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ABSTRACT

Fiscal Policy and Macroeconomic Stability Within a Currency Union*

We analyse the stability of countries within a monetary union in the face of asymmetric shocks, using a simple but widely applicable model. We show that members of the union may be subject to severe, and possibly unstable, cycles following asymmetric shocks if there is a significant backward looking element in inflation behaviour, and if real interest rates influence the level of aggregate demand. This cyclical instability can be mitigated if fiscal policy in each member country reacts to inflation differences, but it can be aggravated if fiscal feedback on debt is too strong.

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1 Introduction

The vulnerability of currency unions to asymmetric shocks is well known. However most of the analysis of these shocks has focused on their relative size, in comparison to some of the advantages of currency unions. (Most notably, in 'One Market, One Money', European Commission, 1990.) There has also been considerable work on the design of *optimal* policy (for example Turnovsky, Basar, and d'Orey (1988), and more recently Beetsma and Jensen (2004b), Beetsma and Jensen (2004a), Benigno and Benigno (2000), Benigno and Lopez-Salido (2006)). Although investigation of optimal policies is important, a vital complement to such work is an analysis of the stability of models under particular policy regimes. Without such an analysis, it is not clear how good a policy will be if the authorities make a small mistake in defining the optimum: will this just lead to slightly lower welfare, or is there a possibility that the system might become unstable?

In this paper we focus on issues of dynamic stability. We will show how members of a monetary union may be vulnerable to cyclical instability, and how the active use of fiscal policy may avoid or mitigate this instability. In this sense, our analysis is a contribution to the literature on the role of fiscal policy within the European Monetary Union. Our analysis is designed to apply to a (relatively) wide class of models, where we identify key sources of instability and investigate whether results are robust to the model modifications. The base model we use is deliberately simple in order to allow a comprehensive algebraic analysis of necessary and sufficient conditions for stability, but we also discuss how robust our results might be for more complex models.

In this paper, the monetary union consists of two countries, which together (as the union) comprise a small open economy. Monetary policy in the union involves following a simple policy rule that obeys the Taylor principle. Inflation in each country is governed by a Phillips curve. Differences in inflation between the two union members determine changes in the real exchange rate between them, which gives rise to two additional dynamic processes (in inflation and the real exchange rate). Within each economy there are two types of asset: government debt and private debt. This gives us two additional dynamic processes in asset accumulation.

We use a static model of consumption, where consumption depends on current income, wealth and real interest rates. Our reason for departing from the more standard, intertemporal model of consumption is two-fold. First, as we shall see, a forward-looking dynamic consumption model would rob us of the ability to present algebraic conditions that are necessary for stability, and we would have instead to resort to calculations using calibration. Second, some effect from real interest rates on the level of aggregate demand (rather than its rate of change) is critical for a potential instability that we focus on here. In another paper, we look at a model that involves both intertemporal consumers and consumers who are credit constrained, and we show (using numerical calculations based on calibration) how similar instabilities to those examined here may arise (see Kirsanova, Vines, and Wren-Lewis (2006)).

In our analysis, fiscal policy operates according to simple feedback rules. These are in the form of changes in government spending since tax rates are constant. In each country, fiscal policy is related to government debt, and one of the key stability issues we consider is how strong this feedback needs to be to ensure solvency. In addition, differences in government spending (between union members) are allowed to respond to differences in inflation, output or the real exchange rate. Our focus is on the impact different elements in this fiscal policy rule can have on the stability of the union members.

Our principle finding is that fiscal policy can play a useful role in dampening differences in inflation between union members. In a monetary union where inflation contains a significant backward looking element, inflation differences will tend to be exaggerated because nominal interest rates are equal across the union, so real interest rates at the national level will move in an unhelpful direction. We show that this instability mechanism, which is well known from discussion of the 'Taylor principle' in relation to closed-economy or flexible-exchange-rate models, is *not* eliminated by competiveness effects on demand. Instead, these competiveness effects can generate cyclicality, and this cyclicality may be explosive in its effects, rather than dampening inflation. We also confirm the familiar point that fiscal policy needs to respond to government debt to ensure solvency. But our analysis additionally suggests that too large a response of government expenditure to debt may actually be unhelpful.

2 Model

In this section we move straight to the presentation of our model's aggregate relationships, rather than deriving such relationships from their microfoundations. Although establishing the microfoundations of a macromodel is important when presenting innovations to standard specifications, the model we use here is entirely standard. Indeed, one of the goals of this paper is to show how certain issues involving stability will arise in a wide class of macromodels, and so deriving our model from specific microfoundations would detract from this aim. For an analysis of how our model can be derived from particular microfoundations, see Kirsanova, Satchi, Vines, and Wren-Lewis (2004).

The aggregate demand curve is

$$y = c + g + nx(s, y) \tag{1}$$

where y is output, c is consumption, g is government spending, and $nx(s, y)$ is net exports which depends on the real exchange rate s and y. We abstract from physical capital in this model. Consumption is given by the following simple static relationship

$$c = \xi_0 y - \xi_1 r + \xi_2 w \tag{2}$$

where w is private wealth, and $r = \iota - \pi_{cpi}$ is the real interest rate. Combining 2 with 1 gives us a staic IS curve, where demand depends on government spending, real interest rates and the real exchange rate.

An alternative, and nowadays more comon, specification for consumption would be based on intertemporal consumers, where consumption would depend on human capital i.e. expectations about future labour income. (However, important contributions continue to use a more backward looking IS curve: see Bean (1998) and Ball (1999) for example.) This would give rise to a dynamic, forward looking IS curve. Although the microfoundations for this set-up are well known, they depend on assumptions about capital markets that are unrealistic. A widely held view is that problems associatred with asymmetric information mean that a significant proportion of consumers are likely to be credit constrained, and as a result their consumption is likely to be related to current income and (because the hold debt) current interest rates. The proportion of credit constrained consumers is likely to vary with the level of financial development of the economy, among other factors.

In Kirsanova, Vines, and Wren-Lewis (2006) we look at a microfounded model with both types of consumers, and examine the issue of stability under fixed exchange rates. The presence of some forward looking consumers means that our analysis in that paper has to be limited to numerical evaluation of eigenvalues. However, we show that the presence of some credit constrained consumers gives rise to exactly the same problems with stability that we examine here. This motivates our assumption of a completely static IS curve in this paper, which in turn allows us to present a more comprehensive, algebraic analysis of stability conditions. We discuss the economics of stability in models with both types of consumers in Section 6 below.

Inflation in each country is governed by a Phillips curve of a form

$$\dot{\pi} = \phi y \tag{3}$$

With $\phi > 0$, we have a continuous time representation of a traditional accelerationist Phillips curve. With $\phi < 0$, we have a continuous time version of a forward-looking Phillips curve. We initially consider $\phi > 0$, because this allows us to derive a full set of necessary conditions for stability, but we subsequently analyse $\phi < 0$ and mixed cases in some detail.

The government's budget constraint is given by

$$\dot{a} = (\iota - \pi_{cpi})a + g - \tau y \tag{4}$$

where τ is the tax rate on income. The consumer's budget constraint is given by

$$\dot{w} = (\iota - \pi_{cpi})w + nx(s, y) + g - \tau y \tag{5}$$

where we assume that the consumer receives the union wide nominal interest rate ι on all assets, domestic and foreign.

Monetary policy sets union wide nominal interest rates according to the following simple rule

$$\iota = (1+\theta)\pi \tag{6}$$

We can linearise and rewrite the model (following Aoki (1981)) into equations for averages and differences (see Appendix A for a definition of all constant parameters):

System for averages:

$$y = \kappa(\xi_2 w - \xi_1(\iota - \pi_{cpi}) + \xi_3 s + g) \tag{7}$$
$$\dot{a} = \iota_0 a + (\iota - \pi_{cpi})\, A + g - \tau y \tag{8}$$
$$\dot{w} = (i - \pi_{cpi})\, W + \iota_0 w + \xi_3 s - (\mu + \tau)\, y + g \tag{9}$$
$$\dot{\pi} = \phi y \tag{10}$$
$$\dot{s} = \iota - \pi \tag{11}$$
$$\pi_{cpi} = \pi + \mu \dot{s} \tag{12}$$

System for differences:

$$y = \kappa(\xi_2 w + \xi_1 \pi_{cpi} + \xi_3 s + g) \tag{13}$$
$$\pi_{cpi} = (1-\mu)\pi \tag{14}$$
$$\dot{a} = \iota_0 a - A\pi_{cpi} + g - \tau y \tag{15}$$
$$\dot{w} = -\pi_{cpi} W + \iota_0 w + \xi_3 s - (\mu+\tau) y + g \tag{16}$$
$$\dot{\pi} = \phi y \tag{17}$$
$$\dot{s} = -\pi \tag{18}$$

Policy reaction functions:

$$i = (1+\theta)\pi \tag{19}$$
$$g = -\lambda_1 \pi - \lambda_2 s - \lambda_3 a \tag{20}$$

Note that after substituting the policy reaction function and leaving only domestic inflation in *both* systems, these systems can be written in the following form:

$$y = \kappa(\xi_2 w - (1-\mu)\theta\xi_1 \pi + \xi_3 s + g) \tag{21}$$
$$\dot{a} = \iota_0 a + (1-\mu)\theta\pi A + g - \tau y \tag{22}$$
$$\dot{w} = (1-\mu)\theta\pi W + \iota_0 w + \xi_3 s - (\mu+\tau)\, y + g \tag{23}$$
$$\dot{\pi} = \phi y \tag{24}$$
$$\dot{s} = \theta\pi \tag{25}$$

If $\theta > 0$ this describes the system for averages (i.e. the monetary union as a whole as a single open economy) under a floating exchange rate relative to the rest of the world , and if $\theta = -1$ it describes the system for differences between two countries in a monetary union. Although the meaning of some of the variables in each case is different, the functional form of the two systems is the same. We will use this similarity in what follows.

3 Stability Analysis of System in Differences

A linearised system (21)-(25) can be written in a matrix form as:

$$\begin{bmatrix} \dot{\pi} \\ \dot{s} \\ \dot{a} \\ \dot{w} \end{bmatrix} = \begin{bmatrix} -\phi\kappa\left(\xi_1(1-\mu)\theta + \lambda_1\right) & \phi\kappa\left(\xi_3 - \lambda_2\right) & -\phi\kappa\lambda_3 & \phi\kappa\xi_2 \\ \theta & 0 & 0 & 0 \\ \begin{array}{c} (1-\mu)\theta A \\ -\left(1-\tau\kappa\right)\lambda_1 \\ +\tau\kappa\xi_1(1-\mu)\theta \end{array} & \begin{array}{c} -\tau\kappa\xi_3 \\ -\left(1-\tau\kappa\right)\lambda_2 \end{array} & \iota_0 - \left(1-\tau\kappa\right)\lambda_3 & -\tau\kappa\xi_2 \\ \begin{array}{c} (1-\mu)\theta W \\ +\left(\mu+\tau\right) \\ \times\kappa\theta(1-\mu)\xi_1 \\ -\left(1-\left(\mu+\tau\right)\kappa\right)\lambda_1 \end{array} & \begin{array}{c} \left(1-\left(\mu+\tau\right)\kappa\right) \\ \times\left(\xi_3-\lambda_2\right) \end{array} & -\left(1-\left(\mu+\tau\right)\kappa\right)\lambda_3 & \iota_0 - \left(\mu+\tau\right)\kappa\xi_2 \end{bmatrix} \begin{bmatrix} \pi \\ s \\ a \\ w \end{bmatrix}$$

Our main focus is on the system in *differences*, which allows us to look at the implications of asymmetric shocks. In this completely backward looking system with $\theta = -1$ under a fixed exchange rate and $\phi > 0$ for the accelerationist Phillips curve, the roots of the characteristic polynomial must all be negative. As the polynomial can be written as $P(X) = X^4 + X^3\left(-\sum z_i\right) + X^2\left(\sum z_i z_j\right) + X\left(-\sum z_i z_j z_k\right) + z_1 z_2 z_3 z_4$ where z_j are eigenvalues, the requirement that $z_j < 0$ for all $j = 1..4$ implies four conditions on the signs of all four coefficients of the characteristic polynomial. These conditions are *necessary*, not sufficient conditions.

3.1 Condition A (Determinant condition)

The requirement that determinant: $D_d = z_1 z_2 z_3 z_4 = \kappa\phi\left(\xi_2 - \iota_0\right)\left(\iota_0\lambda_2 + \left(\lambda_3 - \iota\right)\xi_3\right) > 0$ implies

$$\lambda_3 > \iota_0\left(1 - \frac{\lambda_2}{\xi_3}\right) \tag{A}$$

This condition has a very simple interpretation if λ_2 is zero: the fiscal authority's feedback on debt must be greater than the rate of interest. This is a standard solvency condition required to avoid debt interest spirals emerging from the government's budget constraint.

3.2 Condition B (Trace condition)

The requirement that $T_d = \sum z_i = 2\iota_0 + \phi\kappa(\xi_1(1-\mu) - \lambda_1) - (\mu+\tau)\kappa\xi_2 - \lambda_3(1-\tau\kappa) < 0$ implies

$$\xi_1(1-\mu) - \frac{1}{\phi\kappa}((\mu+\tau)\kappa\xi_2 - \iota_0) - \frac{1}{\phi\kappa}(\lambda_3(1-\tau\kappa) - \iota_0) < \lambda_1 \qquad \text{(B)}$$

Although this condition is more complex, it is also critical. In a monetary union, there is an intrinsic instability stemming from real interest rate effects if $\phi > 0$. As nominal interest rates are fixed, differences in inflation will, ceteris paribus, generate movements in real interest rates which will intensify rather than reduce the inflation difference (because higher inflation reduces real interest rates which adds to demand). This potential instability is at the heart of the Taylor principle in closed economy analysis, and its operation in a monetary union is sometimes referred to as the 'Walters' critique' (see, e.g. Miller and Sutherland (1990)).

As the condition above shows, this instability danger can be reduced if fiscal policy reacts to inflation differences, because it provides a directly offsetting deflationary mechanism. As we shall see below, even if this condition is satisfied, this effect can generate cyclical movements following shocks, and a large value of λ_1 can moderate these cycles.

3.3 Condition C

The requirement that $-\sum z_i z_j z_k > 0$ implies

$$\begin{aligned}&(\xi_3 + (1-\mu)(\iota_0\xi_1 + \xi_2(W-A) + \iota_0 A))\lambda_3 + (\xi_2 - 2\iota_0)(\xi_3 - \lambda_2) \\ &> \iota_0(\xi_2 - \iota_0)\lambda_1 + (\iota_0\xi_1 + \xi_2 W)(1-\mu)\iota_0\end{aligned} \qquad \text{(C)}$$

This condition implies two restrictions on fiscal policy. First, if the propensity to consume out of wealth is sufficiently large ($\xi_2 > 2\iota_0$) then λ_2 cannot also be too large. A positive shock to inflation will reduce competitiveness, and if fiscal policy expands too much this will create an unstable inflation-competitiveness cycle. In addition, a strong fiscal expansion may cause wealth instability[1]. Second, condition (C) also requires that λ_3 should be big enough to deal with wealth (debt) instability. This is most easily seen by considering two limiting cases.

(a) Suppose $W >> A \simeq 1$. (Foreign wealth is large, domestic debt is small.) Then requirement (C) becomes

$$\lambda_3 \gtrsim \iota_0 + \frac{\iota_0(\xi_2 - \iota_0)}{\xi_2 W(1-\mu)}\lambda_1 + \frac{(\xi_2 - 2\iota_0)}{\xi_2 W(1-\mu)}\lambda_2$$

which is a requirement to have a sufficient feedback on debt (if $\lambda_1 = \lambda_2 = 0$).

(b) Suppose $A \simeq W >> 1$ (Foreign wealth is small, domestic debt is large) then (C) yields

$$\lambda_3 \gtrsim \xi_2 + \frac{(\xi_2 - \iota_0)}{W(1-\mu)}\lambda_1 + \frac{(\xi_2 - 2\iota_0)}{\iota_0 W(1-\mu)}\lambda_2$$

[1] This can be seen from the presence of the steady state levels of assets and wealth in (C).

which is a very similar requirement, with the need for larger feedback on debt i.e. $\lambda_3 > \xi_2 > \iota_0$ (if $\lambda_1 = \lambda_2 = 0$).

3.4 Condition D

The requirement that $\sum z_i z_j > 0$ implies

$$\begin{aligned}&(\xi_2 - 2\iota_0)\,\lambda_1 + (\xi_3 - \lambda_2) + (2\iota_0\xi_1 + \xi_2 W)\,(1-\mu) \\ &> \left((\xi_1 + A)\,(1-\mu) - \frac{(\xi_2\mu\kappa - \iota_0(1-\tau\kappa))}{\phi\kappa}\right)\lambda_3 + \frac{\iota_0\,(\kappa\xi_2\,(\mu+\tau) - \iota_0)}{\phi\kappa}\end{aligned} \tag{D}$$

This condition is interesting, because unlike conditions (A) and (C), it places an upper bound on λ_3 i.e. the strength of fiscal feedback on debt. The reason is as follows. In a monetary union a positive inflation shock reduces debt (because nominal rates are fixed). With large λ_3, lower debt will imply a significant increase in government spending, aggravating the real interest rate instability noted above. This instability is more severe if the equilibrium level of debt is large. Indeed, with a large equilibrium debt stock ($A \simeq W >> 1$) condition (D) suggests that λ_3 should be quite small (if $\lambda_1 = \lambda_2 = 0$) :

$$\lambda_3 \lesssim \xi_2 + \frac{(\xi_2 - 2\iota_0)}{W(1-\mu)}\lambda_1 - \frac{1}{W(1-\mu)}\lambda_2$$

In addition, for moderate values of A and W, condition (D) also suggests that λ_2 should not be too big.

3.5 Sufficient conditions for stability and Cyclical behaviour

The four conditions (A), (B), (C) and (D) are necessary but not sufficient for stability[2]. As we have seen, these impose some important restrictions on policy. To find *sufficient* conditions we must impose restrictions on the real parts of eigenvalues, like

$$\{\lambda_1, \lambda_2, \lambda_3\} : \left\{ \begin{array}{l} (\mathrm{Re}(z_i) = 0)\,\&\,(\mathrm{Re}(z_j, z_k, z_l) < 0)\,, \quad i,j,k,l = \{1,2,3,4\} \\ \text{for any } \varepsilon > 0 \text{ there is } \delta < \varepsilon : \mathrm{Re}(z_i + \delta)\cdot \mathrm{Re}(z_i - \delta) < 0 \end{array}\right. \tag{26}$$

which defines a surface in three-dimensional λ space, along which one of the real parts of the eigenvalues of the system matrix changes sign, while the other eigenvalues remain with negative real parts. An attempt to write down explicit formulae for λs leads to algebraic equations of higher than forth order[3]. We can only find solutions to them numerically.

An analysis similar to (26) also tells us about how cyclical any response to shocks may be. Formally, cyclical behaviour is ensured by the presence of a complex pair among the four eigenvalues

[2] For example, all of them will be satisfied for eigenvalues $z_1 = -\alpha, z_2 = -\beta, z_{3,4} = \pm\gamma i$, but such a system will be cyclically unstable.

[3] All eigenvalues of a polynomial of the fourth order can be written explicitely using formulae Ferrari or Descartes-Euler.

(a) System for differences

(b) System for averages

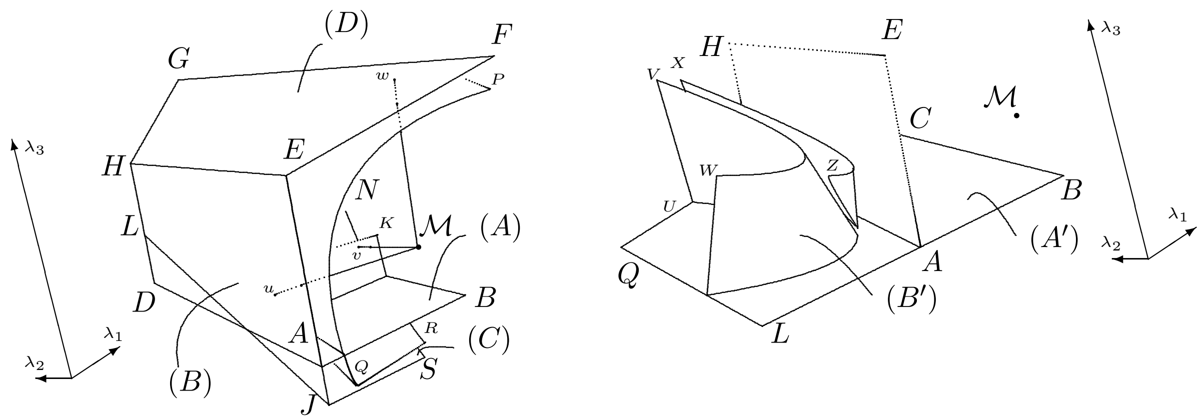

Figure 1: Stability analysis

of the system matrix. One can try to find conditions under which there is at least one pair of eigenvalues with non-zero imaginary parts[4]. These conditions can be written as

$$\{\lambda_1, \lambda_2, \lambda_3\} : \left\{ \begin{array}{l} (\mathrm{Im}(z_i, z_j) = 0)\,, \quad i, j \in \{1, 2, 3, 4\} \\ \text{for any } \varepsilon > 0 \text{ there is } \delta < \varepsilon : \mathrm{Im}(z_i + \delta) > 0, \quad \mathrm{Im}(z_i - \delta) = 0 \end{array} \right. \tag{27}$$

which means that we define a surface in three-dimensional λ space along which one pair of complex eigenvalues emerge. Of course, we are interested in 'cyclicality boundaries' only within the stability area.

A diagrammatic analysis is shown in the left panel of Figure 1. The top surface, EFG, is a stability boundary determined by condition (D). This condition defines a ceiling (not necessarily horizontal) for the feedback coefficient on debt, λ_3. The economy is stable below this surface. The wall, DAE, (which is not necessarily vertical) depicts stability condition (B) which is essentially the lower limit on feedback on inflation λ_1: the economy is stable behind it. There is a floor, DAB, which is not necessarily horizontal and depicts condition (A) which imposes a lower limit on λ_3. There is also 'back wall' JSN which presents condition (C). All necessary conditions, (A), (B), (C) and (D) are linear in λs and can be presented as planes.

There are also conditions on λs which define an area within which the system does not produce cycles, as discussed above. These conditions are highly non-linear and their *union* is schematically plotted in Figure 1 as surfaces going through points P, Q, R and K. The meaning of these conditions is as follows.

Suppose we start at a point like $\mathcal{M}$, which is determined by some feedback coefficients λ_1, λ_2 and λ_3, and then increase λ_3. The economy will start cycling when we first hit cyclicality condition

[4]Eigenvalues with non-zero imaginary parts always exist in pairs, so we are always talking about a pair of complex eigenvalues.

PQ, and then it becomes unstable when we hit the surface with *sufficient* conditions for stability. (This is also illustrated by Figure 4 which presents simulations of dynamic responses to shocks – but we discuss these figures later.) This surface lies somewhere in between surfaces going through PQ and plane EFG, so the economy becomes unstable before reaching the ceiling EFG at point w. On reaching this sufficient stability surface a pair of complex roots will change the sign of their real parts to become positive. Our numerical investigation shows that the sufficient condition surface is close to the necessary condition plane.

A reduction in λ_3 simply causes the economy to become unstable, without generating cycles. Plane DAB defines necessary and sufficient conditions so when we go through it, one of real negative eigenvalues of the system changes sign to become positive.

Similarly, if we start at $\mathcal{M}$ and start reducing the fiscal feedback on inflation, λ_1, we first hit a cyclicality boundary which goes through PQ so the economy will suffer 'Walters' critique' type cycles. Then we hit a sufficient stability condition boundary, which is somewhere in between PQ and the necessary conditions for stability, DAE at point u, and the economy becomes unstable. Figure 2 shows the dynamic responses to shocks for different values of λ_1.

An increase in λ_2 causes first competitiveness-inflation cycles (on hitting KR) and then instability when approaching NSJ. In terms of numbers, this instability occurs when λ_2 is of similar order to ξ_3. This range of feasible λ_2 is also apparent from stability requirements (C) and (D), both of which can yield $\xi_3 - \lambda_2 > 0$ under certain other conditions on other parameters[5].

3.6 Dynamic responses to shocks

This algebraic and diagrammatic analysis has some fairly clear-cut implications for the fiscal policy reaction function. First, a large value of λ_1 (negative feedback on inflation) is nearly always going to be helpful in ensuring stability. This is partly because it helps avoid the intrinsic instability due to real interest rates (the 'Walters' critique'). However it also helps avoid debt interest spirals: if debt increases, this will tend to raise demand and inflation, and with large λ_1 this will reduce spending.

Second, some non-negative value of λ_3 is useful (and without a large λ_2, necessary) to avoid debt interest spirals, but there is a danger of instability if λ_3 becomes too large, because it can reactivate real interest rate instability.

Third, the size of λ_2 is much less important in ensuring stability. Numerical simulations show that as soon as λ_2 is not very close[6] to ξ_3, then the economy is quickly stabilised, without much difference in the adjustment process.

We can illustrate our analysis on stability and cyclicality by examining the model's dynamic

[5] A simpler version of a monetary union, without wealth, leads to an explicit necessary and sufficient requirement of $\lambda_2 < \xi_3$. When the asset accumulation process is modelled, there are additional stability conditions (C) and (D) which are essentially 'infected' by the requirement that λ_2 is small.

[6] A feedback of order $0.8\xi_3$ ensures quick stabilisation.

response to shocks. We calibrate our model as described in Appendix B and look at the dynamic responses to shocks in wealth, the terms of trade and inflation. Figures 2–4 show the response of the system for differences and demonstrate the severe cycles we discuss above. If either λ_1 is small, or λ_3 is big, there is an increased frequency of oscillations. At some point, the system simply becomes unstable, see Figures 2 and 4. The behaviour in Figure 3 is different, with much longer cycles. This is because competitiveness is the integral of inflation: a change in inflation will *steadily* change competitiveness, fiscal expenditures and again inflation. The process is explosive, but slow. Had we done a welfare analysis, we would probably discover that the welfare function is flat in λ_2 when $\lambda_2 < \xi_3$ and cycles are removed.

4 Stability Analysis of System in Averages

With $\theta > 0$ the same system from Section 3 describes the system in averages. As the exchange rate is now a jump variable, for stability we need to have three negative eigenvalues and one positive eigenvalue. This means that we can write only one necessary condition, that the determinant (or the product of all eigenvalues) must be negative: $D_a = -\phi\kappa\theta\left(\xi_2 - \iota_0\right)\left(\iota_0\lambda_2 - \iota_0\xi_3 + \lambda_3\xi_3\right) < 0$, from which it follows that

$$\lambda_3 > \iota_0\left(1 - \frac{\lambda_2}{\xi_3}\right) \tag{A'}$$

which is the same condition (A) from the system in differences. For the model in averages there should be a minimal feedback on debt to prevent a debt interest spiral. This is the only necessary condition which can be obtained from sign requirements on eigenvalues, and simulations show that this condition is also a sufficient condition, i.e. one of *real* eigenvalues changes sign when passing through this surface. The effect of changing λ_3 on the systems dynamics is shown in Figure 5. There are no cycles when λ_3 increases, instead convergence of debt to equilibrium is just faster.

It is apparent from the dynamic simulations that increasing λ_3 increases the volatility of inflation after shocks to wealth/debt, but reduces volatility after inflation shocks. The volatility of output is also higher after shocks to debt. So it is unclear whether large λ_3 is welfare improving. (For a welfare analysis of this issue in a closed economy see Kirsanova and Wren-Lewis (2004)) However, as we have shown above, for the system in differences a large λ_3 causes cyclicality and instability.

There is another stability condition for the system in averages, which can only be obtained numerically from the requirement

$$\{\lambda_1, \lambda_2, \lambda_3\} : \begin{cases} \left(\mathrm{Re}(z_i) = 0\right) \& \left(\mathrm{Re}(z_j, z_k, z_l) < 0\right), \quad i, j, k, l = \{1, 2, 3, 4\} \\ \text{for any } \varepsilon > 0 \text{ there is } \delta < \varepsilon : \mathrm{Re}(z_i + \delta)\,\mathrm{Re}(z_i - \delta) < 0 \\ \lambda_3 \neq \iota_0\left(1 - \frac{\lambda_2}{\xi_3}\right) \end{cases} \tag{B'\&C'\&D'}$$

which says that we are looking for a surface in coordinates $\lambda_1, \lambda_2, \lambda_3$ on which one of eigenvalues is changing the sign of its real part, and the others remain with negative real parts, and this surface is different from the one already defined by condition (A'). This condition partly reflects requirements imposed by conditions (B), (C) and (D) in the following sense. Instability, which arises when we approach sufficient stability boundaries, corresponding to (B'&C'&D') arises when either (i) λ_1 is large and negative, so the policymaker essentially destabilises the economy by creating a fiscal expansion and a boom in response to a positive inflation shock, or (ii) λ_2 becomes large and positive, such that fiscal policy creates a boom in response to an appreciation following a positive inflation shock. So, essentially these two cases define a single instability surface which rules out either large negative λ_1 or big positive λ_2. Both these factors were present when we discussed conditions (B), (C) and (D) for the model in differences.

A diagrammatic analysis is presented in the right panel of Figure 1. The plane $QLABC$ now shows necessary and sufficient condition (A') which is the same as for the system in differences, so it is drawn in a similar way. For easy comparison, we also draw the plane AEH which used to depict necessary condition (B) for the system in differences, even though this is no longer relevant for the system in averages. Instead we have the sufficient stability condition (B'&C'&D') which is plotted as a bending wall UVW. There is also a cyclicality condition surface going through points X and Z.

If we start at a point like $\mathcal{M}$, and reduce λ_1, we first go through the cyclicality condition surface XZ so the economy will start cycling, and only then hit sufficient conditions for stability UVW when the economy will become unstable. However, the instability here is achieved with much lower (more negative) values of λ_1 so it is of no practical interest to the policymaker. If at $\mathcal{M}$ we have sufficiently small λ_2 (potentially negative) then it takes longer to reach the instability boundary (UVW). However, if λ_2 is sufficiently negative, then λ_3 should be large in order to stay above the plane ABC and inside the stability area. With high λ_2 we still hit the ZX and UVW instability boundaries, but much further out than we would do in the model for differences, with much bigger λ_2.

5 Summary of Results

Our analysis of the system in averages (the monetary union as a whole) is entirely conventional. Provided that the central bank controls inflation in a sufficiently strong way, there is no need for additional control of inflation using fiscal policy. In addition to this control of inflation by monetary policy, there must be a minimum fiscal feedback on debt. But there is no instability if debt is strongly, or even very strongly, controlled. Simulations do suggest that a large feedback on debt might not be welfare improving, but this is an issue for welfare analysis which is beyond the scope of this paper.

Our analysis of the system in differences has produced some interesting new results. There are two main findings. First, without some fiscal response to inflation, there is a severe danger that asymmetric shocks will produce acute cyclical behaviour which may even be unstable. Second, debt should not be controlled too strongly, as this may induce cycles or even cause instability. Fiscal feedback on the real exchange rate is less critical for the behaviour of the system, but we find that it should not be excessive.

Feedback on the real exchange rate should not be excessive in the model for averages too, as the same mechanism leading to inflation-competitiveness cycles remains for the union as a whole, vis-a-vis the outside world. However, the processes at work differ in an important way. In the model for differences λ_2 is limited from *above* by ξ_3. In contrast, the model for averages only becomes unstable when λ_2 becomes very high, although this model does cycle for relatively low values of λ_2.

6 Robustness of Results

Our first key finding, reviewed above, was that asymmetric shocks may produce movements in real interest rates that might generate cycles and even instability. In this section we show that this danger disappears if the Phillips curve becomes completely forward looking, but remains if the Phillips curve has some, non-negligible, backward element. We also indicate how this instability disappears if all consumers are forward looking, but re-emerges if some consumers are credit constrained.

A More Sophisticated Phillips Curve

An entirely forward-looking Phillips curve is modelled with exactly the same Phillips curve specification (24), but with $\phi < 0$. As inflation is now a jump variable, for stability of the model for *differences* we will need three eigenvalues with negative real parts and one eigenvalue with a positive real part. Although the system matrix remains the same as in Section 3, we can only state one condition, which is necessary in order that this happen. This is the determinant condition, that the product of eigenvalues is a negative number. This will lead to exactly the same requirement as condition (A), Section 3 above, since ϕ is now negative. This implies, as we would expect, that there still needs to be some minimal feedback on debt to prevent spirals in debt interest payments. (As Leith and Wren-Lewis (2001) note, the determinant stability condition in such systems is often related to the dynamics of asset accumulation.)

With the eigenvalues being required to have different signs, the other necessary conditions, similar to conditions (B), (C) and (D) in Section 3 cannot be stated. To investigate stability properties we therefore have to resort to numerical simulations. These calculations suggest that some of the restrictions imposed by conditions (B), (C) and (D) do not survive. In particular, we no longer require a large λ_1. The reason for this is the following. As we discussed in Section 3, in a monetary union with an accelerationist Phillips curve, higher inflation, generated by a positive demand shock, generates a lower real interest rate which further increases demand. Sluggish inflation will continue to rise slowly, ensuring a prolonged *fall* in real interest rates. That generates a long lasting stimulus to demand. The resulting inflation can cause considerable overshooting; and the end result can be cycles which may become unstable. In contrast, with an entirely forward-looking model of inflation, a positive unexpected demand shock produces a positive unexpected *jump* in inflation. Even if the demand shock persists, inflation will then fall towards its steady state, implying higher real interest rates that will serve to curtail that demand shock. The same reasoning also removes the restriction that λ_3 should not be too large. The issue of whether such a large value of λ_3 is welfare enhancing remains, however, as a separate question.

Nevertheless, our simulations confirm our earlier findings that λ_2 should not be too large. As we noted above, the inflation-competitiveness instability spiral does not depend on real interest rate adjustment, which is why it survives.

As soon as the specification of the Phillips curve includes both forward- and backward-looking components, then the 'Walters' critique' instability reappears. (See Appendix C for a derivation of such a Phillips curve in continuous time.) Numerical simulations of the model in differences with a backward-forward Phillips curve and with a realistic weight on the forward-looking component of inflation in the Phillips curve, $\alpha = 0.3$, are plotted in Figures 6 and 7. A comparison of these figures with Figures 2 and 4 suggests that the dynamics is very similar. In fact, for an uncontrolled economy, (with $\lambda_1 = \lambda_2 = 0$, λ_3 is close to the boundary defined by (A)) and for our base-line calibration) the inflation cycles can be removed only when assuming $\alpha = 0.8$ i.e. a predominantly forward-looking specification.

Interestingly, the important study by Westaway (2003) described the possibility of cycles as a result of the 'Walters critique' problem, which we have been analysing in this paper. In Westaway's simulations this never caused actual instability, even though his setup contained no fiscal feedback on inflation. Inspection of his model shows that he assumed $\alpha = 0.3$ which generated a model which could, at worst, cycle but could not behave explosively.

The balance between forward and backward looking behaviour in the Phillips curve is therefore likely to be crucial in determining how important this instability might be. The estimates of the exact weight of the backward-looking component of inflation, however, differ widely. Gali and Gertler (1999), Benigno and Lopez-Salido (2006) find a predominantly forward-looking specification, while Mehra (2004) finds an extremely backward-looking specification of the Phillips curve. Mankiw (2001) argues that stylised empirical facts are inconsistent with a predominantly forward-looking Phillips curve.

Forward-Looking Consumption

The instability associated with movements in real interest rates depends crucially on lower real interests raising demand, and therefore adding to inflation and raising real interest rates further. If we replace the static consumption function by a model involving infinitely lived, utility maximising consumers with no constraints on borrowing, then consumption becomes a forward looking 'jump' variable. As a result, it is no longer possible to generate a dynamic process whereby higher inflation leads to higher consumption and thereby raises inflation further. Instead, lower real interest rates associated with higher inflation will be reflected in an initial jump in consumption. Thereafter, if real interest rates remain below steady state levels, they will be associated with falling, not rising consumption.

In Kirsanova, Vines, and Wren-Lewis (2006) we examine a mixed model where some consumers are unconstrained intertemporal maximisers, and some are credit constrained. Credit constrained consumers are likely to hold some debt (but less than it would be optimal for them to hold), and will consume all their disposable income.Any increase in real interest rates will reduce their disposable income because of higher debt interest payments, reducing the level of consumption. For these consumers, we get something similar to the static model analysed in this paper. Kirsanova, Vines, and Wren-Lewis (2006) therefore suggests that the problem of instability analysed in this paper may well be an important one.[7]

7 Conclusion

By examining a very simple two country model of a currency union, we have shown that members of the union may be subject to severe or exposive cycles following asymmetric shocks. Two features are required to generate this instability: a significant backward looking element in inflation behaviour, and an effect from real interest rates on the *level* of aggregate demand. The dangers of a fixed nominal interest rate policy under a flexible exchange rate regime are well known. This paper shows that exactly the same problem may arise for asymmetric shocks in a monetary union, despite the influence of changes in competitiveness on demand. We show that this competiveness effect adds cyclicality, but does not mitigate the fundamental inflation/real inteest rate/demand instability.

We have summarised our findings in Section 5. In brief, we show two things. First, this cyclical instability can be mitigated if fiscal policy in each member country reacts to inflation differences (such that higher inflation produces a contraction in fiscal policy). Second, any problems can be aggravated if fiscal feedback on debt is too strong.

We believe our results have clear and important implications for fiscal policy in a monetary union. Of course it may be the case that in all relevant economies the Phillips curve is predominantly forward looking, or that there is little impact of real interest rates on the level of demand (because all consumers are unconstrained intertemporal optimisers, for example). In that case the instability dangers examined here would not arise. However, we would argue that current empirical

[7]Unfortunately, to analyse this model rigorously requires setting out its microfoundations, and this takes us well beyond the scope of the present paper. In addition, as we have already noted, once the model contains jump variables, we are forced to rely on numerical calculation of eigenvalues. However, the basic instability mechanism in this more complex model is exactly the same as the one we are able to analyse more generally in this paper.

evidence on these matters remains rather ambiguous. Because of that, policy should be robust to the dangers which we describe here. This claim gives strong grounds for exploring the possibility of countercyclical fiscal policy by national governments within a monetary union.

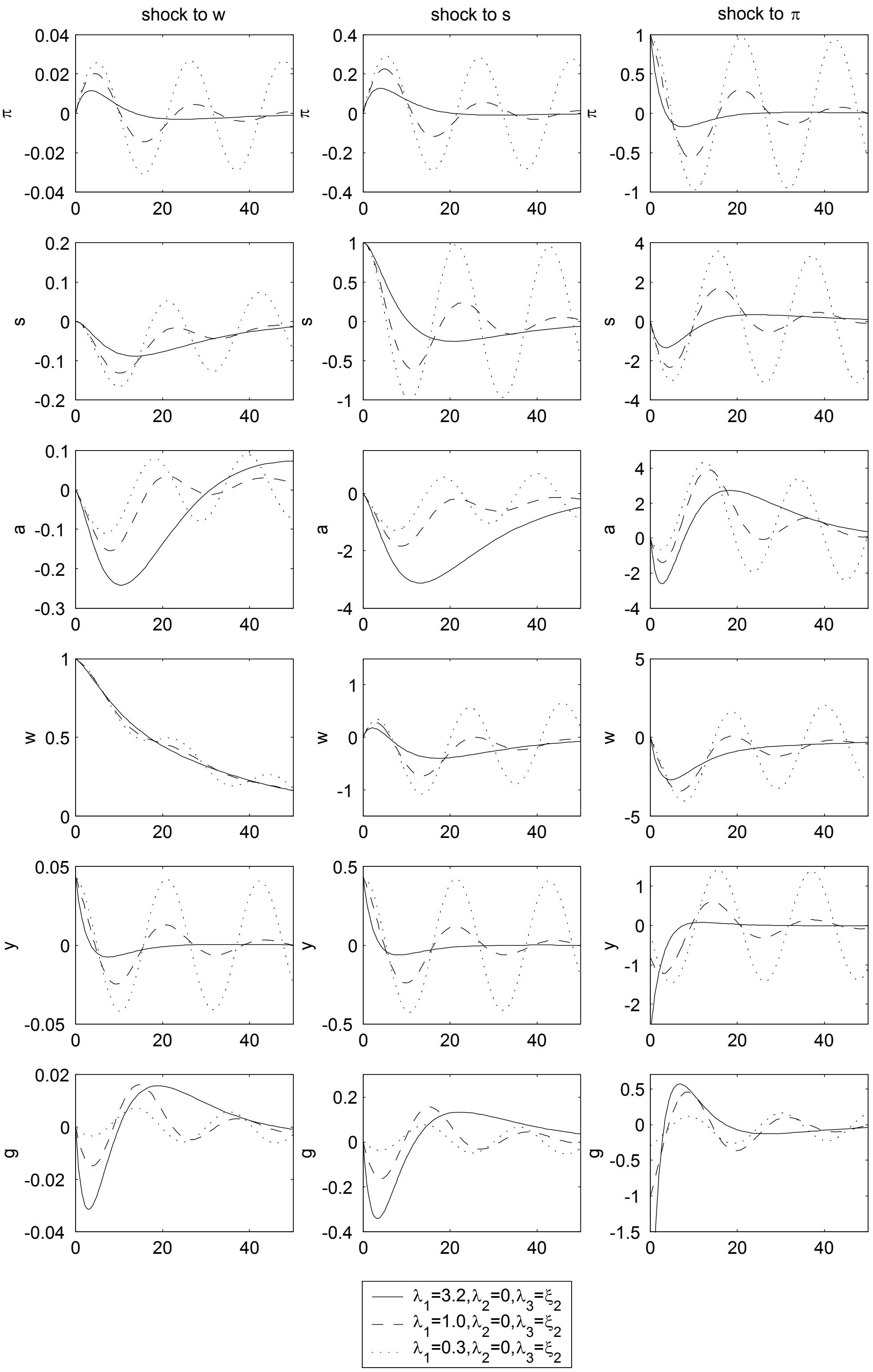

Figure 2: Backward-looking Phillips curve, model for differences. Effect of reduction in λ_1 when wealth cycles are removed. This corresponds to movement away from $\mathcal{M}$ towards u in Figure 1.

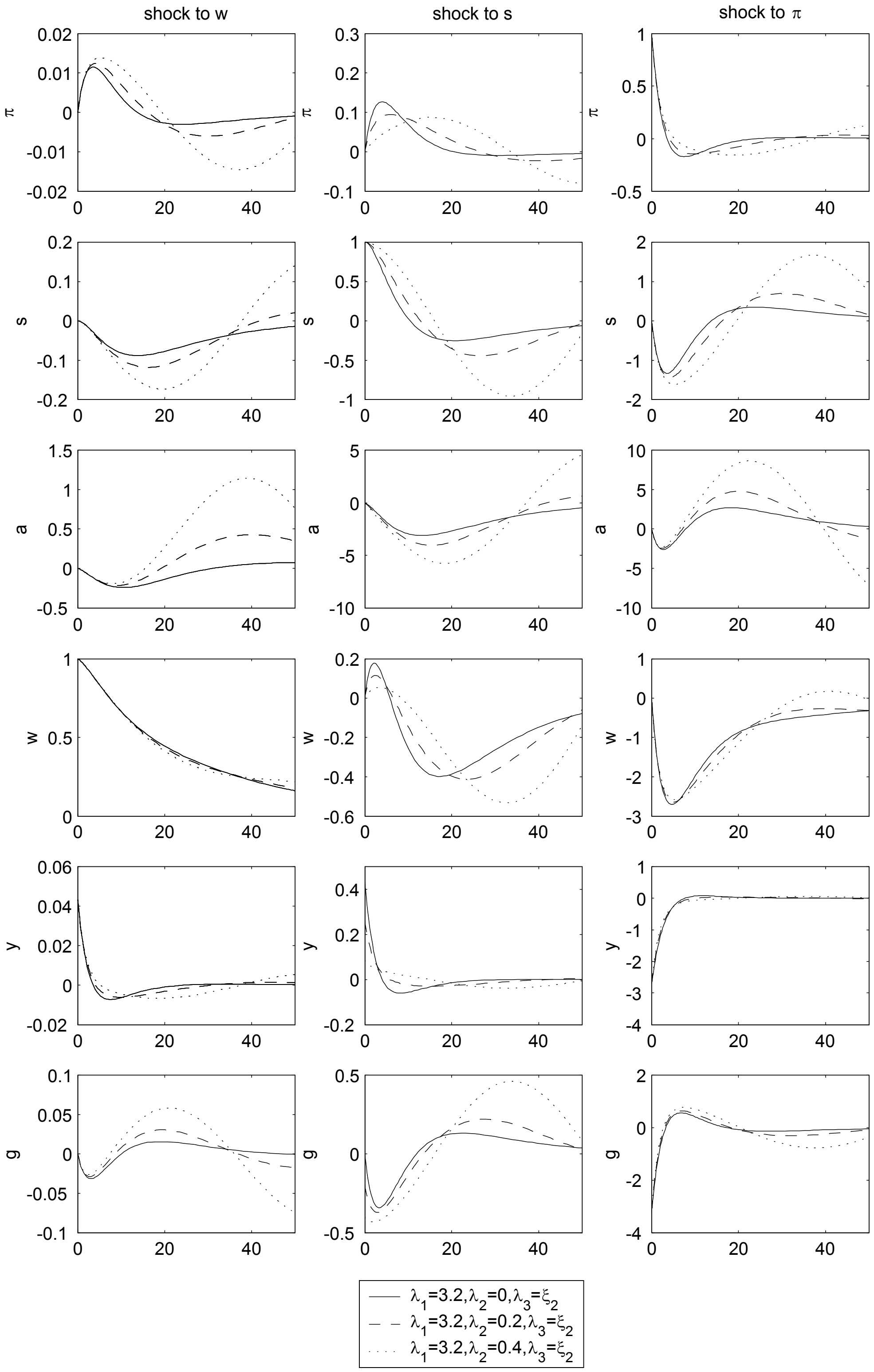

Figure 3: Backward-looking Phillips curve, model for differences. Effect of increase in λ_2 when inflation cycles are removed. This corresponds to movement away from $\mathcal{M}$ towards v in Figure 1.

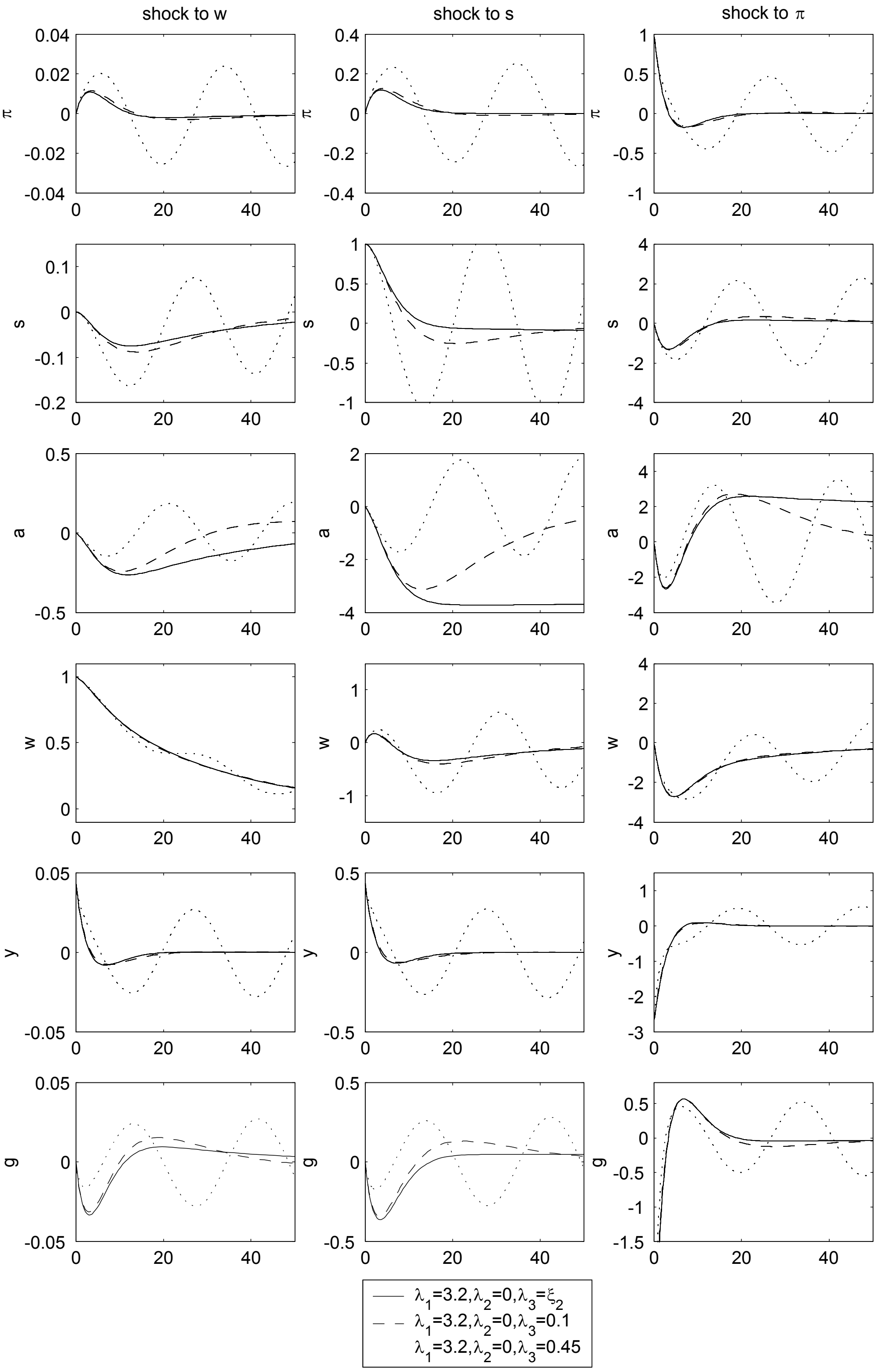

Figure 4: Backward-looking Phillips curve, model for differences. Effect of increase in λ_3 when inflation cycles are removed. This corresponds to movement away from $\mathcal{M}$ towards w in Figure 1.

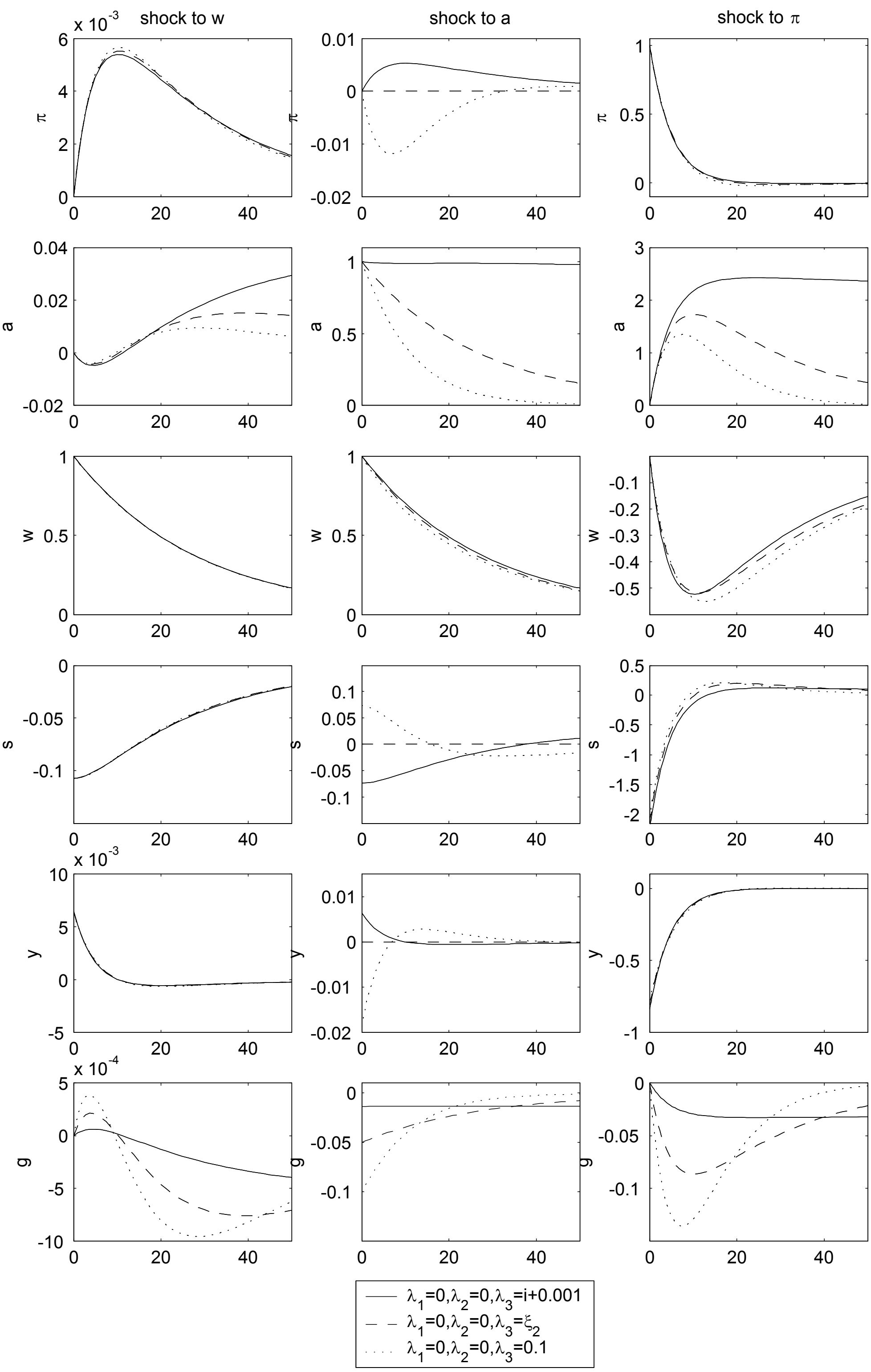

Figure 5: Backward-looking Phillips curve, model for averages. Effect of increase in λ_3 when $\lambda_1 = 0, \lambda_2 = 0$.

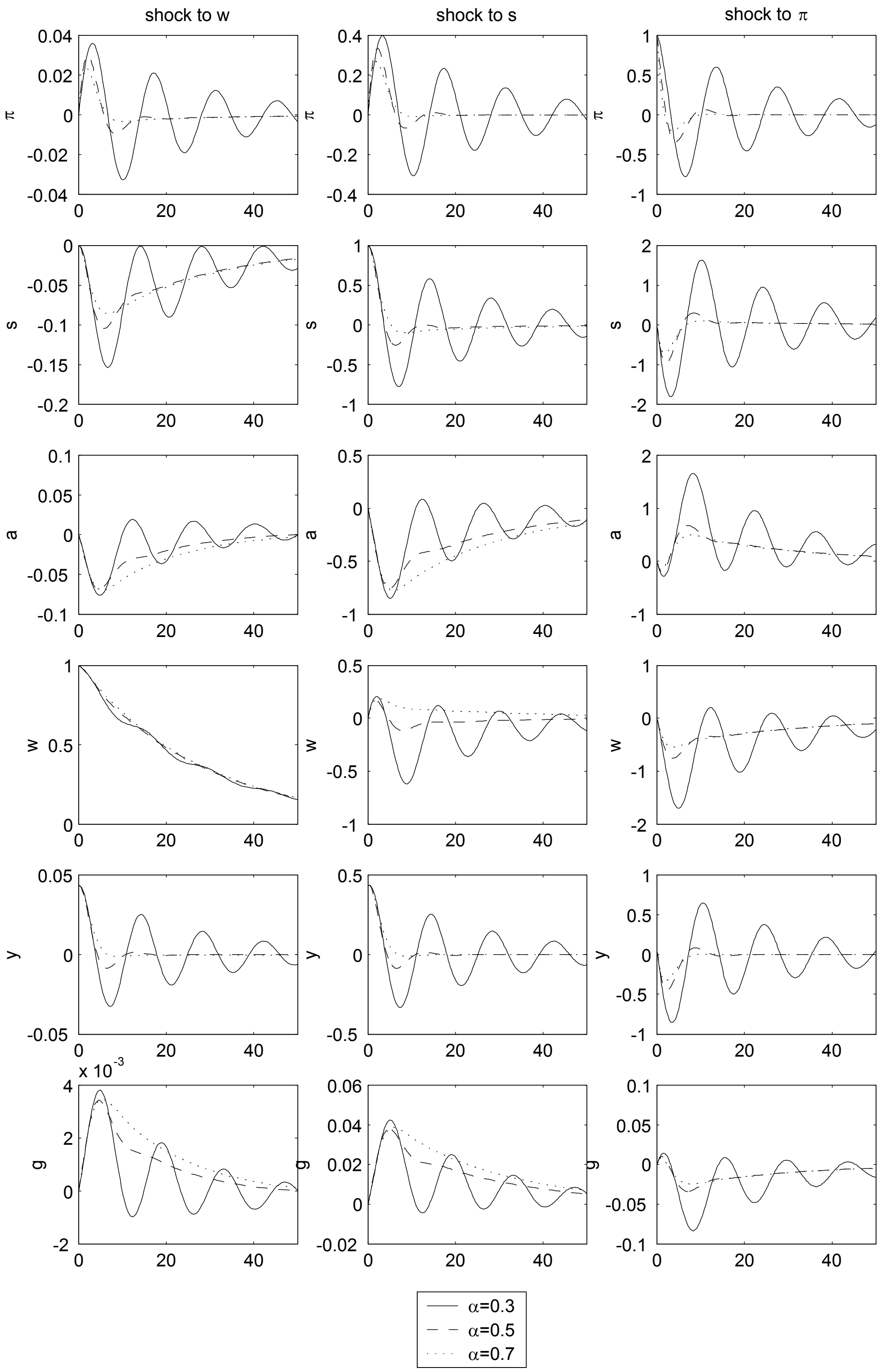

Figure 6: Backward-forward Phillips curve, model for differences. Effect of α on 'Walters critique' cycles. Policy rule: $\lambda_1 = 0, \lambda_2 = 0, \lambda_3 = \xi_2$.

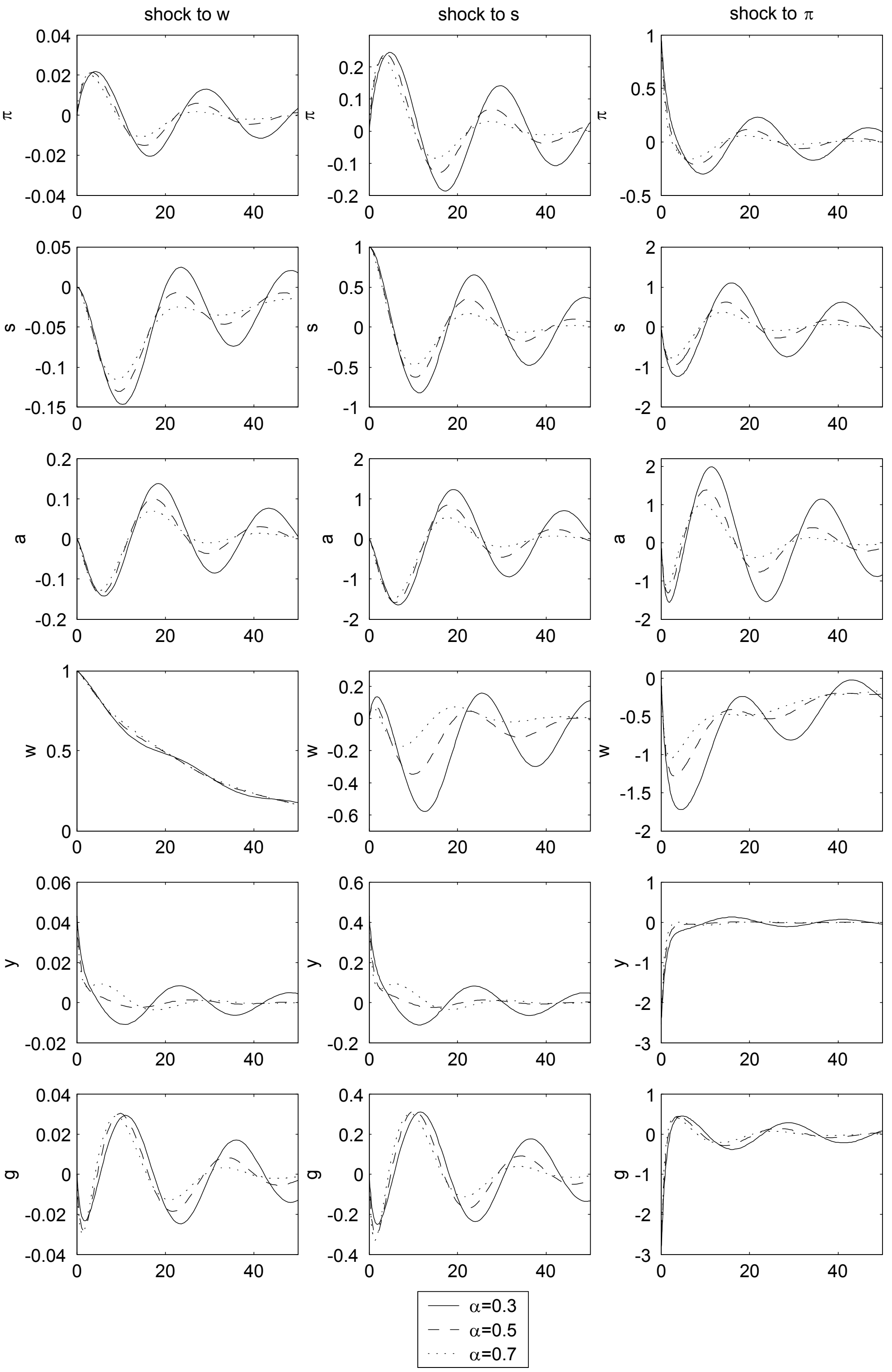

Figure 7: Backward-forward Phillips curve, model for differences. Effect of α on wealth cycles. Policy rule: $\lambda_1 = 3.0, \lambda_2 = 0, \lambda_3 = 0.45$.

A Derivation of system (21)-(25)

A.1 Aggregate demand

Net real domestic product (y) is the sum of private consumption, government consumption and net exports.

$$Y = C + G + NX(s, y)$$

Total household expenditures $C = \xi_0(1-\tau)Y - \xi_1 R + \xi_2 W$ are financed from wage income and from returns from financial assets. Consumption depends negatively on the real interest rate.

It is assumed that there are no imported raw materials but that a constant proportion (ω_0) of total domestic expenditure on finished products ($C+G$) is spent on the import of such goods (M). Thus, $M = \omega_0(C+G) = \omega_0(Y - NX) = \omega_1(Y - X)$, where $\omega_1 = \frac{\omega_0}{1-\omega_0}$ and X are exports, so that $NX = (1+\omega_1)X - \omega_1 Y$.

The real exchange rate is measured as $S = EP^*/P$, where E is the nominal exchange rate, P is the price of domestically consumed goods and P^* is the foreign CPI, which is assumed to be constant. It determines the volume of exports (X), a rise in E representing a depreciation of the domestic currency. Finally, net exports is a function of the real exchange rate and real output: $NX = (1+\omega_1)(\overline{X} + \kappa S) - \omega_1 Y = (1+\omega_1)\overline{X} + \kappa_0 S - \omega_1 Y$. (For derivations leading to a similar formula see e.g. Gali and Monacelli (2005).)

Thus, the output equation takes the form:

$$Y = \kappa(\xi_2 W - \xi_1 R + \xi_3 S + G + (1+\kappa_5)\overline{X})$$

where $\kappa = 1/(1 - \xi_0(1-\tau) + \omega_1) = \frac{1-\omega_0}{(1-\omega_0\xi_0(1-\tau)(1-\omega_0))}$; and its log-linearised form (with all constant terms ignored) can be written as

$$y = \kappa(\xi_2 w - \xi_1 r + \xi_3 s + g)$$

where we use the fact that for any variable $Z = \overline{Z}(1 + \ln\frac{Z}{\overline{Z}}) = \overline{Z} + z$, $z = \overline{Z}\ln\frac{Z}{\overline{Z}}$.

A.2 Asset accumulation equations

Foreign and domestic assets accumulation equations can be written as

$$\dot{A} = rA + G - \tau Y \tag{28}$$

$$\dot{F} = rF + NX \tag{29}$$

where τ is the tax rate on income and we assume UIP holds. Foreign wealth is measured in domestic currency. We denote total financial wealth as $W = F + A$. Then a log-linear form of these equations (domestic debt and total financial wealth) can be written as

$$\dot{a} = (\iota - \pi_{cpi})A + \iota_0 a + g - \tau y$$
$$\dot{w} = (\iota - \pi_{cpi})W + \iota_0 w + nx(s, y) + g - \tau y$$

where capital letters are used to denote steady state values.

Note that $\xi_2 > \iota_0$ must hold, so the consumption-wealth relationship, taken on its own, is not unstable. Households must consume out of wealth faster then the interest rate which is paid on it. This is an important stability condition and we assume always holds.

B Calibration

We calibrate the parameters of the model as:

ϕ	ι_0	μ	κ_1	ξ_1	ξ_2	ξ_3	τ	θ	λ	A	W
0.2	0.0125	0.25	0.8	0.5	0.05	0.5	0.4	0.5	0.3	0.5	0.5

and $\kappa = 1/(1 - \kappa_1(1 - \tau)\lambda + \mu)$.

C Mixed backward-forward Phillips Curve

As most economic problems are most naturally formulated in discrete time (and most easily solved in continuous time), an analogy with discrete time could be useful when deriving the Phillips curve. A conventional accelerationist Phillips curve takes the form $\pi_t = \pi_{t-1} + \phi y_{t-1}$, which is equation (3) in continuous time, with $\phi > 0$. An entirely forward-looking unit-root inflation specification of the Phillips curve can be written as $\pi_t = \pi_{t+1} + \phi y_t$ that trivially leads to the same specification (3) in a continuous time[8], but with $\phi < 0$.

The mixed backward-forward looking version is more complicated. A discrete time version can be written as

$$\pi_t = \alpha\pi_{t+1} + (1 - \alpha)\pi_{t-1} + \alpha\phi y_t + (1 - \alpha)\phi y_{t-1} \tag{30}$$

see Steinsson (2003) for a similar specification derived from microfoundations. We can approximate this equation with a continuous-time differential equation. There is a difficulty with end points: we need the same equation to collapse to both entirely forward- and entirely backward-looking specifications, when α is either 0 or 1.

Equation (30) is a difference equation of the second order and will lead to either a differential equation of the second order or a system of two first order equations. Using that a second-order

[8] Gray and Turnovsky (1979) show how to re-formulate discrete-time problems in continuous time.

derivative can be approximated as $\ddot{u} \approx (u_{t+h} - 2u_t + u_{t-h})/h$, we obtain that (30) can be represented as a pair of first order differential equations:

$$\alpha\dot{u} = -(2\alpha - 1)u - 2(1-\alpha)\phi y$$
$$\dot{\pi} = u - \phi y$$

for $0 < \alpha < 1$. This specification suggests that inflation, π, is a predetermined variable, and its derivative, u, is a jump variable for any α *strictly* inside $[0, 1]$.

The two limiting cases lead to the familiar specifications:

(i) if $\alpha = 0$ then inflation is backward-looking and $u = 2\phi y$. Substitute it into the second equation and obtain

$$\dot{\pi} = \phi y$$

as required.

(ii) if $\alpha = 1$ then inflation is forward-looking and π must become a jump variable, and u must become a predetermined variable, so we need an initial condition on u. We demand $u(0) = 0$, i.e. $\dot{\pi}(0) = -\phi y(0)$ which is consistent with what follows. The first equation collapses to $\dot{u} = -u$ which now has only one trivial solution $u(t) \equiv 0$. The second equation, thus, becomes:

$$\dot{\pi} = -\phi y$$

as required.

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