IS THE PRICE LEVEL DETERMINED BY THE NEEDS OF FISCAL SOLVENCY?*

by

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ABSTRACT

The fiscal theory of price determination suggests that if primary surpluses evolve independently of government debt, the equilibrium price level "jumps" to assure fiscal solvency. In this *Non-Ricardian* regime, fiscal policy – not monetary policy – provides the nominal anchor. Alternatively, in a *Ricardian* regime, primary surpluses are expected to respond to debt in a way that assures fiscal solvency, and the price level is determined in conventional ways. This paper argues that Ricardian regimes are as theoretically plausible as Non-Ricardian regimes, and provide a more plausible interpretation of certain aspects of the post war US data than do Non-Ricardian regimes.

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John Cochrane, Christopher Sims, and Michael Woodford have recently emphasized the role of fiscal policy in price determination.[1] Their work demonstrates that the way in which the government's present value budget constraint is satisfied affects how prices are determined. If primary surpluses move automatically to assure fiscal solvency for any path the price level might take, prices are determined in a conventional way, say by money supply and demand. Following Woodford (1995), we call this a *Ricardian* (R) fiscal regime. If, on the other hand, primary surpluses follow an arbitrary process, then the equilibrium path of prices is determined by the requirement of fiscal solvency; that is, the price level has to "jump" to satisfy a present value budget constraint. Again, following Woodford (1995), we call this a *Non-Ricardian* (NR) regime.[2] The basic distinction between the two regimes is whether monetary policy or fiscal policy provides the nominal anchor for the economy. In NR regimes, fiscal policy becomes the nominal anchor, while in R regimes monetary policy has to play that role.[3]

Woodford (1995) emphasizes NR regimes, suggesting at one point that "it should be evident that Ricardian regimes represent a highly special case." The conventional wisdom is however that monetary policy provides the nominal anchor, and most of the empirical models developed at policy making institutions are solved under that assumption. Following Paul Masson (1987), endogenizing tax policy seems to be the favored way of assuring an R regime in this class of policy models.[4]

It is crucial in many modeling efforts to make the right choice of fiscal regime. Consider first the theoretical (or methodological) issues that are at stake. It is well known that the choice of regime may limit the way in which monetary policy can be modeled. For example, Woodford (1995) shows that the price level is not pinned down if the central bank tries to peg the interest rate in an R regime, but that it would be uniquely determined in an NR regime.[5] In addition, the choice of regime affects the way in which fixed exchange rate systems can be modeled. Matthew Canzoneri, Robert Cumby and Behzad Diba (1997a) show that monetary policy alone can not peg the exchange rate in an NR regime. To keep the exchange rate fixed, fiscal policy needs the discipline of an R regime.

Consider next the policy issues that are at stake. The reduced form for the price level depends in an important way on which regime is in place. In R regimes, the demand for liquidity, and the way it evolves over time, matters for price determination. In NR regimes, we will see that it is just the total supply of outside assets (base money plus government bonds) that matters. Moreover, in NR regimes, monetary policy has to work through seigniorage, and the government's budget constraint, if it is to control the price level; in R regimes, monetary policy works through more familiar channels. Canzoneri and Diba's (1998) numerical calculations suggest that the central banks of OECD countries would lose control of their price levels in an NR regime, since seigniorage is a small part of total revenue in those countries. It is probably not reasonable to hold a central bank accountable for price stability in an NR regime, and this is one interpretation of the concern central banks have about the constraints placed upon them by loose fiscal policies.[6] If this interpretation of their concern is correct, then policy simulations should be based upon the assumption of an NR regime, which is not the usual practice.

All of this suggests that the modeler's choice of regime does not fall under the heading of "innocent assumptions". The choice should not be made lightly. But which assumption is right?

In this paper, we approach the question in two ways. The proponents of the new theory of price determination focus much of their attention on NR regimes. This is understandable since NR regimes are the new element here; they tend to yield unconventional results for monetary policy and price determination, while R regimes embody the conventional macroeconomic wisdom. (Indeed, an important contribution of this new literature is to focus attention on an assumption about fiscal policy that is implicit – and sometimes ignored – in the conventional wisdom.) But this focus on NR regimes can give the (perhaps unintended) impression that they are somehow the natural choice to make, and that R regimes are a very special case. So, the first thing we do is present the theory in a way that dispels this impression. We do this by showing that a wide class of fiscal policy rules leads to R regimes. These rules have the common feature that primary surpluses respond to the level of government liabilities. They can be demanding, or they can be very lax; there is, for example, considerable latitude for both counter cyclical policy and political noise.

Having established the theoretical plausibility of R regimes, we proceed to an assessment of their empirical plausibility. It is more difficult than one might think to develop testable restrictions on the data that would allow us to distinguish between the two regimes. For example, Figure 1 suggests that primary surpluses have responded positively to government liabilities in the United States over the last forty five years. One might take this as prima facie evidence of a fiscal policy rule that would have led to an R regime. However, it turns out that there should also be a positive relationship between surpluses and liabilities in an NR regime, with the direction of causality going the other way. In NR regimes, the liabilities to GDP ratio responds to the expected value of present and future surpluses.[7]

More generally, it is quite difficult (and perhaps impossible) to develop formal tests that discriminate between R and NR regimes, since (as Cochrane (1998) points out) both regimes use exactly the same equations to explain a given data set. Our approach here focuses on a set of impulse response functions involving the primary surplus and total government liabilities (both as ratios to GDP), and the plausibility of the interpretations given to them by the two regimes. Using post war data for the United States, we find that a positive innovation in the surplus decreases liabilities for several periods and increases future surpluses. R regimes offer a very straightforward interpretation of these results: surpluses pay off debt in those regimes. NR regimes offer a rather convoluted explanation that requires the correlation between today's surplus innovation and future surpluses to eventually turn negative. We will argue that this correlation structure seems rather implausible in the context of an NR regime, where surpluses are governed by an exogenous political process.

The rest of the paper is organized as follows: In section I, we review the new theory of price determination, and we illustrate the breadth of the class of fiscal policies that result in R regimes. In section II, we use VAR methods to determine how future surpluses and liabilities (normalized on GDP) respond to shocks in the surplus. Then, we argue that R regimes provide a more plausible explanation of these responses than do NR regimes. In section III, we report several extensions of our empirical work – exploring the role of interest rates and nominal GDP – and we discuss the robustness of our findings in various subsamples. In section IV, we summarize our conclusions, discuss caveats about our findings, and suggest directions for future research.

I. THE THEORETICAL PLAUSIBILITY OF RICARDIAN REGIMES

We begin this section with a review of the theory of price determination that was developed by Leonardo Auernheimer and Benjamin Contreras (1990), Eric Leeper (1991), Woodford (1994, 1995) and Sims (1994, 1995). Once the basic theory is laid out, we present a proposition that illustrates the breadth of the class of fiscal policy rules that lead to R regimes. Finally, we discuss some implications of the theory that will be of use in Section II.

A. Basic ingredients of the fiscal theory of price determination

The theory of price determination revolves around the way in which the government's present value budget constraint gets satisfied. The reduced form for the price level will of course depend upon the way in which the rest of the economy is modeled, and that has been done in a variety of ways.[8] However, the defining features of R and NR regimes can be explained in terms of the budget constraint alone. The theory is, in this sense, quite general.

In nominal terms, the government's budget constraint for period j can be written as

(1) $B_j = (T_j - G_j) + (M_{j+1} - M_j) + B_{j+1}/(1 + i_j),$

where M_j and B_j are the stocks of base money and government debt at the beginning of period j, T_j - G_j is the primary surplus during period j, and i_j is the interest rate for period j. The constraint says that the existing debt has to be paid off, monetized or refinanced. It should be emphasized that we are assuming the government issues nominal liabilities (M and B); while the nominal values of these liabilities are fixed at the beginning of the period, their real values depend on the price level. We will see the importance of this assumption shortly.

We want to express the budget constraint in terms of total government liabilities, M + B, and scale the fiscal variables on GDP. This facilitates policy discussions and the empirical applications that follow. After some algebra, the budget constraint becomes

$$(2)\quad \frac{M_j + B_j}{P_j y_j} = \left[\frac{T_j - G_j}{P_j y_j} + \left(\frac{M_{j+1}}{P_j y_j} \right) \left(\frac{i_j}{1 + i_j} \right) \right] + \left(\frac{y_{j+1}/y_j}{(1 + i_j)(P_j/P_{j+1})} \right) \left(\frac{M_{j+1} + B_{j+1}}{P_{j+1} y_{j+1}} \right).$$

(2) says that the ratio of total government liabilities to GDP has to be equal to the primary surplus (including central bank transfers) to GDP ratio plus the discounted value of next period's liabilities to GDP ratio; the discount factor is the ratio of the real growth in GDP to the real interest rate. Finally, we want to simplify our notation by replacing (2) with

$$(3)\quad w_j = s_j + \alpha_j w_{j+1}.$$

w_j is the liabilities to GDP ratio, s_j is the surplus to GDP ratio, and α_j is the discount factor. It should be kept in mind that s_j includes central bank transfers (or seigniorage).

We will follow Woodford's (1995) development of the theory and focus on the government's present value budget constraint.[9] Iterating equation (3) forward from the current period, t, and taking expectations conditional on information available in period t, we obtain the present value constraint

$$(4)\quad w_t = s_t + E_t \sum_{j=t+1}^{+\infty} \left(\prod_{k=t}^{j-1} \alpha_k \right) s_j \quad \Leftrightarrow \quad \lim_{T \to +\infty} E_t \left(\prod_{k=t}^{T+t-1} \alpha_k \right) w_{t+T} = 0.$$

The two expressions in (4) are equivalent ways of writing the constraint.

Following James Hamilton and Marjorie Flavin (1986), a growing literature has tried to test one or the other of these constraints empirically; this literature interprets the results as a test of government solvency.[10] By contrast, the new theory of price determination treats (4) as an equilibrium condition that must be satisfied.[11] In our empirical application, it is part of the maintained hypothesis. The fundamental question here is: how does (4) get satisfied, and therefore how do we solve the model?

There are a number of possibilities. For example, there may be an endogenous fiscal policy that makes the sequence $\{s_j\}$ satisfy (4), no matter what values the discount factors, $\{\alpha_j\}$, or the initial liabilities to GDP ratio, w_t, take in equilibrium. Another possibility is that $\{s_j\}$ is an arbitrary sequence -- determined by a political process that takes no account of the level of the debt. Then, the discount factors, $\{\alpha_j\}$, and/or the initial liabilities to GDP ratio, w_t, have to move in equilibrium to satisfy (4). How can $w_t = (M_t + B_t)/P_t y_t$ move to satisfy (4)? Nominal liabilities are fixed at the beginning of the period, but a "jump" in nominal income can generate a change in the ratio.[12] Here is where the assumption of nominal public sector liabilities is important. This would not be a theory of price determination without it; all of the onus of the adjustment to equilibrium in (4) would be on the discount factors or real income.

The R and NR regimes can now be defined formally in terms of the present value constraint (4). If primary surpluses (or more precisely the surplus to GDP ratios) are determined by an arbitrary process (unrelated to the level of the debt), then nominal income and/or discount factors must "jump" in equilibrium to satisfy (4). We call this an *NR regime*. If on the other hand primary surpluses are determined in such a way that (4) is always satisfied no matter what nominal income and discount factors are fed into it, then nominal income and the discount factors can be determined elsewhere in the model. We call this an *R regime*.[13] In summary, nominal income is determined by the needs of fiscal solvency in an NR regime; it can be determined in more conventional ways in an R regime. Once we specify the way in which changes in nominal income are split between price and output, we have a theory of price determination. This last step is obviously model specific, and controversial. Fortunately, the empirical analysis in section II will not require us to take a stand on these issues.

B. Is the Ricardian regime a "special case"?

The R regime might seem like a rather special case, but we can show that many different fiscal policy rules lead to an R regime. Moreover, the rules can be quite lax. So in this sense, the R regime is not as implausible as it may at first appear. To illustrate this point, suppose that the sequence $\{s_j\}$ is expected to follow the rule

(5) $s_j = c_j w_j + \epsilon_j$,

where c_j is a time varying response parameter and ϵ_j is a random variable, which could represent political factors and/or economic conditions, such as unemployment.

Consider first the case where $\{c_j\}$, $\{\alpha_j\}$ and $\{\epsilon_j\}$ are deterministic sequences, and assume that $\{\epsilon_j\}$ is bounded. If two conditions, (C1) and (C2), are satisfied, then we can show that the fiscal policy rule (5) will result in an R regime:

(C1) $0 \leq c_j < 1$, $\quad\quad \limsup c_j > c^* > 0$,

and

(C2) $D_t \equiv 1 + \sum_{j=t+1}^{+\infty} (\prod_{k=t}^{j-1} \alpha_k) < +\infty$.

All but one of the restrictions are either a matter of technical convenience or necessary for the theory to make sense (no matter which regime is in place). We begin with these "modeling" restrictions. First, it seems natural to assume that the ratio of the primary surplus to GDP, and thus

$\{\epsilon_j\}$, is bounded and that an increase in debt does not cause a decrease in the primary surplus (so that $c_j \geq 0$ holds). The restriction $c_j < 1$ is a plausible (and analytically convenient) assumption. (C2) is a technical condition requiring that the sum of the discount factors converges; it (or something like it) is an assumption that is implicit in most analyses of NR regimes. For a meaningful assessment of NR regimes we need the government's present value budget constraint to be well defined at least in the simple case where the ratio of the primary surplus to GDP is constant. (C2) is necessary for this (and sufficient for a well defined present value budget given any bounded $\{s_j\}$ sequence). Note also that (C2) holds if limsup $\alpha_j < 1$, may or may not hold if limsup $\alpha_j = 1$, and cannot hold if limsup $\alpha_j > 1$.[14] In our data set (as in earlier analyses of post War U.S. data) the average growth rate of the economy exceeds the average real interest rate; so, the average value of α_j is greater than one. The condition limsup $\alpha_j < 1$ permits the growth rate to exceed the real interest rate for only finitely many periods; so, condition (C2) may well be controversial. As noted above, however, (C2) is implicitly part of the definition of NR regimes; it is not an additional restriction imposed by our empirical analysis of such regimes.

On to what is important: The really substantive assumption we have to make is that limsup c_j exceeds an arbitrarily small positive constant c^* – that is, c_j is bounded away from zero infinitely often. Basically, this will be the case unless the fiscal authority tries to rollover the interest due on the debt indefinitely. In periods in which c_j is positive, s_j is moving to stabilize w_j. However, it need not do so each and every period. A stabilizing policy could be in effect every other year, or every third year, or every decade. Indeed, the required fiscal retrenchment need not occur in the next 100 years, or in any finite data set! All that is necessary for the fiscal rule (5) to result in an R regime is that the private sector expects that there will sooner or later be a retrenchment. In the meantime, fiscal policy can respond to economic or political conditions (as represented here by the random variable ϵ_j).

Our assertion can be stated more formally in the following proposition.

Proposition: Assume that $\{c_j\}$, $\{\alpha_j\}$ and $\{\epsilon_j\}$ are deterministic sequences, $\alpha_j > 0$, $\{\epsilon_j\}$ is bounded, and conditions (C1) and (C2) hold. Then, the flow budget constraint (3) and the fiscal rule (5) imply that the present value constraint (4) holds for any arbitrary value of w_t, and (5) results in an R regime.

This proposition, and its extension to a stochastic setup, are proved in an appendix which is available from the authors. Here, we simply offer some intuition as to why the proposition is true.

The intuition behind the proof is more transparent in the case where c_j and α_j are constant ($c_j = c \geq 0$ and $\alpha_j = \alpha < 1$, for all j). If there is no stabilizing fiscal policy (because $c = 0$), then the flow budget constraint (3) is a dynamically unstable equation (since by assumption its root, $1/\alpha$, is greater than one); in this NR regime, w_t has to jump to suppress this unstable root for (4) to hold in equilibrium.[15] Substituting (5) into (3), the root of the equation becomes $(1-c)/\alpha$. If the fiscal response coefficient, c, is sufficiently large to make $(1-c)/\alpha < 1$ -- which roughly corresponds to a fiscal response larger than the difference between the interest rate and the growth rate of GDP -- then the flow budget constraint is dynamically stable, and (4) holds for any initial condition, w_t.[16] It turns out however that the fiscal response does not have to be strong enough to make the flow budget constraint stable; all that is required by (4) is that the discounted value of w_{t+T} go to zero as T goes to infinity. Any positive value of c implies that this is the case.[17] Moreover, allowing for a time varying fiscal response, condition (C1) says that the requisite fiscal response may be arbitrarily small and infrequent.

C. Useful implications of the theory

With these insights, we are ready to develop some implications of the theory that will help us to differentiate between R and NR regimes in section II. This is not as straightforward as it may at first appear. Figure 1 illustrates the positive correlation between s_t and w_t in the US post-war data. This might be viewed as evidence in favor of an R regime: primary surpluses responded to liabilities in the manner prescribed by (5) and produced an R regime. However, there is an identification problem here; an NR regime would also have produced the positive correlation between s_t and w_t, with causation going the other direction. To see why, consider the effect of a positive s_t innovation in (4). In an NR regime, nominal income and/or expected future discounted surpluses must move to achieve fiscal balance. If an innovation in s_t causes the RHS of (4) to rise, then nominal income must fall to raise the LHS of (4). Simple correlations between s_t and w_t are not very useful for our purposes.

This discussion does however suggest a way to differentiate between R and NR regimes. Consider how a positive innovation in s_t passes to w_{t+1}. In an R regime, the surplus pays off some of the debt, and w_{t+1} falls. In an NR regime, there are three possibilities. Consider first the case in which an innovation in s_t is not correlated with the surpluses and discount factors that follow s_t on the RHS of (4). In an NR regime, the value of w_{t+1} can be found by shifting (4) forward one period. In the case we are considering, w_{t+1} should not be affected by the innovation in s_t.[18] Consider next the case in which an innovation in s_t is positively correlated with future surpluses and discount factors. In this case, w_{t+1} should rise. In either of these cases, it should in principle be possible to differentiate between R and NR regimes. For example, the impulse response function from a VAR in s_t and w_t would tell us how w_{t+1} responds to an innovation in s_t. If w_{t+1} falls, we have an R regime;

if it does not, we have an NR regime.

However, there is also a third case to consider. Suppose innovations in s_t are negatively correlated with future surpluses and discount factors. In this case, w_{t+1} would fall in either an R regime or an NR regime, and we have the identification problem discussed in the introduction. We will revisit this issue in the following section.

II. THE EMPIRICAL PLAUSIBILITY OF RICARDIAN REGIMES

In this section, we assess the empirical plausibility of R regimes. First, we examine annual post War data on US surpluses and liabilities, and derive some implications from it. Then, we interpret the results in terms of R and NR regimes, and ask which interpretation seems more plausible.

A. The Post War Data on US Surpluses and Liabilities

In Figure 2, we present the two key series that we analyze. *Surplus/GDP*, which corresponds to s_t in the previous section, is on budget plus off budget Federal receipts (including central bank transfers) minus Federal outlays (including net Federal interest payments), all divided by nominal GDP for the fiscal year. *Liabilities/GDP*, which corresponds to w_t, is calculated by adding the net federal debt to the money base, both measured at the beginning of the fiscal year, and dividing by nominal GDP for the fiscal year. We take the debt and surplus data from the Historical Tables of the Budget of the United States Government, and the monetary base from Friedman and Schwartz (through 1958) and the Federal Reserve Historical Data, H.3, Table 2.

We begin with a VAR in Surplus/GDP and Liabilities/GDP. As described above, our focus is on the responses of both variables to Surplus/GDP shocks. Identifying these shocks in NR regimes is straightforward because the Surplus/GDP series is assumed to be exogenous. The first equation of the VAR, which describes the evolution of surplus/GDP, is simply a forecasting equation in which liabilities/GDP enters because of its value in forecasting future surpluses. An innovation to the first equation can therefore be identified as an exogenous Surplus/GDP shock. In R regimes, the first equation of the VAR can be thought of as a reaction function (like equation (5) in the last section) in which liabilities/GDP influence the setting of future surpluses. As Christiano, Eichenbaum, and Evans (1999) demonstrate in a different context, the dynamic response of a variable to a shock to Surplus/GDP can be estimated by regressing that variable on the residuals from the reaction function or by computing the impulse responses from a VAR in which any variables on the right-hand-side of the reaction function are prior to Surplus/GDP in the VAR's ordering.

Figure 3 contains plots of the impulse response functions of the VAR computed for both orderings of the variables. In the first ordering, Surplus/GDP comes first. This allows for a contemporaneous effect on Liabilities/GDP, as is consistent with an NR regime (where nominal GDP has to jump to make the value of the existing debt equal to the expected present value of surpluses). In the second ordering, Liabilities/GDP comes first. This ordering may make more sense in an R regime (where GDP can be determined elsewhere in the model), because it does not allow for a contemporaneous affect on Liabilities/GDP and allows us to identify shocks to Surplus/GDP in an R regime. The dashed lines represent the two standard deviation bands obtained by using Kilian's (1998) bias-corrected bootstrap procedure.[19] Likelihood ratio tests using a general-to-specific procedure led us to include two lags and a constant, but the results are robust to other specifications. (For example, we obtained similar results when we added a deterministic trend; used lags of one, three or four years; and estimated the VAR in first differences.)

The response of Liabilities/GDP in period 1 to an innovation in Surplus/ GDP in period 0 is negative and significant, regardless of the ordering used. In fact, the response of Liabilities/GDP is negative and significant for 10 years. This negative response would arise naturally in an R regime.

As we pointed out in the last section, however, this negative response could also arise in an NR regime if a positive Surplus/GDP innovation lowers expected future surpluses sufficiently to reduce the present value. The (univariate) autocorrelations, and the corresponding Q-statistics for Surplus/GDP found in Table 1 do not give any evidence of this. In fact, they clearly indicate that there is significant positive autocorrelation at least at lags of up to 9 years. Next, we return to the joint dynamics of Surplus/GDP and Liabilities/GDP and look at the impulse response functions from the VAR. As the theory presented in section I emphasizes, the level of debt should also be a good predictor of future surpluses, even in NR regimes where surpluses are exogenous. Figure 3 shows that an innovation in Surplus/GDP in period 0 tends to produce a surplus in period 1, regardless of the ordering. Beyond period 1, the impulse responses appear to be insignificant. In other words, there is no evidence of a significant negative correlation within a ten year horizon.

B. Plausibility of R and NR Interpretations of the Post War US Data

So, what do we conclude from all of this? How plausible are the interpretations that R and NR regimes give to the empirical results described above? We begin with R regimes, where the interpretation is more straightforward.

The impulse response functions in Figure 3 have a very straightforward interpretation in R regimes: a positive innovation in s_t pays off some of the debt in period t, and w_{t+1} falls; moreover, since the response of s_{t+1} is also positive, even more of the debt is paid off in period t+1, and w_{t+2} falls. The positive autocorrelations in the surplus process illustrated in Table 1 and Figure 3 also have a very plausible interpretation in R regimes: election cycles and business cycles take years to complete; so, in a fiscal policy rule like (5), the ϵ_j disturbances are likely to be persistent, and we might expect the surplus process to be positively correlated for an extended period of time, as pictured. Of course, a positive innovation in s_t does pay off some of the debt and reduce the need for running surpluses at some time in the future; so, over a longer period of time, we would expect a negative correlation, even though we do not see one in the ten year horizon pictured in Table 1 and Figure 3.

These same impulse response functions and surplus autocorrelations can be interpreted in terms of NR regimes, but the interpretation is rather convoluted. Looking at the positive auto-correlations in the surplus process, a natural presumption from the logic of NR regimes would be that a positive innovation in s_t should cause w_{t+1} to rise: positive autocorrelation should cause the present value of surpluses beginning in period t+1 to increase, and this would force w_{t+1} up. However, our VAR shows that w_{t+1} falls. This apparently anomalous fact can be reconciled with the theory of NR regimes if there is a negative correlation in the surplus process at longer horizons, and if the correlation is strong enough to make the present value of surpluses (beginning in period t+1) fall. These eventual decreases in the surplus will have to be rather large or very persistent, since they have to overcome initial increases in the surplus that are less heavily discounted --increases due to the earlier positive correlation that we do observe in Table 1 and Figure 3.

The interpretation offered by NR regimes is logically consistent, but how plausible is it? What is the political theory that would generate a sequence of surpluses with the required properties? The answer can not be something like the following: (1) politicians (or voters) wake up every decade and respond to the growing level of the debt, or (2) politicians fight wars (against poverty, other countries, or other politicians) for extended periods and pay off the debt later. These fiscal policies fit the requirements of the proposition we proved in the last section; they result in R regimes. The explanation of the eventual negative correlation in the sequence of surpluses has to be a political theory that is unrelated to the level of the debt. Figuratively speaking, politicians would have to remember that they ran primary deficits sometime in the distant past, and then they would have to have some reason to make up for them by running a primary surplus today.[20] The plausibility of the interpretation offered by NR regimes rests on making such an argument.

Cochrane's (1998) analysis of US inflation may be viewed as an initial step in this direction. In a rather ingenious exercise, Cochrane chooses the parameters in a statistical model of the surplus process to match those in an estimated VAR much like ours. Cochrane's surplus process is exogenous, but by construction (and consistent with the logic of NR regimes), liabilities are a good predictor of future surpluses, and his bivariate model is able to produce impulse response functions like the ones in Figure 3. How does Cochrane induce the eventual negative correlation in surpluses needed to explain the seemingly anomalous impulse response function? In Cochrane's model, the surplus is the sum of two components, one cyclical and the other “long run” (reflecting changes in tax rates and spending policy). Cochrane assumes that the structural component is more persistent than the cyclical component and that the correlation between the innovations in the two components is highly negative (-0.95). Given these assumptions, a positive innovation in the cyclical surplus induces a negative innovation of smaller magnitude in the long run surplus (so that the overall surplus innovation is positive). The higher persistence of the long run component eventually leads to the required decrease in future surpluses. Thus, a negative correlation between the innovations in cyclical and long run components of the surplus is critical to Cochrane's attempt to interpret US data in terms of NR regimes. The negative correlation between the cyclical and long run components of the surplus has the problematic implication that politicians raise tax rates or cut spending in response to a deficit caused by a recession; however, Cochrane (2001) provides a theoretical rationale for the pro-cyclical fiscal policy by assuming that the fiscal authorities choose the long-run (non-cyclical) component of the surplus each period to minimize the variance of inflation.

Do the data show a negative correlation between the innovations in cyclical and long run components of the surplus? To address this question, we use the Congressional Budget Office's (1999) estimates of the structural ("standardized-employment") and cyclical components of the surplus as proxies for the two surplus components in Cochrane's model. Cochrane's assumption that the structural component is more persistent than the cyclical component is consistent with the data, but the correlation between innovations in the primary structural deficit and the cyclical deficit (normalized on GDP) is 0.06.

While Cochrane's model has the unappealing feature of pro-cyclical fiscal policy and is inconsistent with the CBO data, it does serve to highlight the severity of the identification problem that hinders formal testing of R and NR regimes. One may question the reliability of the CBO data, and more appealing examples of NR regimes that mimic R regimes may be found. But for now, we conclude that R regimes offer a more plausible interpretation of US data.

III. EXTENSIONS OF THE EMPIRICAL ANALYSIS

In this section, we discuss three extensions of the analysis in section II. In the first extension, we add discount factors to the VAR discussed in the last section. The theory developed in section I involved surpluses, liabilities and discount factors, and we want to make sure that the impulse responses pictured in Figure 3 survive once we control for discount factors. Furthermore, we have good reason to explore the role played by discount factors. The interpretation NR regimes give to these responses might be more plausible if innovations in Surplus/GDP are negatively correlated with future discount factors; this would take some of the onus off of the negative correlation with future surpluses. In the second extension, we want to examine the robustness of the impulse responses pictured in Figure 3 over different sample periods. In particular, one might wonder if fiscal regimes changed between the early post-war period and the Reagan era. In the final extension, we explore the role played by nominal income in NR regimes. A natural presumption from the theory developed in section I is that a positive innovation in Surplus/GDP would decrease nominal income; this would raise the real value of existing government liabilities and help balance the present value budget constraint, (4). This is a prediction that can be tested.

A. Adding Discount Factors to the VAR

Here, we estimate a VAR in Surplus/GDP, Liabilities/GDP and the discount factor Alpha, which we calculate using the yield on 1-year U.S. Treasury securities obtained from McCulloch and Kwon (1993) through 1991 and from Barclays de Zoete Wedd thereafter. (The theory in section I involved surpluses, liabilities and the discount factor; the relationship between these three variables is not linear, so the VAR must be regarded as an approximation.) The VAR has a constant and two lags. Figure 4 shows impulse responses to an innovation in Surplus/GDP. (Once again the results are quite robust: adding a deterministic time trend, or using lag lengths of one, three or four, we get similar pictures.) In the top panel, we place Surplus/GDP first in the ordering (as may make more sense in an NR regime), followed by Liabilities/GDP and Alpha; in the bottom panel, we place Liabilities/GDP first (as is consistent with an R regime), followed by Surplus/ GDP and Alpha. The dashed lines represent the two standard deviation bands, again obtained with Kilian's bias-adjusted bootstrap procedure.

The response of Liabilities/GDP to a surplus shock is significantly negative for the first two periods following the shock. The response of Surplus/GDP to a surplus shock in Figure 4 is about as persistent as it was in Figure 3. So, the basic results of section II are robust to conditioning on Alpha.

The really new information in Figure 4 is the response of the discount factor, Alpha, to an innovation in Surplus/GDP. The initial impact is negative, and it appears to be significant. However, we are more interested in the correlation between innovations in Surplus/GDP and future discount factors. In Figure 4, the response of future discount factors is quite small, and it is statistically insignificant. Current innovations in Surplus/GDP appear to be uncorrelated with future discount factors. Once again, this result is robust to the addition of a deterministic trend or the use of one, three or four period lags.

So, the NR regimes' interpretation of the response in w_{t+1} to an innovation in s_t does not appear to be helped by accounting for the role played by discount factors. The fall in w_{t+1} has to be explained by a negative correlation with s_j's (or α_j's) at some time in the distant future.

B. Robustness across Sample Periods

In the preceding analysis, we were implicitly assuming that there were no regime switches in the post-war period. Eye-balling the data in Figure 2 may cast some doubt on this assumption, and one might wonder if the Reagan era or the Korean War period were somehow different than the rest of the post-war experience. We did not attempt to formally identify statistical breaks in the data; we simply reestimated the VAR reported in section II for arbitrarily selected periods.

In particular, we estimated VARs in Surplus/GDP and Liabilities/GDP, with two lags and a constant, for the following periods: 1954 - 1995 (which excludes the Korean War); 1951 - 1979 & 1980 - 1995 (which controls for the "Reagan Revolution"); 1951 - 1974 & 1975 - 1995 (since eye-balling Figure 2 suggests a break might have occurred in the mid 1970's). In all cases but one (1951 - 1974), an innovation in s_t produces a positive response in s_{t+1}, and in all cases an innovation in s_t produces a fall in w_{t+1} and a further drop in w_{t+2}. The fall in w_{t+1} is significant in all cases. We conclude that the basic results pictured in Figure 3 are quite robust.[21]

C. The Role of Nominal Income in Non-Ricardian Regimes

The theory of R regimes has no particular implication for nominal income, but the theory of NR regimes implies that nominal income moves to help balance the present value budget constraint, (4). A natural presumption is that a positive innovation in Surplus/GDP would lower nominal income in the same period and raise the real value of current government liabilities (though as we will soon see there are other possibilities). To test this presumption, we split the numerator and denominator of Liabilities/GDP, and we estimate a VAR in the log of nominal liabilities, the log of nominal income, and Surplus/GDP. Once again, the VAR has two lags and a constant.

Responses to an innovation in Surplus/GDP are pictured in Figure 5. The ordering of variables in the Cholesky decomposition is: LN(Liabilities), Surplus/GDP, LN(GDP). This is the only ordering that makes sense in NR regimes, since LN(Liabilities) is predetermined and LN(GDP) is predicted to respond to the surplus innovation. We see that LN(GDP) rises in response to the (positive) innovation in Surplus/GDP, and that the rise in LN(GDP) appears to be statistically significant. So, the response that our "natural presumption" associates with NR regimes is not supported by the data.

Of course, the impulse responses pictured in Figure 5 can be interpreted in terms of an NR regime, and the interpretation is consistent with the one given in section II. If the innovation in Surplus/ GDP is negatively correlated with future surpluses, and if the correlation is strong enough to cause the RHS of (4) to fall, then LN(GDP) should indeed rise in response to the innovation. Note however that these requirements are stronger than those in section II. Here, the future deficits have to be large enough that their discounted values overcome the current surplus innovation, and make the entire RHS of (4), $s_t + E_t \sum_{j=t+1}^{+\infty} \left(\prod_{k=t}^{j-1} \alpha_k \right) s_j$, fall.

IV. DISCUSSION AND DIRECTIONS FOR FUTURE WORK

Cochrane, Sims, and Woodford have popularized a theory in which price determination depends critically on the fiscal policy that is in place. In what Woodford (1995) calls *Ricardian* (R) regimes, the conventional wisdom prevails and monetary policy serves as nominal anchor; in *Non-Ricardian* (NR) regimes, unorthodox results emerge and fiscal policy becomes the nominal anchor. In this paper, we have tried to establish two basic tenets: (1) R regimes are at least as theoretically plausible as NR regimes, and (2) R regimes are more empirically plausible than NR regimes.

Our argument for theoretical plausibility was based on a proposition that demonstrated the potential laxity of fiscal policy rules which result in R regimes. The deficit rules that were written into the Maestricht Treaty (and live on in the Stability and Growth Pact) would qualify, but they are much stronger than is necessary. All that is required for an R regime is that primary surpluses respond to the level of debt “infinitely often”; once every decade, or once every century, would do.

Several caveats are worth mentioning here. First, the private sector must believe that a stabilizing fiscal policy is already in place, or that one will eventually be implemented. The proposition we proved did not address issues of credibility, and the need for credibility may limit the laxity of fiscal policy rules that assure R regimes. More work in this area would seem to be warranted. Second, we should note that NR regimes are not necessarily "fiscally irresponsible" regimes; for example, a fiscal policy that obstinately set primary surpluses equal to one percent of GDP each year, but otherwise ignored the dynamics of debt, would result in an NR regime.[22] We are not trying to assert that NR regimes are theoretically implausible, or that the new theory of price determination is only relevant for countries that are fiscally irresponsible. We take the theoretical possibility of NR regimes quite seriously.

Our argument for the empirical plausibility of R regimes was based on the interpretations that R and NR regimes give to post war data on US primary surpluses and government liabilities (both normalized on GDP). We estimated a VAR in surpluses and liabilities, and we estimated the autocorrelation function for surpluses. The estimates show that a positive innovation in the surplus causes a rise in future surpluses and a fall in future liabilities. R regimes offer a straightforward interpretation of these results: the political and economic events that give rise to surplus innovations are likely to be persistent (causing the rise in future surpluses), and surpluses pay off some of the debt (causing the fall in future liabilities). NR regimes can also explain these empirical results, but the explanation is somewhat convoluted: the correlation between today's surplus innovation and future surpluses eventually becomes negative, and this negative correlation has to be strong enough to overcome the effect of the initial positive correlations and make the expected discounted value of future surpluses (starting next period) fall. We think the NR interpretation is rather implausible. What kind of political theory would imply such a process for primary surpluses? The answer can not be something like: (1) citizens wake up every decade and vote for candidates who will respond to the growing level of debt, or (2) governments fight wars for extended periods, planning to pay off the debt when the war is over. Both of these statements imply that the surplus will respond periodically to the level of the debt, and our Proposition shows that this is sufficient for an R regime. The political theory we are seeking has to be unrelated to the level of the debt.

A number of caveats are worth mentioning here. First, in this paper we used federal fiscal data for the entire post war period (1951-1995). Consolidated (federal, state and local) fiscal data are available from the OECD, but only for a relatively short period (1971-1995). In a companion piece, Canzoneri et al (1997b), we find that the consolidated data for the US produce results that are very similar to the ones we have just reported. However, the OECD data sets are very short, and results for many of the other countries were statistically insignificant, and therefore not conclusive. Further analysis of these countries seems warranted. Second, and more fundamentally, we have not been able to develop a formal statistical test that would directly discriminate between R and NR regimes. And indeed, since both regimes use exactly the same equations to explain the data, such tests may not exist.

This does not mean that the issue is moot. Quite the contrary, we have argued that the choice of regime may well determine the outcome of both theoretical and policy analyses; it is important to settle the issue.[23] We think that future work should follow the lead of Cochrane (1998, 2001) in trying to find plausible political and economic theories that would rationalize an NR interpretation of the US data. More generally, we think it would be useful to examine the plausibility of the two regimes' interpretation of a variety of data sets and economic events.

IS THE PRICE LEVEL DETERMINED BY THE NEEDS OF FISCAL SOLVENCY?

by

Matthew B. Canzoneri, Robert E. Cumby and Behzad T. Diba

APPENDIX: Proof of Proposition

Recall from Equation (4) in the text, that the government's present value budget constraint holds if and only if

$$\text{(A1)}\quad \lim_{T\to+\infty} E_t\Big(\prod_{k=t}^{T+t-1}\alpha_k\Big)w_{t+T} = 0$$

is satisfied. In NR regimes, w_t adjusts to satisfy (A1). In R regimes, (A1) holds for all values of w_t. We show below that, under certain conditions, the fiscal rule of Equation (5) in the text is a sufficient condition for an R regime. We first present the proof under perfect foresight, and then outline the extension allowing for uncertainty.

Using (5) and the flow budget constraint (3) in the text, the dynamics of w_j are governed by

$$\text{(A2)}\quad w_{j+1} = \left[\frac{(1-c_j)}{\alpha_j}\right]w_j - \frac{\epsilon_j}{\alpha_j}\ .$$

<u>Proposition 1</u>: Assume that $\{c_j\}$, $\{\alpha_j\}$ and $\{\epsilon_j\}$ are deterministic sequences, $\alpha_j > 0$, $\{\epsilon_j\}$ is bounded, and the following conditions hold:

(C1) $0 \leq c_j < 1$, $\quad$ $\limsup c_j > c^* > 0$,

and

(C2) $$D_t = 1 + \sum_{j=t+1}^{+\infty} \left(\prod_{k=t}^{j-1} \alpha_k\right) < +\infty .$$

Then, (A2) implies that (A1) holds for any arbitrary initial value, w_t.

Proof: Let $\phi_{t-1} = 1$, $\psi_{t-1} = 1$, and

$$\phi_{t+j} = \prod_{k=t}^{t+j} (1-c_k) , \qquad \psi_{t+j} = \prod_{k=t}^{t+j} \alpha_k , \qquad \text{for } j = 0, 1, 2, \ldots$$

Note that ϕ_{t+j} and ψ_{t+j} are non-negative sequences and

(A3) $$\frac{\phi_{t+i}}{\phi_{t+j}} = \prod_{k=t+j+1}^{t+i} (1-c_k) \leq 1,$$

for i > j. Iterating (A2) from date t to date t+T, we get

(A4) $$\left(\frac{\psi_{t+T-1}}{\phi_{t+T-1}}\right) w_{t+T} = w_t - \sum_{j=0}^{T-1} \left(\frac{\psi_{t+j}}{\phi_{t+j}}\right)\left(\frac{\epsilon_{t+j}}{\alpha_{t+j}}\right).$$

Let M denote the largest integer that is less than or equal to T/2. Rearranging terms and bounding ϵ_{t+j} by its supremum, (A4) implies

(A5) $$|\psi_{t+T-1} w_{t+T}| \leq |\phi_{t+T-1} w_t| + \sup|\epsilon_{t+j}| \, [\, F_t(T) + H_t(T) \,] ,$$

where

$$F_t(T) = \sum_{j=0}^{M-1} \left(\frac{\phi_{t+T-1}}{\phi_{t+j}} \right) \psi_{t+j-1} ,$$

and

$$H_t(T) = \sum_{j=M}^{T-1} \left(\frac{\phi_{t+T-1}}{\phi_{t+j}} \right) \psi_{t+j-1} .$$

As T tends to infinity, c_k will be above $c^* > 0$ infinitely often (since limsup $c_k > c^*$). So,

$$\lim_{T\to+\infty} | \phi_{t+T-1} w_t | = 0 .$$

We show below that $F_t(T)$ and $H_t(T)$, and thus the right-hand side of (A5), also tend to zero as T goes to infinity. We have

$$\text{(A6)} \quad F_t(T) = \left(\frac{\phi_{t+T-1}}{\phi_{t+M-1}} \right) \sum_{j=0}^{M-1} \left(\frac{\phi_{t+M-1}}{\phi_{t+j}} \right) \psi_{t+j-1} \leq \left(\frac{\phi_{t+T-1}}{\phi_{t+M-1}} \right) \sum_{j=0}^{M-1} \psi_{t+j-1} ,$$

by (A3). Note that

$$\frac{\phi_{t+T-1}}{\phi_{t+M-1}} = \prod_{k=t+M}^{t+T-1} (1-c_k)$$

is the product of T-M terms each of which is less than or equal to one. As T-M tends to infinity with T, infinitely many of these terms will be below $1\text{-}c^* < 1$ because limsup $c_k > c^*$. So, (A6) implies

$$\lim_{T \to +\infty} F_t(T) \leq D_t \lim_{T \to +\infty} \left(\frac{\phi_{t+T-1}}{\phi_{t+M-1}} \right) = 0.$$

Finally, note that by (A3),

$$H_t(T) \leq \sum_{j=M}^{T-1} \psi_{t+j-1} \leq \sum_{j=M}^{+\infty} \psi_{t+j-1} .$$

By (C2), for any $\eta > 0$, there exists an integer m such that

$$D_t - \eta \leq \sum_{j=0}^{m-1} \psi_{t+j-1} \leq D_t.$$

So, we have

$$0 \leq \sum_{j=m}^{+\infty} \psi_{t+j-1} \leq \eta ,$$

and as m (or M) tends to infinity, we get

$$\lim_{T \to +\infty} H_t(T) = 0.$$

And (A1) holds for the deterministic case because each of the terms on the right-hand side of (A5) tends to zero.

To extend Proposition 1 to a stochastic environment, assume c_t, α_t, and ϵ_t are the first three components of a vector ζ_t generated by a first-order Markov process. The other components of ζ_t may include lags of the first three (capturing higher order dynamics) and other relevant random variables observed at or before date t. We assume that $\zeta_t \in Z$ for all t, where Z is a compact subset of a Euclidean space. Given the state $\zeta_t = \zeta$ at date t, define the probability space $(\Omega, \mathscr{F}, P)$ so that each point $\omega \in \Omega$ corresponds to a sample path $\{\zeta, \zeta_{t+1}, \zeta_{t+2}, ...\}$. The

σ-algebra $\mathscr{F}$ and the probability measure P can be defined so that for any random variable

$f(\zeta, \zeta_{t+1}, ..., \zeta_{t+T})$,

$$E_t f(.) = \int_\Omega f(.)\, dP$$

whenever the expectation on the left-hand-side is well defined [see, for example, Stokey and Lucas (1989), Section 8.2]. We have:

<u>Proposition 2</u>: Assume that $\{c_j\}$, $\{\alpha_j\}$ and $\{\epsilon_j\}$ are generated by the above Markov process (with a compact state space), $\alpha_j > 0$ almost surely, and the following conditions hold:

$$\text{(C1}'\text{)}\quad 0 \leq c_j < 1\ , \qquad \limsup c_j > c^* > 0\ , \qquad \text{almost surely}\ ,$$

and

$$\text{(C2}'\text{)}\quad E_t D_t = 1 + E_t \sum_{j=t+1}^{+\infty} \Big(\prod_{k=t}^{j-1} \alpha_k\Big) < +\infty\ .$$

Then, (A2) implies that (A1) holds for any arbitrary initial value, w_t.

Proof: By (C2′), $D_t(\omega)$ is finite almost surely. So, ignoring sets of measure zero, Proposition 1 implies that the real sequence

$$\Big[\Big(\prod_{k=t}^{T+t-1} \alpha_k\Big)\, w_{t+T}\Big](\omega)\ , \quad T = 1, 2, ...$$

converges to zero. That is, the sequence of random variables

$$(\prod_{k=t}^{T+t-1} \alpha_k)\ w_{t+T}, \quad T = 1, 2, \ldots$$

converges to zero almost surely. Moreover, this sequence is bounded: (C1') and (A5) imply

$$\text{(A7)} \quad (\prod_{k=t}^{T+t-1} \alpha_k)\ |w_{t+T}| \ \leq \ |w_t| \ + \ D_t \ \sup|\epsilon_{t+j}| \ ,$$

for all T > 0. By (C2′) and the fact that P is a probability (finite) measure, the right-hand side of (A7) is P-integrable and, therefore, can serve as the dominating function for the Lebesgue Dominated Convergence Theorem [see, for example, Stokey and Lucas (1989), Theorem 7.10]. Thus, we have

$$\text{(A8)} \quad \begin{aligned} \lim_{T \to +\infty} E_t(\prod_{k=t}^{T+t-1} \alpha_k) w_{t+T} \ &= \ \lim_{T \to +\infty} \int_\Omega [(\prod_{k=t}^{T+t-1} \alpha_k) w_{t+T}]\, dP \\ &= \int_\Omega \lim_{T \to +\infty} [(\prod_{k=t}^{T+t-1} \alpha_k) w_{t+T}]\, dP \ = \ 0. \end{aligned}$$

Figure 1: Primary Surpluses and Liabilities, 1951 - 1995

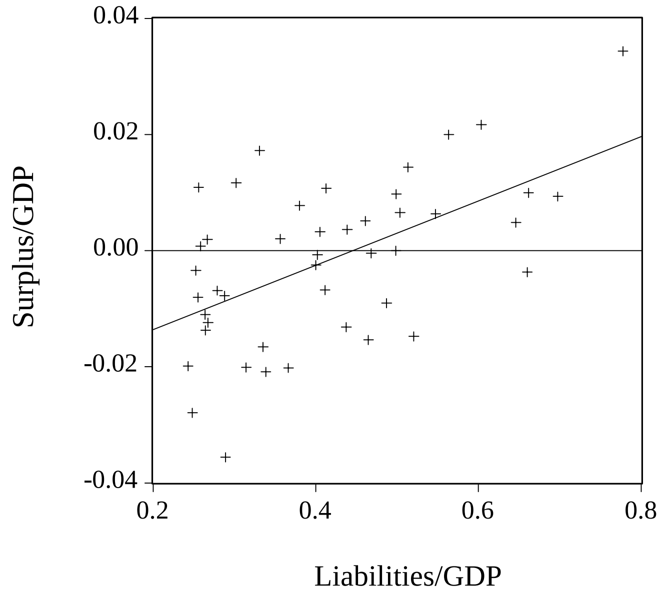
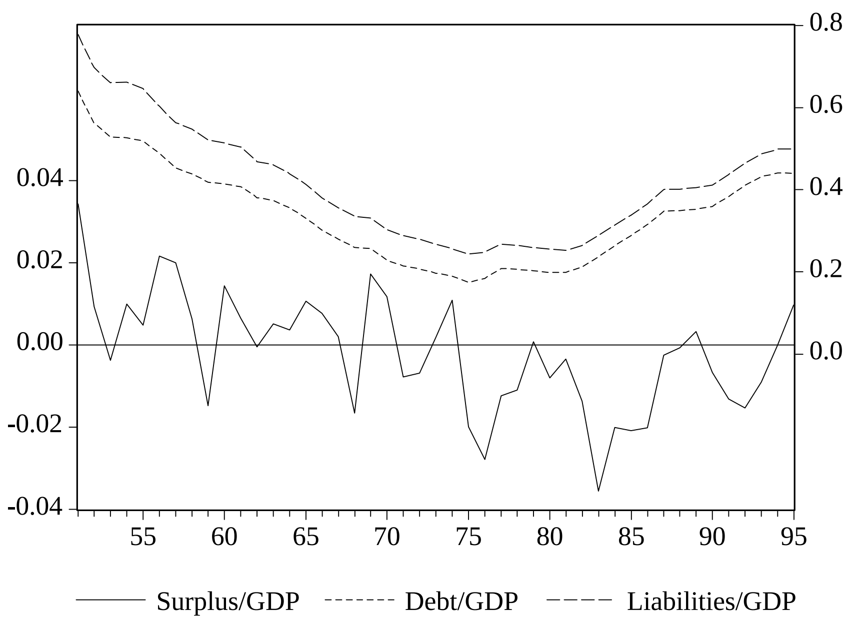


Figure 2: US Fiscal Data, 1951 - 1995

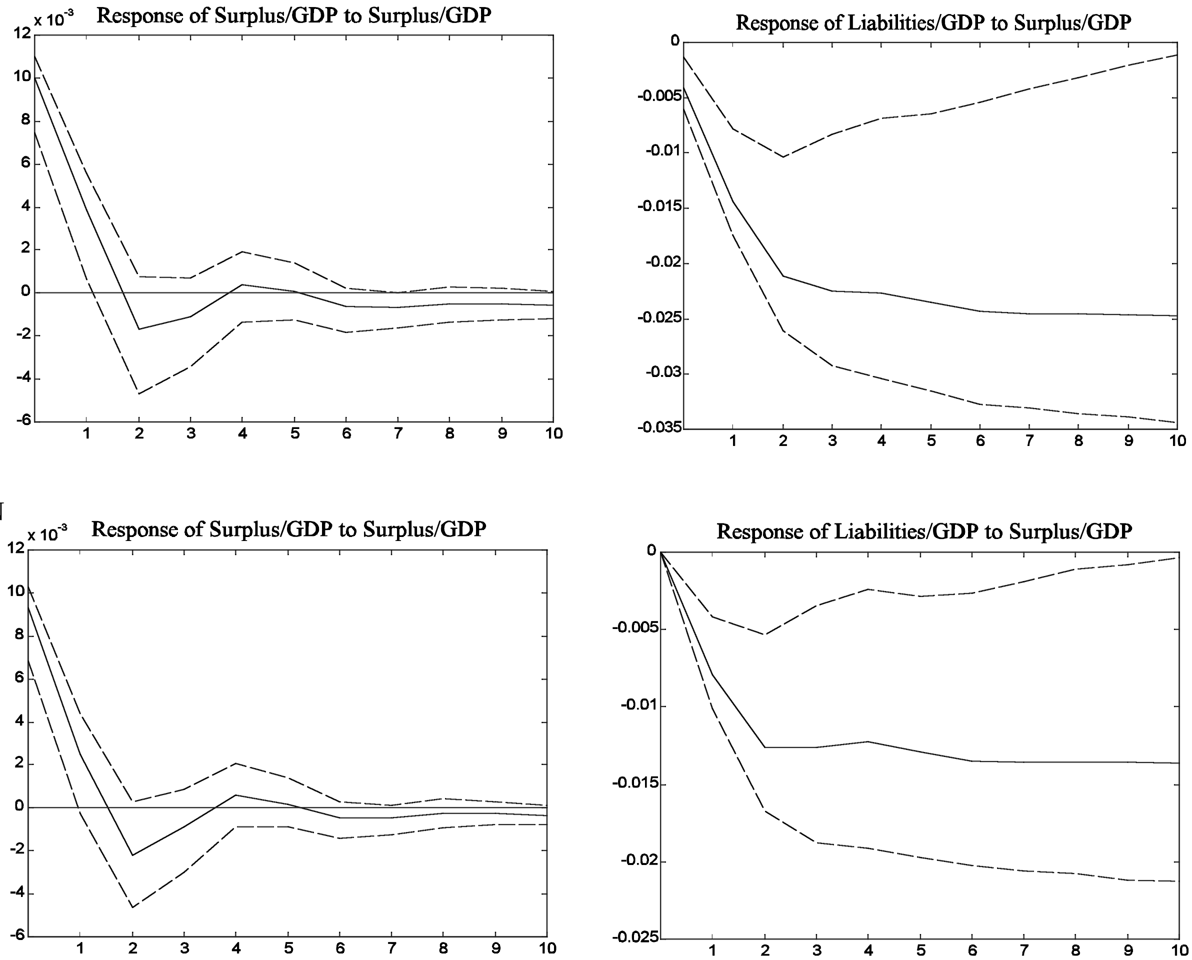


Note:

Scale for Surplus/GDP is on the left.

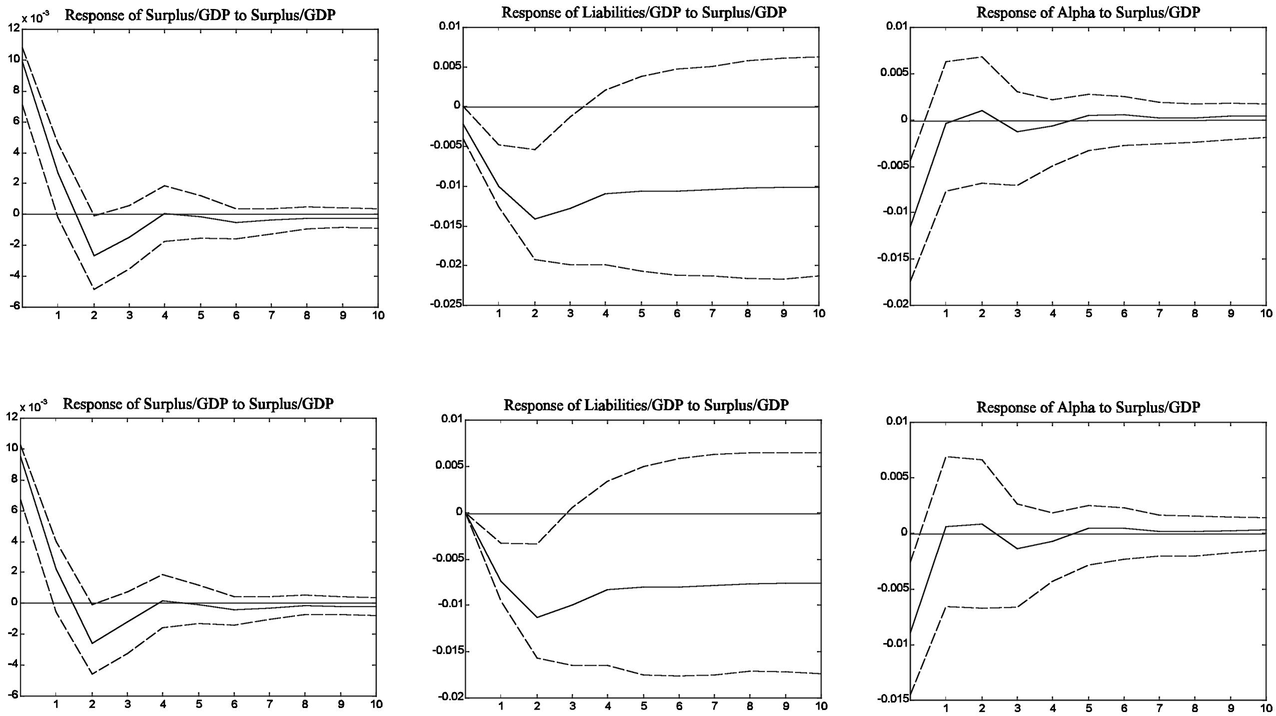
Scale for Debt/GDP and Liabilities/GDP is on the right.

Figure 3: VAR in Surplus/GDP and Liabilities/GDP



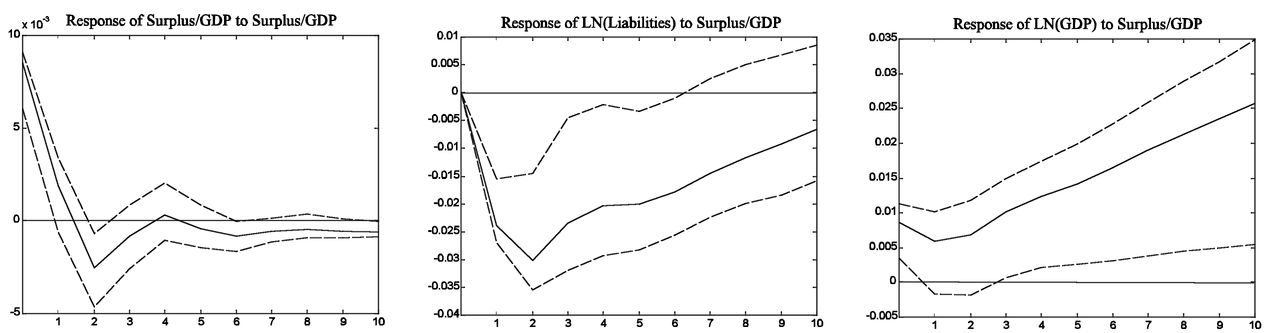
VAR is estimated with two lags and a constant over the sample 1951-1995.
Standard error bounds estimated with bias-adjusted bootstrap procedure.
Top panel ordering, Surplus/GDP, Liabilities/GDP.
Bottom panel ordering, Liabilities/GDP, Surplus/GDP.

Figure 4: VAR in Surplus/GDP, Liabilities/GDP, and Alpha



Notes: VAR is estimated with two lags and a constant over the sample 1951-1995.
Standard error bounds estimated with bias-adjusted bootstrap procedure.
Top panel ordering, Surplus/GDP, Liabilities/GDP, Alpha.
Bottom panel ordering, Liabilities/GDP, Surplus/GDP, Alpha.

Figure 5: VAR in LN(Liabilities), Surplus/GDP, and LN(GDP)



Notes: VAR is estimated with two lags and a constant over the sample 1951-1995.
Standard error bounds estimated with bias-adjusted bootstrap procedure.
Ordering, LN(Liabilities), Surplus/GDP, LN(GDP)

Table 1: Autocorrelations of Surplus/GDP

Lag	Autocorrelation	Q-Statistic	P-Value
1	0.452	9.8084	0.0020
2	0.173	11.274	0.0040
3	0.221	13.74	0.0030
4	0.252	17.022	0.0020
5	0.301	21.797	0.0010
6	0.231	24.698	0.0000
7	0.265	28.611	0.0000
8	0.266	32.652	0.0000
9	0.332	39.132	0.0000
10	0.114	39.914	0.0000
11	-0.068	40.203	0.0000
12	-0.035	40.284	0.0000
13	0.018	40.306	0.0000
14	0.024	40.344	0.0000
15	0.027	40.396	0.0000

REFERENCES:

Ahmed, Shaghil and Rogers, John. "Government Budget Deficits and Trade Deficits: Are Present Value Constraints Satisfied in Long-Term Data?" Journal of Monetary Economics, November 1995, 36(2), pp. 351-74.

Auernheimer, Leonardo and Contreras, Benjamin. "Control of the Interest Rate with a Government Budget Constraint: Determinacy of the Price Level, and Other Results." Mimeo, Texas A&M University, 1990.

Barclays de Zoete Wedd, The Rate Reference Guide: U.S. Treasury Market, 1992-1995.

Benhabib, Jess; Schmitt-Grohe, Stephanie and Uribe, Martin. "Monetary Policy and Multiple Equilibria." Mimeo, 1998, forthcoming in American Economic Review.

Bergin, Paul. "Fiscal Solvency and Price Level Determination in a Monetary Union." Journal of Monetary Economics, February 2000, 45(1), pp. 37 - 55.

Bohn, Henning. "Budget Balance through Revenue or Spending Adjustments? Some Historical Evidence for the United States." Journal of Monetary Economics, June1991, 27(3), pp. 333-59.

______. "The Behavior of U.S. Public Debt and Deficits." Quarterly Journal of Economics, August 1998, 113(3), pp. 949-63.

Brayton, Flint and Tinsley, Peter. "A Guide to FRB/US: A Macroeconometric Model of the United States." Working paper FEDS no. 66, Federal Reserve Board, 1996.

Buiter, Willem. "Neutrality, Price Level Indeterminacy, Interest Rate Pegs, and Fiscal Theories of the Price level." mimeo, 1997.

Canzoneri, Matthew and Behzad Diba. "Fiscal Constraints on Central Bank Independence and Price Stability," in J. Malo de Molina, J. Vinals, F. Gutierrez, eds., Monetary Policy and

Inflation in Spain. London: MacMillan, 1998, pp. 175-99.

Canzoneri, Matthew; Cumby, Robert and Diba, Behzad. "Fiscal Discipline and Exchange Rate Regimes." Working paper, Georgetown University, 1997a, forthcoming in Economic Journal.

______. "Does Monetary or Fiscal Policy Provide a Nominal Anchor?: Evidence from the OECD Countries." Working paper, Georgetown University, 1997b.

Christiano, Lawrence and Fitzgerald, Terry. "Understanding the Fiscal Theory of the Price Level." National Bureau of Economic Research (Cambridge, MA) Working paper no. 7668, April 2000.

Christiano, Lawrence; Eichenbaum, Martin and Evans, Charles. "Monetary Policy Shocks: What Have We Learned and to What End?" in John Taylor and Michael Woodford, eds., Handbook of Macroeconomics. New York: North Holland, 1999, pp. 65-148.

Cochrane, John. "A Frictionless View of US Inflation." NBER Macroeconomics Annual, 1998, pp. 323-84.

______. "Long Term Debt and Optimal Policy in the Fiscal Theory of the Price Level." Econometrica, January 2001, 69(1), pp. 69-116.

Daniel, Betty. "The Viability of a Fixed Exchange Rate Regime." Mimeo, State University of New York, Albany, 1996.

Dupor, Bill. "Exchange Rates and Bank Notes: The Fiscal Theory of the Price Level." Mimeo, University of Pennsylvania, 1997.

______. "Exchange Rates and the Fiscal Theory of the Price Level." Journal of Monetary Economics, June 2000, 45(3), pp. 613-30.

Hamilton, James and Flavin, Marjorie. "On the Limitations of Government Borrowing: A

Framework

for Empirical Testing." American Economic Review, September 1986, 76(4), pp. 808-19.

Henderson, Dale and McKibbin, Warwick. "A Comparison of Some Basic Monetary Policy Regimes for Open Economies: Implications of Different Degrees of Instrument Adjustment and Wage Persistence." Carnegie-Rochester Series on Public Policy, December 1993, 39(0), pp. 221-317.

Kilian, Lutz. "Small-Sample Confidence Intervals for Impulse Response Functions." Review of Economics and Statistics, May1998, 80(2), pp. 652-60.

Kremers, Jeroen. "U.S. Federal indebtedness and the Conduct of Fiscal Policy." Journal of Monetary Economics, March 1989, 23(2), pp. 219-38.

Leeper, Eric. "Equilibria Under Active and Passive Monetary Policies." Journal of Monetary Economics, February 1991, 27(1), pp. 129-47.

Loyo, Eduardo. "Going International with the Fiscal Theory of the Price Level." Mimeo, Princeton University, 1997.

______. "The Wealth Effects of Monetary Policy and Brazilian Inflation." Mimeo, Princeton University, 1998.

Masson, Paul. "The Dynamics of a Two-Country Minimodel Under Rational Expectations." Annales d'Economie et de Statistique, April/September 1987, 0(6/7), pp. 37-69.

McCallum, Bennett. "Issues in the Design of Monetary Policy Rules." National Bureau of Economic Research (Cambridge, MA) Working paper no. 6016, April 1997.

McCulloch, J. Huston and Kwon, Heon-Chul. "U.S. Term Structure Data, 1947-1991." Working paper no. 93-6, Ohio State University, 1993.

Obstfeld, Maurice and Rogoff, Kenneth. Foundations of International Economics. Cambridge, MA:

MIT Press, 1996.

Rudin, Walter. Principles of Real Analysis (Third Edition). New York: McGraw-Hill, 1976.

Sargent, Thomas and Wallace, Neil. “Some Unpleasant Monetarist Arithmetic.” Quarterly Review (Federal Reserve Bank of Minneapolis), Fall 1981, pp. 1-17.

Sargent, Thomas. Rational Expectations and Inflation. New York: Harper and Row, 1986.

________. Dynamic Macroeconomic Theory. Cambridge, MA: Harvard University Press, 1987.

Schmitt-Grohe, Stephanie and Uribe, Martin. “Price Level Determinacy and Monetary Policy under a Balanced-Budget Requirement.” Journal of Monetary Economics, February 2000, 45(1), pp. 211-46.

Sims, Christopher. “A Simple Model for Study of the Price Level and the Interaction of Monetary and Fiscal Policy.” Economic Theory, 1994, 4(3), pp. 381-99.

______. “Econometric Implications of the Government Budget Constraint.” Mimeo, Yale University 1995.

______. “Fiscal Foundations of Price Stability in Open Economies.” Mimeo, Yale University, 1997.

______. “The Precarious Fiscal Foundations of EMU.” Mimeo, Yale University,1998.

Woodford, Michael. “Monetary Policy and Price Level Determinacy in a Cash-in-Advance Economy.” Economic Theory, 1994, 4(3), pp. 345-80.

______. “Price Level Determinacy without Control of a Monetary Aggregate.” Carnegie Rochester Conference Series on Public Policy, December 1995, 43(0), pp. 1-46.

______. “Doing Without Money: Controlling Inflation in a Post-Monetary World.” Review of Economic Dynamics, January 1998a, 1(1), pp. 173-219.

______. “Public Debt and the Price Level.” Mimeo, Princeton University, 1998b.

______. “Comment on Cochrane's 'A Frictionless View of US Inflation'.”, NBER

Macroeconomics Annual,1998c, pp. 390-418.

______. “Control of the Public Debt: A Requirement for Price Stability?” in Guillermo Calvo and Mervyn King, eds., The Debt Burden and its Consequences for Monetary Policy. New York: St. Martin's Press, 1998d, pp. 117-54.

______. “Fiscal Requirements for Price Stability.” Mimeo, Princeton University, 2000, forthcoming in Journal of Money Credit and Banking.

ENDNOTES:

*Georgetown University. Comments from Paul Bergin, John Cochrane, Betty Daniel, Roger Farmer, Herschel Grossman, Berthold Herrendorf, Roger Lagunoff, Eric Leeper, Nelson Mark, Kenneth Rogoff, Matthew Shapiro, Javier Valles, and Michael Woodford and from seminar participants at Berkeley, Brown, Georgetown, MIT, Ohio State, Pompeu Fabre, the Bank of England, and the IMF are acknowledged with thanks. Two referees provided particularly helpful suggestions.

1. See Cochrane (1998, 2001), Woodford (1994, 1995, 1998a,b,c,d, 2000) and Sims (1994, 1995, 1997, 1998). These papers were preceded by Auernheimer and Contreras (1990) and Leeper (1991). And, the theory has its critics: Buiter (1997) and McCallum (1997). Other recent contributions include: Benhabib, Schmitt-Grohe and Uribe (1998), Bergin (2000), Canzoneri and Diba (1998), Canzoneri et ali (1997a, b), Christiano and Fitzgerald (2000), Daniel (1996), Dupor (1997, 2000), Loyo (1997, 1998), Schmitt-Grohe and Uribe (2000).

2. This literature is reminiscent of Sargent and Wallace's celebrated papers (Sargent and Wallace (1981) and Sargent (1986)) on "Unpleasant Monetarist Arithmetic." In our view, their "fiscal leadership"corresponds in spirit to an NR regime; however, there is not a one to one relationship between the two notions. For example, even with "fiscal leadership" in setting taxation and spending, central bank transfers could in theory respond to the level of the debt in a way that satisfies the present value budget constraint and places the economy in an R regime. It is interesting to note that Sargent and Wallace (1981) speculated that the US and other major industrial countries have exhibited "fiscal leadership" for some time.

3. The names of the regimes derive from the fact that government bonds are net wealth in NR regimes; see Woodford (1995). In Canzoneri and Diba (1998), and in earlier versions of this paper, we called R regimes "Money Dominant" and NR regimes "Fiscal Dominant"; this

terminology derives from the fact that monetary policy serves as the nominal anchor in R regimes, while fiscal policy is the nominal anchor in NR regimes.

4. For example, the Federal Reserve Board's model – FRB/US – assumes an endogenous tax policy that appears to ensure that the budget constraint is always satisfied; Brayton and Tinsley (1996) provide a guide to FRB/US.

5. See Auernheimer and Contreras (1990), Leeper (1991), Henderson and McKibbin (1993) and Woodford (1998a), for further discussion of when the price level is – or is not – uniquely determined under various assumptions about monetary targeting and fiscal policy.

6. The fiscal constraints written into the Maastricht Treaty, and perpetuated by the Stability and Growth Pact, can also be rationalized in this way. For example, Canzoneri and Diba (1998) show that the 3% deficit rule would assure an R regime. Woodford (1998d) discusses the 60% cap on the debt to GDP ratio from this perspective.

7. This identification problem makes it difficult to assess Henning Bohn's (1998) finding that the surplus to GNP ratio responds positively to the debt to GNP ratio in the post war period (1948-1989) once temporary government spending and cyclical effects have been accounted for. Although Bohn does not discuss R and NR regimes directly, his finding would constitute evidence in favor of an R regime if we were to assume that his regression equation had properly identified a policy reaction function. As Woodford (1998c) observes, however, the relationship estimated by Bohn could also represent the behavior of the debt to GNP ratio, which anticipates surplus shocks in an NR regime.

8. It should be emphasized that this approach to price determination is not limited to models with flexible prices. Prices can be "sticky" or even "fixed." See Woodford (1998d).

9. Our formulation of the analysis differs from Woodford's (1995) only in that (for empirical

purposes) we deflate liabilities by GDP instead of the price level. This difference only entails algebraic manipulation of Woodford's setup; his arguments extend directly to our formulation.

10. Ahmed and Rogers (1995) provide a recent contribution and a list of references to this literature.

11. See in particular Woodford (1995). The condition must hold as a result of households' utility maximization. One way of making the point is to note that the second expression in (4) follows from the households' transversality condition. Another way to make the point is to use Walras' Law. Households' satisfy their present value budget constraints, so (in a closed economy) the government's present value constraint can be derived from the households' constraint and the goods market equilibrium condition.

12. Cochrane and others have offered the following interpretation: Think of the government debt as equity, and think of the primary surpluses as dividends. When news affects expectations about future dividends, the market value of the asset will change. In our development of the theory, these valuation effects are represented by changes in nominal income.

13. As noted in footnote 10, our analysis differs from Woodford's (1995) in that we have deflated by nominal income instead of the price level. Our definition of the Ricardian and Non-Ricardian regimes differs slightly from Woodford's for exactly the same reason.

14. We are referring to the "ratio test" for convergence of infinite series [see, for example, Rudin (1976), Theorem 3.34].

15. See Sargent's (1987) discussion of solving unstable roots forward and taking the "no speculative bubbles" solution.

16. This case of a "large" fiscal response is the analogue in our setup to Leeper's (1991) regime with "active monetary and passive fiscal policy."

17. This point has been noted in various contexts in earlier versions of Bohn's (1998) paper, in Woodford (1998d), and in Obstfeld and Rogoff (1996).

18. An increase in s_t has two offsetting effects on w_{t+1}. First, a one unit increase in s_t increases w_t by one unit due to a debt revaluation effect which operates through a change in nominal income. Then, the one unit increase in s_t pays off debt, reducing w_{t+1} by one unit.

19. Kilian presents Monte Carlo evidence that adjusting the VAR coefficients before bootstrapping greatly improves the small-sample performance of the impulse response function standard errors. His results suggest that this improvement applies to VARs that include nonstationary variables. This may be useful in our case. Although we are able to reject a unit root in both surplus/GDP and liabilities/GDP, the evidence is stronger for the first of these two. In addition, in section III, we consider VARs that include nonstationary variables.

20. Note that this observation also precludes a political theory based on concerns about the ratio of the total deficit (inclusive of interest payments) to GDP, such as the three percent cap on the deficit to GDP ratio imposed by the Maastricht Treaty and the Stability and Growth Pact for the European Community; as noted earlier, this would result in an R regime. The politicians' focus has to be on primary surpluses, which does not often seem to be the case.

21. Pictures of these impulse response functions are available from the authors on request.

22. More generally, the surplus process can't be just anything. The sum of discounted future surpluses has to be expected to converge. That is the reason for condition C2 in our proposition.

23. Our discussion in this paper has side stepped the possibility that the present value budget constraint, (4), does not bind because the real interest rate is below the economy’s growth rate. We are currently working on a model that allows for this possibility by attributing liquidity services to government bonds.