y = total output, defined as production based GDP, from ABS group NADQ. Service sector defined as for n above.

yg = real government social welfare benefit payments per person of working age, derived from ABS catalogue 5206–37 as the sum of the following series: Commonwealth government social security payments (for sickness, permanent disability, family and child benefits, and other) and other Commonwealth personal benefits payments.

yo = real other income from non-labor sources. Sum of income from unincorporated enterprises, ownership of dwellings, interest and dividends (ABS catalogue, 5206–28).

New Zealand

lf = labor force participation rate, defined as for Australia (Statistics NZ HLFq.sae1az), but available from December 1985 only. Backdated to 1980 using data from NZIER, see Garbey and others (1993) (lff for females, lfm for males).

pop<15 = population under 15/total population (Statistics NZ INFOS group DAE).

fstud = ratio of female students aged 15–25 to female population aged 15–25.

serv = service sector output/total output (Statistics NZ SN3Q.S2AQT/SNBQ.SZAZT).

u = unemployment rate, defined as the ratio of persons unemployed (Statist s NZ HLFQ.S1B3S) to the population of working age (HLFQ.S2D3QZ). Backdated to 1980 using Garbey (1993) (uf for females, um for males).

wt = average weekly ordinary time earnings, total all industries (Statistics NZ QESQ.SD1Z9A) less net direct tax on labor income (TD from Reserve Bank of New Zealand database), deflated by the headline CPI (wtf for females, wtm for males).

yg = real government social welfare benefit payments per person, derived from Statistics N.Z. (Statistics NZ SOWA). Sum of: domestic purposes, invalidity, sickness, family, and family-care benefits and accommodation supplement (backdated using GFS housing subsidy). Annual data was converted to quarterly data using a cubic spline.

yo = real other income from nonlabor sources. Sum of income from interest, dividends and current transfers. Annual data was converted to quarterly data using a cubic spline.

ypen = real government pension payments (National Superannuation) per person aged 60 and over, derived from Statistics NZ (SOWA). Annual data was converted to quarterly data using a cubic spline.

III. Monetary Policy and Uncertainty in the Unemployment-Inflation Process: How Aggressively Should Policymakers Experiment to Find the NAIRU?[1]

A. Introduction

1. In countries enjoying subdued inflation, such as Australia, monetary policy faces the challenge of deciding how much the economy can be allowed (or induced) to expand without permitting the unemployment rate to fall significantly below the nonaccelerating inflation rate of unemployment (NAIRU). The challenge is magnified by the fact that econometric estimates of the NAIRU are very imprecise.[2]

2. In the ongoing debate over monetary policy strategies, some economists have suggested that "experimentation" with pushing unemployment lower can yield more accurate information about the NAIRU and therefore potentially raise welfare by allowing policymakers to move the economy closer to the NAIRU without compromising inflation performance. In Australia's case, the current unemployment rate is only about ½ percentage point above the median estimate of the NAIRU, so the issue is potentially of significant policy relevance. The uncertainty associated with the level of the NAIRU in Australia—which is likely to have been affected to some degree by recent labor market reform—compounds the dilemma faced by policymakers.

3. How aggressive should policymakers be in experimenting to find the NAIRU? The answer depends on an assessment of the possible macroeconomic consequences and welfare costs of allowing the unemployment rate to fall below the NAIRU. Such an assessment in turn depends critically on how the unemployment-inflation process is modeled. The analysis in this chapter assumes a convex Phillips curve relationship between inflation and unemployment. It also treats policy credibility as imperfect and endogenously related to the monetary authorities' success in delivering low inflation.

4. Section B of this chapter summarizes the model that is used in Section C to undertake stochastic simulation experiments comparing macroeconomic performance under alternative monetary policy reaction functions. The chapter illustrates the relative attractiveness of a base-case rule in which the monetary authorities react to deviations of an inflation forecast from target and deviations of the unemployment rate from the NAIRU, as well as to the degree of bias in inflation expectations (or the degree to which policy credibility is imperfect). The presence of NAIRU uncertainty and endogenous policy credibility magnifies the gains from

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[1]This chapter was prepared by Peter Isard and Douglas Laxton. The chapter was presented at a seminar during the 1998 Article IV consultation mission to Australia, and the authors are grateful to the participants and discussants for helpful comments and suggestions.

[2]Staiger, Stock, and Watson (1997) provide perspectives on the degree of imprecision.

pursuing an inflation-forecast targeting strategy—that is, a strategy which tightens (loosens) policy whenever forecast inflation is above (below) the target—relative to a conventional inflation targeting strategy—that is, a strategy which adjusts policy as a result of deviations between actual (as opposed to forecast) and target inflation.

5. Section D turns to the issue of experimentally probing for the NAIRU. The results of some additional stochastic simulations suggest that modest experimental departures from a relatively attractive policy rule would not substantially improve macroeconomic performance. In other words, adding noise to the economy through experimentation does not substantially improve the authorities' ability to identify the NAIRU, given the amount of noise to which the economy is already subjected.

6. Section E presents some simulations designed to gauge the potential benefits from improving the transparency of monetary policy. To do this, it takes the view that when the authorities are less than fully transparent about their policy performances, reaction function, or model of the economy, this can undermine policy credibility and thereby contribute to a bias in the public's inflationary expectations, i.e., a gap between those expectations and the authorities' target inflation rate. The simulation exercise attempts to evaluate the cost of this expectations bias, and the potential benefits from improving transparency. The analysis suggests potentially large welfare gains associated with eliminating inflation expectations bias.

7. Section F provides concluding remarks.

B. A Model of the Australian Unemployment-Inflation Process

8. The analytical frameworks that have been developed for addressing monetary policy issues for an open economy like Australia traditionally assume that the authorities control a short-term interest rate (rs) with the objective of influencing the rates of inflation (π) and unemployment (u). Changes in the policy instrument are transmitted to the policy target variables through several channels. Adjustments in the nominal interest rate can trigger movements in the nominal exchange rate (s), which are transmitted fairly directly to tradable goods prices and inflation and indirectly to unemployment through their effects on the real exchange rate (z) and the gap (y) between actual and potential domestic output. Changes in the nominal interest rate also affect the real interest rate ($rs - \pi^e$), both directly and through the response of inflation expectations (π^e). Changes in the real interest rate in turn influence unemployment through their effects on aggregate demand and the domestic output gap; and changes in the output gap and unemployment rate influence the inflation rate through channels summarized by the Phillips curve. In addition, important feedback mechanisms are at work over time, with inflation expectations responding to the history of inflation and inflation influenced in turn by changes in inflation expectations. The role of monetary policy in such models is to react to observed and anticipated changes in unemployment, inflation, and other

macroeconomic variables, taking account of the behavioral relationships among these variables.

9. In reality, the operation of monetary policy is greatly complicated by two types of uncertainties: imperfect information about the magnitudes of the various transmission effects; and difficulties in identifying the effects on macroeconomic variables of various types of economic shocks. In principle, there can be exogenous shocks that directly affect the exchange rate, the observed inflation rate, or the expected inflation rate; and there can be exogenous shifts in the output gap associated with shocks to either aggregate demand or potential aggregate supply.

10. The operation of monetary policy is also complicated by the fact that policy credibility is imperfect and can vary with the effectiveness of the monetary authorities in achieving desirable outcomes for policy target variables. The endogeneity of policy credibility and its role in the monetary policy transmission mechanism has not yet been adequately incorporated into the models that have been used to analyze monetary policy issues. The analysis in this chapter relies on a model of the Australian unemployment-inflation process that has been developed in Isard and Laxton (1998) and Isard, Laxton, and Eliasson (1998). It is an empirical model that features endogenous policy credibility, convexity in the Phillips curve, as well as uncertainty about the NAIRU. Important features of the model are that policy credibility depends upon the historical track record on inflation and that policy errors can result in a significant bias in inflation expectations. In addition, because the model embodies a convex Phillips curve, the average unemployment rate will be lower if policymakers are relatively successful at stabilizing the business cycle.

C. Comparisons of Policy Rules Under NAIRU Uncertainty

11. In recent years, formal analysis of monetary policy strategies has identified various classes of policy reaction functions with "inflation targeting" or "inflation-forecast targeting," broadly defined as strategies in which the monetary policy instrument—most typically a short-term interest rate—is adjusted in response to, but not necessarily only in response to, deviations of the inflation rate (or an inflation forecast) from an explicit target. Under one prominent class of reaction functions, advocated by Taylor (1993) among others, the interest rate setting is linked to both the deviation of inflation from target and the deviation of the unemployment rate from the NAIRU. Under a second class of rules, proposed by Laxton, Rose, and Tetlow (1993), the interest rate setting is conditioned by an inflation forecast (relative to target), rather than the most recently observed inflation rate. Haldane and Baltini (1998) and others have referred to these as *inflation forecast based* or IFB rules.[3]

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[3]Forward-looking IFB rules have been used for almost a decade at the Bank of Canada to solve nonlinear macroeconomic models designed for policy analysis.

12. As Taylor (1993) was careful to emphasize, "simple, algebraic formulations of . . . [policy] rules cannot and should not be mechanically followed by policymakers," (page 213). But analysis of the hypothetical performance of mechanical rules within simple but fairly realistic macroeconomic models can nevertheless provide valuable guidance about the general types of policy reactions that are likely to be effective for achieving and maintaining macroeconomic stability in the real world.

13. From that perspective, this chapter describes some stochastic simulation experiments that support the following contentions:

- First, in a world with NAIRU uncertainty and imperfect policy credibility, conventional inflation-targeting strategies (Taylor rules) are likely to be significantly outperformed by inflation-forecast targeting strategies (IFB rules). In other words, there are gains to reacting to deviations of projected inflation from target rather than to actual inflation from target.

- Second, the interest rate setting should depend not only on deviations of the inflation forecast from target and the unemployment rate from the NAIRU, but also be positively related to—and thus designed to counteract—the degree of bias in the public's inflation expectations, or the degree to which policy credibility is imperfect.

- Third, although policymakers' estimates of the NAIRU may be highly inaccurate, a rule that places some weight on the estimated unemployment gap can be beneficial.

14. The two classes of candidate rules that are considered—IFB rules and Taylor rules—can be respectively written in the general forms:

$$rr_t = rr^* + \alpha(\hat{\pi}_{t+3} - \pi^{TAR}) + \beta(E_t\pi 4_{t+4} - \pi^{TAR}) + \gamma(\bar{u}_t - u_t) \quad (1)$$

$$rr_t = rr^* + \alpha(\pi_t - \pi^{TAR}) + \gamma(\bar{u}_t - u_t) \quad (2)$$

where

$$rr_t = rs_t - E_t\pi 4_{t+4} \quad (3)$$

Here rs_t is the nominal interest rate setting at time t; rr_t is the concept of the real interest rate on which aggregate demand depends; $E_t\pi 4_{t+4}$ denotes the public's expectations at time t of the

inflation rate over the year ahead;[4] rr^* is a constant corresponding to the equilibrium real interest rate; π^{TAR} denotes the target rate of inflation; $\hat{\pi}_{t+3}$ is the authorities' model-consistent forecast of inflation in quarter t+3, based on information through quarter t-1; π_t and u_t denote the rates of inflation and unemployment in period t; and $\bar{u}_t$ is the authorities' estimate of the NAIRU based on observed data through period t-1.

15. The two right-hand side terms in equation (2), and the first and third terms in equation (1), are relatively traditional components of proposed policy reaction functions, corresponding to the deviation of inflation (or the authorities' inflation forecast) from target and the deviation of the unemployment rate from the NAIRU. The second term in equation (1)—the deviation of the public's inflation expectations from the inflation target—reflects the bias in the public's inflation expectations, or the degree to which policy credibility is imperfect.

16. Table III.1 summarizes the simulation results.[5] Each column corresponds to a different rule, with IFB rules (variants of equation (1)) shown in the first four columns and Taylor rules (variants of equation (2)) in the last two columns. For each rule, the selected parameter values for equations (1) or (2) are described in the top row of the table. The first column represents the base-case rule with $(\alpha, \beta, \gamma) = (1,1,1)$. The second and third columns present examples of inflation-forecast targeting strategies under which the interest rate is set independently of the degree of the bias in inflation expectations; in column 2, α and γ have the same values as in column 1, while in column 3, $\alpha + \beta$ and γ have the same values as in column 1. The fourth column shows an IFB rule with no weight on the unemployment rate. The fifth column shows an inflation-targeting rule with relatively low weight on the inflation rate, as initially suggested by Taylor (1993) in the U.S. context, while the sixth column shows a Taylor rule with more weight on inflation.

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[4]The original Taylor rule used a backward-looking measure of inflation expectations to measure the real interest rate.

[5]The model used and the simulation methodology are described in Isard and Laxton (1998).

Table III.1. Stochastic Simulations with Selected Policy Rules

	IFB Rules (α, β, γ)[1]				Taylor Rules (α, γ)[2]	
	Rule 1:	Rule 2:	Rule 3:	Rule 4:	Rule 5:	Rule 6:
	(1,1,1)	(1,0,1)	(2,0,1)	(1,1,0)	(.5,1)	(1,1)
	Sample Means					
u	7.50	7.12	7.53	7.57	7.82	7.82
π	2.60	2.95	2.63	2.52	4.01	3.20
π^e	2.70	3.22	2.76	2.63	4.43	3.53
c	0.90	0.75	0.87	0.87	0.54	0.70
r - π^e	2.24	2.35	2.25	2.17	2.46	2.42

17. Under the two Taylor rules, the means for unemployment and inflation significantly exceed their respective means under the IFB rules. By the same token, the average level of credibility (c) is lower under the Taylor rules, and the mean of inflation expectations (π^e) is higher.[6] Part of the explanation lies in the different weights that the different rules place on inflation or the inflation forecast; the best inflation performances are achieved under rules 1, 3, and 4, which place a combined weight of 2 on inflation objectives ($\alpha + \beta$), while the worst performance comes from rule 5, which gives inflation a weight of 0.5. But a comparison of rules 2 and 6, which place the same weights on both unemployment and inflation variables, illustrates the significant gains from policies that react to an inflation forecast rather than current inflation. Rule 2 delivers lower average values for unemployment, inflation, and expected inflation, as well as a higher average level of credibility.

18. Some intuition for these results starts with the recognition that with considerable uncertainty about the NAIRU, policymakers are bound to make significant, and possibly persistent, errors in estimating the unemployment gap. Given that the Phillips curve transmits errors about the unemployment gap into inflation, the greater the uncertainty that surrounds estimates of the unemployment gap, the stronger should be the policy reaction to inflation relative to unemployment. Moreover, imperfect policy credibility and convexity in the Phillips

[6]Policy credibility, c, is modeled as a stock that depends on the historical performance of the central bank in controlling inflation.

curve increases the costs of responding slowly to emerging inflation, thus magnifying the advantages of inflation-forecast targeting over conventional inflation targeting.

19. The simulations suggest benefits from policy rules that place some weight on unemployment, however. A comparison of columns 1 and 4 speaks to this point. In particular, the base-case rule (column 1) achieves a lower mean unemployment rate than a rule that places no weight on the unemployment gap but is otherwise comparable (column 4). This does not necessarily imply, however, that the base-case rule dominates the rule shown in column 4, since the latter rule delivers a lower mean inflation rate.

20. A comparison of Rule 1 and Rule 2 illustrates the potential tradeoff that policymakers face between inflation control and minimizing the level of unemployment. Policies that place a large weight on inflation and inflation expectations relative to unemployment—Rule 1—will experience better inflation performance and higher levels of policy credibility but at the cost of higher unemployment.

D. Are There Gains from Experimentation?

21. Are there gains from experimenting with lower unemployment for purposes of pinpointing the NAIRU? In this section, the issue is explored under the assumption that monetary policy is guided—absent experimentation—by the base-case inflation-forecast targeting rule above, namely, equation (1) under the settings $(\alpha, \beta, \gamma) = (1, 1, 1)$.

22. Traditional thinking, linked to an important contribution by Brainard (1967), suggests that monetary policy should deal with uncertainty by exercising more caution in adjusting policy in response to shocks. By contrast, a new line of thinking hypothesizes that well-designed experimental adjustments of policy instruments may enable monetary authorities to reduce their uncertainty about key variables such as the NAIRU. Wieland (1996), for example, has argued the case for modest experimentation to pinpoint the NAIRU.

23. The experimentation undertaken in this section takes the form of deviations from rule-based policy settings, with the random probing oriented exclusively toward stimulating the economy and confined to periods during which the observed inflation rate lies below a specific threshold. The reason for defining experimentation in terms of random deviations from a policy rule, rather than deviations with nonrandom magnitudes linked to observed economic variables, is that the latter design would simply be equivalent to experimenting with a different policy rule.

24. Experimentation is incorporated into the simulation framework by adding the term $EXPER_t$ to equation (1), where

$$EXPER_t = \begin{cases} \omega \ EXPER_{t-1} - \ ABS(\theta_t) & if \ \pi 4_{t-1} < 2.5 + \lambda \\ 0 & otherwise \end{cases} \quad (4)$$

The term $2.5 + \lambda$ represents the threshold for the four-quarter inflation rate ($\pi 4_{t-1}$) below which the authorities undertake experimentation; θ_t is drawn randomly from a normal distribution with zero mean and prespecified variance σ^2_θ, and ABS (θ_t) is the absolute value of θ_t. Note that EXPER is always less than or equal to zero, and that by assigning a magnitude to the parameter ω, the experimentation process can be defined to exhibit a specific degree of persistence.

25. None of the experimentation outcomes succeeded in lowering the means of both the unemployment and the inflation rates. The result, however, suggested that experimentation could lead to small declines in average unemployment at the cost of small increases in average inflation, and in association with declines in average policy credibility. One simulation exercise suggested that reducing the average unemployment rate by 0.02 percentage points (say from 7.51 to 7.49) comes at the cost of raising the average inflation rate by more than 0.1 percentage point (from 2.6 to above 2.7 percent). This finding suggests that society would need relatively strong preferences for lower unemployment (at the margin) for experimentation to be welfare enhancing.

26. By suggesting that any prospective gains from experimentation are relatively small, these simulation results suggest that experimental probing for the NAIRU does not warrant serious attention from policymakers. Put differently, it would appear that adding noise to the Australian economy through random experimentation would not significantly improve the authorities' ability to identify the NAIRU, given the level of noise to which the economy has historically been subjected. This further suggests that a strategy that continuously updates measures of the NAIRU based on new information about inflation and unemployment is more appropriate than policies that continuously "test the waters" and probe for lower unemployment rates.

E. The Gains from Transparency

27. Economists have only just begun to try to analyze the gains from monetary policy transparency in formal models. In particular, Faust and Svensson (1998) have provided a formal analysis in which transparency is taken to connote the degree to which the public is able to infer the monetary authorities' intentions, formally defined as the share of the monetary authorities' control errors that the public can "observe."

28. An attempt to extend the formal analysis of transparency is beyond the scope of this chapter. In the spirit of the Faust-Svensson definition, however, stochastic simulations are undertaken to illustrate the prospective gains from increasing transparency. The degree to which transparency is imperfect is proxied here by the inflation expectation bias, i.e., the gap between expected and target inflation. The argument would be that raising transparency about the authorities' policy preferences, reaction function, and model, would raise policy credibility and in time cause the public's expectations about inflation to converge to the authorities' inflation target, thus eliminating the bias. Raising transparency is thus equivalent in the context of the simulations undertaken in this section to reducing or eliminating the inflation expectation bias.

29. Table III.2 presents stochastic simulations for the base-case IFB rule defined above and a Taylor rule. For each rule, the first column of simulation results is replicated from Table III.1, while the second set of results shows the implications of removing the bias term. The gains from extinguishing inflation expectations bias are shown in the third and sixth columns of the table. The difference in the average unemployment rate is 19 basis points under the IFB rule and 63 basis points under the Taylor rule; the difference in the average inflation rate is more than 1 percentage point under the Taylor rule. The gains from extinguishing inflation expectations bias are thus potentially quite significant.[7]

Table III. 2. The Costs of Inflation Expectations Bias

	IFB Rule (1.0, 1.0, 1.0)[1]			Taylor Rule (0.5, 1.0)[2]		
	$b \neq 0$	$b = 0$	Difference	$b \neq 0$	$b = 0$	Difference
	Sample Means					
u	7.50	7.32	-0.18	7.82	7.19	-0.63
π	2.60	2.60	+0.00	4.01	2.80	-1.21
π^e	2.70	2.58	-0.12	4.43	2.76	-1.67
$r-\pi^e$	2.24	2.16	-0.08	2.46	2.10	-0.36

[1]Derived from Equation 1.
[2]Derived from Equation 2.

[7]Green (1996) provides a recent discussion of related issues, which suggests that transparency about the policy framework, and the enhanced accountability that goes with it, can substantially increase the credibility of policy and reduce inflation expectations bias.

F. Conclusions

30. This chapter has focused on the implications of NAIRU uncertainty for monetary policy, a topical issue at present in Australia, given the imprecision of most estimates of the NAIRU. Stochastic simulations have been employed to compare the attractiveness of different forms of inflation-targeting strategies and to consider the case for adjusting interest rates experimentally to gain information about the NAIRU.

31. In evaluating monetary policy strategies, the chapter has compared the conventional inflation-targeting rules suggested by Taylor (1993) with forward-looking inflation-forecast based rules (i.e., rules that adjust policy to deviations between projected and target inflation rather than between actual and target inflation). The stochastic simulations suggested that IFB rules were relatively more effective in maintaining policy credibility and delivering low average rates of both unemployment and inflation.

32. The chapter also analyzed the case for experimenting with lower unemployment as a strategy for trying to reduce uncertainty about the NAIRU. The stochastic simulations indicated that experimental departures from a relatively attractive inflation-forecast targeting rule would not substantially improve macroeconomic performance. This result was interpreted as suggesting that adding noise to the economy through random experimentation did not substantially improve the authorities' ability to identify the NAIRU, given the amount of noise to which the economy was already subjected. Modest experimentation could succeed in reducing the average unemployment rate very slightly at the cost of somewhat higher inflation, but this would only be welfare enhancing if society placed a very high value on marginal reductions in unemployment relative to marginal increases in inflation.

33. As a final exercise, this chapter attempted to shed some light on the issue of the transparency of monetary policy and the potential gains from improving transparency. To model this issue, it was assumed that increasing transparency about the authorities' policy preferences, reaction function, and model of the economy could raise policy credibility and thereby reduce what the chapter referred to as inflation expectations bias, i.e., the gap between the public's expected inflation rate and the authorities' target for inflation. The simulation results suggested a potential for significant welfare gains from eliminating inflation expectations bias and increasing transparency.