Price Stability and Debt Stability: A Wicksell-Lerner-Tinbergen Framework for Macroeconomic Policy Analysis

J. W. Mason and Arjun Jayadev

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Introduction

Two major preoccupations of recent debates over macroeconomic policy are the choice between the policy-determined interest rate and the government budget balance as tools for stabilizing output; and the importance of maintaining the ratio of pubic debt to GDP on a "sustainable" trajectory. The starting point of this paper is that these two issues should be addressed within a single framework, since both output and the public debt ratio are jointly determined by both the fiscal balance and the interest rate.

Drawing on Tinbergen's familiar language of policy targets and instruments, we present a simple framework within which the joint effects of the two policy instruments on the two targets can be analyzed. This consists of a version of the "three-equation" model familiar from macroeconomics textbooks, plus the law of motion of government debt. In the first part of the paper, we draw some general conclusions from analysis of the framework in the abstract; in the second part of the paper, we apply it to concrete historical data for the postwar United States.

From the formal analysis, we draw two conclusions. First, we show that there will be one set of combinations of interest rates and fiscal balances that will keep output at potential, and another set that will hold the debt ratio constant. A unique point in fiscal balance-interest rate space lies on both loci and satisfies both conditions. The location of this point does not depend on which instrument is assigned to which target. This has a surprising implication: The familiar instrument assignment in which the interest rate is set by the monetary authority to keep output at potential, and the fiscal balance is set to hold the debt-GDP ratio constant, will in general imply the exact same values for the interest rate and fiscal balance, as a rule in which the fiscal balance is set to keep output constant, and the monetary authority sets the interest rate at the level required to hold the debt-GDP ratio constant. In general, macroeconomic outcomes when the monetary authorities are responsible for output and the fiscal authorities face a binding budget constraint, will be indistinguishable from outcomes when the fiscal authorities ignore the debt ratio and focus only on output. From this point of view – which depends only on uncontroversial aggregate relationships – the difference between "sound finance" and "functional finance" has been exaggerated by partisans on both sides.

Our second conclusion in the first section points in a somewhat different direction. While the two instrument assignments imply the same equilibrium values for the two instruments, they do not imply the same behavior away from equilibrium. So they may have different stability properties. We find that, for realistic parameter values, the "functional finance" assignment in which the fiscal balance targets output and the interest rate targets the debt ratio, always converges; but the orthodox "sound finance" assignment converges only if the initial debt ratio is not too high. This is because the higher the debt ratio, the more changes in the debt ratio depend on the effective interest rate, as opposed to the current fiscal balance. Thus, from our point of view, the familiar metaphor of "fiscal space" is exactly backward. In fact, the higher is the current debt ratio, the stronger is the argument for countercyclical fiscal policy, because at high debt ratios the interest rate instrument will be required to stabilize the debt ratio. This is consistent with the historical experience that when public debt ratios are sufficiently high, moderating debt service costs for the government becomes the primary consideration for central bank rate-setting.

In the second, historical-empirical section, we first discuss challenges in matching the terms in the model to historical data series. These problems, while serious, are in no way unique to our framework. A background goal of the paper is to encourage more critical thought about the juncture between formal models and observable social reality. We then address three questions. First, we ask where the loci described in the first section are located in the United States, and how they have evolved over time. While the concrete results are, in our opinion, interesting and credible, the main value of this exercise is as a proof of concept for a tool that we believe could be widely useful in analysis of macroeconomic policy. Second, we ask what we can learn about the historical behavior of private demand from our choice of parameter values. This exercise is useful, on the one hand, for better understanding the scale of historical fluctuations in private demand and the factors that may have driven them, and on the other, as an alternative approach to validating the parameters. Finally, we explore whether the adjustment dynamics discussed in the first section could be relevant to concrete developments in the United States. In particular, is it plausible that output fluctuations could be, at least in part, the result of instability endogenously generated by interactions between the two policy instruments? We tentatively suggest that much of recent macroeconomic history can be viewed as a "sound finance spiral" of the sort described in the first section.

1 A Simple Model of Macroeconomic Policy Rules

1.1 The Consensus Macroeconomic Model

Our starting point is the simple model of aggregate behavior that that underlies most contemporary discussions of macroeconomic policy.[1] The model embodies four key assumptions, none controversial.

1. First, the interest rate is set by the monetary authority. Real economies have many different interest rates. In the equations below, we use i to refer to the average "real" rate on outstanding government debt, but our model naturally generalizes to the case where the various rates do not move together.[2] The fact that the monetary authority is able to set

[1] For good discussions of the "new consensus" macroeconomic models that we follow here, see Palacio-Vera (2005) and Carlin and Soskice (2009).

[2] The need to adjust nominal interest rates for inflation is not in general a point of contention between orthodox macroeconomics and Post Keynesian and other heterodox approaches. (Smithin, 2006) But while this adjustment is straightforward in a formal

the prevailing rate of interest at whatever level is required to achieve its policy objectives has important implications for the nature of interest. In particular, it highlights the fact that the interest rate is a monetary phenomenon, and does not in general reflect any tradeoff between current and future consumption. It is not necessary to pursue this question here, however. Since all modern macroeconomic models begin with the assumption that the interest rate is fixed by the monetary authority, the use of that assumption here requires no further defense.

2. Second, inflation is a positive function of the current level of output, along with its own past or expected values and other variables. Fiscal and monetary policy affect inflation only via output. This assumption is formalized as a Phillips curve:

$$\hat{P} = \hat{P}(Y - Y^*, \hat{P}^E), \tag{1}$$

$$\hat{P}_{Y-Y^*} > 0$$

$\hat{P}$ is the inflation rate, $\hat{P}^E$ is the expected inflation rate, Y is output as measured by GDP or a similar variable, and Y^* is potential output. For our purposes it does not matter how inflation expectations are formed. In contemporary textbook presentations, it is assumed that the long-run Phillips curve is vertical, with $Y = Y^*$ the unique level of output at which inflation is stable.

3. Third, output is a negative function of the interest rate, and a negative function of the fiscal balance (or positive function of the government deficit) via the multiplier.[3]

A multiplier of zero (Ricardian equivalence or full crowding out) is

model, it's not so obvious what adjustment is appropriate when dealing with historical data. Depending on the question being asked, the appropriate inflation rate may be either the *ex ante* expected rate, or the *ex post* realized rate over the term of the loan. There is no reason to expect either of these to coincide with the instantaneous rate at the time the debt is incurred. This problem is discussed a bit further in Section 2.1.3 below.

[3]Modern macroeconomic models derive the path of output from a Euler equation, which is supposed to capture a process of intertemporal optimization. However, this equation is typically linearized into a form similar to Equation 2. (Billi, 2012)

included as a special case. This assumption is formalized as an IS curve:

$$Y = A - \eta i Y^* - \gamma b Y + \tau i d Y \tag{2}$$

A is autonomous spending, here defined as the level of output when both the interest rate and fiscal balance are zero. i is the average interest rate on government debt. For now, we consider i to be the "real" (that is, inflation-adjusted) interest rate. η is the semi-elasticity of output with respect to the interest rate, that is, the percentage increase in output resulting from a point reduction in the interest rate. In the interests of mathematical simplicity, the effect of interest rates on real activity is expressed in terms of potential output Y^* rather than current output Y. Note that the value of η reflects both the responsiveness of real activity to changes in interest rates, and the strength of the correlation of the marginal rate facing private borrowers with the average rate on public debt. So no special assumption is needed about whether all interest rates move one for one with the policy rate. If we think they respond less than proportionately, we simply use a lower value of η. b is the primary balance of the government, with positive values indicating a primary surplus and negative values a primary deficit. γ is the multiplier on whatever mix of tax and spending changes are used to adjust the government fiscal balance. d is the ratio of government debt to current output. τ is the multiplier on interest payments; its helpful to allow the possibility that this multiplier is different from the one on the changes in tax and spending captured by changes in d.

4. Our fourth assumption is simply that the end of period debt is equal to the start of period debt plus the accumulated primary deficits and interest payments. This gives us the law of motion of government debt, "the least controversial equation in macroeconomics." (Hall and Sargent, 2011)

$$\Delta d = \frac{i - g}{1 + g} d - b \tag{3}$$

where i, d and b are defined as above and g is the growth rate of output, again net of inflation. Equation 5 is not an accounting identity since it will be violated not only in the case of defaults but also (under standard definitions of b) by government purchases or sales of private financial assets. In reality, such transactions occupy a gray area between monetary and fiscal policy, and it is not always obvious how they should be classified. In some cases, such as Ireland in 2009-2011, such transactions may dominate the evolution of the public debt. This possibility complicates the question of what constitutes a stable debt trajectory, but these complexities are beyond the scope of this paper. Here, we assume that Equation 5 holds exactly.

These four standard assumptions are all that is required of the analysis that follows.

1.2 Targets

Any version of the Phillips curve is sufficient to make output and inflation a single target, for the purposes of stabilization policy. So for simplicity, we assume that policy targets an output gap of zero, that is, $Y = Y^*$.

We rewrite the IS relationship as:

$$Y = \frac{A - \eta i Y^*}{(1 + \gamma b - \tau i d)}$$

Then for $Y = Y^*$, we need:

$$i = \frac{Z}{(\eta - \tau d)} - \frac{b\gamma}{(\eta - \tau d)} \tag{4}$$

where

$$Z = \frac{A - Y^*}{Y^*}$$

Z then is the output gap when the primary deficit and interest rate are both zero, measured as a fraction of potential output.

Equation 4 has a natural interpretation. To maintain potential output, for a given level of autonomous expenditure, Z, as the primary surplus (b) rises, the interest rate (i) must fall. For a given amount of consumption from revenue from government bonds (τ d) the degree to which it must fall to compensate for the fall in government expenditure will depend on the relative responsiveness of output to the fiscal balance and to the interest rate. As η rises, i needs to fall less to compensate for a rising primary surplus; as γ rises, i needs to fall more.

This gives us our price stability locus. Next we consider debt sustainability.

The law of motion of government debt is:

$$\Delta d = \frac{i - g}{1 + g} d - b \tag{5}$$

where d is the current debt-GDP ratio, i is the effective interest rate on outstanding government debt, g is the growth rate, and b is the primary balance, with positive values for surpluses. (We will do all this in nominal terms.) Then to hold d constant, we need:

$$i = \frac{dg - b(1 + g)}{d} = g + \frac{1 + g}{d} b \tag{6}$$

This is the constant debt ratio locus.

Again, the interpretation is straightforward. For a given debt-GDP ratio, an increase in the growth rate of GDP (g) or the primary surplus(b) will reduce the debt to GDP ratio unless counteracted by an increase in the interest rate to maintain the current ratio.

There is not a consensus on the meaning of debt sustainability[4].The weakest form allows the debt-GDP ratio converge to any finite value. The next strongest is that the ratio remain at or below its current level. The strongest version requires the ratio to remain at or below some exogenously given level. The latter two conditions may be framed as equalities or inequalities; a budget position that implies that the debt fall to zero, or that the government

[4]Some useful discussion of the issue is available in Aspromourgos, Rees and White (2010) and Pasinetti (1998)

ends up with a positive asset position, may or may not be considered sustainable. In the absence of any strong reason for preferring one or the other, we use the middle condition, that the debt ratio remain constant at its current level. Our results could be easily be extended to the third, strongest case. But we have chosen not to do so here, since this would involve adding one or more additional parameters for only a small gain in generality.

Alternative definitions of debt sustainability are shown in Figure 1. Only area A does not satisfy any definition of debt sustainability.

If we define debt sustainability as the debt ratio being stable at its current level, then Equation 6 is the condition for debt sustainability. If we define debt sustainability as a constant or falling debt ratio, then we can write:

$$i \leq g + \frac{1+g}{d} b$$

If we define debt sustainability as the condition that the debt ratio not to rise without limit, then it's sufficient to meet either the above condition or $i < g$.

Combining our price stability and constant debt ratio loci gives us the unique values for i and b for which output is at potential and the debt-GDP ratio is constant.

$$i = \frac{Z(1+g) + \gamma g d}{\gamma d + (\eta - \tau d)(1+g))} \approx \frac{Z}{\eta + (\gamma - \tau) d} \tag{7}$$

$$b = \frac{Zd - gd(\eta - \tau d)}{\gamma d + (\eta - \tau d)(1+g)} \approx \frac{Z}{(\gamma - \tau) + \frac{\eta}{d}} \tag{8}$$

Both approximations are based on the assumption that g will always be much smaller than one.

The equations each have a natural interpretation. For a given τ , the equilibrium value for i indicates that when debt (d) is low, the interest rate responds mostly to changes in output to maintain equilibrium. The responsiveness is also dependent on η, and a larger responsive is required when η is lower (i.e. the interest elasticity of output is lower). With high levels of

d, the response of interest to output will be low, unless the fiscal multiplier is close to zero. The equilibrium value of b indicates that as the d rises, b approaches $Z/(\gamma - \tau)$. In other word, as the debt ratio rises, the primary surplus must respond more to autonomous expenditure. The two equations together telegraph a finding that we discuss in greater detail later. Simply put, as the debt ratio rises, the effectiveness of changes in i in maintaining potential output decreases while that of the budget balance b increases.

One way of thinking about this is in terms of two alternative instrument assignments. We will call the assignment in which the interest rate is assigned to the output gap target and the primary balance is assigned to the debt ratio target sound finance, and the opposite assignment, in which the primary balance is assigned to the output gap and the interest rate is assigned to the debt ratio, functional finance.[5] Sound finance sets i^* as whatever value of i satisfies Equation 2 at last period's (or expected) b, and b^* at whatever level of b satisfies Equation 5 at last period's (or expected) i. In other words, the interest rate instrument is assigned to the output target, and the budget balance is assigned to the debt ratio target. Functional finance sets b^* as whatever value of b satisfies Equation 2 at last period's (or expected) i, and i^* at whatever level of i satisfies Equation 5 at last period's (or expected) b. In other words, the the budget balance instrument is assigned to the output target and the interest rate instrument is assigned to the debt ratio target.

Equations 7 and 8 describe the unique equilibrium combination of i and b for which the output gap is zero and the debt-GDP ratio is constant. Thus, abstracting from any changes in the debt ratio that occur during the process of convergence, if the policy rules converge at all they will bring the economy to the same final state regardless of which set of policy rules is being followed. In other words: Suppose the budge authority is following some fiscal rule that satisfies the conditions for debt sustainability, whatever they may be. And suppose that, given that fiscal rule, the monetary authority is able to follow an interest rate rule that keeps output at its target level. Then it must also be possible for the fiscal authority to instead ignore the debt ratio and set the budget balance at whatever level leads to the target level of output, and the monetary authority to then set the interest rate at whatever level stabilizes

[5]We take the terms "sound finance" and "functional finance" from Lerner (1943). But we should note that Lerner did not treat the debt ratio as a target for policy, but assumed it would passively adjust to accommodate fiscal policy and the independently determined interest rate.

the debt ratio. This equivalence between the superficially contrasting "sound finance" and "functional finance" policy rules is the first significant result of our analysis.

If the debt-targeting instrument adjusts much faster than the output-targeting instrument, then the economy, if it converges at all, will arrive at the point which satisfies Equations 7 and 8 for initial debt d_0, regardless of the initial interest rate and budget balance. Otherwise, the debt ratio will change over the course of the adjustment process, and the final state will in general depend on which set of rules are being followed, as well as on the initial state of the economy and the values of the adjustment speed parameters. The outcome in this case cannot be derived analytically but must be simulated numerically.

Convergence conditions are explored in Section 1.3 below.

We can represent the two loci graphically with the interest rate on the vertical axis and the primary balance on the horizontal axis, as shown in Figure 2. The constant debt ratio locus slopes downward, and passes through the point ($d = 0$, $i = g$). If τ is zero, the price stability locus must slope upward. If τd is large, it may slope downward instead. (In this case the sound finance policy rule will move the economy away from potential output.) If $\eta - \tau d = 0$ – changes in interest rates do not affect output – then the price stability locus will be a vertical line at some value of d. Conversely, if $\gamma = 0$ – that is, full crowding out or Ricardian equivalence – the price stability locus will be horizontal at $i = \frac{1}{\eta} Z$.

A change in autonomous demand A – which captures any exogenous change in demand that policy must respond to – shifts the price stability locus horizontally by an amount equal to A. In any period in which the economy is not on the constant debt ratio locus, there is a change in d. An increase in d rotates the constant debt ratio locus clockwise around the point ($d = 0$, $i = g$), with the locus approaching a horizontal line at $i = g$ as the debt ratio goes to infinity, and a vertical line at $d = 0$ as the debt ratio goes to zero. When $\tau > 0$, then an increase in d also shifts the price stability locus downward and rotates it clockwise, eventually through the vertical (when $\tau d = \eta$) and to a horizontal line at $i = 0$.

1.3 Convergence Under Alternative Instrument Assignments

We are here interested in the behavior of the two rules in achieving convergence to equilibrium from different starting points in the (b,i) space. In what we follows we will work in terms of the output gap y

$$y = \frac{Y - Y^*}{Y^*}$$

The IS curve from the previous sections is now given by

$$y = z - \gamma b - \eta i + \tau d i \tag{9}$$

The linearized equation of motion of the debt-to-income ratio is

$$\dot{d} = -b + (i - g)d \tag{10}$$

Our targets therefore are $y = 0$ and $\dot{d} = 0$.

From the sound finance perspective, interest rates fall when expenditure exceeds the level of expenditure required to maintain full employment and the budget surplus rises when the economy is operating above the debt stability locus[6] The equations of adjustment are therefore given by :

$$\dot{i} = \alpha[\frac{1}{\eta}(z - \gamma b + \tau d i) - i] \tag{11}$$

$$\dot{b} = \beta[-(i - g)d - b] \tag{12}$$

where α and β are adjustment speed parameters.

The interpretation of α and β requires some explanation. We should be clear that these do not reflect any assumption about the process by which the policy instruments are set. In reality, the speed with which fiscal and monetary policy respond to macroeconomic variables depends on a whole range of

[6]The equation can be considered equivalent to the Taylor Rule.

political and institutional factors particular to the country and time period. What α and β capture, rather, is how fast the fiscal balance and interest rate are generally adjusted in a particular context, relative to the frequency with which the authorities receive news about the target variable. This parameter will have some value for *any* policy adjustment process ranging from zero to one.

To illustrate the process of adjustment let us assume that we are at a point of rising debt (i.e above the debt stability locus), but also below potential output. The sound finance implies moving vertically toward potential output locus and horizontally toward debt stability locus as depicted in figure 3. In the figure shown, the budget is moved towards surplus in order to achieve debt sustainability, while the interest rate is set to target output . As drawn, despite overshooting initially, the system spirals clockwise inwards towards the equilibrium.

Under the functional finance rule the budget surplus falls when expenditure exceeds the level of expenditure required to maintain full employment and the interest rate falls when the economy is operating above the debt stability locus. The rules can be written therefore as:

$$\dot{i} = \alpha[g + \frac{b}{d} - i] \tag{13}$$

$$\dot{b} = \beta[\frac{1}{\gamma}(z - \eta i + \tau di) - b] \tag{14}$$

This can be depicted in Figure 4. Starting from the same position as before, the budget balance is moved to deficit in order to hit full employment while the interest rate is lowered to achieve debt sustainability. This is drawn as a counterclockwise spiral inwards towards the equilibrium.

While we have drawn the spiral converging, whether in fact the system converges depends on the starting parameters and the level of debt.

Given a set of linear differential equations as we have with both rules, for stability of the equilibrium we need (from the Routh-Hurwitz conditions) that the Jacobian Matrix satisfies the following :

A. $tr(J) < 0$

B. $det(J) > 0$

1.3.1 Convergence Conditions for the Sound Finance Rule

For the sound finance rule, the Jacobian Matrix is given by

$$J_{sf} = \begin{bmatrix} -\alpha(1-\frac{\tau d}{\eta}) & -\alpha\frac{\gamma}{\eta} \\ -\beta d & -\beta \end{bmatrix}$$

This gives us

$$tr(J_{sf}) = -(\alpha(1-\frac{\tau d}{\eta}) + \beta)$$

$$det(J_{sf}) = \alpha\beta(1-\frac{\tau d}{\eta} - \frac{\gamma d}{\eta}) = \alpha\beta(1-\frac{d}{\eta}(\tau+\gamma))$$

Condition A requires that $\alpha\beta(1-\frac{d}{\eta}(\tau+\gamma)) > 0$ this can be rearranged to be

$$d < (1+\frac{\beta}{\alpha})\frac{\eta}{\tau} \tag{15}$$

Condition B requires that

$$\alpha\beta(1-\frac{d}{\eta}(\tau+\gamma)) > 0$$

which can be rewritten as

$$d < \frac{\eta}{\tau}\frac{1}{(1+\frac{\gamma}{\tau})} \tag{16}$$

It is easy to see that equation 16 is binding since the maximum threshold for d implied by equation 15 is always larger than the maximum threshold level of d for Equation 16

We can summarize the implications of Equation 16 as follows:

The sound finance rule will only converge below some critical value of the debt ratio. That critical value will depend on the three parameters. A low threshold – and hence a greater probability of divergence under the sound finance rule – will result if η is small relative to τ and both are both small relative to γ. Thus for example, with plausible values of the parameters ($\eta = 1$, $\tau = .1$ $\gamma = 1.5$), the threshold level of d is .63. In general, then, stability under sound finance requires that the direct effect of interest rates on expenditure be relatively strong compared to effects of income changes due to either fiscal balance or interest payments. If expenditure is more sensitive to current income than to interest payments, then the sound finance rule will be stable only at low debt ratios.

1.3.2 Convergence conditions for the Functional Finance Rule

For the functional finance instrument assignment, the Jacobian Matrix is given by

$$J_{ff} = \begin{bmatrix} -\alpha & \frac{\alpha}{d} \\ -\beta\frac{\eta-\tau d}{\gamma} & -\beta \end{bmatrix}$$

This gives us

$$tr(J_{ff}) = -(\alpha + \beta)$$

$$det(J_{ff}) = \alpha\beta(1 - \frac{\tau d - \eta}{\gamma d})$$

Condition A is always satisfied.

Condition B requires that :

$$\alpha\beta(1 - \frac{\tau d - \eta}{\gamma d}) > 0 \tag{17}$$

This is always satisfied for: $\gamma > \tau$. If $\tau > \gamma$, the condition requires that

$$d < \frac{\eta}{\tau - \gamma}$$

Thus, from equation 17 all that is required is for the multiplier to be larger than the effect of income from interest receipts. For virtually all historically generated parameters, this will be the case. In the (highly unlikely) case where $\tau > \gamma$, this difference must be large for instability to arise, at moderate values of d for a given η.

Combining Equations 15 through 17, we draw a general conclusion about the stability properties of the two rules. Both rules are stable for a range of debt values. Beyond a certain value of debt, only functional finance will remain a viable assignment for convergence to equilibrium.

Specifically, for

$$\frac{\eta}{\tau + \gamma} < d < \frac{\eta}{\tau - \gamma}$$

only the functional finance instrument will converge.

This can be seen visually by way of a simulation. In Figure **??** and Figure **??** below, the red areas reflect combinations of τ and d for which the sound finance and functional finance assignment leads to instability, while conversely the blue areas reflect combinations that will lead to stability for a given set of plausible parameters ($\alpha, \beta = 0.5$, γ=1.5, η=1.0). As the figure shows, the functional finance instrument is the only assignment that leads to stability after a leverage ratio of 0.6. Moreover, it is stable even for large values of τ.

Based on this analysis, we can see that when the debt-GDP ratio is sufficiently high, stability *requires* that the interest rate instrument target (mainly) the stability of the debt ratio, and the fiscal balance target (mainly) the output gap. Thus, under a very general set of assumptions, the common metaphor of "fiscal space" gets the relationships between debt levels and policy backward. Stability requires that the fiscal authorities make less effort, rather than greater effort, to stabilize the public debt as the debt to GDP ratio rises. Countercyclical fiscal policy not only remains possible at high debt levels, but becomes obligatory.

1.3.3 Discussion

While the results are clear, the intuition behind them is not immediately obvious. So it is worth thinking through why instability arises. In effect, the sound finance assignment suggests that the budget authority should respond to signals from the debt path to decide on spending and tax levels. A rising debt-GDP ratio is a signal that spending is excessively high and/or taxes are excessively low, and a falling debt-GDP ratio is a signal that spending is needlessly low and/or taxes are needlessly high. interest rates as well as tax and spending decisions influence the debt path. If the monetary authorities do not take into account the signals changes in policy send to the budget authorities, then changes in monetary policy will induce additional, unintended changes in the fiscal balance that will amplify the initial effect on output. The larger the current debt, the larger these unintended effects will be, since the bigger an impact a change in interest rates will have on the budget position. These unintended effects will also be larger if the interest rate set by the monetary authority has a stronger relationship with public than with private borrowing costs. Changes in the fiscal position carried out to stabilize the debt ratio will, in turn, affect demand and induce further interest rate changes. When the cross-effects are large, this will lead to a situation where each adjustments in one instrument induces a larger adjustments in the other. This unstable dynamic is possible only under the sound finance rule because while the effects of the two instruments on output are stable, the effect of fiscal policy on the debt ratio goes to zero as the debt ratio rises. This requires ever-larger adjustments of the fiscal balance in response to interest rate changes by the monetary authority.

One may ask whether, even if this analysis is formally correct, it offers a useful tool for understanding the evolution of macroeconomic targets and instruments in real economies. In the remainder of the paper we address this question, using the framework developed here to analyze the trajectory US macroeconomic policy over the past seven decades.

2 Historical Applications of the Framework

While our framework is useful in the abstract, as a tool for clarifying policy discussions, it becomes more valuable when applied to concrete historical material. In the following section, we discuss some challenges in mapping the variables in our framework onto historical data, and the range of plausible parameter values.

Government debts, interest payments and primary balances are widely reported measures, but their definition and measurement is not straightforward and different seemingly plausible choices can produce widely varying values. Interest rates are relatively straightforward to measure, but the complexity of the rate structure and the failure of longer and riskier rates to move one for one with the policy rate set by the central bank, means that one must make a choice about which interest rate is the relevant one for a given application. Both these issues are challenges not only for the application of our framework, but for any empirical discussion of fiscal and monetary policy – ones which are not widely enough appreciated. In addition, applying our framework requires us to choose a particular measure for the output gap, and to assign values to the parameters in Equations 1 through 5.

Once we have assigned values to the variables and parameters, we can use the framework to assess the choices faced by policymakers historically, and to ask whether destabilizing feedback between policy instruments may have contributed to macroeconomic fluctuations in recent decades. An important step in this exercise is distinguishing the contributions of fiscal and monetary policy from underlying fluctuations in private demand. This is necessary in order to assign positions to the debt stability and price stability loci for various periods, but it is also interesting in its own right. The implied historical movements of private demand are a valuable but seldom-used tool to validate estimates of macroeconomic parameters. Any estimated value for the fiscal multiplier, the output-interest sensitivity, or other aggregate parameter, should imply fluctuations in private demand that are consistent with our priors. For example, a large value for the interest sensitivity may imply fluctuations in private demand that are inconsistent with the historical evidence on business and consumer behavior.[7] On the other hand, the implied fluctuations also are informative and may lead us to adjust our priors. In particular, as we will discuss below, it is hard to avoid the conclusion that the fall in private demand in the Great Recession period was substantially greater than the fall in output. With our preferred parameters, the fall in private demand between 2006-2007 and 2009-2010 was on the order of 25 percent of GDP. If

[7]Monetarists are fond of Milton Friedman's metaphor of a car's speed: Differences in the car's speed reflect neither the use of the accelerator, nor the slope it is traveling on, but the *difference* between variation in the amount of gas going to engine and the slope being traversed. But in fact, we generally have a good idea whether we are going up or down hill, so if the car is not accelerating despite the gas being all the way down, that is more likely to reflect a problem with the car than an otherwise undetectable headwind or slope.

private expenditure decisions are subject to instability on this scale, it seems unlikely that any plausible demand management policy – fiscal or monetary – could effectively offset them, implying that macroeconomic stabilization must address the underlying causes of private demand fluctuations and not merely seek to offset them through adjustments in interest rates or the public budget.

2.1 Data and Measurement

2.1.1 Alternative Measures of the Primary Balance and the Debt Ratio

The definition of the primary balance for a government is straightforward: total revenues minus non-interest expenditures. In other words, the primary balance is equal to the overall balance plus interest payments. The problem is that interest payments include both on-budget and off-budget interest payments, with the later including interest payments by trust funds including public retirement systems; both monetary and imputed non-monetary interest payments; and interest payments received by units of government as well as interest expenditures. While in principle our analysis is equally valid regardless of whether we define the primary balance in terms of on-budget interest payments only, monetary interest payments only, and net or gross interest payments, it is essential to be consistent; the choice may also have implications for interpretation. . In particular, since the interest rate that is relevant for the law of motion of government debt is the average effective rate, we must be careful to use the same definition of interest payments for i and for calculating the primary balance, and to use the corresponding measure of the government debt stock d. For this reason, we cannot use published measures of the primary balance, but need to calculate it as the reported overall balance plus our chosen measure of interest payments. In addition, the choice of definition for interest payments is relevant for our the choice of the interest-sensitivity parameter η, since there may be different degrees of correlation between the effective interest rate faced by government under alternative measures, the policy rate, and the average rate faced by private borrowers.

Our preferred measure is gross monetary interest payments to persons, businesses and the rest of the world; this corresponds best to both to a natural concept of interest payments, and to the relevant variable for Equation 5. This is reported by the BEA in NIPA Table 7.12, line 20. Unfortunately, this is not reported for years prior to 1960. For the earlier period, we instead use the net interest payments reported by the OMB, multiplied by the average ratio between gross and net interest payments for the first ten years for which both series are available. We add this number to the overall budget surplus or deficit to give our measure of the primary balance.

With respect to the debt ratio, once an appropriate measure of the debt stock is chosen it can be divided by either current or potential GDP. Current GDP has the advantage of being the measure generally published by statistical agencies and referred to policymakers. And it allows us to take into account the mechanical effects on the debt ratio of deviations of output from potential, which may sometimes be important, especially in deep recessions. On the other hand, the effect of macroeconomic policy on long run growth is outside the scope of this paper, and the formal stability analysis is simpler if we use the potential output as the denominator of the debt ratio. Also, most practical policy discussions assume that output always returns to its long run trend, in which case the current level of output would be irrelevant for the medium-run timeframe we are considering. On balance, we opt for simplicity and measure the debt ratio as debt divided by potential output. We revisit this question in the conclusion.

2.1.2 Alternative Measures of the Interest Rate

For the law of motion of government debt, the relevant interest rate is the average effective rate, meaning total interest payments divided by the total debt stock. In most theoretical work, the distinction between the effective rate and market rates is elided by the focusing on a long-run equilibrium in which the two are the same. But in historical applications, the distinction is important, since the effective rate on the debt stock at any given moment will be an average of the rates on the various vintages of outstanding debt and there is no reason to expect it to be equal to the current market rates, which themselves will vary across maturities. The challenge in computing the effective rate is using consistent measures of interest payments and debt stock. We use debt held by the public, as reported by the Council of Economic Advisors, which should correspond to the monetary interest payments reported by the BEA.

Since the monetary authority does not set the effective rate on government debt, it is more sensible to discuss policy equilibrium conditions and stability in terms of the policy rate. So some assumption must be made about the relationship between the policy rate and the average rate actually paid by the government. Fortunately, the conventional view that sustained changes in the Federal Funds rate are passed through one for one to the effective government borrowing rate appears consistent with the historical data, at least for the United States. So, since our interest here is in shifts in medium-term policy – over a decade or so, or a business cycle as a whole – rather than short-term variation, we can calculate the policy rate consistent with debt stability on the assumption that the effective rate is set as a fixed markup over the policy rate. In the graphs in Figure 8, we use the average observed spread between the policy rate and the 5-year Treasury bill for the period in question. (Throughout the postwar period, the average maturity of federal debt has been around 5 years.) For reasons that remain controversial, this average markup or spread rises from near zero in the immediate postwar period to close to 3 points in recent decades. (Mason and Jayadev, 2014)

Table 1: Regression of 10-Year Treasury Bonds on Policy Rates, First Differences, 1953-2011

Δ Smoothed current policy rate	0.982
	(0.243)**
Δ 10 years forward policy rate	-0.159
	(0.345)
Constant	0.002
	(0.01)
R^2	0.03
N	697

Notes: Dependent variable is the the 10 year Treasury bond rate. Smoothed current short rate is the first difference of the Federal Funds rate after the removal of cyclical components with a Hodrick-Prescott Filter. The 10 years forward policy rate is the geometric average of the Federal Funds rate over the next decade. All variables are in first differences.

Table 1 shows a simple regression analysis of the first differences of the 10-year Treasury bond the smoothed policy rate. As the table shows, changes in the long rate are significantly correlated with changes in smoothed policy rate, with a coefficient not significantly different from one. On the other hand, there is no evidence that long rates incorporate information about future short rates. This failure of long rates to predict future short rates is reflected in the coefficient on the realized average short rate over the following ten years, which is not significantly different from zero (and has the wrong sign). This is consistent with the large literature on the failure of the expectations hypothesis. (Mason and Jayadev, 2014) So the straightforward assumption that a one point change in the policy rate sustained over a decade or so, implies a similar change in the effective rate faced by the government, is not obviously inconsistent with the data. Accordingly we proceed on that basis.

2.1.3 Alternative Adjustments for Inflation

For the law of motion of government debt, we can work entirely in nominal terms; there is no need to separate nominal growth of GDP into price-level and "real" components. For the IS curve underlying the price-stability locus, however, some adjustment should presumably be made for inflation. In conventional theory, this adjustment is based on a model (implicit or explicit) of consumption loans, where the market interest rate reflects the intertemporal price of consumption now relative to consumption in the future. In reality, consumption loans are not very important, and the existence of a financial system means that there is no sense in which "lenders" must sacrifice current consumption. The vast majority of borrowing, by both households and businesses, is undertaken to finance positions in income-producing assets. So inflation matters to the borrower only insofar as it is associated with a higher nominal return on the financed assets. Lenders, meanwhile, have no concern with inflation as such, but only with the future path of interest rates. Nonetheless, since a general rise in the price level will be associated with a rise in both the price and the yield of tangible assets, we still can accept the conventional view that the higher the inflation rate, the more willing will economic units be to engage in debt-financed expenditure at a given nominal interest rate.

The question is: How, concretely, should the adjustment for inflation be made? Borrowers are concerned not with the current inflation rate, but with the increase in asset prices and yields over the life of the loan. Expected inflation will vary less than one for one with current inflation insofar as inflation itself is mean-reverting, and insofar as expectations are conventional, or adaptive or otherwise backward-looking. In addition, interest rates will vary less with inflation than borrower demand does insofar as lenders hold conventional beliefs about the "safe" or "typical" long-run interest rate level, or nominal rates are sticky for some other reason. (Bibow, 2005) Thus, while it is appropriate to regard the interest rate in the IS equation as the nominal rate adjusted for inflation, it seems clear that, except in a notional "long run" that is irrelevant for historical analysis, the appropriate adjustment is less than a one for one subtraction. In Figure 8, which is based on decade-long averages, we subtract one-half the average inflation rate for the decade from the policy rate to give the adjusted interest rate for the IS curve. While this is a somewhat arbitrary choice, we believe, for the reasons given above, that it would be hard to justify an adjustment parameter close to either zero or one, so 0.5 is a reasonable compromise in the absence of a strong argument for some other value.

2.1.4 Alternative Measures of the Output Gap

Finally, to apply our framework to concrete historical questions, we need a measure of potential output or, equivalently, of the output gap. In orthodox theory, the evolution of potential output is not affected by current expenditure, but depends only on the supply conditions as reflected in the labor supply and production technology. There is good reason to doubt that a well-defined potential output in this sense exists. On the one hand, it is clear that labor force growth responds strongly to current unemployment rates, via hysteresis and "anti-hysteresis."[8] (Ball, 2009) On the other hand, productivity growth also responds strongly to current levels of output and employment, primarily through the rate of business investment. The latter relationship is referred to as the Verdoorn or Verdoorn-Kaldor law.[9] (McCombie, 1983) So

[8] Anti-hysteresis is our coinage for endogenous expansion of the laborforce in response to low unemployment, via immigration, skills upgrading, and changes in social norms around participation in wage labor.

[9] See also the discussion in Jeon and Vernengo (2008), though the econometric analysis in this paper cannot be accepted as evidence for the relationship.

it is not meaningful to speak of an output gap in the sense of the difference between current output and some absolute, physically-determined potential output.

Nonetheless, the output gap concept remains usable, in our view, for several reasons. First, even if supply constraints are endogenous to demand over a longer time period, it is still true that at a given moment unemployment, inflation and other measures of the output gap are observable social facts. The unemployment rate may be meaningless as a measure of how much of the labor available in principle to society is currently being utilized, since "the quantity of labor available" does not correspond to any social reality – both the number of human beings present in a given polity, and the fraction of their time spent in wage labor, vary historically in response to economic (and other) conditions. But the unemployment rate remains consequential as a gauge of what fraction of the population that is currently expected – positively and normatively – to exercise its claim on the social product via wage labor, is actually doing so. Similarly, high inflation may not correspond to an "unsustainable" level of output in any absolute sense, and indeed it is entirely possible that periods of high inflation can come to an end without any policy intervention or fall in demand, through the endogenous expansion of supply that is encouraged in inflationary conditions. Nonetheless, the level of inflation at a given moment is an observable sociological fact. Second, even if there were no sensible interpretation of potential output or the output gap as descriptions of the level of economic activity, it would remain the case that policymakers believe that they do offer such a description and act accordingly. Since a major goal of this paper is to characterize the behavior of macroeconomic policymakers more precisely, and to show how policy can be an independent source of macroeconomic instability, we need to put a number of the level of economic activity that policymakers are targeting, even if we don't think it has any meaning beyond that. Third, it may be the case that although there is no good basis for identifying a unique level of potential output, most plausible alternative measures give similar results. In this case, it should not be necessary to answer the difficult question of what exactly potential output refers to, to use the concept in concrete historical analysis. In fact, this turns out to be the case for the postwar U.S. Finally, most fundamentally, the only hard requirement for our analysis is that neither the budget balance nor the interest rate affect inflation or employment except via output. As long as this is that case, any set of relationships between inflation, output and employment, and any weighting of policymakers' objective function, will yield a unique target level for output. "Potential output" then can be considered shorthand for this unique target.

Figure 7 shows five alternative measures of the U.S. output gap over the past 60 years. The first measure is simply the percentage difference between current GDP and the BEA's measure of potential GDP, the latter computed as a trend. The second is based only on unemployment, using an unemployment rate of 5.5 percent as equivalent to a zero output gap and an Okun coefficient of 2.[10] The third and fourth measures use the average of unemployment and inflation. The third uses the deviation of the level of inflation from a 2.5 percent benchmark, while the fourth uses the change in inflation, with constant inflation as the potential output baseline. In both cases the inflation and unemployment terms have equal weight. Finally, the fifth measure uses only the change in inflation, assuming an "expectations-augmented" Phillips curve with a slope of 2 – that is, a one point change in the inflation rate corresponds to a level of output two points above or below potential. The third and fourth measures correspond to two alternative specifications of the Taylor Rule, while the last one corresponds to the definition of potential output used in most modern macroeconomic models.

What is most striking about Figure 7 is the close match between the different measures, despite their independent derivation. The very close fit between the first two measures is especially remarkable since they are derived from two entirely distinct observables, the deviation of output from trend and the deviation of the headline unemployment measure from 5.5 percent. The near-exact correspondence between them is testimony to the stability of the Okun relationship in the postwar US.[11] The inflation measures behave similarly to the output and unemployment based measures in some periods, but the fit is less exact. The level and change in inflation both remained low in the 1950s despite rapid output growth and low unemployment, the level of inflation remained high through the seventies through periods of low output growth and high unemployment, and the change in inflation remained relatively high (that is, non-negative) in the period since 2008, despite the steep fall in output and high unemployment. The latter two anomalies are

[10] In other words, each point of unemployment above or below the baseline corresponds to output 2 points above or below potential.

[11] While parameters vary, a stable relationship between unemployment and changes in output appears to exist in most other developed countries. (Reich, 2012)

straightforwardly explained by inertial inflation and downward stickiness of prices, respectively, but they complicate efforts to construct an inflation-based measure of the output gap. Still, overall, the evidence of Figure 7 is that alternative measures of the output gap tell similar stories, at least for the postwar U.S. So the use of the concept does not have to wait for a resolution of the question of what substantively, if anything, is meant by "potential". We know that macro policy is guided by targets for unemployment and inflation. And as it turns out, because of the stable relationships expressed in Okun's Law and the Phillips curve, the behavior of these targets closely follows the deviation of output from trend. So, both from the point of view of describing the choices faced by policymakers in the abstract, and the concrete behavior of policy historically, we can safely use the simplest measure of the output gap, the percent difference between current output and the BEA's trend-based measure of potential output.

2.2 Locating the Price Stability and Debt Stability Loci Historically

Given the data choices described above and a set of parameter values, it is possible to construct price stability and debt stability loci for concrete historical periods.

2.2.1 Choice of Parameter Values

For our choice of parameter values, we have tried to follow the macro models used in forecasting. We believe these choices are reasonable for the setting we are looking at. We should stress, however, that the validity of our larger analysis does not depend on these particular parameter values. On the contrary , part of the interest of our framework is precisely to provide another form of validation for alternative parameters in macro models. As discussed below, we believe that debates about macroeconomic theory could achieve greater clarity through explicit discussion of the concrete historical narratives implied by different choices of parameter. Our interest is in the logical relationship between a given set of parameters, the choices faced by policymakers, and the historical evolution of the macroeconomy. These logical relationships are the same regardless of the particular parameters chosen.

That said, the loci in the next section were computed based on the following parameter values:

Table 2: Parameter Values Used to Compute Historical Loci

		FRBUS	OECD	CBO
γ	**1.5**	1.2	1.4	1.0 to 2.5
η	**1.0**	0.6	1.1	-
τ	**0.5**	-	-	0.2 to 0.6*
inflation offset	**0.5**	1.0	-	-

* Estimate is for the multiplier on tax cuts for high-income households.

We have chosen these parameter values as follows:

γ**, the fiscal multiplier** is the change in the output gap resulting from a change in the primary balance equal to one percent of GDP. The impulse response functions reported in published forecasting models typically report lower values for the multiplier because they incorporate a positive response of interest rates to changes in the primary balance. Backing out these interest-rate responses to get an implied constant-interest multiplier yields the results shown in the table. Recent policy applications have also assumed multipliers in this range; for example, the incoming Obama administration analyzed the appropriate size of the ARRA stimulus bill on the assumption of a multiplier of 1.6.[12] (Romer and Bernstein, 2009) There is a broad consensus that, for relatively closed economies, fiscal multipliers will be 1.5 or greater when monetary policy is constrained by the zero lower bound. (Blanchard and Leigh, 2013) Insofar as the distinguishing feature of the zero lower bound is that monetary policy does not respond to the output gap, this seems like a safe value to use for the "pure" fiscal multiplier in general. Another context in which monetary policy is held constant in the face of changes in the fiscal position is when the central bank is committed to defending a fixed exchange rate. Estimates of the fiscal multiplier in advanced countries with fixed exchange rates also find average fiscal multipliers around 1.5. (Ilzetzki, Mendoza and Végh, 2013)

[12]Interestingly, the same estimate of a 1.6 fiscal multiplier was used in policy contexts in the 1970s. (Friedman, 1977)

η, **the semi-elasticity of output with respect to the interest rate** is the change in the output gap resulting from a one point change in the interest rate, adjusted for inflation. Despite the central role of interest rate adjustment in modern macroeconomic policy, estimates of this parameter are scarcer than estimates of the fiscal multiplier. But while it is not a focus of the scholarly literature, forecasting models do need to include such a parameter. Most such models assume a value somewhat lower than the fiscal multiplier, typically around one. For example, in addition to the two estimates in Table 2, Billi (2012) uses a value of 1.0 for the real-interest-rate elasticity of the output gap as the baseline calibration. Since the model there regards this parameter as reflecting the intertemporal substitutibility of consumption, it should not be taken too seriously outside of a formal new Keynesian framework. We mention it here only as an example of how our chosen parameter value is one regarded as reasonable by central bank economists.

τ, **the multiplier on interest payments** is the change in the output gap resulting from an increase in interest payments on government debt equal to one percent of GDP. We have not been able to locate any empirical estimates of this parameter, but there are good reasons to think that it is lower than the general fiscal multiplier. Following Baldani and Michl (1987), we treat interest payments as similar to upper-income tax cuts in their likely demand effects. This is certainly an overestimate for recent periods, given the small proportion of federal debt held by households, but may be more reasonable for the earlier postwar years in which significant amounts of federal debt were held directly by households. Today, less than 10 percent of Treasury debt is held directly by households, with another 10 percent or so held indirectly through mutual funds. Only interest payments on this fraction of the debt could plausibly contribute to aggregate demand. About half is held by units outside the United States, with the remainder held by state and local governments and financial institutions. Interest payments to these latter groups will not make any contribution to aggregate demand. So it would be reasonable to use a lower parameter value than 0.5, even zero. Nothing in our results depends on this; all that we need is that τ is significantly less than γ, which is undoubtedly the case.[13]

[13] Fullwiler (2006) suggests a much higher value of τ, perhaps high enough to entirely offset the contractionary effects of higher policy rates. This might be plausible for the

The inflation offset is the fraction of the average inflation rate over the period that we subtract from the nominal interest rate for purposes of determining its effect on the output gap. There are no published estimates for this parameter, presumably because of a strong theoretical commitment to the idea that only the "real," or net of inflation, interest rate matters for private spending decisions. We do not challenge this principle as applied to hypothetical long-term equilibrium situations in which inflation is fully anticipated. But it is inappropriate for historical analysis, where there is no reason to think that changes in the inflation rate were known in advance. Over a decade, it seems reasonable to think that expected inflation will track realized inflation partially, but not completely. For the postwar U.S., this is important for the 1970s and early 1980s. The empirical question of how interest rates are regarded by lenders and borrowers during periods of high inflation deserves further exploration.[14] But as a simple first approximation, we use a parameter value of 0.5.

To work in terms of a single interest rate, we must take into account that the policy interest rate, the rates facing the private sector, and the effective rate on public debt will not be the same. Since we want to relate our framework to concrete policy discussions, the interest rate on the vertical axis is the nominal policy rate – the Federal Funds rate, in the case of the United States.[15] The slope of the debt-stability locus then depends on the change in the rate on government debt resulting from a sustained one point change in the interest rate set by the central bank, as well as on the current debt-GDP ratio and the growth rate of nominal GDP. As discussed above, we assume that the rate faced by the government tracks sustained movements in the policy rate one for one, with the spread between them based on historical data. Private rates are less closely linked to the policy rate, but this is already taken into account in the choice of η.

immediate postwar period, but it is out of the question for the more recent period.

[14]The question is complicated by the fact that the dispersion of inflation expectations is also higher during episodes of high inflation, so that, in general, the two parties to a loan contract will not agree on the "real" interest rate on the loan. (Leijonhufvud, 1975)

[15]For the period before 1955, we use the rate on three month Treasury bills instead.

2.2.2 Price Stability and Debt Stability Loci in the United States, 1950 to 2013

The results of this analysis are reported in Figure 8. The seven panels of the figure show the price-stability (or full employment) and debt-stability loci for each calendar decade from the 1950s, and for the most recent ten-year period. The historical variables – debt level, income growth, inflation, and the observed output gap – are taken at their average values for the period. The parameters γ, η and τ are as described in Section 2. The questions answered by the loci are: Given the historical data and our chosen parameters, what combinations of policy interest rate and primary balance would have been required, on average, to keep output at potential during this period? And what combinations of policy interest rate and primary balance would, on average, have been required to keep the debt-GDP ratio constant? Shifts in the price-stability locus can be understood in Wicksellian terms as shifts in the "natural" interest rate – always recalling that changes in the government primary balance, and in any other component aggregate expenditure, will change the "natural" rate. In other words, in a world of big government, there is never a unique Wicksellian natural rate, but rather a schedule of natural rates depending on government spending (and on exports and other components of autonomous demand.)

What do we see in these graphs? First, we see the debt-stability locus become steeper from the 1950s through the 1970s. This reflects the fall in the debt-GDP ratio over this period: When the debt ratio is low, it is relatively insensitive to the interest rate and responds mostly to the primary balance. The debt-stability locus also shifts to the left during this period, reflecting higher inflation, which tends to reduce the debt ratio and so allows it to be stabilized with a smaller primary surplus– or a higher primary deficit, if the average interest rate on public debt falls below the nominal growth rate. (Note that the debt-stability locus always crosses the vertical axis at a value equal to the average nominal growth rate of income for that period less the difference between the interest rate on government debt and the policy rate.) These movements reverse from the 1980s. The downward shift of the debt-stability locus between the 1980s and the 2000s mainly reflects slower inflation, which meant that a lower interest rate and/or higher primary surplus were needed to hold the debt ratio constant; in part it also reflects the increase in the spread between the policy rate and the average borrowing rate faced by the federal government.

The price stability locus, on the other hand, remains relatively stable between from the 1950s through the 1980s. This apparent stability is somewhat misleading, since it does not reflect an underlying stability in demand conditions. Rather, it is due to the fact that the loci are drawn in the primary balance - policy rate space, with the policy rate of course being the nominal rate set directly by the monetary authority. As it happens, for the U.S. in these four decades, periods of high inflation roughly corresponded with periods of relatively weak private demand, with offsetting implications for the nominal rate. As a result, at the medium time scale we are concerned with here, the nominal policy rate consistent with full employment did not vary much until the 1990s. During the 1990s, however, private demand was strong enough to shift the price stability locus upward, despite a large trade deficit and low inflation, both of which would tend to shift the locus downward. Going by ten year periods, the high point for the price stability locus came in 1993-2002 (not shown). In the 2000s, the price stability locus began shifting downward rapidly, reaching its lowest point to date in the most recent decennium 2004-2013. Holding the primary balance constant, the average policy rate required to maintain full employment in 2004-2013 would have been fully 21 points lower than the policy rate required over 1993-2002.[16] Starting in 2001-2010 and continuing to the present, the intersection of two loci comes at a negative policy rate. This means with current levels of inflation, income growth, trade balance and private demand, it is impossible to achieve both a zero output gap and a constant debt-GDP ratio. Under the conditions of the past decade, and given a zero nominal policy rate, a primary deficit of about 5 percent of GDP would be needed to close the output gap. But holding the debt-GDP ratio constant would require a primary deficit of no more than one percent of GDP. To achieve both goals would require a policy rate of -4 percent. Or, to put it another way, under the conditions of the past decade, achieving both a zero output gap and a constant debt-GDP ratio using conventional policy tools would require inflation to be 4 points higher than its actual level.

[16] The slope of the price stability locus mainly depends on the ratio γ/η, while the height mainly depends on the level of private demand (including the trade balance), as discussed in the next section. Both the level and slope are also somewhat affected by the current debt ratio, but this is only important if τ – the multiplier on interest payments on the government debt – is large. With $\tau = 0.5$, as we have assumed, and at historical debt ratios, this effect is unimportant. Note that our chosen value for τ is probably too large rather than too high; zero would be reasonable.

This general conclusion is familiar in policy debates, and is used both variously as an argument for increased use of countercyclical fiscal policy, a higher target rate of inflation, and for new monetary policy instruments equivalent to a negative policy rate. An important advantage of the framework adopted in this paper is it allows for a more precise quantitative answer to these questions.

Table 3: Data by Decade for Historical Loci

Period	d	π	real g	nom. g	spread	z
1950 - 1959	0.55	2.1	3.6	5.7	0.9	3.5
1960 - 1969	0.36	2.3	4.2	6.5	0.5	4.6
1970 - 1979	0.25	7.1	2.3	9.4	0.3	-0.0
1980 - 1989	0.33	5.6	1.5	7.1	0.4	1.4
1990 - 1999	0.44	3.0	1.9	4.9	1.2	3.3
2000 - 2009	0.36	2.6	0.9	3.4	1.0	-1.5
2004 - 2013	0.50	2.4	0.8	3.2	1.0	-10.2

Sources: See text.
For each period, d is the average debt-output ratio, π is the average inflation rate, real and nominal g are the average growth rate of GDP, spread is the average difference between the policy rate and the 5-year treasury Bill rate, and z is the imputed average output gap with the primary deficit and the policy rate set to 0.

2.3 Implied Behavior of Private Demand

The final column of Table 3 shows decade by decade values of z, the implied output gap with the primary balance and interest rate both equal to zero. This term follows directly from the choice of parameter values – it is equal to the difference between the output gap predicted by Equation 2 with $z = 0$, and the output gap actually observed. It can be thought of as an indicator of the level of demand independent of policy. We should emphasize that this is not an estimate, but a calculation: Any assumptions about the parameters in a standard three-equation macro model imply a corresponding path for z, given the observed historical behavior of the output gap.[17]

[17]As we discuss in the final section of the paper, we believe that explicit historical estimates of z should be published as part of any macroeconomic forecasting model. This would show what kind of historical assumptions about economic behavior are consistent

This is important for two reasons. First, the ability to describe the trajectory of private demand historically is another advantage of the framework here, which explicitly makes the output gap jointly determined by the interest rate and the fiscal balance. Second, the plausibility of the implied trajectory is a valuable form of validation for parameter values, complementary to econometric tests. Parameter values that imply a path of historical demand that is inconsistent with our priors about the determinants of private spending historically should be rejected. Strangely, despite the fact that it is straightforward to calculate the value of z given the fiscal multiplier and interest elasticity (along with the observed historical values of the primary balance, interest rate and output gap), this is rarely if ever done in the scholarly literature.[18] Any macroeconomic model involves a joint hypothesis about functional form and parameter values and the particular pattern of "shocks" the system was subject to, but the conventions of modern economics encourage an exclusive focus on the former at the expense of the latter. In other words, our priors about the effects of changes in the policy instruments are informative about the historical behavior of private demand. And our priors about the behavior of private demand are informative about the effects of changes in the policy instruments. The implied behavior of z is worth examining from both points of view.

In Equation 2, the term z captures all factors affecting aggregate expenditure except for the fiscal position and the interest rate. In investigating the behavior of this variable historically, however, it is useful to separate out changes in the trade balance from changes in private expenditure. A trade surplus increases expenditure, independent of private spending and of fiscal and monetary policy, and a trade deficit similarly reduces expenditure. We call the calculated value of z less the trade surplus *residual private demand*. It indicates the level of private spending (including both consumption and investment, as well as state and local government spending) in the economy relative to income.[19] Figure 9 shows this residual private demand, along with the demand contributions from the trade balance, interest payments, the interest rate and the fiscal balance. Because we are interested in longer-

with the modeler's chosen parameter values.

[18]Private forecasters, by contrast, do sometimes perform exercises of this kind as a form of model validation.

[19]It would be a natural next step to separate state and local spending, and to distinguish between private consumption and investment.

term trends rather than year-to-year variation, the values in the figure are five-year moving averages for periods ending in the year given. So the first point corresponds to the period 1949-1953, and the last point corresponds to the period 2009-2013. The values are the contributions to the output gap from each source. So for instance, the red line is equal to the average policy interest rate for the period less the average inflation rate times the inflation offset, times η, the semi-elasticity of output with respect to the interest rate.

What we see here is that, for the period between 1949 and 1980, there was not much variation in the demand contributions from monetary and fiscal policy and from trade. Or more precisely, there was variation at high frequencies, but no sustained movements. Over this period the contribution of the primary balance gradually became more expansionary (especially after 1975) and the contributions of the interest rate and trade balance gradually became more contractionary. But it is clear that most sustained shifts in the output gap in this period resulted from private demand, and that at a five-year frequency these shifts were within a range of five percentage points of GDP. The post-1980 period, by contrast, has seen a large, though diminishing, contractionary shift in the contribution of interest rates; a steady contractionary shift in the contribution of the trade balance; and periods of both large positive and large negative contributions from the primary balance. At the same time, the shifts in residual private demand have become much larger, as much as 25 points between 1997-2001 and 2009-2013.[20]

Another noteworthy feature of the behavior of private demand in Figure 9 is the absence of any downward trend prior to the Great Recession. It is true that, by all the measures shown in Figure 7, demand was generally weaker (i.e. the demand gap was more negative) in the 1980s and 1990s than in the 1950s, 1960s and 1970s. But this apparent weakness is fully explained by the higher interest rates and negative trade balance of the later period, which were only partly offset by the shift toward primary deficits by the federal government. The conclusion that there is no downward trend in private expenditure is robust to alternative parameter values, mainly because the period from the second half of the 1990s through the first half of the 2000s

[20]The magnitude is different from the one reported in Section 8 because we are looking at five-year periods instead of ten, and because here we are separating out the demand from net exports. The two point decline in the trade deficit during the Great Recession period means that the fall in private demand must have been even greater than the fall in z.

saw such a positive output gap despite historically high levels of the trade deficit, primary balance and interest rates relative to inflation, all of which should have reduced expenditure. Even the early-mid 1980s, a period of large negative output gaps by almost any measure, does not appear to have had any weaker private demand than the previous decades. Low levels of output are fully accounted for by high interest rates in this period. (The shifts toward negative primary balance and negative trade balance largely offset each other.) This is relevant to recent discussions of "secular stagnation." (Teulings and Baldwin, 2014) For the US, at least, it appears that any long-run shift toward lower private expenditure relative to income is a phenomenon only of the post-2007 period.

The shifts in private demand reflected in Figure 9 are, of course, dependent on the choice of parameter values. But the figure as shown is consistent, in our view, with historical and descriptive evidence on the behavior of private demand. The peaks in the late 1960s and late 1990s, and the steep fall in the most recent period, are, in particular, consistent with the historical behavior of business investment. This is evidence for the plausibility of our chosen parameter values. Of course this is not dispositive; parameter choices still need to be justified based on the econometric literature and on theoretical grounds. But there is a stronger argument for rejecting parameter values that imply implausible historical trajectories. Most importantly, the fact that interest rates are generally low during periods of negative output gaps, and high during periods of positive output gaps, puts an upper limit on the plausible values of the interest sensitivity parameter. For example, if instead of $\eta = 1$, we were to use $\eta = 3$, that would imply a 30-point rise in private demand between 1976 and 1981, a 21-point fall in private demand between 1989 and 1992, and a 33-point fall between 2007 and 2009. Historical evidence, theory and general knowledge make shifts of these magnitude wildly implausible. So we can be confident that any usable macroeconomic model should not include an interest sensitivity parameter much greater than one. Put another way, the fact that the economy experiences cyclical changes in the output gap despite the countercyclical behavior of the policy interest rate, gives us important information about the maximum plausible strength of the effect of the policy rate on output.

Finally, the size of the shifts shown in Table 3 and Figure 9 should make us somewhat skeptical about the effectiveness of countercyclical policy of any kind. Under virtually any set of parameter values, the observed output gap cannot be explained without swings of private demand of 10, 15 or more points over just a few years.[21] This makes successful countercyclical policy look unachievable. Even if the instruments were adjusted perfectly, the required movements would be impractically large. The zero lower bound on the policy rate is just one instance of this larger problem.

The conclusion one is drawn to is that successful stabilization policy must address the sources of unstable private demand, and not merely seek to offset it with adjustments of the interest rate and/or government budget balance. Using our preferred parameters of $\gamma = 1.5$ and $\eta = 1$, maintaining output at full potential via conventional policy tools would have required the policy interest rate to fall by 25 points between the late 1990s and the late 2000s, or the federal budget deficit to rise by 18 percent of GDP. Both these implied adjustment are several times larger than anything found in developed countries outside of wartime; the interest rate adjustment would also require an inflation rate or a normal federal deficit at least 10 points higher than at present, to allow for sufficient space above the zero lower bound. We therefore suggest that the severity of the Great Recession, and the slow recoveries following the previous two recessions, cannot be attributed simply to a failure of policymakers to make correct choices about fiscal and monetary policy. Rather, the scale of recent shifts in private demand are too large for any realistic adjustment of conventional policy variables to offset.[22]

Interestingly, this was Keynes' view as well. Neither in *The General Theory* nor in his extensive writing on policy in the decade prior, or his more limited later writings, did Keynes unambiguously endorse the idea of countercyclical fiscal policy. On the contrary, he was skeptical about its effectiveness, and in particular did not believe that consumption spending would respond strongly

[21]Because the contributions of the policy variables are generally countercyclical, the behavior of residual private demand will appear most stable when small values are chosen for η and γ. But even setting both parameters to zero, there is still a ten-point fall in private demand between 2007 and 2009, a 7-point rise between 1995 and 2000, a 9-point rise between 1982 and 1986, and an 8-point fall between 1979 and 1982. Any positive parameter values will imply even larger shifts. And of course if one assumes that the values of the policy parameters are small, this leads to the same conclusion about the infeasibility of countercyclical policy.

[22]The question, "how much further would interest rates have had to fall to maintain full employment" seems like an obvious one, but it seldom is posed in the macroeconomic literature.

to short-run changes in public spending or taxes.[23] The prominence of this kind of policy in postwar "Keynesianism" is a product of later, mainly American, economists. (Mehrling, 2002, 2003) And Keynes was equally skeptical of the effectiveness of interest rate adjustments, at least if they were limited to the short end of the yield curve. (Hansen, 1955) Rather, he believed that the solution to cyclical instability was to shift responsibility for long-lived investment from profit-seeking private enterprises to semiprivate or quasipublic institutions analogous to today's nonprofit sector of universities, hospitals, etc. Because institutions of this kind would make investment decisions with the goal of developing their capacity to serve their particular social function, rather than by criteria of profit maximization, the desirability of a given investment project would depend less on inherently unstable forecasts of economic conditions in the distant future. (Crotty, 1995, 1999) The famous suggestion of the "euthanasia of the rentier" is usually interpreted as a response to the need to maintain investment spending in an environment where expected returns would be too low to satisfy private entrepreneurs (when it is not simply dismissed). But it also is a reaction to cyclical instability. In a world where production requires long-lived, specialized capital goods with substantial scale economies, production for profit requires entrepreneurs to make guesses about profitability many years in the future, something about which they inherently can have little confidence. Under these conditions, private spending will inevitably be highly unstable, especially given the social and psychological factors that cause expectations of the future to change in the same way simultaneously across the whole society.

[23]See for instance his skepticism about James Meade's 1943 proposal to stabilize output after the war via countercyclical adjustment of tax rates:

> People have established standards of life. Nothing will upset them more than to be subject to pressure constantly to vary them up and down. A remission of taxation on which people could only rely for a ... short period might have very limited effects in stimulating their consumption. And, if it was successful, it would be extraordinarily difficult from the political angle to reimpose the taxation again when employment improved. (quoted in Crotty, 1995)

2.4 A Role for Endogenous Policy Cycles in Recent Macroeconomic History?

Analysis of macroeconomic policy typically focuses on optimal policy rules. The concrete conduct of policy is less often an object of analysis.[24] But a natural extension of the analysis in the previous sections is to ask, has the interaction between policy instruments played a part in macroeconomic instability historically?

The logic is straightforward. Under the policy orthodoxy of the postwar period, the policy interest rate (or equivalent instrument) has been used to target output, while the federal budget position has been adjusted to target debt stability. These rules were, of course, suspended during World War II, and were contested to some extent into the 1970s. But since 1980 or so, this "sound finance" instrument assignment has been held to fairly strictly. Indeed, the delegation of responsibility for output stabilization exclusively to the central bank has been seen as a major step forward in macroeconomic policy, a "glorious counterrevolution" that is "directly responsible ... for the virtual disappearance of the business cycle." (Romer, 2007)

Under this assignment, we would expect to see the policy instruments follow clockwise cycles as in Figure 3. An increase in the interest rate will tend to increase the debt ratio at a given primary balance, requiring the budget authorities to shift the primary balance toward surplus. A surplus will tend to reduce demand, leading the monetary authorities to reduce interest rates. Lower interest rates will imply slower growth of the debt ratio, allowing the fiscal authorities to shift the budget back toward deficit. And so on. The scale and duration of these cycles will depend on the speed with which aggregate expenditure responds to the policy variables, the speed with which the effective interest rate facing the government responds to the policy interest rate, and the speed with which each instrument responds to deviations in its target, as well as the scale and frequency of exogenous shifts in aggregate expenditure. In Section 1.3, we suggested that for plausible parameter values,

[24] The obvious exception is the public choice literature, and the related idea of time-inconsistency of policy, as well as the broader but less explicitly theorized presumption that macroeconomic policy in democratic polities suffers from a bias toward deficits and inflation. (Portes and Wren-Lewis, 2014). For a critical assessment of time-inconsistency arguments about macroeconomic policy, see Bibow (2004).

these cycles may even amplify rather than dampen over time – that is, there may not be convergence, especially under the sound finance rule when the debt-GDP ratio is already high. It's important not to put too much weight on the formal convergence results, though. Even if policy cycles are dampened, they still represent an independent source of macroeconomic instability, since any initial shift in demand will produce "echoes" as the policy variables spiral back toward equilibrium. In principle, some large fraction of business cycles could be explained in terms of endogenous interaction between policy instruments, rather than exogenous "shocks".

The view that business cycles are largely produced by stabilization policy is most commonly associated with Milton Friedman and more recent monetarists. The monetarist story involves only a single policy instrument, with cycles being the result of lags. (Friedman, 1960) An account of destabilizing interaction between monetary and fiscal policy closer in spirit to the one proposed here, is found in Woodford (2001). Woodford, like us, argues there that the question of what monetary policy rule is the best route to price stabilization cannot be separated from what fiscal rule is followed by the budget authorities. Similarly, any target for the public debt cannot be reduced to a budget rule, but depends on the policy followed by the monetary authorities. As Woodford observes, this interdependence between the policy instruments is rejected by today's macroeconomic orthodoxy: "It is now widely accepted that the choice of monetary policy to achieve a target path of inflation can ..., and ought, to be separated from ... the choice of fiscal policy." Most macroeconomists think that monetary policy is irrelevant for the debt-GDP ratio, he says,

> because seignorage revenues are such a small fraction of total government revenues. ... [This] neglects a more important channel ... the effects of monetary policy upon the real value of outstanding government debt, through its effects on the price level and upon the real debt service required, ... insofar as monetary policy can affect real as well as nominal rates.

Similarly, "fiscal policy is thought to be unimportant for inflation? [because] inflation is a purely monetary phenomenon," or else because "insofar as consumers have rational expectations, fiscal policy should have no effect on aggregate demand." But this is not correct, Woodford argues: Even if people are individually rational, the economy as a whole can be "non-Ricardian" in the sense that changes in government spending will not be offset one for one by changes in private spending. "This happens essentially through the effects of fiscal disturbances upon private sector budget constraints and hence on aggregate demand." For this reason, "A central bank charged with maintaining price stability cannot be indifferent as to how fiscal policy is set."

While Woodford's article is one of the few we are aware of to directly address the interdependence between fiscal and monetary policy, the specifics of his argument are very different from ours. In particular, he remains committed to a basically monetarist account of inflation, via a fiscal theory of the price level. What is relevant for our purposes is that he explicitly considers the ways in which a failure to take this interdependence into account, can lead to destabilizing interactions between the policy instruments.

We suggest that this is more than a theoretical possibility. In particular, we suggest that the evolution of output and the federal budget position over the last 40 years can be understood as a long "policy cycle" of the kind analyzed in Section 1.3. The story we suggest is this:

In the immediate postwar period, the United States was effectively operating under a functional finance instrument assignment, with interest rates set to stabilize the federal debt and fiscal policy playing the central role in keeping output at potential. Over the next 25 years, the assignment of instruments was gradually switched, with interest rates moving to target mainly output in the 1950s, and fiscal policy coming to target government debt by the end of the 1970s. At this time, the debt ratio was stable but output was above the level consistent with price stability (in the eye of policymakers), so the application of the sound finance rule implied a large upward movement in interest rates.[25] Higher interest rates brought output to its desired level, but increased government interest payments, moving the economy off the debt-stability locus to a path of rising debt. Fiscal policy eventually responded to this monetary policy-induced rise in federal borrowing as the sound finance rule requires, by shifting the primary balance toward surplus. Large surpluses reduced aggregate demand, as became evident in the early 2000s, when interest rates were reduced to then-unprecedented levels in order to bring output up to potential. Low interest rates opened up space for the move toward primary deficits under Bush, which might have carried the cy-

[25]This is intended as an alternative way of describing, rather than an alternative explanation for, the Volcker shock.

cle back toward its starting point if it had not been cut short by the collision of the interest rate instrument with the zero lower bound.

In this context, it is important to realize that the majority of the rise in federal debt during the 1980s was due to higher interest rates, not to the tax and expenditure decisions of the Reagan administration. Between 1949 and 1981, the overall federal budget deficit averaged 1.1 percent of GDP and interest on the federal debt averaged 1.7 percent of GDP. (In other words, there was, on average, a primary surplus of 0.6 percent of GDP.) Between 1982 and 1990, the overall federal deficit averaged 4.0 percent of GDP, and interest payments on the federal debt averaged 3.7 percent of GDP, implying a primary deficit of 0.3 percent of GDP. In other words, while the overall deficit during the Reagan years was about three points higher than the deficit during the preceding three decades, the primary deficit was only about one point higher. So two-thirds of the increase in federal borrowing under the Reagan Administration was due to higher interest costs, not to the (genuine) shift toward primary deficits.

These movements are illustrated in Figure 10, which shows 5-year moving averages of the inflation-adjusted policy rate and the primary balance from 1971to 2013. The figure shows a clear counterclockwise movement, as predicted for policy interactions under a sound finance rule.

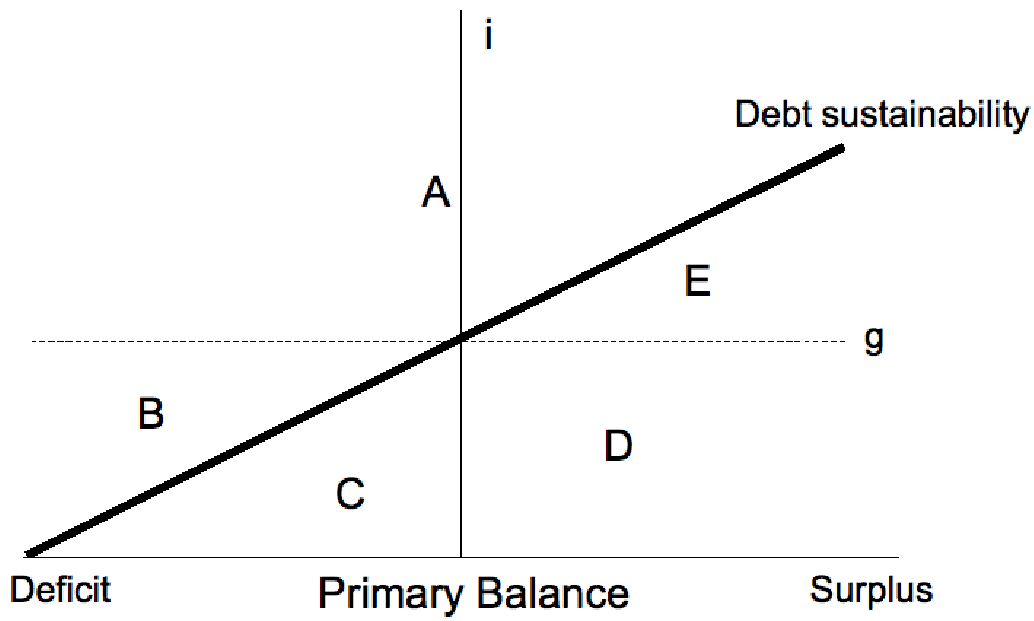
Conclusions

The starting point of this paper is a simple observation: both the output gap and the trajectory of public debt-output ratio are jointly determined by both the fiscal balance and the interest rate set by the monetary authority. So both targets and both instruments should be analyzed within a single framework – rather than, as is more often the case, discussing the stabilization of output through monetary policy and the stabilization of public debt ratios through appropriate budget rules as if they were two independent questions. It follows that there is no such thing as a Wicksellian natural interest rate, but at best a schedule of such rates, one for each value of the primary balance. And similarly, we cannot specify a budget rule consistent with a stable debt-GDP ratio unless we also describe the behavior of (policy-determined) interest rates. In this perspective, the familiar distinction between an orthodox "sound finance" instrument assignment and the alternative "functional finance" assignment takes on a different appearance. The case for functional finance does not depend on arguments about the economic costs, or lack thereof, of changes in the debt-GDP ratio, since that ratio can in general be held constant under either rule. If both policy instruments can be set instantly to their optimal values, then the two rules are in general equivalent. If the instruments are adjusted incrementally in response to deviations of the targets from their desired values, then the rules are distinguished by the different adjustment paths they follow. We show that while both policy rules converge at low debt-GDP ratios, only the functional finance rule converges at high debt ratios. Thus, counterintuitively, the case for countercyclical fiscal policy becomes stronger, not weaker, when public debt ratios are already high.

In the second part of the paper, we apply this framework to historical data for the postwar United States. Using parameters consistent with those used in major forecasting models, we derive price-stability and debt-stability loci by decade. This is a device we hope might be adopted more widely in macroeconomic policy discussions and in macroeconomics pedagogy. Next, we use the same parameter values to compute the implied behavior of private demand over the period since World War II. We draw two main conclusions from the results. First, for the US at least, it is not clear that there is any secular downward trend in aggregate demand prior to 2008. Second, the fluctuations in private demand – especially but not only over the past 10 years – appear to be too large to offset with any plausible countercyclical policy, either fiscal or monetary. Stabilizing output and employment, it appears, requires addressing the underlying sources of instability in private expenditure. This second conclusion suggests a broader methodological point. Macroeconomics conventionally divides phenomena into some that are modeled and others that are treated as "shocks." But no such distinction exists in reality. The sources of "exogenous" disturbances should be much part of the subject of economics as the adjustments to them. Finally, we ask whether medium-term fluctuations can be explained, at least in part, by interactions between the two policy instruments. We tentatively suggest that the macroeconomic history of the past 40 years can be understood in these terms. Monetary tightening in response to inflation causes the debt ratio to increase, inducing (with a lag) a shift toward primary surpluses. The contractionary effects of surpluses lead the monetary authority to lower interest rates, which reduces debt service costs for the government, contributing to the fall in the debt ratio. Falling debt ratios encourage an increase in public spending, boosting demand until the monetary authority tightens again. And so on, at least potentially – only one full cycle is visible in the record. This is the result of each instrument being adjusted only in response to one of the targets, even though both instruments affect both; the result is cycles in policy space, with destabilizing economic effects. So perhaps shocks are not so important after all.

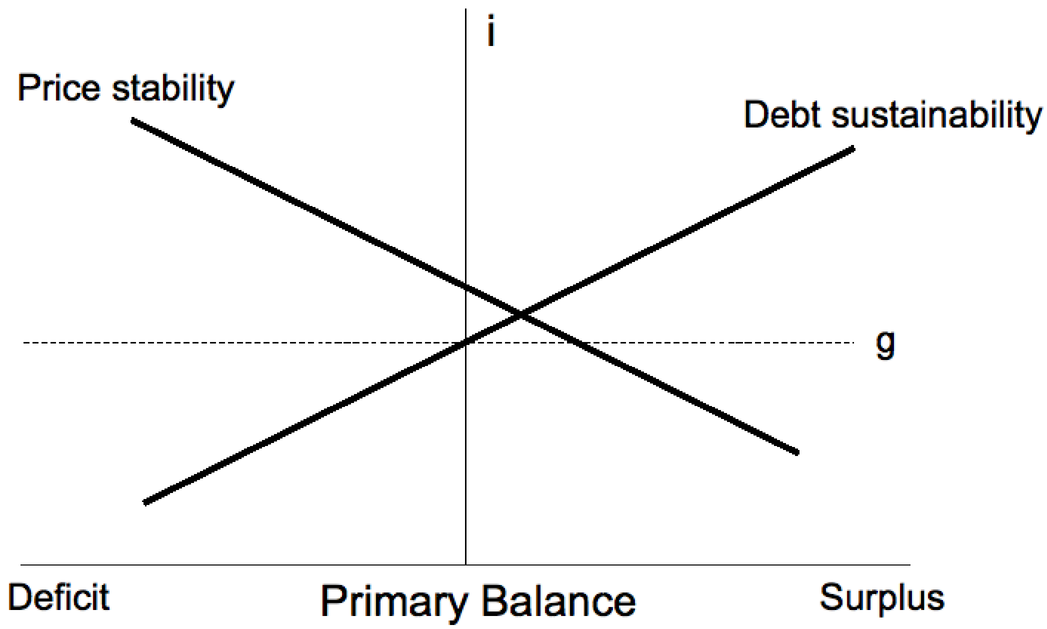
The framework offered here is limited in some important respects. Most obviously, we take no view on why, or whether, a stable debt-GDP ratio should be a target of policy. We simply accept this as a premise, on the grounds that it is, for the moment at least, a presupposition of most policy discussions, and evidently shapes the choices of policymakers. We also ignore the effects of changes in output and inflation on the debt-GDP ratio, though these have been important historically. And we ignore open-economy complications. For the US, this is probably not a serious limitation, but for most other countries it is unclear whether the analysis here would be meaningful, at least as applied to concrete historical developments, without considering the balance of payments and exchange rate fluctuations. Clearly this dimension cannot be ignored when a significant fraction of public debt is financed in a foreign currency. In a somewhat different direction, this paper invites, but does not attempt to answer, a political economy question: If the sound finance and functional finance rules are formally equivalent, why is there such a strong commitment – among both policymakers and the economics profession – to the idea that the fiscal balance instrument must be assigned to the debt ratio and the interest rate instrument to the output gap? Answering this question might be an important step in understanding the ideological constraints on macroeconomic policymaking, which may in the end be more important than the economic constraints explored here.

Figure 1: Alternative Debt Sustainability Conditions



The line label debt sustainability indicates those combinations of interest rates and fiscal balances for which the debt to GDP ratio is constant. It passes through the vertical axis at $i = g$ and has a slope of $\frac{1+g}{d}$. In area A, above the locus with $i > g$, the debt-GDP ratio rises to infinity. In area B, above the locus but with $i < g$, the debt-GDP ratio rises toward some finite value. In area C, below the locus with a primary deficit, the debt-GDP ratio falls to some finite value. In area D, below the locus with a primary surplus and with $i < g$, the debt-GDP ratio falls to zero and the government then acquires a positive net asset position which rises to some finite fraction of GDP. Finally, in area E, below the locus with a primary surplus and $i > g$, the debt-GDP ratio falls to zero and the government then acquires a positive net asset position which rises without limit as a fraction of GDP.

Figure 2: Price Stability and Debt Sustainability Conditions



The line labeled price stability indicates those combinations of interest rates and fiscal balances for which $Y = Y^*$. It passes through the vertical axis at $i = \frac{1}{\eta}Z$ and has a slope of $\frac{\gamma}{\eta}$. The line label debt sustainability indicates those combinations of interest rates and fiscal balances for which the debt to GDP ratio is constant. It passes through the vertical axis at $i = g$ and has a slope of $\frac{1+g}{d}$. The "sound finance" instrument assignment implies that interest rates are adjusted towed the price stability locus and the fiscal balance is adjusted toward the debt sustainability locus; out of equilibrium, this implies movement in a clockwise direction. The "functional finance" instrument assignment implies that interest rates are adjusted toward the debt sustainability locus and the fiscal balance is adjusted toward the price stability locus; out of equilibrium, this implies movement in a counterclockwise direction.

Figure 3: Convergence using Sound Finance Rule

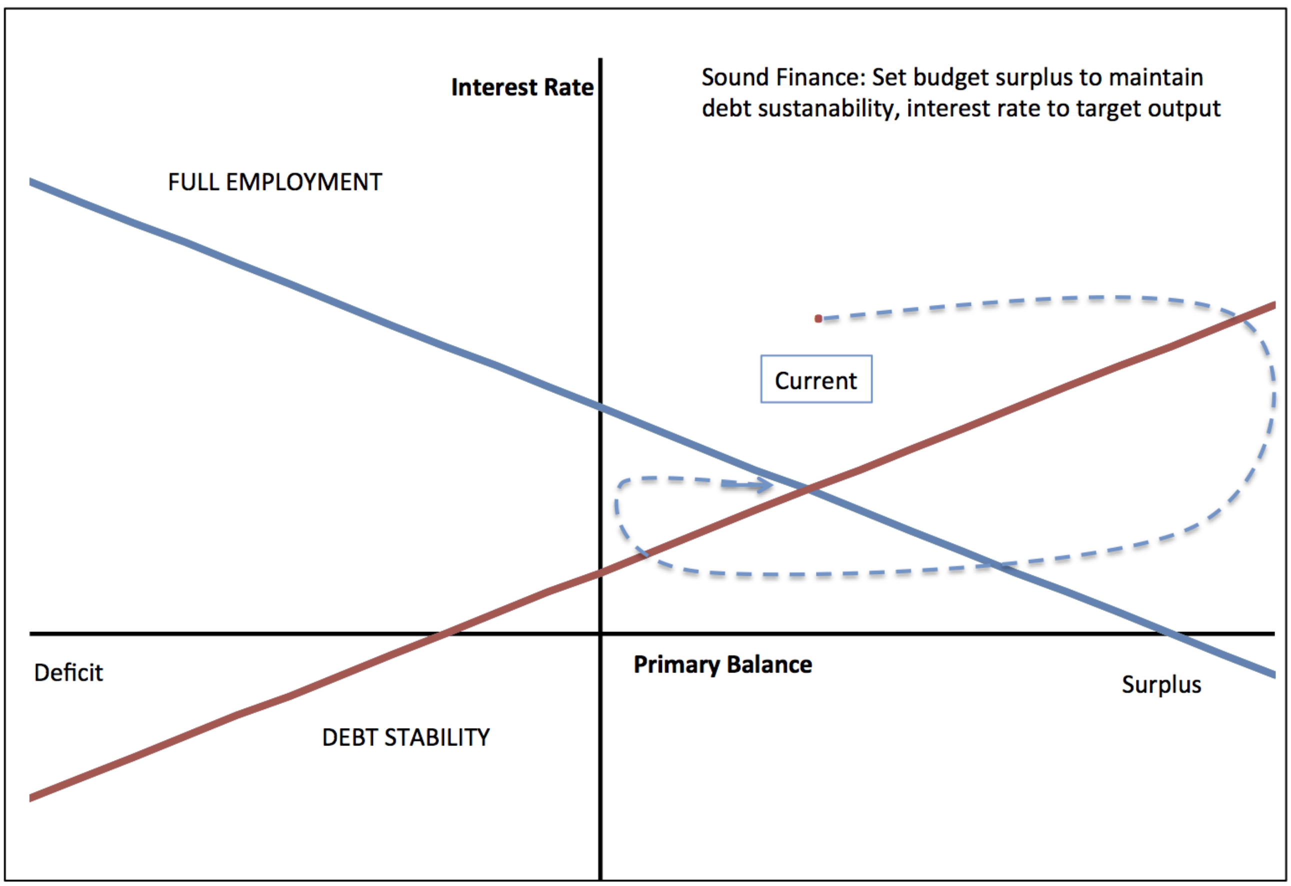


Figure 4: Convergence using Functional Finance Rule

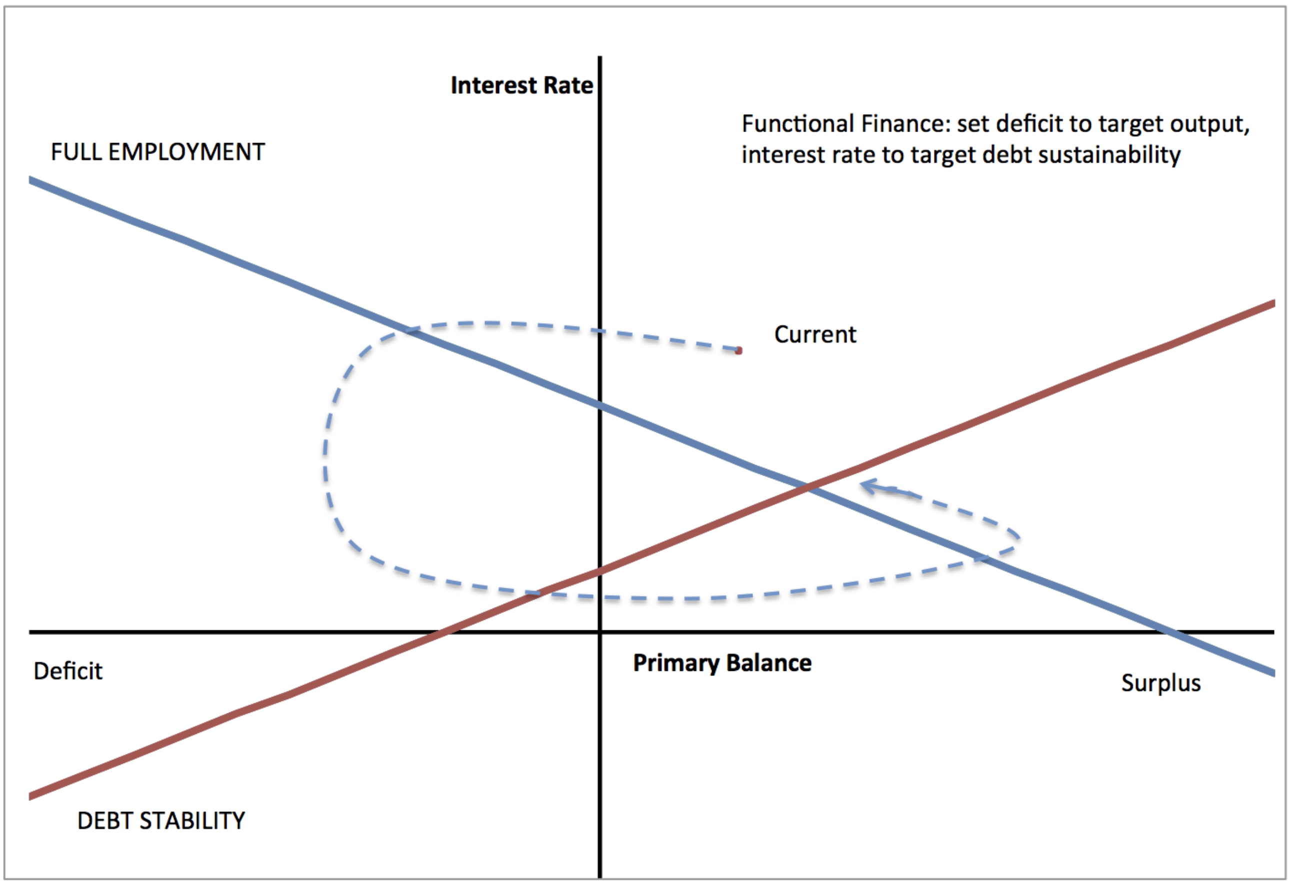


Figure 5: Regions of Stability and Instability using the Sound Finance assignment

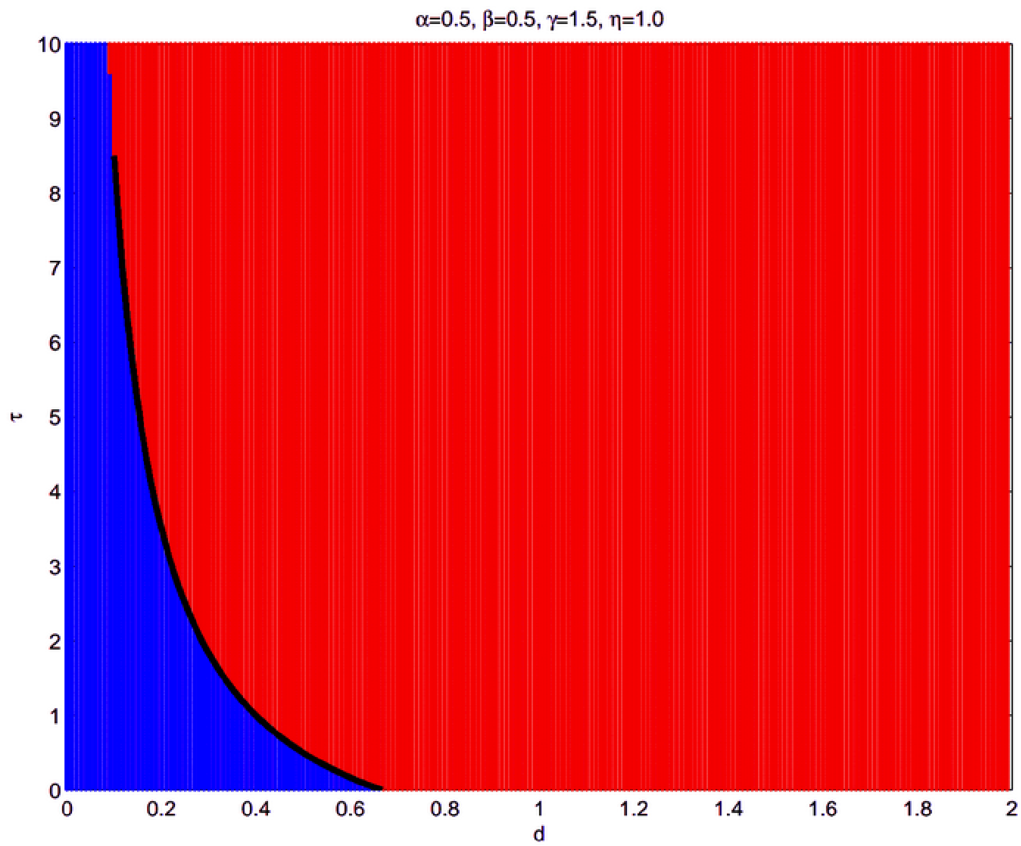
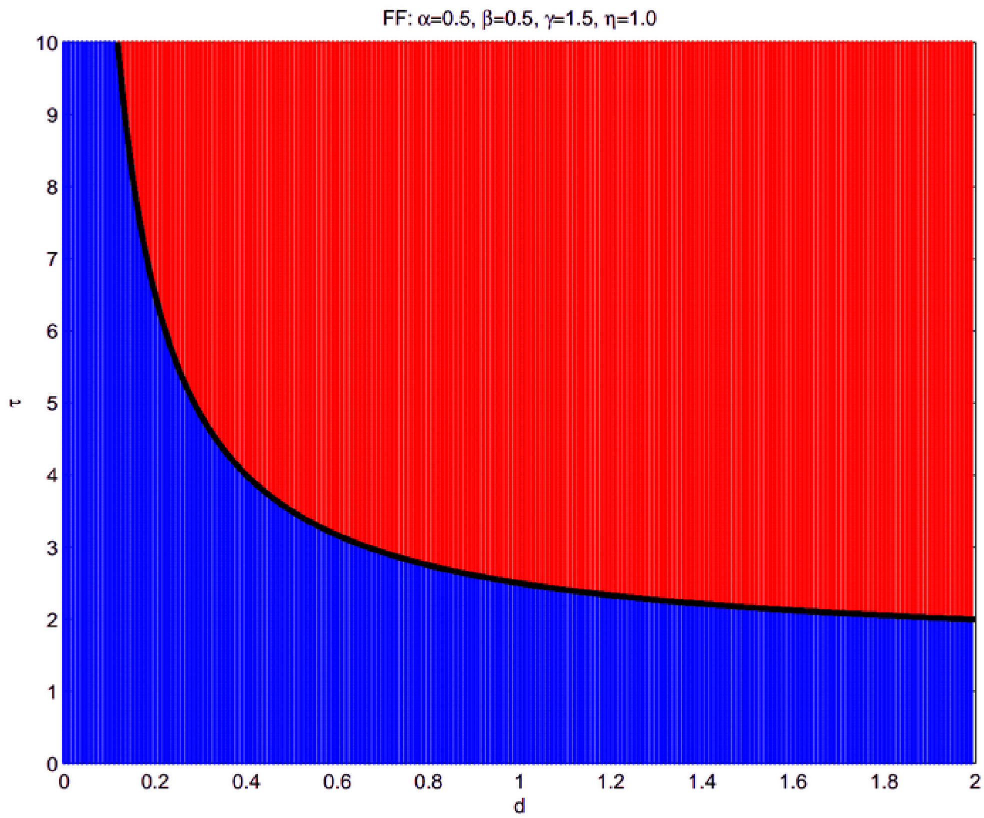


Figure 6: Regions of Stability and Instability using the Functional Finance assignment



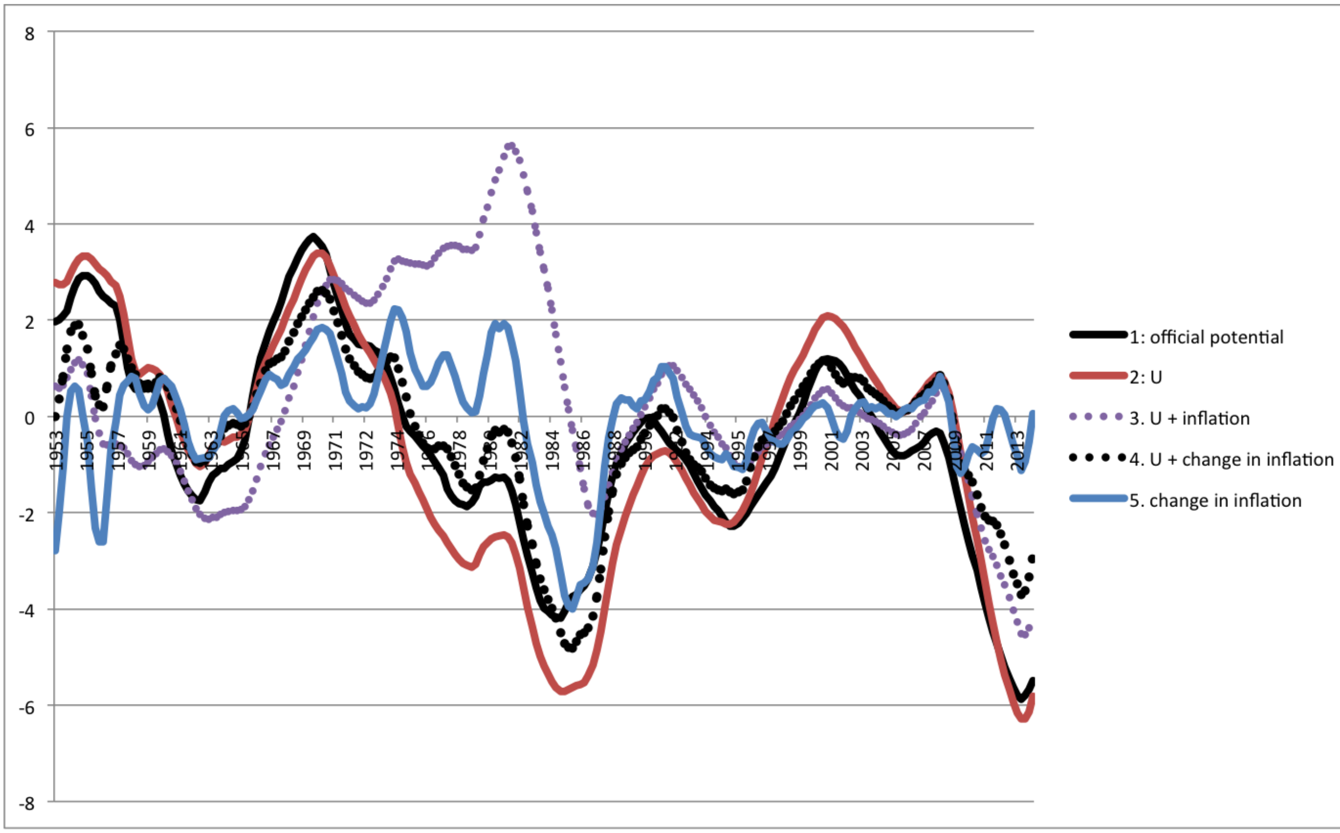
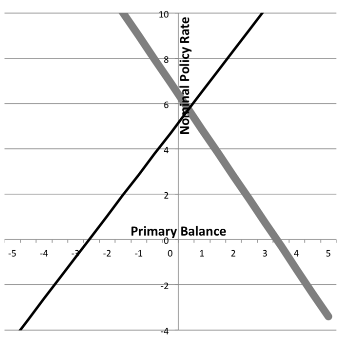
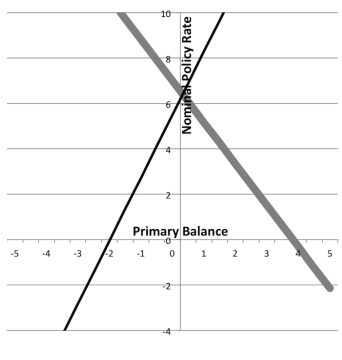


Figure 7: Alternative Measures of the Output Gap

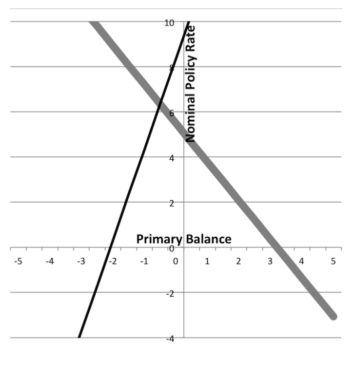
Figure 8: Price Stability and Debt Stability Loci Based on US Historical Data, by Decade



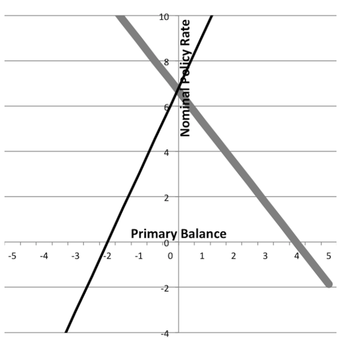
(a) 1950-1959



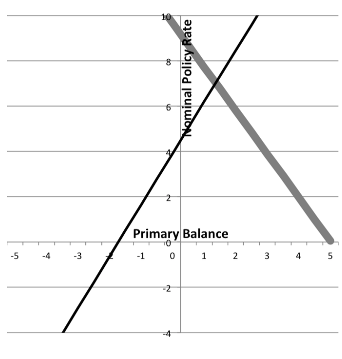
(b) 1960-1969



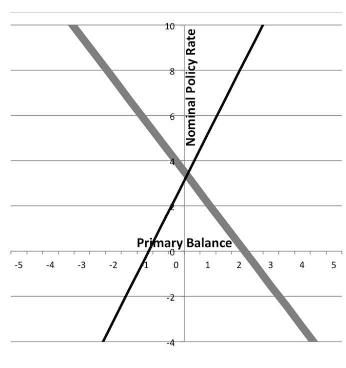
(c) 1970-1979



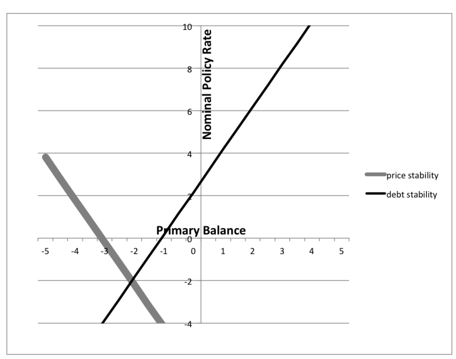
(d) 1980-1989



(e) 1990-1999



(f) 2000-2009



(g) 2004-2013

Sources: See text.

Figure 9: Estimated Contributions to Demand, 5-year Moving Averages

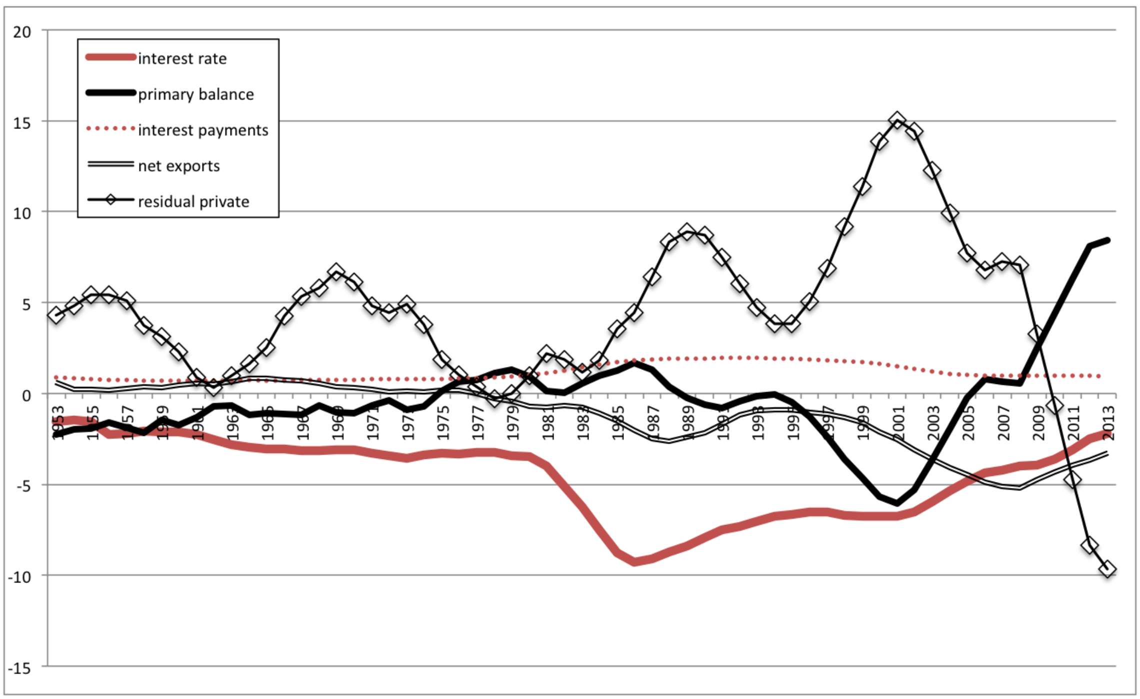
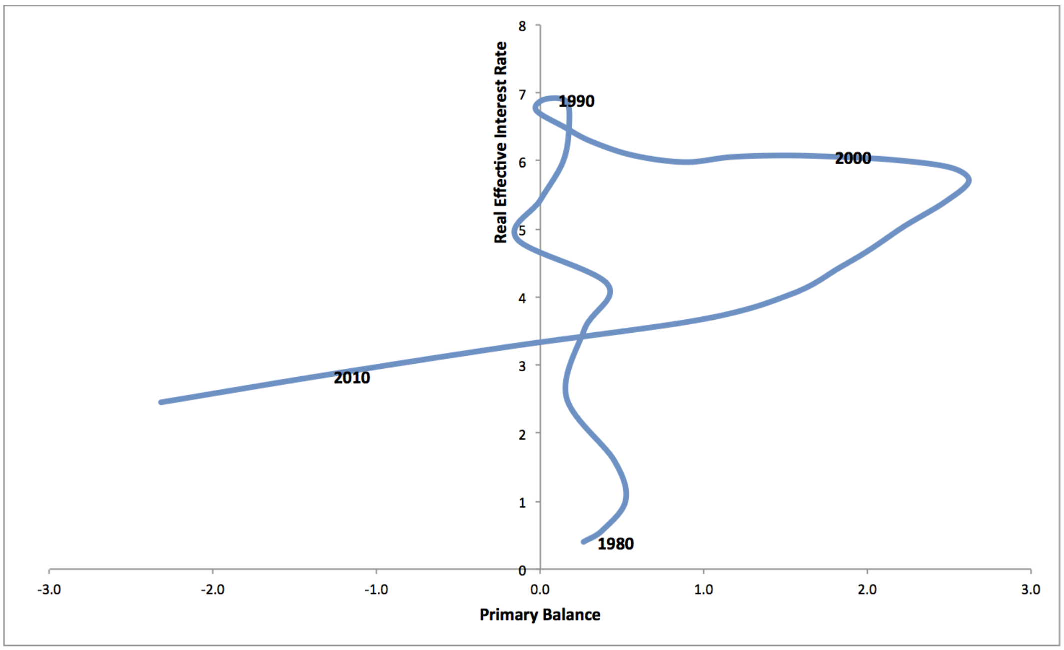


Figure 10: Price Stability and Debt Sustainability Conditions



The figure shows rolling 10-year averages for the primary balance and the inflation-adjusted effective interest rate on public debt. The labels show the ending date, so the starting point represents average values for 1971-1980 while the ending point, on the left, shows the average values for the period 2005-2014. The trajectory is approximately a clockwise spiral, similar to what we suggest might be expected given destabilizing feedback between policy instruments under a "sound finance" policy rule.

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