_{t-1} refers to actual CPI inflation rate lagged one quarter; estimation done using ordinary least squares with Newey-West heteroskedasticity autocorrelation consistent standard errors; *** indicates statistical significance at 99 per cent level; *t*-statistics are indicated in parentheses
Sources: Authors' calculations; RBA

4. Empirical Evidence on Shocks

4.1 The 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, such that an inflation-targeting central bank faces no trade-off between achieving the price and output stability objectives.[8] However, in the case of supply shocks that create divergent paths for price and output, such divine coincidence disappears, creating

8 Divine coincidence occurs when the stabilisation of both inflation and output can be achieved with a single monetary instrument.

a stark trade-off between achieving price stability and output stability (see Blanchard and Galí (2007) and Kim (2016)). There are a number of studies of the Australian economy that have attempted to evaluate whether shocks historically have been demand or supply shocks. A brief overview of empirical evidence on the nature of shocks (demand versus supply) that characterised Australia's business cycle over the years is provided below.

Empirical evidence on the nature of shocks (demand versus supply) underpinning Australia's business cycle is mixed. Using a structural VAR model developed for the Australian economy covering the period 1980–98, 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. In a study analysing key features of Australia's business cycles covering the period 1959–2000, Cashin and Ouliaris (2001) find strong empirical evidence demonstrating a persistent countercyclical relationship between output and prices over the entire period, indicative of the dominance of supply shocks in explaining fluctuations in output.

Similar findings, that supply shocks were the dominant drivers of Australia's macroeconomic fluctuations, were reached by Backus and Kehoe (1992) covering different periods spanning 1861–1985 and Fisher, Otto and Voss (1996) for the period 1959–95. 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, Smith and Hall (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 (mark-up 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, it is also useful to be forward thinking about the likely nature of future shocks to the global and Australian economies.[9] 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.

9 Such a historical review of performance was the basis of the Brookings model comparison project (see Bryant *et al* (1993)).

4.2.1 Climate change and policy responses

In a recent paper, McKibbin *et al* (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 future macroeconomic stabilisation policy. 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.

There are several issues raised by McKibbin *et al*. 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 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 stabilises or reduces emissions. The more ambitious the carbon target, the higher and more volatile the carbon price will be. The carbon price feeds directly into the price of energy and therefore into the inflation rate. 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 Agreement. Thus, an inflation-targeting regime would need to adjust for both a change in trend inflation due to the carbon price as 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, however, 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 in its emissions target; and the nature of the actual climate policy that is eventually implemented in Australia. McKibbin *et al* (2017) conclude that considering 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.[10] 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 macrofinancial 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 the 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 realisation of their impacts on output and productivity (Brynjolfsson, Rock and Syverson 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 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 periods. 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 economy. They would need to continually relax monetary policy to attempt to raise inflation to the target. Over time, failure to achieve this would undermine the credibility of the inflation target.

Under a nominal income target, suppose the target of the RBA is 6 per cent per year calculated assuming 3 per cent potential growth and 3 per cent inflation. If growth was surprisingly strong because of higher-than-expected productivity growth, output growth may turn out to be 4 per cent with inflation at 2 per cent. 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.

10 For example, see Bostrom (2014), Brynjolfsson and McAfee (2014), Benzell *et al* (2015), Acemoglu and Restrepo (2016), Kavuri and McKibbin (2017) and Kavuri (2018).

4.2.3 Continued emergence of developing economies into the global economy

The accession to the World Trade Organization 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, Fry-McKibbin and Linehan (2014) and Dungey *et al* (2017).

An emerging country boom would affect 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 of Australian country risk, as investment in Australia is seen as a high return activity given Australia's 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 RBA 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-targeting 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 (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 in the future.

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 of the nature of the shocks in the Australian economy, which have largely been domestic and foreign demand shocks. The key issue is what will be the nature of future shocks hitting the Australian economy. In recent years, productivity shocks have become more important globally. This has seen central banks, including the RBA, become less successful at forecasting inflation and achieving the inflation target. 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: (1) how forecastable is nominal income growth relative to inflation? and (2) what precise definition of nominal income is most appropriate given the ultimate objectives of policy (e.g. nominal GDP, nominal GNP, domestic demand netting out terms of trade shocks – or some other measure that is available at high frequency)? Also, whether the target should be specified in growth rates or levels is an open research question analogous to the choice between inflation targeting and price level targeting.

It would be a mistake to argue that there is no need to change the monetary policy regime because the existing monetary policy 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 (as has been the case with 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.

References

Acemoglu D and P Restrepo (2016), 'The Race between Man and Machine: Implications of Technology for Growth, Factor Shares and Employment', NBER Working Paper No 22252, rev June 2017.

Amano R, J Engle-Warnick and M Shukayev (2011), 'Price-Level Targeting and Inflation Expectations: Experimental Evidence', Bank of Canada Working Paper 2011-18.

Backus DK and PJ Kehoe (1992), 'International Evidence on the Historical Properties of Business Cycles', *The American Economic Review*, 82(4), pp 864–888.

Beckworth D and JR Hendrickson (2018), 'Nominal GDP Targeting and the Taylor Rule on an Even Playing Field', AIER Sound Money Project Working Paper No 2018–10, January.

Benzell SG, LJ Kotlikoff, G LaGarda and JD Sachs (2015), 'Robots are Us: Some Economics of Human Replacement', NBER Working Paper No 20941.

Bernanke BS (2015), 'The Taylor Rule: A Benchmark for Monetary Policy?', Brookings Institution blog post, 28 April, viewed 22 February 2018. Available at <https://www.brookings.edu/blog/ben-bernanke/2015/04/28/the-taylor-rule-a-benchmark-for-monetary-policy/>.

Bernanke BS (2017), 'Monetary Policy in a New Era', Paper presented at the Peterson Institute for International Economics Conference 'Rethinking Macroeconomic Policy', Washington DC, 12–13 October.

Blanchard O and J Galí (2007), 'Real Wage Rigidities and the New Keynesian Model', *Journal of Money, Credit and Banking*, 39(s1), pp 35–65.

Blinder AS (2000), 'Central-Bank Credibility: Why Do We Care? How Do We Build It?', *The American Economic Review*, 90(5), pp 1421–1431.

Borio C and P Lowe (2002), 'Asset Prices, Financial and Monetary Stability: Exploring the Nexus', BIS Working Paper No 114.

Bostrom N (2014), *Superintelligence: Paths, Dangers, Strategies*, Oxford University Press, Oxford.

Bryant RC, P Hooper and CL Mann (eds) (1993), *Evaluating Policy Regimes: New Research in Empirical Macroeconomics*, The Brookings Institution, Washington DC.

Brynjolfsson E and A McAfee (2014), *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, W.W. Norton & Company, New York.

Brynjolfsson E, D Rock and C Syverson (2017), 'Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics', NBER Working Paper No 24001.

Buncic D and M Melecky (2008), 'An Estimated New Keynesian Policy Model for Australia', *The Economic Record*, 84(264), pp 1–16.

Cagliarini A, C Kent and G Stevens (2010), 'Fifty Years of Monetary Policy: What Have We Learned?', in C Kent and M Robson (eds), *Reserve Bank of Australia 50th Anniversary Symposium*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 9–37.

Carvalho C, S Eusepi, E Moench and B Preston (2017), 'Anchored Inflation Expectations', Unpublished manuscript, 15 August. Available at <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3018198>.

Cashin P and S Ouliaris (2001), 'Key Features of Australian Business Cycles', IMF Working Paper No WP/01/171.

Demertzis M, M Marcellino and N Viegi (2008), 'A Measure for Credibility: Tracking US Monetary Developments', De Nederlandsche Bank Working Paper No 187

Disyatat P (2010), 'Inflation Targeting, Asset Prices, and Financial Imbalances: Contextualizing the Debate', *Journal of Financial Stability*, 6(3), pp 145–155.

Dungey M, R Fry-McKibbin and V Linehan (2014), 'Chinese Resource Demand and the Natural Resource Supplier', *Applied Economics*, 46(2), pp 167–178.

Dungey M, R Fry-McKibbin, V Todoroski and V Volkov (2017), 'Recovery from Dutch Disease', Australian National University, Crawford School of Public Policy, Centre for Applied Macroeconomic Analysis, CAMA Working Paper 69/2017.

Dungey M and A Pagan (2000), 'A Structural VAR Model of the Australian Economy', *Economic Record*, 76(235), pp 321–342

Eggertsson GB and M Woodford (2003), 'The Zero Bound on Interest Rates and Optimal Monetary Policy', *Brookings Papers on Economic Activity*, 2003(1), pp 139–211, 230–233.

Ehrmann M (2015), 'Targeting Inflation from below: How Do Inflation Expectations Behave?', *International Journal of Central Banking*, 11 (Supplement 1), pp 213–249.

Evans CL (2012), 'Monetary Policy in a Low-Inflation Environment: Developing a State-Contingent Price-Level Target', *Journal of Money, Credit and Banking*, 44(s1), pp 147–155.

Feldstein M (2017), 'Understanding the Real Growth of GDP, Personal Income, and Productivity', *Journal of Economic Perspectives*, 31(2), pp 145–164.

Fischer S (1995), 'The Unending Search for Monetary Salvation', in BS Bernanke and JJ Rotemberg (eds), *NBER Macroeconomics Annual 1995*, 10, The MIT Press, Cambridge, pp 275–286.

Fisher LA, G Otto and GM Voss (1996), 'Australian Business Cycle Facts', *Australian Economic Papers*, 35(67), pp 300–320.

Frankel JA (2011), 'A Comparison of Product Price Targeting and Other Monetary Anchor Options for Commodity Exporters in Latin America', *Economia*, 12(1), pp 1–57, 66–70.

Gillitzer C and J Simon (2015), 'Inflation Targeting: A Victim of Its Own Success', *International Journal of Central Banking*, 11(Supplement 1), pp 259–287.

Gordon RJ (2016), *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War,* The Princeton Economic History of the Western World, Princeton University Press, Princeton.

Gruen D, T Robinson and A Stone (2002), 'Output Gaps in Real Time: Are They Reliable Enough to Use for Monetary Policy', RBA Research Discussion Paper No 2002-06.

Henderson DW and WJ McKibbin (1993), 'A Comparison of Some Basic Monetary Policy Regimes for Open Economies: Implications of Different Degrees of Instrument Adjustment and Wage Persistence', Board of Governors of the Federal Reserve System International Finance Discussion Paper No 458.

Honkapohja S and K Mitra (2018), 'Price Level Targeting with Evolving Credibility', Bank of Finland Research Discussion Paper 5/2018.

Kavuri AS (2018), 'Technology, Leisure, Growth', PhD dissertation, Australian National University.

Kavuri AS and WJ McKibbin (2017), 'Technology and Leisure: Macro Economic Implications', Australian National University, Crawford School of Public Policy, Centre for Applied Macroeconomic Analysis, CAMA Working Paper 43/2017.

Kim B-G (2016), 'Supply Shocks and the Divine Coincidence', *Economics Letters*, 145, pp 210–213.

King M (1997), 'Changes in UK Monetary Policy: Rules and Discretion in Practice', *Journal of Monetary Economics*, 39(1), pp 81–97.

King M (2005), 'Monetary Policy: Practice ahead of Theory', Mais Lecture 2005 delivered at the Cass Business School, City University London, London, 17 May.

Lagarde C (2017), 'Central Banking and Fintech—A Brave New World?', Address given at the Bank of England 'Independence: 20 Years On' Conference, London, 28–29 September.

Łyziak T and M Paloviita (2016), 'Anchoring of Inflation Expectations in the Euro Area: Recent Evidence Based on Survey Data', European Central Bank Working Paper Series No 1945.

McCallum B (2011), 'Nominal GDP Targeting', Shadow Open Market Committee Position Paper, 21 October.

McCallum B (2015), 'Nominal GDP Targeting: Pollicy Rule or Discretionary Splurge?', *Journal of Financial Stability*, 17, pp 76–80.

McKibbin WJ, AC Morris, PJ Wilcoxen and AJ Panton (2017), 'Climate Change and Monetary Policy: Dealing with Disruption', Brookings Climate and Energy Economics Discussion Paper, 30 November.

McKibbin WJ and PJ Wilcoxen (2013), 'A Global Approach to Energy and the Environment: The G-Cubed Model', in PB Dixon and DW Jorgenson (eds), *Handbook of Computable General Equilibrium Modeling: Volume 1B*, Handbooks in Economics, Elsevier, Amsterdam, pp 995–1063.

Orphanides A (2001), 'Monetary Policy Rules Based on Real-Time Data', *The American Economic Review*, 91(4), pp 964–985.

Orphanides A and S van Norden (2002), 'The Unreliability of Output-Gap Estimates in Real Time', *The Review of Economics and Statistics*, 84(4), pp 569–583.

Poole W (1970), 'Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model', *The Quarterly Journal of Economics*, 84(2), pp 197–216.

Rees D, P Smith and J Hall (2015), 'A Multi-Sector Model of the Australian Economy', RBA Research Discussion Paper No 2015-07.

Rogoff K (1985), 'The Optimal Degree of Commitment to an Intermediate Monetary Target', *The Quarterly Journal of Economics*, 100(4), pp 1169–1189.

Saniee I, S Kamat, S Prakash and M Weldon (2017), 'Will Productivity Growth Return in the New Digital Era? An Analysis of the Potential Impact on Productivity of the Fourth Industrial Revolution', *Bell Labs Technical Journal*, 22.

Sheedy KD (2014), Debts and Incomplete Financial Markets: A Case for Nominal GDP Targeting', *Brookings Papers on Economic Activity*, Spring, pp 301–361.

Sumner S (2011), *The Case for NGDP Targeting: Lessons from the Great Recession*, Adam Smith Institute, London.

Sumner S (2014), 'Nominal GDP Targeting: A Simple Rule to Improve Fed Performance', *Cato Journal*, 34(2), pp 315–337.

Svensson LEO (1999), 'Price-Level Targeting versus Inflation Targeting: A Free Lunch?', *Journal of Money, Credit and Banking*, 31(3, Part 1), pp 277–295.

Taylor JB (1993), 'Discretion versus Policy Rules in Practice', *Carnegie-Rochester Series on Public Policy*, 39, pp 195–214.

Williams JC (2017), 'Preparing for the Next Storm: Reassessing Frameworks and Strategies in a Low R-Star World', *FRBSF Economic Letter*, No 2017-13.

Woodford M (2012), 'Inflation Targeting and Financial Stability', NBER Working Paper No 17967.

Woodford M (2013), 'Macroeconomic Analysis without the Rational Expectations Hypothesis', *Annual Review of Economics*, 5, pp 303–346.