# MONETARY POLICY AND EXCHANGE RATE BEHAVIOUR IN THE FISCAL THEORY OF THE PRICE LEVEL

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**Monetary Policy and Exchange Rate Behavior in the**

**Fiscal Theory of the Price Level[*]**

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**Abstract**

The fiscal theory of the price level has challenged the conventional view that monetary factors drive prices and exchange rates and has also provided a rationale for fiscal restrictions in a monetary union. This paper reviews the main results and compelling criticisms of this theory, analyzing the effects of monetary and fiscal shocks under a fiscal regime. We pay special attention to the determinants of the exchange rate and to the ways to eliminate the exchange rate indeterminacy that arise under interest rate peg.

Key words: fiscal theory of the price level, exchange rates, endogenous rules

JEL classification: E31; E63; F31

## I. Introduction

Fiscal behavior has been of central interest in the European Monetary Union process. The concern with macroeconomic stability led first to the imposition of specific ceilings on public debts and deficits of candidate States as a precondition to join the Union. Once the Union is formed, the Growth and Stability Pact imposes an even tighter fiscal discipline to member States. Fiscal criteria have been the most controversial among the requirements adopted in the Monetary Union process for two reasons. First, they forced governments to make fiscal adjustments at a time when their economies were stagnant or in recession. Second, although price stability is perceived as desirable, neither society nor many of its elected politicians appear to see a clear connection between price stability and fiscal restrictions. In fact, the most widely held view seems to be that price stability can be achieved with an independent central bank and a credible monetary policy, whereas more fiscal flexibility is needed precisely when national monetary policy is not available.

The link between price stability and fiscal restrictions is also controversial in the economic literature, where two views have developed. One view is that the Growth and Stability Pact has higher potential costs than benefits, as has been recently argued by Eichengreen and Wyplosz (1998). According to these authors the Pact will reduce the macroeconomic stabilization capacity of governments by limiting both automatic and discretionary fiscal actions, and besides will undermine the political capital needed to undertake the labor market structural reforms required for a proper development of the Union. On the benefit side, Eichengreen and Wyplosz take as a main rationalization of the Pact its potential capacity to reduce the risk of inflationary financial bailouts by the European Central Bank, but they argue that the Pact will not significantly affect this risk. They neither see the Pact as a necessary tool to neutralize possible national governments pressure over the European Central Bank to accept inflationary financing of excessive public debt. In fact, the authors consider the institutional independence of the central bank as a sufficient condition to guarantee both price stability and fiscal discipline.

This is questioned by the second view in the literature on two grounds. First, there is no reason why central bank independence *per se* should guarantee fiscal discipline. Second, if tax and spending decisions are taken by the public sector disregarding their effects on the present value of net surpluses, an independent central bank with a clear anti-inflationary objective may not be sufficient to guarantee price stability. Macroeconomists have long recognized the connection between the fiscal and monetary authorities induced by the fact that the government has two sources of revenue, taxes and seignorage, which allow to achieve public sector solvency through alternative coordination schemes. This connection imposes limits to the efficacy of monetary policies.[1]

The *fiscal theory of price determination* takes that interaction one step further and explores the implications of the intertemporal budget constraint of the government in macroeconomic models. This theory has being developed by Leeper (1991), Sims (1994), and Woodford (1994, 1995). When the fiscal authority guarantees its own solvency the price level is determined by the evolution of the monetary aggregates in the economy, whereas the determination of the nominal variables hinges on fiscal factors when the fiscal policy is set disregarding solvency considerations. This result, which challenges conventional wisdom, is especially relevant when a central bank tries to achieve its objective of price stability through the control of the short-term interest rates as it happens in many western economies.

Although still controversial, the fiscal theory of price determination has important implications for the conduct of macroeconomic policy in open economies and, in particular, in a monetary union, and is the purpose of this paper to review its main results. Previous papers in that area are Woodford (1996), Canzonery, Cumby and Diba (1998), Dupor (1999), and Bergin (2000). Specifically, the paper contains two core sections that provide a comprehensive discussion of the theory and its implication for the design of monetary policy in open economies using a stylized dynamic open macroeconomic model. Section 2 takes the closed economy model as a benchmark and presents the main analytical results of the literature on price determinacy in open economies. Section 3 then specifies endogenous monetary

[1] See Sargent (1999) for a clear exposition of that view.

and fiscal policy rules that contain the polar rules of section 2 as particular cases and reconsiders the results on price determinacy. This section also presents simulations of the effects of monetary and fiscal shocks when the economy is operating under alternative policy-mixes.

The literature reviewed and the exercises carried out in this paper suggest two main conclusions. First, to the extent that the price level is determined by the government's fiscal stance, the appearance of fiscal (or monetary) shocks may determine the observed inflation rate at each period of time. Monetary policy determines the expected inflation rate but the *fiscal theory* is about the *determination of the price level* and hence about what determines the *realized or ex post inflation rate*. This makes the issue of how prices are determined something more than a matter of academic interest: if the model incorporates some nominal friction, a monetary contraction, which rises the interest rate, may also push prices upwards to compensate for the higher service of the debt. Hence, the central bank looses control over the inflation rate and can hardly be held responsible for price stability. Unfortunately the effects of fiscal misdirection in one country spill over other countries unless the exchange rate adjusts; this adjustment does not take place in fixed exchange regimes which allow this contagion to operate at full strength. Thus, the Growth and Stability Pact is, according to this view, not of secondary importance but a crucial arrangement to serve the purpose of price stability within EMU.

Second, very often correlations among macroeconomic variables are considered puzzling when they cannot be rationalized within models that exclude the conditions under which the fiscal theory of prices applies.[2] The response of output and, mainly, of inflation and exchange rates to policy shocks are non-standard and show that the design of monetary policy in open economies may be more complex than suggested by the conventional monetary view.

## II. Fiscal policy and the price level

[2] Examples of these facts are the important role of fiscal shocks in the variability of exchange rates, mentioned by Canzoneri, Cumbi and Diba (1998), and the interpretation of some, seemingly puzzling, monetary events suggested by Woodford (1999).

This section presents a compact exposition of the main results of the *fiscal theory of price determination* in open economies, along with a discussion of some limitations of this approach. The closed economy case is reviewed first as the benchmark case where a stylized general equilibrium model provides a simple framework in which the issue of price determination under alternative monetary and fiscal policies can be set out as a matter of variables and equations accounting. Then we move to two alternative open economy models, one of them incorporating a monetary union, and analyze the influence of this theory on the behavior of the exchange rates.

II.1. <u>Closed economy model</u>

Consider the following consumer's problem:

$$Max\, E_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{1}{1-\sigma} c_t^{1-\sigma} + \frac{\chi}{1-\varepsilon} \left( \frac{M_t}{P_t} \right)^{1-\varepsilon} \right] \qquad [1]$$

subject to the budget constraint and to the transversality condition,

$$P_t c_t + P_t \tau_t + B_t + M_t \leq P_t y_t + (1+i_{t-1}) B_{t-1} + M_{t-1} \qquad [2]$$

$$\lim_{T\to\infty} E_0 \left( \prod_{s=0}^{T-1} (1+i_s)^{-1} \right) W_T = 0 \qquad [3]$$

where $c_t$ represents real consumption, $M_t$ nominal balances, $P_t$ the price level, $\tau_t$ real taxes, $B_t$ the level of nominal outstanding government debt and $i_t$ is the net nominal interest rate. Beginning-of-period nominal wealth ($W_{t+1}$) is defined as:

$$W_{t+1} = M_t + (1+i_t) B_t \qquad [4]$$

We assume some initial positive values for the government liabilities, $M_{-1}$ and $B_{-1}$. The first order conditions with respect to consumption, real balances and bonds are:

$$c_t^{-\sigma} = \beta (1+i_t) E_t \left[ c_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} \right] \qquad [5]$$

$$\frac{M_t}{P_t} = c_t^{\sigma/\varepsilon}\left[\chi\left(1+\frac{1}{i_t}\right)\right]^{1/\varepsilon} \quad [6]$$

The government budget constraint and the aggregate resource constraint are:

$$P_t g_t - P_t \tau_t = M_t - M_{t-1} + B_t - (1+i_{t-1})B_{t-1} \quad [7]$$

$$c_t + g_t = y_t \quad [8]$$

Leaving [3] aside for a moment, the equilibrium is defined by [2], [4], [5], [6], [7] and [8]. Since there are three aggregate constraints ([2], [7] and [8]], one of them is a combination of the others and we choose to include [7] and [8]. Output (*y*) and government spending (*g*) are assumed to be exogenous stochastic processes. Thus for any path of taxes the system has six endogenous variables ($c_t$, $i_t$, $P_t$, $M_t$, $B_t$, $W_{t+1}$) and five equations, and is completed once the monetary policy rule is specified.

We shall consider initially two polar cases of monetary policy. When the central bank sets an exogenous path for the money supply (for example, $M_t = M, \forall t$) and when the central bank pegs the interest rate (for example, $i_t = i, \forall t$). Nevertheless the characterization of equilibrium under both monetary policies (money and interest rate peg) is incomplete since they do not guarantee that the transversality condition is satisfied. To see what this condition implies let us iterate [7] forward, assuming perfect foresight for the sake of simplicity, imposing [3] and making use of [8]:

$$\frac{W_t}{P_t} = \sum_{j=0}^{\infty}\left(\prod_{s=t}^{t+j-1} r_s^{-1}\right)\left(\tau_{t+j} - g_{t+j} + \Delta_{t+j} m_{t+j}\right) \quad [9]$$

where,

$$\Delta_t = \frac{i_t}{1+i_t} \quad , \qquad (1+i_s) = r_s\left(P_{s+1}/P_s\right)$$

The transversality condition implies that the real value of outstanding wealth ($W_t/P_t$) must be equal to the present value of expected future surpluses including seignorage revenues ($\Delta_t m_t$). The extent to which [9] imposes an additional constraint on the equilibrium of the model depends on the behavior of the public sector surpluses $\{\tau_{t+j}-g_{t+j}\}$ and its interaction with the monetary policy.

Fiscal policy is labeled passive (Leeper (1991)) or Ricardian (Woodford (1994)) whenever current and future surpluses $\{\tau_{t+j}-g_{t+j}\}$ are set in a way that [9] is satisfied for any path of prices and in particular for any value of $P_t$. Then the government compensates any change in current surpluses by an expected change in the future of different sign and equal present value. If the central bank sets an exogenous path for $\{M_{t+j}\}$ and the fiscal authority follows a passive fiscal rule, real and nominal variables are uniquely determined.[3] The level of prices is driven by the money supply whereas the nominal rate and expected inflation are determined in [5] and [6]. Changes in the fiscal stance have no effect whatsoever on prices. By contrast, the price level is indeterminate when the central bank fixes the path of $\{i_{t+j}\}$ and the fiscal authority follows such a passive fiscal rule. Since the transversality condition [9] is satisfied for any price level it cannot be used to solve the indeterminacy associated with interest rate pegging.

Fiscal policy is defined as active or non-Ricardian when the government sets a tax policy such that $\{\tau_{t+j}-g_{t+j}\}$ is an exogenous process (in the sense of not being set as to guarantee the constancy of the right hand side of [9] in the first place). Fiscal policy is active since it is pursuing its own objectives disregarding the present value constraint; the regime is non-Ricardian in the sense that the present value constraint is always met by changes in $P_t$, rather than in future fiscal surpluses. A policy combination in which the central bank sets a target for $\{i_{t+j}\}$ and the fiscal authority follows an active fiscal rule yields a unique equilibrium for nominal and real variables. To see that the equilibrium is unique notice that the transversality condition can be written as:

[3] Monetary models, like the one in the text, display infinite solutions for the price level, all of them consistent with the same path for real variables even if the central bank sets $\{M_{t+j}\}$. However, in this case, only one of these solutions is bubble free. We choose to impose that solution, thus removing a source of price indeterminacy under money peg. McCallum (1998) and Kocherlakota and Phelan (1999) discuss the merits of the fiscal theory of the price level as an alternative 'equilibrium selection device' which gives rise to speculative bubbles.

$$P_t = W_t \left[ \sum_{j=0}^{\infty} \left( \prod_{s=t}^{t+j-1} r_S^{-1} \right) \left( \tau_{t+j} - g_{t+j} + \Delta_{t+j} m_{t+j} \right) \right]^{-1} \qquad [9']$$

Since current nominal wealth is predetermined at *t*, the real interest rate is given by [5], and the real balances are determined by [6], then [9'] can be interpreted as an equation determining the price level. When current surplus $(\tau_t\text{-}g_t)$ falls, the new equilibrium is not achieved by means of an expected increase of the surplus some time in the future but by a rise in current prices that erodes the real value of debt. The tax cut rises permanent income if households do not expect a compensating tax increase in the future. Thus, current consumption increases and, for an unchanged supply, prices also rise. This is known as the fiscal theory of price determination. Notice the change in the price level does not violate the budget constraint from t onwards since, for a given path of taxes, government spending and nominal interest rates, *M* increases with *P* (equation [6]) and so does *B* to satisfy the current budget constraint [7]. A final polar case arises when the fiscal policy is active and the monetary policy sets a path for $\{M_{t+j}\}$. In this case the price level is determined by two, not necessarily compatible, constraints, [6] and [9'], and the model has no solution.

As Carlstrom and Fuerst (1999) argue, the fiscal theory of prices is related to Sargent and Wallace's (1981) unpleasant monetarist arithmetic. Sargent and Wallace showed that an increase in the fiscal deficit would be inflationary, whether the money stock increases today or in the future. In the latter case, the process of portfolio reallocation by rational consumers may translate the expected increase in future seignorage into an increase in current prices. This is a game of chicken in which the government commits to a path of primary surpluses $\{\tau_{t+j}\text{-}g_{t+j}\}$ and monetary policy is forced to blink. Under an interest rate peg and an exogenous fiscal rule we can also consider that monetary policy blinks since the public chooses the initial price level that satisfies the intertemporal budget constraint and then the monetary authority chooses the stock of money that leaves the interest rate unchanged.

The fiscal theory of prices puts the interaction among monetary and fiscal policies under a close scrutiny. It is appealing since it shows that the lack of fiscal discipline does undermine the capability of monetary policy to achieve price stability even if the monetary authority is willing to accept high interest rates to face inflationary shocks. Besides the fiscal theory of prices is built around the role of the transversality condition in well defined general equilibrium models, thus its results hold across any class of macroeconomic models one can think of, regardless of the way other features of the model are defined. Nevertheless, many economists are still quite skeptical about the main tenets of this approach or at least about their practical relevance beyond its academic interest.

Within the general equilibrium framework, two of the most compelling criticisms are due to Buiter (1999) and Cushing (1999) who disagree with the interpretation given to the transversality condition in this class of models. Cushing (1999) argues that fiscal price determination under the non-Ricardian regime requires a set of implausible assumptions. The assumptions behind [9] in a non-Ricardian setting mean that private agents firmly believe that the public sector will honor its debt without default, even if they do not expect the government to adjust its taxes and spending plans to do so. But, as Cushing argues, if default is allowed and private consumers truly expect that inconsistent fiscal plans will not be altered in the future, the assumption that the public sector will repay its debt at its nominal value is difficult to maintain. In such a case, government debt will not be taken, thus forcing the public sector to vary its future fiscal plans rising taxes. This would ensure that [9] holds for any price sequence.

In a recent series of papers, Buiter has forcefully argued that this theory is simply wrong since it is based on a misconception about how the present value government budget constraint should be interpreted. First, since default is not allowed, the government budget constraint is not an equilibrium condition that holds for a particular sequence of prices but a proper resource constraint that must hold for any value of the other variables in the model. Thus, the assumption that a non-default fiscal and financial program can have all its components (current and future taxes, spending and seignoriage) exogenous is plain wrong. To be consistent with no default, the surplus must adjust, thus making the non-Ricardian regime logically impossible. Furthermore, if the government budget constraint were to fix one endogenous variable this ought to be one which is not incorporated in the model by the advocates of the fiscal theory of prices: the default discount factor. The present value budget constraint should be specified as in [9''] to allow for a default premium ($\phi_t$) on the probability of default that will be determined by the consistency of the different components of the fiscal and monetary program,

$$\frac{\Phi_t W_t}{P_t} = \sum_{j=0}^{\infty} \left( \prod_{s=t}^{t+j-1} r_s^{-1} \right) \left( \tau_{t+j} - g_{t+j} + \Delta_{t+j} m_{t+j} \right) \qquad [9'']$$

The model includes the same number of equations, but since the transversality condition determines the default risk premium (only appearing in this condition) it cannot fix the price level, that would have to be determined by the money rule or remain undetermined under an interest rate peg.[4]

The fiscal theory of prices has also been controversial in the empirical front. Canzoneri, Cumby and Diba (1999), based on empirical estimates with US data, show that changes in the Surplus/GDP ratio are followed by negative changes in the Liabilities/GDP ratio in the next periods while there is a significant positive autocorrelation in the first ratio. Although it is possible to postulate an exogenous surplus process that matches the regularities found in the data (see Cochrane (1999)) and that is consistent with a non-Ricardian regime, these authors find more plausible a Ricardian interpretation. A positive innovation in surplus pays off some of the debt so that the liabilities (debt plus monetary base) fall in the following periods.

### II.2. A two country model

Even if the fiscal theory of prices is right, its open economy implications are not straightforward as Dupor (1999), among others, has made clear. Consider a two-country model with perfect capital mobility in which a single consumer chooses $c_{1t}$, $c_{2t}$, $M_{1t}$, $M_{2t}$, $B_{1t}$, and $B_{2t}$, to maximize [10] subject to [11], [12] and [13]. Money and

[4] Cochrane (2000) disputes Buiter's view in a model in which the government debt is considered a state-contingent security.

government bonds are defined in home currency in each case and total wealth ($W_{t+1}$) is defined in country 1 currency units.

$$Max\ E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{1-\sigma}(c_{1t}+c_{2t})^{1-\sigma} + \frac{\chi}{1-\varepsilon}\left[\left(\frac{M_{1t}}{P_{1t}}\right)^{1-\varepsilon} + \left(\frac{M_{2t}}{P_{2t}}\right)^{1-\varepsilon}\right]\right\} \quad [10]$$

$$\begin{aligned} &P_{1t}c_{1t} + P_{2t}e_t c_{2t} + P_{1t}\tau_{1t} + P_{2t}e_t\tau_{2t} + B_{1t} + e_t B_{2t} + M_{1t} + e_t M_{2t} \leq \\ &P_{1t}y_{1t} + P_{2t}e_t y_{2t} + (1+i_{it-1})B_{it-1} + (1+i_{2t-1})e_t B_{2t-1} + M_{1t-1} + e_t M_{2t-1} \end{aligned} \quad [11]$$

$$W_{t+1} = M_{1t} + e_{t+1}M_{2t} + (1+i_{1t})B_{1t} + (1+i_{2t})e_{t+1}B_{2t} \quad [12]$$

$$\lim_{T\to\infty} E_0\left(\prod_{s=0}^{T-1}(1+i_{1s})^{-1}\right)W_T = 0 \quad [13]$$

Non-negativity is imposed on $M_{1t}$ and $M_{2t}$ but not on $B_{1t}$, $B_{2t}$. The equilibrium is defined by equations [12]-[21], plus a monetary rule for each country:

$$c_t^{-\sigma} = \beta(1+i_{1t})E_t\left[c_{t+1}^{-\sigma}\frac{P_{1t}}{P_{1t+1}}\right] \quad [14]$$

$$P_{1t} = e_t P_{2t} \quad [15]$$

$$e_t(1+i_{1t})E_t\left(c_{t+1}^{-\sigma}/P_{1t+1}\right) = (1+i_{2t})E_t\left(c_{t+1}^{-\sigma}/P_{1t+1}\right)e_{t+1} \quad [16]$$

$$\frac{M_{1t}}{P_{1t}} = c_t^{\sigma/\varepsilon}\left[\chi\left(1+\frac{1}{i_{1t}}\right)\right]^{1/\varepsilon} \quad [17]$$

$$\frac{M_{2t}}{P_{2t}} = c_t^{\sigma/\varepsilon}\left[\chi\left(1+\frac{1}{i_{2t}}\right)\right]^{1/\varepsilon} \quad [18]$$

$$P_{1t}g_{1t} - P_{1t}\tau_{1t} = M_{1t} - M_{1t-1} + B_{1t} - (1+i_{1t-1})B_{1t-1} \quad [19]$$

$$P_{2t}g_{2t} - P_{2t}\tau_{2t} = M_{2t} - M_{2t-1} + B_{2t} - (1+i_{2t-1})B_{2t-1} \quad [20]$$

$$c_t + g_{1t} + g_{2t} = y_{1t} + y_{2t} \quad [21]$$

When both central banks set an exogenous path for money supply ($M_{1t} = M_{2t} = M, \forall t$) all real and nominal variables are determined. In the case of interest rate pegging ($i_{1t} = i_{2t} = i, \forall t$), real variables are still determined in equilibrium but nominal variables are not. The model is recursive, with real variables determined by equations [14] and [17]-[21]; [16] gives the expected depreciation of the exchange rate. The remaining equation [15] simply ensures that purchasing power parity holds but is uninformative about absolute price levels and hence about the exchange rate.

Again, as in the one country case, the characterization of the equilibria is incomplete until the transversality condition is taken into account. To see this let us proceed as before iterating forward the consumer budget constraint under perfect foresight, which imposing [13] and [16] leads to:

$$\frac{W_t}{P_{1t}} = \sum_{j=0}^{\infty} \left( \prod_{s=t}^{t+j-1} r_{1s}^{-1} \right) \left[ \left( c_{1t+j} + \tau_{1t+j} - y_{1t+j} + \Delta_{1t+j} m_{it+j} \right) + \left( c_{2t+j} + \tau_{2t+j} - y_{2t+j} + \Delta_{2t+j} m_{2t+j} \right) \right] \qquad [22]$$

and imposing [21]:

$$\frac{W_t}{P_{1t}} = \sum_{t=0}^{\infty} \left( \prod_{s=t}^{t+j-1} r_{1s}^{-1} \right) \left[ \tau_{1t+j} + \tau_{2t+j} - g_{1t+j} - g_{2t+j} + \Delta_{1t+j} m_{1t+j} + \Delta_{2t+j} m_{2t+j} \right] \qquad [23]$$

As in the closed economy model, the transversality condition may or may not impose an additional constraint in the model, thus helping to fix one price level. Nevertheless, unlike the closed economy model, in a two country model that condition is not enough to provide a nominal anchor (see Dupor (1999)). When both countries follow a money supply rule and some of them lack fiscal discipline prices are over-determined. When the monetary authorities follow an interest rate rule, even if all countries are in a non-Ricardian regime, at least one price, and thus the nominal exchange rate, is undetermined.

It must be emphasized that this result does not rely on the assumption of one single consumer: equilibrium requires that the present value of each household's wealth must be zero, which in turn means that the present value of total outstanding wealth must be backed by future surpluses. But this condition applies in aggregate no matter how many governments are involved and thus only provides an additional restriction to fix one price level[5]. In the closed economy case the amount of prices left undetermined by an interest rate peg (one) equals the number of restrictions imposed by the transversality condition whenever fiscal authorities lack discipline. In a multi-country model under interest rate pegging *n-1* prices are left undetermined even if the fiscal theory of prices applies. Table 1 summarizes the main results on nominal indeterminacy of prices and the exchange rate in the two-country model for the polar cases of money and interest rate pegging in both countries.

**Table 1**

| | Ricardian Fiscal policy in both countries | Non-Ricardian Fiscal Policy at least in one country |
|---|---|---|
| Money peg in both countries | One (monetary) Equilibrium | No equilibrium |
| Interest rate peg in both countries | Indeterminacy (of $P_{1t}$, $P_{2t}$ and $e_t$) | Indeterminacy (of $e_t$ and $P_{1t}$ or $P_{2t}$) |

There are several ways to avoid this indeterminacy problem when interest rate rules are operating in both countries. The simplest one is making one price level given as if it were a small open economy model. Alternatively, the two-country model can be solved choosing an exchange rate peg as well. Then, in a non-Ricardian regime, one price level is determined by the transversality condition and the other price level is so by [15]. In the extreme case of an exchange rate peg and a monetary union, the single price level can be determined under a fiscal regime by the transversality condition, as in the closed economy model. It is interesting to notice how a monetary union is a sort of extreme solution to the indeterminacy problem, very much as monetary policy coordination was often invoked to maintain exchange rate stability in a world of high capital mobility.

## II.3. The Monetary Union

[5] The terminal condition can be thought as fixing $P_{1t}$ or, substituting out (15) in (23), $e_tP_{2t.}$

The monetary union is not just a useful device to eliminate indeterminacy in the open economy but it raises interesting policy issues on its own. Bergin (2000) explores a number of these issues specially the effect of non-Ricardian fiscal policies in some countries belonging to the union. In Bergin's model though the monetary union is itself a closed economy. In what follows we explore the implications for nominal determinacy specially for the nominal exchange rates, and for the conduct of monetary policies in a two-country model in which one of the countries is a monetary union, with one single currency, but two independent fiscal authorities. Using the same notation as in previous sections (the indices *A* and *B* label the two countries belonging to the monetary union (country *1*)) the model can be written now as:

$$Max\ E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{1-\sigma}\left(c_{1At} + c_{1Bt} + c_{2t}\right)^{1-\sigma} + \frac{\chi}{1-\varepsilon}\left[\left(\frac{M_{1t}}{P_{1t}}\right)^{1-\varepsilon} + \left(\frac{M_{2t}}{P_{2t}}\right)^{1-\varepsilon}\right]\right\} \qquad [24]$$

$$\begin{aligned} & P_{1t}(c_{1At} + c_{1Bt}) + P_{2t}e_t c_{2t} + P_{1t}(\tau_{1At} + \tau_{1Bt}) + P_{2t}e_t\tau_{2t} + B_{1At} + B_{1Bt} + e_t B_{2t} \\ & + M_{1t} + e_t M_{2t} \le P_{1t}(y_{1At} + y_{1Bt}) + P_{2t}e_t y_{2t} \\ & + (1 + i_{1t-1})(B_{1Ai-1} + B_{1Bi-1}) + (1 + i_{2t-1})e_t B_{2t-1} + M_{t-1} + e_t M_{2t-1} \end{aligned} \qquad [25]$$

$$W_{t+1} = M_{1t} + e_{t+1}M_{2t} + (1 + i_{1t})(B_{1At} + B_{1Bt}) + (1 + i_{2t})e_{t+1}B_{2t} \qquad [26]$$

$$\lim_{T\to\infty} E_0\left(\prod_{s=0}^{T-1}(1 + i_{1s})^{-1}\right)W_T = 0 \qquad [27]$$

Non-negativity is imposed on $M_{1t}$ and $M_{2t}$ but not on $B_{1At}$, $B_{1Bt}$, $B_{2t}$. The equilibrium is defined by equations [26]-[36], since [25] is made redundant by [33]-[36], plus a monetary rule for each country:

$$c_t^{-\sigma} = \beta(1 + i_{1t})E_t\left[c_{1t+1}^{-\sigma}\frac{P_{1t}}{P_{1t+1}}\right] \qquad [28]$$

$$P_{1t} = e_t P_{2t} \qquad [29]$$

$$e_t(1 + i_{1t})E_t\left(c_{t+1}^{-\sigma}/P_{1t+1}\right) = (1 + i_{2t})E_t\left(c_{t+1}^{-\sigma}/P_{1t+1}\right)e_{t+1} \qquad [30]$$

$$\frac{M_{1t}}{P_{1t}} = c_t^{\sigma/\varepsilon}\left[\chi\left(1+\frac{1}{i_{1t}}\right)\right]^{1/\varepsilon} \quad [31]$$

$$\frac{M_{2t}}{P_{2t}} = c_t^{\sigma/\varepsilon}\left[\chi\left(1+\frac{1}{i_{2t}}\right)\right]^{1/\varepsilon} \quad [32]$$

$$P_{1t}g_{1At} - P_{1t}\tau_{1At} = \frac{1}{2}(M_{1t} - M_{1t-1}) + B_{1At} - (1+i_{1t-1})B_{1At-1} \quad [33]$$

$$P_{1t}g_{1Bt} - P_{1t}\tau_{1Bt} = \frac{1}{2}(M_{1t} - M_{1t-1}) + B_{1Bt} - (1+i_{1t-1})B_{1Bt-1} \quad [34]$$

$$P_{2t}g_{2t} - P_{2t}\tau_{2t} = M_{2t} - M_{2t-1} + B_{2t} - (1+i_{2t-1})B_{2t-1} \quad [35]$$

$$c_t + g_{1At} + g_{1Bt} + g_{2t} = y_{1At} + y_{1Bt} + y_{2t} \quad [36]$$

Seignorage within the union is split on equal grounds among countries *A* and *B*. As in the previous model, the characterization of the equilibrium is incomplete until the transversality condition is taken into account. Iterating forward, under perfect foresight and imposing [27] and [30], the consumer budget constraint leads to:

$$\frac{W_t}{P_{1t}} = \sum_{j=0}^{\infty}\left(\prod_{s=t}^{t+j-1} r_{1s}^{-1}\right)\left[\left(c_{1t+j} + \tau_{1t+j} - y_{1t+j} + \Delta_{1t+j}m_{it+j}\right) + \left(c_{2t+j} + \tau_{2t+j} - y_{2t+j} + \Delta_{2t+j}m_{2t+j}\right)\right] \quad [37]$$

and imposing [36]:

$$\frac{W_t}{P_{1t}} = \sum_{t=0}^{\infty}\left(\prod_{s=t}^{t+j-1} r_{1s}^{-1}\right)\left[\tau_{1t+j} + \tau_{2t+j} - g_{1t+j} - g_{2t+j} + \Delta_{1t+j}m_{1t+j} + \Delta_{2t+j}m_{2t+j}\right] \quad [38]$$

where countries *A* and *B* variables are aggregated into union wide ones.

Again, the characterization of equilibria crucially depends on the definition of monetary and fiscal policy rules. Under interest rate peg, non-Ricardian policies in one or all countries, cannot restore nominal determinacy since as in the previous model there is just one aggregate fiscal restriction and two prices. More precisely, in this case, the absolute level of prices are determined in either currency (so either $\{P_{1t},\ e_t P_{2t}\}$ or $\{(P_{1t}/e_t),\ P_{2t}\}$) but the exchange rate is not, as in Dupor's model.

At this point is worth exploring yet another possible device to render the exchange rate determinate under interest rate peg, provided that some fiscal authorities pursue non-Ricardian policies. Consider equilibria in which $b_{it}$ is required to be strictly positive at any time (see Canzoneri, Diba and Cumbi (1998)). In such cases the consumer's transversality condition requires not a single (worldwide) present value condition but one of these for each country. If that condition is not imposed, equilibria in which $b_{1t}$, say, grows without bound could not be ruled out, provided that $b_{2t}$ becomes large and negative as fast as it is needed to keep $W_{1t}$ bounded. In a two representative consumer model, that situation would imply that country 2 would be making a permanent transfer to country 1, that had to be paid by country 2's tax-payers. Before this permanent wealth transfer is achieved, the market for country 1 bonds would collapse since households would not be willing to accept any more of them unless a large risk premium is paid. In absence of such insurance market, Bergin (2000) argues, that situation would not be feasible. It is true that this argument is less compelling in our one-world-representative-consumer model, in which no income transfer takes place. Still, it can still be reasonably assumed that the household is not willing to borrow from government 2 in order to buy an unlimited amount of country 1 bonds.

Assumptions about non negativity on $b_{1A}$, $b_{1B}$ and $b_2$ further complicates the analysis, since then the model would have to satisfy three instead of one additional present value conditions.[6] A more realistic case would entail imposing non-negativity on $b_{1t}$ as a whole (but neither on $b_{1At}$ nor on $b_{1Bt}$, thus allowing full risk sharing among the monetary union members) and $b_{2t}$. In this case for [38] to be satisfied the two intertemporal government budget constraints must be satisfied. Iterating forward in [33]-[34] and [35] gives,

$$\frac{\left(M_{1t-1} + (1 + i_{1t-1}) B_{1t-1}\right)}{P_{1t}} = \sum_{j=0}^{\infty} \left( \prod_{s=t}^{t+j-1} r_{1s}^{-1} \right) \left[ \tau_{1t+j} - g_{1t+j} + \Delta_{1t+j} m_{1t+j} \right] \qquad [39]$$

[6] In the case of all countries following non-Ricardian policies the model would become over-determined and no pair of prices could possibly satisfy all three restrictions at the same time.

$$\frac{\left(M_{2t-1}+(1+i_{2t-1})B_{2t-1}\right)}{P_{2t}}=\sum_{j=0}^{\infty}\left(\prod_{s=t}^{t+j-1}r_{2s}^{-1}\right)\left[\tau_{2t+j}-g_{2t+j}+\Delta_{2t+j}m_{2t+j}\right] \qquad [40]$$

With interest rate peg and non-Ricardian fiscal policies in both countries, price determination can be recovered since the transversality condition imposes two constraints, which pick up both $P_{1t}$ and $P_{2t}$. Following a tax cut in country 2, say, $P_{2t}$ would rise (by [40]). Similarly the price response to a rise in $i_{1t}$ would depend on the impact of such a rise in the right hand side of [39]. In this case the fiscal theory of prices can be interpreted as a fiscal theory of the exchange rate (Canzoneri, Cumbi and Diba, 1998). The exchange rate is determined by the purchasing power parity condition and would move along with $P_{1t}$ and $P_{2t}$; thus, any non standard response of prices to monetary or fiscal policy shocks would produce equally non standard exchange rate movements. For example, an increase in $i_{1t}$ may, under some circumstances, lead to a rise in $P_{1t}$ and, then, to a depreciation of the currency, the opposite of what could be expected in a Ricardian or monetary regime.

Two interesting features of the model illustrate the link between fiscal behavior and the price level providing a rational for the fiscal restrictions incorporated in the Growth and Stability Pact of the European Monetary Union. First, it can be shown that the objective of price stability of the monetary union is in jeopardy if one government follows an active fiscal policy, even if the other does not so. To see this, let us assume that the monetary authority pegs the interest rate, that government 1A sets taxes to ensure its own solvency, and that government 1B has an exogenous constant tax rate. To simplify, assume also that the exogenous levels of output and government spending are constant. Then, since government 1B gets the union into a fiscal regime, [39] will determine $P_{1t}$. Consider, for example, a tax reduction in period t with no future offsetting change. Then, the right hand side of [39] will decrease by exactly the amount of the tax reduction in t. Therefore, with predetermined nominal wealth, $W_{1t}$, guaranteeing solvency at t requires an increase in $P_{1t}$ and an exchange rate depreciation that will affect prices and output in country 2.

The second result is that individual government solvency is a sufficient condition for price stability. To show this, maintain the simplifying assumption of constant output and government spending levels and suppose that the central bank of the union targets price stability defined as ($P_{1t} = P_1, \forall t$). Then, consumption will be constant and the nominal interest rate will be constant as well, so targeting price stability requires a monetary policy that pegs interest rate. With constant consumption, price and interest rate, equilibrium nominal balances must be also constant. Therefore, [39] becomes:

$$(1+i)(B_{1At-1} + B_{2Bt-1}) + M_1 = P_1 \sum_{j=0}^{\infty} \left( r_1^{-(j-1)} \right) \left( \tau_{1At+j} - g_{1A} + \tau_{Bt+j} - g_{2B} + \Delta m_1 \right) \qquad [39']$$

This condition requires joint fiscal responsibility without the need of additional transfers from the central bank. Thus, any change in the outstanding joint government debt must be backed in present value terms by just future joint tax revenues. Clearly, a sufficient condition to satisfy [39´] is to require individual government solvency, an asymptotic condition that, as pointed out by Bergin (2000), provides some justification for, but is much less restrictive than, the fiscal ceilings imposed by the Stability and Growth Pact.

## III. Policy Shocks under Endogenous Monetary and Fiscal Rules

There are theoretical difficulties testing if observed data has been under a monetarist or a fiscal regime since both regimes are possible equilibrium outcomes and the only difference rests on how the transversality condition is satisfied. For this reason we have decided to simulate the effects of different policy shocks when the combination of monetary and fiscal rules are such that we are in a regime or in other.

In the previous section the importance of the fiscal solvency condition for price determination was analyzed in the context of interest rate pegging. Fiscal policies were defined as either passive or active according to whether changes in future surpluses were announced to compensate for changes in current ones or not.

Nevertheless, central banks and governments rarely rely in such extreme policy rules. In this section we extend the analysis to allow for monetary and fiscal rules that are function of other endogenous variables in the model. These rules can be thought of as generalized expressions of the ones discussed in section 2, which can be obtained for particular values of the parameters in [41] and [42].

We specify a monetary policy reaction function under the assumption that the central bank operating instrument is the short-term interest rate ($i_t$). Following Leeper (1991), we use a more general interest rate rule than Taylor (1993), allowing for current interactions between output, inflation ad interest rates instead of lagged interactions:

$$\hat{i}_t = \delta_1 \hat{\pi}_t + \delta_2 \hat{y}_t + \varepsilon_t^i \qquad [41]$$

Where variables are defined as log-linear approximations around their steady state values. Monetary policy adjusts gradually and in a forward looking way (Clarida, Galí and Gertler (1998)), but to simplify matters we choose the specification of Leeper (1991) in which simple rules do not allow for interest rate smoothing or an inflation expectation effect. The random term $\varepsilon_t^i$ represents unexpected movements in monetary policy. The fiscal authority sets lump-sum taxes $\tau_t$ according to the rule:[7]

$$\hat{\tau}_t = \alpha_1 \left( \frac{\hat{B}_{t-1}}{\hat{P}_{t-1}} \right) + \alpha_2 \hat{y}_t + \varepsilon_t^\tau \qquad [42]$$

where $\varepsilon_t^r$ represents a random shock of the part of the fiscal authorities. We assume that both authorities follow counter-cyclical policies implying that the coefficients $\delta_1$, $\delta_2$, $\alpha_1$, and $\alpha_2$ are positive.

Leeper (1991) shows that the nature of the solution obtained, as far as price determination is concerned, hinges crucially on the two policy parameters, $\delta_1$ and $\alpha_1$,

[7] Alternatively, the fiscal policy could be defined in terms of the primary deficit ($g_t$-$\tau_t$) as the instrument.

as well as on $\beta$. Two possible equilibrium regions appear denoted as *Ricardian:* $\{\delta_1\beta>1$ and $(\beta^{-1}-\alpha_1)<1\}$, and *non-Ricardian:* $\{\delta_1\beta<1$ and $(\beta^{-1}-\alpha_1)>1\}$. In the first region (*R*), monetary policy responds strongly to inflation ($\delta_1>1/\beta$) and the fiscal policy acts to satisfy its intertemporal budget constraint, preventing real debt from growing explosively ($1/\beta<(1+\alpha_1)$). By contrast, in the n*on-Ricardian* case the monetary policy is unresponsive to inflation and fiscal policy is unresponsive to real debt. In this case what determines the initial response of the price level is the long run bound imposed on real wealth[8]. A similar characterization of policy regimes can be derived for the two-country and the monetary union models discussed in section 2. This characterization and the stability analysis for all three models (closed economy, two-country and monetary union) are summarized in Appendix A.

As discussed in section 2, in a two country model with free capital mobility in which one country is not prevented from holding limitless amounts of the other country 's debt, only an aggregate transversality condition must hold, leading to nominal indetermination under interest rate peg. This is so regardless of the way fiscal policies are conducted in both countries; hence, in that setting, the fiscal regime could never be obtained. We depart now from the world of perfect international insurance and assume that $b_{it+j}$ cannot take negative values. In this case the requirement of neither $B_{1t}$ nor $B_{2t}$ exploding provides the model with two transversality conditions, and both the Ricardian (region 1) and the non-Ricardian (region 2) regimes are possible.[9] Moreover, in such a model there are two new regions of stability. Region 3 results from the combination of policies of region 1 in one country (say 1) and region 2 in the other. The relevance of this case stems from the fact that the price level in country 1 is determined by the stance of monetary policy whereas $P_{2t}$ is determined by the government budget constraint in country 2.

The range of parameter values that brings the economy into region 4 combines a situation that would produce price indeterminacy in one country (say,

[8] Schmitt-Grohé and Uribe (2000) analyze this result in a model with production and where the Government follows a balance-budget requirement.

[9] The Ricardian regime happens when both countries follow polices corresponding to region 1 in the closed economy; similarly, the non-Ricardian regime requires that both countries' polices are of the type of those in region 2. Thus, we use the same labels in the open economy model.

country 1) and over-determination in the other if the two countries were closed.[10] However, a two-country model has the right amount of stable roots and both nominal and real variables are determined. The indetermination of the forward looking $P_{1t}$ is solved to satisfy the *PPP* condition [15]. Since what happens in country 2 is so relevant in this region the response of both economies to policy shocks will crucially depend on the country in which the shock is originated. The next section addresses this issue.

For simplicity the simulations under a monetary union are carried out for a closed economy model. We leave for further research simulations under the open economy model with a monetary union displayed in section II.3. In a monetary union with two countries the dynamics around the steady state are summarized by a price equation and two real debt equations. Since we require individual government solvency, one additional root must lie outside the unit circle relative to the closed economy case in order to avoid price over-determination. We show in Appendix A that policy combinations generating Ricardian and non-Ricardian regimes depend now on the three policy parameters corresponding to the unique monetary policy rule ($\delta_1$) and the two fiscal rules in each country ($\alpha_{11}$, $\alpha_{21}$).

III.1. Monetary policy shocks and fiscal regimes

We study the transmission of monetary policy shocks under alternative fiscal regimes in the open economy model, both with flexible exchange rate and under monetary union. The simulations are carried out in a slightly modified version of models in section 2, now assuming that output in both economies is driven by a Lucas supply curve (see Appendix B for a detailed description of the parameter values) and that $b_{1t}$ and $b_{2t}$ cannot be negative.[11]

Figure 1 shows the responses of output, inflation and taxes in each country as well as that of the exchange rate to a monetary policy shock in country 1 when

[10] For country 2 the parameter region considered is $(\delta_{21}\beta)>1$, $(\beta^{-1}-\alpha_{21})>1$ and for country 1 $(\delta_{11}\beta)<1$, $(\beta^{-1}-\alpha_{11})<1$.

[11] The regions of stability are unaltered when the supply curve is represented by a Lucas equation in which only surprise changes in inflation affect the production of goods. By contrast if the aggregate supply curve were represented by a forward Phillips curve (e.g. Rotemberg and Woodford (1997)

the policy parameters are in region 2. Following a rise in interest rates output falls in country 1 and inflation rises sharply, after a moderate short-lived fall, as ought to be expected according to the fiscal theory of prices. The soft reaction of taxes to the rise in real debt, along with the increase in the interest rate, makes it necessary for prices to increase by the amount required to bring the real value of outstanding debt back to the path that ensures government solvency (see equation [22]). Consequently, the level of real debt first rises and then falls to its steady state value, whereas taxes show almost no response. The exchange rate slightly appreciates on impact to depreciate over the long run. The depreciation minimises the overall effect in country 2 of the shock originated in country 1; in particular, the inflation rate is almost unaffected. These results are the opposite to what would happen in a Ricardian regime in which the positive tax response to the increase in debt level would allow inflation to be driven by the monetary contraction, falling on impact.

Figure 2 shows the effects of a common monetary policy shock when the fiscal authorities in each country behave differently. Specifically we are in region 3 that combines the Ricardian policy mix of country 1 with the non-Ricardian one of country 2. The responses to a symmetric monetary contraction shock confirm in each country the pattern associated with its regime. In country 1, output and inflation fall and the initial debt increase is paid off with higher taxes. In country 2, inflation rises sharply after a slight initial decrease, and the initial debt increase is much larger because the interest rate shock is amplified, by the lower decreases of output and inflation, increasing much more the cost of servicing the debt. In contrast with country 1, this new debt is not met by an increase in taxes but by the sharp increase in prices which quickly erodes its real value up to a level compatible with the government budget constraint. These different responses induce an exchange rate adjustment consistent with the interest rate and price dynamics. First an initial appreciation corresponding with both the interest rate and the price level lower in country 1. Thereafter the exchange rate depreciates as the interest rate of country 2 decreases below the rate of country 1 and the price gap narrows. In the long run the exchange rate returns to its steady state value since prices adjust completely. Recall the difference with the standard monetary theory of exchange rate determination in a

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sticky price model) the stability region would change. In particular stability would also depend on the policy parameter $\delta_2$ as well as on the supply curve parameters.

two-country world: had both countries been in a monetary regime, the exchange rate should not have been reacted to a common shock in symmetric economies. Nevertheless, differences in the policy reaction functions drive a wedge among the initial response of $i_{1t}$ and $i_{2t}$ thus inducing an exchange rate adjustment.

Figure 3 presents an asymmetric monetary shock to either country 1 (Figure 3a) or country 2 (Figure 3b) when the world is in region 4. In this parameter combination, country 1 is in a situation in which monetary policy responds very little to the level of inflation, whereas the fiscal authority reacts quickly and strongly to prevent the level of debt from explosion. With this policy scheme, the price level in country 1 would not be uniquely determined in a closed economy framework (i.e., this economy on its own would display price level indeterminacy). Country 2 is just in the opposite situation: since the fiscal authority lacks discipline, the price level has to adjust to prevent the real debt from exploding, but at the same time, an aggressive monetary reaction function is at work to determine the level of nominal variables. Thus, there would be no equilibrium in a closed economy framework (i.e., this economy on its own would display price level over-determination). Nevertheless, as discussed before, in the open economy context this combination of policies helps to determine two nominal variables whereas the third one is determined by the PPP condition.

Figure 3a shows the response of the variables to a monetary contraction in country 1. The response of the price level in country 1 follows the non-Ricardian pattern, despite the fact that $b_{1t}$ is bound by the fiscal discipline of that country and, thus, taxes increase to balance the government budget constraint. In fact, given the small decrease in output, taxes react so strongly that the level of debt goes below the steady state for several periods. Thus, the reason for this price dynamics in country 1 must be found somewhere else. Since the debt level of country 2 is not affected by the shock, its price level does not move either.[12] After the shock, an interest rate differential persists for a while, thus $e_t$ must depreciate all the way to the new steady state; since $P_{1t}$ moves along with $(e_t+P_{2t})$, inflation breaks out in country

[12] If it did the new value of real debt would violate the intertemporal budget constraint and prices would have to move in the opposite direction to restore the equilibrium.

1.[13] Thus the time path of $P_{1t}$ is mostly driven by the necessity of satisfying the transversality condition of $b_{2t}$ (i.e. $P_{2t}$ must not change on impact since otherwise the debt in country 2 would explode) and by the PPP condition. Notice that the exchange rate adjustment prevents the effects of the shock to affect country 2 that remains unaffected despite the fact that the policy combination in this country is crucial to obtain the responses observed in country 1.

Figure 3b depicts the impulse-responses functions following an unanticipated rise on country 2 interest rates. Economy 2 behaves very much like a Ricardian regime, except for the fact that taxes do not rise in response to higher debt levels and so the after-shock adjustment of the debt is slow, in line with the interest rate adjustment. Prices in this country are prevented from rising sharply by an aggressive counter-inflationary monetary policy. On the other hand, economy 1 is not isolated from the effects of the shock, and its responses are non-standard: an strong unanticipated deflation produces a sharp recession which in turn leads to a decrease of the interest rate. Again we observe an exchange rate response at odds with what monetary models would predict: it appreciates despite the fact that the monetary policy stance seems expansionary in country 1 and tight in country 2.

Finally, Figure 4 refers to the monetary union model and shows the responses of the variables in both countries to a monetary contraction under a *non-Ricardian* parameterization: weak monetary policy reaction to inflation, fiscal solvency guaranteed in country 1, and fiscally irresponsible behavior in country 2. As can be seen, the positive impact on debt is immediately offset by a tax increase in country 1. Country 2, however, does not adjust taxes, and so inflation rises to restore its solvency. Unlike what happened in the two-country model, now the exchange rate is no longer able to adjust as to isolate one country from the negative effects of the lack of fiscal discipline in the other. This pattern of responses confirms

[13] Notice that the dynamics of the exchange rate is very much the same that would take place in a monetary model, where it depreciates after the initial jump. In an overshooting model, that depreciation partly compensates the initial (impact) appreciation and the domestic currency is valued more after the monetary contraction. Here, the initial jump is nil, thus the depreciation afterwards takes the currency to a lower steady state value vis-a-vis the foreign currency.

that a single irresponsible government can place the union as a whole in a fiscal regime.[14]

III.2. Fiscal policy shocks and fiscal regimes

The effects of an unanticipated fiscal shock in an open economy model are shown in Figure 5. We observe that a tax cut in a Ricardian regime (region 1), say in country 1, has an immediate opposite effect in the level of debt but it has no other real or nominal effect (see the starred line (*)). That corresponds with the Ricardian equivalence proposition. By contrast, under a non-Ricardian regime (region 3) the shock has nominal and real effects both domestically and abroad (see the continuous line). The country in which the fiscal shock originates (country 1) is subject to a demand shock that rises output and inflation. The currency depreciation in country 1 generates a slight deflation in country 2 and a corresponding fall in the interest rate and consumption. Notice also the lower debt service is met by a delayed tax decrease in country 2.

When the same shock takes place in a monetary union under a non-Ricardian regime, the impossibility of exchange rate adjustment makes the pattern of response of output similar in both countries (Figure 6). Thus, a fiscal shock in country 1 has significant and persistent effects not only in that country but also in the remaining countries of the union. In particular, a tax cut might be inflationary.

## IV. Summary and conclusions

The fiscal theory of prices challenges the conventional wisdom that the price level is determined by the evolution of the monetary aggregates. The fiscal theory shows that the behavior of prices is heavily dependent on the way monetary and fiscal policies are conducted. The most striking conclusion to be drawn is that the ability of the monetary authority to maintain price stability, through nominal interest rate management, is severely undermined if the fiscal authority lacks of sufficient discipline to satisfy its intertemporal budget constraint. The extension of this analysis

[14] In fact, part of the blame for this response of inflation must be borne by the soft reaction of monetary policy to inflation. However, if the monetary authority is very tough against inflation there would be no solution due to price over-determination.

to a multi-country world raises a number of interesting issues. In such a setting things are far more complicated since then prices and output in one country depend also on the way other countries fiscal and monetary policies are set. In particular, the exchange rate may not be determined under interest rate peg unless some restrictions are imposed on risk sharing and capital mobility across countries. A fixed exchange rate regime, or its extreme case of a monetary union, restores price determinacy but at the cost of across boundaries contagion of the negative effect of some shocks that hit economies with non-Ricardian fiscal policies.

As simulations in Section III confirm, a rise in the interest rate in a non-Ricardian economy might be inflationary although a flexible exchange rate may prevent inflation from rising in other countries. Interestingly, for this isolating effect to happen in our model, the currency must depreciate in the country in which the interest rate has increased. Thus, both the behavior of prices and that of the nominal exchange rate might contradict what ought to be expected in a monetary or Ricardian regime. A cut in taxes (or a rise in government spending for that matters) in a non-Ricardian country has largely the same effects. Other more complicated patterns of responses are obtained depending on the policy combinations across countries, the country in which the shock takes place and the very nature of the shock itself. In a monetary union, the exchange rate cannot adjust and the non standard responses in the country in which the shocks originates spill over other members of the union. In this case, the ability to target price stability depends on the fiscal behavior of member countries: if one country lacks fiscal discipline the price level of the union will be affected. Consequently, the requirement of individual government solvency may be considered a justification for the fiscal ceilings imposed by the Stability and Growth Pact. This result highlights the importance of fiscal coordination as a necessary condition for macroeconomic stability in a monetary union. Moreover, since we may characterize EMU as an open economy, the value of the euro will depend on the way fiscal policy is conducted in each country member as well as on fiscal policies in third countries.

To the extent that the foes raised by the fiscal theory of prices are more than a matter of academic interest, simulations like the ones conducted here are a first modest step towards understanding some economic policy dilemmas. But before that is achieved, the study of aggregate price determination must go beyond its current state to assess the internal consistency of competing theories as well as their empirical relevance. In this respect the non-standard patterns of response to monetary and fiscal shocks suggest that the multi-country version of the fiscal theory of price determination may explain seemingly puzzling patterns of output, inflation and exchange rate correlations. Many macroeconomic models aimed at explaining observed cyclical movements and co-movements of macroeconomic variables more often than not abstract from the possibility of different fiscal policy regimes. Fiscal policy in these models is passive and designed to support equilibria within the monetary regime, thus leaving no room for correlations and business cycle facts that are at odds with the predictions of monetary models. However, events in the world economy are the result of shocks hitting different economies which in turn are characterized by very different economic policies. We have not pursued this avenue here, but it seems a natural way to test the relevance of the fiscal approach to price determination.

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## APPENDIX A: EQUILIBRIUM AND STABILITY REGIONS.

We consider exogenous sequences for output and public expenditure $\{y_t, g_t\}$ that follow some stationary process. Also, for the sake of simplicity, the stability analysis is carried out assuming that $\delta_2=\alpha_2=0$.

Closed economy

To study the dynamic properties of the model, we take a log-linear approximation around the deterministic steady state with constant inflation ($\pi$), nominal interest rate ($i$) and real variables ($m, b, c, \tau$). Substituting out in the log-linear system [6], [41] and [42] in [5] and [7], the dynamics around the steady state are summarized by the following price and real debt equations:

$$E_t\left(\hat{P}_{t+1}-\hat{P}_t\right)=\delta_1\beta\left(\hat{P}_t-\hat{P}_{t-1}\right)-\sigma E_t\left(\hat{c}_{t+1}-\hat{c}_t\right) \qquad \text{[A1]}$$

$$\hat{b}_t=\left(\beta^{-1}-\alpha_1\right)\hat{b}_{t-1}-\left(\frac{m}{\pi b}-\frac{m\delta_1\pi}{b}\varepsilon_i+\beta^{-1}\right)\left(\hat{P}_t-\hat{P}_{t-1}\right)-\left(\frac{m\delta_1}{b}\varepsilon_i-\delta_1\right)\left(\hat{P}_{t-1}-\hat{P}_{t-2}\right)$$
$$-\frac{m\varepsilon_c}{b}\left(\hat{c}_t-\frac{1}{\pi}\hat{c}_{t-1}\right)+g\,\hat{g}_t \qquad \text{[A2]}$$

where $\varepsilon_c$ and $\varepsilon_i$ correspond to the coefficients on consumption and interest rate in the log-linear real balance equation [6]. A sufficient condition for a unique equilibrium is that only one root of the system [A1] and [A2] lies inside the unit circle. Two possible outcomes appear denoted, following Leeper (1991), as *Ricardian (R),* when $\{\delta_1\beta>1$ *and* $(\beta^{-1}-\alpha_1)<1\}$ and *non-Ricardian (NR)* when $\{\delta_1\beta<1$ *and* $(\beta^{-1}-\alpha_1)>1\}$. There are two other possible solutions that combine the parameter values for $\alpha_1$ and $\delta_1$ in the regimes previously discussed. One of these solutions ($\delta_1$ low and $\alpha_1$ large) generates indeterminacy of equilibria. The other generates no equilibrium ($P_t$ is over-determined) since each policy acts in such a way that it determines the initial price level ($\delta_1$ large and $\alpha_1$ low).

Two country model

We focus on the case in which, due to imperfect insurance, each country must satisfy its present value government budget constraint [24] and [25] and $B_{it+j}$ cannot take negative values. From the log-linear versions of [14], [15] and [16] jointly with the monetary policies for each country, we obtain two difference equations in $P_{1t}$ and $P_{2t}$:

$$E_t\left(\hat{P}_{1t+1}-\hat{P}_{1t}\right)=-\sigma E_t\left(\hat{c}_{t+1}-\hat{c}_t\right)+\delta_{11}\beta\left(\hat{P}_{1t}-\hat{P}_{1t-1}\right) \quad \text{[A3]}$$

$$E_t\left(\hat{P}_{2t+1}-\hat{P}_{2t}\right)=E_t\left(\hat{P}_{1t+1}-\hat{P}_{1t}\right)+\delta_{21}\beta\left(\hat{P}_{2t}-\hat{P}_{2t-1}\right)-\delta_{11}\beta\left(\hat{P}_{1t}-\hat{P}_{1t-1}\right) \quad \text{[A4]}$$

The difference equations for real debt, $b_{1t}$ and $b_{2t}$, are obtained as before upon substitution of the corresponding monetary and fiscal rules and money demand in the government budget constraint of each country:

$$\hat{b}_{1t}=\left(\beta^{-1}-\alpha_{11}\right)\hat{b}_{1t-1}-\left(\frac{m_1}{\pi_1\ \ b_1}-\frac{m_1\delta_{11}\pi_1}{b_1}\varepsilon_i+\beta^{-1}\right)\left(\hat{P}_{1t}-\hat{P}_{1t-1}\right)-$$

$$-\left(\frac{m_1\delta_{11}}{b_1}\varepsilon_i-\delta_{11}\right)\left(\hat{P}_{1t-1}-\hat{P}_{1t-2}\right)-\frac{m_1\varepsilon_c}{b_1}\left(\hat{c}_t-\frac{1}{\pi_1}\hat{c}_{t-1}\right)+g_1\,\hat{g}_{1t} \quad \text{[A5]}$$

$$\hat{b}_{2t}=\left(\beta^{-1}-\alpha_{21}\right)\hat{b}_{2t-1}-\left(\frac{m_2}{\pi_2\ \ b_2}-\frac{m_2\delta_{21}\pi_2}{b_2}\varepsilon_i+\beta^{-1}\right)\left(\hat{P}_{2t}-\hat{P}_{2t-1}\right)-$$

$$-\left(\frac{m_2\delta_{21}}{\beta}\varepsilon_i-\delta_{21}\right)\left(\hat{P}_{2t-1}-\hat{P}_{2t-2}\right)-\frac{m_2\varepsilon_c}{b_2}\left(\hat{c}_t-\frac{1}{\pi_2}\hat{c}_{t-1}\right)+g_2\,\hat{g}_{2t} \quad \text{[A6]}$$

The stability of the system [A3]-[A6] depends on the policy parameters, $\delta_{11}$, $\delta_{21}$, $\alpha_{11}$, $\alpha_{21}$ and $\beta$, where the first index makes reference to the country. A sufficient condition to get a unique solution in this model is to have just two roots outside the unit circle. Then we can define four possible regions of stability depending on the values of those five parameters:

R1): $(\delta_{i1}\beta)>1$ *and* $(\beta^{-1}-\alpha_{i1})<1$, $i=1,2$

R2): $(\delta_{i1}\beta)<1$ *and* $(\beta^{-1}-\alpha_{i1})>1$, $i=1,2$

R3): $(\delta_{i1}\beta)>1$, $(\beta^{-1}-\alpha_{i1})<1$, $(\delta_{j1}\beta)<1$, $(\beta^{-1}-\alpha_{j1})>1$, $i, j = 1,2$, $i\neq j$

R4): $(\delta_{i1}\beta)<1$, $(\beta^{-1}-\alpha_{i1})<1$, $(\delta_{j1}\beta)>1$, $(\beta^{-1}-\alpha_{j1})>1$, $i, j = 1,2$, $i\neq j$

The first two stable regions are equal to the ones analyzed in a closed economy. Region 3 results from the combination of Ricardian policies in one country and non-Ricardian ones in the other. The range of parameter values that brings the economy into region 4 combines a situation of indetermination in one country with over-determination in the other if the two countries were closed.

Monetary union

The dynamics around the steady state is summarized by a price equation and two real debt equations, obtained from the log-linear version of the model in its closed economy version. The resulting price equation is the same as the one-country-closed economy case [A1], whereas the two real debt equations are similar to [A5] and [A6] in the two-country-flexible-rate case, with the difference that they now share the interest rate rule parameter ($\delta_1$) and the values for inflation and real balances. A sufficient condition for a unique solution in this case is that one root be inside and two outside the unit circle, which leads to two regions of stability depending on the values of the parameters ($\delta_1$, $\alpha_{11}$, $\alpha_{21}$, $\beta$):

*Ricardian:* $\{\delta_1\beta>1, (\beta^{-1}-\alpha_{11})<1, (\beta^{-1}-\alpha_{21})<1\}$

*Non-Ricardian:* $\{\delta_1\beta<1, (\beta^{-1}-\alpha_{i1})>1, (\beta^{-1}-\alpha_{j1})<1\}$, $i,j = 1,2$, $i\neq j$.

Notice that since we require individual government solvency, one additional root must lie outside the unit circle relative to the closed economy case in order to avoid price over-determination. If only joint government solvency was required, the stability analysis would be exactly analogous to the closed economy model, with one root inside and one outside, since just a single price must be determined in both cases.

## APPENDIX B: PARAMETER VALUES.

The simulations reported in the text used the following Lucas type of aggregate supply function:

$$y_{it} = (1-\phi_{i1t})\phi_{i0} + \phi_{i1} y_{it-1} + \phi_{i2}(P_{it} - E_{t-1}P_{it})/P_{it-1} + \varepsilon_{it}^{y}$$

The following parameter values correspond to a model simulated for quarterly data.

Preference parameters:

$\beta$= 0.994, $\varepsilon$=6.0, $\sigma$=3.0, $\chi$=0.001

Aggregate supply

$\phi_{i0}$ = 1.0 , $\phi_{i1}$ = 0.85, $\phi_{i2}$=0.25

Parameters fiscal rule

$\alpha_{i1}$ =0.001(non-Ricardian)/0.5 (Ricardian), $\alpha_{i2}$ = 0.25

Parameters interest rate rule

$\delta_{i1}$= 0.3 /1.3, $\delta_{i2}$ = 0.25

The imposed steady state fiscal variables and nominal interest rate are:

$g_i$ =0.3, $\tau_i$ = 0.3

$i_i$ = 0.01

FIGURE 1

Responses to an Asymmetric Monetary Shock in Country 1

(Region 2: non-Ricardian countries)

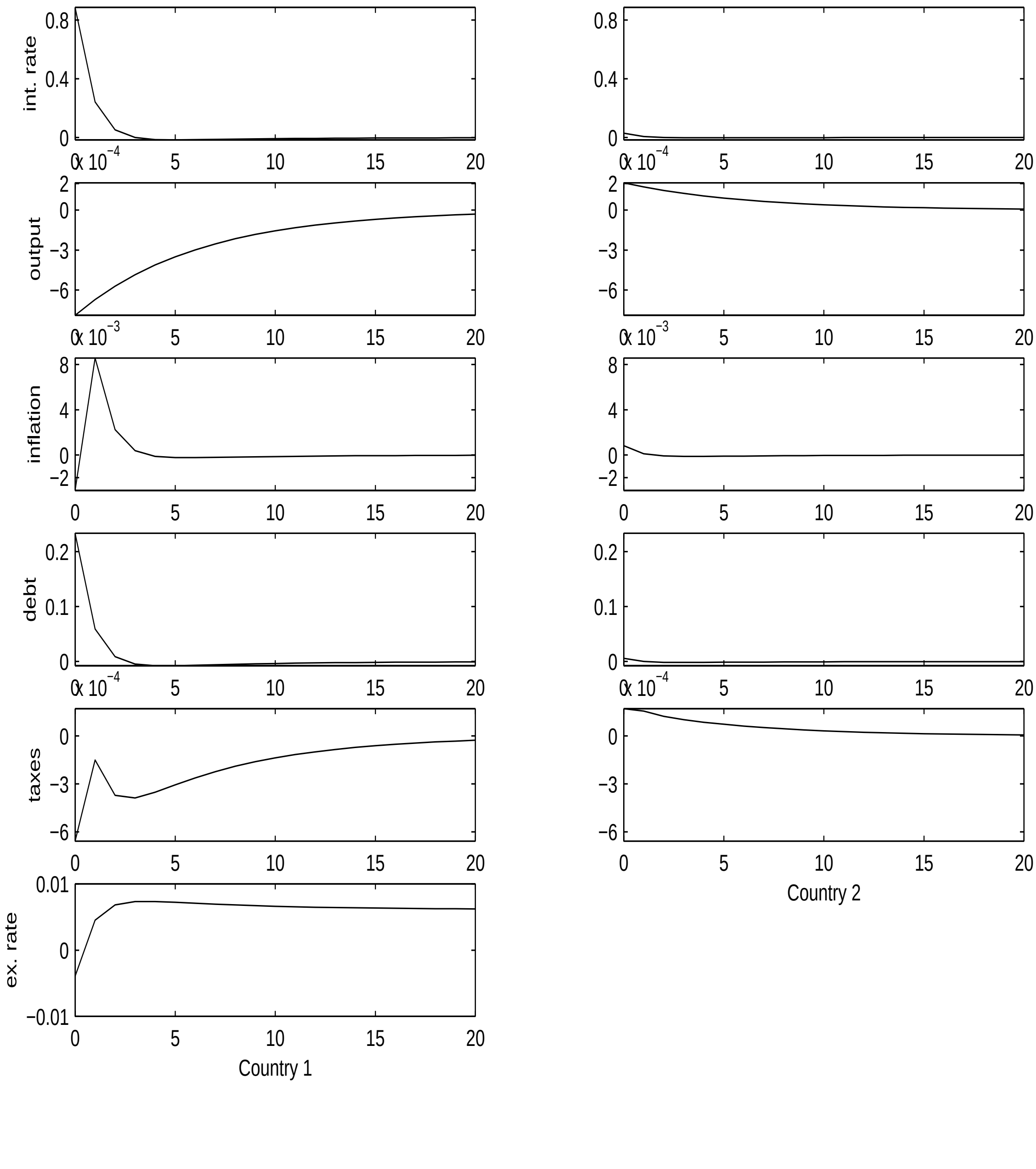


FIGURE 2

Responses to a Common Monetary Policy Shock

(Region 3: Ricardian vs. non-Ricardian Countries)

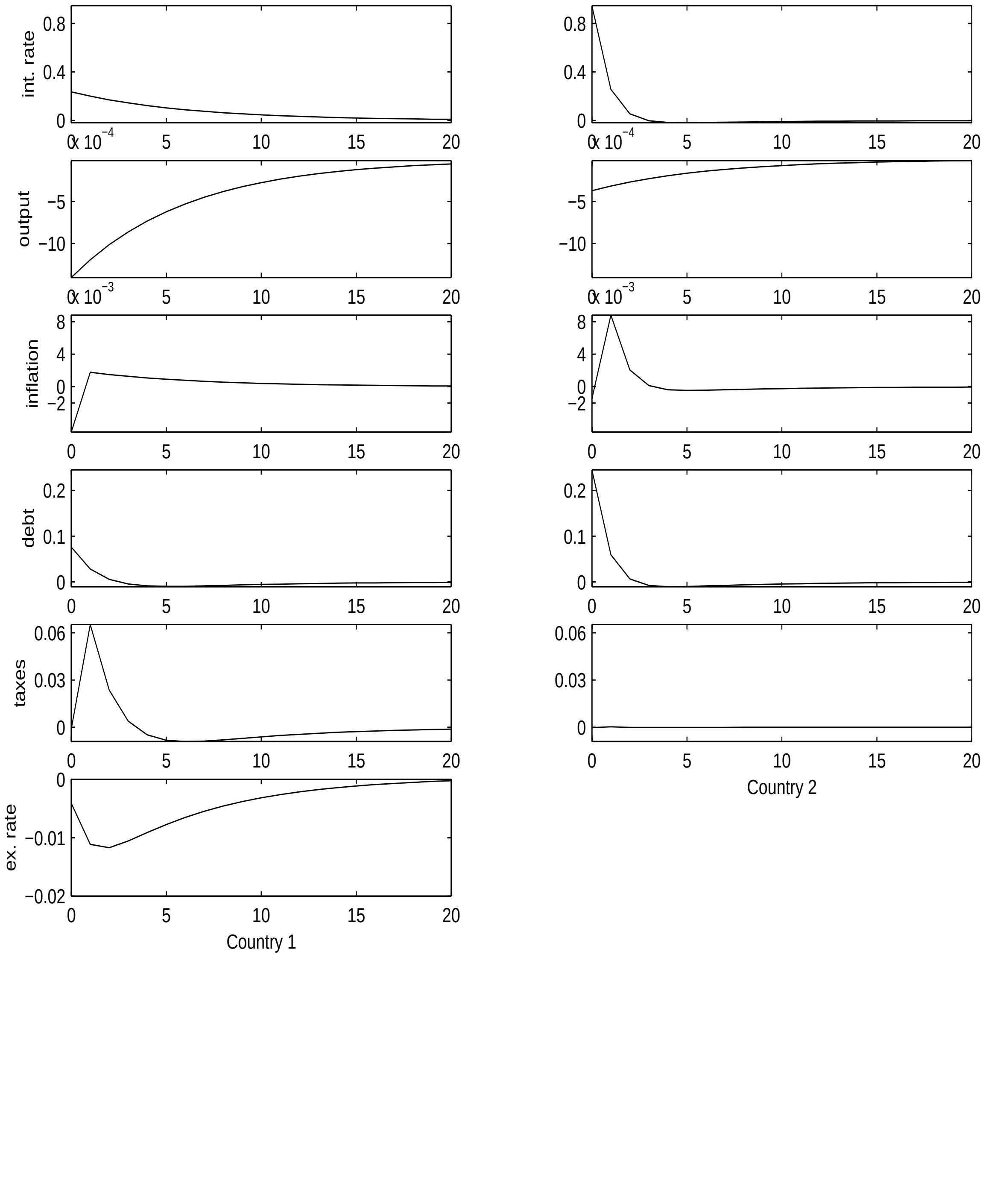


FIGURE 3a

Responses to a Monetary Policy Shock in Country 1

(Region 4)

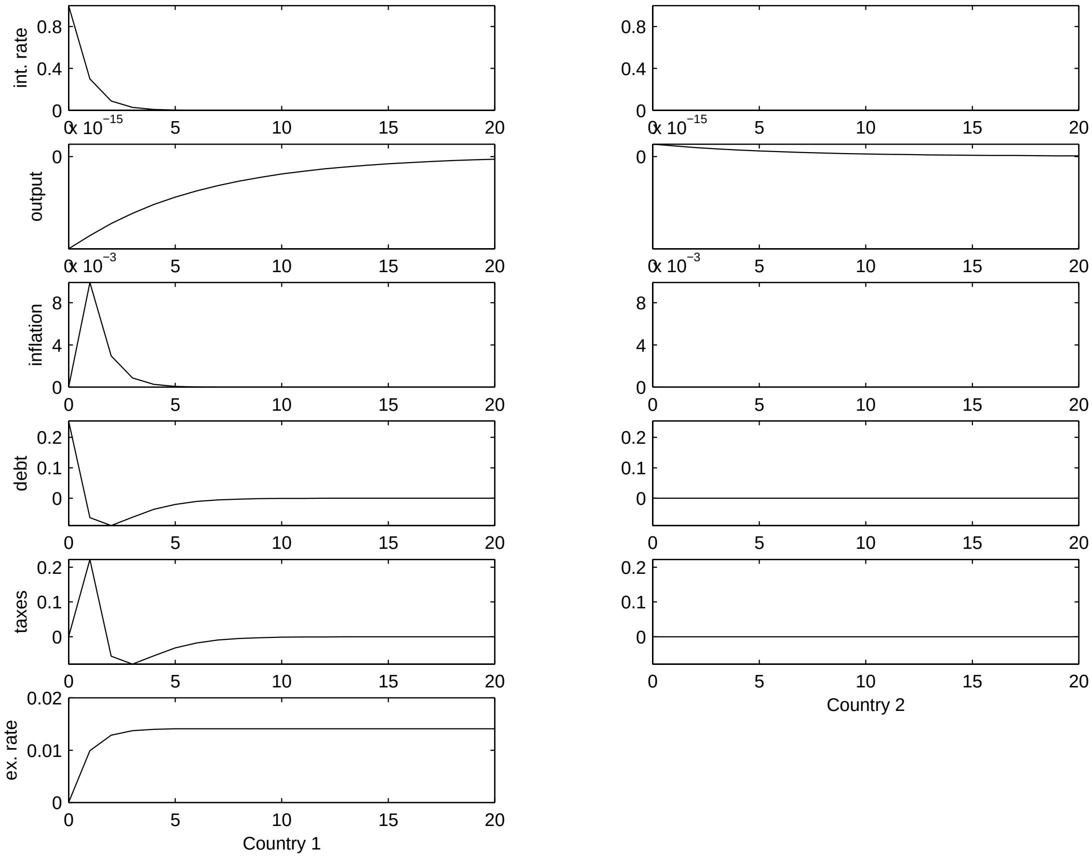


FIGURE 3b

Responses to a Monetary Policy Shock in Country 2

(Region 4)

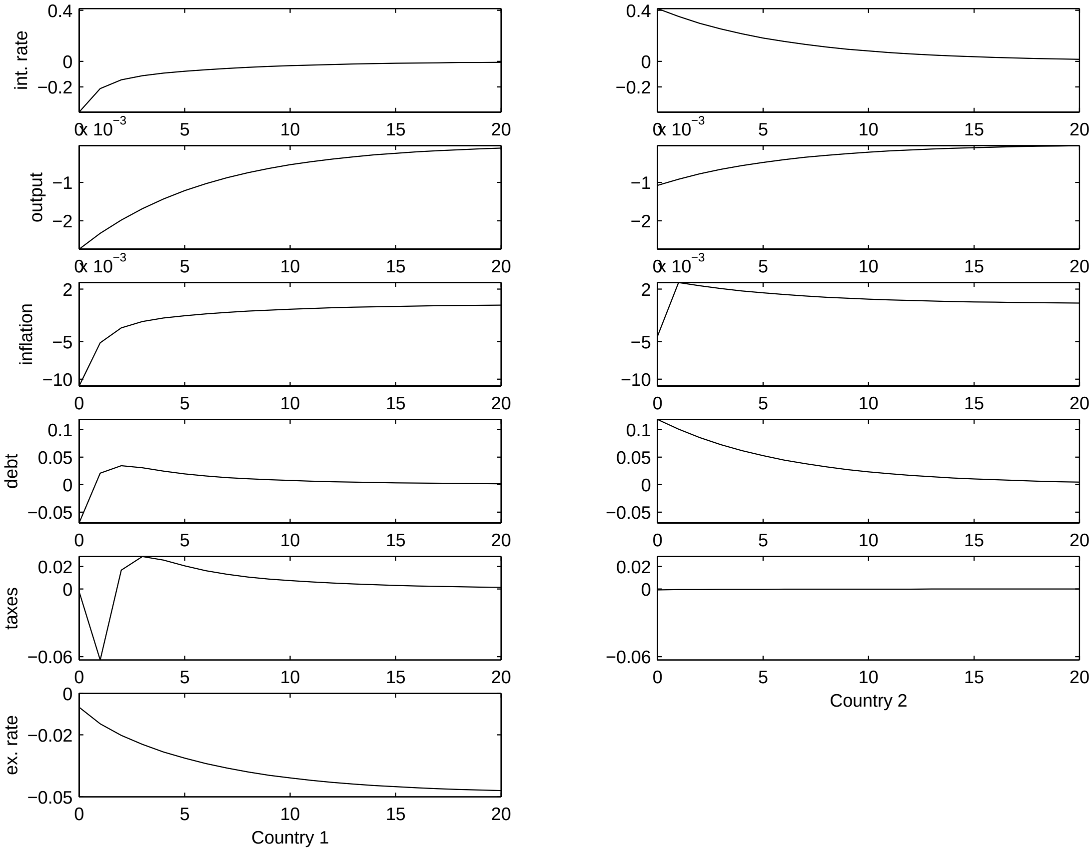


FIGURE 4

Responses to a Monetary Policy Shock in a Monetary Union

(Non- Ricardian regime)

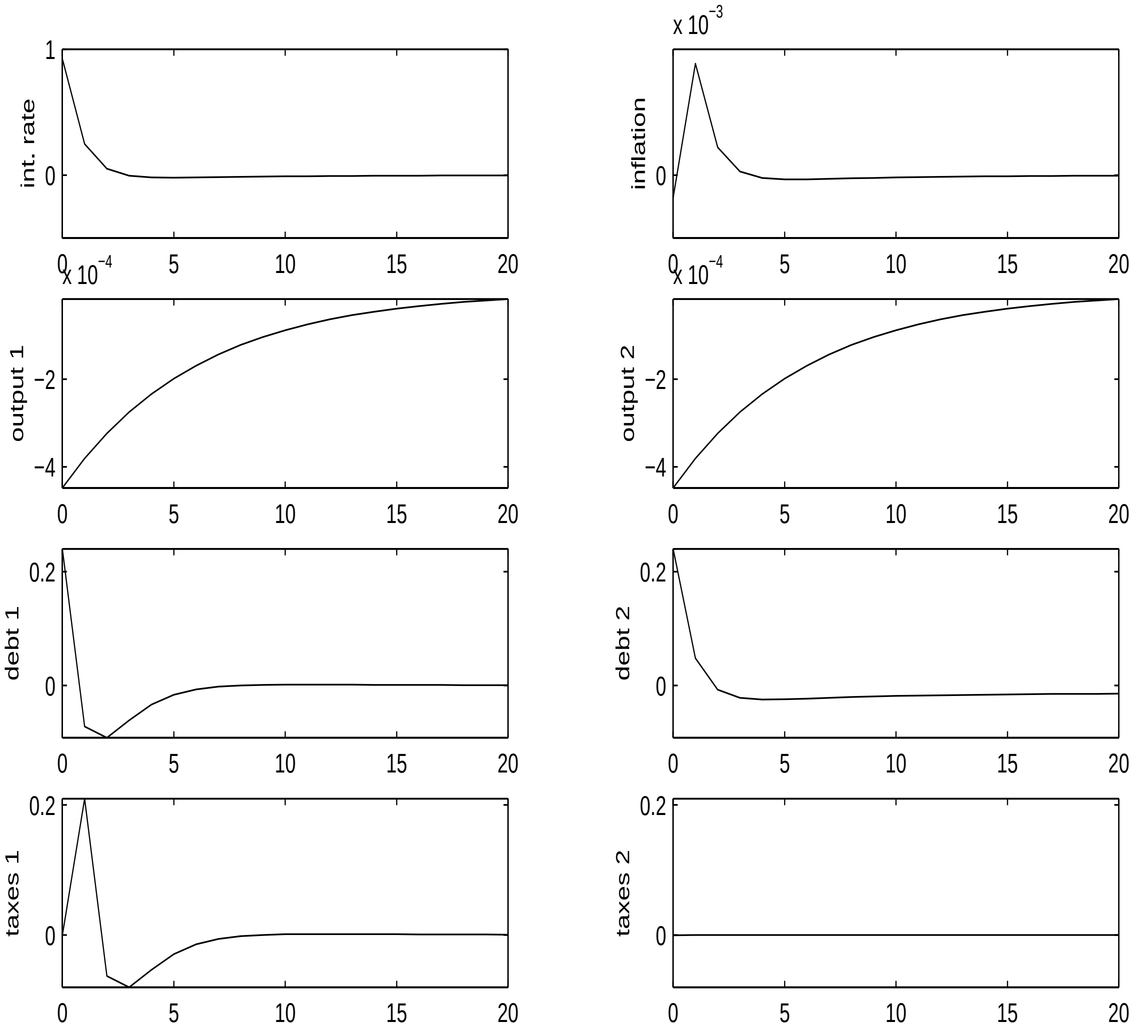
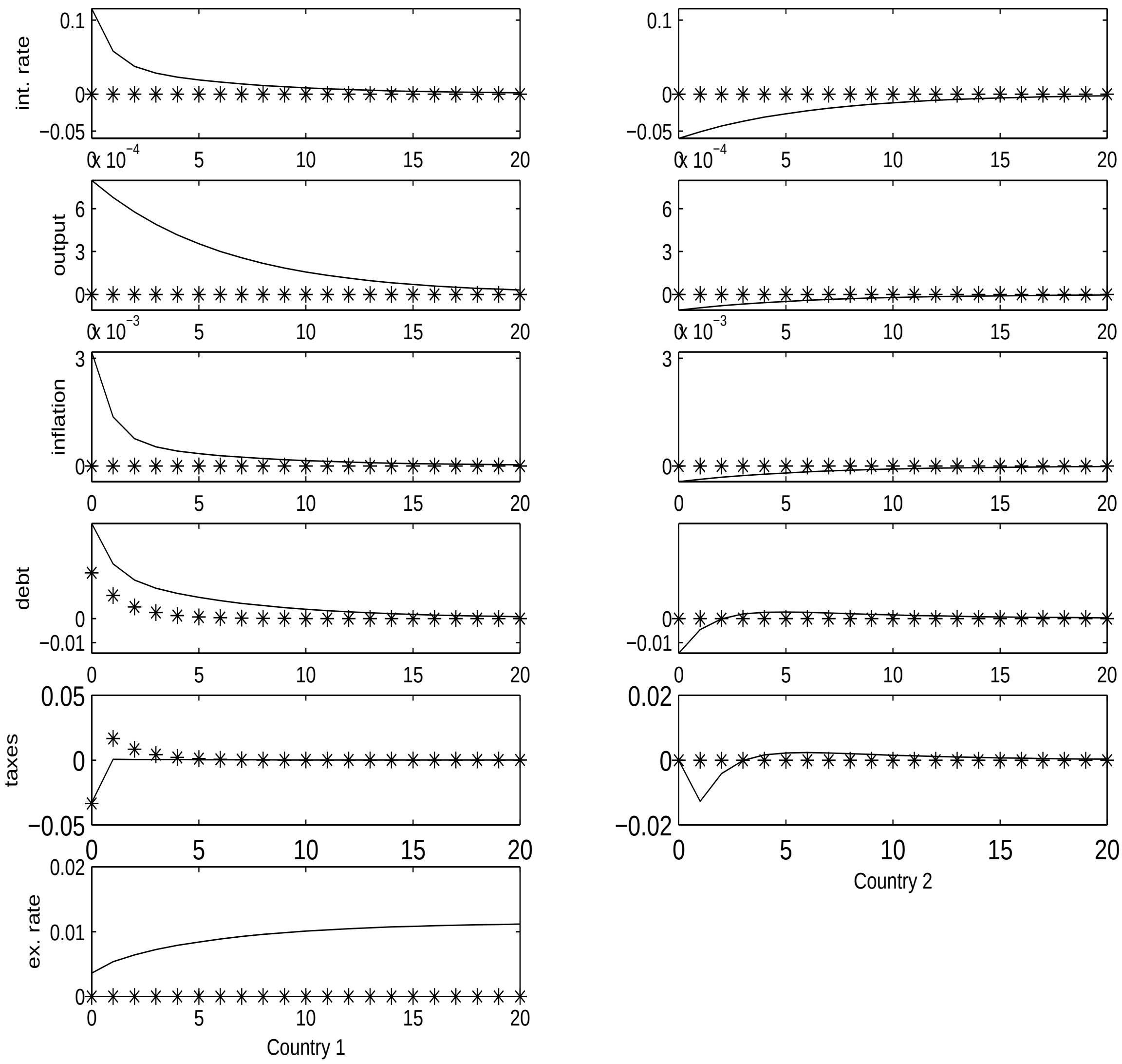


FIGURE 5

Responses to a Fiscal Policy Shock in Country 1




Note: The starred line (*) corresponds to a Ricardian regime (region 1) and the continous line corresponds to a non-Ricardian regime (region 3).

FIGURE 6

Responses to a Fiscal Policy Shock in a Monetary Union

(Non- Ricardian regime)