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Fiscal Policy in the European Monetary Union

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Abstract

An EMU country that adheres to the Maastricht and the Stability and Growth Pact limits is implicitly promising not to allow its fiscal stance to deteriorate to a position in which it places pressure on the European Central Bank to forgo its price level target to finance fiscal deficits. Violation of these limits has raised questions about potential fiscal encroachment on the monetary authority's freedom to determine the price level. We show that for the monetary authority to have the freedom to control price, the primary surplus must respond strongly enough to lagged debt. Panel estimates are consistent with monetary control of the price level.

Keywords: European Monetary Union, monetary policy, fiscal policy, Fiscal Theory of the Price Level, panel cointegration, error correction.
JEL Classification: C32, C33, E42, E62, F33.

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Fiscal Policy in the European Monetary Union

1 Introduction

The joint responsibility of monetary and fiscal policy for price stability poses a potential problem for a monetary union. A single monetary authority and many fiscal authorities all have the potential to influence the price level. Recognizing possible conflicts of interest across national governments, the founders of the European Monetary Union (EMU) drafted limits in the Maastricht Treaty and the Stability and Growth Pact (SGP) to restrain fiscal expansion, by limiting deficits and debt relative to GDP. Their main objective was to eliminate fiscal influence on the price level, thereby assigning full responsibility for price stability to the European Central Bank (ECB). However, these fiscal limits have been violated by several countries with no apparent ill effects, seemingly strengthening arguments that the limits are unnecessary to minimize fiscal influence on the price level. This leaves an open question regarding the role of fiscal policy in determining the price level in the EMU.

This paper addresses the question: Are EMU countries following fiscal policies which give the monetary authority the freedom to control the price level? This issue is normally posed in the context of the fiscal sustainability literature, in which satisfaction of a country's intertemporal budget constraint implies sustainability. This literature originally focused on cointegration between real debt and real surpluses (Flavin and Hamilton 1986; Trehan and Walsh 1991). However, Bohn (2007) demonstrates that cointegration is unnecessarily restrictive for satisfaction of the intertemporal budget constraint and argues that a positive response of the primary surplus to debt is sufficient for the expected present value of debt to be zero in the limit. Bohn (2008) and Mendoza and Ostry (2006) provide estimates of the primary surplus response to debt to determine fiscal sustainability. Bohn finds a positive coefficient for the US, and hence sustainable fiscal policy, while Mendoza and Ostry find some emerging market countries have positive coefficients, while others do not.

These criteria are related to requirements for fiscal policy to be passive. The literature on the Fiscal Theory of the Price Level (FTPL) requires passive fiscal policy as a necessary condition for the monetary authority to have freedom to use active monetary policy to control the price level. A passive fiscal policy requires satisfaction of the government's intertemporal budget constraint for any sequence of prices and, hence, adjustment of the primary surplus to debt. But since the government's intertemporal budget constraint holds in equilibrium even when fiscal policy is active, cointegration tests, based on the government's budget constraint, cannot distinguish between passive and active policies. VAR techniques, as in Canzoneri, Cumby, and Diba (2001), which determine how debt responds to the surplus, are plagued by the fact that at low frequencies they move together (Cochrane 1998). Without an additional assumption on fiscal policy, determination of whether fiscal policy is passive or active is plagued by serious identification problems. Davig, Leeper, and Chung (2007) add the assumption that fiscal policy follows a rule.[1] Under this assumption, the response of the primary surplus to lagged debt can be used to infer whether fiscal policy is passive or active. Given a fiscal rule with time-invariant parameters, a positive coefficient on lagged debt is

[1] Davig, Leeper, and Chung (2007) assume two fiscal rules with constant parameters and allow stochastic switching over time between them.

sufficient to assure that the present value of debt is always zero in the limit, irrespective of the initial real value of debt implied by the initial price level. This is the criterion for passive fiscal policy, and it is identical to Bohn's criterion for sustainable fiscal policy. However, if the coefficient on lagged debt is not positive, the FTPL interpretation differs from that in the sustainability literature. The alternative to passive fiscal policy is active fiscal policy, not unsustainable fiscal policy. Under active fiscal policy, the intertemporal budget constraint holds only for a unique initial real value of debt and hence for a unique initial price level. The assumption of a rule with time-invariant parameters is essential for this inference. Without it, we could not reject the hypothesis of passive fiscal policy because fiscal policy could change sometime in the future to assure intertemporal budget balance for any price level sequence, a possibility that is unobservable to the econometrician today.[2]

The problem with assessing either the sustainability of fiscal policy or its passivity with the criterion of a positive primary surplus response to debt is that the government's intertemporal budget constraint can be satisfied with debt growing boundlessly, as long as it grows more slowly than the interest rate.[3] Is it really possible for debt to reach the SGP limits and keep growing? Is it possible for debt to reach double those limits and keep growing? triple? As debt grows beyond its SGP limits, primary surpluses are required to increase to service that debt. Since taxes are distortionary, there is a limit on the fraction of output that can be raised in taxes. The limit implies an upper bound on debt. This paper departs from the standard assumption that there are no upper bounds on debt and primary surpluses.

[2] This is the implicit assumption for a non-positive coefficient in the sustainability literature.
[3] This can be expressed in terms of real surpluses, real debt and real interest rates, or in terms of surpluses relative to output, debt relative to output and real growth-adjusted interest rates.

Explicitly, we assume that at each point in time, there is an upper bound on the present-value of future primary surpluses. Since debt is the expected present value of future primary surpluses, there is an upper bound on debt.

We follow Davig, Leeper, and Chung (2007) and assume that fiscal policy is governed by a rule. This allows us to rule out unobservable and unverifiable future policy changes which keep debt from rising above its upper bound. We show that the assumption of the upper bound on debt changes the focus of the analysis from the government's intertemporal budget constraint to dynamic stability of the system in government debt and the primary surplus. Explosive paths for deviations of debt from its long-run equilibrium values must be ruled out since these cannot be equilibria; global stability rules them out. Therefore, necessary conditions for equilibrium require that initial debt be below its upper bound and that the model in deviations be globally stable. This assures that deviations of debt from long-run equilibrium are expected to vanish.

We derive restrictions on parameters in the fiscal rule necessary for global stability. Not only must the primary surplus respond positively to lagged debt, as Bohn (2008) showed was necessary for sustainability and Canzoneri, Cumby, and Diba (2001) for passivity, but the response must be large enough to rule out explosive debt. We refer to a fiscal policy with restrictions assuring global stability as "strongly passive." If fiscal policy is not strongly passive, then the economy could be shocked into a position from which debt is expected to explode relative to its upper bound. Such a path cannot be an equilibrium. As in the FTPL, this places pressure on the monetary authority to allow a price level jump such that the value of real debt jumps to a feasible path.[4] Therefore, failure of fiscal policy to be strongly passive threatens the monetary authority's control of the price level.

We estimate the parameters of the fiscal rule with annual data on real debt, real primary surpluses, and real GDP for a panel of ten EMU countries over the period 1970-2006. Our estimation technique for the fiscal rule differs from others in the literature by exploiting the time series characteristics of the data, with cointegration and error correction techniques. These variables are integrated of order one, and, in the presence of the upper bound, theory says that they should be cointegrated.[5] Therefore, the fiscal rule can be expressed as an error correction model, and the objective of the empirical work is estimation of its parameters. Another advantage of our approach is that we estimate the parameters using panel data, allowing heterogeneity across countries in both the cointegrating parameters and in the loadings on the error correction terms. Panel data techniques are increasingly used to test macroeconomic hypotheses like purchasing power parity and output convergence. Panels have greater power than the usual time series tests because they combine information from both the cross-section and the time dimension.

We find that over the sample period, fiscal policy has been sufficiently responsive to increases in debt in our panel of ten EMU countries to imply that it is strongly passive. This provides evidence that violation of the limits in the Maastricht Treaty and the SGP have not been serious enough to threaten the ability of the ECB to control the price level.

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[4] As Leeper (1991) demonstrated, there is no equilibrium if both monetary and fiscal policy are active. Therefore, if fiscal policy is active, there is pressure on the monetary authority to become passive and vice versa.

[5] In the absence of an upper bound, the intertemporal budget constraint is satisfied with debt growing boundlessly, as long as it grows more slowly than its interest rate. However, such an equilibrium does not necessarily imply cointegration. See Bohn (2007).

The paper is organized as follows. Section 2 describes the behavior of monetary and fiscal policy in a monetary union and derives the restrictions on the parameters of the fiscal rule necessary for a strongly passive policy. Section 3 contains the empirical analysis, and Section 4 provides conclusions.

2 Model

2.1 Goods and Asset Markets

We assume that countries in the monetary union are small enough that they cannot affect the world price level or world interest rate. There is a single good in the world, implying that equilibrium in goods markets requires the law of one price. Normalizing the world price level at unity and assuming no world inflation implies that, in equilibrium, the price level in the monetary union is the exchange rate.

We assume that international creditors are willing to buy and sell government bonds in the monetary union as long as the interest rate on these bonds (r_t) satisfies interest rate parity. Interest rate parity can be derived using Euler equations for a representative world agent when the covariance of the monetary union interest rate with the world agent consumption is zero, or when the world agent is risk neutral. Under the additional assumption that the world interest rate (r) is constant, interest rate parity can be expressed as

$$\frac{1}{1+r_t} = \left(\frac{1}{1+r}\right) E_t\left[\frac{P_t}{P_{t+1}}\right], \tag{1}$$

where E_t denotes the expectation conditional on time t information and P_t denotes the price level, and equivalently the exchange rate, in the monetary union.

The monetary authority can control expected inflation because it can control the nominal interest rate (r_t). Interest rate parity implies that the monetary authority's choice of the nominal interest rate determines expected inflation.[6] Leeper (1991) demonstrated that in order for the monetary authority to also be able control the price level and not just its rate of change, fiscal policy must be passive. We show below that in the presence of the upper bound, fiscal policy must be strongly passive.

2.2 Fiscal Policy

2.2.1 Government Flow Budget Constraint

Consider the flow government budget constraint for the i^{th} country in a monetary union. Letting G_{it}, T_{it}, B_{it}^p and M_{it} denote, respectively, nominal government spending, tax revenue, publicly held government bonds, and the money supply backed by the i^{th} country's bonds at time t, the i^{th} government's nominal flow budget constraint is given by

$$B_{it}^p + M_{it} = (1 + r_{t-1}) B_{it-1}^p + M_{it-1} + G_{it} - T_{it}.$$

Dividing by P_t, the real values of debt and primary surplus can be expressed respectively as

$$b_{it} = \frac{1}{P_t}\left[B_{it}^p + \frac{1}{1+r_t}M_{it}\right],$$

$$s_{it} = \frac{1}{P_t}\left[T_{it} + \frac{r_t}{1+r_t}M_{it} - G_{it}\right].$$

where $\frac{r_t}{1+r_t}M_{it}$ is seigniorage revenues returned to the i^{th} country by the monetary authority.

The government's real flow budget constraint can be expressed as

$$b_{it} = (1 + r_{t-1}) \frac{P_{t-1}}{P_t} b_{it-1} - s_{it}. \quad (2)$$

[6] Daniel (2007) demonstrates that monetary policy retains control of expected inflation even under passive monetary policy and active fiscal policy, as in the FTPL.

Imposing interest rate parity from equation (1) and defining

$$\gamma_{it} = \left(1 - \frac{P_{t-1}}{P_t}\right)(1 + r_{t-1})\, b_{it-1}, \tag{3}$$

such that $\gamma_{it} > 0$ denotes positive inflation, which reduces the real value of outstanding debt, the equation for the evolution of real debt can be expressed as

$$b_{it} = (1 + r)\, b_{it-1} - s_{it} - (\gamma_{it} - E_{t-1}\gamma_{it})\,. \tag{4}$$

where $(\gamma_{it} - E_{t-1}\gamma_{it})$ represents unanticipated inflation or, equivalently, a price level shock. Unanticipated inflation acts like a tax, which raises revenue and lowers the value of real debt. Additionally, this equation reveals that real debt accumulates in response to expectations of inflation, which are not realized. Expectations of inflation raise the interest rate, and when the inflation does not occur, debt accumulates in response to the higher interest rate.

We assume that there is an upper bound on taxes that can be raised to service debt and that the bound is increasing in output. This allows the upper bound on debt service $\left(r\bar{b}_{it}\right)$ to be expressed as a linear function of output according to

$$r\bar{b}_{it} = \bar{k}_i + \bar{\varphi}_i y_{it}, \tag{5}$$

where y_{it} is real GDP, and $\bar{\varphi}_i$ and $\bar{k}_i$ are country-specific parameters. We motivate this assumption with the realization that governments face limits on their ability to raise taxes, which in turn implies an upper bound on the value of debt that can be serviced.

In what follows we determine the restrictions on fiscal policy necessary to assure that debt remains below its upper bound and test whether these restrictions are empirically satisfied.

2.2.2 Fiscal Policy Rule

We assume that the fiscal authority is able to commit to a rule for the primary surplus. We allow the primary surplus to respond to its own lag, a time-varying target surplus $\left(s^*_{it-1}\right)$, and debt service (rb_{it-1}). The fiscal rule for the i^{th} country is given by

$$s_{it} = \beta_{0i} + \beta_{1i}s_{it-1} + \beta_{2i}s^*_{it-1} + \beta_{3i}rb_{it-1} + \nu_{it}, \tag{6}$$

where ν_{it} is a stochastic disturbance representing fiscal shocks. Fiscal shocks reflect both politically-determined shocks to taxes or government spending, and responses, perhaps countercyclical or optimal tax, of the fiscal authority to the fundamental shocks that affect the economy. Most recently, they reflect the fiscal response to the global financial crisis of 2007-2009. The lagged value of the primary surplus allows persistence and reflects the desire to smooth the effect of shocks over time. The commitment to honor debt for any sequence of shocks, which each country makes to enter the monetary union, implies that the primary surplus should respond positively to lagged debt.

It is necessary to make some assumptions about the behavior of the target surplus in an economy with growing income. We assume that the target surplus is linear in real GDP, and test the assumption in the empirical implementation. The target surplus is given by

$$s^*_{it} = k_i + \varphi_i y_{it}, \tag{7}$$

where $k_i \leq \bar{k}_i$ and $\varphi_i \leq \bar{\varphi}_i$ represent country-specific parameters. Substituting for the target surplus in equation (6) yields a fiscal rule in which the surplus responds to the lagged surplus, lagged output, lagged debt, and is subject to a stochastic shock.

2.3 Equilibrium

Definition 1 *Given constant values for the world interest rate and price level, a time series process for each* y_{it}*, a fiscal rule for each of the* i *countries (equation 6), and an upper bound on each country's debt (equation 5), an equilibrium is a set of time series processes for the monetary union price level, represented by* γ_{it}*, and a set of time series processes for each country's primary surplus and debt,* s_{it} *and* b_{it}*, such that each government's flow budget constraint (equation 4) holds, the debt for each country is not expected to exceed its upper bound, expectations are rational, and world agents expect to receive the return on assets determined by interest rate parity (equation 1).*

Explosive debt relative to output is not consistent with equilibrium when there is an upper bound. Therefore, equilibrium requires existence of a stationary long-run equilibrium in which debt relative to output is not changing systematically. This in turn requires restrictions on the parameters of the fiscal rule to assure the existence of a stationary long-run equilibrium.

Restrictions sufficient to assure a stationary long-run equilibrium are not sufficient to assure that the monetary authority can follow active monetary policy and control the price level. The long-run equilibrium could be achieved with price level jumps $(\gamma_t - E_{t-1}\gamma_t)$ as in the FTPL. To rule out price-level jumps, the system must be expected to reach its stationary long-run equilibrium in their absence. This requires that the model be globally stable instead of saddlepath stable. We derive additional restrictions on the fiscal rule to assure global stability and test for these.

2.3.1 Long-run Equilibrium

Given that each of the three variables, real primary surplus, real debt, and real output appear integrated of order one, the stationary long-run equilibrium can be characterized by cointegrating relationships. We test for $I(1)$ behavior of the variables and use cointegration techniques to estimate the parameters of the cointegrating vectors representing the long-run equilibrium relationships. The use of cointegration to estimate the parameters of the relationship between debt and the primary surplus follows earlier work on fiscal sustainability (Hamilton and Flavin 1986; Trehan and Walsh 1991).

To complete the model, we need a stochastic process for output. The stochastic representations of the long-run equilibrium relationships differ depending on whether we allow output growth to be represented by an exponential or a linear process. For empirically reasonable growth rates, the two representations for output are virtually identical over our sample of only thirty-seven years.[7] Additionally, a linear representation allows us to exploit the time series characteristics of the data using cointegration to obtain super-consistent estimates of the long-run cointegrating parameters. The more typical exponential representation, necessary for longer time series, requires representation of the model either in as fractions of output or as logarithms. We cannot use logarithms of the debt and primary surplus since they are undefined when the values are negative. With representation as fractions of output, we lose the $I(1)$ properties of the data that we are trying to exploit. The linear representation of growth should be viewed as an approximation for the geometric representation, and is reasonable when the sample is not too long.

We assume that real GDP in levels is integrated of order one, consistent with our empirical

[7] Adjusted R^2 coefficients for linear and exponential growth models differ only in the third decimal place for most countries, and the adjusted R^2 coefficient is actually higher with linear growth for Italy. Both Ireland and Greece experienced an increase in growth rates over the sample, and neither model with constant growth fits very well. Exponential growth does fit significantly better than linear growth for these two countries.

evidence presented below. Additionally, we assume that output does not respond to the primary surplus or to debt,[8] yielding a stochastic process for GDP as

$$y_{it} = y_{it-1} + \rho_i \left(y_{it-1} - y_{it-2}\right) + \left(1 - \rho_i\right) g_i + \eta_{it}, \tag{8}$$

where ρ_i reflects autocorrelation in growth, g_i is the equilibrium linear growth rate, and η_{it} is a well-behaved output shock.

With this assumption, the long-run equilibrium relationships are characterized by cointegrating relationships and can be expressed as

$$s_{it} = k_i + \varphi_i y_{it} = rb_{it} - \frac{\varphi_i g_{i(1+r)}}{r} \tag{9}$$

where the first requires deviations of the primary surplus from its target to be stationary, and the second requires the deviations of the primary surplus from debt service, adjusted for growth, to be stationary. When equation (9) holds, the primary surplus is expected to change by $\varphi_i g_i$, and debt is expected to change by $\frac{\varphi_i g_i}{r}$.[9] Since output is expected to change by g_i, variables are expected to retain the relationship given by equation (9).[10] Given the assumptions in equation (5), the stationary long-run equilibrium value for debt satisfies the upper bound restrictions.

Lemma 1 *The long-run equilibrium relationships, characterized by equations (9), hold if and only if* $\beta_{0i} = \varphi_i g_i - \beta_{3i} \left(\frac{\varphi_i g_i (1+r)}{r}\right)$ *and* $\beta_{1i} + \beta_{2i} + \beta_{3i} = 1$

[8] This assumption holds in many models with Ricardian Equivalence and in many others there is only a short-run response, which would affect the dynamic behavior of the residuals, but not the long-run characteristics.
[9] To show this, substitute the second long-run cointegrating expression for the primary surplus into equation (4) and solve for the change in debt, $(b_{it} - b_{it-1})$. In a stationary long-run equilibrium, the change in the primary surplus $(s_{it} - s_{it-1})$ equals the change in debt service $r\left(b_{it} - b_{it-1}\right)$.
[10] Under exponential output growth, with $y_{it} = \left(1 + g_{it}\right) y_{it-1}$, the cointegrating relationships would have the same form, but the coefficients would have a different interpretation. Specifically, the cointegrating relationships would be $s_{it} = \varphi_i y_{it} = \frac{r - g_i}{1 + g_i} b_{it}$. The constants in the cointegrating relationships would be zero and the coefficient on debt would have the interpretation of the real growth-adjusted interest rate, instead of the real interest rate.

Proof. Substituting equation (7) into equation (6) yields

$$s_{it} = \beta_{0i} + \beta_{1i} s_{it-1} + \beta_{2i}(k_i + \varphi_i y_{it-1}) + \beta_{3i} r b_{it-1} + \nu_{it}.$$

If the long-run equilibrium conditions hold, then $s_{it-1} = k_i + \varphi_i y_{it-1}$, $rb_{it-1} = s_{it-1} + \frac{\varphi_i g_i (1+r)}{r}$ and the primary surplus is expected to change by $\varphi_i g_i$, such that $s_{it} = s_{it-1} + \varphi_i g_i$. Substituting these long-run conditions and the mean value for ν_{it} of zero into the equation above yields

$$s_{it-1} + \varphi_i g_i = \beta_{0i} + \beta_{3i} \left(\frac{\varphi_i g_i \left(1+r\right)}{r} \right) + \beta_{1i} s_{it-1} + \beta_{2i} s_{it-1} + \beta_{3i} s_{it-1}.$$

Equating coefficients on s_{it-1} and the constant to zero, yields the relationships above. ■

These restrictions allow the fiscal rule to be expressed as an error correction model in which the change in the primary surplus responds to two error correction terms. Substituting the parameter restrictions from Lemma 1 into equation (6), and rearranging yields

$$s_{it} - s_{it-1} = \varphi_i g_i - \beta_{3i} \left(s_{it-1} - r b_{it-1} + \frac{\varphi_i g_i \left(1+r_i\right)}{r} \right) - \beta_{2i} \left(s_{it-1} - \varphi_i y_{it-1} - k_i \right) + \nu_{it}. \quad (10)$$

Substituting equation (10) into the government's flow budget constraint, given by equation (4), yields

$$\begin{aligned} b_{it} - b_{it-1} \quad = \quad & \frac{\varphi_i g_i}{r} - (1 - \beta_{3i}) \left(s_{it-1} - r b_{it-1} + \frac{\varphi_i g_i \left(1+r_i\right)}{r} \right) + \beta_{2i} \left(s_{it-1} - \varphi_i y_{it-1} - k_i \right) \\ & - \nu_{it} - \left(\gamma_{it} - E_{t-1} \gamma_{it} \right) \qquad (11) \end{aligned}$$

Equations (8), (10), and (11) are the dynamic equations of the model, written to reveal the nature of a stationary long-run equilibrium. In a stationary long-run equilibrium, the primary surplus equals its target and pays less than the interest rate on debt, allowing debt service to grow with output. Deviations from the cointegrating relations are due to shocks and are stationary. The shocks to the primary surplus can be transitory or permanent. A positive fiscal shock created by a permanent change in output will be largely permanent in contrast to a fiscal shock created by a temporary reduction in government spending, which must vanish since it reduces the primary surplus relative to output.

2.3.2 Stability

We assess stability under the parameter restrictions necessary for existence of a long-run equilibrium. The time paths for each country's surplus and debt can be determined by solving equations (8), (10), and (11). Denoting deviations of the primary surplus from its equilibrium values, given by output and debt service, and deviations of output growth from its equilibrium value, respectively, as

$$Y_{it} = s_{it} - \varphi_i y_{it} - k_i$$

$$B_{it} = s_{it} - rb_{it} + \frac{\varphi_i g_i (1+r)}{r},$$

$$\Gamma_{it} = y_{it} - y_{it-1} - g_i = \Delta y_{it} - g_i$$

equations (8), (10), and (11) can be rearranged as

$$Y_{it} = (1 - \beta_{2i}) Y_{it-1} - \beta_{3i} B_{it-1} - \varphi_i \rho_i \Gamma_{it-1} - \varphi_i \eta_{it} + \nu_{it} \tag{12}$$

$$B_{it} = -(1+r)\beta_{2i} Y_{it-1} + (1+r)(1-\beta_{3i}) B_{it-1} + r(\gamma_{it} - E_{t-1}\gamma_{it}) + (1+r)\nu_{it} \tag{13}$$

$$\Gamma_{it} = \rho_i \Gamma_{it-1} + \eta_{it} \tag{14}$$

Trivially, a stationary long-run equilibrium requires that $\lim_{t\to\infty} Y_{it} = \lim_{t\to\infty} B_{it} = \lim_{t\to\infty} \Gamma_{it} = 0$. We have assumed the existence of such an equilibrium in which debt satisfies its upper bound restrictions. The system reaches the stationary long-run equilibrium if it is either globally stable or saddlepath stable.

Stability properties are determined by the roots of the dynamic system, given by equations (12), (13) and (14). Letting θ_i represent the roots of the dynamic system, the characteristic equation for country i is given by

$$(\theta_i - \rho_i)\left\{\beta_{1i}(1+r) - \theta_i\left[1 + r(1-\beta_{3i}) + \beta_{1i}\right] + \theta_i^2\right\} = 0, \tag{15}$$

where $\beta_{2i} = 1 - \beta_{1i} - \beta_{3i}$, as required for existence of a stationary long-run equilibrium.

We assume that the roots of the characteristic equation for each country are real and distinct. The ρ_i are empirically less than one[11]. If the remaining roots of the characteristic equation for the i^{th} country are within the unit circle, then the economic system for the i^{th} country is globally stable. If the system is globally stable for each country, then each country is expected to reach the stationary long-run equilibrium, characterized by equation (9), for *any* initial values of the variables and *any* shocks it receives, where shocks include the fiscal shock (ν_{it}) and the output shock (η_{it}). This leaves the monetary authority free to choose the price level in equilibrium, which given the assumed price-level target, implies $\gamma_{it} = E_{t-1}\gamma_{it} = 0$ for each country. Therefore, global stability is necessary to give the monetary authority freedom to control the price level in equilibrium.

Alternatively, if one of the roots of the characteristic equation for one country is outside

[11] The group mean estimate of ρ is 0.35.

of the unit circle, then the economic system is only saddlepath stable. If the system is only saddlepath stable, then it can reach the stationary long-run equilibrium only along the saddlepath. There must be a jumping variable to offset shocks which move the system away from the saddlepath, equivalently to set the coefficient on the unstable root to zero. The only candidate is the real value of debt through a price level surprise $(\gamma_{it} - E_{t-1}\gamma_{it})$. Therefore, if a saddlepath stable system is to attain an equilibrium, then the monetary authority is not free to choose the price level.

Equation (15) can be used to show that global stability for country i requires that

$$\beta_{3i} > 1 - \beta_{1i} \quad \text{and} \quad -1 < (1 + r)\,\beta_{1i} < 1. \tag{16}$$

Satisfaction of the inequalities in equation (16) assures that all roots are within the unit circle and we refer to a fiscal policy with these restrictions as strongly passive. The criterion explored by other authors for fiscal policy to be sustainable or passive is simply a positive response of primary surplus to debt, $\beta_{3i} > 0$. This criterion assures intertemporal budget balance in the absence of upper bounds, but it does not prevent explosive behavior of debt relative to output. Our criteria require a relatively strong response of primary surplus to debt, not just a positive response. Strongly passive fiscal policy restricts debt to grow slowly than output in the limit. By requiring debt relative to output to reach a stationary long-run equilibrium value, strongly passive fiscal policy also assures intertemporal budget balance.

If all countries have strongly passive fiscal policy, our inference is that the monetary authority can control the union price level. Dupor's (2000) work could be used to argue that only the aggregate fiscal stance matters, not each country's individual stance. However, if one country's debt embarks upon an explosive path and union debt does not, then there is some member country whose debt in on an implosive path, as it taxes its citizens and transfers resources to the other country. Given the reasonable assumption that governments choose fiscal policy to maximize the welfare of their own citizens, no country would choose such a policy.[12] Therefore, the relevant criterion for monetary policy freedom is strongly passive fiscal policy for each country, not for the set of aggregated countries.

In summary, consideration of upper bounds implies that a necessary condition for the monetary authority to be able to choose the price level is that the response of the primary surplus to debt is strong enough in each country that equation (16) holds for all i countries. This restriction assures that the system of equations containing the debt and primary surplus for each country is globally stable. We refer to a fiscal rule which yields global stability as strongly passive fiscal policy.[13]

It is important to recognize that the assumption that fiscal policy commits to a rule with time-invariant parameters is an assumption. Even if we found that the response of the primary surplus to lagged debt was too small for both roots to be within the unit circle, the monetary authority could still control the price level if the government was expected to adjust the primary surplus in the future in some way that differs from the current estimated rule. However, promises of future changes to resolve current insolvency might not be credible.

[12] Sims (1997) and Daniel (2001) make this argument. Additionally, there is an explicit covenant in the EMU agreements whereby member countries are not responsible for the debts of others.

[13] Of course, global stability cannot assure that extremely large negative surplus shocks do not yield a violation of the upper bound. Therefore, strongly passive fiscal policy is not sufficient to rule out all risk that the monetary authority would lose control of the price level. But strongly passive fiscal policy is necessary to assure that the monetary authority is expected to retain control of the price level. See Daniel and Shiamptanis (2009).

The justification for committing to a rule is that it enhances transparency and credibility of policy and avoids problems of dynamic inconsistency.

3 Empirical Results

The purpose of the empirical work is to test whether the restrictions on fiscal policy necessary for the monetary authority to have control of the price level hold in the EMU countries. These restrictions include 1) the existence of cointegrating relationships between the primary surplus and debt, and between the primary surplus and output; and 2) a strong enough response of the surplus to debt to yield global stability for the dynamic system. Additionally, estimation of the parameters of fiscal policy provides parameter values which other researchers can use to calibrate fiscal policy. We have annual data on the real primary surplus, s_{it}, real debt, b_{it}, and real GDP, y_{it}, for the period 1970-2006 for a panel of ten EMU countries.[14]

First, we establish that the variables behave as unit root processes, $I(1)$. We use panel unit root tests which have more power than the time series unit root tests. Following Im, Pesaran and Shin (2003), we test the null hypothesis that all series in the panel contain a unit root, against the alternative hypothesis that some of the series in the heterogeneous panel are stationary. The test is based on the average of N individual augmented Dickey-Fuller (1979) (ADF) t-statistics. The tests include an individual specific constant and trend. They are computed alternately using one lag, two lags, and heterogeneous numbers of lags across countries, with the lag order estimated using consistent information criteria such as

[14] The countries were chosen based on data availability. They include Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands and Spain. For more details see the Data Appendix.

the Akaike and Schwarz criteria. Table 1 reports the results with one lag. All the tests fail to reject the null hypothesis of a unit root in s_{it}, b_{it}, and y_{it} at the 5 percent level, implying that the variables s_{it}, b_{it} and y_{it} are $I(1)$.[15]

Given that the variables in the fiscal rule appear to behave as unit root processes, we test for the existence of long-run equilibrium relationships, equations (9), using cointegration techniques. Since the time dimension of our sample is not long enough to allow estimation of cointegrating relationships for each country, we use panel cointegration techniques. We estimate the following cointegrating model

$$s_{it} = a_i + \varrho_i x_{it} + e_{it} \tag{17}$$

and test for the existence of cointegrating relationships between the real primary surplus and real debt, and between the real primary surplus and real GDP. In equation (17), a_i denotes the country specific fixed effects, s_{it} is the real primary surplus, x_{it} is the regressor, b_{it} or y_{it}, and ϱ_i is the cointegrating parameter, r_i or φ_i. In the panel, we allow the long-run cointegrating parameters to differ across countries. Even though theory implies that the real interest rates should be identical across countries, we allow them to vary due to possible differences in the definitions of debt or the primary surplus across countries. We model heterogeneity across countries by allowing each country's policy parameters to differ randomly from the EMU panel policy parameters. Letting ζ_i be the i^{th} country's vector of

[15] We also fail to reject the null of a unit root when we use Breitung (2000), Maddala and Wu (1999), Choi (2001) tests, and we reject the null of no unit root when we use Hadri (2000) test. Additionally, we confirm the unit root behavior of the series using panel unit root tests suggested by Breitung and Das (2005), Moon and Perron (2004) and Pesaran (2006), which account for various forms of cross-sectional dependence. The tests are computed using one lag and two lags. For Moon and Perron's (2004) procedure we use one unobserved factor. All tests include an individual specific constant and trend.

policy parameters, and ζ the vector of EMU policy parameters, we assume that $\zeta_i = \zeta + \epsilon_{\zeta i}$, where the $\epsilon_{\zeta i}$ have zero-means and constant variances for all i.

We begin with two group-mean panel cointegration t tests suggested by Pedroni (1999, 2004).[16] Both tests are residual-based cointegration tests, which test the null hypothesis that the variables of interest are not cointegrated for all the countries in the panel against the alternative hypothesis that there exists a heterogeneous cointegration vector for all the countries in the panel. Under the null hypothesis of no cointegration, the residuals, $\hat{e}_{it}$, are $I(1)$. Denoting the autoregressive coefficient of the i^{th} country's residuals by δ_i, the group-mean statistics test the null hypothesis of no cointegration, $H_o : \delta_i = 1$ for all i, versus the heterogeneous alternative hypothesis, $H_A : \delta_i < 1$ for all i. The alternative does not presume a common value for $\delta_i = \delta$. The first group-mean test uses semi-parametric corrections, while the second is a parametric ADF test.[17] The tests are extensions of the single time series Phillips-Perron (1988) t-test and the ADF t-test. We account for cross-sectional dependence and cross-member cointegration by using common time effects.[18] For the semi-parametric

[16] The group-mean statistics allow modeling an additional source of potential heterogeneity across individual members of the panel. Moreover, Gutierrez (2003) finds that Pedroni's tests have higher power than the system test proposed by Larsson, Lyhagen and Lothgren (2001). Additionally, Banarjee, Marcellino and Osbat (2004) show that for small N the size distortions of Pedroni's tests are lower than those of Larsson and Lyhagen (1999) test.

[17] The specifications are given in the Appendix.

[18] Common time effects allow us to model a limited form of cross-sectional dependence and cross-member cointegration (which is a form of long-run cross-sectional dependence). Common time effects assume that the cross-sectional dependence correlation between country i and j is identical for all i, j. Thus, in the presence of heterogeneous cross-sectional dependence, subtracting off the cross-sectional average does not completely eliminate cross-sectional dependence. The method by which cross-sectional dependence is modeled in panels is still an active area of research. Bai and Ng (2002) and Moon and Perron (2004) consider models in which the error terms have a factor structure in panel unit root tests, however the implications for such factor models have not been studied in the panel cointegration context. Notice though that time effects are a special case of a factor model where there is a single common factor and the response of each country is similar. Therefore, time effects account for both cross-sectional dependence and cross-member cointegration when the source of dependency is due to a single common time specific shock.

test we use the Bartlett kernel and the Newey-West bandwidth selection procedure, and for the parametric ADF-type test, we use the step-down procedure to estimate the number of lags. The results, reported in Table 2, indicate that both tests reject the null hypothesis of no cointegration at the 5 percent level.[19] Therefore, Pedroni's tests provide strong evidence that s_{it} and b_{it} are cointegrated and that s_{it} and y_{it} are also cointegrated.

We confirm that there are two cointegrating relations in the trivariate model using the system panel cointegration test proposed by Larsson, Lyhagen and Lothgren (2001). Their test is a panel version of Johansen's (1988, 1995) full information maximum likelihood method. The null hypothesis is that all of the N countries in the panel have at most q cointegrating relationships among the 3 variables, $H_o : q$ cointegrating relations for all i, and the alternative is that all the countries have 3, $H_A : 3$ cointegrating relations for all i. This is a sequential procedure where first $q = 0$ is tested. If this hypothesis is rejected, $q = 1$ is tested. The sequential procedure continues until the null is not rejected or the hypothesis $q = 2$ is rejected. The test is computed using one-lag difference terms and it includes individual specific fixed effects. In Table 3 we verify that there are two cointegrating relations in the model. The panel test statistic indicates that $q = 2$ in the model with three variables s_{it}, b_{it} and y_{it}. This implies that there is a single stochastic trend in the data, implying that there are cointegrating relations between s_{it} and b_{it}, and between s_{it} and y_{it}, consistent with previous results.

We conclude that the data satisfy restrictions necessary for existence of a stationary long-

[19] We also reject the null of no cointegration at the 5 percent level when we use all seven panel statistics of Pedroni (1999, 2004). Additionally, we reject the null of no cointegration at the 5 percent level when we do not use the common time effects.

run equilibrium relationship between the primary surplus and debt, and between the primary surplus and output. Therefore, the first set of restrictions, necessary for the monetary authority to have control of the price level, is satisfied. The second set of restrictions are those requiring global stability of the model, equations (16). To determine whether these are satisfied, we estimate the parameters of the error correction model, equation (10). To do so, we use a two-step procedure, in which we initially estimate the cointegrating parameters. In the second step, we estimate the coefficients on the error correction terms.

To estimate the cointegrating parameters, we use Pedroni's (2000, 2001) group-mean fully modified OLS (FMOLS) procedure for cointegrated panels, which is based on equation (17).[20] The group-mean FMOLS procedure accommodates the heterogeneity that is typically present both in the transitional serial correlation dynamics and in the long-run cointegrating relationships. It is a semi-parametric approach that adjusts for the effects of endogenous regressors and short-run dynamics of the errors.[21] We use the Bartlett kernel and the Newey-West bandwidth selection procedure as suggested by Pedroni (2000). The results, in Table 4, indicate that the group-mean panel estimate for the real interest rate is 4.22 percent ($r = 0.0422$) and the group-mean panel estimate for the target primary surplus is 3.80 percent

[20]Bohn (2008) considers a similar equation with x_{it} given by debt, using over two centuries of US data on the primary surplus, output, and debt. His real data series have severe heteroskedasticiy, due to two centuries of growth in real GDP. He reduces, but does not eliminate, these problems by dividing by real GDP. Standard deviations for real variables are 64 to 98 times as high in the second period as in the first. For variables expressed as a fraction of GDP, this number falls to something a little larger than 2. We have a very different data set from Bohn's – a relatively short time dimension and ten countries. The shorter time dimension implies that we do not have Bohn's heteroskedasticity problem. Ratios of standard deviations in the second half of the sample relative to the first half average to something less than 2, similar to his adjusted data.

[21]Since FMOLS is designed to reduce bias associated with short-run dynamics and the estimates in the $I(1)$ model are super-consistent, it is not necessary to add stationary variables, like HP-filtered measures of the data, as in Bohn's model with stationary data (2008) .

of GDP ($\varphi = 0.0380$).[22]

In the final step we consider estimation of the group-mean panel fiscal policy parameters β_1, β_2, and β_3, subject to the restrictions in Lemma 1, yielding the error-correction specification, equation (10). It is important to recognize that the residuals in equation (10) could be autocorrelated in the data. If so, then the residuals could be correlated with the right-hand-side variables, biasing estimates of the coefficients on the error correction terms. Therefore, we use Sims' (1980) likelihood ratio test to determine the appropriate number of lags to fully capture the dynamics for each country. For some countries, the test chooses a single lag in levels, implying that equation (10) is appropriately specified. However, for others, two lags are chosen. Therefore, to be sure that we are not omitting relevant lags and thereby biasing estimates of coefficients, we estimate the model with an additional lag, such that the error correction specification becomes[23]

$$\begin{aligned} s_{it} - s_{it-1} &= \varphi_i g_i - \beta_{3i}\left(s_{it-1} - r_i b_{it-1} + \frac{\varphi_i g_i (1+r_i)}{r_i}\right) - \beta_{2i}\left(s_{it-1} - \varphi_i y_{it-1} - k_i\right) + \\ &\quad \pi_{1i}\left(s_{it-1} - s_{it-2} - \varphi_i g_i\right) + \pi_{2i}\left(b_{it-1} - b_{it-2} - \frac{\varphi_i g_i}{r_i}\right) + \pi_{3i}\left(y_{it-1} - y_{it-2} - g_i\right) + \nu_{it}. \end{aligned} \tag{18}$$

A persistent, but negative surplus shock, perhaps created by a war, would imply a negative error in the first cointegrating relationship and rising lagged debt, implying a negative correlation between the two terms. Therefore, failure to include the lagged change in debt could

[22]The FMOLS results are robust to the choice of kernel and bandwidth. We obtain almost identical estimates when we use the Parzen and quadratic spectral (QS) kernels and the Andrews (1991) bandwidth selection procedure. Additionally, we obtain similar estimates when we use the group mean dynamic OLS (DOLS) procedure of Pedroni (2004) and the two-step estimator of Breitung (2005).

[23]The additional dynamics modify slightly the conditions under which $\beta_{3i} > 1 - \beta_{1i}$ is necessary to assure global stability, that is for all roots to be within the unit circle. For $\pi_{1i} = 0$, as is verified empirically, we need $-1 < \beta_{1i}(1+r) + \pi_{2i} < 1$, which also holds empirically.

bias the estimate on the coefficient on the error correction terms.[24]

Now, consider estimation of the coefficients on the error correction terms in equation (18). First, we use the estimated cointegrating parameters of the interest rate and target surplus to construct the error correction terms for each country (r_i, φ_i), yielding an equation in which all the variables are stationary. Asymptotically, the fact that we use the estimated error correction terms rather than the true error correction terms in (18) does not affect the standard properties of our estimates due to the super-consistency properties of the estimator of the cointegrating relationships.[25] After constructing the error correction terms, we estimate the coefficients of the error correction model, augmented with lagged changes in variables, providing estimates for β_2 and β_3. Under the restrictions in Lemma 1, this also gives an estimate of β_1. We use the group-mean procedure recommended by Pesaran and Smith (1995).[26]

Table 5 indicates that $\beta_1 = 0.4882$, $\beta_2 = -0.1214$ and $\beta_3 = 0.6332$, where β_3 is statistically significantly larger than $1 - \beta_1$.[27] Using our terminology, we cannot reject the null that fiscal policy in each country is strongly passive. Therefore, fiscal policy in the EMU

[24] Using long US samples of one and two centuries that highlight the role of wars, Bohn (1998, 2008) expresses the fiscal rule in terms of the surplus and debt as a fraction of output, and finds it necessary to add HP-filter measures of transitory values of the variables to distinguish between the response of the surplus to permanent and transitory shocks and reduce "omitted variables bias." Transitory, but persistent government spending, as associated with a war, would be accompanied by rising debt implying that the residual would be low when debt is high relative to the surplus. The error correction model deals with this by adding lagged changes of the model variables. In this example the lagged change in debt would be high in a war and would play the role of Bohn's transitory military spending, and the lagged change in output would play the role of Bohn's HP-filtered output.

[25] See Engle and Granger (1987), Toda and Phillips (1993) and Urbain (1992) for the properties of estimators in cointegrated systems.

[26] They show that when the parameters of interest are heterogeneous, the group-mean procedure provides consistent estimates, whereas the pool panel procedures give inconsistent estimates.

[27] We obtain almost identical estimates when we use the hierarchical Bayes estimator of Hsiao, Pesaran and Tahmiscioglu (1999) and the weighted estimator of Swamy (1980) (also referred as the empirical Bayes estimator). We also find that each country's β_{3i} is larger than $1 - \beta_{1i}$, not only the panel estimates.

countries satisfies the second set of restrictions for monetary policy to have the ability to determine the price level, those of global stability. We note also, that our tests imply fiscal sustainability and passive fiscal policy, according to earlier definitions, since the criteria for both is a positive value for β_3.

At first glance the estimated coefficient on target surplus, β_2, might seem that it has the wrong sign. However, target variables should always be viewed as reference points relative to another variable. The fiscal rule in equation (10) can also be written as

$$s_{it} - s_{it-1} = \beta_{0i} + (1 - \beta_{1i}) \left(s^*_{it-1} - s_{it-1} \right) + \beta_{3i} \left(r_i b_{it-1} - s^*_{it-1} \right) + \nu_{it}$$

which implies that the primary surplus increases whenever the target surplus is above the current value and whenever the debt service is above the target value. Restrictions for strongly passive fiscal policy, $\beta_{3i} > 1 - \beta_{1i}$, together with the long-run equilibrium restriction, $\beta_{1i} + \beta_{2i} + \beta_{3i} = 1$, imply that $\beta_{2i} < 0$.

We have not allowed estimates of the parameters of the error correction model to change as the monetary union has evolved over time. However, if the coefficients in the cointegrating relationships had changed and no account were taken for the change, then we should not have rejected the null of no cointegration. The values for the coefficients on the error correction terms could have changed. To test for a change in β_1, β_2 and β_3, we break the sample into two sub-periods, the pre-Maastricht era $(1970 - 1993)$ and the post-Maastricht era $(1994 - 2006)$.[28] Table 6 shows that $\beta_3 > 1 - \beta_1$ in both sub-samples, although standard errors are too high to yield significance.[29] The split sample evidence suggest that the primary

[28] The Maastricht Treaty entered into force on November 1, 1993.

[29]

surplus is sufficiently responsive to debt to give the monetary authority control of the price level in both sub-samples.[30]

4 Conclusion

A country entering the EMU surrenders its monetary policy and its debt becomes denominated in terms of a currency over which it has no direct control. A country's promise to uphold the limits in the Maastricht Treaty and the SGP is implicitly a promise not to allow its fiscal policy to threaten the ability of the ECB to control the price level. However, many countries have violated these limits. This leaves an open question regarding the role of fiscal policy in determining the price level in the EMU.

We assume that there is an upper bound on debt, motivated by an upper bound on distortionary taxes which a government can raise to service the debt. Fiscal policy is assumed to follow a fiscal rule with time-invariant parameters. For the ECB to have power to control the price level in the EMU, the fiscal rule must imply that debt is not expected to explode relative to its upper bound. We show that this requires that the dynamic model of the primary surplus and debt be globally stable. This in turn requires that the primary surplus responds to an increase in debt by at least one minus the persistence in primary surplus. We call such a policy "strongly passive" since the criterion is stronger than those requiring intertemporal budget balance, as with passive policy. We show that a strongly passive fiscal

The sub-samples are not long enough to allow reliable inference. Most of our panel techniques require the time series dimension to be substantially larger than the cross-section dimension, and we lose this when we split the sample.

[30] Afonso (2005) and Annett (2006), who use a similar EMU data set and other empirical techniques, do not find evidence for a change in the fiscal policy after the signing of the Maastricht Treaty.

policy yields a model which is globally stable, such that initial deviations of the primary surplus from its target and from debt service are expected to vanish in the long run. This gives the monetary authority the freedom to determine price in equilibrium. Additionally, global stability assures intertemporal budget balance, but the converse does not hold.

This paper provides estimates of a rule for the primary surplus to determine whether fiscal policy in the EMU countries is strongly passive. Using panel cointegration and panel data techniques that allow for heterogeneity, we estimate the coefficients of the error correction model for the primary surplus in a panel of ten EMU countries over the period 1970-2006. The group-mean estimate for the coefficient on lagged debt is consistent with the hypothesis that fiscal policy in EMU countries is strongly passive, giving the monetary authority control over the price level.

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Appendix

A Data Appendix

Nominal primary surplus, nominal GDP and GDP deflator are from the OECD database. The nominal debt is also from OECD database and for missing years data is obtained from the ECB's AMECO database. The sample consists of annual data from 1970-2006 for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands and Spain. For Luxembourg and Portugal there was not data available for a lot of years. For Germany we use the data for West Germany before unification and Germany after unification. The real values of the variables for each country are obtained by dividing the nominal values by the GDP deflator.

For the nominal primary surplus we use the general government primary balances (OECD Annex Table 29) and for nominal debt we use the general government gross financial liabilities (OECD Annex Table 33).

B Panel Cointegration Statistics (Pedroni (1999))

1. Group mean $t - statistic$ (semi-parametric):

$$N^{-1/2}\tilde{Z}_{t_{N,T}} \equiv N^{-1/2}\sum_{i=1}^{N}\left(\hat{\sigma}_i^2\sum_{t=1}^{T}\hat{e}_{i,t-1}^2\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{e}_{i,t-1}\Delta\hat{e}_{i,t}-\hat{\omega}_i\right)$$

2. Group mean $t - statistic$ (parametric):

$$N^{-1/2}\tilde{Z}^*_{t_{N,T}} \equiv N^{-1/2}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{s}_i^{*2}\hat{e}_{i,t-1}^{*2}\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{e}^*_{i,t-1}\Delta\hat{e}^*_{i,t}\right)$$

where

$$\hat{\omega}_i = \frac{1}{T}\sum_{s=1}^{k_i}\left(1-\frac{s}{k_i+1}\right)\sum_{t=s+1}^{T}\hat{\mu}_{i,t}\hat{\mu}_{i,t-s}, \quad \hat{s}_i^2 \equiv \frac{1}{T}\sum_{t=1}^{T}\hat{\mu}_{i,t}^2, \quad \hat{\sigma}_i^2 = \hat{s}_i^2 + 2\hat{\omega}_i, \quad \hat{s}_i^{*2} \equiv \frac{1}{T}\sum_{t=1}^{T}\hat{\mu}_{i,t}^{*2}$$

and where the residuals $\hat{\mu}_{i,t}$ and $\hat{\mu}^*_{i,t}$ are obtained from the following regressions:

$$\hat{e}_{i,t} = \hat{\delta}_i \hat{e}_{i,t-1} + \hat{\mu}_{i,t} \qquad \hat{e}_{i,t} = \hat{\delta}_i \hat{e}_{i,t-1} + \sum_{k=1}^{K_i} \hat{\delta}_{i,k} \Delta \hat{e}_{i,t-k} + \hat{\mu}^*_{i,t}$$

and $\hat{e}_{i,t}$ are the residuals from equation (17).

Table 1. Panel Unit Root Tests

Test statistic	s_{it}	b_{it}	y_{it}
t_{IPS}	-1.06	1.70	2.42
t_{BD-rob}	-1.24	-0.30	-0.95
t_{MP-a}	-0.49	-0.69	1.13
t_{MP-b}	-0.40	-0.79	0.64
t_{CIPS}	-2.13	-1.70	-1.46

Note: t_{IPS} is the group mean t-statistic proposed by Im, Pesaran and Shin (2003), t_{BD-rob} is the OLS robust t-statistic proposed by Breitung and Das (2005), t_{MP-a} and t_{MP-b} are the t-statistics based on the factor model proposed by Moon and Perron (2004) and t_{CIPS} is the test proposed by Pesaran (2006). They all test the null of a unit root against the alternative of stationarity. All tests are computed using one lag and they include individual specific constants and trends. The test statistics with ** reject the null of a unit root at the 5 percent level. For the t_{IPS}, t_{BD-rob}, t_{MP-a} and t_{MP-b} tests, the null is rejected if $t < -1.64$ and for the t_{CIPS} test, the null is rejected if $t_{CIPS} < -2.85$.

Table 2 : Residual Based Panel Cointegration Tests

Test Statistics	s_{it} and b_{it}	s_{it} and y_{it}
Group mean t (semi-parametric)	-4.22**	-4.54**
Group mean t (parametric)	-4.53**	-4.83**

Note: See the Appendix for details. The statistics are distributed standard normal. They test the null hypothesis of no cointegration against the alternative of cointegration. All the tests include individual specific fixed effects and common time effects. The test statistics with ** reject the null hypothesis at the 5 percent level. The 5 percent critical value is -1.64.

Table 3 : System Based Panel Cointegration Tests

		s_{it}, b_{it}, y_{it}		
	$q = 0$	$q = 1$	$q = 2$	Cointegrating relations
Panel test	14.26**	7.77**	0.81	2

Note: The panel cointegration statistic tests the null hypothesis that there are q cointegrating relationships against the alternative that there are 3 cointegrating relationships. The test includes individual specific fixed effects. The test statistics with ** reject the null at 5 percent level. The panel test has a 5 percent critical value of 1.64. The moments used for the panel test are tabulated in Shiamptanis (2008).

Table 4 : Panel Estimates of the Cointegrating Parameters

	r	φ
coefficients	0.0422**	0.0380**
standard errors	(0.0061)	(0.0076)

Note: r and φ are the group-mean panel FMOLS estimates of real interest rate and target surplus. The estimates are based on the Bartlett kernel and the Newey-West bandwidth selection procedure. They include individual specific effects. The ** indicate statistical significance at the 5 percent level. The 5 percent critical value is 1.96.

Table 5 : Panel Estimates of the Fiscal Parameters

	β_1	β_2	β_3	π_1	π_2	π_3
coefficients	0.4911**	-0.1186**	0.6277**	0.0607	-0.0911**	0.1888**
standard errors	(0.0766)	(0.0452)	(0.0846)	(0.0689)	(0.0388)	(0.0706)

Note: β_1, β_2 and β_3 are the group-mean panel estimates for the coefficient on lagged surplus, on target surplus and debt service, respectively. π_1, π_2 and π_3 are the group-mean panel estimates for the coefficients on the lagged change in surplus, the lagged change in debt and the lagged change in output. The ** indicate statistical significance at the 5 percent level.

Table 6 : Panel Estimates of the Fiscal Parameters Before and After Maastricht Treaty

	β_1	β_2	β_3	π_1	π_2	π_3
Pre-Maastricht	0.3205**	-0.0060	0.6855	0.0885	-0.1831**	0.1212
	(0.1219)	(1.3239)	(1.2825)	(0.1079)	(0.0451)	(0.0685)
Post-Maastricht	0.3186**	-0.0501	0.7315	0.0909	-0.0521	0.3302**
	(0.1425)	(1.5249)	(1.4951)	(0.0935)	(0.0759)	(0.1318)

Note: The ** indicate statistical significance at the 5 percent level.