RESEARCH DISCUSSION PAPER

OPERATING OBJECTIVES
FOR MONETARY POLICY

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RESEARCH DEPARTMENT

RESERVE BANK OF AUSTRALIA

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Abstract

This paper investigates simple monetary policy rules using a theoretical model of a small open economy. The analysis is intended to highlight two problems in policy formulation that are of particular importance to Australia: instability of the money demand function, and exposure of the economy to external shocks. Among the class of simple rules that are considered, it is shown that nominal income targeting consistently gives the lowest short-run variability of real output. In particular, such a policy outperforms both a monetary target and a fixed exchange rate. Problems of inaccurate information and recognition lags reduce the attractiveness of all targeting rules relative to the alternative of fixing the exchange rate. However, these problems do not provide grounds for a return to simple forms of monetary targeting.

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1. INTRODUCTION

The shift away from monetary targeting in the 1980s reflected a belief that demand for the monetary aggregates had become highly unstable. This was unfortunate, because simple monetary growth rules could be claimed to have a number of attractive features, at least in theory. In particular, it was argued that such rules could provide an anchor for price expectations in the medium to long term, as well as providing a reasonable degree of short-term stabilisation against exogenous shocks (excluding shocks to money demand). The abandonment of strict monetary targeting in many countries has raised the question as to whether alternative operating principles can be devised which have similar properties but are not subject to the same problems of short-term instability.

Goodhart (1989) notes that two main alternatives to monetary targeting have been pursued by different groups of countries. The first, applicable mainly to the smaller European countries, has been to move towards fixed exchange rates, effectively bypassing domestic problems of monetary instability by fixing to a suitably stable external currency. For many countries, however, this is not an attractive option because of their vulnerability to external shocks, such as shocks to the terms of trade. As argued recently by Blundell-Wignall and Gregory (1989) Australia falls fairly clearly within this group. The second alternative described by Goodhart is the use of an interest rate as the operating instrument of policy, with policy being aimed directly at stabilisation of ultimate objectives, rather than being defined in terms of a monetary target. Although this formulation is somewhat imprecise, Freedman (1989) has suggested that, for countries with floating exchange rates, this would become the dominant model for thinking about monetary policy in the 1990s. This view is endorsed by B. Friedman (1989) who notes that although such an approach is a logical consequence of money-demand instability, it has so far been given relatively little formal analysis.

The aim of this paper is to provide a systematic discussion of issues arising under this second approach to policy, using a formal theoretical model intended to capture some of the important features of the Australian economy. In particular, it is assumed that money demand is not sufficiently stable to serve as a basis for policy, and that the economy is subject to real shocks arising both domestically and externally. Operating rules for policy are designed so as to satisfy two criteria:

- long-run anchoring of inflation at a targeted rate;
- satisfactory short-run properties with respect to the stabilisation of prices and output.

Rather than attempt to derive general expressions for optimal policy, which would inevitably result in a rather uninformative "look at everything" conclusion, the paper proposes three simple policy rules and compares their properties using the performance criteria mentioned above.[1] The three rules are nominal income targeting, targeting of consumer prices and, as a benchmark for comparison, a fixed exchange rate.[2]

A number of arguments could be given in defence of this focus on simple rules, and two in particular seem worth emphasising. First, simple rules are likely to be more widely understood than complex rules, and may therefore promote accountability and credibility of

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1 The analysis here extends earlier work on the closed economy case by Edey (1989). It is also related to work by Blundell-Wignall and Gregory (1989), who examined optimal policy reactions to terms-of-trade and money-demand shocks, while retaining the assumption that the instrument of policy is a monetary quantity. Other related work by Aizenman and Frenkel (1986) and by Alogoskoufis (1989) uses a similar method to that employed here, but does not specifically cover terms-of-trade and money-demand shocks.

2 Nominal income targeting has been studied by Bean (1983) and Taylor (1985), amongst others. Adoption of a formal price level target was recently advocated by Gavin (1990).

targets.[3] Secondly, simple rules have the advantage of imposing relatively small information requirements on the monetary authorities and are less likely to be dependent on detailed knowledge of the dynamics of the economic system. These arguments were important in earlier advocacy of simple money growth rules, for example by Friedman (1968).

The discussion that follows is divided into three parts:

- the need for a nominal anchor;
- short-run stabilisation properties of alternative rules;
- the information requirements of monetary policy.

2. THE NEED FOR A NOMINAL ANCHOR

In terms of comparative statics, the relative merits of interest rate as against money supply rules are well summarised by Poole (1970): an interest rate rule is preferred (i.e. produces lower output variance) when the variance of money demand is sufficiently high relative to the variance of shocks in the real sector. But this comparative static result ignores an important feature of the dynamics of price level determination, namely, that when rates are set exogenously, the price level is generally either unstable or indeterminate.[4] The reason for this is that a fixed interest rate regime fails to provide automatic stabilisation when there are disturbances to demand; for example, a tendency towards excess demand will reinforce itself by raising the inflation rate and thus driving down the real rate of interest. When combined with a rational expectations assumption, these problems of instability collapse to indeterminacy of the price level even in the short run. Thus, Sargent and Wallace (1974) and Sargent (1979)

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[3] This argument has been formalised in the literature on reputational equilibria, for example, by Barro and Gordon (1983).

[4] This problem was recognised at least as early as Henry Thornton's analysis (1802) of the inflationary consequences of the fixed interest rate policy then being maintained by the Bank of England.

conclude that there is no interest rate policy rule capable of achieving price level determinacy.

It has subsequently been shown by McCallum (1981, 1986) and B. Friedman (1989a)[5] that these strong conclusions are not strictly correct. As a general result, they apply only to the case where an interest rate is the final objective of policy, rather than ruling out the use of interest rates as an instrument. The indeterminacy problem can be overcome by specifying policy rules in which the interest rate reacts systematically to movements in nominal variables, such as money, prices, or nominal income. The indeterminacy literature thus highlights the need for policies to be designed in such a way as to provide a long-run nominal anchor.

At this point, it will be useful to introduce the theoretical model to be used in the remainder of the paper, and to specify the requirements for price level determinacy in that model. The model assumes that there are three goods: non-tradeables, exportables, and importables. Supply of the domestically-produced goods responds positively to relative prices and to unanticipated inflation. Demand for the non-traded goods is a function of real income, relative prices, and the real interest rate. Equilibrium is defined by equating supply and demand in the non-traded goods sector.

Production of non-tradeables: $$y_t^n = \beta(p_t^n - E_{t-1}p_t) + u_t \quad (1)$$

Production of exportables: $$y_t^x = \beta(p_t^x - E_{t-1}p_t) + v_t \quad (2)$$

Total production: $$y_t = \lambda y_t^n + (1-\lambda)y_t^x \quad (3)$$

Product price index: $$p_t = \lambda p_t^n + (1-\lambda)p_t^x \quad (4)$$

Consumption price index: $$p_t^c = \lambda p_t^n + (1-\lambda)p_t^m \quad (5)$$

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5 See also Edey (1989) for a further exposition of these results.

Demand for non-tradeables: $d_t^n = h(y_t+p_t-p_t^c) + g(p_t^c - p_t^n)$

$$- \alpha(R_t-E_t(p_{t+1}^c-p_t^c))+w_t \quad (6)$$

Export prices: $p_t^x = e_t + x_t \quad (7)$

Exchange rate: $e_t = E_t(e_{t+1}) - R_t \quad (8)$

Equilibrium condition: $y_t^n = d_t^n \quad (9)$

The terms u, v, w and x represent exogenous shocks to the supply of the two domestically produced goods, to demand for non-tradeables, and to export prices, respectively. For simplicity, it is assumed that import prices are fixed, so that terms of trade disturbances arise only on the export side (a reasonable approximation in Australia's case). The above model thus has five behavioural equations and six endogenous variables (two outputs, two prices, the exchange rate and the interest rate).

Although it may appear somewhat complicated, the model has a very simple dynamic structure, and the stability condition is easily described. Assuming all shocks are temporary, the expected nominal exchange rate in equation (8) is proportional to the expected future price level, and thus equation (8) can be thought of as an equation relating the current real exchange rate to the real interest rate. The system as a whole can then be thought of as reducing to a solution for the real interest rate, which must be of the form

$$R_t - E_t(p_{t+1}^c-p_t^c) = f_1 z_t \quad (10)$$

where z_t is some linear combination of the exogenous variables. To complete the model, assume that the nominal interest rate is determined by a policy rule of the form

$$R_t = f_2 z_t + \gamma p_t^c . \quad (11)$$

The interest rate thus reacts to a combination of real shocks and to the price level.[6]

Combining equations (10) and (11), we obtain

$$(1+\gamma)p_t^c = (f_1-f_2)z_t + E_t p_{t+1}^c . \qquad (12)$$

It can be seen from this expression that a necessary and sufficient condition for the price level to have a convergent solution is that $\gamma>0$; in other words, the requirement is that the interest rate is adjusted positively in response to deviations of the price level from target.

An intuitive presentation of this argument is given in Diagram 1. Equilibrium in the real economy determines the equilibrium interest rate, and the policy reaction function ensures that this equilibrium is attained only when prices are at the target level. When the price level is above target, the interest rate is raised, tending to reduce demand and putting downward pressure on prices; the reverse occurs when prices are below target. The nominal anchor for the system is thus the expectation that policy will react to any deviations of the price level from target.[7]

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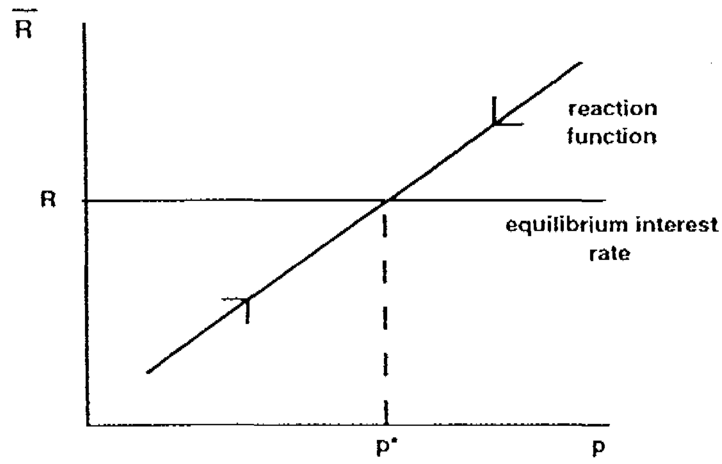
6 Since z can be defined to include relative prices, the above formulation is quite general, and does not depend on which nominal price is specified as the target. The target value of the price level is normalised to zero.

7 This of course leaves open a number of interesting questions about how the authorities can gain credibility for their targets.

Diagram 1: Determination of the Price Level



Three further points can be made concerning the requirements for price level determinacy in this model:

- the mechanism for price determination requires that there is some sensitivity of demand to the real interest rate. This requirement is easier to meet in the open economy than in the closed economy case, since the interest rate can affect demand both directly, and indirectly through the exchange rate;

- under the assumptions used here, money can be entirely excluded from the model.[8] A money demand function could be added, but its only role would be to determine the quantity of money, given the outcomes for all other variables;

- the price level determinacy result depends only on the nominal part of the policy rule, defined by the parameter γ. The real part of the policy rule plays no role in determining the long-run path of prices, but does affect the short-run stabilisation properties of the rule. It is these short-run properties that are dealt with in the next section.

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8 McCallum (1990) has pointed out that this is not possible if the demand equation includes a real balance effect.

3. SHORT-RUN STABILISATION PROPERTIES OF ALTERNATIVE RULES

This section considers three simple rules for interest rate policy which satisfy the requirements for long-run determinacy of the price level. The rules are defined as follows:

(i) Fixed exchange rate: $e_t = 0$

(ii) Price target: $R_t = \gamma p_t^c$

(iii) Nominal income target: $R_t = \gamma(p_t + y_t)$.

The specifications differ from earlier treatments of price and nominal income targeting by assuming an interest rate, rather than a monetary quantity, is the policy instrument.

The aim is to compare the amount of stabilisation provided by each rule in the face of various exogenous shocks.

A convenient way to simplify the notation, for the purpose of studying the short-run properties of the model, is to assume that all shocks are temporary.[9] The model can then be written in terms of deviations from the non-stochastic equilibrium, as follows:

$$y_n = \beta p_n + u \qquad \text{(I)}$$
$$y_x = \beta p_x + v \qquad \text{(II)}$$
$$(y_n =)\quad d_n = h(y + p - p_c) + g(p_c - p_n) - \alpha(R + p_c) + w \qquad \text{(III)}$$
$$p_x = e + x \qquad \text{(IV)}$$
$$p_m = e \qquad \text{(V)}$$
$$e = -R. \qquad \text{(VI)}$$

This short-run version of the model incorporates the usual small country assumptions: world prices are exogenous, and therefore export volumes are determined entirely on the supply side; changes to the terms of trade have explicit real income effects as well as

[9] This method was proposed by Aizenman and Frenkel (1986).

export volumes are determined entirely on the supply side; changes to the terms of trade have explicit real income effects as well as inducing reallocation of resources between the traded and non-traded goods sectors; and changes to monetary policy, operating through the short-term interest rate, affect aggregate supply and demand in the short term, and also affect the real exchange rate. The rational expectations assumption underlying the model might be regarded as unduly restrictive, but in fact it serves as no more than a convenient stylisation which divides the analysis between the short run (the current period) and the long run (all future periods). For this purpose, the short run is to be thought of as the period within which expectations do not adjust or, alternatively, monetary policy is non-neutral; this is not necessarily very restrictive since there is nothing in the formal analysis which requires us to specify how long a "period" is.

In principle, the comparative analysis of policy rules can proceed along the following lines. First, an objective function must be defined. We assume that the objective is to minimise some weighted combination of price and output variances:

$$F = f.\mathrm{var}(p^c) + (1\text{-}f)\mathrm{var}(y).$$

Second, for each policy rule, the model is solved and expressions for the price and output variances can be derived as functions of the variances of the exogenous shocks. These expressions are of the form:

$$\mathrm{var}(p^c) = \pi_1\sigma_u^2 + \pi_2\sigma_x^2 + \pi_3\sigma_w^2 + \pi_4\sigma_x^2$$

$$\mathrm{var}(y) = \lambda_1\sigma_u^2 + \lambda_2\sigma_v^2 + \lambda_3\sigma_w^2 + \lambda_4\sigma_x^2$$

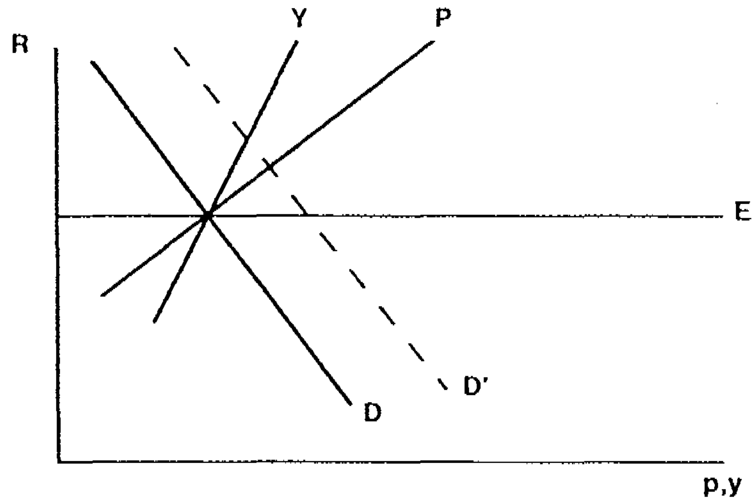
These derivations are somewhat cumbersome, and are reported in the Appendix. Third, the welfare costs associated with price and output variances under the different policy rules can be evaluated using the objective function. In general, the ranking of policy rules on this criterion will depend on a number of factors which can only be determined empirically: for example, the configuration of model parameters, the relative sizes of the exogenous variances, and the relative weights given to price and output stabilisation in the objective function. However, it is possible, for any given shock, to rank the stabilising properties of the three rules. What follows is an informal presentation along these lines, based on the results derived in the Appendix. The exogenous shocks included in the model are considered in turn.

(a) Domestic demand shocks

The effects of a positive shock to domestic demand are illustrated in Diagram 2. The downward sloping D curve is really a reduced form combining all the behavioural equations in the model excluding the policy rule; this implies that as the interest rate is lowered, both prices and output rise in the short term. Equilibrium for the system as a whole occurs where this curve intersects with whichever policy rule is operating. The rules are labelled E (fixed exchange rate) P (price target) and Y (nominal income target) respectively.

Starting with the fixed exchange rate case, the shock increases both prices and output in the non-traded goods sector, while output in the export sector is unaffected because there is no change in the domestic currency price of exports. The interest rate is unchanged because it is tied to the world interest rate when the exchange rate is fixed. A price targeting rule, by comparison, responds to this disturbance by raising the interest rate, thus tending to raise the exchange rate and dampen the price and output effects relative to results under a fixed exchange rate. Output is reduced in both the non-tradeables and export sectors. For a given policy parameter γ, a nominal income targeting rule raises the interest rate still further, and therefore achieves greater stabilisation of both prices and output than in either of the other two cases.

Diagram 2: Domestic Demand Shock



(b) Shocks to the terms of trade[10]

An upward shock to the price of exports has effects which are similar to those of a simultaneous shock to supply and demand in a closed economy. Aggregate supply is increased, and the income effect arising from the export sector pushes the demand curve for non-tradeable goods outwards, putting upward pressure on domestic prices. Both prices and output rise and, starting from the case where the nominal exchange rate is fixed, there is a rise in the real exchange rate. At an intuitive level it is fairly clear that a policy which raises the nominal exchange rate in response to this shock will dampen these price and output effects. Both the nominal income and price-targeting rules have this property.

The full-system effects of the shock under the three regimes are shown in more detail in Diagrams 3 and 4. The downward sloping line in each case represents the reduced form relationship between the interest rate and either prices or output. Full system equilibrium occurs where this condition intersects with the policy reaction function; in the fixed exchange rate case, the reaction function is

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[10] The case of a supply shock to the export sector (for example, a natural resource discovery) is not discussed separately. It is shown in the Appendix that the qualitative results are identical to those for a terms-of-trade shock.

horizontal because policy does not respond to changes in prices or output, while in the other cases, the reaction functions are upward sloping.

Effects of an Export Price Shock

Diagram 3

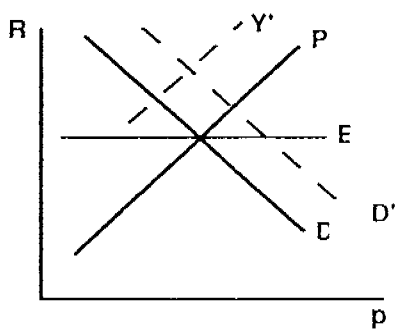
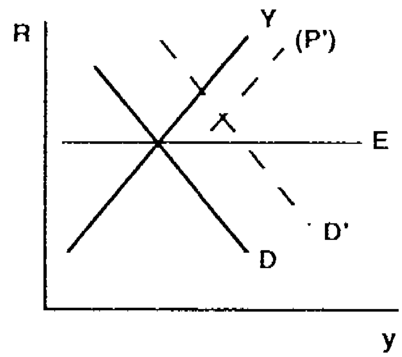


Diagram 4



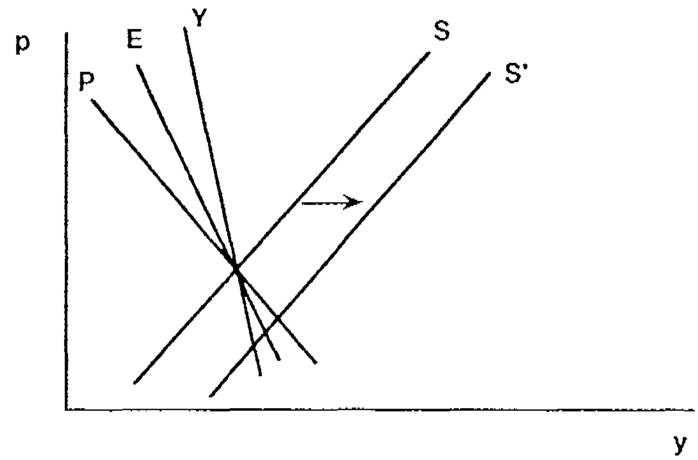
In Diagram 3, the export price shock shifts outward the equilibrium R-p locus, because the increased demand for non-tradeables raises the price level for a given interest rate. Under a price targeting rule, the interest rate and exchange rate rise to offset some of this effect so that the short-run variance of the price level is reduced. A further effect of the shock is that if a nominal income target is operating, the policy reaction function is itself shifted to the left as income rises. This further raises the interest rate and exchange rate, and may actually result in the price level falling. It is shown in the Appendix that this still results in a smaller absolute change in prices than under the fixed exchange rate case, but that the relativity between variances of prices under nominal income and price targeting rules is ambiguous.

Diagram 4 shows the same disturbance in R-y space, in order to demonstrate the relative variabilities of output. In this case the ranking of policy rules is unambiguous, with the nominal income target producing the lowest output variation, and fixed exchange rates the highest.

(c) Supply shocks to the non-traded goods sector

An example of such a shock would be an exogenous change in real wages, assuming the non-traded sector is relatively labour intensive. An expansionary domestic supply shock raises output and reduces prices relative to the non-stochastic equilibrium. The general equilibrium effects of such a shock can be illustrated as in Diagram 5. The curve labelled S is the supply function for non-traded goods (equation (1)), and the "demand curve" is a reduced form of the remaining equations in the model, whose slope depends on which of the three policy rules is adopted.

Diagram 5: Domestic Supply Shock



Taking the fixed exchange rate case as a benchmark, the reduced form demand curve is downward sloping because, other things equal, a higher domestic price level reduces real income and raises the expected real interest rate, thus lowering the demand for non-traded goods. Relative to the fixed exchange rate case, the demand curve under a price level target has a flatter slope, and hence stabilises prices more, and output less, in response to a domestic supply shock. The reason for this is that by reducing prices, an expansionary supply shock acts as a signal for interest rates to be lowered, which dampens the fall in prices but adds to the output effect. In the case of a nominal income target this result is reversed, because the net effect of an expansionary supply shock is to expand nominal income and hence to act as a signal for interest rates to be raised; this stabilises output relative to the fixed exchange rate case, but amplifies the effect on prices.

It follows from these considerations that the preferred response to a supply shock depends on the relative weights of price and output variances in the policymaker's objective function. If the objective is primarily to stabilise output, the order of preference among the three policy rules is: nominal income target, fixed exchange rate and price level target. If the short-run objective is to stabilise prices, this ranking is reversed.

(d) Summary

The conclusions from the preceding analysis are summarised below in Table 1.

Table 1: Stabilisation Rankings of Alternative Policy Rules

Source of disturbance	Criterion	Ranking 1	2	3
Domestic demand	Output	Y	P	E
	Prices	Y	P	E
Terms of trade	Output	Y	P	E
	Prices			E
Domestic supply	Output	Y	E	P
	Prices	P	E	Y
Export supply	Output	Y	P	E
	Prices			E

Notes: For each type of disturbance, the table provides rankings for the variances of output and prices under the three policy rules: a fixed exchange rate (E), price target (P) and nominal income target (Y). A ranking of 1 indicates the lowest variance. Blanks appear where the rankings are ambiguous.

Although an unambiguous preference for any one of the policy rules cannot be established from these results, a number of clear principles nonetheless emerge.

(i) Nominal income targeting always produces the lowest output variance among the three policy rules studied. It follows that if the weight given to output stabilisation in the policymaker's objective function is sufficiently high (f close to one), then nominal income targeting is the preferred policy rule. This preference is independent of information about the relative variances of the exogenous shocks.

(ii) For all shocks except one (to domestic supply), the fixed exchange rate is dominated by the other two policy rules. Therefore, fixing the exchange rate can never be optimal in this analysis unless the variance of domestic supply shocks is large enough to outweigh the combined effect of terms-of-trade and domestic-demand shocks. Even then, fixing the exchange rate is inferior to the nominal income rule when f is close to one, and is inferior to price targeting when f is close to zero.

(iii) When shocks to domestic demand are predominant, the nominal income target is unambiguously preferred over the two alternatives, giving the lowest variances for both prices and output.

4. THE INFORMATION REQUIREMENTS OF MONETARY POLICY

The preceding analysis has ignored an important problem associated with the direct targeting of final objectives: this is that the target variables are not accurately observed as policy is being made. Rather, the policy instruments must be adjusted in response to imperfect signals. In principle, there would seem to be two ways of allowing for this in the design of simple policy rules. First, one could make the policy instrument respond to lagged, rather than current, values of the target variable. However, this can easily be seen to lead to unsatisfactory results. Suppose, for example, the targeting rule defined by equation (11) is modified to be of the form

$$R_t = f_2 z_t + \gamma p^c_{t-1}.$$

Then the solution equation for prices (given by equation 12 above) becomes

$$p^c_t + \gamma p^c_{t-1} = (f_1 - f_2) z_t + E_t p^c_{t+1},$$

from which it can be seen that the condition $\gamma > 0$ no longer guarantees convergence of the price level. The policy rule fails to anchor price expectations because it is responding to information that is no longer relevant to the determination of current prices.

This indeterminacy result is of course a consequence of the rational expectations assumption, and presumably the problem can be overcome if there is sufficient price rigidity in the model. Even then, however, the results are not entirely satisfactory, as the following simple example shows. Suppose the inflation process is generated by

$$p_t - p_{t-1} = \alpha y_t$$

where y_t is excess demand, and excess demand is regulated by the interest rate

$$y_t = -\beta R_t.$$

If the policy rule responds to current prices, we have $R_t = \gamma p_t$, which leads to the solution $p_t(1+\alpha\beta\gamma) = p_{t-1}$. As before, any arbitrary positive value for the policy parameter γ ensures long-run stability of the price level. This is not the case, however, if policy responds to lagged prices:

$$R_t = \gamma p_{t-1};$$

here the solution is

$$p_t = p_{t-1}(1 - \alpha\beta\gamma),$$

which is unstable for sufficiently large values of γ. Choice of the policy parameter thus requires a knowledge of the economy's structural parameters in order to ensure stability, and this would remove much of the attractiveness of operating policy according to simple rules of thumb.

An alternative approach to the problem of imperfect information is to retain the assumption that policy responds to current movements in the target variables, but to replace the actual values of those variables with estimates. Suppose that instead of observing the actual price level p_t,[11] the authorities observe a signal $\hat{p}_t$, generated by

$$\hat{p}_t = p_t + \varepsilon_t.$$

The optimal estimate of the price level conditional on the information in the signal is

$$E(p_t \mid \hat{p}_t) = \phi\hat{p}_t$$

where $\phi = \dfrac{\text{var } p}{\text{var } \hat{p}}$

An operating rule for policy can then be defined by

$$R_t = \gamma E(p_t \mid \hat{p}_t) = \gamma\phi\,\hat{p}_t = \gamma\phi p_t + \gamma\phi\varepsilon_t.$$

In terms of the model introduced in Section 2, this rule has equivalent long-run properties to those defined by equation (12), and thus ensures long-run price stabilisation for any positive value of γ. In

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11 This argument applies equally when the target variable is nominal income.

the short run, however, such a rule introduces the equivalent of a stochastic shock to monetary policy, associated with measurement error of the final objective. This problem does not affect the fixed exchange rate case, where there is no important measurement error, but adds to the short-run variances of both prices and output under the two nominal targeting rules. Their attractiveness as alternatives to a fixed exchange rate is therefore diminished.

It might also seem that the imperfect information problem provides an argument for reverting to rules based on monetary aggregates; however, in the context of the model under discussion here, this is not the case. Consider the following three rules.

(i) Fixed money supply.
Assuming the money demand function is of the form

$$m_t = p_t + y_t - \delta R_t + \upsilon_t,$$

a fixed money supply rule implies that the interest rate is determined by

$$R_t = \frac{1}{\delta}(p_t + y_t) + \frac{1}{\delta}\upsilon_t .$$

(ii) Money supply target.
Under this rule the interest rate is assumed to adjust according to

$$R_t = \gamma m_t.$$

Combining this with the money demand function, the equation for the interest rate is

$$R_t = \left(\frac{\gamma}{1+\gamma\delta}\right)(p_t + y_t) + \left(\frac{\gamma}{1+\gamma\delta}\right)\upsilon_t .$$

(iii) Nominal income target. $R_t = \gamma E(p_t + y_t)$.

Expressed in this way, it can be seen that rule (ii) is in fact a restricted version of rule (iii), because the money supply can be interpreted as one possible component of a signal providing information about nominal income. Whatever the information problems associated with estimating current nominal income, the nominal income target

It should further be noted that rule (i) is a restricted version of rule (ii), because the response parameter γ in rule (ii) can be chosen optimally by the authorities, rather than being fixed. The money supply target must therefore perform at least as well as a fixed money rule. This implies that the rules can be unambiguously ranked in the following order of preference: nominal income target, money target, fixed money supply. It can be concluded from this discussion that although measurement errors worsen the absolute performance of nominal income targeting, they do not worsen its relative performance compared with rules based on the quantity of money.

The imperfect information problem also has an important bearing on the optimal choice of the policy response parameter γ. This parameter can be thought of as representing the degree of "activism" in a policy regime: a high value indicates a high willingness to move interest rates in response to any given piece of information. If information about final objective variables was perfectly accurate and up-to-date, it would be theoretically possible to achieve perfect stabilisation of the targeted variable by making γ arbitrarily large. This is not optimal, however, under imperfect information, because the benefits of a more activist policy must be traded off against the additional variability introduced by making policy respond too much to inaccurate signals. This argument can be formalised (Edey, 1989) by saying that the optimal degree of policy activism decreases as the accuracy of information about the final objective variables decreases.

5. CONCLUSIONS

The paper essentially argues for four propositions.

(i) It is possible to develop a coherent framework for monetary policy based on the short-term nominal interest rate as the policy instrument. In other words, one does not <u>necessarily</u> have to rely on control of either a monetary quantity or an exchange rate to anchor the system.

(ii) Within such a framework, it is essential that the policy rule be specified so as to respond to a variable that contains a nominal component. This requirement could be satisfied either by strict targeting of the price level or, more generally, by choosing a target variable which is some combination of nominal and real components, such as nominal income.

(iii) There are important practical reasons for favouring policy rules that are relatively simple. Simple rules help to focus expectations, and place less stringent information requirements on the authorities than complicated ones.

(iv) These arguments provide some support for the use of nominal income as a guide for policy. As a matter of formal modelling, the paper has argued that nominal income targeting provides relatively good short-run stabilisation properties, against a range of shocks, when compared with the obvious alternatives.

Putting aside the question of what variable might be chosen as a target, it is important to recognise both the similarities and differences between an approach based on simple targeting rules, and one which attempts to design a fully optimal policy. Both approaches can, in principle, require the authorities to "look at everything": the former, because a range of imperfect signals must be used in estimating what is currently happening to the target variable; and the latter, because it is generally true that optimal policy responds to all shocks.

The essential difference between the approaches lies in the way that information is interpreted. On the one hand, to construct an optimal policy one would have to know the full dynamic structure of the macroeconomic system, including the variances of all unobservable shocks, and then use these to calculate the optimal response weights to all sources of information. It would be hard to argue that this is a feasible programme in practice and, in the absence of the required structural knowledge, there is no clear principle for determining the response weights to be used. A simple targeting rule, however, does provide such a principle. Policy responds to only one, possibly composite, variable, namely the current estimate of the chosen target. A wide range of signals is still looked at, but these are responded to only for the information they provide about the path of the target variable; in other words, policy responds to a signal to the extent that it causes revisions to the estimates of the variable being targeted. In this way, simple targeting rules would seem to gain important advantages in terms of clarity and transparency, although admittedly at the cost of giving up some degree of flexibility.

APPENDIX

DERIVATION OF RESULTS IN SECTION 3

The full model consists of equations (I) to (VI), combined with one of the following policy rules:

(i) Fixed exchange rate: $e = 0$, which implies $R = 0$.
(ii) Consumer price target: $R = \gamma p_c$.
(iii) Nominal income target: $R = \gamma(p+y)$.

For each choice of policy rule, the model has solutions for prices and output which are of the form

$$y = \pi_1 u + \pi_2 v + \pi_3 w + \pi_4 x \tag{A1}$$
$$p_c = \lambda_1 u + \lambda_2 v + \lambda_3 w + \lambda_4 x . \tag{A2}$$

Assuming the stochastic terms are all independent, comparative results for price and output variables under the three rules can be obtained by comparing the absolute values of corresponding coefficients in the above solution equations. For example, π_1 measures the effect of domestic supply shocks on the variance of output, and we aim to rank the values of π_1 obtained using each of the policy rules. The procedure is then repeated for the remaining coefficients in equaztions (A1) and (A2).

To solve the model, we begin by collapsing equations (I) to (VI) down to the following two-equation system:[12]

$$y = \lambda\beta\pi\Delta_0 + \lambda u + (1-\lambda)v + (1-\lambda)\beta x - \beta R$$

[12] For simplicity of exposition, it is assumed that the demand elasticities g and h are equal to one, but this does not materially affect the qualitative results.

$$p_C = \lambda\pi\Delta_0 - R\,,$$

where
$$\pi = -(1-\lambda)u + (1-\lambda)v + w + (1-\lambda)(1+\beta)x$$
$$\Delta_0^{-1} = (1-\lambda)(1+\beta) + \alpha\lambda\,.$$

The interest rate rules can then be expressed in terms of the exogenous shocks as follows:

(i) $R = 0.$

(ii) $R = (\frac{\gamma}{1+\gamma})\,.\,\lambda\pi\Delta_0 = \lambda\pi\Delta_0.\Delta_1\,.$

(iii)
$$\begin{aligned} R &= \frac{\gamma}{1+\gamma(1+\beta)}\{\lambda(1+\beta)\pi\Delta_0 + \lambda u + (1-\lambda)v + (1-\lambda)(1+\beta)x\} \\ &= \Delta_2\{\lambda(1+\beta)\pi\Delta_0 + \lambda u + (1-\lambda)v + (1-\lambda)(1+\beta)x\}\,. \end{aligned}$$

This provides sufficient information to determine the coefficients in equations (A1) and (A2). It will be useful to note that Δ_1 and Δ_2 are both less than one, and that $\Delta_1 < (1+\beta)\Delta_2 < 1$.

Domestic supply shock

(i)
$$\begin{aligned} \pi_1 &= \frac{dy}{du} = \lambda\beta\Delta_0.\frac{d\pi}{du} + \lambda - \beta\frac{dR}{du} \\ &= -(1-\lambda)\lambda\beta\Delta_0 + \lambda > 0 \quad \text{(since } (1-\lambda)\beta\Delta_0 < 1)\,. \end{aligned}$$

$$\lambda_1 = \frac{dp}{du} = -\lambda(1-\lambda)\Delta_0 < 0\,.$$

(ii)
$$\begin{aligned} \pi_2 &= -(1-\lambda)\lambda\beta\Delta_0 + \lambda + \beta\lambda(1-\lambda)\Delta_0\Delta_1 \\ &= -\lambda\beta\Delta_0(1-\lambda)(1-\Delta_1) + \lambda\,, \end{aligned}$$
which is positive and greater than π_1.

$$\begin{aligned} \lambda_2 &= -(1-\lambda)\lambda\Delta_0 + \lambda(1-\lambda)\Delta_1\Delta_0 \\ &= -\lambda(1-\lambda)\Delta_0(1-\Delta_1)\,, \end{aligned}$$
which is negative and less than λ_1 in absolute value.

(iii) $\pi_3 = -(1-\lambda)\lambda\beta\Delta_0 + \lambda + \beta\lambda(1+\beta)(1-\lambda)\Delta_0\Delta_2 - \beta\lambda\Delta_2$
$= -(1-\lambda)\lambda\beta\Delta_0(1 - (1+\beta)\Delta_2) + \lambda(1-\beta\Delta_2)$.

This expression is positive because $1-(1+\beta)\Delta_2 < 1-\beta\Delta_2$, and is less than π_1 , since $(1+\beta)(1-\lambda)\Delta_0 < 1$.

$\lambda_3 = -\lambda(1-\lambda)\Delta_0 + \lambda(1+\beta)(1-\lambda)\Delta_2\Delta_0 - \lambda\Delta_2$.

Here the sum of the second and third terms is negative, so λ_3 is greater than λ_1 in absolute value.

Export supply shock

(i) $\pi_1 = \lambda\beta(1-\lambda)\Delta_0 + (1-\lambda) > 0$
$\lambda_1 = \lambda(1-\lambda)\Delta_0 > 0.$

(ii) $\pi_2 = \lambda\beta(1-\lambda)\Delta_0 + (1-\lambda) - \beta\lambda\Delta_1\Delta_0 (1-\lambda)$
$= \lambda\beta(1-\lambda)\Delta_0 (1-\Delta_1) + (1-\lambda) < \pi_1.$

$\lambda_2 = \lambda(1-\lambda)\Delta_0 - \lambda(1-\lambda)\Delta_1\Delta_0$
$= \lambda(1-\lambda)\Delta_0(1-\Delta_1) < \lambda_1.$

(iii) $\pi_3 = \lambda\beta(1-\lambda)\Delta_0 + (1-\lambda) - \beta\lambda(1+\beta)(1-\lambda)\Delta_2\Delta_0 - \beta(1-\lambda)\Delta_2$
$= \lambda\beta(1-\lambda)\Delta_0(1-(1+\beta)\Delta_2) + (1-\lambda)(1-\beta\Delta_2)$, which is positive and less than π_2.

$\lambda_3 = \lambda(1-\lambda)\Delta_0 - \lambda(1-\lambda)(1+\beta)\Delta_2\Delta_0 - (1-\lambda)\Delta_2$.

This expression is ambiguous in sign, and it is also ambiguous whether or not it is smaller in absolute value than λ_1 or λ_2 . It should be noted, however, that there exist values of the policy parameter γ for which $\lambda_3 < \lambda_1$ in absolute value: γ (and hence Δ_2) can always be chosen to be sufficiently small that the second and third terms in the above expression do not over-compensate for the absolute size of the first.

Domestic demand shock

(i) $\pi_1 = \lambda\beta\Delta_0 > 0$
$\lambda_1 = \lambda\Delta_0 > 0.$

(ii) $\pi_2 = \lambda\beta\Delta_0 - \lambda\beta\Delta_0\Delta_1 < \pi_1$
$\lambda_2 = \lambda\Delta_0 - \lambda\Delta_0\Delta_1 < \lambda_1.$

(iii) $\pi_3 = \lambda\beta\Delta_0 - \lambda\beta\Delta_0(1+\beta)\Delta_2 < \pi_2$ (since $(1+\beta)\Delta_2 > \Delta_1$)
$\lambda_3 = \lambda\Delta_0 - \lambda(1+\beta)\Delta_0\Delta_2 < \lambda_2$ (since $(1+\beta)\Delta_2 > \Delta_1$).

Terms of trade shock

(i) $\pi_1 = \lambda\beta\Delta_0(1-\lambda)(1+\beta) + \beta(1-\lambda) > 0$
$\lambda_1 = \lambda\Delta_0 (1-\lambda)(1+\beta) > 0.$

(ii) $\pi_2 = \lambda\beta\Delta_0(1-\lambda)(1+\beta) + \beta(1-\lambda) - \beta\lambda\Delta_0(1-\lambda)(1+\beta)\Delta_1 < \pi_1$
$\lambda_2 = \lambda\Delta_0(1-\lambda)(1+\beta) - \lambda\Delta_0(1-\lambda)(1+\beta)\Delta_1 < \lambda_1.$

(iii) $\pi_3 = \lambda\beta\Delta_0(1-\lambda)(1+\beta) + \beta(1-\lambda) - \beta\Delta_0\lambda(1-\lambda)(1+\beta)\Delta_2$
$- \beta(1-\lambda)(1+\beta)\Delta_2 < \pi_2$ (since $(1+\beta)\Delta_2 < 1$) .

$\lambda_3 = \lambda\Delta_0(1-\lambda)(1+\beta) - \lambda(1+\beta)(1-\lambda)(1+\beta)\Delta_0\Delta_2 - \Delta_2(1-\lambda)(1+\beta).$

This expression has the same ambiguity of relative size as was remarked upon in the case of the export supply shock above.

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