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The Monetary Policy Rule in Australia: Does the RBA Target Inflation Only?

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This paper estimates a simple monetary policy reaction function for Australia. Although the reaction function is rather simple, it is shown to be able to capture the essential elements across different policy regimes. The empirical findings mostly corroborate the RBA's own claims made through Reserve Bank Report and Financial Statements. During the pre-inflation targeting period (1985-1992), the RBA targeted external factors such as the current account deficit and the Federal Funds Rate, in addition to inflation. Over time, the policy focus has, however, become directed explicitly towards price stability. During the post announcement period (1990-1999), the RBA targeted only future inflation up to one-year ahead. As the forecast horizon became longer than one year, however, the RBA targeted short-run output fluctuations in order to allow medium-run expected inflation to adjust rather slowly to the medium-run target. The results show that, in a flexible inflation targeting regime, medium-term price stability can be maintained while allowing some scope for targeting output variability.

Keywords: inflation targeting, policy reaction function, Australia

1. INTRODUCTION

This paper examines how the Reserve Bank of Australia (RBA) has conducted monetary policy since 1985 when the RBA abandoned the use of an intermediate monetary target for policy. The features of monetary policy during this period are worth identifying since Australia has enjoyed a period of dramatic price stability after a decade of high inflation. The identification of policy rule, that underpinned successful inflation controls, will provide useful guidance for future policy.

The monetary policy in Australia has gone through several regime changes: a loose form of monetary targeting from 1976 to 1985; a period of *ad hoc* policy without any explicit rule from 1985 to 1989; announcement of the changes to the policy stance reflected in the cash rates from 1990; and finally inflation targeting since 1993 (Grenville 1997). Two factors are worth noting among others. Firstly, the RBA implemented monetary policy via the cash rate instead of a money aggregate since its abandon of monetary targeting (Macfarlane 1987). Secondly, since 1990, monetary policy became a stand-alone instrument directed principally to price stability. Until 1990, monetary policy was integrated into other macroeconomic policies such as wages policy and fiscal policy. Therefore, this paper attempts to identify the RBA's empirical monetary policy reaction function embedded in the cash rates, mainly during the two sub-periods: pre inflation targeting (1985-92) and post announcement (1990-99).

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There have been very few attempts to estimate the RBA's reaction function, despite the fact that numerous policy reaction functions have been estimated for the Fed in the US. Smets (1997) estimates a policy reaction function for the RBA during the period 1989-96 to test whether financial asset prices are significant objectives of the policy. He shows that the RBA does not react to changes in financial asset prices such as exchange rate, but reacts only to the deviations of inflation. This paper uses a method proposed by Clarida-Gali-Gertler (1998), which is a generalization of Taylor's (1993) rule, as a gauge for characterizing and evaluating the essential elements of monetary policy. The main questions include: What is the RBA's reaction function that is consistent with the success of controlling inflation? How important are the external economic factors such as the current account and interest rate differential in policy setting? What are the differences in policy reaction (relative weights given to policy objective variables) between the two sub-periods? Are there any differences in policy reaction according to inflation forecast horizons?

Although the policy reaction function specified in this paper is rather simple, it is shown to be able to capture the essential elements across the different policy regimes. It also successfully captures the RBA's policy objectives especially when the RBA "looks at everything" in policy setting. The empirical findings coincide mostly with the RBA's own claims made through Reserve Bank Board Report and Financial Statements. During the pre inflation targeting period, the RBA was concerned more about inflation and external factors such as the current account deficit and the Federal Funds Rate rather than about the output gap. Over time, however, the policy focus has become directed more strongly towards price stability. During the post announcement period, the RBA treated external factors simply as forecasters of future inflation and targeted only future inflation up to one year ahead. As the forecast horizon becomes longer than one year, however, the RBA targeted short-run output fluctuations in order to allow medium-run expected inflation to adjust rather slowly to the medium-run target.

2. EVOLUTION OF POLICY RULES AND OBJECTIVES

2.1. Pre-Inflation Targeting: 1985-1992

The monetary policy framework in Australia has shown a substantial change since the middle of the 1980s. Grenville (1997) provides a detailed review of the evolution of the monetary policy framework in Australia (Table 1). This section will mainly focus on the factors that may have potentially influenced the setting of monetary policy as the policy framework evolved. In examining the monetary policy rule in Australia, we can observe that a loose form of monetary targeting which began in 1976 was suspended in February 1985. The main reason for this was a breakdown of the relationship between money and nominal income, as was the case in many other countries. The Labor Government, which came to power in 1983, thought of wages policy as the principal means of achieving price stability. Although the money target was set down in the budget, the RBA did not see the money target as providing day-to-day operational guidance for policy. The RBA implemented monetary policy via the cash rate instead of a money aggregate (Macfarlane 1987). The price stability and employment objective set out in the Reserve Bank Act were the main policy concerns.

After the suspension of the monetary targeting rule in February 1985, there was no explicit rule to guide monetary policy until the 1990s. In 1985/86, the RBA began to 'look at

everything' by using a 'check-list' which was a mixture of various type of objectives.[1] The task of monetary policy was to cope with the business cycle and the overall macroeconomic problems in general. The large current account deficit, the big depreciation of the Australian dollar and economic activity were the main concerns. The following statements reflect the concern of the policy authority, especially the RBA: 'The most pressing macro issue was the external problem - the large current account deficit - which put major downward pressure on the exchange rate (and thus upward pressure on inflation). Monetary policy could not fix the basic problem (the savings/investment imbalance), but had to respond to the symptom - inflation' (Grenville 1997: 132).[2]

The exchange rate has not served either as a target or an instrument of monetary policy in Australia since the float, except during 1986/1987. In July 1986, monetary policy was tightened in response to the continuing sharp depreciation of the Australian dollar. In January 1987, the exchange rate plummeted again sharply in response to events abroad. The cash rate was raised by 2 percentage points to prevent the currency returning to the low levels recorded in mid-1986. In addition to the tightening of monetary policy, large sales of foreign exchange were made out of official reserves. A key operating objective of monetary policy throughout 1986/87 was to deal with extremely strong pressures in the foreign exchange market (Reserve Bank Board 1987). This suggests that the RBA is not always indifferent to the exchange rate. The main reason is that a prolonged misalignment could seriously affect economic activity or inflation (Rankin 1998).

While inflation has been a clear priority throughout the period, economic activity has also been important in the setting of monetary policy. Nominal interest rates were eased to 11 per cent in 1987 in response to the weak economic activity. Later they were raised to 18 per cent in early 1989 in response to signs of excess demand (and possibly to the current account deficit).

Although the RBA did not target asset prices, they were also of great concern to the RBA. In response to the sharp fall (crash) of the share market in 1987, the RBA delayed tightening for longer than it otherwise would have. The main reasons for this were to avoid possible disorder and further to achieve market stability. The asset price boom in 1989 was also one of the factors behind the growing concern about excess demand and inflation.

Another task for monetary policy was 'to maintain conditions conducive to the continuing inflow of foreign capital needed to offset the current account deficit and to retain the already large and growing stock of short-term funds invested in Australia (Reserve Bank Board 1987).' This suggests that the RBA may have been concerned about the movement of the US Federal Funds Rate or interest differentials between foreign and domestic short-term interest rates.

Keeping inflation low was an important objective throughout the period. During the 1980s, however, the RBA seems to have been constrained by various macro problems such as fluctuations in output, the external imbalance, the fall in the real exchange rate, etc.

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[1] Johnston (1985: 812) described the check-list as follows: "The relevant indicators include all the monetary aggregates, interest rates, the exchange rate, the external accounts, the current performance and outlook for the economy, movements in asset prices, inflation, the outlook for inflation and market expectations about inflation".

[2] Beginning in February 1985, the exchange rate fell by 35 percent over the next 18 months and the current account deficit reached 6 percent of GDP, compared with a traditional 2-3 percent of GDP in earlier decades.

Table 1. The Evolution of Monetary Policy Framework

	Policy Rule	Transmission	Policy Context
Phase I: The End of Monetary Target (1984-Feb 1985)	• M3 target set down in the Budget • price stability & employment objective set out in the Act	• policy makers see that inflation depends on excess demand	• monetary policy was seen as closely integrated with wages policy and fiscal policy
Phase II: *Ad hoc* Policy (1985-1986)	• no explicit rule • high degree of discretion • objective described as non-inflationary growth	• inflation depends on excess demand & exchange rate	• monetary policy was fully integrated into the overall policy-making framework
Phase III: The Asset-price Boom (1987-1989)	• determination to lower inflation without specifying an exact objective	• income/output to inflation • exchange rate has an important role	• monetary policy still coordinated with other macro policies
Phase IV: The Fall in Inflation (1990 to Date)	• specific final objective (2-3% inflation over the course of the cycle since 1993) • no specific intermediate objective or operational rule	• income/output to inflation • exchange rate has an important role • price expectations became central factor in successful policy	• monetary policy as a stand-alone instrument directed principally to price stability • the Reserve Bank's independence to make monetary policy

Note: Compiled from Grenville (1997).

2.2. Post Announcement and Inflation Targeting: 1990-present

From January 1990, the RBA started to announce and explain the changes to the stance of monetary policy, reflected in the level of the cash rate. Until then, the RBA did not announce its changes to the monetary policy stance and left market participants to draw their own conclusions about policy changes. With the beginning of the policy announcement, price stability became an increasingly important focus for monetary policy. This system finally evolved to an adoption of a rule-based explicit inflation targeting in 1993.

This framework is characterized as follows (Table 1): First, the RBA adopted *a specific final objective* of '2-3 per cent inflation over the course of the cycle'. This was subsequently endorsed by the Treasurer. There was no specific intermediate objective or operational rule. The main operating instrument of monetary policy was the cash rate; Second, the RBA viewed *transmission channel* as being via output to inflation, with the exchange rate having an important role; Third, in terms of policy independence or context, monetary policy became a *stand-alone* instrument, directed principally to the objective of price stability. The monetary policy, unlike in the 1980s, was not constrained by other macroeconomic policies such as wages policy (Grenville 1997).

The empirical monetary reaction function that we want to analyze, therefore, should encompass all the factors we discussed throughout the pre-inflation targeting and post announcement periods. The standard form of central bank's objective function may not be adequate to capture all these factors. Consequently, we consider an extended form of

objective function[3], which comprises squared deviation of inflation from its target (π^*), output from potential (y_t^*) and other macroeconomic objective from its target (z_t^*):

$$L_t = E_t \sum_{s=t}^{\infty} \delta^{s-t} [(1-\lambda)(\pi_{s+n} - \pi^*)^2 + \lambda(y_s - y_s^*)^2 + \kappa(z_s - z_s^*)^2]$$

The central bank minimizes above loss function by choosing the level of the cash rate. When $\lambda \neq 0$ and $\kappa \neq 0$, the central bank considers various macroeconomic objectives in addition to inflation and output. The monetary policy during the pre-inflation targeting period falls into this category. However, the monetary policy regime can be referred to as inflation targeting if $\kappa = 0$. More specifically, the objective function with $\kappa = 0$ and $\lambda \succ 0$ is interpreted as flexible inflation targeting, and the objective function with $\kappa = 0$ and $\lambda = 0$ as strict inflation targeting regimes. In most cases, inflation targeting countries have adopted flexible regimes which consider output as well as inflation. Output considerations are still important because of the critical role that output plays in determining future inflation, even in a strict inflation targeting regime.

The following section will discuss the policy behavior of the RBA in more detail, by estimating its monetary policy reaction function.

3. A POLICY REACTION FUNCTION AND ISSUES OF ESTIMATION

Observing that the main operating instrument of monetary policy is the cash rate in Australia throughout the period since 1985, the methodology suggested by Clarida *et al.* (1998) can be applied to estimate an empirical monetary policy reaction function in Australia. The main idea is to assume that within each operating period the central bank has a target for the nominal short term policy interest rate, r_t^*, that is based on the state of the economy. The target is assumed to depend, especially, on both expected inflation and output. Other macroeconomic problems such as external imbalances and financial asset prices are not totally excluded from the target setting of the central bank. Therefore the target for the nominal policy interest rate is as follows:

$$r_t^* = \bar{r} + \beta(E[\pi_{t+n} \mid \Omega_t] - \pi^*) + \gamma(E[y_t \mid \Omega_t] - y_t^*) + \omega(E[z_t \mid \Omega_t] - z_t^*) \quad (1)$$

where $\bar{r}$ is the long run equilibrium nominal interest rate, π_{t+n} is the rate of inflation between periods t and $t+n$, y_t is real output, and z_t is an additional objective variable besides inflation and output that may potentially influence policy interest rate setting, independently of its use for forecasting inflation. The reason for using forward-looking inflation[4] is that the central bank can only affect future inflation (Svensson 1997). Additionally, π^*, y_t^* and z_t^* are respective bliss points for inflation, real output, and additional macro variable that may influence policy decision. y_t^* is assumed to be given by real potential output and z_t^* is assumed to be a linear time trend of the relevant variable z_t. E is the expectation operator and Ω_t is the information available to the central bank at the

[3] Debelle (2001) discusses an extended form of objective function that takes account of the exchange rate.

[4] Smets (1997) estimated a policy reaction function for Australia, using current trend inflation. The main differences from Smets (1997) will be discussed throughout the text.

time it sets interest rates. This specification allows for the possibility that the central bank may not have a direct information about the current values of π, y and z.

Equation (1), however, cannot capture the tendency of central banks to smooth changes in interest rates. The main reasons why central banks may want to smooth changes of interest rates are: a fear of disrupting capital markets and a loss of credibility from sudden drastic policy reversals; the need for consensus building to support a policy change and etc.[5] The policy interest rates in Australia, as in many other countries, have typically been moved many times in one direction before a reversal is made (Battellino *et al*. 1997). This is clear evidence of interest rate smoothing in Australia. In order to capture this factor, it is assumed that the actual rate partially adjusts to the target as follows:

$$r_t = (1-\rho)r_t^* + \rho r_{t-1} + v_t \tag{2}$$

where $\rho \in [0,1]$ is the degree of interest rate smoothing. The bigger the size is, the slower the adjustment to the target is. v_t is an exogenous random shock to the interest rate and assumed to be i.i.d.[6] The term v_t could reflect a pure random component to policy, or it could arise as the central bank imperfectly forecasts specific reserve demand. If the central bank does not instantly adjust reserves to offset the shock, the interest rate jumps in response to an unexpected movements in reserve demand that are orthogonal to movements in π, y and z. Combining (1) and (2), and letting $\alpha \equiv \bar{r} - \beta\pi^*$, $y_t^G \equiv y_t - y_t^*$ and $z_t^D \equiv z_t - z_t^*$, yields the following policy rule.

$$r_t = (1-\rho)(\alpha + \beta E[\pi_{t+n} \mid \Omega_t] + \gamma E[y_t^G \mid \Omega_t] + \omega E[z_t^D \mid \Omega_t]) + \rho r_{t-1} + v_t \tag{3}$$

Finally, in order to obtain an estimable equation, the unobserved forecast variables can be eliminated by rewriting the policy rule (3) in terms of realized variables as follows:

$$r_t = (1-\rho)(\alpha + \beta\pi_{t+n} + \gamma y_t^G + \omega z_t^D) + \rho r_{t-1} + \varepsilon_t \tag{4}$$

where the composite error term ε_t is a linear combination of the forecast errors of inflation, output gap, de-trended alternative macro variable and the exogenous random shock v_t. It is expressed as

$$\varepsilon_t = -(1-\rho)\{\beta(\pi_{t+n} - E[\pi_{t+n} \mid \Omega_t]) + \gamma(y_t^G - E[y_t^G \mid \Omega_t]) + \omega(z_t^D - E[z_t^D \mid \Omega_t])\} + v_t$$

The composite error term ε_t exhibits serial correlation in general. It follows MA of order n since the reaction function (4) has $t+n$ future expectation of endogenous variable on the right hand side. Without proper correction for serial correlation, parameter estimates will be relatively inefficient and the asymptotic variance-covariance matrix will be inconsistent. Furthermore, indiscriminate use of lagged endogenous variables as instruments may lead to inconsistent parameter estimates.[7] This paper uses following procedure to obtain consistent

[5] An extensive explanation of smoothing interest rate changes is found in Lowe and Ellis (1997).

[6] If we fail to reject the over-identifying restrictions of the model, the implication is either that this i.i.d. assumption is valid or that this shock is not economically important.

[7] Cumby *et al*. (1983), Hansen (1982) and Pesaran (1988), for example, provide appropriate methods

estimates even when ε_t is serially correlated or conditionally heteroscedastic. Now let X_t be a vector of instrumental variables within the central bank's information set, Ω_t that are orthogonal to ε_t at the time it chooses the policy interest rate. Since ε_t follows MA (n) process, any variables in Ω_t dated at or before period $t-n$ can enter the instrument sets X_t. Then, the generalized method of moments (GMM) using the following orthogonality conditions provides consistent estimates of the parameter vector $[\alpha, \beta, \gamma, \omega, \rho]$. The set of orthogonality conditions we are using for the estimation is:

$$E[r_t - (1-\rho)(\alpha + \beta\pi_{t+n} + \gamma y_t^G + \omega z_t^D) - \rho r_{t-1} \mid X_t] = 0 \qquad (5)$$

The instrument set X_t includes the interest rate, inflation, output gap, log difference of the world commodity price, log difference of real effective exchange rate, and additional objective variables if they are relevant in the estimation (Table 2). Each of the instruments is dated at or before period $t-n$.

There are at least four points to note regarding the GMM estimation of equation (4). Firstly, since the instrument set - and hence the number of orthogonality conditions ($E[\varepsilon_t \mid X_t] = 0$) - exceeds the parameter vector, the model is over-identified. Under the null hypothesis of over-identifying restrictions test, there exist values for $[\alpha, \beta, \gamma, \omega, \rho]$ such that the implied residual ε_t is orthogonal to the instrument set X_t. If the null hypothesis is accepted, this means that the central bank adjusts the policy interest rate each period so that equation (4) holds based on all the relevant information available to the central bank at the time. Under the alternative hypothesis, however, the orthogonality conditions will be violated and the model will be statistically rejected.

Secondly, the estimated magnitude of the parameters provides an important basis for evaluating a central bank's policy rule. For the target real interest rate to adjust to stabilize inflation as well as output, β should be greater than one ($\beta > 1$) and γ positive ($\gamma > 0$). If $\beta < 1$ (with given $\gamma > 0$), although the central bank raises the nominal interest rate in response to an expected rise in inflation, it does not increase it sufficiently to raise the real rate.

Thirdly, it is possible to recover an estimate of the central bank's target inflation rate π^*. If the sample average of the real interest rates is taken as the long run equilibrium real interest rate $\overline{rr} = \bar{r} - \pi^*$, the target inflation rate is given as $\pi^* = (\overline{rr} - \alpha)/(\beta - 1)$.

Fourthly, the reason for including other macro variable besides inflation and output is to check whether the central bank has any other policy constraints or concerns. Other macroeconomic problems such as external imbalances and financial asset prices may potentially influence policy interest rate setting. Therefore, the policy reaction function is estimated with inflation and output only (baseline case), and then with additional macro variable (alternative case). The additional alternative variables are: the current account, the real effective exchange rate, the US Federal Funds Rate and the stock price.

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for consistent estimator in this situation.

4. EMPIRICAL EVIDENCE

4.1. Data

As discussed in section 2, the RBA abandoned the use of an intermediate monetary target for policy in early 1985. Therefore, 1985Q1 is a reasonable starting point in the empirical analysis. The monetary policy reaction function (4) is estimated mainly over two sub-periods using quarterly data. The first sub-period starts from the suspension of monetary targeting rule in 1985Q1, and ends in 1992Q2 just before the announcement of inflation targeting. The second sub-period covers the 'post announcement' period starting from 1990Q1 (the announcement of an operational target for the cash rate) to 1999Q3 which is the latest quarter available. Since it is necessary to allow lags of instruments and leads of expectation, the actual samples used for estimation are adjusted: 1986Q2-1992Q4 for the pre-inflation targeting period; 1990Q1-1999Q3 for the post announcement period. The transition period 1990Q1-1992Q4 is included in both sub-periods in the sense that this period has some characteristics that reflect the two policy regimes simultaneously.

The interest rate r_t is the quarterly average cash rate in percent per annum. The real output gap y_t^G is expressed as percent deviation from real potential output. Real potential output is generated by using a Hodrick-Prescott (λ=1600) filter of real GDP. The current account as per cent of the GDP, and the US Federal Funds Rate as percent per annum are de-trended by using linear time trend (expressed as deviations to the linear time trend). The real exchange rate is the real trade weighted exchange rate index (1970=100), and the stock price is the All Ordinaries index (end of Dec. 1979=500). Both the real exchange rate and the stock price are also expressed as percent deviations from respective linear time trends.

Before estimating, it is necessary to decide the horizon of the inflation forecast that enters the reaction function. Gruen *et al*. (1997) shows evidence that the average transmission lag of the short-term interest rate on demand is about five to six quarters in Australia. Because of this policy lag, policy makers usually cannot avoid looking into the future. Since policy-makers are generally more concerned about medium-run trends in inflation, I start with one-year forecast horizon. We find further justification for using one-year forecast horizon from de Brouwer and Ellis (1998), where one-year forecast horizon is shown to be better than longer horizon because forecast error variance rises over time.[8] I also choose shorter horizons of inflation forecast (i.e. with quarterly data, $n = 2$ and 1) with a view to comparing the results at different forecast horizons. To measure the inflation rate, the Treasury underlying price index is used. The inflation rates at various horizons are entered as annualized rates. All data are from the Database of the RBA, except the Federal Funds Rate and the world commodity price index (1995=100) that are from IFS CD-Rom.

4.2. One-Year Forecast Horizon

Table 2 shows the results of the GMM estimation with one-year inflation forecast horizon. Since the GMM estimation procedure provides asymptotically correct standard errors, it is possible to assess the statistical significance of the results. The over-identifying restrictions

[8] See also Dungey and Pagan (2000). The horizon problem raises two questions: the first is the periodicity of inflation (monthly, quarterly, etc.); and the second is the optimal targeting horizon n (Haldane, 1997).

are not rejected in most of the estimation results, which means that the policy reaction functions appear correctly specified and the instrumental variables used are valid instruments.

The baseline specification is statistically rejected during the pre-inflation targeting period. Instead, the current account and the Federal Funds Rate enter into the policy reaction function significantly and with right signs, individually and together. Therefore, the alternative specification with the current account/the Federal Fund Rate represents the RBA's policy reaction during the pre-inflation targeting period. During the post announcement period, however, the baseline specification is accepted and none of the other macro variables are statistically significant at the traditional 5 % level.

Several points are worth noting from the two results mentioned above. Firstly, an anticipated one percent rise in one-year ahead inflation induces the RBA to raise nominal cash rate by 0.90 points during the pre-inflation targeting period, but by 2.50 points during the post announcement period. This result implies that the RBA was concerned not only about the expected inflation, but also about external factors such as the current account and the foreign interest rate. This factor led the RBA to raise nominal policy rates in response to the expected inflation, but not enough to push up the real interest rates during the pre-inflation period. During the post announcement period, however, the RBA has raised real interest rates in response to the expected inflation ($\beta = 2.50 > 1$). This means that the policy focus has become directed more strongly towards price stability over time. In particular, the disinflation of the early 1990s is associated with an increase in estimated inflation reaction parameter, compared to that of previous period. This result is in line with the standard result of Taylor's (1993) rule used by Judd and Rudebusch (1998), where they show the disinflation of the early 1980s in the US is associated with an increased inflation reaction parameter of the Fed's rule.[9]

Secondly, external factors were taken as policy targets during the pre-inflation targeting period, but not during the post announcement period. During the pre-inflation target period, the current account and the Federal Funds Rate were taken by the RBA as external constraints. The last row of the pre inflation target period shows that if the ratio of current account to GDP deteriorates one percent from the trend, the RBA responds to it by raising the nominal cash rate by 1.71 points. A one percent rise in the Federal Funds Rate from the trend also induces the RBA to raise the Australian nominal cash rate by 1.80 points. This result implies that the RBA had tried to keep the interest rate differentials to a certain level so as not to allow a sharp depreciation of exchange rates and/or a sudden outflow of foreign capital already invested in Australia. However, none of these external constraints was significant at 5 % level during the post announcement period. This implies that the RBA began to shift policy focus explicitly to the stability of inflation since the beginning of the policy announcement in 1990. Each of these variables was treated only as an inflation forecaster by the RBA during the post announcement period.

[9] But, Nelson (2000) shows some contrasting result for the UK: where the disinflation and the increase in the real interest rate during the 1979-1987 periods are related to changes in the structure of the economy rather than to the increased inflation reaction parameter.

Table 2. Policy Reaction Function with One-Year Forecast Horizon ($n = 4$)

$$r_t = (1-\rho)(\alpha + \beta\pi_{t+4} + \gamma y_t^G + \omega z_t^D) + \rho r_{t-1} + \varepsilon_t$$

	β	γ	ρ	α	ω_1	ω_2	π^{*} [1]	O.I.R. [2]
Pre-Inflation Targeting: 1986. II - 1992. IV								
Baseline	**1.15**	**2.11**	**0.83**	4.82			15.5	χ^2 (7)=17.1
	(0.46)	(0.97)	(0.08)	(2.36)				(0.02)
Alternative: [3]								
Current Account	**0.87**	0.56	**0.68**	**7.96**	**-2.62**		6.23	χ^2 (8)=14.3
	(0.25)	(0.53)	(0.09)	(1.51)	(0.82)			(0.08)
Real Ex. Rate	**2.03**	0.38	**0.72**	0.97	**0.36**		6.00	χ^2 (8)=14.7
	(0.45)	(0.59)	(0.06)	(2.80)	(0.15)			(0.08)
Fed Funds Rate	**1.08**	-1.06	**0.67**	**6.49**	**2.81**		8.25	χ^2 (8)=13.0
	(0.28)	(0.91)	(0.06)	(1.44)	(0.98)			(0.11)
Stock Prices	**2.29**	**1.75**	**0.80**	-0.00	-0.17		5.54	χ^2 (8)=13.9
	(1.09)	(0.71)	(0.09)	(6.05)	(0.13)			(0.09)
Current Account/	**0.90**	-0.82	**0.60**	**7.96**	**-1.71**	**1.80**	8.10	χ^2 (9)=10.3
Fed Funds Rate	(0.18)	(0.40)	(0.05)	(0.77)	(0.64)	(0.27)		(0.33)
Post-Announcement: 1990. I – 1998. III								
Baseline	**2.50**	0.63	**0.78**	0.61			2.66	χ^2 (7)=9.6
	(0.99)	(0.38)	(0.04)	(2.13)				(0.21)
Alternative: [3]								
Current Account	2.81	-0.64	**0.81**	-0.00	-2.59		2.54	χ^2 (7)=1.6
	(1.44)	(0.82)	(0.05)	(3.47)	(2.01)			(0.95)
Real Ex. Rate	**2.89**	0.33	**0.70**	0.02	0.10		2.42	χ^2 (8)=8.5
	(0.47)	(0.45)	(0.09)	(1.22)	(0.09)			(0.39)
Fed Funds Rate	**2.28**	0.31	**0.77**	1.17	0.38		2.68	χ^2 (8)=10.3
	(0.66)	(0.66)	(0.03)	(1.57)	(0.32)			(0.25)
Stock Prices	2.27	0.81	**0.77**	1.06	-0.03		2.78	χ^2 (8)=9.3
	(1.31)	(0.76)	(0.03)	(2.93)	(0.07)			(0.32)

Table 2. Continued

$$r_t = (1-\rho)(\alpha + \beta\pi_{t+4} + \gamma y_t^G + \omega z_t^D) + \rho r_{t-1} + \varepsilon_t$$

	β	γ	ρ	α	ω_1	ω_2	π^{*} [1]	O.I.R. [2]
				The Whole Period: 1986. II – 1998. III				
Baseline	**1.27**	**2.46**	**0.80**	**4.00**			5.85	$\chi^2(7)=18.3$
	(0.53)	(1.02)	(0.06)	(1.49)				(0.01)
Alternative: [3] Fed Funds Rate	**1.53**	0.06	**0.72**	**3.58**	**1.50**		3.77	$\chi^2(8)=14.5$
	(0.34)	(0.72)	(0.05)	(1.31)	(0.71)			(0.07)

Note: The estimates are obtained by GMM with correction for MA(4) autocorrelation. The numbers in parentheses are standard errors. The bolded coefficients are significant at 5% level. The instruments for the baseline case are constant, two lags (dated at t-4 and t-5) of the cash rate, the underlying inflation rate, the output gap, the log difference of the world commodity price index, and the log difference of the real effective exchange rate.

[1] The sample averages of the real interest rates are 7.15% during the pre inflation target period, 4.60% during the post announcement period and 5.58% during the whole period.

[2] Tests of over-identifying restrictions. Numbers in parentheses below the χ^2 statistics are p-value.

[3] Two lags of additional variables (dated at t-4 and t-5) are also included in the instruments set for the alternative cases.

Thirdly, output gap was not significant in both sub-periods. The intuition for this is that adjusting one-year ahead expected inflation to the medium-run target requires more output fluctuations. This result is similar to that of Smets (1997) who, unlike this case, used current trend inflation instead of one-year ahead future inflation.

Fourthly, the estimated degree of interest rate smoothing parameter ρ is about 0.78 during the post announcement period. The implication of this partial adjustment should also be noted: the condition $\beta = 2.50 > 1$ and $\gamma = 0.63 > 0$ does not guarantee that the real interest rate goes up immediately when expected inflation rises, but that it eventually goes up. This result is supported by the observation that policy interest rates in Australia have typically been moved several times in one direction before a reversal is made.

Fifthly, if the sample average of the real interest rates is taken as the long run equilibrium real interest rate $\overline{rr} = \bar{r} - \pi^*$, the target inflation rate can also be calculated using the estimated parameters and the formula $\pi^* = (rr - \alpha)/(\beta - 1)$. The resulting target inflation rates can be obtained as the second column from the right in Table 2. Especially for the baseline case during the post announcement period, the target rate of inflation is shown to be 2.66% given the sample average real interest rate of 4.60%. The target rates of inflation for the alternative specifications also fall between 2.42% and 2.78%, that is, within the target range of inflation between two and three per cent in Australia. Policy makers in the 1980s, however, relied on other macro policies as well as monetary policy to control inflation. Therefore, it is not sufficient to deduce the RBA's implied target for inflation from the estimated monetary policy rule for the period such as pre inflation targeting period.

Finally, a clear shift in monetary policy regime is detected judging from the second and third findings above. The RBA seems to target explicitly one-year ahead inflation during the post announcement period ($\kappa = 0$ and $\lambda = 0$).

4.3. Alternative Forecast Horizons

It is also interesting to examine if there is any difference in policy reaction according to inflation forecast horizon. Table 3 shows the results of the GMM estimation with various inflation forecast horizons. The data for inflation are annualized in each horizon. During the pre inflation targeting period, the RBA seems to have been concerned not only about the expected inflation but also about the current account and/or the foreign interest rate in its policy setting. Since the overall pattern of policy reaction is similar to that of one-year forecast horizon, we do not report the results of the pre inflation targeting period.

During the post announcement period, however, none of the other macro variables is statistically significant at 5 % level. Instead, the results show that the RBA has adopted a flexible inflation targeting regime. Up to one-year forecasting horizon (n = 1, 2, 4), the RBA seems to have paid direct concern to inflation deviation, but not to output deviation directly ($\kappa = 0$ and $\lambda = 0$). The cash rate is adjusted so that the expected inflation rate up to one year is equal to the target inflation rate.

However, direct concern is paid to the output variability rather than to inflation variability as the forecast horizon becomes longer than one year (n = 5, 6). The relative weight on output variability becomes higher as the forecast horizon becomes longer ($\kappa = 0$ and $\lambda \to 1$). This is because the RBA, independently of medium-run inflation targeting, may have reacted to the real excess demand in the short-run. Debelle (1999) deals with the case, where medium-term price stability can be maintained while still allowing some degree of short-run inflation variability, thus providing scope for lower output variability.

Debelle (1999) suggests some aspects that allow some degree of output stabilization in Australia's inflation target: First, the target band of inflation rate between 2 and 3 per cent has allowed for the increased flexibility; Second, the medium-term nature of Australia's inflation target has allowed room for output stabilization. The more medium term the inflation target, the greater weight the RBA can give to output stabilization.

Another interesting thing to note is that the finding on relative weights supports the theoretical prediction of Svensson (1997), where the higher the weight on output stabilization, the slower the adjustment of the expected inflation towards the medium-run target. A higher weight on output stabilization makes the inflation temporarily deviate from the target. This is quite similar to the case where interest rate smoothing objective makes the inflation deviate temporarily from the target to reduce the necessary interest rate changes.

Table 3. Policy Reaction Function with Various Forecast Horizons:
Post-Announcement

$$r_t = (1-\rho)(\alpha + \beta 2\pi_{t+n} + \gamma y_t^G + \omega z_t^D) + \rho r_{t-1} + \varepsilon_t$$

	β	γ	ρ	α	ω_1	ω_2	π^{*} [1]	O.I.R. [2]
One-Quarter Forecast Horizon (n = 1): 1990. I - 1999. II								
Baseline	**1.86**	0.43	**0.66**	**1.91**			**3.12**	χ^2 (7)=9.4
	(0.39)	(0.26)	(0.12)	(0.64)				(0.23)
Two-Quarter Forecast Horizon (n = 2): 1990. I – 1999. I								
Baseline	**1.71**	0.58	**0.75**	**2.20**			**3.39**	χ^2 (7)=9.4
	(0.46)	(0.36)	(0.05)	(1.02)				(0.16)
Four-Quarter Forecast Horizon (n = 4): 1990. I – 1998. III								
Baseline	**2.50**	0.63	**0.78**	0.61			2.66	χ^2 (7)=9.6
	(0.99)	(0.38)	(0.04)	(2.13)				(0.21)
Five-Quarter Forecast Horizon (n = 5): 1990. I – 1998. II								
Baseline	0.34	**1.40**	**0.83**	5.32			1.09	χ^2 (7)=5.2
	(1.33)	(0.42)	(0.03)	(3.12)				(0.64)
Six-Quarter Forecast Horizon (n = 6): 1990. I – 1998. I								
Baseline	-1.45	**1.48**	**0.85**	**9.17**			**1.87**	χ^2 (7)=3.8
	(1.15)	(0.52)	(0.03)	(2.95)				(0.80)

Note: See Table 2. The estimates are obtained by GMM with correction for MA (n). The instruments are the same as in Table 2, but dated at $t-n$ and $t-n-1$ for the case of MA (n) process. Since we allow different lags of instruments and leads of expectation, the sample periods are automatically adjusted accordingly.

5. CONCLUSIONS

The findings of this study are mostly consistent with the RBA's own claims in its Reserve Bank Board Report and Financial Statements. During the post announcement period, the RBA has raised nominal interest rates sufficiently to push up real rates in response to the one-year ahead expected inflation. The policy focus has become more concentrated towards price stability since 1990. It has also smoothed changes in interest rates, which implies the real interest rate does not go up immediately when expected inflation rises, but it eventually goes up. The recovered target rates of inflation from the policy rule fall between 2.42% and 2.78%, within the target range of inflation between two and three per cent in Australia.

Unlike during the post announcement period, external factors such as the current account and the Federal Funds Rate were taken by the RBA as external constraints during the pre-inflation targeting period.

Up to one-year forecasting horizon (n = 1, 2, 4), the RBA seems to have paid direct concern to inflation deviation, but not to output deviation directly. However, direct concern is paid to the output variability rather than to inflation variability as the forecast horizon becomes longer than one year (n = 5, 6). The relative weight on output variability becomes higher as the forecast horizon becomes longer. This is because the RBA, independently of medium-run inflation targeting, may have reacted to the real excess demand in the short-run. In other words, when the policy rule becomes more forward-looking, the relative weight on output becomes higher. Therefore, the adjustment of the inflation to the medium-run target becomes slower with more forward-looking policy rule.

Overall, the estimation results of the policy reaction function point to a regime change in the monetary policy of Australia since 1990. The policy rule we considered, especially for the post announcement period, is simple for the public to follow and to predict. One of the merits of adopting simple policy rule is that it is relatively easy to obtain policy credibility through transparency.

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