2000/9

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September 18, 2000

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by

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ISSN 0801-2504

ISBN 82-7553-166-7

Strategic Interaction between the Fiscal and Monetary Authorities under Inflation Targeting*

Kai Leitemo†

September 2000

Abstract

This paper studies the strategic interaction between the fiscal and monetary authorities when the monetary policymaker pursues an underlying inflation target. Given that monetary policy is transparent and the fiscal policymaker can commit to a particular policy stance, the Stackelberg equilibrium can be implemented. If the conditions for Stackelberg leadership is not present, policies may end up in a Nash equilibrium, resulting in excessive interest and exchange rate volatility. Legislative restrictions on fiscal policy may then be stabilising, whereas they may be counterproductive in the Stackelberg case.

Keywords: Small open economy, inflation targeting, policy coordination, policy interdependencies

JEL codes: E61, E63, E42, E52.

*Comments and suggestions from Ylva Søvik, Lars-Erik Borge, Steinar Holden, Tommy Sveen, Bent Vale and participants at seminars at the University of Oslo and Norges Bank (central bank of Norway), are gratefully acknowledged. Remaining errors are the responsibility of the author. Views and conclusions expressed are the responsibility of the author alone.

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1. Introduction

There is a broad consensus among practitioners of economic policy that both monetary and fiscal policy influence aggregate demand and aggregate output in the short run. Monetary policy affects demand through several channels, of which the interest rate and the exchange rate channels may be the two most important in a small open economy.[1] Fiscal policy may influence demand directly through the public budget.[2] Given a sufficient degree of nominal rigidity, increased demand results in temporarily higher output. In the longer run, markets clear and output is determined by supply side factors.[3] In this neoclassical view, economic policy may have a potential for real as well as nominal stabilisation that may be exploited in different ways. The recent literature on stabilisation policy only to a small extent addresses the potential problems resulting from the interaction of the different branches of economic policy. Most often, the literature assumes that stabilisation policy is carried out by the monetary authorities, while the fiscal authorities remain passive; or fiscal policy is set independently of monetary policy, and hence fiscal policy is perceived to be exogenous to the monetary policymaker.

For several reasons this may be unsatisfactory. At least in countries where fiscal policymakers have preferences with regard to the variables affected by the business cycle,[4] there is reason to believe that fiscal policymakers may react systematically to the state of the economy. As the state of the economy is normally believed to affect election results, fiscal policymakers may indeed possess strong incentives for using budget policies in affecting the economy.[5] Currently, the fiscal financial situation is improving in several countries, increasing fiscal policy maneuverability and ability to pursue other goals beyond debt control. In such a policy setting, the behaviour of each branch of economic policy may be influenced by strategic considerations.

[1]Several researchers have called attention to the possibility of a credit channel of monetary policy (see, e.g. Bernanke, 1993). In an imperfect credit market, the amount of reserves made available by the central bank to the banking sector may have an independent effect upon aggregate demand due to a required reserve ratio. However, most of these effects would be complimentary to the interest rate channel, exacerbating the effect on aggregate demand of interest rate changes. We therefore choose to refrain from modeling this channel explicitly.

[2]Andersen and Holden (1998) discuss the effects and welfare implications of fiscal policy stabilisation in an optimising two-sector model.

[3]Fiscal policy may influence real variables also in the long run in various ways, e.g., by affecting the level of distortionary taxes. The analysis of such effects are not central to the ideas in this paper, and are hence ignored.

[4]Fiscal policymakers in Norway, Denmark and the Netherlands have even publicly announced their responsibility for stabilisation policy.

[5]Drazen (2000) provides a thorough treatment of the literature on political economy in macroeconomics.

Economic analysis that fails to take this into account may miss important aspects of optimal policymaking.

Svensson (1999b) defines inflation targeting as a monetary policy regime where the central bank uses all available information to reduce the variance of inflation around a given target level. Inflation targeting has formally been implemented in several small open economies, such as New Zealand, Canada, the United Kingdom, Sweden, Australia, Spain and Finland. It should therefore be of interest to analyse the strategic interactions between the branches of economic policy that may arise under such a monetary policy regime. This article attempts to do just that. We will use a simple macroeconomic model that is close to the models of Ball (1999) and Svensson (1997a). The model is basically an AD/AS model of a small open economy where both fiscal and monetary policy authorities may influence aggregate demand. Monetary policy is assumed to target a measure of underlying inflation. The fiscal authority is potentially concerned with several factors such as employment, cost-competitiveness, the level of interest rates and the size of the budget deficit.

This analysis has much in common with Nordhaus (1994), who analyses the strategic interaction in a model of a closed economy, where the focus is set on the difficulty of achieving a reduction in public debt. Andersen and Schneider (1986) analyse the interaction in economic policy when each branch of policy is concerned with stabilising output and inflation around target levels, although with different relative weights. Agell et al. (1996) study the effects of fiscal policy on inflation and the public debt in a monetary union compared to a discretionary exchange rate policy. This paper differs by focusing on the stabilisation properties resulting from strategic policy interaction when the fiscal policymakers care about a broad spectre of macroeconomic variables. The paper offers new insight in how inflation targeting may perform conditional on fiscal preferences.

Section 2 presents the open-economy model and describes the monetary and fiscal policy frameworks. Section 3 discusses the strategic interaction between the economic policy branches. The possibility of implementing the Stackelberg equilibrium in reality is briefly discussed in section 4 and some conclusions are offered in section 5.

2. The model

In order to analyse the effect of inflation targeting in a small open economy, it is crucial to model the various transmission channels to which such an economy is exposed. The analysis would, however, be extremely complicated if all the relevant dynamic processes were to be included, in which case one would have to apply numerical solution procedures. In order to obtain analytical expressions and results, the model is kept within a static framework. We believe that this strategy is a simple way of representing the most essential mechanisms of the problem at hand.

The model is intended for short-run analysis. Therefore, it is not useful for analysis of long-run public debt issues. The model displays neoclassical features, as a level of aggregate demand resulting in output exceeding the natural level will result in a delayed increase in the rate of inflation. Monetary policy influences demand through the interest rate and exchange rate channels. The interest rate influences demand by changing the perceived benefits in spending resources now relative to waiting until the next period. The interest rate may also influence demand for investment goods by affecting the user-cost of capital. The exchange rate affects the economy through both a direct and an indirect channel. Through the direct channel, the exchange rate affects consumer prices directly by affecting the price of imported goods. The exchange rate also affects consumer prices indirectly through its effects on demand by changing the price of foreign goods relative to domestic goods. We also assume that there is perfect capital mobility and that agents in the financial markets form expectations rationally.

Furthermore, the fiscal policymakers use the fiscal budget as a way of influencing demand. Correspondingly, the central bank uses the real interest rate as its policy instrument.[6] The central bank sets an interest rate that brings about an expected rate of next-period (underlying) inflation that is equal to the target. We assume that the central bank enjoys full credibility.

[6]In practice, the central bank may only control the short *nominal* interest rate. However, as inflation moves sluggishly and may be forecast by the central bank, the real interest rate may be set through a suitable choice of the nominal rate.

2.1. The relationships

All the variables are log-transformed (except for the interest rate) and measured as deviations from their unconditional expectations. The period length may best be interpreted as being one to two years.

The supply side of the model is governed by an expectations-augmented Phillips curve relationship,

$$\pi_{t+1} = \pi_t + \phi(e_t - e_{t-1}) + \gamma y_t + \varepsilon_{t+1}, \tag{2.1}$$

where $\pi \equiv p_t - p_{t-1}$ is domestic inflation and p_t is the price of domestically produced goods; $e_t \equiv s_t + p_t^* - p_t$ is the real effective exchange rate, s_t is the nominal effective exchange rate, p_t^* is the foreign price level; y_t is the output gap, that is, the percentage difference between the natural level and actual output, and ε is a cost-push shock with $E_t\varepsilon_{t+1} = 0$.

A detailed derivation of (2.1) is presented in Appendix A. The domestic price level is implicitly assumed to be a mark-up on wage cost. Wages are determined by the pressure in the labour market (as measured by the output gap) as well as the expected changes in consumer prices. Consumer price inflation is affected by the domestic inflation rate as well as imported goods price inflation which again is influenced by changes in the exchange rate. The agents in the labour market is assumed to form expectations adaptively, where the expected rate of consumer price inflation is equal to the actual rate in the previous period. Domestic inflation is hence predetermined for one period.

The output gap is determined by demand in the short run. Demand is influenced by a number of factors. The real interest rate[7], r, affects demand through intertemporal consumption and investment decisions. The real exchange rate, e, which is the price of the foreign good measured in units of the domestic good, influences domestic demand through intratemporal consumption decisions. Fiscal policy influence on domestic demand is captured in an indicator of the fiscal stance, g, which we will refer to as the structural[8] budget deficit.[9] Moreover,

[7]The real interest rate is defined in terms of the domestic good.

[8]We abstract from the effects of automatic fiscal stabilisers that would be present irrespective of the discretionary decisions on fiscal stance analysed here.

[9]Alternatively, we could assume that the structural tax revenue is kept constant and the level of public expenditure is the policy instrument.

domestic demand is subject to a random shock, u, in each period with the property $E_t u_{t+1} = 0$. Hence, domestic demand is given by

$$y_t = -\alpha r_t + \beta e_t + \kappa g_t + u_t. \tag{2.2}$$

There is perfect capital mobility and the expected pay-off from holding different currency denominated bonds is equalised, hence the real exchange rate is determined by uncovered interest rate parity,

$$e_t = E_t e_{t+1} - r_t + r_t^*. \tag{2.3}$$

We assume, as Ball (1999), that monetary policy targets the rate of underlying inflation as targeting the domestic inflation rate directly may lead to endogenous oscillations and even instability. Ball defines underlying inflation as

$$\hat{\pi}_t \equiv \pi_t - \phi e_{t-1}. \tag{2.4}$$

Underlying inflation is defined by domestic inflation, $\pi_t \equiv p_t - p_{t-1}$, less the component that reflects the compensation in wages for previous consumer price inflation movements caused by temporary changes in the exchange rate. The process of underlying inflation is found by substituting the expression for the domestic inflation rate given implicitly from (2.4) into equation (2.1), giving

$$\hat{\pi}_{t+1} = \hat{\pi}_t + \gamma y_t + \varepsilon_{t+1}, \tag{2.5}$$

which corresponds to a closed-economy expectations-augmented Phillips curve. (2.5) illustrates that the change in underlying inflation is determined by the tightness in the labour market. The monetary policy target is given by

$$E_t \hat{\pi}_{t+1} = 0, \tag{2.6}$$

where the inflation target level has been normalised to zero. By using (2.4), (2.6) may be written as

$$E_t \pi_{t+1} = \phi e_t. \tag{2.7}$$

Ball argues that targeting underlying inflation in this way is equivalent to targeting domestic inflation with a longer targeting horizon. Targeting domestic inflation at a shorter horizon, e.g., by setting $E_t \pi_{t+1} = 0$, may produce endogenous oscillations in key variables, which should be avoided.[10]

An example may illustrate the properties of this targeting scheme. Assume that the rate of underlying inflation is below target (in period 0). The central bank then pursues an expansionary policy. The interest rate is lowered, causing a real exchange rate depreciation through (2.3). The depreciation produces an immediate increase in the imported goods price inflation, raising the expected rate of domestic inflation in the next period (period 1) through wage compensation. Since the depreciation is of a transitory nature, the central bank allows it to take place. In this period, expected underlying inflation will be back on target and the central bank sets a neutral policy stance by raising the interest rate back to the natural level. The exchange rate appreciates, raising imported goods price inflation and causing the domestic rate of inflation to be once again back on target in the subsequent period (period 2). A target for the underlying rate of inflation is hence long-run domestic inflation target.

The central relationships of the model are (2.2), (2.5) and (2.3), which represent the demand side, the supply side and an equilibrium condition for the exchange rate market, respectively. If we combine (2.2), (2.5) and (2.6), we can derive an equilibrium condition for the interest rate,

$$r_t = \alpha^{-1} \left(\gamma^{-1} \hat{\pi}_t + \beta e_t + \kappa g_t + u_t \right), \tag{2.8}$$

which expresses the real interest rate as a function of the rate of underlying inflation, the real exchange rate, the budget deficit and the demand shock. An increase in the budget deficit will increase demand, which will require the interest rate to rise in order to reduce inflation expectations. As the interest rate determines the real exchange rate level, (2.8) is only a partial

[10]We show within a somewhat simplified model in Appendix B that a one-period domestic inflation target is likely to produce explosive and unstable solutions.

relationship for the interest rate. In order to find a reduced-form expression, we need to solve for the exchange rate. If we substitute for the interest rate from (2.3) in (2.8), we get

$$e_t = (\alpha + \beta)^{-1} \left(\gamma^{-1} \hat{\pi}_t - \kappa g_t - u_t + \alpha r_t^* \right). \tag{2.9}$$

If we substitute for the real exchange rate from (2.9) into (2.8), we arrive at the reaction function for the central bank,

$$r_t = (\alpha + \beta)^{-1} \left(\gamma^{-1} \hat{\pi}_t + \beta r_t^* + \kappa g_t + u_t \right). \tag{2.10}$$

The inclusion of exchange rate dynamics reduces the response from the different arguments in the reaction function, as an increase in the interest rate achieves an additional contractionary effect through an appreciating exchange rate. The foreign real interest rate level becomes an argument in the reaction function, as it influences inflation expectations through its effects on the exchange rate.

2.2. Fiscal policy preferences

We assume for simplicity that fiscal policymakers act in a coordinated manner and minimize a quadratic loss function given by

$$L_t = \eta_y y_t^2 + \eta_g g_t^2 + \eta_r r_t^2 + \eta_e e_t^2. \tag{2.11}$$

This loss function is flexible and may reflect a number of aspects with which fiscal policymakers may be concerned. η_g may be interpreted as reflecting the cost the fiscal policymakers face in adjusting the deficit to the business cycle instead of other political cost-benefit considerations. It may also be interpreted as the cost of reaching a political majority vote for prioritising stabilisation goals. Finally, it may be interpreted as institutional or legislative (supra-national) restrictions on the size of the budget deficit. η_r may similarly be interpreted as reflecting the political cost of shifts in the interest rate, as interest rate movements redistribute wealth among creditors and debtors that may contribute to a distribution of income that is not consistent with the preferences of the politically elected representatives. Moreover, η_e may be interpreted as reflecting the cost of a variable level of cost-competitiveness which produces an unstable situation for the export sector. If, for instance, adjustment is particularly costly in the export sector, owing, e.g. to a high capital factor share, welfare would increase if this sector can be stabilised relatively more than other sectors. Finally, η_y reflects cost attributable to output and employment instability, e.g., political as well as social and economic cost of adjustment.[11] As the fiscal policymakers have delegated the task of stabilising inflation and the central bank enjoys full credibility, we assume that fiscal policymakers are not explicitly concerned with inflation stabilisation when setting policy.

In the following analysis, we will neglect one potentially important aspect of fiscal policy; that it may be the outcome of a strategic game between the parties represented in the parliament. We assume that they act as one body with a given loss function. This is of course a great simplification, but may not be as crucial as one may initially believe. If we were able to specify the enormously complicated game between the parties, it is by no means certain that the outcome of that game would deviate systematically in any interesting (given the problem at hand) way from the results obtained here.

3. Strategic interaction

In order to solve for the optimal fiscal policy behaviour, it is necessary to specify the environment of strategic interaction between the policy branches within which decisions are taken. From equation (2.10) it is clear that the interest rate set by the central bank depends partly on the level of the structural budget deficit. We also note that the interest rate affects variables that are important to the fiscal policymaker. The combination of these two factors sets the stage for the possibility of strategic interaction. It is customary to characterise the outcome of this interaction in a coordinated equilibrium, a Nash equilibrium or a Stackelberg equilibrium, depending on the institutional setting in which decisions are being made. This paper focuses on the outcome when the central bank has already been assigned a specific role. Thus, we disregard the possibility of a coordinated equilibrium in which both branches set their policy instruments

[11] In a previous version of this paper, we included fiscal preference for having output above the natural level. This extension did not add anything interesting to the analysis of the stabilisation issues discussed in this paper. It was hence ignored in the present paper.

to minimize a common loss function. We believe that the literature[12] provides a good case for greater credibility and superior outcome when the central bank can independently pursue its objective.[13] Although our model is not suitable for studying the credibility problems of discretionary policymaking and the endogeneity of inflation expectations, increased credibility may allow the central bank to pursue inflation targeting by affecting inflation expectations in an advantageous way (Svensson, 1999a). In consequence, the central bank may not need to adjust interest rates and hence output and employment as much as would otherwise be necessary. For these reasons, we do not study the outcome of the coordinated equilibrium, but address the issues raised by the two other types of equilibria.

If each policy branch does not take into account its own effect upon the other branch's policy setting, e.g., due to policy non-transparency, and, furthermore, assumes (incorrectly) that the other branch's instrument remains unaffected by the first branch's instrument, then it can be shown that the outcome will converge towards a Nash equilibrium, given that the equilibrium is stable. If, on the other hand, the fiscal policymakers can commit to a specific budget deficit level, and correctly perceive the interdependence of economic policymaking by having knowledge about how the interest rate is set, they will be able to act as a leader in a sequential game with the central bank and attain the Stackelberg equilibrium. These equilibria will be considered in more detail in the following sections.

3.1. The Nash equilibrium

First, assume that neither party has any knowledge of the other party's policy setting. They both assume, for e.g., reasons of simplicity, that the other party's behaviour is independent of their own behaviour. The no-knowledge assumption may seem unrealistic given our very simple and transparent model, but in the real world, where each party's often use different, often large-scale models, and may in addition have access to different sets of information, such an assumption may not be as unrealistic as it may appear.

If this assumption of independence is maintained, the policy setting will converge towards

[12] See Rogoff (1985); Walsh (1995); Svensson (1997b); Cukierman (1992) for important contributions to this literature.

[13] Although the perceived benefits are mostly related to the formation of private agents' expectations.

the Nash equilibrium through a Cournot process (Fudenberg and Levine, 1998). An example may illustrate how this may come about. Assume that underlying inflation is above target. The central bank raises the interest rate so as to lower output and next-period inflation expectations. The fiscal policymakers observe that output is falling below the natural level, and make the fiscal stance more expansionary, contributing to increased output. The central bank now observes that output is not in line with the level necessary to bring about the inflation target and the interest rate is raised even further. This process converges to the Nash equilibrium in which the marginal cost of expanding fiscal policy is equal to the perceived (by the fiscal policymakers) benefit in terms of increased output. In our static framework, we assume that this process has converged within one period.

Minimising (2.11) with respect to the budget deficit, g, given that the fiscal policymaker assumes an unchanged interest rate (and, thereby, an unchanged real exchange rate), yields the following solution for the fiscal deficit:

$$g_t = \frac{\kappa}{\frac{\eta_g}{\eta_y} + \kappa^2} \left[(\alpha + \beta) r_t - \beta r_t^* - u_t \right], \tag{3.1}$$

where we have used (2.3) to substitute for the real exchange rate.

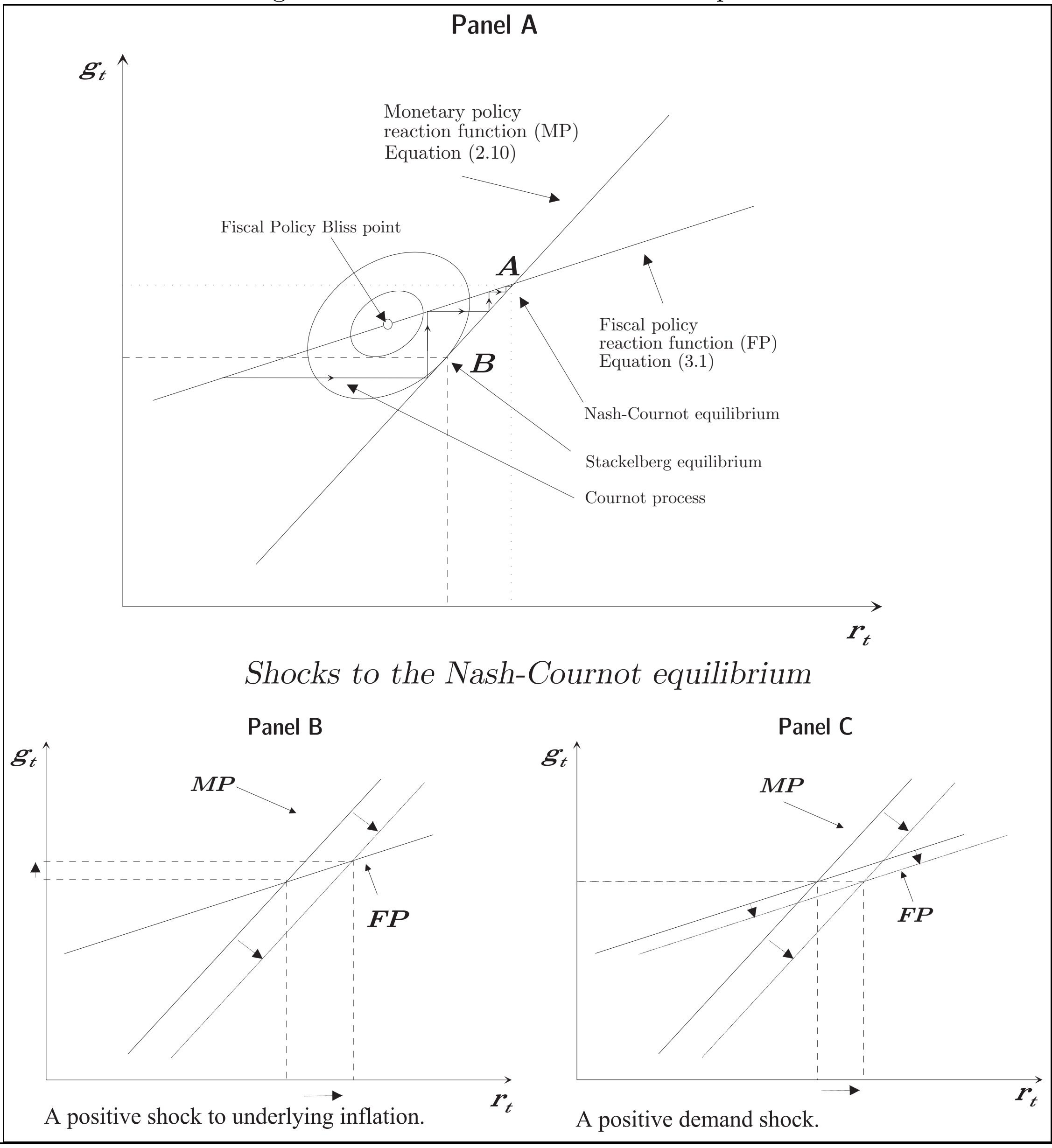
Equation (3.1) suggests that the budget deficit will be determined by the other determinants of aggregate demand. Moreover, increased preference for stabilising the fiscal deficit, as represented by η_g, reduces the response of the deficit to its determinants. This follows from the fiscal policymakers attaching a greater cost to using their instrument to influence output. Similarly, an increased desire to stabilise output, represented by η_y, unambiguously increases the response of the budget deficit to its determinants.

The equilibrium is found by solving equations (3.1) and (2.10) for each instrument, yielding

$$\begin{aligned} g_t &= \frac{\eta_y \kappa}{\eta_g} \left[\gamma^{-1} \hat{\pi}_t \right], & (3.2) \\ r_t &= (\alpha + \beta)^{-1} \left[\gamma^{-1} \left(1 + \frac{\kappa^2 \eta_y}{\eta_g} \right) \hat{\pi}_t + \beta r_t^* + u_t \right]. & (3.3) \end{aligned}$$

The Nash equilibrium in (3.2) and (3.3), and the Cournot process are graphically illustrated

Figure 3.1: An illustration of the two equilibria



in Figure 3.1. In panel A, the equilibrium is shown for a given rate of underlying inflation, foreign interest rate and level of shock to demand. Point A indicates the location of the Nash equilibrium as the intercept of the two reaction functions. Panels B and C illustrate the equilibrium solutions to a change in underlying inflation (B) and a shock to demand (C).

An increase in the rate of underlying inflation causes the budget deficit to rise, implying an expansionary policy, whereas monetary policy act in a contractionary manner by raising interest rates. Fiscal policy thus counteracts monetary policy. The core of the conflict between the two policy branches lies in the fact that as monetary policy must set a level of output that brings inflation expectations equal to target, fiscal policy pursues a level of output equal to the natural level, i.e., $y_t = 0$. Assume that the cost of adjusting the fiscal deficit is very small and hence there is a large stabilisation policy potential, then there is almost no limit to how expansionary fiscal policy may be in the policymakers' eagerness to attain the natural level of output. The result is that the interest rate becomes very high, as monetary policy needs to attain the level of output consistent with the inflation target being reached.

A positive demand shock produces a level of output that is inconsistent with the level necessary for achieving the inflation target in the next period. Given that the rate of underlying inflation is presently on target, the level of output consistent with inflation remaining on target is equal to the natural level, $y_t = 0$. This follows from the combination of (2.5) and (2.6). The natural level of output is also the level preferred by the fiscal policymakers. As the central bank raises interest rate to achieve this level of output, the fiscal policymakers have no incentive to adjust the level of the deficit and it remains unchanged.

One interesting case is when there are high costs involved in adjusting the budget deficit (high η_g) or, alternatively, a sufficiently low desire to stabilise output (low η_y). In the limit, this implies that fiscal policy becomes passive and the interest rate is set independently of the arguments in the fiscal loss function, as

$$g_t = 0, \tag{3.4}$$

$$r_t = (\alpha + \beta)^{-1} \left[\gamma^{-1} \hat{\pi}_t + \beta r_t^* + u_t \right]. \tag{3.5}$$

This solution turns out to be the best attainable solution for the fiscal policymakers (with respect to their loss function in (2.11)) of the various outcomes in the Nash game. Under (3.4) and (3.5) there is no variation in the structural budget deficit, output will be at a level that ensures that inflationary expectations are on level with the target, and most importantly, monetary policy does not have to counteract fiscal policy by causing excessive changes in the interest and exchange rates. This implies that fiscal policy should be restricted by institutional and legislative measures not to pursue output stabilisation policies and hence solely pursue long-term goals.[14]

3.2. The Stackelberg equilibrium

The only level of output consistent with the inflation target is found by combining (2.6) with (2.5),

$$\tilde{y}_t = -\gamma^{-1}\hat{\pi}_t.$$

If the fiscal policymakers correctly perceive that fiscal policy will not be able to allow output to deviate from this level, realising that monetary policy is conducted in accordance with (2.10), and are able to commit to a given budget deficit, the fiscal policymakers may act as a leader in a sequential game with the central bank. They choose the point on the monetary policy reaction function (2.10) that minimizes the loss function stated in (2.11). Point B in Figure 3.1 illustrates the Stackelberg equilibrium, which is at the point of tangency of the isoloss curves to the monetary reaction function.

Setting (2.9) and (2.10) into (2.11), and minimising the loss with respect to the budget deficit, yields the following first order condition,

$$g_t = -\left(\frac{(\alpha+\beta)^2}{(\eta_r+\eta_e)\,\kappa}\eta_g+\kappa\right)^{-1}\left(\gamma^{-1}\hat{\pi}_t+u_t\right)-\frac{\kappa\,(\eta_r\beta-\eta_e\alpha)}{(\alpha+\beta)^2\,\eta_g+(\eta_r+\eta_e)\,\kappa^2}r_t^*. \tag{3.6}$$

The Stackelberg equilibrium implies a policy that differs fundamentally from the solution obtained in the Nash game. The fiscal policy response to demand and underlying inflation shocks is unambiguously contractionary. The more the fiscal policymakers prefer interest rate and exchange rate stability, the stronger the contractionary response in fiscal policy is to these shocks. Note that the fiscal policy preference for output stability, η_y, is not present in (3.6), as the fiscal policymakers take into account that they are not able to influence the level of output. As stated before, fiscal policy is more passive if the cost attached to adjusting the budget deficit is high. Fiscal policy reactions are also reduced if the effects of monetary policy on demand are strong.

[14]This could be regarded as being one possible argument for the restrictions imposed by the Stability Pact of the European Union.

Fiscal policy reaction to the foreign real interest rate is ambiguous. If there is an increase in the foreign real interest rate, this will in itself contribute to a real depreciation. Since the fiscal policymakers prefer a stable real exchange rate, they wish to increase the domestic real interest rate in such a way that the depreciation is halted. This means a more expansionary fiscal policy. However, as interest rate stability is also preferable, they want to counteract the effect of the depreciation on domestic demand by pursuing a contractionary policy, resulting in a more modest increase in the interest rate. These two effects pull in opposite directions, and neutralise each other when $\eta_r \beta = \eta_e \alpha$. The net effect is small for plausible values of the parameters.

The monetary policy equilibrium condition is found by setting (3.6) into (2.10). This yields

$$r_t = \left(\alpha + \beta + \frac{\kappa^2 (\eta_r + \eta_e)}{(\alpha + \beta)\eta_g}\right)^{-1} \left[\gamma^{-1}\hat{\pi}_t + u_t + \left(\beta + \frac{\eta_e \kappa^2}{(\alpha + \beta)\eta_g}\right) r_t^*\right]. \tag{3.7}$$

From (3.7) we observe that the effect of a shock to inflation, demand and the foreign real interest rate is unambiguously contractionary. The response is stronger if the fiscal policymakers face fiscal deficit adjustment costs. Hence, the result from the Nash equilibrium is turned around completely. The response is weaker if the fiscal policymakers prefer interest rate and exchange rate stability and act in order to achieve this. Note that, in the limit, $\eta_r \to \infty$, monetary policy will be completely passive. The budget deficit is now adjusted so as to achieve the inflation target, without any need for interest rate adjustment. Another interesting case appears when $\eta_e \to \infty$, that is, the fiscal policymakers prefer complete real exchange rate stability. In this case, monetary policy is left with real exchange rate targeting, setting $r_t = r_t^*$.

4. Should we believe in achieving the Stackelberg equilibrium?

The Stackelberg equilibrium offers several advantages over the Nash equilibrium. By taking into account the fiscal policy effect on monetary policy, the fiscal policymakers reduce the likelihood of strong movements in interest rates and hence corresponding movements in the exchange rate. The result may be an economic policy mix that is less likely to cause distress in the financial and foreign exchange markets. Furthermore, given a firm understanding of how monetary policy is implemented and the inflation targeting strategy being firmly rooted in the society in which it resides, fiscal policy may be less likely to pursue over-ambitious employment targets, as such efforts will conflict with the monetary policy objective.

However, how likely is the Stackelberg solution, and what institutional arrangements should be implemented to support it? The Stackelberg equilibrium requires two important conditions to be fulfilled. First, the fiscal policymaker would need to make a policy commitment that remains in place for some time. Second, the monetary policymaker would need to be transparent about their policy responses. The first condition could be satisfied by an appropriate change in the constitution or through supra-national restrictions regarding how frequent fiscal policy may change. Furthermore, the second condition of transparency on the part of the central bank could be achieved by requiring that the monetary policymaker publishes the monetary policy reaction function (or the models in which it is derived, coupled with a detailed description of the policy targets). However, this may be more difficult than perceived in our simple model. As noted above, in the real world, central banks often use large-scale models to guide policy. Such models often consist of hundreds of state variables, which could imply an extremely complicated reaction function. Moreover, there is little consensus on macroeconomics in general and hence which model to use, leading to several descriptions of the right inflation targeting strategy.

One idea, which has been discussed in the book edited by Taylor (1999), is to agree on a simple rule that may be robust enough to work well in a number of models. The Taylor (1993) rule, relating the interest rate to the inflation gap (deviations of the rate of inflation from target) and the output gap, is probably one of strongest contenders for being robust enough to work well within different model specifications.

Another solution would be for the central bank to publish the expected path of the interest rate and forecast for other variables contingent on the different choices for the fiscal policy instrument. The fiscal policymakers could then choose from a menu of different monetary policy stances, reflecting their preferences.

5. Conclusions

The analysis provided suggests that the strategic interaction between the fiscal and monetary authorities may be important to the relative stance of their respective policies. A situation in which each branch takes the other branch's instrument setting as given leads to a Nash equilibrium in which there is a conflict between the branches owing to different output goals. If, however, monetary policy is transparent and the fiscal policymakers take into consideration the fiscal policy effects on monetary policy, the fiscal policymakers may act as leaders and improve the policy mix, resulting in lower real interest rate and hence lower exchange rate volatility.

If the Cournot-Nash equilibrium is unavoidable, there is reason to make institutional changes that make the use of the fiscal budget deficit costly for stabilisation purposes. This would reduce the costs associated with a volatile monetary policy. However, if the Stackelberg equilibrium is implemented, this conclusion is completely reversed, as this would only limit the degree to which the policy mix can be improved.

Appendix

A. Derivation of the open-economy Phillips curve

We assume wages follow a wage curve according to

$$\Delta w_{t+1} = \pi_t^c + \gamma y_t + \varepsilon_{t+1}, \tag{A.1}$$

where w is nominal wages; Δ is the one-period backward difference operator; $\pi^c \equiv \Delta p_t^c$ is the rate of change in consumer prices; y is the output gap, and ε is a cost-push shock. (A.1) may be intepreted as the result of the wage setters having a real wage target which is conditional on the tightness in the labour market, approximated by the output gap. The agents have simple, adaptive expectations about the rate of consumer price inflation, as expected inflation within the period is equal to inflation in the previous period.

Domestic products are sold in markets characterised by monopolistic competition. Prices of domestic goods are set as a mark-up on wage cost, as

$$p_t = w_t. \tag{A.2}$$

Small open economies are price-takers on international markets, and prices for imported goods are given by

$$\begin{aligned} p_t^i &= s_t + p_t^* \\ &= s_t + p_t^* - p_t + p_t \\ &= e_t + p_t, \end{aligned} \tag{A.3}$$

where s is the effective nominal exchange rate, p^* is the foreign price level and $e \equiv s_t + p_t^* - p_t$ is the effective real exchange rate. Equation (A.3) implies a rapid, within-period pass-through from the exchange rate to the imported goods prices. Given the periodicity of the model of one to two years, this should not be controversial.

The rate of imported goods price inflation, $\pi_t^i \equiv \Delta p_t^i$, is given from (A.3) as

$$\pi_t^i = \Delta e_t + \pi_t, \tag{A.4}$$

where $\pi_t \equiv \Delta p_t$ domestic price inflation. Consumer prices are a weighted average of domestic and imported goods prices, that is,

$$p_t^c = \phi p_t^i + (1 - \phi) p_t, \tag{A.5}$$

where ϕ is the imported goods share of consumer consumption. Using equation (A.5), consumer price inflation may be written

$$\pi_t^c = \phi \pi_t^i + (1 - \phi)\pi_t. \tag{A.6}$$

By combining (A.4) and (A.6), consumer price inflation may be written as

$$\begin{aligned} \pi_t^c &= \phi(\Delta e_t + \pi_t) + (1 - \phi)\pi_t \\ &= \pi_t + \phi \Delta e_t. \end{aligned} \tag{A.7}$$

By taking differences in (A.2) and substituting for wage growth determined by (A.1), and using (A.7), we get

$$\begin{aligned} \pi_{t+1} &= \pi_t^c + \gamma y_t + \varepsilon_{t+1} \\ &= \pi_t + \phi \Delta e_t + \gamma y_t + \varepsilon_{t+1}, \end{aligned} \tag{A.8}$$

which is equivalent to the open-economy equation in (2.1) of the text.

B. Derivation of the short-horizon domestic inflation targeting policy

A short-horizon inflation target produces persistent fluctuations, as may be be shown using a simplified version of the model. Domestic inflation follows the open-economy Phillips curve,

$$\pi_{t+1} = \pi_t + \phi(e_t - e_{t-1}) + \gamma y_t + \varepsilon_{t+1}. \tag{B.1}$$

Demand is determined by the real interest rate,

$$y_t = -\alpha r_t, \tag{B.2}$$

and the uncovered real interest rate parity condition is invoked,

$$e_t = E_t e_{t+1} - r_t. \tag{B.3}$$

The central bank targets domestic inflation at the shortest possible horizon,

$$E_t \pi_{t+1} = 0. \tag{B.4}$$

Combining (B.4), (B.1) and (B.2) yields an equilibrium condition for the interest rate,

$$r_t = \frac{1}{\gamma\alpha}\pi_t + \frac{\phi}{\gamma\alpha}\left(e_t - e_{t-1}\right). \tag{B.5}$$

In order to solve for the real exchange rate, we assume a minimal state variable solution (McCallum, 1983) of the form,

$$e_t = \theta_1 \pi_t + \theta_2 e_{t-1} \tag{B.6}$$

where the coefficients, θ_1 and θ_2, are so far undetermined. (B.6) implies furthermore that

$$\begin{aligned} E_t e_{t+1} &= \theta_1 E_t \pi_{t+1} + \theta_2 e_t \\ &= \theta_2 \theta_1 \pi_t + \theta_2^2 e_{t-1}, \end{aligned} \tag{B.7}$$

where we have used (B.4). By setting (B.5) into (B.3) and using both (B.6) and (B.7), we get

$$\left(1+\frac{\phi}{\gamma\alpha}\right)(\theta_1\pi_t+\theta_2 e_{t-1})=\theta_2\theta_1\pi_t+\theta_2^2 e_{t-1}-\frac{1}{\gamma\alpha}\pi_t+\frac{\phi}{\gamma\alpha}e_{t-1}.$$

Equating the coefficients in front of each state variable yields two equations for the undetermined coefficients, i.e.,

$$\begin{aligned}\left(1+\frac{\phi}{\gamma\alpha}\right)\theta_1 &= \theta_2\theta_1-\frac{1}{\gamma\alpha},\\ \left(1+\frac{\phi}{\gamma\alpha}\right)\theta_2 &= \theta_2^2+\frac{\phi}{\gamma\alpha}.\end{aligned}$$

The solution to this set of equations, using the minimal state variable criterion that $\phi=0\rightarrow\theta_2=0$, is given by

$$\begin{aligned}\theta_1 &= -\frac{1}{\gamma\alpha},\\ \theta_2 &= \frac{\phi}{\gamma\alpha}.\end{aligned}$$

The reduced-form solutions to the key variables are hence given by

$$\begin{aligned}e_t &= -\frac{1}{\gamma\alpha}(\pi_t-\phi e_{t-1}),\\ r_t &= \frac{1}{\gamma\alpha}\left(1-\frac{\phi}{\gamma\alpha}\right)(\pi_t-\phi e_{t-1}),\\ y_t &= -\frac{1}{\gamma}\left(1-\frac{\phi}{\gamma\alpha}\right)(\pi_t-\phi e_{t-1}).\end{aligned}$$

If $\phi>\gamma\alpha$, as is not implausible, the model will be unstable.

References

Agell, Jonas, Lars Calmfors, and Gunnar Jonsson (1996). "Fiscal Policy When Monetary Policy Is Tied to the Mast." *European Economic Review*, 40(7):1413–40.

Andersen, Torben M. and Steinar Holden (1998). "Business Cycles and Fiscal Policy in an Open Economy." Working paper 1998-5, Department of Economics, University of Aarhus.

Andersen, Torben M. and Friedrich Schneider (1986). "Coordination of Fiscal and Monetary Policy Under Different Institutional Arrangements." *European Journal of Political Economy*, 2:169–191.

Ball, Laurence (1999). "Policy Rules for Open Economies." In John B. Taylor (ed.), "Monetary Policy Rules," chap. 3, pp. 129–156. The University of Chicago Press, Chicago.

Bernanke, Ben (1993). "Credit in the Macroeconomy." *Federal Reserve Bank of New York Quarterly Review*, 18:50–70.

Cukierman, Alex (1992). *Central Bank Strategy, Credibility and Independence: Theory and Evidence*. The Mit Press, Cambridge, MA.

Drazen, Allan (2000). *Political Economy in Macroeconomics*. Princeton University Press, Princeton, New Jersey.

Fudenberg, Drew and David K. Levine (1998). *The Theory of Learning in Games*. The MIT Press, Cambridge, MA.

McCallum, Bennett T. (1983). "On Non-Uniqueness in Rational Expectations Models: An Attempt at Perspective." *Journal of Monetary Economics*, 11(2):139–68.

Nordhaus, William D. (1994). "Policy Games: Coordination and Independence in Monetary and Fiscal Policies." *Brookings Papers on Economic Activity*, 0(2):139–216.

Rogoff, Kenneth (1985). "The Optimal Degree of Commitment to an Intermediate Monetary Target." *Quarterly Journal of Economics*, 100(4):1169–89.

Svensson, Lars E.O. (1997a). “Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets.” *European Economic Review*, 41:1111–1146.

— (1997b). “Optimal Inflation Targets, ”Conservative” Central Banks, and Linear Inflation Contracts.” *American Economic Review*, 87(1):98–114.

— (1999a). “How Should Monetary Policy Be Conducted in an Era of Price Stability?” NBER Working Paper 7516.

— (1999b). “Inflation Targeting: Some Extensions.” *Scandinavian Journal of Economics*, 101(3):337–61.

Taylor, John B. (1993). “Discretion versus Policy Rules in Practice.” *Carnegie Rochester Conference Series on Public Policy*, 39(0):195–214.

— (1999). “Introduction.” In John B. Taylor (ed.), “Monetary Policy Rules,” pp. 1–14. The University of Chicago Press.

Walsh, Carl E. (1995). “Optimal Contracts for Central Bankers.” *American Economic Review*, 85(1):150–67.

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Arbeidsnotat 2000/9

KEYWORDS:

Small open economy
Inflation targeting
Policy coordination
Policy interdependencies