

Inflation Targeting Through Short Term Interest Rate: Australian Experience

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Abstract: The article is based on empirical data from Australian Economy. It made an attempt to evaluate the success of Reserve Bank of Australia (RBA) in controlling inflation by aggressively using cash rate. The main objective of the research is to find out the relationship of RBA's monetary policy with Taylor Rule; whether it follows the Taylor Rule mechanically or uses a different form (e.g. forward looking) or depends on other factors as well. Other models have been used for estimation and the results are analyzed subsequently. The evidences from the test results suggest the successful implementation of interest rate rule by the Reserve Bank to stabilize the inflationary pressure in terms of forward looking perspective.

1.0 INTRODUCTION

The monetary policy has evolved in the last few decades towards a new concept—*inflation targeting*. Many countries are already practicing inflation targeting as a tool for monetary policy. New Zealand was the first country that introduced inflation targeting in 1990. Till then it dispersed to other countries, i.e. Canada, UK, Sweden, Australia, Finland etc. The basic idea of inflation targeting is that, central bank adjusts the short term interest rate in such a way that ensures the projections of inflation and other variables satisfy the target criterion. Though the objective of inflation targeting is to stabilize the inflation around the target, it also takes into account the importance of output gap by allocating some weight onto it. The inflation targeting is based on the following characteristics:

- ◆ *Numerical Inflation Target:* Central bank usually specifies the target as a range rather than point estimation.
- ◆ *Inflation-Forecasting-Targeting:* The decision making process is stated as inflation-forecasting-targeting.
- ◆ *Transparency & Accountability:* The overall process must be transparent and central bank must be accountable for the consequences. Usually, in the inflation targeting regime, central bank makes public announcements about any changes in policy indicating both current inflation and expected future inflation states and steps needed to keep inflation in track.

The desired level of target inflation actually achieved gradually over a period than in one instance. The stability is linked with the concept “Price Stability”, and this price stability does not refer to zero inflation rather it is closer to a low level (i.e. 2%) annual rate of price changes. The target price level need not remain constant indefinitely, but could be allowed to drift upward in a predetermined way over time (Goodhart and Vinals, 1994; Svensson, 1996).

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The inflation targeting ignores the unanticipated shocks and does not try to offset; thus in the long run it might result in large variation in price level. In contrast, under strict price level targeting, the shocks are offset by counter policy implementations that keeps the long run variances at minimal though it creates large swings in short run.

1.1 The Monetary Policy Rule

The central bank in an economy sets the short term interest rate in response to economic activity. The $r = \pi + gy + h(\pi - \pi^*) + r^f$ (see *Appendix A* for notation) rule can be used to set the short term interest rate once the parameters are determined given real GDP and inflation. Taylor's basic rule suggests that:

- ◆ Easing money market conditions in response to lower inflation or declines in production
- ◆ Tightening money market conditions in response to higher inflation or increase in production
- ◆ In both the cases the g and $1+h$ would be positive

As the size of the parameters is not stated; too high or low value could result in poor economic performance. Even though monetary policy rule has been proven to be effective based on empirical evidence, still there are some arguments whether policy rule or discretion will dominate the monetary decisions. Generally, policy rules are algebraic expressions entailing fixed settings for the policy instruments; whereas discretion is the settings for the instruments of policy and are determined from scratch each period with no attempt to follow a reasonably well defined contingency plan for the future (Taylor, 1993). The general idea about policy rule is the fixed settings of the instruments of monetary policy. But Taylor has presented his view for policy rule in different way:

“The rules are responsive, calling for changes in the money supply, the monetary base, or the short term interest rate in response to changes of the price level or real income.”¹

Policymakers do not need to follow the policy rules mechanically. Policy rules do not provide entire explanations of the monetary issues. Such as, whether a rise in the price is temporary or permanent requires analyzing several measures; i.e. consumer price index, producer price index, employment cost index, expectation on inflation, term structure of interest rates, surveys etc. The quantitative methods aid to analyze these issues more precisely but only algebraic expression is not sufficient to explain these measures. Therefore, policy rule and discretion should be complement to each other not substitute.

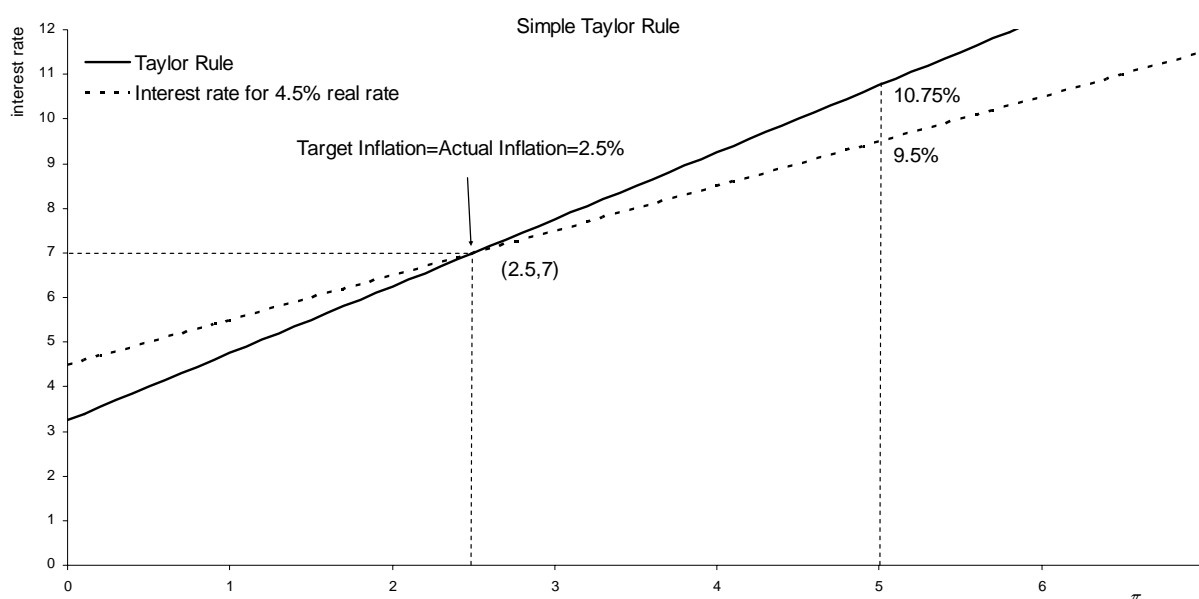
The concept of policy rule is also changing. Economists suggest that policy rules should not be interpreted as fixed settings for the policy instruments. Flexibility (i.e. feedback or responsiveness) should be part of the policy rules that is policy rule also incorporates judgments. In light of view, *a policy rule would include a nominal income rule in which the central bank takes action to keep nominal income on target, but it would not include pure discretionary policy* (Taylor, 1993).

A simple example of Taylor Rule that how it works is as follows:

$$r_t^* = (r^n + \pi^*) + \lambda_\pi (\pi_t - \pi^*) + \gamma_x x_t \text{ (see Appendix A for notation)}$$

¹ *Discretion versus policy rules in practice*—John B. Taylor, 1993

Figure I: Simple Taylor Rule



Assumptions:

Long Run Real Interest Rate $r^n = 4.5\%$, Target Inflation Rate $\pi^* = 2.5\%$, $\gamma_\pi = 1.5$, $\gamma_x = 0.5$.
For simplicity it is assumed that output gap, $x_t = 0$

1.2 IMPLICATIONS OF THE PARAMETERS λ_π & γ_x

Inflation Parameter: If, $\lambda_\pi > 1$

$\lambda_\pi > 1$ means that it is the condition for the interest rate rule where inflation and economic activity will be **stabilizing**, (given $\gamma_x > 0$). It implies that, if the inflation rises above the target level, then the central bank must increase the nominal interest rate more than in line with the increase in inflation; so that it will raise the real interest rate. Therefore, it will dampen the real economic activity in the short run, and subsequently it will result in decrease in inflation rate. Therefore, the trade off between inflation control and output growth exists in the short run in this policy regime.

Inflation Parameter: If, $\lambda_\pi < 1$

$\lambda_\pi < 1$ means that it is the condition for the interest rate rule where inflation and economic activity will be **destabilizing** or it will accommodate the shocks of the economy. In this instance, though the central bank increases the nominal rate in response to an expected rise in inflation, but the increase in nominal rate is not enough to stop the real interest rate from declining. In this, “accommodative” regime, self fulfilling burst of inflation and output may be possible (Bernanke and Woodford, 1996; Clarida et al., 1997).

Output Deviation Parameter: γ_x

$\gamma_x > 0$: Similar logic applies here as well. $\gamma_x > 0$ means stabilizing condition, (given $\lambda_\pi > 1$).

$\gamma_x < 0$: Destabilizing condition.

$\gamma_x = 0$: There is no output gap.

Benchmark: $\lambda_\pi = 1$ & $\gamma_x = 0$ to evaluate differences in the estimated policy rules.

1.3 FORWARD LOOKING MODEL

Pure forward looking model can be defined as the one in which the bank’s action at any time is conditioned solely upon those aspects of the state of the world that are relevant for forecasting the subsequent evolution of the bank’s target variables--inflation rate & aggregate economic activity (M.Woodford, 2000). Other authors also described forecasted inflation

targeting in other ways. According to Lars E. O. Svensson (1999) “inflation forecasting targeting” is an economic model which is used to generate conditional forecast paths for the target variables from the present onwards associated with alternative feasible policies. The central bank thus selects the best applicable option depending on its criterion, i.e. target future inflation.

Clarida, Gali, & Gertler (2000) developed simple forward looking model based on Taylor’s backward looking reaction function (1993). The applicability of this rule depends on the degree of autonomy of a central bank over its economy. They assumed that the domestic monetary policy is independent of any external constraints. The main operating instrument is the short term nominal interest rate because by varying the nominal interest rate the real interest can be changed. But then again, the relationship between short term interest rate and the real economic activity is short run as well. In the medium run, the output actually comes to its natural level and the policy results in only nominal changes in prices. Still, the policy’s effect on the short run output in the economy actually limits central bank’s policy management. As an example, if central bank intends to reduce inflation in the short run then it has to increase nominal short term interest rate. As a result this will reduce the output as well, depending on the nominal stickiness. Thus, the central bank has to consider these issues while taking its policy decision. It is assumed that in each period the central bank has a target for the nominal short term interest rate.

2.0 EMPIRICAL RESEARCH

The empirical research is based on Australian economy. It mainly focuses on how Reserve Bank of Australia (RBA) exercises its monetary policies and how it controls the inflation and how it achieves the inflation stabilizing. An overview of Australian monetary policy and RBA’s operations are discussed in the following section.

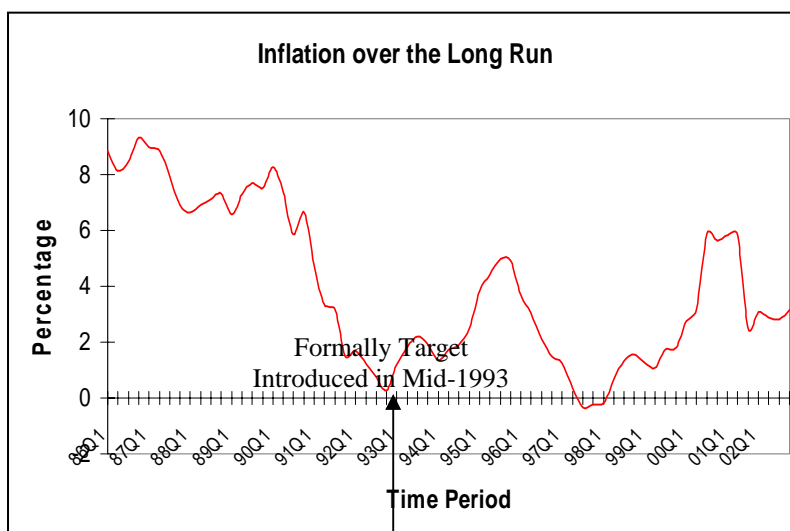
2.1 OVERVIEW OF AUSTRALIAN MONETARY POLICY

The objectives of monetary policy in Australia are formally developed in the *Reserve Bank Act (1959)*.²

- I. *The stability of currency of Australia*
- II. *Maintenance of full employment in Australia*
- III. *The economic prosperity and welfare of the people of Australia*

The first objective is related to inflation targeting. The stability of currency means the stability of price that is the equality in purchasing power parity. In order to achieve this objective RBA started to target inflation.

Australia started its informal inflation targeting as early as 1989. Reserve Bank of Australia (RBA) started achieve low inflation target during 1989 (Stevens, 1999). In 1993, Bernie Fraser, then governor of RBA, first announced the inflation



² Monetary Policy—Reserve Bank of Australia, http://www.rba.gov.au/Education/monetary_policy.html

targeting as 2-3%. The inflation target was formalized in a joint government-RBA *Statement on the conduct of Monetary Policy* in 1996.³

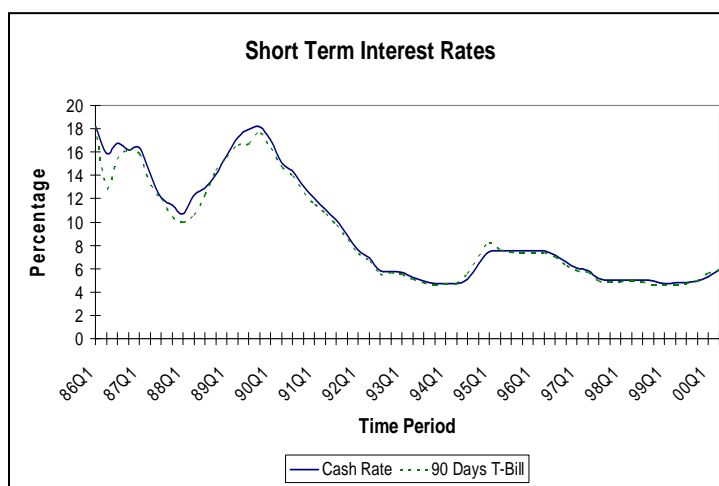
The monetary policy in Australia is responsible for short term trade-offs between inflation and activity or employment keeping in mind the policy objective that is meeting the target on average over the course of an economic cycle. The trade-offs can be described as:

- ⊕ A policy relaxation helps to stimulate the economic activities and ultimately it will increase inflation and accommodate economic growth.
- ⊕ In contrast, tightening of policy will result in slower economic growth and inflation in the following period.

Hence, it is evident that in the short term, policy makes a choice between inflation control and economic growth.

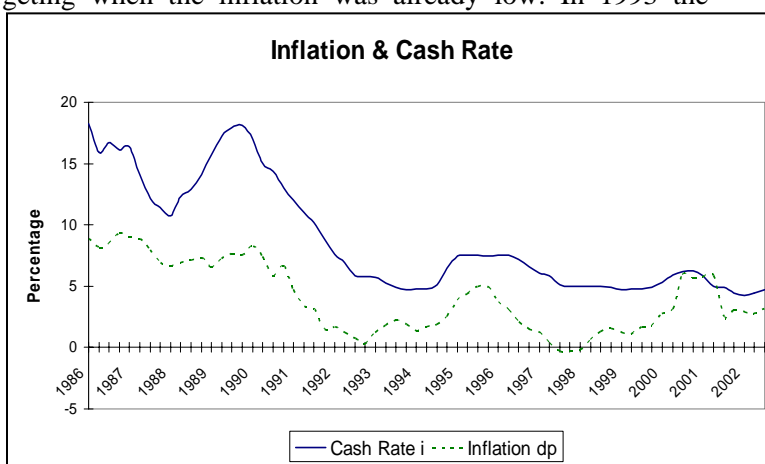
2.1.1 Implementation of Monetary Policy

The monetary policy instrument used by RBA is the short term interest rate; in this case it is Cash Rate—a market interest rate on overnight funds charged by financial intermediaries. RBA operates through the open market operations to exercise the changes. The cash rate is determined in the money market through the demand and supply equilibrium of the overnight funds. The cash rate itself is highly related to other short term interest rates in the market and thereby it fixes all the short term interest rates (money market rates and key rates of banks & financial intermediaries) in overall economy. Thus, cash rate can be very powerful in controlling the aggregate economy. The closeness of cash rate and other short term rates (i.e. 90 days T-Bill) is given in the above diagram.



2.1.2 RBA's Performance over the Inflation Targeting Period

Australia started its inflation targeting when the inflation was already low. In 1993 the inflation was just over 2% after the high inflation of late 80s. Its objective was to lock the inflation at low level and consequently form a framework for expectations. One of the important features of RBA's policy is that it ignores the unavoidable temporary fluctuations in inflation.



³ *Optimal Monetary Policy Rules and Inflation Targets: Are Australia, Canada, and New Zealand Different from the U.S.?*—Sean Collins and Pierre L. Siklos, March 2004.

The economic outcomes of the two periods, period of inflation targeting and previous period, have been given below⁴:

Comparison of Inflation during Targeting and Previous Period

	1980-1992	1993-June 2000
Inflation (Standard Deviation)	7.0 (2.4)	2.1 (0.6)
GDP Growth (Standard Deviation)	2.8 (2.7)	4.4 (0.8)

The main points are:

- ◆ The inflation was low during targeting period relative to its previous period.
- ◆ Over this period the average inflation were just over 2%. The variability of inflation in targeting period was lower than the previous period as well.
- ◆ But interestingly, the inflation targeting did not hamper the output growth of the economy. The output growth averaged over 4% per annum since 1993.

2.2 OBJECTIVES OF THE RESEARCH

The two main objectives demonstrated in this research are as follows:

1. Identification of the existence of a relationship between Cash Rate with inflation and output gap by using simple Taylor Rule.
2. Identification of the existence of a relationship between Cash Rate and forecasts of future inflation and output gap along the lines suggested by the Forward Looking Model.

2.3 METHODOLOGY

2.3.1 Data

The data are quarterly time series seasonally adjusted data. The data have been collected from the data base called '*Data Stream*'. For the model estimation and the parameters estimation, *STATA* program is used.

Cash Rate is used as short term interest rate. Cash Rate is the market interest rate on overnight funds that is directly controlled by Reserve Bank of Australia (RBA).

Real *Gross Domestic Product* (GDP) is used to measure output. To measure the output gap, the log of real GDP was de-trended using a quadratic trend. The real GDP is measured in 1997-98 prices.

Consumer Price Index (CPI) is used to measure the inflation. The baseline inflation measure is the rate of change of CPI between two subsequent quarters. The base year for CPI is 1990. The inflation target is interpreted in terms of a measure of the overall CPI, a change to which the Treasurer and RBA agreed (1998).⁵

2.3.2 Assumptions & Rationales

- ◆ The main operating instrument of monetary policy, used by RBA, is a short term interest rate (cash rate). RBA can affect real activity in the short run by changing the cash rate.
- ◆ RBA is assumed to have a target for nominal short term interest rate within each operating period based on the state of the economy.
- ◆ RBA is assumed to make one year-ahead forecast in inflation as it seems good indicator of the medium term trend in inflation.

⁴ Australia's Experience with Inflation Targeting---Ian J. Macfarlane (2000)

⁵ Monetary Policy—Reserve Bank of Australia, http://www.rba.gov.au/Education/monetary_policy.html

- ◆ RBA has its total autonomy to conduct its operation.
- ◆ The domestic monetary policy is assumed to be free of any external constraints.
- ◆ Exchange rate shocks are ignored in the setting of policy as they are expected to have only temporary impact on inflation.

2.3.3 Time Horizon

The data have been collected for 71 quarters starting from 1985:1 to 2002:3. After calculating the inflation, 4 quarters' data were lost. Therefore, Taylor Rule has been formed during 1986:1 to 2002:3. For dynamic model, with one lag period in cash rate, assumed that the RBA set cash rate considering last quarter's figure. Thus the cash rate was lagged by one quarter. In forward looking model it is assumed that the RBA looks ahead one year for inflation forecast and one quarter ahead of output gap. In addition, in the model, the RBA is assumed to set its target by adjusting to last one year's actual rate.

2.3.4 Implementation of Taylor Rule

In *section 3.1*, simple Taylor Rule has been estimated and plotted against the two policy rules (1 & 2). The simple Taylor Rule takes the following form: [*Notations: Appendix A*]

$$r_t^* = (r^n + \pi^*) + \lambda_\pi (\pi_t - \pi^*) + \gamma_x x_t \dots \dots \dots \text{Taylor Rule}$$

$$3.5 + 1.5\lambda_t + 0.5 * x_t; \quad t=1986:Q1 \text{ to } 2002:Q3 \dots \dots \dots \text{Policy Rule 1}$$

$$3.5 + 1.5\lambda_t + 1.0 * x_t; \quad t=1986:Q1 \text{ to } 2002:Q3 \dots \dots \dots \text{Policy Rule 2}$$

2.3.5 Model Estimation

In *section 3.2.1* static model is estimated. The static model takes the following form:

$$> r_t^* = \alpha_0 + \alpha_1 \pi_t + \alpha_2 x_t; \text{ Where } \alpha_0 = r^n + \pi^* - \lambda_\pi \pi^*$$

In *section 3.2.2* the dynamic model with one quarter lag in cash rate is estimated. The following model is used:

$$> r_t = \rho r_{t-1} + (1 - \rho)\alpha_0 + (1 - \rho)\alpha_1 \pi_t + (1 - \rho)\alpha_2 x_t$$

In *section 3.2.3* the forward looking model is estimated by using the following form:

$$r_t = (1 - \rho)\{\alpha + \gamma_\pi E\pi_{t+1,k} + \gamma_x Ex_{t+1,q}\} + \rho r_{t-1}, \text{ where } \alpha = r^n + \pi^* - \gamma_\pi \pi^*$$

Finally, in *section 3.2.4*, the backward looking model is estimated by:

$$r_t = (1 - \rho)\{\alpha + \gamma_\pi \pi_{t+1,k} + \gamma_x x_{t+1,q}\} + \rho r_{t-1} \dots \dots \dots (7)$$

Where, $\alpha = r^n + \pi^* - \gamma_\pi \pi^*$ and $k = q = -ve$ [*Notation: Appendix A*]

3.0 DATA ANALYSIS AND FINDINGS

In the beginning of this section, data has been utilized to depict the simple Taylor Rule and its implications have been discussed. In the following sections four models (*static, dynamic, forward looking, & backward looking*) have been estimated and their implications been discussed.

3.1 SIMPLE BASE LINE POLICY RULE: TAYLOR RULE

Taylor Rule has been implemented in Australian economy taking the actual output gap and inflation for period 1986:1 to 2002:3. γ_π is assumed to be 1.5 (*stabilizing condition*) in both Policy Rule 1 and 2, and the γ_x is assumed to be 0.5 in Policy Rule 1 and 1.0 in Policy Rule 2.

$$r_t^* = (r^n + \pi^*) + \lambda_\pi (\pi_t - \pi^*) + \gamma_x x_t \dots \dots \dots \text{Base Rule}$$

$$\begin{aligned}
 > r_t^* &= (r^n + \pi^* - \lambda_\pi \pi^*) + \gamma_\pi \pi_t + \gamma_x x_t \\
 > r_t^* &= (4.5 + 2 - 1.5 * 2) + 1.5\pi_t + 0.5x_t
 \end{aligned}$$

Here, $\pi^* = 2, \gamma_\pi = 1.5, \gamma_x = 0.5, t=1986:Q1$ to 2002:Q3,

Constant=3.5 calculated taking $r^n=4.5\%$, is the sample average.

$$> r_t^* = 3.5 + 1.5\pi_t + 0.5x_t \dots\dots\dots\text{Policy Rule 1}$$

Again,

$$> r_t^* = (4.5 + 2 - 1.5 * 2) + 1.5\pi_t + 1.0x_t$$

Here, $\pi^* = 2, \gamma_\pi = 1.5, \gamma_x = 1.0, t=1986:Q1$ to 2002:Q3

$r^n=4.5\%$, is the sample average

$$> r_t^* = 3.5 + 1.5\pi_t + 0.5x_t$$

$$> r_t^* = 3.5 + 1.5\pi_t + 1.0x_t \dots\dots\dots\text{Policy Rule 2}$$

3.2 IMPLICATION OF POLICY RULE VS CASH RATE

Policy Rule 1: $3.5 + 1.5\lambda_t + 0.5 * x_t; t=1986:Q1$ to 2002:Q3

Policy Rule 2: $3.5 + 1.5\lambda_t + 1.0 * x_t; t=1986:Q1$ to 2002:Q3

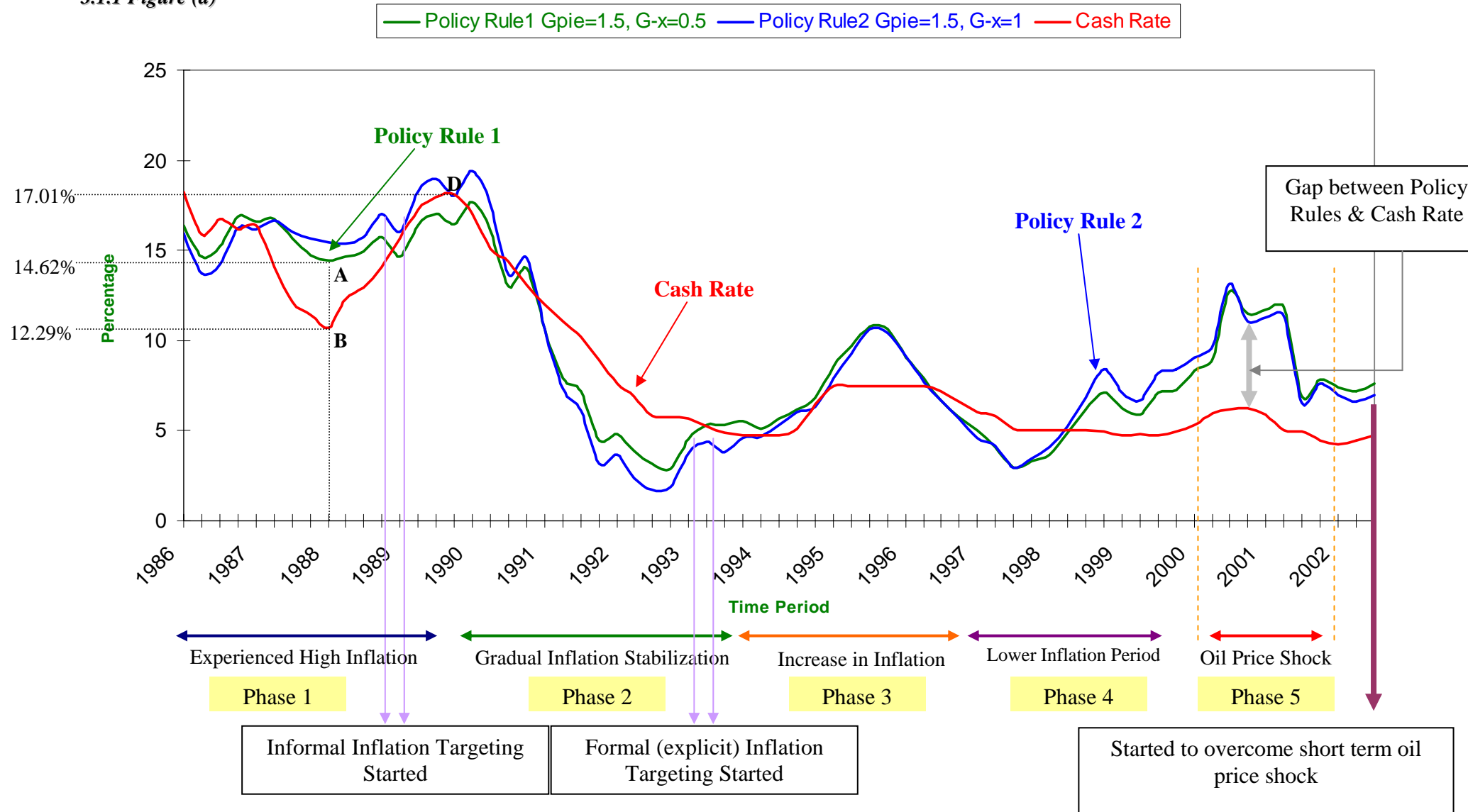
According to the policy rule, after experiencing high inflation during the 80s, Reserve Bank should have increased the Cash Rate high enough to increase the real rate that would ultimately pull down the demand; as a result economic growth would be slowed down and subsequently the inflation would fall. The trade-off between inflation stability and economic growth always been an issue but still in inflationary situation economic slow-down can be considered as viable macro-objective; because in the long run it would create a sound basis for growth.

In the policy rule 1(a) and 2(a), the γ_π is assumed to be 1.5 and thereby based on that, the desired level of cash rate been calculated while considering the γ_x as 0.5 (in rule 1a) or 1.0 (in rule 2a). Under policy rule 1(a), in 2nd quarter of 1988, according to the policy rule 1(a), the Cash Rate should have been 14.62% (point ‘A’ in figure 1) whereas the actual cash rate was 12.29%--way below the target interest rate. In contrast, in 1990 (quarter 1) the cash rate was roughly the same (point ‘D’ in the figure 1) as required by policy rule 1(a)—that is Reserve Bank was aggressively controlling the inflation by setting higher cash rate.

Further down the line, during early-90s the cash rate was way above the policy rules. Despite the decreasing trend, the cash rate superceded the rate suggested by the policy rule. Reserve Bank took more aggressive monetary policy than suggested by Taylor Rule. The responsiveness of the policy taken by Reserve Bank was higher. Objective of Reserve Bank of Australia is to keep the inflation rate between 2 to 3% on an average, over the business cycle.

Cash Rate and Policy Rule 1 and 2: 1986:Q1 to 2002:Q3

3.1.1 Figure (a)



3.3 Chronological Explanations⁶

✦ Phase 1: Experienced High Inflation and Set High Cash Rate

Major rises in the interest rate occurred during 1981/82, 1985 and 1988/89, which were designed to reduce the inflationary boom and resulted in slower growth in demand. Market experienced high inflation during 1988 and 1989; money market interest rate increased by 7% since the early months of 1988 till 1990 and subsequently market slowed down a bit due to reduced spending. The 3rd/4th quarter in 1989, the cash rate reached to its **highest level around 18%**.

✦ Phase 2: Gradual Reduction of Cash Rate to Reactivate the Economy

Starting from the 1990 the Reserve Bank realized that the economy was slowed down because of such high cash rate set in early period. Even in the 1st quarter 1990, the cash rate was at **one of its highest levels, 17.0133%**. The objective was to slowdown the economy in order to reduce the inflation. The effect of this move was working out throughout the economy by slowing down the economic activities.

Later, Reserve Bank took the other way round—boosts the economy by reducing cash rate. In January 1990, Reserve Bank reduced the interest and this reduction in the cash rate was expected to flow through the security yields and interest rates charged by the intermediaries. But economy was still in inflationary pressure. In February, 1990 Reserve Bank further reduced the cash rate by 0.5% as the aggregate demand was decreasing. Inflation remained at high level and in order to move to the right direction Reserve Bank thought to reduce the cash rate further down. Thus, it kept on reducing the cash rate in August/October/December roughly by one percentage point respectively, aiming to reduce the inflation in the medium run while avoiding excessive slowdown in the economy. During that time, retail trade was flat, investment reduced, and employment was also falling, imports declined, and credit growth also declined resulted from earlier higher rate.

Reserve Bank maintained the trend of cash rate reduction during 1991 (May/September/November) by 1 percentage point. In late 1991 the inflation came down to around 1.5% which is lower than their target inflation rate: 2--3%. In spite of the lower inflation rate, Reserve Bank gradually kept on reducing the interest rate because the economy didn't recover the earlier higher interest rate effect as it was expected. The unemployment rate was fairly high.

The early period of 1993 followed the similar trend—that is the reduction in cash rate but at a lower level. The economic activities were stronger than the earlier period. The Australian economy about to enter into the period of sustained low inflationary growth.

✦ Phase 3: Periods of Cash Rate Increase: Forward Looking Approach

In August 1994, Reserve Bank increased cash rate by 0.75%, in October it raised the cash rate by another 1%; these increases were first in almost over the last four years. Their policy was forward looking and therefore the major reason for the rate increase was to avoid overheating of the economy and consequently prolonging the period of sustained growth. It was necessary to sustain non-inflationary growth as the economy was growing robustly. The economic recovery was already achieved and the total output was about 10% higher than its low point in mid-1991. The pace of activity was accelerated in the previous year and unemployment rate decreased. Household spending increased than the forecasted figure and aggregate credit was increased with sustained expansion in economic activity. The reduction in cash rate was to avoid any overheating in economy.

⁶ Media Release by Reserve Bank of Australia.

The inflation itself was in target level—2%. At the end of the year (December) Reserve Bank further increased the cash rate by 1% as the growth was stronger than expectation. The implied consumer price index was increasing at 2% rate.

◆ **Phase 4 Periods of Relatively Lower Inflation**

The 1997 was a period of economic growth with low inflation. In 1997, RBA reduced the interest rate two times (May, June) and pulling it down to 5% from 6%. The forecasted inflation was less than 2%, thus RBA went for easing of monetary policy. Actually, the economy was freed from the inflationary pressure; the underlying consumer price inflation was 1.7% (lower than their target) in mid year. In December 1998, RBA further reduced the cash rate by 25 basis points as the Australian economy was growing faster than the Bank or most other forecasters had expected. Therefore, RBA increased the cash rate by 25 basis points in November, 1999.

◆ **Phase 5: Periods of Oil Price Increase, Fluctuating Economy & Effect of Sept 11**

2000: Increase in Cash Rate:

Australia's economy had stronger GDP growth and employment growth which was higher than expectation during 2000. CPI rose to 3.2 % over the year to June quarter due mainly to international oil price increase and also domestic overheating of economy. Expectations of inflations increased as well. The oil price increase seemed to be a temporary shock; therefore RBA had to deviate from its inflation targeting. In 2000, RBA increased the cash rate to 6.25% from 5%.

2001: Decrease in Cash Rate:

The picture changed in 2001. International economic conditions weakened due to the terrorist attack on the USA on September 11. Through the trading partners, it affected Australian economy as well. Oil price declined sharply. There was downward pressure on inflation. Equity prices declined, corporate profit reduced and demand for credit by business reduced as well. Thus, RBA reduced the cash rate six times throughout the year and pulled down the cash rate to 4.25% in December 2001.

2002: Increase in Cash Rate

The economic climate changed markedly in 2002. The economic conditions were better both in Australia and rest of the world. There were upturn among Australia's main trading partners in the East Asia region (except Japan). Businesses were expanding their investments, household spending increased and employment increased as well. Inflation reached 2.9% that is close to the upper target level. Thus, RBA increased the cash rate to 4.75% in mid 2002.

3.2 ESTIMATION OF FOUR MODELS

In this section four models have been estimated and the results are discussed:

1. The Static Model
2. Dynamic Model with 1 Lag Period in Interest Rate (Cash Rate)
3. Forward Looking Model
4. Pure Backward Looking Model

3.2.1 Static Model

The static model considered the actual inflation and output gap in each period to identify the policy rule, hence calculated the γ_π , γ_x and the constant.

Table I: Reaction Function: Static Model

Parameters	Value	P Value	Implication
γ_π	1.3114 > 1	$P=0.000$	<i>Stabilizing Condition</i>
γ_x	0.2647 > 0	$P=0.133$	<i>Statistically not significant</i>
α_0	3.532263	$P=0.000$	<i>Statistically significant</i>

Explanations of the estimation of the Static Model

The γ_π is significantly higher than one, $\gamma_\pi=1.31$. It means that a rise in inflation of one percentage point induces the Reserve Bank to raise real rates by 31 basis points. The coefficient γ_x is positive but statistically not significant. The constant is positive and statistically significant.

3.2.2 Dynamic Model: With 1 Lag Period in Interest Rate

In dynamic model the interest rate setting is assumed to be done with a smoothing adjustment. Actually in real situation the Reserve Bank does not want to change the interest too different from its previous period's rate, because of fear of disruption of capital markets, loss of credibility from sudden large policy reversals etc. In this section it is assumed that Reserve Bank adjusts the actual rate to the target in the following way:

Table II: Reaction Function: Dynamic Model with 1 Lag in Cash Rate

Parameters	Value	Test Value	Implications
γ_π	1.0478 > 1	$P=0.8725$	<i>Not significantly higher than 1</i>
γ_x	1.2841 > 0	$t=2.86 (H_0: x=0)$	<i>Statistically significant</i>
ρ	0.8758647	$SE: 0.0369322$	<i>Statistically significant</i>
α_0	3.1332943	$t=1.84 [H_0: (1-\rho)\alpha_0 =0]$	<i>Statistically not significant</i>

The lag in cash rate is one quarter, i_{t-1} .

We assume that Reserve Bank of Australia looks behind 1 quarter of cash rate in order to define its policy.

Explanations of the estimation of the Dynamic Model with 1 lag period in r

Generally, interest rate rule implies that the sign of the response of the real rate target to changes in expected inflation and output gap depends on whether γ_π is greater or less than one and on the sign of γ_x respectively. The result depicts that a rise in the inflation of one percent induces the Reserve Bank to raise real rates by 5 basis points. The statistical result stated that γ_π is not higher than one, the null hypothesis could not be rejected in this case that γ_π is equals to one. Therefore, here γ_π could be equals to or lower than one. The coefficient γ_x is positive and statistically significant. It means that one percent rise in the

output gap induces the Reserve Bank to increase the nominal rates by 28 basis points, taking inflation as constant. But most importantly, as the γ_π is not statistically higher than one (or could be lower than one), it can be deduced from the empirical evidence that RBA might not follow this backward looking model while implementing their monetary policy.

3.2.3 Forward Looking Model

Reserve Bank of Australia believes that the inflation targeting has to be forward looking, as evidenced by the operation of monetary policy since its inception. However, at the same time it believes that the formulation allows for both forecasting and lags in the effects of monetary policy in the economy.⁷ Therefore, the policy rule followed by the Reserve Bank includes both expectations and also the past inflation experiences. Thus, in the following forward looking model, both expectations and lagged inflations have been estimated and discussed. The Reserve Bank has target for short term nominal interest rate, that is cash rate (the market interest rate on overnight funds) in Australia, r_t^* . In the baseline case, the assumption has been made that the target depends on both expected inflation and output.

Table III: Reaction Function: Forward Looking Model

	γ_π	γ_x	ρ	α_0
Base Line (C)	2.1374115 $p=0.0507$	0.48431173 $t=0.74$ ($H_0: x=0$)	0.6074498 (SE: 0.0668521)	0.01132639 $t=0.01$ [$H_0: (1-\rho)\alpha_0=0$]
Adding: Lagged Inflation ^a (D)	1.7293043 $p=0.323$ test_b[dp]=(1-_b[l.i])	0.47082143 $t=0.83$ ($H_0: x=0$)	0.5466824 (SE: 0.1457823)	0.63336941 $t=0.29$ [$H_0: (1-\rho)\alpha_0=0$]

Estimate of π^* for baseline specification, $\pi^*=3.95$.

The instruments are $x_{t-1}, x_{t-2}, x_{t-3}, x_{t-4}$ and $\pi_{t-1}, \pi_{t-2}, \pi_{t-3}, \pi_{t-4}$ and i_{t-4} .

Estimate of π^* assumes that long-run equilibrium real interest rate is equal to sample average of $r^t=4.5$.

We assume that Reserve Bank of Australia looks ahead 4 quarters for inflation and 1 quarter for output gap that is $k=4, q=1$.

^a π_{t-4}, t

Explanations of the estimation of the Forward Looking Model

The top line of the **Table III** reports the results for the baseline specification. The most important estimation is the coefficient on the inflation gap, $\gamma_\pi : 2.14$. The result depicts that a rise in the expected annual inflation of one percent induces the Reserve Bank to raise real rates by 114 basis points. The general rule states that in order to stabilise the inflationary pressure the γ_π should be greater than one, but in this case the γ_π is high above one. The prediction of the Reserve Bank that it increases the real rate in case of inflationary pressure is statistically significant as long as γ_π is significantly greater than one. The estimation of the output gap is also interesting. The coefficient γ_x is positive. One percent rise in the output

⁷ About Monetary Policy—Reserve Bank of Australia, http://www.rba.gov.au/Monetary_Policy/about_monetary_policy.html. pg. 2.

gap induces the Reserve Bank to increase the nominal rates by 48 basis points, taking inflation constant. The interest rate smoothing parameter ρ is statistically significant as well. The long run inflation target $\pi^*=3.95$. The sample average real rate was taken as the estimation of the long run real rate that is 4.5 (approx.). Then the following expression was used to calculate the π^* :

$$\pi^* = (r^n - \alpha) / (\gamma_\pi - 1)$$

The estimated value, 3.95, actually is higher than the Reserve Bank's target of 2-3%. Alternative to the baseline specification has been considered as well. The results are mentioned in the second row of table III. The lagged inflation for four quarters has been included in the reaction function along with the expected inflation and output. After estimation with lagged inflation the γ_π becomes 1.73 but it is not statistically significant.

The interest rate smoothing parameter ρ is statistically significant. And the coefficient γ_x is roughly unchanged.

3.2.4 Simple Backward Looking Model

In this section, backward looking model has been estimated in order to find out whether the Reserve Bank follows the backward model for its policy rule or not. Two time horizons are considered here by assuming:

- A. Reserve Bank follows last quarter's inflation & output gap to take its current policy
- B. Reserve Bank follows last year's inflation and last two quarters' output gap to take its current policy

Table IV: Reaction Function: Pure Backward Looking Model

	γ_π	γ_x	ρ	α
A. k=q=-1; (1.i)	0.5805325 <i>p</i> =0.2820	1.6490642 <i>t</i> =2.76; (<i>H</i> ₀ : <i>x</i> =0)	0.9016162 (SE: 0.0418369)	4.2876505; <i>t</i> =1.86 [<i>H</i> ₀ : (1- ρ) α_0 =0]
B. k=-4, q=-2; (14.i)	0.6358965 <i>p</i> =0.0723	1.4124478 <i>t</i> =4.61; (<i>H</i> ₀ : <i>x</i> =0)	0.5176188 (SE: 0.1084923)	4.6353185; <i>t</i> =3.79 [<i>H</i> ₀ : (1- ρ) α_0 =0]

The lags: A. x_{t-1} and π_{t-1} , and i_{t-1} . B. x_{t-2} and π_{t-4} , and i_{t-4} .

Explanations of the estimation of Backward Looking Model

The γ_π in both the cases is lower than one depicting the destabilizing condition as outcome of monetary policy. Thus, it can be concluded from the above result against its monetary policy evidence, that Reserve Bank does not follow pure backward looking model for its policy decision.

4.0 CONCLUSION

Among the different models, the forward looking model (section 3.2.3, Cases: C & D), has γ_π , which is statistically higher than one. Thus, from the empirical evidence and in comparison with the test results, it is evident that Reserve Bank of Australia successfully implemented interest rate rule to stabilize the inflationary pressure in terms of forward looking perspective. The test values also suggest that the value of γ_π should be higher than one. In conclusion, it can be deduced that Reserve Bank of Australia has been fairly responsive to inflation rate and this also confirms with the empirical result that they changed the cash rate aggressively to control the inflation rate during its inflation targeting period.

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APPENDIX: A: NOTATIONS

TAYLOR RULE:

$$\mathbf{A.} \quad r = \pi + gy + h(\pi - \pi^*) + r^f$$

r : Short term interest rate, π : Inflation rate, π^* : Target Inflation rate, y : % change in real output (Y) from trend, r^f : Central bank's estimate of the equilibrium real rate of interest, h : Amount by which the central bank raises the ex-post real interest rate ($r-\pi$) in response to an increase in inflation, g & $(1+h)$: response coefficients.

$$\mathbf{B.} \quad r_t^* = (r^n + \pi^*) + \lambda_\pi(\pi_t - \pi^*) + \gamma_x x_t$$

r^n : Long Run Real Interest Rate, π^* : Target Inflation rate, λ_π : Inflation Parameter, γ_x : Output Deviation Parameter, π_t : Inflation at period t , x_t : Output gap in period t

FORWARD LOOKING MODEL:

$$\mathbf{A.a.1:} \quad r_t^* = r^* + \beta(E\{\pi_{t,k} | \Omega_t\} - \pi^*) + \gamma E\{x_{t,q} | \Omega_t\}$$

r_t^* : Target Rate for nominal interest rate in period t , β : Inflation Parameter, $\pi_{t,k}$: The percentage change in the price level between periods t and $t+k$; $x_{t,q}$: Average output gap between period t and $t+q$, E : Expectation operator, π^* : Target Inflation, r^* : The Desired nominal rate when both inflation and output at their target level, Ω_t : The information set at time t , γ : Output gap parameter.

$$\mathbf{A.a.2:} \quad r_t = \rho r_{t-1} + (1-\rho)r_t^* + v_t$$

r_t : Actual Fund Rate set by Reserve Bank; r_t^* : Target Rate for nominal interest rate in period t ; ρ : Degree of Smoothing of interest rate changes; r_{t-1} : Interest rate in period $t-1$ (previous period).

$$\mathbf{A.a.3:} \quad rr_t^* = r_t - E\{\pi_{t,k} | \Omega_t\} \text{ and } rr^* = r^* - \pi^*$$

rr_t^* : Real Rate Target at period t ; rr^* : Long run equilibrium real rate; E : Expectation operator; π^* : Target Inflation; Ω_t : The information set at time t ; $\pi_{t,k}$: The percentage change in the price level between periods t and $t+k$.

BACKWARD LOOKING MODEL

$$r_t = (1-\rho)\{rr^* - (\beta-1)\pi^* + \beta\pi_{t,k} + \gamma x_{t,q}\} + \rho(L)r_{t-1} + \varepsilon_t \text{ Where } k = q = \textit{negative}$$

r_t : Target rate; ρ : Degree of Smoothing of interest rate changes; r_{t-1} : Interest rate in period $t-1$ (previous period); β : Inflation Parameter; $\pi_{t,k}$: The percentage change in the price level between periods t and $t+k$; $x_{t,q}$: Average output gap between period t and $t+q$; γ : Output gap parameter