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ABSTRACT

Fiscal Discipline and Exchange Rate Regimes*

This paper explores the implications of a new theory of price determination (due to Leeper, Woodford and Sims) for the maintenance of various exchange rate systems – crawling pegs, fixed pegs, and common currency areas. It shows that deeper monetary integration requires more fiscal discipline, especially if price stability is an objective; these monetary arrangements cannot be achieved by monetary policy alone, as conventional wisdom would seem to suggest. A particularly striking result is that a currency peg is simply not sustainable if fiscal surpluses are determined by an exogenous political process; maintenance of a fixed currency peg requires the government to guarantee fiscal solvency for any equilibrium sequence of prices (which Woodford calls a Ricardian Regime). Interestingly, the debt and deficit constraints that were written into the Maastricht Treaty, and will continue in the Stability Pact after EMU, are examples of the fiscal discipline that is required.

JEL Classification: E31, F33, F41
Keywords: exchange rate regimes, fiscal discipline, price determination

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NON-TECHNICAL SUMMARY

Conventional macroeconomic models emphasize the monetary nature of exchange rate determination. And, according to this view, fixed rate systems constrain national monetary policies without significantly impinging upon the autonomy of national 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 Sims, Woodford and others have challenged this presumption by emphasizing the role of fiscal policy in price determination. In this paper, we explore the implications of this new theory of price determination for the maintenance of a variety of exchange rate systems: first, we consider a unilaterally maintained crawling peg (which is equivalent in our set-up to inflation targeting); then, we move to a unilateral fixed peg; and, finally, we consider multilaterally maintained pegs and common currency areas. 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. From a policy perspective, the new theory of price determination may give the best justification yet for the type of fiscal policy rules that were written into the Maastricht Treaty.

In equilibrium, the real value of the nominal liabilities issued by the government is equal to the expected present value of current and future budget surpluses. The fundamental insight of the new theory of price determination is that, if fiscal policy does not insure that equality, the price level must move to do so. Thus, the equilibrium price level has to satisfy two distinct conditions: the government's present value budget constraint and the money market's equilibrium condition. The conventional 'monetary approach' to exchange rate determination focuses almost exclusively on the latter.

According to the new theory, the price level can be determined in two very different ways; that is, there are two alternative characterizations of monetary and fiscal policy that yield a unique, determinate price level. In a *fiscal dominant* (FD) regime, primary surpluses are determined by an exogenous (perhaps political) process, and the central bank targets the nominal interest rate. In this regime, the government's present value budget constraint determines the price level, and the money supply adjusts to maintain equilibrium in the money market. In a *money dominant* (MD) regime, the central bank targets the money supply, and fiscal policy has discipline, in the sense that current and/or future primary surpluses are expected to adjust to

satisfy the government's present value budget constraint for any real value of current government liabilities.

In a MD regime, monetary authorities can control their national price levels, and conventional views of exchange rate determination prevail. In a FD regime, unconventional results emerge. We will show that the central bank's interest rate policy is still capable of maintaining a crawling peg. Stability of the price level and the spot rate depend on fiscal policy, however, since fiscal policy provides the nominal anchor in a FD regime. Moreover, we will show that a fixed peg or a common currency area can only be maintained with the help of fiscal policy.

Section II shows how the new theory of price determination can be extended to exchange rate determination. It develops the framework we will use to analyse the fiscal requirements of various exchange rate systems. Our focus here (and throughout the paper) is on FD regimes, since MD regimes yield conventional results.

Section III studies crawling pegs that are unilaterally imposed and maintained. In a FD regime, the central bank's interest rate policy sets the expected rate of depreciation (or inflation). If this is all that is meant by the notion of a crawling peg, then there are no fiscal requirements. In a FD regime, however, fiscal policy determines the price level, and the central bank loses effective control of its spot rate in countries where seigniorage accounts for a small percentage of total tax revenues. To illustrate this, we present numerical examples that suggest a typical OECD country would have to raise its interest rate by 1000 basis points to offset the effect on its spot rate of a deficit shock of 1% of GDP. Indeed, we will argue that fiscal shocks become the primary source of price and exchange rate variations in a FD regime. These observations have two important implications: from an empirical perspective, they may allow us to test whether a given country has been operating in a MD regime or a FD regime; and from a policy perspective, they suggest that we should not hold a central bank responsible for price or exchange rate stability in a FD regime.

Section III also discusses the role of indexation in the new theory of price determination. In the conventional wisdom, indexing the government's debt is thought to be a remedy for 'surprise inflation'; with full indexation, for example, the central bank could not be tempted to inflate away the real value of the debt. In a FD regime, however, surprise inflation is not just associated with discretionary monetary policy. Equilibrium movements in the price level create a surprise inflation tax that balances the government's present value budget constraint; without this tax, there would be no equilibrium. Partial indexation of bonds would increase the price and exchange rate movements necessary for this equilibrating process, since indexation decreases the inflation tax's base; full indexation of all government liabilities (both bonds and money) would eliminate the base entirely; there could be no equilibrium. We also argue that issuing debt denominated in a foreign currency would have much the same effect as indexation.

Section IV analyses fixed pegs that are unilaterally imposed and maintained. We show that the central bank's interest rate policy alone cannot peg the exchange rate in a FD regime; the central bank has to have help from the fiscal authorities. In effect, we show that fiscal policy has to have the discipline to place the economy in a MD regime for a fixed peg to be credible.

Section IV determines the fiscal requirements for a unilaterally maintained peg. Section V extends the discussion to coordinated exchange rate systems (such as the EMS) and common currency areas (such as the proposed EMU). We show how the new theory of price determination augments existing criteria for an 'optimal currency area'. A country that has already achieved the discipline necessary for a MD 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 are forced to operate in a FD regime, and the fiscal policy of the undisciplined country would serve as the nominal anchor for the system as a whole. A country that values price stability will want to impose rules assuring fiscal discipline on all participants in a fixed rate system or monetary union. We show that the new theory of price determination may provide the most compelling rationale to date for the fiscal rules that were written into the Maastricht Treaty, and will carry over to EMU in the Stability Pact to EMU.

I. INTRODUCTION

Conventional macroeconomic models emphasize the monetary nature of exchange rate determination. And, according to this view, fixed rate systems constrain national monetary policies without significantly impinging upon the autonomy of national 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 Sims (1994, 1995, 1997), Woodford (1994, 1995, 1996) and others have challenged this presumption by emphasizing the role of fiscal policy in price determination.[1] In this paper, we explore the implications of this new theory of price determination for the maintenance of a variety of exchange rate systems: first, we consider a unilaterally maintained crawling peg (which is equivalent in our setup to inflation targeting); then, we move to a unilateral fixed peg; and finally, we consider multilaterally maintained pegs and common currency areas. 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. From a policy perspective, the new theory of price determination may give the best justification yet for the type of fiscal policy rules that were written into the Maastricht Treaty.

In equilibrium the real value of the nominal liabilities issued by the government is equal to the expected present value of current and future budget surpluses. The fundamental insight of the new theory of price determination is that if fiscal policy does not insure that equality, the price level must move to do so. Thus, the equilibrium price level has to satisfy two distinct conditions: the government's present value budget constraint and the money market's equilibrium condition. The conventional "monetary approach" to exchange rate determination focuses almost exclusively on the latter.[2]

According to the new theory, the price level can get determinated in two very different ways;

that is, there are two alternative characterizations of monetary and fiscal policy that yield a unique, determinate price level. In a *fiscal dominant* (FD) regime, primary surpluses are determined by an exogenous (perhaps political) process, and the central bank targets the nominal interest rate. In this regime, the government's present value budget constraint determines the price level, and the money supply adjusts to maintain equilibrium in the money market. In a *money dominant* (MD) regime, the central bank targets the money supply, and fiscal policy has discipline in the sense that current and/or future primary surpluses are expected to adjust to satisfy the government's present value budget constraint for any real value of current government liabilities.[3]

In a MD regime, monetary authorities can control their national price levels, and conventional views of exchange rate determination prevail. In a FD regime, unconventional results emerge. We will show that the central bank's interest rate policy is still capable of maintaining a crawling peg. However, stability of the price level and the spot rate depend on fiscal policy, since fiscal policy provides the nominal anchor in a FD regime. Moreover, we will show that a fixed peg or a common currency area can only be maintained with the help of fiscal policy.

This paper contains a number of specific theoretical results and policy implications. It may be helpful to summarize them at the outset, and indicate where they are to be found. The rest of the paper is organized as follows:

Section II shows how the new theory of price determination can be extended to exchange rate determination.[4] It develops the framework we will use to analyze the fiscal requirements of various exchange rate systems. Our focus here (and throughout the paper) is on FD regimes, since MD regimes yield conventional results.

Section III studies crawling pegs that are unilaterally imposed and maintained. In a FD regime, the central bank's interest rate policy sets the expected rate of depreciation (or inflation). If this is all that is meant by the notion of a crawling peg, then there are no fiscal requirements. But, in a FD regime, fiscal policy determines the price level, and the central bank loses effective control of its spot rate in countries where seigniorage accounts for a small percentage of total tax revenues. To illustrate this, we present numerical examples that suggest a typical OECD country would have to raise its interest rate by 1000 basis points to offset the effect on its spot rate of a deficit shock of 1% of GDP. Indeed, we will argue that fiscal shocks become the primary source of price and exchange rate variations in a FD regime. These observations have two important implications: from an empirical perspective, they may allow us to test whether a given country has been operating in a MD regime or a FD regime; and from a policy perspective, they suggest that we should not hold a central bank responsible for price or exchange rate stability in a FD regime.

Section III also discusses the role of indexation in the new theory of price determination. In the conventional wisdom, indexing the government's debt is thought to be a remedy for "surprise inflation"; with full indexation for example, the central bank could not be tempted to inflate away the real value of the debt. In a FD regime, however, surprise inflation is not just associated with discretionary monetary policy. Equilibrium movements in the price level create a surprise inflation tax that balances the government's present value budget constraint; without this tax, there would be no equilibrium. Partial indexation of bonds would increase the price and exchange rate movements necessary for this equilibrating process, since indexation decreases the inflation tax's base; full indexation of all government liabilities (both bonds and money) would eliminate the base entirely; there could be no equilibrium. We also argue that issuing debt denominated in a foreign currency would have much the same effect as indexation.

Section IV analyzes fixed pegs that are unilaterally imposed and maintained. We show that the central bank's interest rate policy alone cannot peg the exchange rate in a FD regime; the central bank has to have help from the fiscal authorities. In effect, we show that fiscal policy has to have the discipline to place the economy in a MD regime for a fixed peg to be credible.

Section IV determines the fiscal requirements for a unilaterally maintained peg. Section V extends the discussion to coordinated exchange rate systems (such as the EMS) and common currency areas (such as the proposed EMU). We show how the new theory of price determination augments existing criteria for an "optimal currency area."[5] A country that has already achieved the discipline necessary for a MD 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 are forced to operate in a FD regime, and the fiscal policy of the undisciplined country would serve as the nominal anchor for the system as a whole. A country that values price stability will want to impose rules assuring fiscal discipline on all participants in a fixed rate system or monetary union. We show that the new theory of price determination may provide the most compelling rationale to date for the fiscal rules that were written into the Maastricht Treaty, and will carry over to EMU in the Stability Pact to EMU.

Section VI, our concluding section, evaluates the significance of the results derived in this paper. Here, we argue that the new theory of price determination is not really at odds with the conventional wisdom; our view is that the real contribution of this new theory is to highlight an assumption -- the assumption of a MD regime -- that is implicit in the conventional wisdom, but rarely articulated in standard models of exchange rate determination. We also suggest some new directions for empirical work, theoretical work, and policy analysis in this area.

II. THE NEW THEORY OF EXCHANGE RATE DETERMINATION

First, we must extend the new theory of price determination to an international setting. Consider a two country model with a representative world household, a single consumption good, and perfect capital mobility.[6] At date t, the household maximizes the expected utility from its consumption of goods produced in country 1 and country 2:

$$(1)\quad U_t \equiv E_t \sum_{k=t}^{+\infty} \beta^{k-t} u(c_{1,k} + c_{2,k}), \qquad 0 < \beta < 1,$$

where E_t is the conditional expectations operator, and $c_{j,k}$ is consumption of country j goods at date k. 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.

Each household is endowed with $y_{j,t}$ units of country j goods at date t. Goods are perishable; so, in equilibrium, we have:

$$(2)\quad c_{j,t} + g_{j,t} = y_{j,t},$$

where $g_{j,t}$ are purchases by government j at date t. $\{g_{j,t}\}$ and $\{y_{j,t}\}$ are exogenous stochastic processes.

Each government imposes taxes on the representative household, issues its own currency, and borrows by issuing bonds denominated in its own currency. The flow budget constraint of government j at date t is:

$$(3)\quad (M_{j,t+1} - M_{j,t}) + \frac{B_{j,t+1}}{(1 + i_{j,t})} + p_{j,t}\tau_{j,t} = B_{j,t} + p_{j,t}g_{j,t}\,;$$

$M_{j,t+1}$ is the supply of currency j carried from date t into date t+1; $B_{j,t+1}$ is the face value of bonds maturing at t+1; $i_{j,t}$ is the nominal interest rate (or more precisely the discount) on these bonds; $p_{j,t}$ is the price of the consumption good in terms of currency j; and $\tau_{j,t}$ are lump sum taxes. (3) states that money creation, borrowing and taxes must finance the maturing debt and government purchases.

We employ a standard cash in advance (CIA) framework. In the financial exchange that begins each period, households observe the state of the economy (endowments and the government policy variables) and execute all of their transactions except the actual buying and selling of goods. In the goods exchange that follows, households purchase goods with the currency of the seller; government purchases are not subject to CIA constraints. If (as we will assume) nominal interest rates are positive in equilibrium, then the household's CIA constraint is binding, and in equilibrium:

$$(4)\quad M_{j,t+1} = p_{j,t}c_{j,t} = p_{j,t}(y_{j,t} - g_{j,t}).$$

After incorporating the CIA constraint, the household's budget constraint for period t becomes:

$$(5)\quad p_{1,t}c_{1,t} + e_t p_{2,t}c_{2,t} + \frac{B_{1,t+1}}{(1 + i_{1,t})} + \frac{e_t B_{2,t+1}}{(1 + i_{2,t})} + p_{1,t}\tau_{1,t} + e_t p_{2,t}\tau_{2,t}$$

$$= M_{1,t} + e_t M_{2,t} + B_{1,t} + e_t B_{2,t} + p_{1,t}y_{1,t} + e_t p_{2,t}y_{2,t}\,,$$

where e_t is the nominal exchange rate, defined as units of currency 1 per unit of currency 2.

Households maximize (1) subject to (5) over non negative values of $c_{1,t}$, $c_{2,t}$, $B_{1,t+1}$ and $B_{2,t+1}$.

The consumption choices determine currency demands by (4). The first order conditions for the household's optimization problem imply:

$$(6)\quad p_{1,t} = e_t p_{2,t},$$

$$(7)\quad \frac{1}{1+i_{j,t}} = E_t\left[\alpha_t\left(\frac{p_{j,t}}{p_{j,t+1}}\right)\right],$$

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; $c_t \equiv c_{1,t} + c_{2,t}$ denotes total consumption. Total equilibrium consumption is, by (2), an exogenous stochastic process; so the discount factor α_t is also an exogenous stochastic process. Equation (6) is the familiar purchasing power parity (PPP) condition; it says that in equilibrium the nominal exchange rate is ratio of the two price levels.[7] Equation (7) is an Euler equation required for the optimal intertemporal smoothing of consumption.

Transversality conditions pin down the present value budget constraints that are at the heart of the new theory of price and exchange rate determination. Because we assume currency and government bond holdings can not be negative, the transversality condition for the household's optimization problem is:

$$(8)\quad \lim_{n\to+\infty}\beta^n E_t u'(c_{t+n})\left[\frac{B_{1,t+n}+M_{1,t+n}}{p_{1,t+n}} + \frac{B_{2,t+n}+M_{2,t+n}}{p_{2,t+n}}\right] = 0.$$

Since the terms inside the brackets can not be negative, (8) implies:

$$(9)\quad \lim_{n\to+\infty}\beta^n E_t u'(c_{t+n})\left[\frac{B_{j,t+n}+M_{j,t+n}}{p_{j,t+n}}\right] = 0,$$

for j = 1, 2. Using the definition of α_t, (9) can be expressed as:

$$(10)\quad \lim_{n\to+\infty} E_t\left[\left(\prod_{k=t}^{t+n-1}\alpha_k\right)\left(\frac{B_{j,t+n}+M_{j,t+n}}{p_{j,t+n}}\right)\right] = 0,$$

for j = 1, 2. Equation (10) is a no Ponzi Game (NPG) condition that is imposed on each government by the household's transversality condition; it restricts the rate of growth of government liabilities.[8,9]

Substituting equations (6) and (7) into (3) and rearranging terms, the flow budget constraint of government j can be expressed as:

$$(11)\quad \frac{M_{j,t}+B_{j,t}}{p_{j,t}} = \alpha_t\left(\frac{M_{j,t+1}+B_{j,t+1}}{p_{j,t+1}}\right) + \tau_{j,t} - g_{j,t} + \left(\frac{M_{j,t+1}}{p_{j,t}}\right)\left(\frac{i_{j,t}}{1+i_{j,t}}\right).$$

Iterating (11) forward and imposing the NPG condition, we get the present value budget constraint (PVBC) of government j:

$$(12)\quad \frac{B_{j,t}+M_{j,t}}{p_{j,t}} = s_{j,t} + \theta_{j,t} + E_t\left(\sum_{n=t+1}^{+\infty}\left[\prod_{k=t}^{n-1}\alpha_k\right]\left[s_{j,n}+\theta_{j,n}\right]\right),$$

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;[10] where $s_{j,t} \equiv \tau_{j,t} - g_{j,t}$ is the primary surplus, exclusive of central bank transfers; and where (it will be recalled) the equilibrium sequence of discount factors $\{\alpha_k\}$ is independent of the other variables in (12).[11]

The PVBC is the focal point of the new theory of price and exchange rate determination. It states that the real value of existing public sector liabilities must be equal to the present value of current and expected future primary surpluses (inclusive of central bank transfers). Following Hamilton and Flavin (1986), a growing literature has developed empirical tests of the hypothesis that the constraint is satisfied.[12] By contrast, the new theory of price determination treats this constraint as an equilibrium condition. Given the right hand side of equation (12), and the predetermined value of nominal public sector liabilities on the left hand side, the equilibrium price level, $p_{j,t}$, must satisfy the PVBC. Otherwise, the household's transversality condition would be violated, and the economy would not be in equilibrium.

Or course, each country's price level must also satisfy the CIA constraint, (4). In general, $p_{j,t}$ cannot satisfy both (4) and (12) unless some other variable in one of the equations adjusts as well. Two possibilities exist for the required adjustment to equilibrium, and they define the two policy regimes we turn to next.

The Money Dominant (MD) Regime --

In a MD regime, each central bank sets its money supply, $M_{j,t+1}$, exogenously. Since $y_{j,t}$ also evolves exogenously, the CIA constraint determines the equilibrium price level, $p_{j,t}$. Given $p_{j,t}$ and the predetermined value of nominal liabilities, the left hand side of the government's PVBC is fixed; the right hand side must adjust to it. That is, in a MD regime, primary surpluses (inclusive of central bank transfers) must be expected to adjust endogenously to satisfy the needs of fiscal solvency.

Woodford (1995) provides a theoretical characterization of the endogenous fiscal policies that lead to a MD regime: these policies satisfy the government's PVBC constraint in nominal terms, regardless of the path of the price level.[13] Since Woodford's characterization involves the path of fiscal variables in the indefinite future, it is not a practical guide to assessing the regime in which a particular economy operates. More practical conditions that assure a MD regime have been discussed in the literature: Woodford (1996) for example considers the role of an upper bound imposed on the debt to GDP ratio, and Canzoneri and Diba (1996) discuss the role of an upper bound imposed on the the total deficit (inclusive of interest payments) to GDP ratio.[14] Canzoneri, Cumby and Diba (1997a), motivated by Leeper (1991) and Bohn (1995), consider fiscal reaction functions that raise the primary surplus to GDP ratio in response to an increase in the debt to GDP ratio. They show that a lax and infrequent fiscal response is sufficient to assure a MD regime.

The Fiscal Dominant (FD) Regime --

In a FD regime, real tax revenues and government purchases evolve exogenously, and the central bank sets the nominal interest rate. In equilibrium, real money balances are determined by the CIA constraint. So, the central bank's interest rate target pins down central bank transfers, $\theta_{j,t}$, and the right hand side of the government's PVBC is determined. On the left hand side, nominal liabilities are predetermined. The equilibrium price level, $p_{j,t}$, is therefore the only variable that can adjust to satisfy the PVBC. Given $p_{j,t}$ and the realizations of $y_{j,t}$ and $g_{j,t}$, the money stock, $M_{j,t+1}$, adjusts to satisfy the CIA constraint.

To summarize, fiscal policy provides the nominal anchor in a FD regime, while monetary policy provides the nominal anchor in a MD regime. The latter reflects a more conventional view of price determination, and as we will see that conventional views about exchange rate systems implicitly assume a MD regime.

III. CRAWLING PEGS AND MANAGED FLOATS

In a MD regime, prices and exchange rates are determined in a conventional way; there are no new implications for the maintenance of either a crawling peg or a fixed peg. So in this section and the next, we will assume that country 1 is in a FD regime. Country 2 could be in either a MD regime or a FD 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.[15] In this case, PPP implies that $p_{1,t} = e_t$, and currency depreciation is equivalent to inflation. In our set up, a crawling peg is equivalent to inflation targeting.

In a FD regime, the central bank can use its control over the interest rate to target the expected rate of inflation, and therefore the expected rate of devaluation. This fact can be seen by rewriting the Euler equation (7):

$$(13)\quad E_t\left(\frac{p_{1,t}}{p_{1,t+1}}\right) = \left(\frac{1}{E_t\alpha_t}\right)\left[\frac{1}{1+i_{1,t}} - Cov_t\left(\alpha_t, \frac{p_{1,t}}{p_{1,t+1}}\right)\right].$$

The covariance term on the right hand side is related to the (inflation) risk premium on nominal bonds. We calculate this term in the appendix and show that it depends on the stochastic process generating future endowments and fiscal and monetary variables. Given the expectations based on this process, however, the central bank can set the nominal interest rate to achieve any desired target for the left hand side of (13).[16] (In the appendix, we also show that the sequence of future prices implied by the central bank's interest rate policy is consistent with the equilibrium sequence emerging from the government's present value budget constraint.[17]) Thus, monetary policy alone can maintain a crawling peg, if setting the expected rate of devaluation is all that is meant by that term. There are no fiscal prerequisites, even in a FD regime.

In a managed float, the central bank tries to limit fluctuations in the spot exchange rate, perhaps in addition to setting the expected rate of devaluation. The main point of this section is to suggest that monetary policy alone may not be able to maintain a managed float, since fiscal policy provides the nominal anchor in a FD regime. The PVBC, (12), determines the current price level, and therefore the spot exchange rate. Moreover, the date t+1 PVBC will determine next period's price level and exchange rate. The central bank's interest rate policy determines the expected rates of inflation and devaluation, but fiscal policy determines the actual outcome each period.

This observation suggests a number of interesting questions which we will explore in the remainder of this section and in an appendix. First, one might wonder about the internal consistency of a FD regime. The PVBC generates a stochastic process for the equilibrium price level. But is this process consistent with the household's expectations of inflation, as expressed in the Euler equation (13)? The answer to this question is yes. In an appendix, we show that a FD regime generates a rational expectations equilibrium. Second, in a FD regime, innovations in fiscal policy produce inflation surprises that generate seigniorage. Conventional wisdom suggests that bond indexation eliminates the temptation for discretionary policy to produce inflation surprises. This reasoning is clearly based on the (perhaps implicit) assumption of a MD regime. What does indexing do in a FD regime? Third, the central bank's interest rate policy does have fiscal ramifications. Real balances are fixed by the CIA constraints (4), but the central bank's interest rate determines the amount of transfers -- $\theta_{1,t} \equiv \left(\frac{M_{1,t-1}}{p_{1,t}}\right)\left(\frac{i_{1,t}}{1+i_{1,t}}\right)$ -- it makes to the government each period. In theory, these transfers could be used to control the right hand side of the PVBC (12), and therefore the price level and the spot 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? And more generally, what is the likely source of price and exchange rate fluctuations in a FD regime -- monetary policy innovations or fiscal policy innovations? We turn to these questions next.

To answer these questions, we develop an equation that explains how innovations in fiscal policy are transmitted to price levels and exchange rates in a FD regime. Denoting the right hand side of the PVBC (12) 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:

$$(14) \quad \delta_t\left(\frac{p_{1,t-1}}{p_{1,t}}\right) = \left(\frac{p_{1,t-1}}{M_{1,t}+B_{1,t}}\right)\delta_t z_{1,t}.$$

Positive innovations in fiscal policy (higher than expected surpluses), $\delta_t z_{1,t}$, produce unexpected deflations and currency appreciations, and the size of these fluctuations depends inversely on the real value of public sector liabilities.

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 inclusive of central bank transfers) on those liabilities. Suppose 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.

In effect, whenever tax revenues are not large enough to balance the PVBC, an automatic and unexpected inflation tax is levied on the holders of nominal government liabilities, and this tax ensures that the PVBC is satisfied. The real value of government liabilities is the base for this tax. The larger is the tax base, the smaller is the change in the tax rate (surprise inflation) that is needed to generate the requisite amount of revenue. The surprise inflation tax is at the heart of the new theory of price determination. If it were somehow eliminated -- by, say, the indexation of money and bonds -- then the model would not have an equilibrium solution in a FD regime.

Innovations in the central bank's interest rate policy have similar effects on the price level and the exchange rate, since they too affect government revenue (via central bank transfers). We can use (14) to get an idea of the magnitude of the effects of interest rate innovations, $\delta_t i_{1,t}$, and surplus innovations, $\delta_t s_{1,t}$, on prices and exchange rates. These magnitudes will in general depend upon the autocorrelations and 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, it turns out that certain broad empirical regularities immediately present themselves.

First, it seems clear that, in a FD regime, primary surplus and deficit shocks will be a much more important source of price and exchange rate variation than monetary policy shocks. To see this, consider the relative sizes of $\delta_t s_{1,t}$ and $\delta_t \theta_{1,t}$ innovations, and their likely effect on $\delta_t z_{1,t}$. 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. However, this may overstate the actual 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. Because the autoregressions indicated positive persistence the effect of these innovations on $\delta_t z_{1,t}$ innovations is larger. All things considered, a reasonable benchmark for the standard deviation of $\delta_t z_{1,t}$ innovations coming from surplus and deficit shocks is probably on the order of 1.5 or 2% of GDP.

What is the order of magnitude of the standard deviation of $\delta_t z_{1,t}$ innovations coming from innovations in monetary policy? More specifically, how big are the likely innovations in central bank transfers resulting from innovations in the interest rate? The two innovations are approximately related by $\delta_t \theta_{1,t} \equiv \left(\frac{M_{1,t-1}}{p_{1,t}} \right) \delta_t \left(\frac{i_{1,t}}{1 + i_{1,t}} \right)$. This approximation (motivated by our CIA setup) abstracts from the potential inverse relationship between changes in the interest rate and changes in money demand. As such, the approximation provides an upper bound for the effect of changes in interest rates on central bank transfers. 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.[18] How big are innovations in G-7 interest rates? It is hard to imagine an annual interest rate surprise of more than 150 basis points.[19] Letting the money base be 10% of GDP (which is on the high side), and assuming an interest rate innovation of 150 to 200 basis points (also on the high side), we only get an innovation in transfers of .15 to .2% of GDP.

Putting these results together, in a FD regime, fluctuations in prices coming from surplus and deficit shocks would seem to be ten times as large as those coming from monetary policy shocks. This result is interesting for at least two reasons. First, it suggests a way of distinguishing between MD and FD regimes empirically. Are surplus and deficit innovations actually the dominant source price variation, as the new theory of price determination requires? And second, the calculations behind our result suggest that a central bank should not be held accountable for price or exchange rate stability in a FD regime. Consider what the central bank would have to do to offset an unexpected increase in the primary deficit of, say, 1% of GDP. With a money base that is 10% of GDP (which is on the high side), the central bank would have to increase its interest rate by 1000 basis points to keep the price level constant! Such a policy would surely be deemed infeasible (for reasons that are not modeled here).

Consider finally the effect of bond indexation. We have already noted that there would be no equilibrium in a FD regime if all public sector liabilities were indexed; jumps in the price level could not make the left hand side of the PVBC equal to the right hand side. Suppose however that just bonds are indexed. In particular, denote the real face value of bonds maturing at date t+1 by $b_{1,t+1}$, and the real interest rate (discount) on these bonds by $r_{1,t}$. The government's flow budget constraint becomes:

$$(15)\quad \frac{M_{1,t+1}}{p_{1,t}} + \frac{b_{1,t+1}}{(1+r_{1,t})} + \tau_{1,t} = \frac{M_{1,t}}{p_{1,t}} + b_{1,t} + g_{1,t},$$

and, following the same steps as above, the PVBC becomes:

$$(16)\quad b_{1,t} + \frac{M_{1,t}}{p_{1,t}} = s_{1,t} + \theta_{1,t} + E_t\left(\sum_{n=t+1}^{+\infty} [\prod_{k=t}^{n-1} \alpha_k][s_{1,n} + \theta_{1,n}] \right).$$

All the variables in (16) are defined as before.

Consider first equilibria in which the right hand side of the PVBC is strictly greater than the real face value of bonds. In a FD regime, these equilibria work exactly as before except for the fact that the tax base for the surprise inflation tax has now been reduced to real money balances. Instead of (14), we now get:

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

From this perspective, the main implication of the model is that indexation magnifies the effects of shocks on prices and exchange rates. The increase in volatility would be substantial for the typical OECD country, where bond liabilities may be five to ten times larger than the monetary base.

Consider next situations in which the right hand side of the PVBC is less than the real face value of bonds. This case is similar to the case of full indexation of all public liabilities; there is no (positive) price level that will satisfy the PVBC. Such policies would not be feasible. Primary surpluses and/or central bank transfers would have to rise to satisfy the PVBC. This problem is closely related to Sargent and Wallace's (1991) discussion of "unpleasant monetarist arithmetic."

Finally, we note in passing that issuing debt denominated in a foreign currency would have much the same effect as indexation. In our present framework, this fact is quite transparent. Since we are assuming that the foreign price level, $p_{2,t}$, is held fixed, the real value of foreign currency denominated debt is also fixed.

IV. FIXED PEGS

Consider now a fixed peg; that is, we let $e_t = \bar{e}$, a constant, for all t. The household's first order conditions, (6) and (7), indicate two requirements for the maintenance of this peg: first, PPP requires that the two countries' price levels be proportional, and second, given this proportionality, the Euler equations require that nominal interest rates equalize each period. Proportionality in the price levels and interest rate equalization are necessary conditions for the maintenance of a currency peg in both MD and FD regimes. Suppose country 1 is responsible for maintaining the peg. And suppose once again that monetary and fiscal policy in country 2 fixes its price level each period; that is, we let $p_{2,t} = 1$ for all t.[20] With this assumption, the proportionality requirement becomes $p_{1,t} = \bar{e}$; country 1's price level must be fixed at $\bar{e}$.

In a MD regime, the central bank can fix $p_{1,t}$ at $\bar{e}$ by following the rule:

$$(18)\quad M_{t+1} = \bar{e}(y_t - g_t).$$

Then, with proportionality guaranteed, the Euler equations force interest rates to equalize. The MD regime illustrates the conventional view that only monetary policy needs to be dedicated to fixing the exchange rate. As long as the fiscal authority is providing the basic discipline necessary for a MD regime, the central bank can maintain a currency peg.

In a FD regime, the PVBC provides the nominal anchor, and if the peg is to be maintained, proportionality requires:

$$(19)\quad \frac{B_{1,t} + M_{1,t}}{\bar{e}} = s_{1,t} + \theta_{1,t} + E_t\left(\sum_{n=t+1}^{+\infty} [\prod_{k=t}^{n-1} \alpha_k][s_{1,n} + \theta_{1,n}] \right).$$

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 automatically to guarantee fiscal solvency in a FD regime. So, the sequence of central bank transfers is all that is left to balance the PVBC. But if the currency peg is to be maintained, the central bank must surrender its interest rate policy to the requirement of interest rate equalization; central bank transfers are also determined independently of the PVBC. In a FD regime, there is no way of simultaneously pegging the exchange rate and assuring fiscal solvency: PPP implies one price level while the PVBC will generally require another.

The bottom line is that the central bank cannot maintain a fixed peg in a FD 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. But this is tantamount to assuming a MD 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 a MD regime will not have the credibility to maintain a currency peg. Alternatively, it may be held that the fiscal discipline of a MD 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.[21] 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 a MD regime.

V. COORDINATED SYSTEMS AND 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 design of the original EMS was an example of this, and the process is now being repeated for EMS II. Similarly, the decision to adopt a common currency is 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 .

We begin with the decision to adopt a common currency. Suppose that country 1 and country 2 want to form a monetary union, but maintain separate fiscal policies.[22] The equilibrium price level (or common value of $p_{1,t}$ and $p_{2,t}$) must satisfy the CIA constraint:

$$(20)\quad M_{t+1} = p_t c_t = p_t(y_t - g_t),$$

where M_{t+1} is the money supply set by the common central bank (in a MD regime) or determined endogenously under interest rate targeting (in a FD regime). The household's first order conditions will imply:

$$(21)\quad \frac{1}{1+i_t} = E_t\left[\alpha_t\left(\frac{p_t}{p_{t+1}}\right)\right],$$

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.[23] If we continue to impose a non negativity constraint on each government's liabilities (so that one government can not borrow from the other), then household transversality condition imply that each government's PVBC must be satisfied. Derivations similar to those of Section II imply that p_t must satisfy:

$$(22)\quad \frac{B_{j,t}}{p_t} = s_{j,t} + \omega_j\theta_t + E_t\left(\sum_{n=t+1}^{+\infty}\left[\prod_{k=t}^{n-1}\alpha_k\right][s_{j,n} + \omega_j\theta_n]\right),$$

where ω_j is the share of central bank transfers that go to fiscal authority j (j = 1, 2). Bergin (1995) and Woodford (1996) discuss similar (though richer) models in the context of European Monetary Union.

If each government has the fiscal discipline of a MD regime, then once again conventional results prevail. The central bank's money supply policy determines the price level via the CIA constraint (20); the Euler equation (21) determines the nominal interest rate; and endogenous fiscal policies satisfy the PVBC's (22). As before, the surprising results come when one, or both, of the governments lack fiscal discipline.

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 a MD regime, then the whole union is thrown into a FD regime. In this case, the central bank's interest rate policy determines the expected rate of inflation via the Euler equation. Government 2's PVBC determines the price level for the union as a whole, and the CIA constraint determines the money supply.

If both governments lack the discipline of a MD regime, and if the central bank continues to set the interest rate, then the price level is simply over determined. Since the central bank is setting the interest rate, any price level can appear in the CIA constraint. But there are still two PVBC's to be satisfied, and one price level can not in general assure solvency in both.

The basic point here is that something has to give. One interpretation is that one of the fiscal authorities would be forced to take the price level as given and actively adjust its surpluses to satisfy its PVBC. Another possibility is that the central bank would be forced to relent and devote its interest rate policy to satisfying one of the PVBC's. This takes us back once again to Sargent and

Wallace's (1991) "unpleasant monetarist arithmetic." The basic difference is that we now have two fiscal authorities instead of one. In Wallace's "game of chicken," one of the fiscal authorities or the central bank would have to blink.[24] To the best of our knowledge, however, there has not been any formal modeling of a resolution to this coordination problem.

We are now ready to assess the implications of the new theory of price determination for the theory of optimal currency areas. Suppose country 1 has the fiscal discipline of a MD regime and values price stability; that is, it prefers low inflation rates on average, and small fluctuations in the price level around the average. (In the European context, a country like Germany comes to mind.) Should country 1 try to impose fiscal requirements on countries that seek a monetary union? According to our analysis, country 1 need not worry about another country that has already achieved the discipline of a MD regime. The union would operate in a MD regime, monetary policy would continue to provide the nominal anchor, and the common central bank could be held responsible for price stability. If however just one of the countries in the union lacks the discipline of a MD regime, then the union as a whole will operate in a FD regime.[25] Fiscal policy in the undisciplined country would provide the nominal anchor, and the numerical exercises discussed in Section III suggest that, while the central bank might be able to achieve a low average rate of inflation, it would not be able to achieve price stability. If a second fiscally undisciplined country were admitted to the union, then coordination problems of Sargent and Wallace would arise. At least one of the governments would become insolvent, provoking a crisis. Of course, elements within the undisciplined governments might see the union as a means of achieving discipline. (Again, several countries within the EU come to mind.) The modeling of such crises, and their resolution, is however beyond the present state of the theory of price determination.

At present, the main implication of the new theory of price determination seems to be that country 1 should only be willing to enter a monetary union with countries that have already achieved the fiscal discipline of a MD regime. The 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 a MD regime. Interestingly, the fiscal criteria built into the Maastricht Treaty are sufficient for this purpose. Canzoneri and Diba (1996) show that limiting the government's total deficit (primary deficit plus interest payments) to 3% of GDP will suffice, and Woodford (1996) shows that limiting the government's debt to 60% of GDP will also suffice.

So far, we have only discussed the decision to form a full monetary union, like EMU; it should be apparent however that the same analysis carries over to the decision to form an exchange rate system, like EMS II. A country (or monetary union) that has already achieved fiscal discipline and values price stability, would not want to share responsibility for maintaining a fixed exchange rate with a country that does not have fiscal discipline. If it did, the PVBC of the undisciplined country would serve as the nominal anchor for the whole system, and, as our calculations in Section III have shown, price stability would probably not be achievable. The country (or monetary union) with fiscal discipline might want to want to make its participation conditional on the adoption of a rule that guaranteed the fiscal discipline in all participating countries. The fiscal criteria written into the Maastricht treaty are examples of just such a rule. On the other hand, the country lacking fiscal discipline might see the fixed exchange rate system as a way to achieve discipline (though the theory of price determination does not as yet provide an explicit model of this process).

VI. CONCLUSION

In this paper we examine the fiscal requirements of various exchange rate systems -- from crawling and fixed pegs that are unilaterally imposed and maintained to mutually agreed pegs and common currencies. The new theory of price determination implies that tighter forms of monetary integration can not be maintained by the central bank and monetary policy alone; fiscal authorities have to lend their active support to these "monetary" endeavors. We summarized our specific finding in the introduction, and we need not repeat them here. In this section, ask what should be made of all this, and what directions future research might take. We will discuss directions for empirical work, for theoretical work, and for policy analysis.

Many of our results seem at odds with conventional views on exchange rate determination and the requirements of various exchange rate systems. However, on closer inspection, it is clear that the new theory of price determination is not inconsistent with conventional views on exchange rate matters; rather, its contribution is to make clear an assumption that is rarely articulated in the conventional theories of exchange rate determination. Conventional views about price and exchange rate determination implicitly assume that the economy operates in what we call a *money dominant* (MD) regime, where primary surpluses are expected to automatically balance the government's present value budget constraint for any sequence of equilibrium prices that is fed into it. In this case, 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 what we call a *fiscal dominant* (FD) regime, where primary surpluses (inclusive of central bank transfers) are an exogenous political 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 regime right. Is the economy operating in a MD regime, or in a FD regime? To the best of our knowledge, there has been surprisingly little empirical work on this question. Canzoneri, Cumby and Diba (1997a) present empirical evidence strongly suggesting that the US economy has operated in a MD regime since 1950. Canzoneri, Cumby and Diba (1997b) report some initial tests for the other OECD countries. The results are broadly consistent with a MD regime, but the evidence for a number of countries is less conclusive (probably due to data limitations). More work in this area is clearly needed.

The literature on the new theory of price determination has focused much of its attention on characterizing the circumstances in which a model does, or does not, have a unique equilibrium solution for the price level (or exchange rate). For example, a fundamental motivation for the new theory of price determination was to show that, contrary to conventional wisdom, interest rate targeting does not necessarily lead to price level indeterminacy. In a FD regime, the equilibrium price level is pinned down by the government's present value budget constraint.[26]

This result is of potential interest to central bank staffs, as they formulate empirical policy experiments that are based on interest rate rules. Such experiments must somehow overcome the methodological problem of how the price level gets determined when the central bank sets the nominal interest rate (instead of the money supply). Conventional approaches may be used to get around this problem while continuing to assume that the economy operates in the MD regime.[27] Alternatively, the methodological problem may be "solved" by assuming that the FD regime prevails and, therefore, the price level is determined by the government's present value budget constraint. Since the MD and FD regimes have very different implications for the results of policy experiments, it is important to know (or take a stand on) which regime prevails before deciding how to address the methodological problem of price indeterminacy.

While the theoretical literature on the new theory of price determination has done much to characterize the situations in which a model does yield a unique equilibrium price level, it has done little or nothing to suggest what might happen in an economy when it does not. For example, we know of no formal attempts to model a resolution to Wallace's "game of chicken," and we know of no formal arguments explaining how the game might be altered by institutions like the EMS or EMU. Clearly this an area in which theoretical developments would be most welcome.

Until such results are available, policy analysis will probably be limited to circumstances in which the price level is uniquely determined; and as we have seen, this will place some restrictions on the questions that can be analyzed. However, within these confines, we could investigate a number of questions that are suggested by the results presented in this paper. For example, we can ask what kinds of constraints on fiscal policy would assure that the economy is operating in a MD regime (if, as seems likely to us, that is deemed to be desirable). We have already noted that the debt and deficit constraints written into the Maastricht Treaty are examples. However, we have no reason to believe that they are the only, or the best, constraints that can 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

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

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

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

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

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

In this appendix, we calculate the covariance term in (A2). We also show that the stochastic process generating equilibrium prices, (A3), is consistent with household's expected inflation, (A2). In other words, we verify that the FD regime constitutes a rational expectations equilibrium.

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

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

(A4) describes the actu^l 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 tedious algebra, (A4) becomes:

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

(A5) is a reduced form for the equilibrium rate of inflation in a FD 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) $$\mathrm{Cov}_t\left(\alpha_t, \frac{p_{1,t}}{p_{1,t+1}}\right) = \left[\frac{1}{(1+i_{1,t})}\right]\left[1 - \frac{(E_t\alpha_t)(E_t z_{1,t+1})}{E_t(\alpha_t z_{1,t+1})}\right].$$

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

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

This equation is consistent with (A5). The FD regime does indeed result in a rational expectations equilibrium. Also, 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).

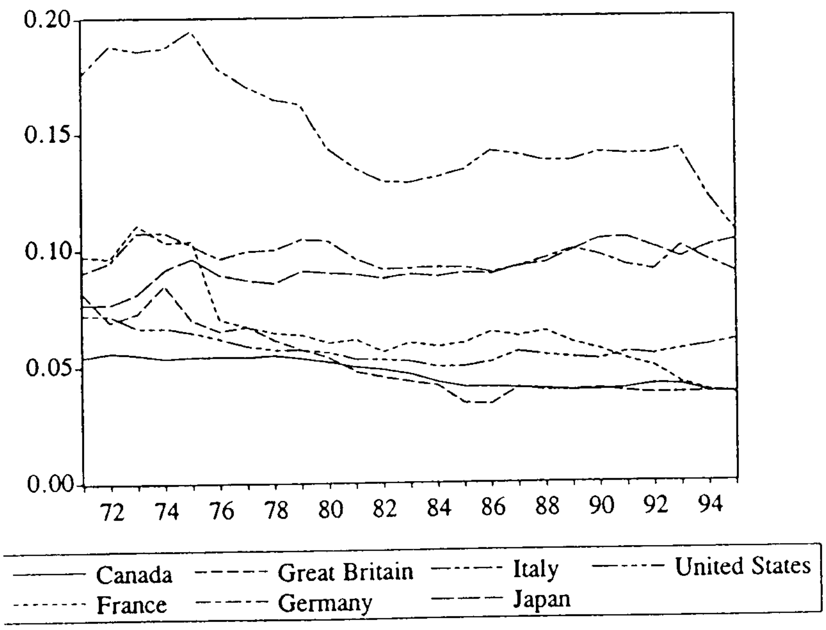
TABLE 1: Statistics for the G-7 Countries

	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. These papers were preceded by Auernheimer and Contreras (1990) and Leeper (1991). More recent work in this area includes Bergin (1995), Schmitt-Grohe and Uribe (1997), Canzoneri and Diba (1996), Canzoneri, Cumby and Diba (1997a, 1997b), McCallum (1997), Buiter (1997), Kupor (1997), and Loyo (1997). Recent work by Daniel (1996) is in our view closely related, although (in contrast to the above literature) she focuses on models with real bonds. The new theory is also reminiscent of -- but not equivalent to -- Sargent and Wallace's (1981) "unpleasant monetarist arithmetic."

2. To be more precise, the "monetary approach" implicitly assumes what we will call a money dominant regime. As we shall see, that assumption allows it to focus on the money market.

3. The FD MD terminology originated with Canzoneri and Diba (1996). Woodford (1995) calls the regimes "Ricardian" (MD) and "non Ricardian" (FD).

4. We are not the first to do so. Kupor (1997), Loyo (1997) and Sims (1997) discuss the issue of exchange rate determinacy within the context of the new theory of price determination. Since that issue has already been well discussed in the literature, we take steps to avoid it; that is, we define regimes in such a way that the exchange rate is uniquely determined in our models. Woodford (1996) and Bergin (1995) use richer models to discuss EMU.

5. Kenen (1969) and Sachs and Sala-i-Martin (1992) argued that a federal fiscal system would alleviate the problems caused by "sticky" wages and prices in a fixed rate system. Our discussion in Section V adds new fiscal dimensions to the criteria for Mundell's notion of an optimal currency area.

6. Our analytical framework is a stripped down version of Lucas's (1982) model. In his setup, 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 representative household pays taxes to both governments. These assumptions do not play a substantive role in our analysis; they do economize on the algebra.

7. 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 money and tax policy experiments we perform in the sections that follow.

8. The NPG condition discounts both government's liabilities at the intertemporal marginal rate of substitution even though the two bonds may have (differential) inflation risk. This feature of the NPG condition would be preserved even if we allowed for default risk, an extension of the present setup which might be of some interest in the context of developing countries. In a model with a representative lender and multiple borrowers, the NPG conditions discount each borrower's real liabilities at the rate associated with the lender's intertemporal marginal rate of

substitution. The riskiness of any borrower's liabilities affects all the NPG conditions similarly, and only to the extent that it affects aggregate consumption.

9. If a risk free (or indexed) bond were introduced into the model, the equilibrium risk free real interest rate, r_t, would satisfy: $\frac{1}{(1+r_t)} = \frac{\beta E_t u'(c_{t+1})}{u'(c_t)}$.
So, (10) says that the real value of either government's liabilities can not grow faster than this risk free rate. (The statement ignores the distinction between the expectation of products and the product of expectations of future values of α.)

10. 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. This calculation is equivalent to our definition of $\theta_{j,t}$ because $i_{j,t}$ represents the discount on bonds in our notation.

11. This resulted from our assumption that $\{y_{j,t}\}$ and $\{g_{j,t}\}$ are exogenous stochastic processes. This is not an entirely innocent assumption for our purposes here. In models in which $\{y_{j,t}\}$ is endogenous, the discount factor can become the equilibrating variable (instead of the price level) in a FD regime; see for example Woodford (1996).

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

13. Woodford calls such a policy regime Ricardian, because it implies that Ricardian Equivalence holds.

14. In other words, the rules written into the Maastricht Treaty are sufficient to assure a MD regime. We will discuss this further in Section V.

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

16. In a non-stochastic environment, the covariance term would be absent and (13) 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 (13).

17. This amounts to verifying that the FD regime constitutes a rational expectations equilibrium.

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

19. Consider for example the nominal yield on 1-year US Treasury bonds. Using annual data from 1951-1975, an AR1 (with an intercept and quadratic trend) has a standard regression error

of about 175 basis points. An expectation error of this size actually seems rather unlikely to us.

20. With this assumption, it does not matter for our purposes whether country 2 is in a MD or a FD regime. As in the last section, this assumption allows us to cut in half the number of cases we consider, but it is not necessary for the results that follow.

21. Here again, the FD regime seems to turns the conventional wisdom on its head. There is a long literature, exemplified by Giavazzi and Pagano (1988), that holds that monetary policy can be disciplined by tying the central bank's hands with a fixed exchange rate. Once again, that literature implicitly assumes a MD regime.

22. 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).

23. 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.

24. See Sargent (1987), page 176, for a description of Wallace's game of chicken.

25. This result depends crucially on our assumption that government debt is non-negative, so that country 1 can not lend to country 2. Our setup could be modified to yield a MD 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 2 would have to stand ready to guarantee the fiscal solvency of country 1, no matter how profligate country 1's policy might be. We have not emphasized this theoretical possibility, as it does not sound likely in practice.

26. If monetary policy sets the nominal interest rate when surpluses adjust to satisfy the present value budget constraint (as in our MD regime), then the price level will be under determined (i.e., there will be multiple equilibria); this is the conventional result. There is yet another possibility: if monetary policy attempts to set the money supply when surpluses follow an exogenous process (as in our FD regime), then the price level will be over determined (i.e., the model will have no equilibrium solution). We focused on the two regimes that result in a unique price level.

27. See for example Henderson and McKibben (1993) for a discussion of the problem, and various resolutions of it, in a MD regime. (The assumption of a MD regime is implicit in their work.)