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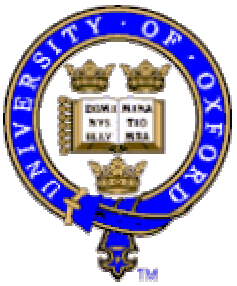

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INFLATION TARGETING: DELEGATION AND COORDINATION OF MONETARY POLICY

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ABSTRACT

This paper provides an empirical assessment of the implications of delegating monetary policy to a central bank. We argue that the theoretical literature justifying central bank independence is highly stylised and is deficient in that it assumes there is only a single policy instrument under the control of a single policymaking authority and it typically assumes rational expectations. We are able to address all of these issues in an empirical model based analysis with expectations determined by learning. We apply new optimisation techniques to investigate the possible loss in welfare from uncoordinated fiscal and monetary policies. Our results seem to imply that such losses are small if the two authorities pursue congruent objectives. However, we then show that a sub-optimal non-cooperative outcome can arise if the authorities have competing objectives.

Keywords: *Inflation targeting, monetary policy, optimal control, learning.*

JEL Classification: E58, E63

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1 INTRODUCTION

A large empirical literature has investigated the relationship between central banking independence and macroeconomic performance. This literature appears to suggest that greater independence is negatively correlated with both average inflation and its variability (see for example, Grilli et. al., 1991; Banaian et. al., 1983; Cukierman, 1992; Cukierman et. al. 1992 and Eijffinger and de Haan, 1996). Also, central bank independence shows no correlation with real variables, such as average GDP growth or its variability (see Alesina and Summers, 1993). These findings have underpinned the intellectual support for reforms of central banks around the world. In the UK for example, one of the first acts of the new Labour government, was to grant the Bank of England operational independence to set monetary policy. The reaction amongst commentators and academics, was generally highly supportive of this move.

The empirical support for this mentioned above is, however, based on cross sectional comparisons of economic outcomes: there is much less evidence on the effects of institutional changes within a given country, and this makes it difficult to make predictions about the impact of a change in central banking laws would have within a single country. Posen (1995) has also argued that institutions such as central banks are endogenous, and their political independence is a function of the relative political strengths of competing interest groups. Eijffinger and de Haan (1996) survey a number of papers that treat independence as endogenous. This would suggest that one cannot use cross-sectional evidence to predict the outcome of a major change in regime such as making the central bank more independent. In fact, Campillo and Miron (1996) have argued that the empirical correlation between inflation and central bank independence disappears once other potential explanatory variables that might account for cross-sectional variations in average inflation rates are incorporated into the analysis[i], although De Haan and Kooi(2000) have found results to the contrary.

While most of the recent work relating central banking structures to economic outcomes has focussed on variables such as average inflation or real growth, a number of authors (Debelle and Fischer, 1994; Walsh, 1995a; Froyen and Waud, 1995; Fischer 1996) have found that measures of central bank independence are correlated with measures of the short run output-inflation trade- off and measures of the costs of disinflation (ie. the sacrifice ratio). For example, Debelle and Fischer note that Grilli et. al.'s (1991) index of central bank independence is positively correlated to Ball's (1993) estimates of the output cost of disinflation. Using three alternative measures of central bank independence, Walsh (1995) estimates the effect of central bank independence on the short-run output inflation trade-off for twelve member states of the European Community and finds that increasing independence is associated with a greater real output effect of changes in nominal income growth. Somewhat surprisingly then, countries with relatively independent central banks seem to bear the highest cost of reducing inflation. This finding runs counter to expectations. Independent central banks are expected to be more credible in their dis-inflationary policies; they should therefore receive a credibility bonus that should reduce the output cost of lowing inflation. Yet the short-run output-inflation trade-off faced by an independent central bank appears to be larger (ie. a flatter short-run Phillips curve in output-inflation space) than that faced by more dependent central banks. We argue in this paper that one reason why this increased cost of central bank independence results could be due to a non-cooperative "game" where the fiscal authority and the central bank pursue competing objectives for macroeconomic policy.

Few countries have experienced the major changes in their central banking institutions that would allow one to determine whether institutional changes actually do influence inflation and other economic outcomes. This paper therefore examines changes to central bank institutional structures in the context of a single country empirical macro-model. In particular, we consider the applicability of the results from theoretical models that underpin these developments, using an empirical analysis game theoretic techniques to model non-cooperative policy setting and in empirical testing we are able to show how the move to a more "conservative" policy maker might reduce the inflationary bias in the economy, thus confirming the theoretical insights of the model. We also show that when both authorities pursue congruent objectives the stabilisation loss suggested by Rogoff (1985) appears to be small; off-set by the positive externality of the increased credibility that delegating monetary policy brings. Finally, we examine the case of competing objectives between the authorities, and this shows that adverse outcomes are possible. The resulting outcome of higher interest rates and a strong exchange rate appreciation is indeed strongly reminiscent of recent experience of the UK. A related paper to this part of our analysis is Demertzis, Hughes Hallett and Viegi(1999).

The rest of the paper begins, in section 2, by very briefly setting out the background to our estimates of the gains to independence. Apart from the Barro-Gordon model of inflation bias and its extension by Rogoff, we outline the model of Nordhaus (1994) of a non-cooperative game between the fiscal authority and an independent central bank. Section 3 presents the substantive part of the paper, an evaluation of the empirical importance of this issue using a large empirical model of the UK economy. Finally section 4 draws some general conclusions.

2. THE THEORETICAL FRAMEWORK FOR DELEGATING MONETARY POLICY

The idea that there is an "inflation bias" to discretionary policy making was first formalised by Kydland and Prescott (1977) and subsequently popularised in the monetary policy game of Barro and Gordon (1983a, 1983b). As is well known, the inflation-bias problem derives from the incentives of the policy maker to spring surprise inflation on economic agents in order to secure a short term boost to output and employment. Rational agents engage in pre-emptive nominal bargaining in anticipation of this, and the optimal response of the authorities is then to justify these expectations - hence the inflation bias. The familiar Barro-Gordon framework will not be repeated here, except to note that it is based around a standard Lucas supply function which is subject to shocks (e) where the policy makers have a quadratic loss function in inflation(ð) and output (y) relative to the natural rate of output (y^*). The weight on inflation is a>0, and the desired value of output is above the natural rate by a factor k>1. Finally a parameter b>0 is the effect of surprise inflation on output. The resulting solution for inflation forms much of the basis for the independent Central Bank debate. Under Rational expectations the standard solution for inflation is

$$p = (b/a)z - (b/(a + b^2))e \qquad (1)$$

where z =(k-1)y*.

The first term in (1) is the inflation bias that results from the deterministic solution to the problem. The second term in (1) defines the authorities' stabilisation effort in the face of shocks which can be shown to be the equivalent to that under an optimal state contingent rule. The freedom to respond to shocks under discretion therefore ensures that the discretionary solution secures optimal policy stabilisation (ie. lower output variance) but at the expense of an inflation bias.

Various strategies have been suggested in the literature as ways of eradicating or diminishing this inflationary bias. One of the best known is that by Rogoff (1985) which proposed the delegation of monetary policy to an authority with greater inflation aversion - a "conservative" central bank. Such a model probably comes closest to what many people think of as central bank independence: delegation of monetary policy to an inflation adverse authority with instrument independence. As the degree of inflation aversion rises the first term in (1) goes to zero, so that in the limit inflation reaches its bliss point of zero but at the cost of zero stabilisation of shocks. However, Rogoff showed that when the degree of inflation aversion is chosen optimally, delegation to the conservative central bank secures a welfare outcome, which is preferable to either discretion or the use of non-contingent rules (such as zero inflation). This result is usually taken as lending strong support to moves to grant independence to a central bank as a solution to the inflation bias problem.

Our argument is that these results depend on three key assumptions: there is only a single policy maker and a single instrument, (interest rates or the money supply) so it does not address the losses that may arise from a failure to coordinate monetary and fiscal policy. The model is a closed economy model, so there is no separate channel for monetary and fiscal policy to act on inflation, they both work only through output. Finally, the model assumes fully rational expectations, which means that the monetary authority may rapidly gain full credibility and the transition process to full credibility and its associated costs are played down. These three points are discussed briefly before the estimates of their possible effects are given in the next section.

It is important to realise that Barro and Gordon model is always a single player game, all that is happening is that we force the one player to be more or less inflation avers. Part of the essence of making a Central Bank independent is however that we create a second policy maker in the system who can exercise some degree of independent decision making. The creation of an independent central Bank is therefore a fundamental move from a single player game to a two-player game and this raises important issues of co-ordination and co-operation. Just creating two players within the Barro and Gordon framework is not sufficient however to create an interesting and realistic game structure. The reason for this is that the Barro and Gordon model is a closed economy where inflation is generated by a standard Phillips curve. Even if we have two players (say a fiscal authority controlling government spending and a Central Bank controlling interest rates), there is only one route to affect inflation (output relative to the natural rate). So if the fiscal authority raises output the central Bank can exactly neutralise this effect by raising interest rates to exactly offset the rise in output. Once the fiscal authority realise this, there is no reason for them to attempt to cheat, as they can never profit in any way. However this situation changes fundamentally when we develop the model into an open economy with effects of the exchange rate on inflation. Then if the fiscal authorities attempt to raise output at the cost of undesirable inflation, the Bank will raise interest rates but this will have two channels to work through an output effect **and** a real

exchange rate effect. Hence the reduction in output to offset the inflation will always be less than the increase caused by the rise in fiscal expenditure and the government will always make a positive gain in output at no cost to inflation. The costs come in the form of an overvalued exchange rate and a loss of competitiveness to the tradable sectors of the economy.

Nordhaus (1994) gives a formal analysis of a strategic policy game between the fiscal and monetary authorities using a short run, non-repeated game with a differential impact of fiscal and monetary policy on inflation and growth which demonstrates the general point made above. (see also Blinder ( ) for a general analysis of possible strategic conflicts between monetary and fiscal policy setting)

The expectations formation mechanism is not made explicit in the Nordhaus framework but this is clearly an important element of the whole story. Even if expectations are rational the uncoordinated game problem outlined above still exists, but if expectations are less than fully rational then the period during which agents misunderstand the behaviour of the Central Bank can be extremy costly in economic terms

To investigate how credibility may be built up gradually it is necessary to introduce the concept of endogenous learning , where past inflation is used by agents to form their expectations of future inflation. This introduces an important additional feature, in that accommodating temporary shocks may increase future expectations of inflation as credibility is reduced (King 1996). In such a world the presence of nominal inertia and real rigidities make private agents' task even more difficult since at any given point in time, they have to partition inflation into that caused by lags in the economy and that caused by profligacy on the part of the central bank.

An analysis of the recent deflation in the UK would require us to determine how quickly agents were able to come to understand the new regime created by making the Central Bank independent. So we must allow expectations to evolve over time to properly model credibility effects, by implementing a bounded rational form of learning in our macro model. Here agents are assumed to use some 'reasonable'' rule of learning and to use this rule to form expectations where the form of the rule remains constant over time but agents learn the parameters of the rule. This form of bounded rationality entails that even in the absence of regime changes the reduced form of the model is a combination of the stable structural equations and the changing parameters of the expectations rule, so that it is time-varying. It is this form of learning - which we refer to as "adaptive learning" - which is applied in the solutions we give below[ii].

Before leaving these models of policy conflict it is perhaps instructive to consider their possible relevance to recent experience in the UK, since it instituted much greater central bank independence. As the figure 1 shows, the UK has experienced very significant nominal exchange rate appreciations in its attempt to head off inflation. There is a very strong presumption that fiscal policy was set independently of the objectives of the central bank. For example, successive Budgets since the Bank's independence, have eased fiscal policy at a time when interest rates were being raised. At the same time numerous policy statements have emphasised the Government's commitment to reducing unemployment and increasing the rate of (long term) growth of the economy. In some instances, for example, the adoption of a minimum wage or increasing excise duties, the actions of the Government have been to

directly increase inflationary pressure. This is strikingly reminiscent of the sort of non-cooperative behaviour envisaged above. If this is the case then the conclusions are clear: the non-cooperative solution will deliver the same rate of inflation but with higher interest rates and a higher budget deficit.

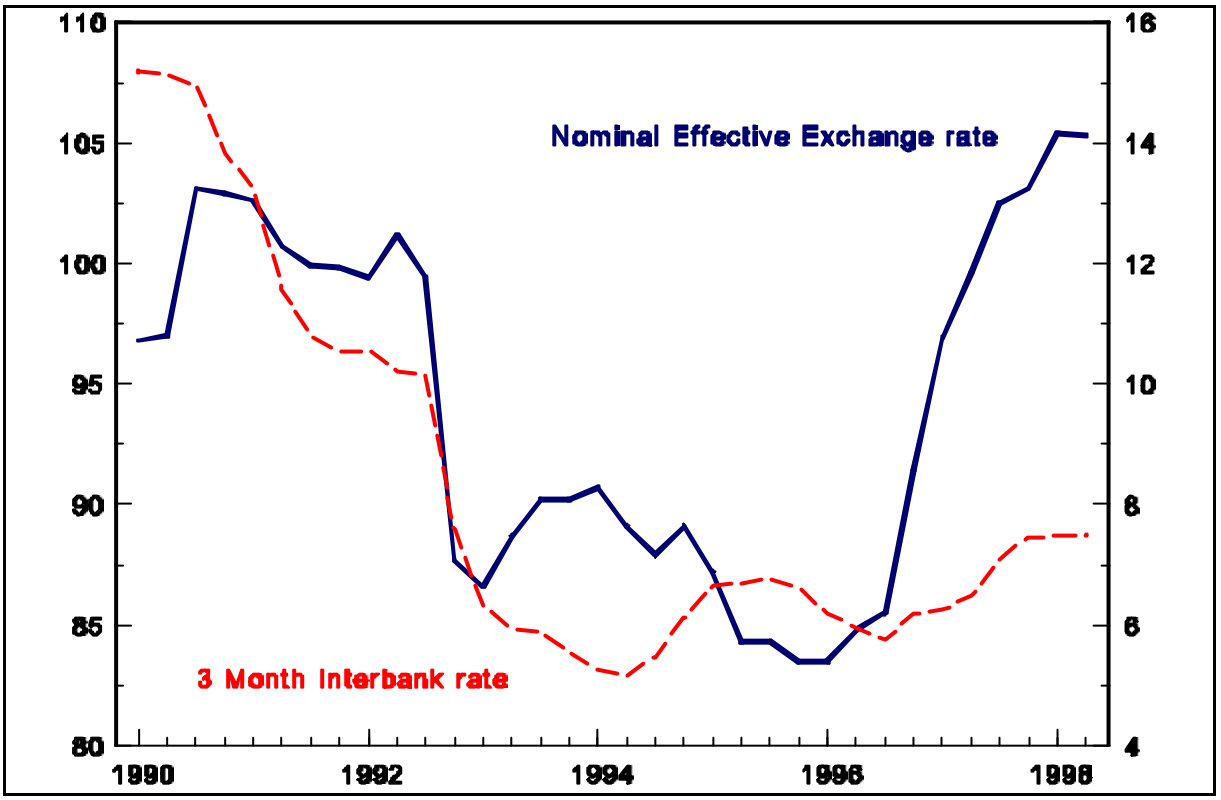


Figure 1: Exchange Rates and Interest rates in the UK.

To conclude this section, it is possible for theoretical models to point to both benefits and costs of an independent Central Bank. The balance between these costs and benefits is an empirical issue, which can only be addressed, in a well-founded empirical setting. It is this we turn to in the next section.

3. AN EMPIRICAL ANALYSIS OF MONETARY POLICY DELEGATION

In this section we present an empirical analysis of the gains to inflation performance that results from the delegation of monetary policy to an independent central bank. For this we use the structural model of the UK economy developed at the London Business School. It is particularly suitable for this purpose as it has a high degree of theoretical consistence based around a complex supply side system which is estimated econometrically and it fully incorporate boundedly rational learning as its main expectations formation hypothesis. As the model is a large one, it is not possible to review even its main features here. We give a short description of the models main features in appendix A (See Allen and Hall (1997) for full description). The policy exercises which follow using this model, begin by considering the single policy instrument analysis of Rogoff. We then turn to the issue of the losses which

may arise from [co-ordination] when the fiscal and monetary authorities have compatible objectives. Finally we analyse the Nordhaus case of incompatible objectives.

3.1 The inflation bias with a single policy maker

We begin by examining the Rogoff case where macroeconomic policy is conducted in order to maximise a known objective function, but where policy is delegated to a successively more conservative authority. To do this we compare the results from three simulations where the objective function is maximised over a five ten, and thirteen year time horizons[iii] . This is equivalent to reducing the authority's discount factor or, in Rogoff's terminology, of increasing the relative weight given to deviations of inflation from target. This is simply because the optimisation exercise gives no weight to events after the end of the simulation and so the shorter the simulation period the more myopic the behaviour of the policy maker

We model macroeconomic policy by an open loop control solution using the basic rate of income tax and the short term interest rate. A single authority is assumed to maximise an objective function that includes inflation and growth but this authority, in the spirit of the Nordhaus and Rogoff models, aims for a combination that is inconsistent with the long run Phillips curve. In addition, the deficit-GDP ratio enters the objective function to insure that whatever combination is chosen, it is not at the expense of fiscal solvency. The objective function is completed by including terms that penalise excessive movements in the instruments. The objective function for the policy maker is then of the basic quadratic form,

$$V = \sum_{i=1}^{N} \left[\beta_1 (\pi - \pi^*)^2 + \beta_2 (d - d^*)^2 + \beta_3 (\dot{y} - k)^2 + \beta_4 \Delta T + \beta_5 \Delta i \right] \quad (2)$$

where ð is (underlying) retail price inflation, d is the public sector deficit ratio, y is output, k is a constant rate of growth assumed to be higher than the growth of potential output, T is the tax rate, i is the short term interest rate and N is the time horizon of the policymaker. Each of the elements of the objective function is accorded the same weight, after taking account of scaling. All the weights are held constant in the following simulations.

Figures 2 and 3 show the results of three experiments, when the policy maker's objective function (21) is maximised over 5, 10 and 13 year time horizons respectively. Figure 2 shows the deviations of inflation target from a solution and figure 3 shows unemployment, as the authorities attempt to trade off inflation for higher growth. In each case they are successful in achieving lower unemployment (see figure 3), and inflationary pressure only builds up significantly towards the end of the planning horizon. The results in this figure show that as the time horizon is increased successively from 5 years to 10 and finally to 13 years, the policy maker's ability to exploit this trade off is reduced and both average inflation rate and the decreases in unemployment are reduced. These results illustrate empirically how delegating policy to an authority with a lower discount rate or a greater aversion to inflation, reduces the inflationary bias. There is an important feature of the inflation-unemployment trajectives as the two span over which the solution is done is extended.

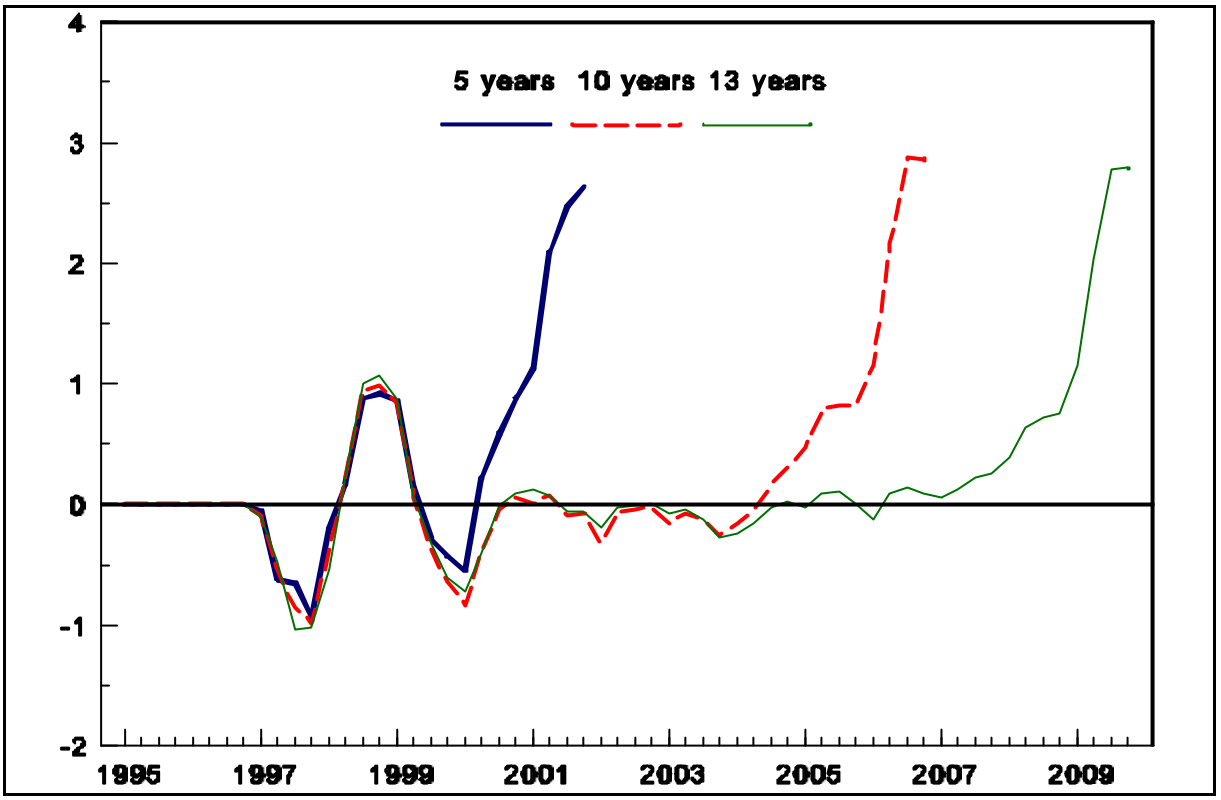


Figure 2:The Increase in Inflation for varying time horizons

A relevant empirical question to ask is how limited that trade off is; or more specifically, what is the slope of the Phillips curve ? Our results for example, suggest that for modest fiscal expansions (ie. for a government with an eye on fiscal solvency), the reduction in the inflation bias may be relatively modest and the Government does have some facility to exploit the inflation-output tradeoff in the short run. This last property derives from the weak effect of unemployment on wage settings, a "real inertia" property which is a typical feature of many wage equations estimated on UK data (see for example, Darby and Wren-Lewis, 1993; Hall and Nixon, 1997; Greenslade, Henry and Jackman, 1998)

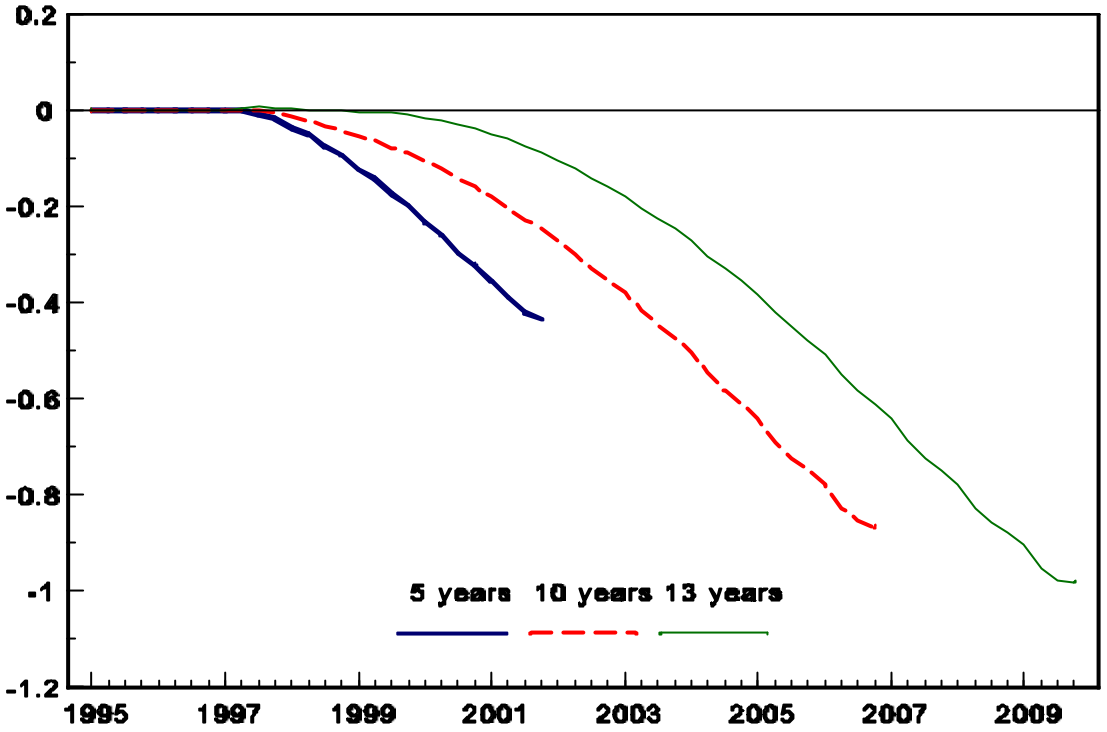


Figure 3: the fall in unemployment for varying time horizons

3.2 Cooperative and non-cooperative reactions with two policy makers

The other key feature of the Rogoff model however, is that the reduction in the inflation bias is only achieved at the expense of a loss in the optimal degree of stabilisation. To analyse this, we analyse optimal policy in a stochastic environment and this time compare stabilisation under a single policy maker to the case where monetary policy is controlled by the central bank, and fiscal policy is controlled the government. Each institution's objective function is optimated numerically, subject to the reaction of the other authority. This Nash solution is then compared with a cooperative solution where only one joint objective function is minimised. As the issue here is one of stabilisation we assume both authorities set policy in response to a shock, each aiming at returning the economy to its long run sustainable state. Their objective functions are taken to be combatable, although not identical. Thus the fiscal authorities seek to minimise the
following objective function:

$$V = \sum_{i=1}^{N} \left[b_1 (p - p^*)^2 + b_2 (d - d^*)^2 + b_3 (y - \bar{y})^2 + b_4 \Delta T + b_5 \Delta i \right] \quad (3)$$

using just the basic rate of tax as an instrument. This minimises deviations of inflation, output and the deficit ratio from base, as well as penalising instrument instability. The monetary authority in turn concentrates solely on inflation, using short term interest rates to minimise:

$$V = \sum_{i=1}^{N} \left[\frac{b_1}{2} (p - \bar{p})^2 + \frac{b_2}{2} (\Delta i)^2 \right] \quad (4)$$

The cooperative solution is achieved by minimising the fiscal authorities objective function using both short term interest rates and the tax rate jointly.

Figures 4 compare the performance of the two policy regimes (which we label *cooperative* and the non-cooperative *Nash* solution), in response to a one period (domestic) demand shock We find very little difference between the performance of the two regimes in either case, a result which seems to indicate that the potential risks of failure to coordinate policy in the delegated regime are small when the authorities are pursing congruent objectives. In the present case both authorities wish to stabilise the economy as fast as possible, so non-coordination appears to make little difference.

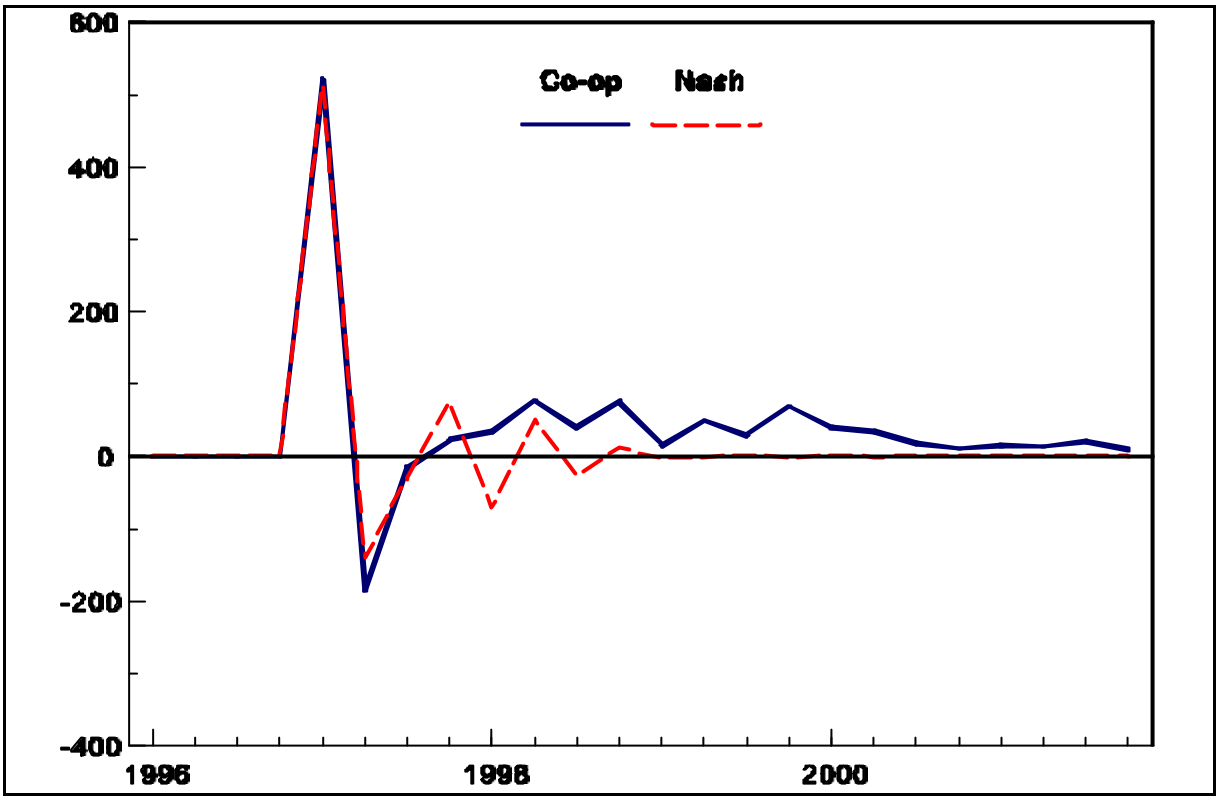
This appears to be a direct consequence of the 'credibility' that is derived from dedicating the interest rate instrument solely to inflation targeting. Hence, in our model, agents 'learn' that inflation will be targeted aggressively and this reduces the output cost of uncoordinated policy instruments. This may explain one of the puzzles of the Rogoff model. The most important prediction of that model, namely an inverse correlation across countries between inflation and various indices of central bank independence appears empirically well established (see Bean (1998)). However, it does not seem to be the case that countries with more independent central banks have achieved lower inflation at the cost of greater variability in output - which is the trade-off for the reduced inflation bias implied by the Rogoff model. The empirical results above suggest that one possible explanation for this is that any stabilisation loss is offset by the positive
externality due to increased credibility in monetary policy.

3.3. Competing Objectives

Finally, in the last set of simulations (shown in figure 5 and 6) we repeat the exercise but now where it is assumed the fiscal authority's objective function is the same as in section 3.1: ie. the fiscal authority is no longer concerned with the stabilisation of output in response to a shock but instead attempts to inflate the economy. The monetary authority attempts to target inflation as before. The result in this case is a significant difference between the Nash and the cooperative solutions. In the non-cooperative case interest rates are raised significantly to counter the expansionary policy of the fiscal authority. This leads to an appreciation of the exchange rate and a marked shift in the composition of demand away from net trade to domestic consumption as taxes are lowered. The inflation target is broadly achieved under both policy regimes but the lack of co-ordination in the Nash game now leads to considerable real imbalance in the economy, as compared with the previous example of complementary objectives.

It is worth emphasising that in both the cooperative and Nash game the authorities are very successful at controlling inflation. The costs of the lack of co-ordination do not appear as a failure to control inflation but in the unnecessarily high exchange rates which results from the lack of co-ordination.

Figure 5: Deviations in Inflation from base following the shock


600
400
200
0
-200
-400
1996
1998
2000
Co-op
Nash

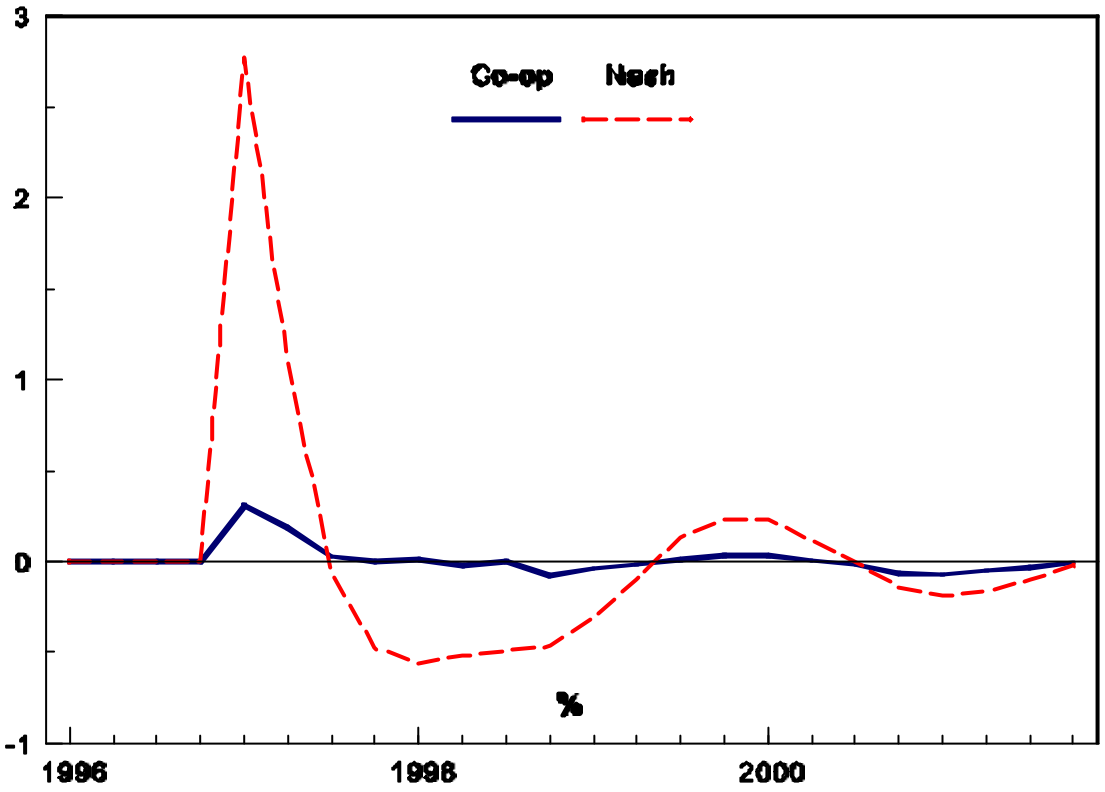


Figure 6: The interest rate response to the Inflation Shock

4.CONCLUSION

This paper has considered the delegation and coordination of monetary policy in inflation targeting regimes where instrument independence is granted to the central bank. In reviewing the theoretical models used to justify moves towards greater central bank independence we have highlighted three issues:

Firstly, that these models typically tend to be simple representations of the economy that do not take into account the openness of the macro economy, exchange rate effects, nominal inertia or real rigidities.

Secondly, that these simple models ignore the possibility of two policy instruments impacting on the economy and that these may individually be under the control of separate authorities and crucially that they work through different channels.

And finally that the usual assumption of Rational Expectations limits the degree to which the credibility of inflation targeting regimes can be investigated.

While much of the empirical literature on the effects of central bank independence focuses on cross sectional regressions of quantitative indices of independence, we have addressed the three points above using policy simulations with an empirically estimated macro model. This enables us to assess the implications of the theoretical models in a more realistic framework. In particular we can allow for the presence of significant lags in policy responses that arise because of nominal or real rigidities, we consider the case where there are two instruments, monetary and fiscal policy and where they may not be coordinated, and finally we allow for

learning in expectations formation and therefore for monetary policy to gain credibility over time.

At one level, our results are very supportive of a delegation regime: we have shown empirically that there are gains from delegating monetary policy to an institution with a more hawkish stance on inflation in terms of a reduced inflationary equilibria. Moreover, we have applied game theoretic techniques to analyse the possible reductions in efficiency that may stem from the future inability to coordinate monetary and fiscal policy. Our results appear to indicate that such loses are small if the two authorities pursue broadly congruent objectives, such as stabilisation. In particular we argue that the stabilisation loss suggested by the Rogoff model can be off-set by the gain in credibility that is achieved if interest rates are assigned to targeting inflation.

However, in the final part of our analysis we show that if the two authorities pursue competing objectives then the resulting non-cooperative macroeconomic outcome can be distinctly sub-optimal. Interest rates will tend to be higher and demand will be shifted away from the traded-goods section. This leads us to conclude that the worsened trade-off or higher sacrifice ratio associated with central bank independence may be related to policy reactions of the fiscal authorities in these regimes and the competing objectives they pursue compared with the monetary authority. For example, if the fiscal authority is not as concerned with stabilisation as the monetary authority, then non-cooperation leads to a distinctly inefficient outcome. This latter result is important and seems to be particularly relevant in explaining the sharp nominal exchange rate appreciations recently experienced in both the UK and New Zealand.

APPENDIX A, The LBS Model

The model we employ has a high degree of theoretical consistency and seeks to model the economy at an aggregate level, with the highest possible degree of data consistency. Full details of the model can be found in Allen and Hall (1997) whilst its overall structure is summarised in Allen, Hall and Nixon (1994) and Hall and Nixon(1998). The model has a number of advanced features including the ability to determine expectations using an estimated learning model of expectations formation (see Garratt and Hall (1996)).. This is an empirical counterpart to the learning assumption made in the theoretical discussion above.

The supply side of the model is based around a translog cost function which is used to derive consistent factor demand and pricing equations and the whole system is then estimated subject to the full set of non-linear cross equation restrictions implied by economic theory. The demand side of the model is made up of a fairly conventional set of demand component equations which have all been fully estimated using modern approaches to e.g. cointegration.

The model is actually quite large in terms of variables or the total number of equations (there are around 200 variables and 100 equations) but the main structural core of the model consists of about thirty aggregate equations which capture the overall behaviour of the economy in a theoretically consistent way.

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NOTES

1. They find that for a sample of high income countries, average inflation from 1973 to 1994 is significantly related to average inflation from 1948 to 1972, a measure of political instability, the ratio of imports to GDP, debt to GDP and income. The addition of central bank independence or a dummy for exchange rate regime has no further explanatory power.

2. Garratt and Hall (1997) illustrate how assumptions about learning are applied in a large macro model.

Each iteration of the control algorithm solves the model with interest rates given and then compares the model solution to the objective function. This is effectively solving the model under fixed interest rates. It is often not possible to calculate the optimal control solution using this algorithm under rational expectations since the model typically unique saddle-path solution. In this instance the learning solution converges to the rational expectations solution in 13 years: this therefore represents the maximum time horizon over which we can run this experiment.