FISCAL DISCIPLINE AND EXCHANGE RATE SYSTEMS*

by

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ABSTRACT

This paper examines the implications of a new theory of price determination (due to Leeper, Sims, and Woodford) for the maintenance of various exchange rate systems and common currency areas. It shows that deeper monetary integration requires the fiscal discipline of what Woodford calls a *Ricardian regime*; that is, the government must guarantee fiscal solvency for any sequence of prices or exchange rates. Monetary policy alone can control the expected rate of inflation (or depreciation), but in Non-Ricardian regimes monetary policy can not control the variability of prices (or exchange rates) in countries where seigniorage revenues are negligible. Particularly striking results are that a currency peg is simply not credible unless fiscal policy has the discipline of a Ricardian regime, and a common currency area is not viable if fiscal policy in two (or more) of the countries in the union is Non-Ricardian. Interestingly, the constraints written into the Maastricht Treaty (and continuing in the Stability and Growth Pact) are sufficient conditions for a Ricardian regime.

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I. INTRODUCTION

Conventional macroeconomic models emphasize the monetary nature of exchange rate determination. According to this view, fixed rate systems constrain monetary policies without significantly impinging upon the autonomy of fiscal policies. These conventional views about exchange rate determination are intimately linked to a presumption that central banks are able to control their national price levels. Recent contributions by Christopher Sims, Michael Woodford and others have challenged this presumption by emphasizing the role of fiscal policy in price determination.¹ In this paper, we draw on our own work and a selective review of the literature, to assess the implications of this new fiscal theory of price determination (or FTPD, for short) for the maintenance of various exchange rate systems. We ask what it takes for the central bank to be able to meet an exchange rate target on average (or in expected value), what it takes for the central bank to be able to limit the variance of the exchange rate around its target, and finally what it takes to actually peg the exchange rate at its target. We consider unilaterally maintained exchange rate systems (like the Dutch peg to the DM), and we consider multilaterally maintained systems (like the EMU). Our basic message is that tighter monetary integration requires more fiscal discipline, and allows less autonomy in the setting of national fiscal priorities, than is commonly perceived.

A fundamental insight of the FTPD is that the public sector's present value budget constraint (PVBC) should in fact be viewed as an equilibrium condition. The private sector's optimizing behavior implies that the real value of the nominal liabilities issued by the government is equal to the expected present value of current and future primary surpluses. If fiscal policy does not ensure this equality, then the price level must do so; that is, the equilibrium price level has to make the real value of current government liabilities equal to the expected present value of current and future surpluses.

In a *Ricardian* (R) regime, fiscal policy has discipline in the sense that current and/or future primary surpluses are actively adjusted to satisfy the government's PVBC for any real value of current government liabilities. In this regime, monetary policy provides the nominal anchor, and the price level is determined in a conventional manner.² By contrast, in a *non-Ricardian* (NR) regime, primary surpluses are not actively adjusted to guarantee fiscal solvency; for present purposes, we can think of these surpluses being determined by an exogenous political process.³ In this regime, the price level is determined by the PVBC, the central bank targets the nominal interest rate, and the money supply adjusts to maintain equilibrium in the money market.⁴ NR regimes lack fiscal discipline in the sense that the fiscal authority does not actively try to satisfy its PVBC, but they do not necessarily imply that fiscal policy is irresponsible. For example, a fiscal policy that holds primary surpluses at a fixed fraction of GDP is NR.⁵

In summary, monetary policy serves as the nominal anchor in R regimes, and conventional views of exchange rate determination prevail. Fiscal policy serves as the nominal anchor in NR regimes, and unconventional results can emerge. NR regimes will be the focus of our attention throughout the paper, since that is where the surprises come in the FTPD.

In NR regimes, it seems natural to presume – as did Sims (1997) – that an extension of the FTPD to a model with two countries and a single good would imply that the nominal exchange rate is determined by fiscal policy. However, Dupor (2000) and Loyo (1997) show that this presumption is not always correct. Their extensions of the FTPD leave the exchange rate and the cross-country allocations of wealth and consumption indeterminate. In section II, we present a simple model in which the exchange rate is determined by fiscal policy, and we relate it to the existing literature.⁶ We also identify a class of fiscal policies that can be counted on to produce R regimes. This will be

useful in the discussion that follows. Since we argue that tighter forms of monetary integration require the discipline of an R regime, it will be useful to know what kinds of constraints on fiscal policy provide the necessary discipline.

Section III studies exchange rate systems that are unilaterally imposed and maintained. We show that even in an NR regime, the central bank's interest rate policy determines the expected rate of depreciation (or inflation). But, we also show that the central bank loses control of the variability of the exchange rate around its expected path in countries where seigniorage accounts for a small percentage of total tax revenues. The reason for this is that fiscal policy serves as the nominal anchor in an NR regime. Our claim that the central bank can target the expected rate of inflation may seem to contradict Cochrane's (1998) analysis, which focuses on how fiscal policy determines the inflation rate. And our claim may also seem to contradict some of the simulations reported in Woodford (1996). We will discuss these issues in Section III.

Section IV analyzes fixed pegs that are unilaterally imposed and maintained. We show that the central bank's interest rate policy is incapable of enforcing a peg in an NR regime; the central bank has to have help from the fiscal authority. The inability of the central bank to target the exchange rate is more severe than what may be surmised from closed economy models.⁷ In a closed economy, the central bank can conceivably use its leverage over seigniorage revenues to offset the effects of (small) fiscal shocks on the price level; also in models with long term debt [Cochrane (1999a) and Woodford (1998b)], changes in the interest rate would affect the price level through changes in the market value of outstanding bonds. By contrast, with a unilaterally pegged exchange rate, the "interest parity condition" constrains the central bank's choice of the interest rate; this puts the entire onus of maintaining equilibrium in the goods market on fiscal policy. In effect, we show

that fiscal policy has to have the discipline of an R regime for the peg to be credible. This striking result has a number of important implications that are discussed in the conclusion.

Section V draws on the basic results of Section IV to make some points about models with centralized monetary policy and decentralized fiscal policy (such as the EMU or the US system, with its federal, state and local fiscal authorities). Bergin (2000) and Woodford (1996) have used richer models than ours to discuss EMU, and we need not duplicate their results.⁸ Our remarks deal with the consequences of a restriction that rules out Ponzi games between fiscal authorities. Such a constraint implies that each fiscal authority's PVBC must be individually satisfied in equilibrium. But the common price level cannot move to satisfy more than one PVBC. We will argue that a monetary union with more than one NR fiscal authority is untenable. It leads to what, in a different context, Sargent and Wallace call a "game of chicken".⁹

From a policy perspective, it is interesting to know what kinds of fiscal constraints assure us that an R regime will prevail. In section V, we also show that the constraints written into the Maastricht Treaty (and the Stability and Growth Pact) are precisely the sort of rules that assure an R regime. If the constraints are expected to be occasionally binding, they avoid the issues raised in this paper and confirm the conventional wisdom about monetary policy and exchange rate systems.

Section VI evaluates the significance of the results derived in this paper. The implications of NR regimes (for what monetary policy can or cannot do) are dramatically different from the conventional views of central bankers. The inevitable conclusion is either that most central banks do not operate in NR regimes in reality, or else that a fundamental rethinking of the conventional wisdom is in order. We will articulate the issues that we consider most pertinent for this judgement call, and we will suggest new directions for theoretical and empirical work on the question.

II. THE FISCAL THEORY OF EXCHANGE RATE DETERMINATION

We rely on Lucas's (1982) approach of assuming complete financial markets to make our stochastic two country model analytically tractable, and we follow Woodford's (1995) development of the new theory of price determination. Consider a two country model with a single (or world) representative household, a single consumption good, and perfect capital mobility.¹⁰ In period t , the household maximizes the expected utility derived from consumption and liquidity services:

$$(1) \quad U_t \equiv E_t \sum_{k=t}^{+\infty} \beta^{k-t} \left[u(c_{1,k} + c_{2,k}) + v\left(\frac{M_{1,k+1}}{p_{1,k}}\right) + v\left(\frac{M_{2,k+1}}{p_{2,k}}\right) \right], \quad 0 < \beta < 1,$$

where E_t is the conditional expectations operator. $c_{j,k}$ is the household's consumption of goods produced in country j during period k ; $p_{j,k}$ is the currency- j price of consumption goods; and $M_{j,k+1}/p_{j,k}$ is the stock of country- j real money balances.¹¹ All stocks (monies and bonds) are specified as beginning of the period balances. So, for example, $M_{1,k+1}$ is the stock of country-1 money at the beginning of period $k+1$. It is also the total stock of money that was available in period k (after new injections by the central bank), and $M_{1,k+1}/p_{1,k}$ is therefore the real stock of country-1 money that provides liquidity services during period k .

The household's budget constraint for period k is:

$$(2) \quad p_{1,k}c_{1,k} + e_k p_{2,k}c_{2,k} + M_{1,k+1} + e_k M_{2,k+1} + \frac{B_{1,k+1}}{(1+i_{1,k})} + \frac{e_k B_{2,k+1}}{(1+i_{2,k})} + p_{1,k}\tau_{1,k} + e_k p_{2,k}\tau_{2,k} \\ \leq M_{1,k} + e_k M_{2,k} + B_{1,k} + e_k B_{2,k} + p_{1,k}y_{1,k} + e_k p_{2,k}y_{2,k},$$

where e_k is the nominal exchange rate; $B_{j,k}$ is the face value of country- j bonds maturing in period

$i_{j,k}$ is the nominal interest rate on these bonds; $\tau_{j,k}$ is the tax levied by government j ; and $y_{j,k}$ is the household's income from goods produced in country j . We assume that output in each country, $\{y_{j,k}\}$, is generated by an exogenous stochastic process. (2) says that the household's consumption and acquisition of new assets must not exceed the value of its initial assets plus its disposable income.

The representative household maximizes (1) subject to (2) over non-negative values of $c_{1,t}$, $c_{2,t}$, $M_{1,t+1}$, $M_{2,t+1}$, $B_{1,t+1}$ and $B_{2,t+1}$. The first order conditions for this optimization problem imply:

$$(3) \quad p_{1,t} = e_t p_{2,t},$$

$$(4) \quad v' \left(\frac{M_{j,t+1}}{P_{j,t}} \right) = u'(c_t) \left(\frac{i_{j,t}}{1 + i_{j,t}} \right),$$

$$(5) \quad \frac{1}{1 + i_{j,t}} = E_t \left[\alpha_t \left(\frac{P_{j,t}}{P_{j,t+1}} \right) \right].$$

for $j = 1, 2$. $\alpha_t \equiv \frac{\beta u'(c_{t+1})}{u'(c_t)}$ is the intertemporal rate of substitution, or discount factor, and

$c_t \equiv c_{1,t} + c_{2,t}$ denotes total consumption. Equation (3) is the familiar purchasing power parity (PPP) condition.¹² Equation (4) says that the marginal utility of increased liquidity services has to be offset by the marginal disutility of foregone consumption (due to holding more real balances instead of bonds). Since $u(\cdot)$ and $v(\cdot)$ are concave functions, (4) can be rewritten as a “money demand” function:

$$(6) \quad \frac{M_{j,t+1}}{P_{j,t}} = h(i_{j,t}, c_t),$$

where $h_1 < 0$ and $h_2 > 0$. (5) is an Euler equation required for the optimal intertemporal smoothing of consumption.

Consumption goods are perishable; so, in equilibrium, we have:

$$(7) \quad c_{j,t} + g_{j,t} = y_{j,t},$$

for $j = 1, 2$. $g_{j,t}$ is spending by government j ; it falls entirely on the production of country j . We assume that the sequences $\{g_{j,k}\}$, like the sequences $\{y_{j,k}\}$, follow exogenous stochastic processes. In equilibrium, these processes fully determine the world consumption of goods produced in country j , $c_{j,t}$. This in turn determines total world consumption, $c_t \equiv c_{1,t} + c_{2,t}$, and the equilibrium discount factor, α_t .¹³

The flow budget constraint of government j in period k is:

$$(8) \quad (M_{j,k+1} - M_{j,k}) + \frac{B_{j,k+1}}{(1 + i_{j,k})} + p_{j,k} \tau_{j,k} = B_{j,k} + p_{j,k} g_{j,k}.$$

(8) says that money creation, borrowing and taxation must finance government purchases and the maturing debt. It is convenient to rewrite (8) in terms of total government liabilities as:

$$(9) \quad \frac{M_{j,k+1} + B_{j,k+1}}{1 + i_{j,k}} = M_{j,k} + B_{j,k} - p_{j,k} (s_{j,k} + \theta_{j,k}),$$

where $\theta_{j,t} \equiv \left(\frac{M_{j,t+1}}{p_{j,t}} \right) \left(\frac{i_{j,t}}{1 + i_{j,t}} \right)$ represents transfers from the central bank to the fiscal authority, or seigniorage,¹⁴ and where $s_{j,t} \equiv \tau_{j,t} - g_{j,t}$ is the primary surplus, exclusive of central bank transfers.

Using (5) in (9), we get:

$$(10) \quad \frac{M_{j,k} + B_{j,k}}{p_{j,k}} = E_k \left[\alpha_k \left(\frac{M_{j,k+1} + B_{j,k+1}}{p_{j,k+1}} \right) \right] + s_{j,k} + \theta_{j,k},$$

And, iterating (10) forward, we have:

$$(11) \quad \frac{B_{j,t} + M_{j,t}}{p_{j,t}} = s_{j,t} + \theta_{j,t} + E_t \left(\sum_{n=t+1}^{+\infty} \left[\prod_{k=t}^{n-1} \alpha_k \right] [s_{j,n} + \theta_{j,n}] \right) + \lim_{n \rightarrow +\infty} E_t \left[\left(\prod_{k=t}^{t+n-1} \alpha_k \right) \left(\frac{B_{j,t+n} + M_{j,t+n}}{p_{j,t+n}} \right) \right],$$

assuming that the relevant limits exist.

Present value budget constraints are at the heart of the FTPD. To pin down the government constraints, (11), we must determine the two limit terms. To do this, we need to make assumptions about public and private borrowing in the limit (as $t \rightarrow \infty$). Even when government behavior is not modeled explicitly, it is traditional to assume that no government will allow agents in the private sector to run a Ponzi scheme on it. (Some such assumption must be made if the household's maximization problem is to have a finite solution.) This is often done by assuming that government debt – money plus bonds – is non-negative, each and every period. While this assumption is stronger than necessary, it does not limit our discussion, and we will make it here.

The next assumption we make is more controversial, and it will affect our results in several important ways. We assume that no government will allow another government to run a Ponzi scheme on it. In fact, this assumption is implicit in the way we have written the flow budget constraints, (8): neither government purchases the other government's debt.¹⁵ Short of articulating an optimizing model of government behavior, we have no formal grounds for asserting that one government will not lend indefinitely to another. We strongly suspect that a broad class of models

incorporating explicit government objective functions would imply just that.¹⁶ However, a number of recent studies have not made this assumption, and the implications are more far reaching than one might at first imagine. We will return to this issue at the end of the section.

Since no government will allow agents in the private sector to run Ponzi scheme on it, the household's optimization problem implies a transversality condition which can be written as:

$$(12) \quad \lim_{n \rightarrow +\infty} \beta^n E_t u'(c_{t+n}) \left[\frac{B_{1,t+n} + M_{1,t+n}}{p_{1,t+n}} + \frac{B_{2,t+n} + M_{2,t+n}}{p_{2,t+n}} \right] = 0,$$

Since neither government's debt can be negative, this transversality condition can be split in two:

$$(13) \quad \lim_{n \rightarrow +\infty} \beta^n E_t u'(c_{t+n}) \left[\frac{B_{j,t+n} + M_{j,t+n}}{p_{j,t+n}} \right] = \lim_{n \rightarrow +\infty} E_t \left[\left(\prod_{k=t}^{t+n-1} \alpha_k \right) \left(\frac{B_{j,t+n} + M_{j,t+n}}{p_{j,t+n}} \right) \right] = 0,$$

where $j = 1, 2$. (The definition of α_k has been used in deriving the first equality.)

Using (13) in (11), we get the present value budget constraint (PVBC) of government j :

$$(14) \quad \frac{B_{j,t} + M_{j,t}}{p_{j,t}} = s_{j,t} + \theta_{j,t} + E_t \left(\sum_{n=t+1}^{+\infty} \left[\prod_{k=t}^{n-1} \alpha_k \right] [s_{j,n} + \theta_{j,n}] \right).$$

The PVBC says that the real value of the beginning of period debt must be equal to the expected present discounted value of primary surpluses (inclusive of central bank transfers). Following Hamilton and Flavin (1986), a growing literature has tried to test the PVBC empirically; this literature interprets the results as a test of government solvency.¹⁷ By contrast, the FTPD treats (14) as an equilibrium condition – derived from the household's transversality condition – that must be

satisfied. The fundamental question becomes: how does the PVBC get satisfied in equilibrium, and how do we solve the model?

There are a number of possibilities. First, there may be an endogenous fiscal policy that makes the sequence $\{s_{j,k} + \theta_{j,k}\}$ satisfy the PVBC, no matter what values the discount factors, $\{\alpha_j\}$, or the initial debt, $(M_{j,t} + B_{j,t})/p_{j,t}$, take in equilibrium. A second possibility is that $\{s_{j,k} + \theta_{j,k}\}$ is an arbitrary sequence – determined for example by political factors. Then, the RHS of (14) is fixed, and the real value of existing debt, $(M_{j,t} + B_{j,t})/p_{j,t}$, must adjust in equilibrium to satisfy the PVBC;¹⁸ nominal liabilities, $M_{j,t} + B_{j,t}$, are fixed at the beginning of the period, but a “jump” in $p_{j,t}$ can generate a change in the ratio.¹⁹ Of course, in either case, the sequence of equilibrium prices must also be consistent with the PPP equation (3), the Euler equations (5), and the money market equations (6) (recalling that c_t and α_t have already been determined by the exogenous sequences $\{y_{j,t}\}$ and $\{g_{j,t}\}$).

Since PPP holds in our model, the determinacy of the nominal exchange rate hinges on the determinacy of the two price levels. And since the model is symmetric across countries, we might as well assume that prices in terms of currency 2 are somehow pinned down and focus on the determination of currency-1 prices for the remainder of this section. We are now ready to define the Ricardian (R) and Non-Ricardian (NR) regimes formally.

Ricardian Regimes –

In R regimes, the fiscal authority actively pursues solvency. More precisely, Woodford (1995) defines an R regime as one in which, given any price sequence, the sequence of primary surpluses adjusts to satisfy the PVBC. For the economy to have a nominal anchor in an R regime, the central bank must either set its money supply directly or its feedback rule for setting the interest

rate must be sufficiently “active” to pin down a unique price sequence.²⁰ Given a nominal anchor set by monetary policy, the price level is determined, and the PPP equation (3) determines the exchange rate.

Non-Ricardian Regimes –

In NR regimes, the fiscal authority does not actively pursue solvency. For our purposes, it is sufficient to think of an NR regime as one in which primary surpluses (inclusive of central bank transfers) follow an exogenous stochastic process.²¹ In NR regimes, the central bank can set the nominal interest rate without providing a nominal anchor. The central bank’s interest rate policy fixes central bank transfers; the PVBC determines the price level;²² and money supplies adjust to satisfy the money market equations (6). It can be shown that the prices set by the PBVC are consistent with the inflation forecasts in the Euler equation (5) (see the appendix). Finally, the PPP equation pins down the exchange rate.

A Class of Fiscal Policies that Result in R Regimes –

In what follows, it will be interesting to know what kind of constraint on fiscal policy will assure an R regime; a result found in Canzoneri, Cumby and Diba (1999) is useful in this regard. Canzoneri, Cumby and Diba identify a broad class of fiscal policies that bring about R regimes. Consider fiscal policies of the form:

$$(15) \quad s_{j,t} + \theta_{j,t} = \gamma_{j,t} \left(\frac{B_{j,t} + M_{j,t}}{P_{j,t}} \right) + \epsilon_t,$$

where $\gamma_{j,t} \geq 0$ and ϵ_t is a random shock (which may be correlated with other economic variables like output). (15) says that the primary surplus (inclusive of seigniorage revenue) responds positively

to the level of the debt whenever $\gamma_{j,t}$ is positive. Canzoneri, Cumby and Diba show that (given some regularity conditions) (15) results in a R regime if $\gamma_{j,t}$ is positive infinitely often. The basic intuition for their result is straightforward: R regimes need to rule out Ponzi schemes in which government debt is simply rolled over each year, and the level of debt grows as fast as the real rate of interest. Whenever $\gamma_{j,t}$ is positive, some of the debt is retired, and if this happen repeatedly over time, debt will not grow as fast as the real rate of interest. The Canzoneri, Cumby and Diba requirement is actually quite lax. Fiscal policy need not respond to the level of debt every year. In theory, the response might be every other year, every decade, or every century. Of course, the policy has to be credible. We will return to this discussion in Section V.

Other Extensions of the FTPD –

Our extension of the FTPD to open economies preserves the original message of the closed economy models: the price level and the exchange rate are uniquely determined by fiscal policy in NR regimes. Dupor (2000) and Loyo (1997) consider other extensions of the FTPD in which money supplies, price levels and the exchange rate are left indeterminate in NR regimes. Moreover, this nominal indeterminacy leads to real indeterminacy in their models: domestic and foreign households have different initial holdings of nominal assets; so, the price level indeterminacy leads to indeterminacy in the real values of wealth and consumption in the two countries.²³

How does our model rule out nominal indeterminacy? The key restriction that leads to our result – and where we differ with Dupor (2000) and Loyo (1997) – is that we assume governments can not run Ponzi schemes on each other. As we have seen, this restriction ensures that each fiscal authority faces its own PVBC (14). Given these distinct PVBCs, the two price levels and the exchange rate are uniquely pinned down in NR regimes. Dupor (2000) and Loyo (1997) allow one

government to borrow indefinitely from the other. This in effect allows them to aggregate the two separate government budget constraints into one consolidated budget constraint. Applying the household transversality condition, (12), they then arrive at a single present value budget constraint for the consolidated government sector. This reduces the number of equilibrium conditions by one, and gives them their indeterminacy result.

In the following sections, we examine the implications of our solution for alternative exchange rate systems. The “no Ponzi game” (NPG) assumption will once again be crucial for our results on monetary unions.

III. MANAGED FLOATS

In this section, we assess the fiscal requirements for a managed float. Managed floats can be defined in various ways. We choose a definition that emphasizes the degree of monetary integration. In the loosest possible managed float, the central bank (perhaps with help from the fiscal authority) simply brings the expected value of the exchange rate in line with an arbitrarily selected target path. In a tighter managed float, the central bank also tries to limit the variance of exchange rate realizations; we associate smaller variances with tighter monetary integration. The basic question here is whether the central bank can define and maintain a given level of monetary integration all by itself, or whether it needs help from the fiscal authority.

In an R regime, prices and exchange rates are determined in a conventional way. Central banks control prices (and interest rates) through the money market equations (6) and the Euler equations (5), and the exchange rate is determined by the PPP equation (3). In a crawling peg or a managed float, there are well known coordination problems between the two central banks, but the

central banks do not need any help from the fiscal authorities. R regimes reflect the conventional wisdom. The new theory of price and exchange rate determination has nothing to add, except to note the importance of an assumption that is often implicit in conventional analyses of exchange rate regimes; that is, there has to be an active fiscal policy assuring that the PVBC is satisfied.

Expected Exchange Rate (or Inflation) Targeting –

Suppose instead that country 1 is in an NR regime. Country 2 could be in either an R regime or an NR regime, but to avoid having to consider the two cases separately we will simply assume that monetary and fiscal policy in country 2 keep its price level fixed; that is, $p_{2,t} = 1$ for all t .²⁴ In this case, PPP implies that $p_{1,t} = e_t$, and currency depreciation is equivalent to inflation. In our set up, expected exchange rate targeting is equivalent to expected inflation targeting.

Since the price level is determined by fiscal policy in an NR regime, the expected rate of inflation must be consistent with both the PVBC (14) and the updated version of (14) which holds at date $t+1$. This may seem to suggest that expected inflation is also pinned down by fiscal policy in an NR regime. But the central bank's ability to set the interest rate also constrains the expected rate of inflation (and therefore the expected rate of devaluation). This fact can be seen by rewriting the Euler equation (5):

$$(16) \quad E_t \left(\frac{p_{1,t}}{p_{1,t+1}} \right) = \left(\frac{1}{E_t \alpha_t} \right) \left[\frac{1}{1 + i_{1,t}} - \text{Cov}_t \left(\alpha_t, \frac{p_{1,t}}{p_{1,t+1}} \right) \right].$$

The covariance term on the right hand side is related to the (inflation) risk premium on nominal bonds.

Because we are dealing with rational expectations equilibria, the expected rate of inflation

implied by (16) must be the same as the one implied by the evolution of the PVBC. Calculations in the appendix confirm this. More to the point, the calculations show that the risk premium on the right hand side of (16) depends on the stochastic process generating future output endowments and future monetary and fiscal policy variables. Given this covariance, however, the central bank can set the nominal interest rate to achieve any desired target for the left hand side of (16).²⁵ Thus, the central bank does not need any direct help from the fiscal authority in maintaining the expected exchange rate (or inflation) target of its choice, even in an NR regime.

Our claim that monetary policy controls expected inflation in an NR regime stands in stark contrast to Cochrane's (1998) analysis, which focuses on how fiscal policy determines inflation. The difference comes from a fundamental difference in our definition of fiscal policy. Following Woodford (1995) and others, we view fiscal policy as setting primary surpluses. Cochrane assumes that fiscal policy sets both the primary surplus and the face value of government liabilities maturing next period.²⁶

To see what Cochrane's view of fiscal policy entails, consider (9) for country 1 at date t . $M_{1,t+1} + B_{1,t+1}$ is the face value of government liabilities maturing at $t+1$, which Cochrane assumes is set by fiscal policy.²⁷ On the RHS of (9), the price level is pinned down by (14); $M_{1,t} + B_{1,t}$ is predetermined in period t ; and the primary surplus is also set by fiscal policy. Under Cochrane's assumptions, a unique value for the interest rate is implied by equation (9). Fiscal policy implicitly determines the interest rate and inflation, and there is no substantive role for monetary policy.

What would happen to Cochrane's fiscal theory of inflation if the fiscal authority implicitly set an interest rate via (9) and the central bank tried to set a different interest rate (perhaps in an attempt to target a different rate of inflation)? The equations of the model would not solve, and a

“game of chicken” would ensue. The outcome of such a game has not (to our knowledge) been analyzed formally.

A useful informal way to think about this may be to ask what the two players can do to enforce their own targets for the interest rate. It is generally conceded that a central bank could set the price of bonds (achieving an implied interest rate target) by standing ready to buy or sell at that price. The central bank has the ability to convert the entire stock of bonds into money; it can also redeem the entire monetary base by disposing of the assets that were acquired when money was created. So, the central bank would seem to have a good bit of leverage over the interest rate. By contrast, the options open to a fiscal authority seem quite limited. Suppose it sets the face value of liabilities on the LHS of (9) and then discovers that the prevailing interest rate is too low or too high for financing the obligations on the right hand side. If the interest rate is higher than what was intended, then the fiscal authority has to either default on its obligations or to issue more debt. If the interest rate is too low, then either some debt must be retired or the surplus must be reduced. So, Cochrane’s assumption that the fiscal authority sets both the face value of its debt and its primary surplus seems unrealistic; it would need the cooperation of the central bank, which would have to accommodate the chosen fiscal policy with an appropriate interest rate.

Our claim that monetary policy controls expected inflation in an NR regime may also seem to contradict some simulations reported by Woodford (1996). Woodford's fundamental contribution in this paper is to analyze NR regimes in a model with price rigidities. Woodford’s model has staggered price setting and a feedback rule for interest rates; the central bank is assumed to respond to inflation by raising the nominal interest rate. The simulations that may seem to contradict our claims show that the central bank’s feedback rule does poorly in offsetting the inflationary effects

of deficit shocks. In fact, the stronger is the response of interest rates to inflation in Woodford's simulations, the worse is the inflationary outcome.

Note that our equation (16) implies that the central bank must cut (not raise) the interest rate to fight expected inflation. This is not surprising for our model with flexible prices. But we suspect that the same may also be true in Woodford's model with sticky prices. To settle the point using Woodford's model, we would have to resort to simulations that we have not pursued. However, Canzoneri and Diba (2000) simplify Woodford's model to one that can be solved analytically.²⁸ Despite the presence of price rigidities, the resulting model shares the implication of the present flexible price model: the central bank can effectively target the expected rate of inflation, but it would have to cut interest rates to fight inflation. We will return to this point in the concluding section.

Limiting the Variance of Exchange Rate Realizations –

Suppose the central bank wants to limit fluctuations in the spot exchange rate. Can it do so without help or cooperation from the fiscal authority? Once again, R regimes tend to reflect the conventional wisdom on these issues, and our focus will be on NR regimes. We continue to assume that country 1 is in an NR regime (and that $p_{2,t} = 1$), and we ask whether the central bank can limit exchange rate fluctuations arising from primary surplus shocks. In the previous section we saw that the central bank can set the expected rate of depreciation. Here, we want to see whether the central bank can achieve a tighter form of monetary integration.

Fiscal policy provides the nominal anchor in an NR regime, and one might speculate that the central bank would lose control of prices and exchange rates in such a regime. Its interest rate policy may determine the expected rate of inflation, but the actual outcome for prices is determined by the

fiscal authority's surplus policy and the PVBC. Of course, monetary policy does have fiscal ramifications. Real balances are determined by the money market equations (6), and the central bank's interest rate policy determines the amount of transfers – $\theta_{1,t} = h(i_{1,t}, c_t) \left(\frac{i_{1,t}}{1+i_{1,t}} \right)$ – it makes to the government each period. In theory, these transfers could be used to control the right hand side of the PVBC, and therefore the price level and the exchange rate. In practice, however, central bank transfers are a small component of the revenue collected in OECD countries today. Can the central bank be expected to work through fiscal policy to control the level of prices and exchange rates?²⁹

To answer this question, we develop an equation that explains how innovations in monetary and fiscal policy are transmitted to prices and exchange rates in an NR regime. Denoting the right hand side of the PVBC by $z_{1,t}$, defining the innovation operator $\delta_t(\cdot)$ by $\delta_t = E_t - E_{t-1}$, and noting that $M_{1,t}$ and $B_{1,t}$ are in the information set of date $t-1$, it is straightforward to show that:

$$(17) \quad \delta_t \left(\frac{P_{1,t-1}}{P_{1,t}} \right) = \left(\frac{P_{1,t-1}}{M_{1,t} + B_{1,t}} \right) \delta_t z_{1,t}.$$

Both surplus innovations, $\delta_t s_{1,t}$, and interest rate innovations, $\delta_t i_{1,t}$, produce innovations in $z_{1,t}$. For example, a negative innovation in fiscal policy – bad news about deficits – produces an unexpected inflation and currency depreciation. The size of these fluctuations depends inversely on the real value of public sector liabilities.³⁰

We can use (17) to get an idea of the magnitude of the effects of surplus innovations on prices and exchange rates; we can also get an idea of the size of the interest rate innovations that would be needed to counteract them. These magnitudes will in general depend upon the autocorrelations and the cross correlations of the variables appearing in $z_{1,t}$. For example, a deficit

innovation will have more than a one to one effect on $\delta_{t,z_{1,t}}$ if it is viewed as the first of a series of deficits associated with a major political swing. Or, a surplus innovation might elicit a lower interest rate from the central bank; that is, a positive $\delta_{t,s_{1,t}}$ might be associated with a negative $\delta_t\theta_{1,t}$ that partially offsets its effect on $\delta_{t,z_{1,t}}$. A serious empirical investigation of these correlations is beyond the scope of the present paper; however, certain broad empirical regularities immediately present themselves.

First, we estimate the size of a typical surplus innovation, $\delta_{t,s_{1,t}}$, and its effect on the RHS of (14), $\delta_{t,z_{1,t}}$. Table 1 presents some helpful data on the G-7 countries. Sample standard deviations in primary surpluses vary from 1 to 3% of GDP, depending on the country, but this may overstate the size of surplus innovations since $\delta_{t,s_{1,t}}$ is a conditional innovation. Standard errors from AR1 regressions are somewhat smaller, varying from 1 to 1.5% of GDP. On the other hand, the autoregressions indicate (positive) persistence in surplus innovations, and this would magnify the effect of a $\delta_{t,s_{1,t}}$ on $\delta_{t,z_{1,t}}$. All things considered, a reasonable benchmark for the magnitude of $\delta_{t,z_{1,t}}$ innovations coming from surplus shocks is probably on the order of 1.5 or 2% of GDP.

Next, we estimate the interest rate innovation that would be needed to offset a $\delta_{t,z_{1,t}}$ of this size, and keep it from passing on to prices and exchange rates, via (14). Interest rate innovations cause innovations in central bank transfers; these two innovations are approximately related by $\delta_t\theta_{1,t} \equiv \left(\frac{M_{1,t+1}}{P_{1,t}} \right) \delta_t \left(\frac{i_{1,t}}{1+i_{1,t}} \right)$. The approximation provides an upper bound on the effectiveness of monetary policy since it abstracts from the inverse relationship between changes in the interest rate and changes in money demand.³¹ Figure 1 shows that money base to GDP ratios in the G-7 have either trended down or held constant over the last 25 years. By 1995 money base in the US, Canada, France and Great Britain was about 5% of GDP; money base in Japan, Italy, and Germany was about

10% of GDP.³²

What would the central bank have to do to offset an unexpected increase in the primary deficit of 1.5 - 2% of GDP? Even with a money base that is 10% of GDP, and an inelastic money demand, the central bank would have to increase its interest rate by 1500 - 2000 basis points to keep the price level constant! Such a policy would surely be infeasible (for reasons that are not modeled here).

Of course, there are reasons to think that these estimates may be biased, one way or the other. The money base used in the calculations is on the high side, and money demand is probably not interest inelastic; these assumptions make our estimates of the required interest rate hike too small. On the other hand, we made a simplifying assumption in specifying the model that makes our estimates too large. We assumed that all government debt matures after one period (a year). In a model with long-term debt [Cochrane (1999a), Woodford (1998b)], an increase in the interest rate would lower the market value of bonds, and help the LHS of the PVBC adjust to a deficit shock.

In any case, our benchmark estimates suggest that the central bank should not be held responsible for price and exchange rate stability in an NR regime. Fiscal policy provides the nominal anchor; price and exchange rate stability is primarily in the hands of the fiscal authority.

IV. FIXED PEGS

In this section, we assess the fiscal requirements for a fixed peg; we regard this as the highest degree of monetary integration, short of a monetary union. R regimes reflect the conventional wisdom on fixed pegs, and once again we focus our attention on NR regimes. We assume that country 1 is in an NR regime, and that country 2 uses its monetary and fiscal policies to keep its price level

fixed at $p_{2,t} = 1$. But now, country 1 is responsible for pegging the exchange rate at $e_t = \bar{e}$. The question here is whether the central bank can choose the parity, $\bar{e}$, and make the peg credible, or whether it needs some kind of commitment from the fiscal authority.

In view of the PPP condition (3), a commitment to peg the exchange rate is equivalent to a commitment to fix the price level; that is, $p_{1,j} = e_t p_{2,j} = \bar{e}$. In the last section, we saw that it was theoretically possible – though difficult in practice – for a central bank to limit exchange rate fluctuations in an NR regime. Here, we will see that it is not even theoretically possible for the central bank to actually peg the exchange rate.

The PVBC, which provides the nominal anchor in an NR regime, requires:

$$(18) \quad \frac{B_{1,t} + M_{1,t}}{\bar{e}} = s_{1,t} + \theta_{1,t} + E_t \left(\sum_{n=t+1}^{+\infty} \left[\prod_{k=t}^{n-1} \alpha_k \right] [s_{1,n} + \theta_{1,n}] \right).$$

Nominal liabilities, $B_{1,t} + M_{1,t}$, are predetermined at the beginning of the period, and the sequence of primary surpluses is not expected to automatically guarantee fiscal solvency in an NR regime. So, the sequence of central bank transfers is all that is left to balance the PVBC. As pointed out in the last section, the central bank could (in theory, anyway) dedicate its interest rate policy to this task. However, that is not possible here. If the exchange rate is to be pegged, then the PPP condition (3) requires inflation rates to converge across countries; and if inflation rates are expected to converge, then the Euler equations (5) imply that the interest rates must equalize. The central bank can not match the foreign country's interest rate policy and, at the same time, satisfy the PVBC.³³

The bottom line is that the central bank cannot maintain a fixed peg in an NR regime without the help of fiscal policy. The central bank's interest rate policy is dictated by the foreign interest

rate, and the fiscal authorities must help by assuring fiscal solvency at a price level that is consistent with PPP.³⁴ But this is tantamount to assuming an R regime.

Our basic result here can be interpreted in two very different ways. First, it may be held that a country lacking the fiscal discipline of an R regime will not have the credibility to maintain a currency peg. Alternatively, it may be held that the fiscal discipline of an R regime might be imported by “tying ones hands” in a fixed rate agreement: an increase in the budget deficit creates pressures on the exchange rate that can only be eliminated by a fiscal contraction.³⁵ Either way, our finding suggests that fiscal authorities must participate in, and be held accountable for, any attempt to fix the exchange rate. A currency peg requires the fiscal discipline of an R regime.

V. MONETARY UNIONS

In the last section, we identified fiscal requirements for a currency peg that is unilaterally imposed and maintained. That discussion is most relevant for the world's smaller countries, many of which have decided to peg their currencies to a key currency (or currency basket). Among the larger countries, however, these decisions have not been made unilaterally, and responsibility for the maintenance of the agreed system was, in some cases, to be shared. In Europe, the original design of the EMS was an example of this. Similarly, the decision to adopt a common currency was made jointly. In this section, we investigate the implications of the new theory of price determination for these coordination problems. We will see that there are certain fiscal prerequisites that a country valuing price stability would probably want to impose upon its potential partners .

For our purposes here, there is little difference between a fixed exchange rate system and a common currency; so we will discuss the latter. Suppose that country 1 and country 2 want to form

a monetary union, but maintain separate fiscal policies.³⁶ The money market equations (6) would be replaced by:³⁷

$$(19) \quad M_{t+1}/p_t = h(i_t, c_t),$$

where $h_1 < 0$ and $h_2 > 0$, p_t is the price of consumption goods, and M_{t+1} is the money supply set by the common central bank (in an R regime) or determined endogenously under interest rate targeting (in an NR regime). The household's first order conditions will imply:

$$(20) \quad \frac{1}{1+i_t} = E_t \left[\alpha_t \left(\frac{p_t}{p_{t+1}} \right) \right],$$

where i_t is the common interest rate and $\alpha_t \equiv \frac{\beta u'(c_{t+1})}{u'(c_t)}$ is once again an exogenous stochastic process in equilibrium.³⁸ Our analysis in the text will continue to impose the NPG conditions discussed in Section II. We will use footnotes to indicate how the results would change if we did not impose the NPG conditions.³⁹ As in Section II, the NPG conditions imply that each government's PVBC must be satisfied. Derivations similar to those of Section II imply that p_t must satisfy:

$$(21) \quad \frac{B_{j,t}}{p_t} = s_{j,t} + \omega_j \theta_t + E_t \left(\sum_{n=t+1}^{+\infty} \left[\prod_{k=t}^{n-1} \alpha_k \right] [s_{j,n} + \omega_j \theta_n] \right),$$

where ω_j is the share of central bank transfers that go to fiscal authority j ($j = 1, 2$).

If each government has the fiscal discipline of an R regime, then once again conventional results prevail. Monetary policy can determine the price level, and endogenous fiscal policies satisfy the PVBC's. As before, the surprising results come when one, or both, of the governments lack the

fiscal discipline of an R regime.

Suppose now that the surplus policy of government 2 is exogenous, while the policy of government 1 assures that its PVBC is always satisfied. If just one government lacks the discipline of an R regime, then the whole union is thrown into an NR regime.⁴⁰ In this case, the central bank's interest rate policy determines the expected rate of inflation via the Euler equation, and government 2's PVBC determines the price level for the union as a whole. This suggests that country 1 – if it values price stability – should not be willing to enter a monetary union with countries that have not achieved the fiscal discipline of an R regime.

What if both fiscal authorities lack the discipline of an R regime? Then our model implies the price level is over determined. There are two PVBC's to be satisfied, and one price level cannot in general assure solvency in both. The equations of the model do not solve, and we have another “game of chicken”. A monetary union would not seem to be viable under these conditions.⁴¹

None of these problems arise in R regimes. So, an important question becomes: what kind of rules or criteria can be imposed on perspective union members that will assure that they have the fiscal discipline of an R regime. Interestingly, the fiscal criteria built into the Maastricht Treaty and the Stability and Growth Pact are sufficient for this purpose.⁴² Constraints were put on both debt levels and deficits; however, the deficit constraint has received most of the attention.⁴³ For union members, total deficits (inclusive of interest payments) should not to exceed 3% of GDP:

$$(22) \quad \left[\frac{G_{j,t} - T_{j,t}}{P_t} - \omega_j \frac{M_{t+1}}{P_t} \left(\frac{i_t}{1 + i_t} \right) \right] + \left(\frac{i_{t-1}}{1 + i_{t-1}} \right) \left(\frac{B_t}{P_t} \right) \leq .03y_{j,t}.$$

Or, rearranging terms:

$$(23) \left[\frac{T_{j,t} - G_{j,t}}{P_t} + \omega_j \frac{M_{t+1}}{P_t} \left(\frac{i_t}{1+i_t} \right) \right] \geq \left(\frac{i_{t-1}}{1+i_{t-1}} \right) \left(\frac{M_t + B_t}{P_t} \right) - \left[\left(\frac{i_{t-1}}{1+i_{t-1}} \right) \frac{M_t}{P_t} + .03y_{j,t} \right].$$

Note that (aside from the inequality sign) (23) is a fiscal policy rule of the form (15); the interest rate term corresponds to the coefficient $\gamma_{j,t}$, and the last term in (23) corresponds to the random variable ϵ_t . So, drawing on the discussion in Section II, if (22) is binding infinitely often, then country j must be in an R regime.⁴⁴

VI. DISCUSSION OF THE CONCLUSIONS

In this paper, we examine the fiscal requirements of exchange rate systems that involve varying degrees of financial integration. The new fiscal theory of price determination (FTPD) implies that tighter forms of monetary integration cannot be maintained by the central bank and monetary policy alone; fiscal authorities have to lend their active support to these “monetary” endeavors. We have already summarized our results in the introduction, and we need not repeat them here. In this section, we ask what should be made of these results, and what directions future research might take.

Many of our results seem at odds with conventional views on exchange rate determination. However, on closer inspection, it is clear that the FTPD is not inconsistent with the conventional theory; rather, it clarifies the importance of an assumption that is rarely articulated. Conventional views about price and exchange rate determination implicitly assume that the economy operates in what Woodford (1995) calls a *Ricardian* (or R) regime, where primary surpluses are expected to balance the government’s present value budget constraint for any sequence of prices that is fed into it. In an R regime, prices and exchange rates can be determined by the supply and demand for

money, as is consistent with the “monetary approach” to exchange rate determination. If on the other hand, the economy operates in a *Non-Ricardian* (NR) regime, where primary surpluses are an exogenous process, then prices and exchange rates are determined by the fiscal policies of the various governments, and unconventional results can emerge.

From this perspective, it appears to be of paramount importance in any modeling effort to get the choice of fiscal regime right. Is the economy operating in an R regime, or in an NR regime? There has been surprisingly little empirical work on this question. Canzoneri, Cumby and Diba (1999) argue that R regimes present a more plausible explanation of certain aspects of the post-war US data than do NR regimes; however, Cochrane (1998) argues just the opposite. More work in this area is clearly needed.

One of the results in this paper is of considerable interest in this context: we showed that a fixed peg is not possible in an NR regime. So, those countries that have been able to maintain a credible peg have presumably been operating in an R regime, at least during the period of the peg. This result is also interesting within the context of the literature on speculative currency crises. It suggests that a currency crisis could be triggered by the switch from an R regime to an NR regime. The crisis would be caused by “bad fundamentals”, as in the “1st generation models” of Krugman (1979) and Flood and Garber (1984). However, there would not be any tell tale drain of reserves, or increase in the money supply, in the run up to the crisis; so, empirically, the crisis could look like a “2nd generation model”.⁴⁵

Our discussion of inflation targeting in NR regimes calls for further research, especially if one thinks that price stickiness is a salient feature in real world economies. We would be surprised if future research contradicts our claim that the central bank can target expected inflation. An Euler

equation like (5) is implied by a very broad class of models and, in turn, implies some rendition of a “Fisher equation” like (16). So, the ability of the central bank to control expected inflation seems likely to be a generic feature in both R and NR regimes, and in models with and without sticky prices. That is, the central bank should be able to take account of the effects of various shocks or its own policy on the real interest rate and then adjust the nominal interest rate to hit a target for expected inflation.

But, two important issues relating to price stickiness remain to be addressed. First, our model with flexible prices is likely to be misleading because it abstracts from the consequences of inflation targeting for output. More work is needed on NR models with sticky prices to examine the output-inflation tradeoffs that monetary policy may face. Second, it is somewhat surprising that our result linking lower nominal interest rates with lower expected inflation survived the introduction of price rigidities in the model of Canzoneri and Diba (2000). It would be interesting to know if this is a generic implication of NR regimes, even in models with sticky prices. If so, economists with a firm conviction that sticky prices require the central bank to raise interest rates to fight inflation will question the empirical plausibility of NR regimes. Like our result on fixed exchange rates, this result may help us assess the plausibility of NR regimes.

Finally, given the above argument about the problems that central banks may face in an NR regime, it would be interesting to know what kinds of constraints on fiscal policy would assure that the economy is operating in an R regime. We have already noted that the debt and deficit constraints written into the Maastricht Treaty and the Stability and Growth Pact are examples. These constraints are stronger than necessary, and we have no reason to believe that they are the best constraints that could be designed. This too would seem to be a fruitful area of research.

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APPENDIX

In Section II, we derived the household's Euler equation for the intertemporal smoothing of consumption:

$$(A1) \quad \frac{1}{1+i_{1,t}} = E_t \left[\alpha_t \left(\frac{p_{1,t}}{p_{1,t+1}} \right) \right],$$

and in Section III, we showed that the central bank's interest rate policy determines the expected rate of inflation via this Euler equation:

$$(A2) \quad E_t \left(\frac{p_{1,t}}{p_{1,t+1}} \right) = \left(\frac{1}{E_t \alpha_t} \right) \left[\frac{1}{1+i_{1,t}} - \text{Cov}_t \left(\alpha_t, \frac{p_{1,t}}{p_{1,t+1}} \right) \right].$$

We have also argued that fiscal policy provides the nominal anchor in an NR regime; that is, the sequence of equilibrium prices, $\{p_{1,t}\}$, is determined by the PVBC:

$$(A3) \quad \frac{B_{1,t} + M_{1,t}}{p_{1,t}} = s_{1,t} + \theta_{1,t} + E_t \left(\sum_{n=t+1}^{+\infty} \left[\prod_{k=t}^{n-1} \alpha_k \right] [s_{1,n} + \theta_{1,n}] \right).$$

In this appendix, we calculate the covariance term in (A2). The calculations also confirm that the stochastic process generating equilibrium prices, (A3), is consistent with household's expected inflation, (A2)—which is not surprising, given that the NR regime constitutes a rational expectations equilibrium.

Denoting the right hand side of the period $t+1$ PVBC by $z_{1,t+1}$, we have:

$$(A4) \quad \left(\frac{M_{1,t+1} + B_{1,t+1}}{p_{1,t+1}} \right) = \left(\frac{M_{1,t+1} + B_{1,t+1}}{p_{1,t}} \right) \left(\frac{p_{1,t}}{p_{1,t+1}} \right) = z_{1,t+1}.$$

(A4) describes the actual inflation that will be generated by the PVBC between t and $t+1$. Using the flow budget constraint, (3) in the main text, in conjunction with the PVBC, (A3), we can calculate the term $\left(\frac{M_{1,t+1} + B_{1,t+1}}{P_{1,t}} \right)$. After some algebra, (A4) becomes:

$$(A5) \quad \frac{P_{1,t}}{P_{1,t+1}} = \left[\frac{1}{(1+i_{1,t})} \right] \left[\frac{Z_{1,t+1}}{E_t(\alpha_t Z_{1,t+1})} \right].$$

(A5) is a reduced form for the equilibrium rate of inflation in an NR regime.

We need to show that (A2) is consistent with (A5). From (A5), we can calculate the conditional covariance between the equilibrium rate of deflation and the equilibrium intertemporal rate of substitution, α_t :

$$(A6) \quad \text{Cov}_t \left(\alpha_t, \frac{P_{1,t}}{P_{1,t+1}} \right) = \left[\frac{1}{(1+i_{1,t})} \right] \left[1 - \frac{(E_t \alpha_t)(E_t Z_{1,t+1})}{E_t(\alpha_t Z_{1,t+1})} \right].$$

Using (A6) to eliminate the covariance term, (A2) becomes (after some simplifying):

$$(A7) \quad E_t \left(\frac{P_{1,t}}{P_{1,t+1}} \right) = \left[\frac{1}{(1+i_{1,t})} \right] \left[\frac{E_t Z_{1,t+1}}{E_t(\alpha_t Z_{1,t+1})} \right],$$

This equation is consistent with (A5). The NR regime does indeed result in a rational expectations equilibrium. More to the point, given the relevant expectations on the right hand side, the central bank can always adjust the interest rate at date t to hit its target for the left hand side of (A7).

TABLE 1: Statistics for the G-7 Countries

	Base/GDP (in 1995)	Unconditional % Std. Deviation of Surplus/GDP	Conditional % Std. Deviation of Surplus/GDP
Canada	0.04	1.9	1.6
France	0.04	1.1	0.9
Great Britain	0.04	2.3	1.4
Germany	0.09	1.6	1.3
Italy	0.11	3.2	1.3
Japan	0.10	2.7	0.9
United States	0.06	1.2	1.1

Notes:

1. Data Sources --

Surplus/GDP ratios are calculated from OECD data.

The sample period is 1971-1995 for all countries except Japan; it is 1978-1995 for Japan.

Money Base figures are from the IFS tapes.

2. Unconditional standard deviations of Surplus/GDP are sample standard deviations.

3. Conditional standard deviations of Surplus/GDP ratios are standard errors from AR1 regressions that include an intercept and a time trend.

FIGURE 1: Money Base to GDP ratios

ENDNOTES:

1. See Woodford (1994, 1995, 1996, 1998a,b,c, 2000) and Sims (1994, 1995, 1997, 1998, 1999). These papers were preceded by Auernheimer and Contreras (1990), Masson (1987) and Leeper (1991). And, the theory has its critics: Buiter (1997) and McCallum (1997). Other recent contributions include: Benhabib, Schmitt-Grohe and Uribe (2000), Bergin (2000), Canzoneri and Diba (1998, 2000), Canzoneri, Cumby and Diba (1997, 1999), Christiano and Fitzgerald (2000), Cochrane (1998, 1999a,b), Daniel (1999a,b), Dupor (2000), Kocherlakota, and Phelan (1999), Loyo (1997, 1998).

2. Canzoneri, Cumby and Diba (1999) illustrate a class of fiscal policies that results in R regimes. Loosely speaking, an R regime emerges in this class if primary surpluses are expected to respond (positively) to the level of debt infinitely often. In theory, the response might be every year, every other year, every decade, or every century. Of course, the policy must be credible.

3. Fiscal policy need not be exogenous in an NR regime. Primary surpluses may respond to economic conditions as long as they do not actively guarantee that the PVBC is satisfied for any price sequence that is fed into it. We will not need this level of generality here.

4. Woodford (1995) coined the R/NR terminology to highlight the fact that government bonds are net wealth in a Non-Ricardian regime.

5. In fact, one key point of the literature is that such a responsible fiscal authority can rest assured that its PVBC will be satisfied in equilibrium via adjustment of the price level. Under some circumstances, NR fiscal policies may also be desirable from a normative perspective (see Sims (1999) and Woodford (1998b)), but the literature is only beginning to address the issue of optimal design of NR fiscal policies (see Cochrane (1999a)).

6. More precisely, in our model, the exchange rate depends on fiscal policy and the fiscal ramifications of monetary policy (seigniorage or transfers from the central bank to the fiscal authority).

7. There is a closed economy counterpart to our main result here; it is discussed in footnote 33.

8. We think the most important point made by these papers is that a country that has already achieved the discipline necessary for an R regime, and values price stability, will not want to share responsibility for maintaining a currency peg with a country that does not have the same discipline; nor will it want to form a monetary union with such a country. Doing so would mean that both countries operate in an NR regime, and the fiscal policy of the undisciplined country would serve as the nominal anchor for the system as a whole.

9. See Sargent and Wallace (1981) and Sargent (1987).

10. In Lucas' model, domestic and foreign households are effectively identical because they can trade contingent claims for country specific effects (tax liabilities, for example). We suppress Lucas's equity markets and his contingent claims, and we assume that the world representative household pays taxes to both governments. These assumptions do not play a substantive role in our analysis; they do economize on the algebra.

11. We assume that the utility function and the stochastic processes for exogenous variables (which will be specified below) satisfy the standard regularity conditions guaranteeing the existence of a unique interior solution to the household's optimization problem.

12. PPP is in no way essential for the results that follow. If the two countries' goods were imperfect substitutes, then the equilibrium terms of trade, $q_t \equiv e_t p_{2,t}/p_{1,t}$, would be determined by the marginal rate of substitution; that is, $q_t = u_2(y_{1,t} - g_{1,t}, y_{2,t} - g_{2,t})/u_1(y_{1,t} - g_{1,t}, y_{2,t} - g_{2,t})$. $e_t = (p_{1,t}/p_{2,t})q_t$, where q_t is an exogenous variable, independent of any of the money and tax policy experiments we perform in the sections that follow.

13. That is, $c_{j,t} = y_{j,t} - g_{j,t}$ and $\alpha_t = \frac{\beta u'(c_{1,t+1} + c_{2,t+1})}{u'(c_{1,t} + c_{2,t})}$.

14. The central bank makes profits by issuing liabilities that do not pay interest (the monetary base) in exchange for interest bearing assets. A stylized central bank's real profits can be calculated as the product of the net nominal interest rate and the real monetary base. Our definition of $\theta_{j,t}$ discounts this product from date $t+1$ to date t .

15. Here again, the assumption is stronger than necessary to rule out Ponzi schemes, but that will not limit our discussion. The important question is whether one government will lend indefinitely to another.

16. One type of model we have in mind would assume that the government gets utility from its own purchases (perhaps in addition to caring about the welfare of its citizens); see, for example, Canzoneri and Diba (1991). If a government enjoyed spending more, and got no utility from allowing its claims on the other government to grow without bound, then a transversality condition analogous to (11) would most likely be implied by its optimizing behavior.

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

18. Recall that the discount factors, $\{\alpha_k\}$, are already determined by the exogenous processes $\{y_{j,k}\}$ and $\{g_{j,k}\}$.

19. An intuitive way of understanding this second possibility is as follows: The flow budget constraint driving real debt is an unstable dynamic equation when primary surpluses (inclusive of central bank transfers) are an exogenous forcing variable. In equilibrium, we need a "jumping" variable to eliminate this unstable root. In our model, the price level is the only variable available. By contrast, when fiscal policy is assuring that (13) holds, there is no instability to be eliminated. See Leeper (1991) and Canzoneri, Cumby and Diba (1999) for a fuller discussion.

20. An active rule for setting interest rates may involve feedback from the price level or a strong feedback from inflation as in Leeper (1991). See Henderson and McKibbin (1997) 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.

21. See footnote 3.

22. In a sense, price determination in NR regimes offers a resolution of Sargent and Wallace's (1981) "game of chicken"-- also discussed in Sargent (1987). Sargent and Wallace treated the real value of existing debt as given and focused on how the primary surpluses generated by the fiscal authority and the seigniorage revenues of the monetary authority must be expected to add up over time, to satisfy the PVBC. They didn't address the question of what happens if neither the central bank nor the fiscal authority are willing to yield to the requirements of fiscal solvency. The FTPD answers this question for models with nominal debt: the PVBC gets satisfied through changes in the price level, which adjust the real value of outstanding debt.

23. Dupor and Loyo's observations about the real implications of nominal indeterminacy are obviously important, but they do not arise from a fundamental distinction between open and closed economies. They arise because their models allow for heterogeneous agents.

24. This also has the effect of eliminating certain covariance terms that are not germane to our discussion.

25. In a non-stochastic environment, the covariance term would be absent and (16) would reduce to the Fischer equation. It would be more transparent in such an environment that the central bank can use the interest rate to set the rate of inflation, via equation (16).

26. Cochrane does not distinguish between primary surpluses inclusive and exclusive of central bank transfers. To relate his setup to ours, the following paragraph in the text assumes that the surplus inclusive of transfers is set by the fiscal authority.

27. The central bank only gets to choose how much of this debt is monetized.

28. The main simplification is to take out Woodford's specification of staggered price setting by assuming that all prices are set one period in advance.

29. Note that we are now modifying our definition of NR regimes. We are assuming that the primary surpluses (exclusive of seigniorage revenue) follow an exogenous process.

30. A natural interpretation of this result can be made by analogy with present value models of asset prices. Looked at this way, the PVBC says that the real value of government liabilities must equal the expected present value of the "payments" (primary surpluses) on those liabilities. If fiscal conditions unexpectedly deteriorate at date t , so that the expected payments stream has to be revised downward, the corresponding decrease in the equilibrium real value of liabilities requires an increase in the price level because the nominal (face) value of the liabilities is predetermined.

31. If, for example, real balances entered the household's utility function log linearly, then (4) would imply that $\theta_{1,t} = h(i_{1,t}, c_t)[i_{1,t}/(1+i_{1,t})] = 1/u'(c_t)$. Interest rate innovations would have no effect on central bank transfers.

32. One might think 15% of GDP is a better figure for Italy, but this would not make much difference in the conclusions that follow.

33. There is a “closed economy” analogue to this result. The central bank can not hit an expected inflation target and a target for the current price level. Given the equilibrium real rate of interest, the Fischer Equation implies one relationship between the nominal rate of interest and the expected rate of inflation (the analogue to the interest parity condition in the “open economy”). And, the PVBC implies another relationship between the nominal interest rate and the current price level. The central bank has a tradeoff between these two targets.

The “open economy” version of this result has more bite, since it is the foreign country that gets to choose the expected rate of inflation.

34. The same reasoning would apply in a model with long-term debt. It might at first be thought that adding long-term debt would provide some slack in the PVBC: the price of long-term debt would appear on the left hand side of the PVBC, and it might move in equilibrium to balance the equation. However, the price of long-term debt depends on present and expected future interest rates, and these interest rates are already pinned down by the interest parity condition if the currency peg is to be credible. So, adding long-term debt would not affect our basic result.

35. Here, the NR regime seems to turn the conventional wisdom on its head. There is a long literature, exemplified by Giavazzi and Pagano (1988), holding that monetary policy can be disciplined by tying the central bank’s hands with a fixed exchange rate. That literature, and most of the conventional wisdom, implicitly assumes an R regime.

36. Most of the discussion in this section would also be relevant to a single country with multiple fiscal authorities. The US for example has federal, state and local governments, each of which has the authority to levy taxes, set spending levels, and issue debt (with restrictions in many cases).

37. Here, we assume that $v(M_{1,t+1}/p_{1,t}) + v(M_{2,t+1}/p_{2,t})$ is replaced by $v(M_{t+1}/p_t)$ in the household utility function. A first order condition similar to (4) emerges from the household's optimization problem, and it implies equation (19).

38. In equilibrium $c_t = y_{1,t} + y_{2,t} - g_{1,t} - g_{2,t}$, and we will continue to assume that both output and government spending in each country are exogenous stochastic processes.

39. Bergin (2000) and Woodford (1996) discuss similar (though richer) models in the context of European Monetary Union but do not preclude the possibility of one fiscal authority allowing the other to run a Ponzi scheme.

40. This result depends crucially on our NPG conditions. Our setup could be modified to yield an R regime in which the consolidated present value budget constraint of the two governments is satisfied endogenously by the surplus policy of country 1 [see Woodford (1996)]. But for this to happen, country 1 would have to stand ready to guarantee the fiscal solvency of country 2, no matter how profligate country 2's policy might be.

41. Without our NPG conditions, such a union would be viable (although it would imply that the central bank cannot control the price level). In Woodford's (1996) setup, for example, the consolidated PVBC of the two governments would uniquely determine the common price level.
42. These fiscal criteria have been widely criticized in the academic literature. We think that this is the best justification for their existence is that they ensure the fiscal discipline of an R regime.
43. Woodford (1996, 2000) discusses the 60% cap on the debt to GDP ratio from the same perspective.
44. Woodford (1998b, 2000) points out (in the context of a cap on the debt to GDP ratio) that we cannot rule out NR equilibria in which (22) never binds.
45. See Eichengreen, Rose, and Wyplosz (1995) for a discussion of 1st and 2nd generation models of currency crises and empirical attempts to distinguish between the two.