Alma Mater Studiorum - Università di Bologna
DEPARTMENT OF ECONOMICS

Fiscal shocks, public debt, and long-term interest rate dynamics

Luigi Marattin
Paolo Paesani
Simone Salotti

Quaderni - Working Paper DSE N° 740

Fiscal shocks, public debt, and long-term interest rate dynamics

Luigi Marattin
University of Bologna (Italy)

Paolo Paesani
University of Rome-Tor Vergata (Italy)

Simone Salotti
National University of Ireland Galway (Ireland)

November 17, 2011

Abstract

Public finances worldwide have been severely hit by the late 2000s Great Recession, stimulating the debate on the consequences of growing fiscal imbalances. This paper focuses on the USA, Germany and Italy over the 1983-2009 period and studies the effects of government debt accumulation on long-term interest rates in a common trends framework. The results show that sustained debt accumulation leads to higher long-term interest rates and steep yield curves in Germany and Italy, but not in the USA. There is also evidence of cyclical cross-country linkages, mainly between Italy and the USA.

Keywords: Public debt, long-term interest rates, cointegration, common trends.

JEL: E6, H63.

1 Introduction

Recent events in the world economy (the late 2000s financial crisis, the ensuing Great Contraction) contributed to the sharp and persistent deterioration of fiscal balances in many developed countries. In some cases, this phenomenon has been so intense as to trigger confidence crisis and contagion effects. Investigating the implications of fiscal shocks and government debt accumulation is therefore gaining momentum in the debate among researchers and policy makers.

We aim to contribute to this debate by empirically investigating the effects of fiscal shocks on government debt and long-term interest rates, focusing on the USA, Germany and Italy, three among the principal issuers of government securities at the global level. In those countries public debt has significantly increased, both in absolute and relative (to GDP) terms.

Building on Paesani et al. (2006), we investigate three specific issues. First, we analyse the impact of domestic fiscal shocks on nominal and real long-term interest rates and on the slope of the yield curve, controlling for inflation and money-market conditions. Second, we assess whether this impact is transitory or permanent. Third, we examine the role of international linkages in determining long-term interest rates. We believe this to be relevant both for the assessment of debt sustainability and as a contribution to the debate on domestic vs. international determinants of interest rates.

The empirical literature analysing the relationships between fiscal shocks, public debt and long-term interest rates includes a vast set of contributions which differ along several dimensions: the countries of interest, the econometric methodology (single equation/Vector Auto Regression - VAR - methods), and the nature of the fiscal variables employed to proxy the fiscal position (actual/projected debt/deficit). Most of the studies estimate a positive relationship between increases in the fiscal variables and long-term interest rates, although the evidence is not unanimous (see, e.g., Ardagna et al. 2007, Evans and Marshall 2007). Estimates based on US data mostly point to 10/60 basis points increases of long-term interest rates following a 1% increase in the budget deficit (Thomas and Wu 2009, Gale and Orszag 2003, Canzoneri et al 2002), whereas an analogous increase in debt makes long-term interest rates increase by 2-7 basis points (Engen and Hubbard 2004, Laubach 2009). European-focused analyses also point towards increasing interest rates following deteriorating fiscal balances. Bernoth et al. (2004) find that a 1% increase in primary deficit is associated with a 10 basis points increase in the nominal long-term interest rate. On the other hand, they find that a debt-service ratio 5% higher than the German one, corresponds to a 32 basis points spread, with substantial non-linear effects. Similar results are found by Heppke-Falk and Hufner (2004) and Afonso (2010), among others. On the other hand, Caporale and Williams (2001) find that the impact of the debt/GDP ratio on the 10-year rate for Germany and the US has a negative sign. The reasons seem to be a strong liquidity effect, since "these governments issue high-quality, low-risk debt, which when added to the overall debt stock reduces the aggregate risk premium and so the interest rate itself. The demand for new issues of such debt is likely to be high, which will put upward pressure on the bond price and therefore further downward pressure on the interest rate. International capital flows may also play a role. If US and German long-term debts are indeed viewed as less risky than issues in other countries, foreign purchases may add to domestic demand raising the price of the issue and so reducing the yield" (Caporale and Williams 2001, 126-127). Interestingly, in the case of Italy, where the debt/GDP ratio has recently come close to 120%, they find a positive impact on long-term interest rates.

Our investigation of the within-country relationships between fiscal shocks, public debt and on long-term interest rates is based on a Vector Error Correction (VEC) model including the debt/GDP ratio, inflation, the short and the long-term interest rate. We distinguish permanent from transitory shocks using the common trends methodology. As for the cross-country part of our analysis, the economic literature offers a number of contributions on the issue of interest rate convergence. This is partly related to the so-called international Fisher effect, according to which expected real returns are equal across countries (Mishkin 1984). The evidence offered by the previous literature is mixed due to the fact that there are many unresolved methodological issues (Fujii and Chinn 2001, Arghyrou et al. 2009). We investigate the cross-country linkages among long-term interest rates with a simple analysis based on the structural (common-trends) analysis coming from the country-by-country part of the analysis.

The main findings of the paper can be summarized as follows. First, while fiscal shocks crucially determine both the permanent and cyclical component of the long-term interest rate in Germany and the USA, in the case of Italy another structural shock with permanent effects also plays a non-negligible role. Second, a 1% increase in the debt/GDP ratio in Germany and Italy leads, respectively, to a 7 and 11 basis points increase in real interest rates after five years and to yield curve increases of a similar magnitude. On the other hand, in the USA the liquidity effect seems to prevail, as a 1% increase in government debt relative to GDP lowers the real interest rate by 13 basis points five years after the shock. We also find evidence of asymmetric effects of debt shocks depending on the level of its ratio over GDP in Italy and Germany, but not in the USA. Finally, international linkages seems to connect the cyclical components of the US and the Italian long-term interest rates. On the other hand, there is no evidence in favour of permanent linkages among the long-term interest rates of the three countries.

The rest of the paper is organized as follows. Section 2 describes the econometric model and the identification strategy. Section 3 reports the results of the empirical analysis on each of the countries object of this study. Section 4 is devoted to the analysis of cross-country linkages. Section 5 concludes and discusses the main policy implications of the analysis.

2 The model

The following VEC model constitutes the basis of our investigation.

$$
\begin{bmatrix} \Delta b_t \\ \Delta \pi_t \\ \Delta i_t^S \\ \Delta i_t^L \end{bmatrix} = \sum_{i=1}^{m-1} \Gamma_i \begin{bmatrix} \Delta b_{t-i} \\ \Delta \pi_{t-i} \\ \Delta i_{t-i}^S \\ \Delta i_{t-i}^L \end{bmatrix} + \Pi \begin{bmatrix} \Delta b_{t-1} \\ \Delta \pi_{t-1} \\ \Delta i_{t-1}^S \\ \Delta i_{t-1}^L \end{bmatrix} + \Omega \begin{bmatrix} Const \\ Trend \\ Seas.d. \\ I.d. \end{bmatrix} + \begin{bmatrix} \varepsilon_t^b \\ \varepsilon_t^\pi \\ \varepsilon_t^s \\ \varepsilon_t^l \end{bmatrix} \quad (1)
$$

where $t = 1983{:}1,...,2009{:}4$ and $\varepsilon_t \sim N_4(0, \Sigma)$.

The four variables are the following: inflation (π_t), the short-term interest rate (i_t^S), the long-term interest rate (i_t^L), and the government debt/GDP ratio (b_t). The theoretical relationships affecting the four variables included in our system can be easily summarized using the following four equations coming out of a simplified version of the New Keynesian general equilibrium model of Andres et al.2004 (for details see Marattin et al. forthcoming):

$$
\begin{aligned}
\hat{\imath}_t^L &= \frac{1}{L}\sum_{j=0}^{L-1} \hat{\imath}_{t+j}^S + \frac{1}{L}\phi_l \hat{b}_{L,t} && (2) \\
\hat{\imath}_t^S &= \phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t && (3) \\
\hat{b}_t &= \phi_b \hat{y}_{t-1} && (4) \\
\hat{\pi}_t &= \beta E_t \hat{\pi}_{t+1} + \Omega \hat{y}_t && (5)
\end{aligned}
$$

Equation (2) is the term structure relating the long term-interest rate to the average of expected short term rates over horizon L and to the supply of long-term government bonds under the assumption of imperfect substitutability between bonds and bills. Equation (3) is the standard Taylor rule, according to which the Central Bank sets the short-term interest rate reacting to the inflation and the output gap (with $\phi_y > 0$ and $\phi_\pi > 1$ to ensure determinacy). Equation (4) is the fiscal rule, governing the evolution of the stock of government liabilities in response to aggregate demand movements (with $\phi_b \lesseqgtr 0$ depending on pro/counter cyclicality of fiscal policy). Finally, equation (5) is the New Keynesian Phillips Curve, where inflation responds to inflation expectations ($0 < \beta < 1$ being the individual discount factor) and to the output gap (Ω being a function of price rigidity and labor supply elasticity). Our empirical model (1) aims at capturing these relationships described by these four equations resulting from a general equilibrium model.

We apply the common trends methodology (Stock and Watson 1988, King et al. 1991, Mellander et al. 1992, Warne 1993, Gonzalo and Granger 1995, Mosconi 1998) to our small-scale macroeconomic system and we rely on the forecast error variance decomposition to identify the nature of the structural shocks of the model. Some of the structural shocks have permanent effects on the variables of the model, others have only transitory effects. Cointegration tests are needed to understand the number of cointegrating relationships, which also determines the number of shocks that exert permanent effects on the model (in our case there are two cointegrating relationships among the four variables, therefore we have to deal with two permanent effects shocks - see Section 3 for details). Then, three sources of restrictions can be identified: separation of transitory from permanent innovations, long-run effects of permanent innovations, instantaneous impact of both types of innovations (Warne 1993). Part of these restrictions are provided by the cointegrating relations, additional ones are suggested by economic theory (e.g. the long-run neutrality assumption).

Omitting the deterministic component, the moving average representation of the model defines the data generating process as a function of the initial conditions and of the reduced form shocks ε_t. This is given by:

$$\begin{bmatrix} b_t \\ \pi_t \\ i_t^S \\ i_t^L \end{bmatrix} = \xi + C \sum_{i=1}^{t} \begin{bmatrix} \varepsilon_i^b \\ \varepsilon_i^\pi \\ \varepsilon_i^s \\ \varepsilon_i^l \end{bmatrix} + C^*(L) \begin{bmatrix} \varepsilon_t^b \\ \varepsilon_t^\pi \\ \varepsilon_t^s \\ \varepsilon_t^l \end{bmatrix} \tag{6}$$

where the matrix $C = \beta_\perp \left[\alpha_\perp' (I - \Sigma_i \Gamma_i)^{-1} \beta_\perp \right] \alpha_\perp'$ measures the impact of cumulated shocks to the system, $C^*(L)$ is an infinite polynomial in the lag operator L. The relationship between reduced form and structural form innovations is assumed to be:

$$\begin{bmatrix} \varepsilon_t^b \\ \varepsilon_t^\pi \\ \varepsilon_t^s \\ \varepsilon_t^l \end{bmatrix} = B \begin{bmatrix} \xi_t^\varphi \\ \xi_t^v \\ \xi_t^\theta \\ \xi_t^\eta \end{bmatrix} \tag{7}$$

where B is a $4X4$ non-singular matrix. The model is in moving average form, and may therefore be rewritten as:

$$\begin{bmatrix} b_t \\ \pi_t \\ i_t^S \\ i_t^L \end{bmatrix} = \xi + CB \textstyle\sum_{i=1}^{t} B^{-1} \begin{bmatrix} \varepsilon_i^b \\ \varepsilon_i^\pi \\ \varepsilon_i^s \\ \varepsilon_i^l \end{bmatrix} + C^*(L) B B^{-1} \begin{bmatrix} \varepsilon_t^b \\ \varepsilon_t^\pi \\ \varepsilon_t^s \\ \varepsilon_t^l \end{bmatrix} =$$

$$\xi + \Phi \sum_{i=1}^{t} \begin{bmatrix} \xi_i^\varphi \\ \xi_i^v \\ \xi_i^\theta \\ \xi_i^\eta \end{bmatrix} + \Phi^*(L) \begin{bmatrix} \xi_t^\varphi \\ \xi_t^v \\ \xi_t^\theta \\ \xi_t^\eta \end{bmatrix} \tag{8}$$

where the matrix Φ contains the permanent component of the model, and the matrix polynomial $\Phi^*(L)$ the cyclical (transitory) component. Me make the following assumptions on the nature of the four shocks in the system. As for the permanent shocks, we consider a fiscal policy shock (ξ_i^φ), motivated by the importance of public debt developments in influencing the variables of the system, and a monetary policy shock (ξ_i^ν). The two temporary shocks are assumed to be a financial shock without contemporaneous effects on inflation (ξ_i^θ, possibly reflecting portfolio re-adjustments costs) and an inflationary shock (ξ_i^η). We therefore need the following restrictions. The standard assumption of orthonormal structural innovations places $4(4{+}1)/2 = 10$ identification restrictions on B.

$4(4-1)/2 = 6$ more restrictions are needed in order to get exact identification. Since the last two shocks of the model only exert transitory effects on the variables of the system, we set to zero the last two columns of matrix Φ (this gives us two linearly independent restrictions), then by post-multiplying it by matrix U we impose additional $(4-r)r = 2$ restrictions on B. Identification of the two permanent shocks requires imposing $(4-2)(4-2-1)/2 = 1$ restrictions either on Φ_l or on the matrix $\Phi^*_{01} = B^{'}_{\perp}$, which measures the simultaneous impact of permanent innovations. We distinguish the two permanent shocks by imposing the neutrality assumption that the monetary policy shock has no long-term impact on the debt/GDP ratio, justified by the fact that the level of that ratio in the long-run is politically determined (restricting to zero the $(1, 2)$ element of matrix Φ_l). Finally, the identification of the two transitory shocks requires imposing one additional restriction on the matrix of the instantaneous impacts. Thus, we restrict to zero the simultaneous impact of the transitory financial shock on inflation (i.e. element $(2, 1)$ of matrix Φ^*_{02}) to distinguish it from the temporary inflationary shock. The overall number of restrictions $(4+1+1 = 6)$ plus the 10 orthonormality restrictions guarantees the just identification of the structural model.

We back up the construction of these four shocks in two ways. First, we rely on the Forecast Error Variance Decomposition (FEVD) in order to assess the importance of the shocks in determining the variables of the system, therefore checking for the reasonableness of the labels attached to the shocks (see Section 3). Second, we conform to the previous literature that suggests the importance of assuming a limited number of shocks in a macroeconomic framework (e.g. Bai and Ng 2007). In particular, Forni and Gambetti (2010) focus on a specification with two policy and two non-policy demand and supply shocks as we do here (although they use a structural factor model, which differs from the VEC model used here). Their results on the persistence of the shocks do not contrast with the permanent/temporary distinction that we assume in our framework.

The chosen structural identification strategy makes it possible to decompose each of the four time series into the sum of a permanent and of a cyclical component. Concentrating on the long-term interest rate i^L_t we have:

$$i^L_t = \delta_l + l^P_t + l^C_t \tag{9}$$

where δ_l is a function of the initial condition and of the deterministic component of the model, l^P_t is the permanent stochastic component driving the long-term interest rate and l^C_t is the cyclical component. The permanent component can be further decomposed into the sum of the two cumulated permanent shocks according to the formula:

$$l^P_t = \Phi_{41} \sum_{i=1}^{t} \xi^{\varphi}_i + \Phi_{42} \sum_{i=1}^{t} \xi^{\nu}_i \tag{10}$$

where Φ_{41} (Φ_{42})is the element occupying the fourth row, first (second) column of matrix Φ and Φ_{43} and Φ_{44} are restricted to zero. This decomposition makes it possible to understand to what extent both the fiscal shock $\sum \xi_i^{\phi}$ and the monetary shock $\sum \xi_i^{\upsilon}$ contribute to determining the long-run movements of the long-term interest rate in each of the three countries.

The cyclical component l_t^C, instead, can be decomposed as follows:

$$l_t^C = \sum_{i=1}^{t} \Phi_{1,41}^* \xi_i^{\varphi} + \sum_{i=1}^{t} \Phi_{1,42}^* \xi_i^{\nu} + \sum_{i=1}^{t} \Phi_{1,43}^* \xi_i^{\theta} + \sum_{i=1}^{t} \Phi_{1,44}^* \xi_i^{\eta} \tag{11}$$

where $\Phi_{i,41}^*$ is the element occupying the fourth row, first column of matrix Φ_i^*. This decomposition makes it possible to understand to what extent each of the four stochastic shocks included in the model contributes to determining the cyclical component of the long-term interest rate.

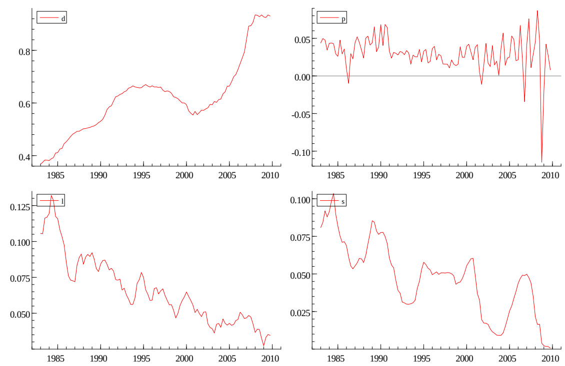
3 Results of the empirical analysis

Standard unit root tests show that all variables of the model can be treated as $I(1)$ processes for the three countries under analysis (see Tables A2, A5 and A8 for the USA, Germany and Italy respectively). Cointegration analysis carried out using the Johansen (1988) test shows that there are two cointegrating vectors in all countries (see Tables A3, A6 and A9 for details). In the common trends framework, the existence of two cointegrating relationships among four variables implies the presence of two distinct sources of shocks having permanent effects on at least some of the variables (Warne 1993). This implies a rank equal to 2 for the Π matrix, i.e. the presence of two cointegrating vectors ($r = 2$) in the model. The following results are based on the estimates of the model whose structural identification has been described in the previous section.

3.1 USA

As Figure shows, the US public debt/GDP ratio (upper panel, left) increased over the sample period, going from 38% in 1983 to 93% in 2009. Meanwhile, inflation (upper corner, right) fluctated irregularly around an average value equal to 3% while both the short-term (lower left corner) and the long-term interest rate (lower right corner) declined, following irregular cyclical patterns.

Figure 1: The US data



The VEC model used to analyse US data includes six lags, chosen on the basis of standard information criteria. A constant, a linear trend and seven impulse dummies are also included (the latter to account for outliers[1]) Misspecification tests for residual autocorrelation, normality and heteroscedasticity indicate that the model is well specified.[2] Having identified the four structural shocks as specified in Section 2 above, Figure 2 shows the corresponding Forecast Error Variance Decomposition (hence FEVD) graphs.

The first column of Figure 2 refers to fiscal shock ξ^{φ}. This shock absorbs almost entirely the FEV of the debt/GDP ratio and contribute significantly to explaining unexpected changes in inflation. The second column supports the identification of ξ^{υ} as a monetary policy shock mainly determining the short-term and the long-term interest rate. The third column shows that the only significant contribution of the financial shock ξ^{θ} is to the FEVD of the two interest rates. Finally, the fourth column confirms our identification of the last stochastic component as a transitory nominal shock ξ^{η}.

[1] The dummies refer to the following quarters: 2001:1, 2001:4, 2006:4, 2008:4 (all because of negative spikes in inflation), 2000:2 (spikes in both interest rates), 2007:3 and 2007:4 (drops in both interest rates).

[2] Vector AR 1-5 test: F(80, 183) = 1.03 [0.42], Vector Normality test: $\chi^2(8) = 12.11$ [0.15], Vector hetero test: F(500, 119) = 0.34 [1.00]. Details on the methodology to compute these tests may be found in Doornik and Hendry (2001).

Figure 2: Forecast Error Variance Decomposition, USA

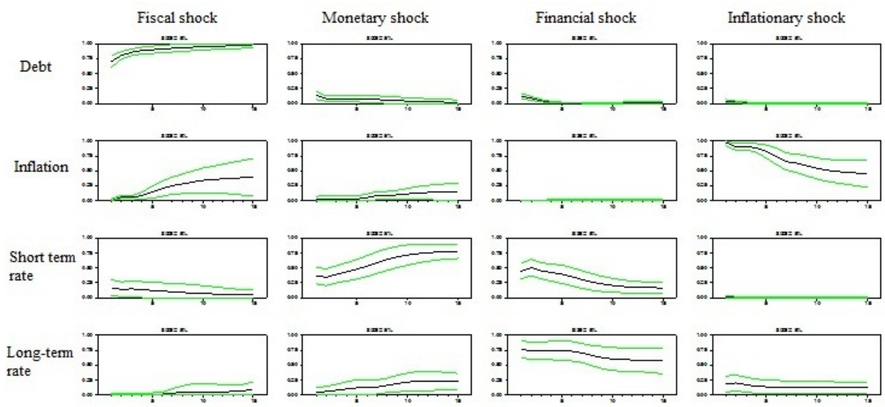


Figure 3 illustrates the US long-term interest rate (upper panel, left) and its three components as indicated by Equation (9) above: the permanent stochastic component (lower panel, left), the cyclical stochastic component (lower panel, right) and the the residual component, orthogonal to the previous two (upper panel, right). This residual is a function of initial conditions and of the deterministic elements included in the estimation of the model. Although quantatively significant, what remains of the residual component after linear de-trending is close to zero and only marginally correlated with the short-term interest rate (at 10% significance, detailed results available on request). We interpret the residual component as reflecting the disinflation of the US economy over the sample period, sharper in the wake of the Volker years, more gradual from the early 1990s onwards. Estimating the model allowing for the possibility of a quadratic trend does not change the nature of the residual (results are available upon request). We are going to analyse the importance of the structural shocks in determining both the permanent and the cyclical components of the long-term interest rate.

Figure 3: Decomposing the US long-term interest rate

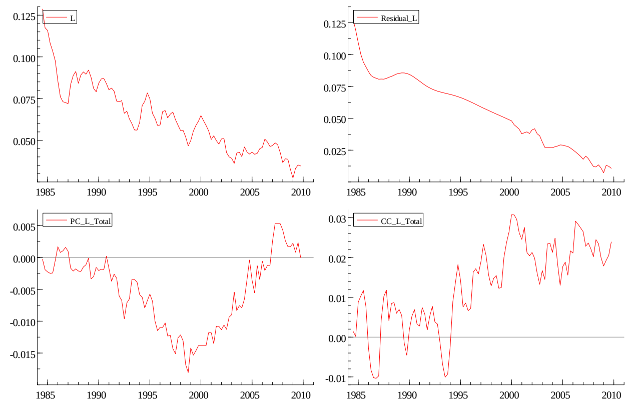


Figure 4 shows the permanent stochastic component driving the long-term interest rate (dashed line) and the contribution of cumulated fiscal shocks $\Phi_{41} \sum_{i=1}^{t} \xi_i^{\varphi}$ (solid line, upper left panel) and cumulated monetary policy shocks $\Phi_{42} \sum_{i=1}^{t} \xi_i^{\nu}$ (solid line, lower left panel).[3] The observed patterns indicate that the permanent stochastic component driving the long-term interest rate l_t^P is almost entirely determined by cumulated fiscal shocks. Also, the pattern seems compatible with fiscal deterioration (retrenchment) leading to higher (lower) interest rates. The fact that this contribution is negative for most of the sample period, might reflect a liquidity effect, as already observed by Caporale and Williams (2001), possibly coupled with a flight-to-quality effect, where the high demand for safe assets contributes to lowering their return.

[3] The two graphs on the right reflect the fact that permanent stochastic components do not depend on transitory shocks as indicated by Equation (10) above.

Figure 4: Permanent component of the US long-term interest rate

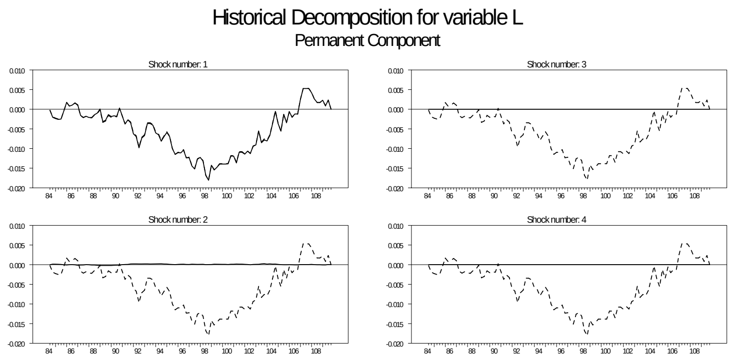
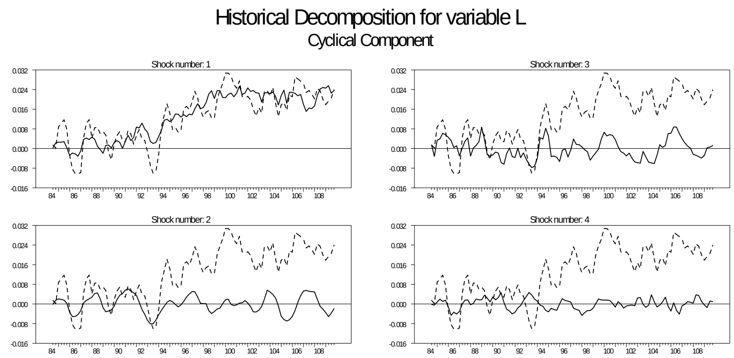


Figure 5 decomposes the cyclical component driving the US long-term interest rate l_t^C (dashed line) into its determinants: cumulated fiscal shocks $\sum_{i=1}^{t} \Phi_{1,41}^{*} \xi_i^{\varphi}$ (upper left panel), cumulated monetary shocks $\sum_{i=1}^{t} \Phi_{1,42}^{*} \xi_i^{\nu}$ (lower left panel), cumulated financial shocks $\sum_{i=1}^{t} \Phi_{1,43}^{*} \xi_i^{\theta}$ (upper right panel), cumulated nominal shocks $\sum_{i=1}^{t} \Phi_{1,44}^{*} \xi_i^{\eta}$ (lower right panel). The observed cyclical patterns conform with the idea that long-term interest rates tend to increase during phases of fiscal deterioration. The direction of changes is compatible with changes in default risk premia, although the magnitude is much larger than what could be expected given the credit status of the US debt that was considered to be risk-free for the whole sample period. There are minor contributions from the monetary and inflationary shocks, especially in the second half of the sample period.

Figure 5: Transitory component of the US long-term interest rate



Finally, Figure 6 contains the impulse responses of the real long-term interest rate (obtained by subtracting the impulse response function of inflation to that of the long-term interest rate - left panel) and of the slope of the yield curve (obtained by subtracting the impulse response function of the short-term to that of the long-term interest rate - right panel) to a 1% shock to the debt/GDP ratio. The shock makes the real interest rate fall by 13 basis points after five years. The slope of the yield curve temporarily increases (up to the eleventh quarter after the shock, with a peak in the seventh quarter), then decreases, determining a cumulative change close to zero after five years. Jointly, these results seem to point towards the importance of a liquidity effect, possibly coupled with the response of fiscal authorities to the business cycle.[4] No significant (increasing) risk premium effect appears in the data.[5]

The literature on public debt has highlighted the fact that the effects of debt accumulation can differ according to different levels of the debt/GDP ratio (e.g., see Reinhart and Rogoff 2010). Based on this intuition and following the hints coming from the literature on threshold structural VAR models (Tsay 1998), we divide the sample according to the different values of the debt/GDP ratio. In the US case, we use the sample average (61.7%) as the threshold, which leaves 52 observations with a debt/GDP ratio value above average and 56 observations with a below average value. The impulse response functions of the real long-term interest rate and of the yield curve in the two cases, shown in Figure 7 (left and right panel respectively), indicate the absence of any significant asymmetric

[4] As might happen in the case of the US economy entering into a recession (expansion) with, aggregate demand and real GDP contracting (expanding), real interest rates falling (increasing) and the budget deficit and government debt increasing (falling).

[5] Steep yield curves have been associated in the past to unsustainable fiscal positions (and debt downgrades, as in the case of Japan at the beginning of the Nineties). Therefore, it seems that increasing debt in the USA does not worsen the expectations about the sustainability of its debt position.

Figure 6: Impact of a debt/GDP shock on the real long term interest rate and on the slope of the yield curve, USA 1983:1-2009:4

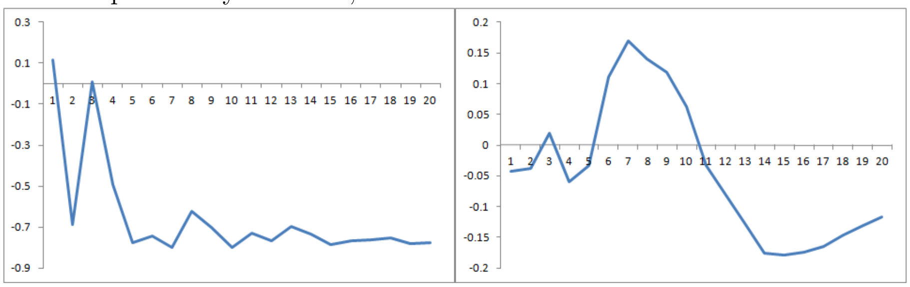
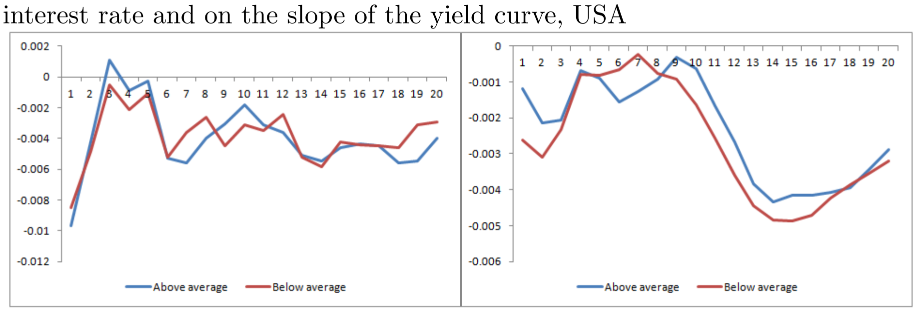


Figure 7: Asymmetric impacts of a debt/GDP shock on the real long term interest rate and on the slope of the yield curve, USA



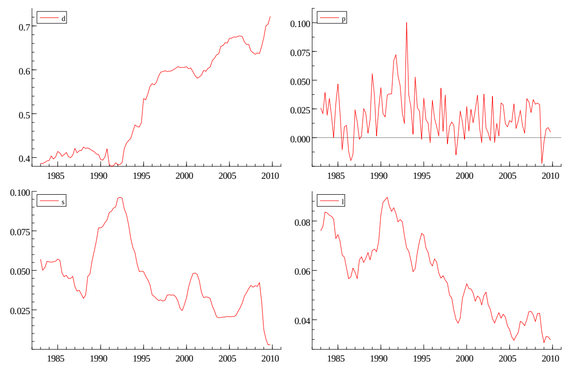
effect.

Summarizing the available evidence, and excluding the presence of default risk in the case of the USA, our analysis shows that as public debt accumulates long-term interest rate tend *ceteris paribus* to be higher, both through permanent and cyclical stochastic components. However, the observed impact of a 1% increase in the debt/GDP ratio on the real long-term interest rate (negative) and on the yield curve slope (initially close to zero, then slightly positive, but negative after 10 quarters from the shock) might reflect the fact that the main source of these shocks comes from fiscal authorities reacting to recession and deflation in an accommodating fashion, rather than from exogenous fiscal stimuli.

3.2 Germany

Figure 8 depicts the German data series. The two upper panels reflect the costs of German reunification in terms of (permanently) higher debt/GDP ratio (upper panel, left) and (transitorily) higher inflation (upper panel, right). The short-term interest rate rose sharply bewteen 1989 and 1993, in response to inflationary pressures and to the Bundesbank prompt intervention to extinguish

Figure 8: The German data



them. The long-term interest rate followed a more jagged profile, gradually diminishing over the sample period. Indications of asynchronous movements between the inflation rate and the debt/GDP ratio emerge again at the end of the sample period (financial crisis).

A VEC model including an unrestricted constant, a restricted trend, and seasonal dummies is chosen to analyze the data. Standard information criteria and residual autocorrelation tests recommend choosing four lags. Graphic and residual analyses suggest adding five impulse dummies to the system.[6] Misspecification tests for residual autocorrelation, normality and heteroscedasticity indicate that the model is well specified.[7]

As in the case of the US, fiscal shocks seem to entirely explain the FEV of the debt/GDP ratio (Figure 9, column 1). However, in the case of Germany they also contribute significantly to explaining errors in forecasting inflation and the two interest rates. The second column conforms with the neutrality assumption and with monetary shocks being mainly related with the two interest rates. Financial shocks matter only in explaining the FEV of the short-term interest rate. Finally, the graphs of the fourth column conform with our identification of the fourth stochastic component of the model as a transitory inflation shock.

[6] The dummies refer to the following quarters: 1991:1 (German reunification), 1993:1 (spike in inflation), 1995:1 (spike in the debt/GDP ratio), 2008:4 (negative spike in inflation), 2009:1 (negative spikes in both interest rates).

[7] Vector AR 1-5 test: F(80, 129) = 1.19 [0.16], Vector Normality test: $\chi^2(8) = 11.60$ [0.17], Vector hetero test: F(340, 354) = 0.66 [1.00]. Details on the methodology to compute these tests may be found in Doornik and Hendry (2001).

Figure 9: Forecast Error Variance Decomposition, Germany

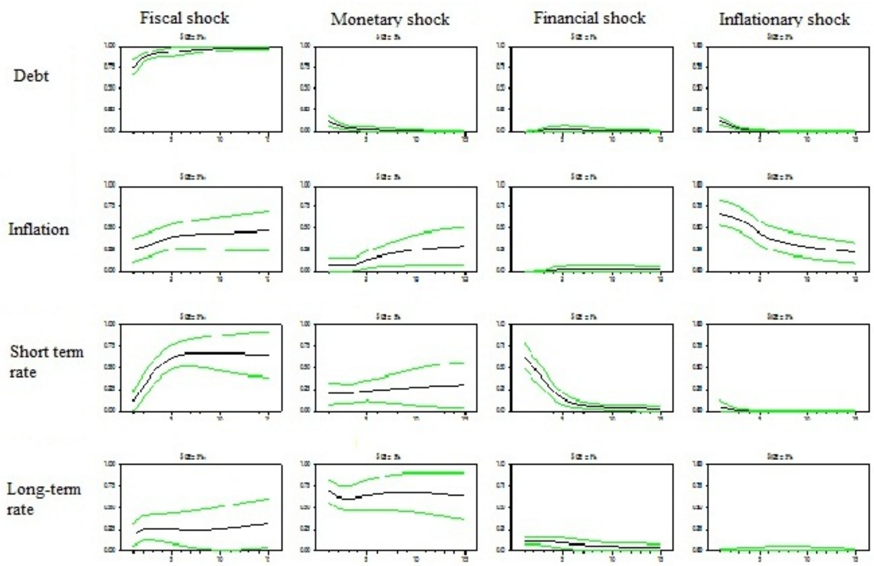
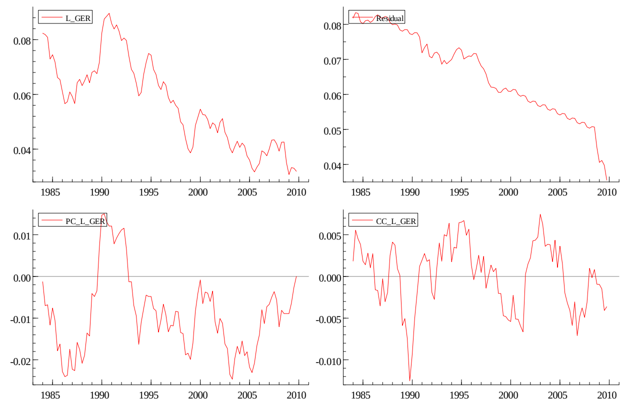


Figure 10 shows the graph of the long-term interest rate (upper left panel) and of its three components. The contribution of the permanent stochastic component is negative throughout the sample period (as in the US case), with the notable exception of the reunification years (1989-1993) as if anticipating the subsequent sharp rise in the debt/GDP ratio. The contribution of the cyclical component oscillates during the sample period without any clear connection with the fiscal patterns. The upper right panel shows the residual element reflecting initial conditions plus deterministic components. We interpret this component as capturing the disinflation of the international and German economies over the sample period, and the effects of price stability under EMU (with the reunification break).[8] Once de-trended, the residual is quantitatively close to zero and not correlated with any of the variables of the system (nor with the structural shocks, with respect to which it is orthogonal by definition).[9]

[8] The sharp drop at the end of the period might be attributed to the recent financial crisis having a particularly strong deflationary impact on Germany.

[9] As in the US case, estimating the model with an unrestricted trend does not alter the properties of the residual term.

Figure 10: Decomposing the German long-term interest rate



Figures 11 and 12 analyze the permanent and the cyclical components, respectively. Figure 11 decomposes the permanent stochastic component l_t^P (dashed line) into its two determinants: the fiscal shock (upper left panel) and the monetary shock (lower left panel). l_t^P appears to be almost entirely explained by cumulated fiscal shocks ($\Phi_{41} \sum_{i=1}^{t} \xi_i^{\varphi}$) from the beginning of the 1990s to the end of the sample period (upper left panel). The effect is prevalently negative, in line with the liquidity and flight to quality effects interpretation, proposed in the case of the US. The observation of a negative effect starting in 1990 (preceding the deterioration of the debt/GDP ratio) may reflect the fact that the massive financing of reunification before 1995 was largely done outside the official general government budget using special funds (see von Hagen and Strauch 1999). Cumlated monetary shocks ($\Phi_{42} \sum_{i=1}^{t} \xi_i^{\nu}$) appear to be relevant only in the first part of the sample period (lower panel, left).

Figure 11: Permanent component of the German long-term interest rate

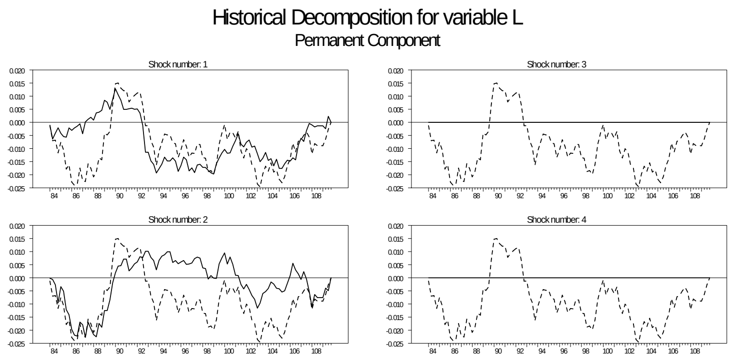


Figure 12 portrays the cyclical stochastic component driving the German long-term interest rate l_t^C (dashed line) and the relative contribution of the four structural shocks to its formation (solid lines). As the four graphs indicate, l_t^C is mainly driven by cumulated fiscal shocks ($\sum_{i=1}^{t} \Phi_{1,41}^{*} \xi_i^{\varphi}$, upper left panel) and cumulated financial shocks ($\sum_{i=1}^{t} \Phi_{1,43}^{*} \xi_i^{\theta}$, upper right panel). This latter effect, not observed in the case of the USA, might reflect the specific impact of reunification of the German domestic financial market and the subsequent monetary policy response.

Figure 12: Transitory component of the German long-term interest rate

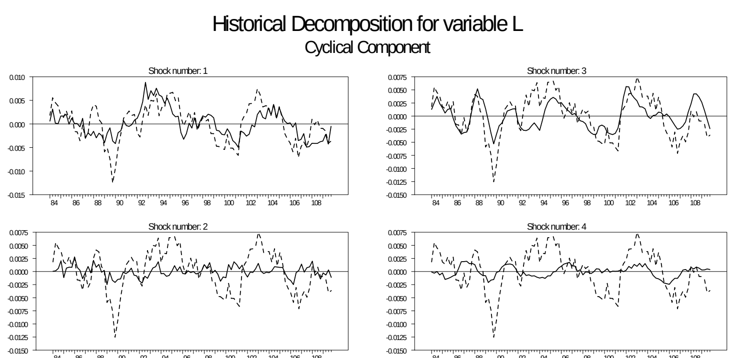
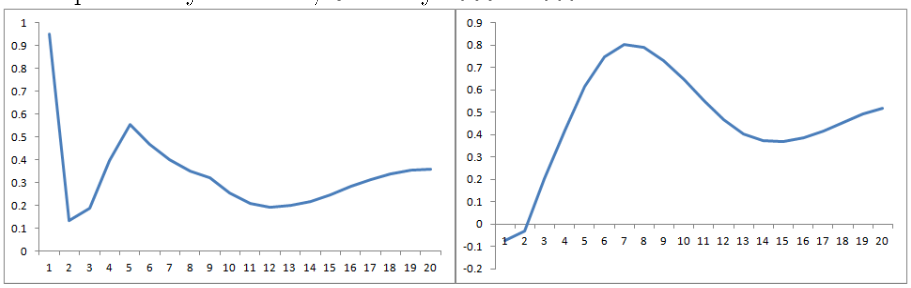


Figure 13 contains the impulse responses to an adverse fiscal shock equal to 1% of the debt/GDP ratio of the real ex-post long-term interest rate (left

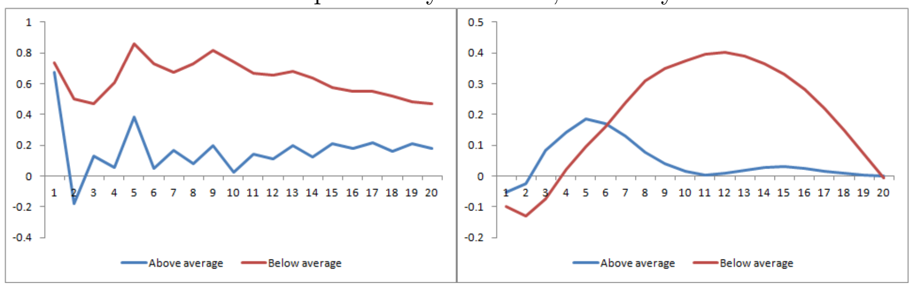
Figure 13: Impact of a fiscal shock on the real long term interest rate and on the slope of the yield curve, Germany 1983:1-2009:4



panel) and of the yield curve (right panel). The real long-term interest rate increases by almost 7 basis points after five years, while the differential between long and short-term interest rates widens by 9 basis points after five years. Both effects are different from those observed in the case of the US and might reflect a different market perception of the fiscal solidity of the two countries. However, since the German debt has been perceived as risk-free during the whole sample period, the explanation may be that in Germany the source of the fiscal shocks has been different from that of the USA. In the USA fiscal shocks may arise from the accommodating response of fiscal authorities to changes in the business cycle. In Germany the main source of fiscal shocks might be related to reunification costs having crowding-out effects. In particular, the reunification created a tremendous demand for capital (both public and private) for a number of years to rebuild the capital stock in former East-Germany. The positive effects on the real interest rate may therefore also reflect some crowding-out of private capital acquisition through (partly extra-) budgetary financing requirements of the public sector.

To investigate the possibility of asymmetric effects of fiscal shocks on interest rates, we divide the sample according to the different values of the debt/GDP ratio using as a threshold its average value (52.9%). This leaves 60 observations with a debt/GDP ratio value above average, and 48 observations with a below average value. The impulse response functions of the real long-term interest rate and of the yield curve are shown in Figure 14 (left and right panel respectively) and indicate a stronger (weaker) impact in the low (high) debt/GDP ratio regime. Our explanation of this finding is the following. With solvency never being put in doubt, the 'below average' period, starting in 1983 and ending in 1995, captures the structural shock of the German reunification. It is not surprising to find that crowding-out effects were stronger then in the run-up to and EMU years, both in terms of real interest rates and of the yield curve slope.

Figure 14: Asymmetric impacts of a debt/GDP shock on the real long term interest rate and on the slope of the yield curve, Germany

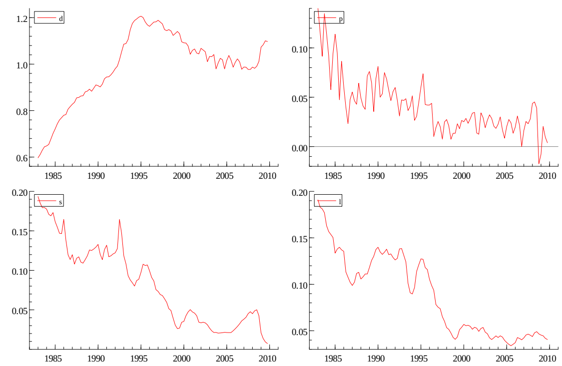


Summarizing the available evidence, and excluding the presence of any default risk effect for Germany, as fiscal shocks cumulate over time, their impact on the long-term interest rate, especially through the permanent stochastic component, is compatible with interest rates increasing with the debt/GDP ratio. The positive impacts of debt shocks on the real long-term interest rate and on the yield curve slope may be explained by a crowding-out effect, reflecting the specific circumstances of the German reunification and the possible presence of asymmetric effects.

3.3 Italy

As Figure 15 shows, the publict debt/GDP ratio in Italy doubled between 1980 and 1994, going from 60% to 120%. After 1994, fiscal retrenchment set in and the debt/GDP ratio began declining, up to the recent financial crisis, when it started rising again. Inflation declined during the first half of the 1980s, stabilizing around 5% until 1997 and falling thereafter. Both interest rates gradually fell, along a very irregular cyclical pattern. The spike in the short-term interest rate observed in 1992 corresponds to the EMS crisis.

Figure 15: The Italian data



A VEC model including a constant, a restricted trend, and seasonal dummies is chosen to analyse the data. Standard information criteria and the lack of residual autocorrelation recommend choosing five lags. Graphic and residual analyses suggest adding three impulse dummies to the system.[10] Misspecification tests for residual autocorrelation, normality and heteroscedasticity indicate that the model is well specified.[11]

Figure 16 contains the FEVD graphics. As in the case of the USA and Germany, fiscal shocks absorb almost entirely the FEV of the debt/GDP ratio (column 1, Figure 16). They also contribute significantly to explaining errors in forecasting the long-term interest rate. Monetary policy shocks conform with the neutrality assumption (column 2, Figure 16) and explain almost entirely the FEV of both inflation and the short-term interest rate from the fourth quarter onwards. The low but significant influence on the debt/GDP ratio may be related to the specific composition of the Italian public debt and to the high share of Treasury bills and medium-term indexed bonds over most of the sample period (Missale 1999). The graphs in the third column indicate that the only significant contribution of the financial shock is to the FEV of the short-term interest rate, as in the case of Germany. Finally, the fourth column confirms that the fourth stochastic component of the model is an inflationary shock.

[10] The dummies refer to the following quarters: 1986:1 (sharp drop in inflation and interest rates), 1992:3 (EMS crisis), 2008:4 (drop in inflation, effect of the financial crisis).

[11] Vector AR 1-5 test: F(80, 207) = 1.17 [0.18], Vector Normality test: $\chi^2(8) = 9.43$ [0.31], Vector hetero test: F(420, 253) = 0.68 [1.00]. Details on the methodology to compute these tests may be found in Doornik and Hendry (2001).

Figure 16: Forecast Error Variance Decomposition, Italy

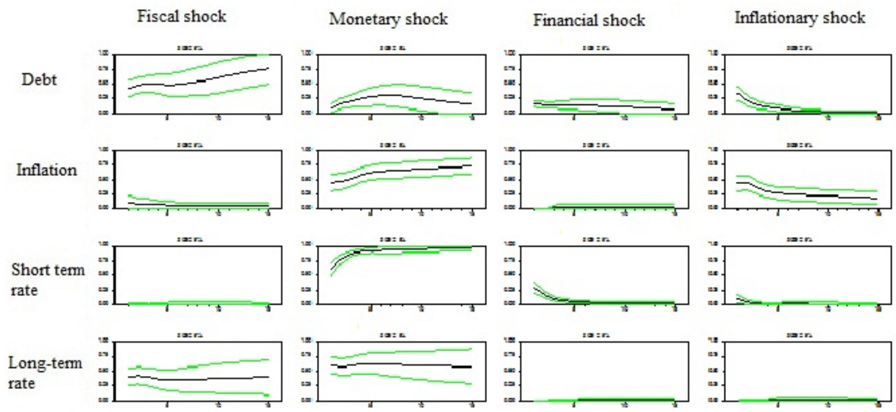
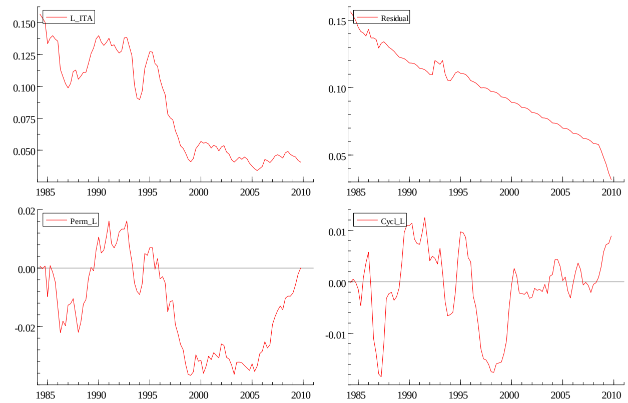


Figure 17 portrays the graph of the long-term interest rate (upper left panel) and of its three components. It is hard to figure out a clear link between the pattern of the permanent stochastic component (lower left panel) and the fiscal developments during the sample period. The cyclical component (lower right panel) shows a similarly puzzling behaviour, which is close to zero starting from 2000. Finally, the element associated to initial conditions plus a deterministic component (upper right panel) captures the disinflation of the Italian economy in the run-up to the EMU and the effects of the fiscal and exchange rate crisis of the beginning of the 1990s. The effects of the recent crisis are evident in the drop of the final part of the sample period, as in the case of Germany. As for the other two countries, once detrended, the quantitative and qualitative importance of this residual element is negligible (being not correlated to any of the variables, nor to the structural shocks).[12]

[12] Estimating the model with an unrestricted trend instead of a restricted one does not change the nature of the residual component either.

Figure 17: Decomposing the Italian long-term interest rate



Figures 18 and 19 analyze the permanent and the cyclical components, respectively. Figure 18 decomposes the permanent stochastic component of the long-term interest rate (dashed line) into its two determinants: the fiscal shock ($\Phi_{41}\sum_{i=1}^{t}\xi_i^{\varphi}$, upper left panel) and the monetary shock ($\Phi_{42}\sum_{i=1}^{t}\xi_i^{\nu}$, lower left panel). The importance of the former is evident up to the mid-1990s (a period of increasing debt), while that of the latter is high for the whole period. As noted above, this finding is consistent with a pricing of bonds giving stronger weight to the level of inflation, and the term and exchange rate premia reflecting nominal uncertainties and fluctuations. This is also a notable difference with the US and German findings, where the fiscal shock is by far the most important determinant of the permanent stochastic component of the long-term interest rate.

Figure 18: Permanent component of the Italian long-term interest rate

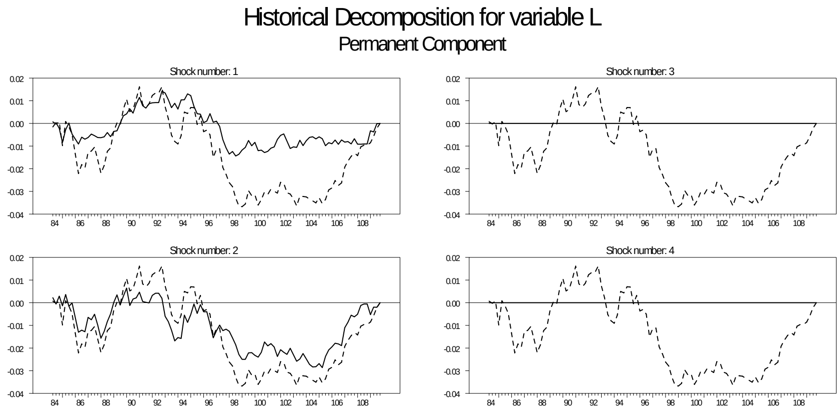


Figure 19 portrays the cyclical stochastic component of the long-term interest rate (dashed line) and the relative contribution of the four structural shocks to its formation (solid lines). The contribution of the cumulated fiscal ($\sum_{i=1}^{t} \Phi^*_{1,41}\xi_i^{\varphi}$, upper left panel) and monetary policy shocks ($\sum_{i=1}^{t} \Phi^*_{1,42}\xi_i^{\nu}$, lower left panel) is more pronounced than that of the other two shocks. The shape of this contribution is consistent with a supply and default risk effect positively affecting the level of the long-term interest rate from the beginning of the sample period up to 1994-1995, when the growth of Italy's debt/GDP ratio was finally stabilized.

Figure 19: Transitory component of the Italian long-term interest rate

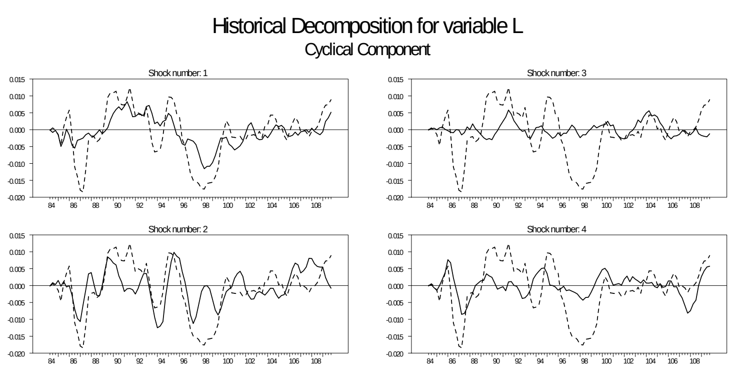


Figure 20: Impact of a fiscal shock on the real long term interest rate and on the slope of the yield curve, Italy 1983:1-2009:4

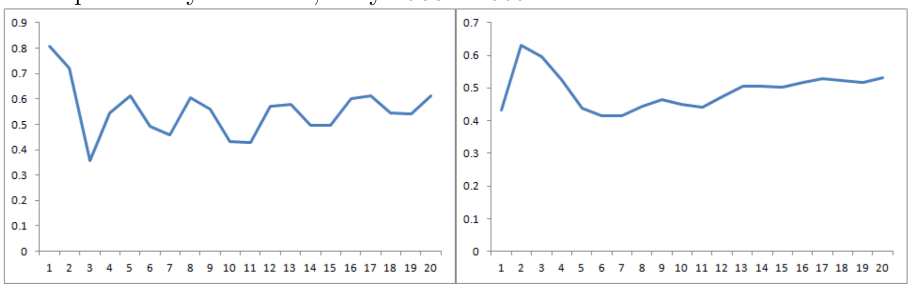
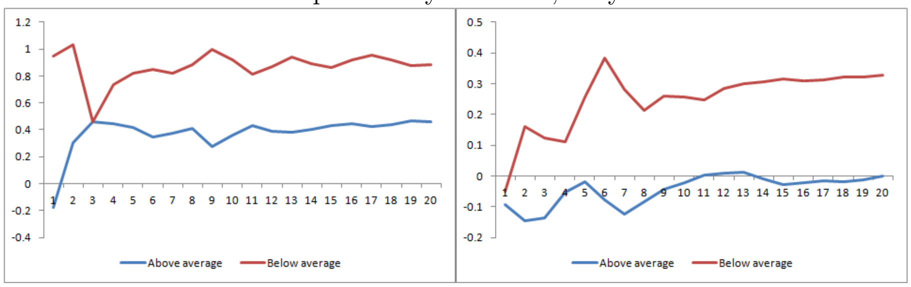


Figure 20 contains the impulse responses of the real long-term interest rate (left panel) and of the yield curve (right panel) to a 1% increase of the debt/GDP ratio. As in the German case, both variables tend to increase. In particular, the real long-term interest rate increases by 11 basis points after five years, and there is a comparable increase (9 basis points) of the differential between long and short-term interest rates. This is consistent with the existence of default risk premium effects.

As a robustness check, we investigate the possibility of asymmetric effects of debt shocks dividing the sample according to the different values of the debt/GDP ratio using as a threshold its average value (98.9%, leaving 61 observations with a debt/GDP ratio value above average, and 46 'below average' observations). The impulse response functions of the real long-term interest rate and of the yield curve are shown in Figure 21 (left and right panel respectively). As in the German case, the reactions of both the real long-term interest rate and the yield curve appear to be stronger in the case of the "low debt" regime. The intuition behind these results once again seems to lie in the different historical periods in which the 'below average'-'above average' distinction splits the sample. The 'below average' period is a period of increasing public debt and high perceived risk about the sustainability of the Italian fiscal position (it also includes the Italian currency crisis of 1992-1993). On the contrary, the 'above average' period coincides with the EMU and its preceding years, periods in which Italy benefited from the credibility of the monetary union managing to keep high debt values but paying low interest rates.

Figure 21: Asymmetric impacts of a debt/GDP shock on the real long term interest rate and on the slope of the yield curve, Italy



Summarizing the available evidence, the Italian analysis supports a positive relationship between public debt and long-term interest rates. The impact of the fiscal shock in shaping the interest rates is particular relevant up to the early 1990s, i.e. when Italy was finally accepted in the EMU. Subsequently, Italy - along with other national economies with poor fiscal discipline reputation - could benefit from the macroeconomic shield provided by the common currency against the effect of residual national fiscal imbalances on nominal variables (i.e., the imported credibility effect of the Euro). Still, there is evidence of a strong and positive impact of public debt increases on the real long-term interest rate. As an additional explanation for that, we cannot exclude the possibility of a default risk effect of fiscal deterioration on the level of the long-term interest rate, adding to the normal supply effect observed German case. This would be consistent with expected debt downgrades associated to a steep yield curve.

4 Cross-country linkages

The analysis of cross-country linkages between the three long-term interest rates is based on the permanent-temporary decomposition described above and consists of two steps. First, we test whether the three $I(1)$ permanent stochastic components of the long-term interest rates are cointegrated over the sample period. The purpose of this test (which can be viewed as an extension of the Gonzalo & Granger 1995 methodology to investigate the properties of large cointegrated systems) is to check for the possibility of long-term stochastic linkages between the series, once the effects of initial conditions, deterministic component and of cyclical stochastic elements have been eliminated. Second, we analyze the properties of a trivariate VAR containing the three $I(0)$ cyclical components contained in the long-term interest rate. The purpose of this exercise is to investigate the short-term/transitory linkages between the series.

4.1 Long-term linkages

The Johansen trace test reported in Table 1 below indicates that the US (i^L_{USA}), German (i^L_{GER}), and Italian (i^L_{ITA}) permanent components of the long-term interest rates do not share any stochastic element.

Table 1.
Johansen trace cointegration test on l^P_{USA}, l^P_{GER}, l^P_{ITA}

Trace	p value	H0: $r \leq$
26.15	[0.338]	0
8.72	[0.763]	1
3.63	[0.481]	2

Note: included lags (levels): 1; intercept included; optimal lag selection: AIC: 1, FP: 1, SBC: 1, HQ: 1.

This result indicates that domestic factors, including the different timing and magnitude of fiscal deterioration in each of the three countries and the different debtor status, have been more important in determining the permanent movements of long-term interest rates, rather than international market dynamics related to the gradual lowering of financial barriers.

4.2 Short-term linkages

The second step of the cross-country analysis consists in estimating a structural VAR model containing the three stationary cyclical components driving the US, German and Italian long-term interest rates, respectively labelled: l^C_{USA}, l^C_{GER}, l^C_{ITA}. Optimal lag length determination criteria suggest choosing two lags. A constant is also included in the model. Misspecification tests for residual autocorrelation, normality, and heteroscedasticity indicate that the model is well specified.[13] The structural VAR model is identified using the Cholesky structure reported in Table 2, with l^C_{USA} having a simultaneous impact on l^C_{GER} and l^C_{ITA}, and l^C_{GER} having a simultaneous impact on l^C_{ITA}.

Table 2. The matrix of simultaneous relationships

	l^C_{USA}	l^C_{GER}	l^C_{ITA}
l^C_{USA}	1.00	.	.
l^C_{GER}	-0.13 (0.11)	1.00	.
l^C_{ITA}	0.05 (0.13)	-0.04 (0.20)	1.00

Note: Standard errors in parentheses.

As Table 3 indicates, the FEVD based on the structural VAR model indicates that, as it could be expected, in all of the three cases the domestic element is by far the most important explanatory variable. After all, the previous analysis

[13] Limiting ourselves to the p-values we obtain Portmanteau test (16) [0.40], LM-test for autocorrelation of order 5 [0.08], Test for non-normality (Doornik & Hansen 2008) [0.65], Jarque-Bera test [0.22, 0.71, 0.91].

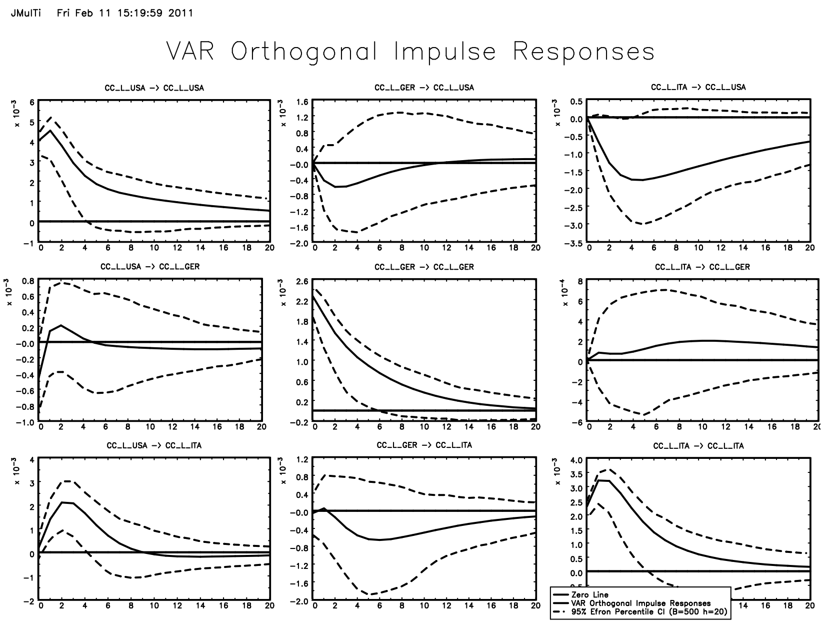
indicates that all of the three cyclical components driving the long-term interest rates are mostly determined by domestic fiscal developments. In the US case the contribution of the Italian component is significant, absorbing 24% of the overall FEVD twelve quarters ahead. In the German case, both the US and the Italian component play marginal roles in explaining the FEVD of l^C_{GER}. In the Italian case, the FEVD of l^C_{ITA} appears to be influenced more by l^C_{USA} than by l^C_{GER}.

Table 3. Structural VAR FEVD analysis

	l^C_{USA} exp by l^C			l^C_{GER} exp by l^C			l^C_{ITA} exp by l^C		
Qrts. ahead	USA	GER	ITA	USA	GER	ITA	USA	GER	ITA
1	1.00	0.00	0.00	0.04	0.96	0.00	0.01	0.00	0.99
4	0.91	0.01	0.07	0.02	0.98	0.00	0.24	0.00	0.75
8	0.80	0.02	0.18	0.02	0.98	0.01	0.25	0.03	0.72
12	0.75	0.02	0.24	0.02	0.97	0.01	0.24	0.04	0.72

Structural VAR impulse response functions, depicted in Figure 22, provide additional evidence on the relationship between the three cyclical components of the long-term interest rates. A positive shock to the cyclical component driving the US long-term interest rate has a positive impact on itself and on the Italian rate, while it barely affects the German rate. However, the positive impact on l^C_{ITA} is statistically significant in the first three quarters after the shock only. A positive shock to the cyclical component driving the German long-term interest rate (second column) has virtually no impact on the other two rates. A similar finding holds for a shock to the cyclical component of the Italian interest rate.

Figure 22: Figure 22: SVAR impulse responses



Although the cyclical components of the three interest rates appear to be strongly dominated by within-country fiscal developments (in a way mostly consistent with fiscal deterioration leading to a higher temporary component), the previous impulse responses are consistent with the possibility of financial linkages between the USA and Italy, with a minor role played by Germany .

5 Conclusions

In this paper we analyse the effects of fiscal shocks and public debt accumulation on the long-term interest rates, controlling for inflation and monetary policy. The analysis focuses on the USA, Germany and Italy, three among the principal issuers of government securities at the global levels, with different merit of credit. The empirical analysis is mainly based on a structural VEC model including the debt/GDP ratio, inflation, and the short-term and long-term interest rates. We use a structural identification strategy based on the common trends methodology to disentangle the permanent and the transitory impact of debt developments on bond yields. We concentrate on three main areas. First, we study the importance of both policy (fiscal and monetary) and non-policy (financial and inflationary) developments in explaining the long-term interest rate dynamics; second, we assess the impact of debt accumulation on real interest rates and on the slope of the yield curve; finally, we analyze the international linkages among the countries under analysis.

Our main results are the following. We find that fiscal shocks play a major role in driving interest rates' permanent and cyclical stochastic components in the USA and in Germany. In the Italian case, monetary policy also plays a non-negligible role. We quantify the five year impact of a 1% increase in debt to be a 7 and a 11 basis points increase in - respectively - the German and the Italian real long-term interest rates (yield curves' slopes increase by 9 basis points in both countries). While the crowding-out/ risk premium effect dominates in those two European economies, the liquidity effect seems to prevail in the USA, where the real interest rate decreases by 13 basis points (with an effect which is close to zero on the yield curve). A flight to quality effect may also help explain the different result for the USA, due to the low-risk role of US assets in the international financial markets. Our estimates are in line with the previous empirical literature, both qualitatively and in terms of magnitude.

Finally, international linkages do not seem to matter in determining the permanent developments of the long term interest rates of the three countries under investigation. On the other hand, the analysis on the cyclical components shows the existence of short-term financial linkages between the USA and Italy. The linkage between German and Italian cyclical components requires further investigation, since it is surprising not to find evidence between the two.[14]

Our results offer a twofold perspective on the current macroeconomic situation, featured by the fiscal imbalances recalled in the introduction. On one hand, the preponderance of the liquidity effect in the US case - along with the fiscal retrenchment plan announced by the US administration - seems to downplay the case for a generalized fiscal-led increase in real interest rates. On the other, the opposite findings for Germany and Italy confirm the weakness of European economies in this respect, with a particular concern for countries with a less consolidated tradition in public finance sustainability (e.g., Italy). Moreover, our results support those who question the general effectiveness of monetary policy strategies (such as the "quantitative easing") devoted to affect the longer maturities of the yield curve in presence of a loose fiscal policy. Under such a perspective, fiscal discipline might be viewed as a necessary condition for monetary policy to successfully affect the yield curve.

6 References

References

[1] Andrès, J., Lopez-Salido, J.D., Nelson, E. (2004). Tobin's imperfect asset substitution in optimizing general equilibrium. Journal of Money, Credit and Banking 36(4), 665-690.

[14] Our cross-country.evidence also stands against the findings of Den Butter and Jansen (2004), according to which the German yield is determined by the US interest rate. However, they do not decompose the interest rates into cyclical and permanent components.

[2] Ardagna, S., Caselli, F., Lane, T. (2007). Fiscal discipline and the cost of public debt service: Some estimates for OECD countries. The B.E. Journal of Macroeconomics 7(1), art. 28.

[3] Arghyrou, M.G., Gregoriou, A., Kontonikas, A. (2009). Do real interest rates converge? Evidence from the European union. Journal of International Financial Markets, Institutions & Money 19, 447-460.

[4] Bai, J., Ng, S. (2007). Determining the number of primitive shocks in factor models. Journal of Business & Economic Statistics 25(1), 52-60.

[5] Bernoth, K., Von Hagen, J., Schuknecht, L. (2004). Sovereign risk premia in the European government bond market. ECB working paper 369.

[6] Canzoneri, M.B., Cumby, R.E., Diba, B.T. (2002). Should the European Central Bank and the Federal Reserve be concerned about fiscal policy? Proceedings Federal Reserve Bank of Kansas City, 333-389.

[7] Caporale, M.G., Williams, G. (2001). Monetary policy and financial liberalization: The case of United Kingdom consumption. Journal of Macroeconomics 23(2), 177-197.

[8] Chinn, M., Frankel, J.A. (2007). Will the Euro eventually surpass the dollar as leading international reserve currency? In: R.H. Clarida G7 current account imbalances: Sustainability and adjustment, NBER.

[9] Den Butter, F.A.G., Jansen, P.W. (2004). An empirical analysis of the German long-term interest rate. Applied Financial Economics 14(10), 731-741.

[10] Doornik, J.A., Hansen, H. (2008). An omnibus test for univariate and multivariate normality. Oxford Bulletin of Economics and Statistics 70(s1), 927-939.

[11] Doornik, J.A., Hendry, D.F. (2001). *Modelling dynamic systems using Pc-Fiml 10.0 for Windows*, International Thomson Business Press, London.

[12] Evans, C., Marshall, D.A. (2007). Economic determinants of the nominal treasury yield curve. Journal of Monetary Economics 54(7), 1986-2003.

[13] Engen, E.M., Hubbard, G.R. (2004). Federal government debt and interest rates. In: M. Gertler and K. Rogoff (eds.) NBER Macroeconomics Annual 2004, Cambridge: MIT Press.

[14] Forni, M., Gambetti, L. (2010). Macroeconomic shocks and the business cycle: Evidence from a structural factor model. UFAE and IAE working paper.

[15] Fujii, E., Chinn, M. (2001). Fin de Siecle real interest parity. Journal of International Financial Markets, Institutions & Money 11, 289-308.

[16] Gale, W., Orszag, P. (2003). Economic effects of sustained budget deficits. National Tax Journal 56, 463-485.

[17] Gonzalo, J., Granger, C. (1995). Estimation of common long-memory components in the cointegrated systems. Journal of Business & Economics Statistics 13(1), 27-35.

[18] Johansen, S. (1988). Statistica analysis of cointegration vectors. Journal of Economic Dynamics and Control 12, 231-254.

[19] King, R., Plosser, C., Stock, J., Watson, M. (1991). Stochastic trend and economic fluctuations. American Economic Review 85, 819-840.

[20] Laubach, T. (2009). New evidence on the interest rate effects of budget deficits and debt. Journal of the European Economic Association 7(4), 858-885.

[21] Marattin, L., Paesani, P., Salotti, S. (forthcoming). Some considerations on the relatioship between public debt, the real long-term interest rate and the yield curve, Cambridge University Press.

[22] Mellander, E., Vredin, A., Warne, A. (1992). Stochastic trends and economic fluctuations in a small open economy. Journal of Applied Econometrics 7(October/December), 369-394.

[23] Mishkin, F. (1984). Are real interest rates equal across countries? An empirical investigation of international parity conditions. The Journal of Finance 39(5), 1345-1357.

[24] Missale, A. (1999). *Public debt management*. Oxford: Oxford University Press.

[25] Mosconi, R. (1998). MALCOLM (Maximum Likelihood CoOintegration analysis in Linear Models). The theory and practice of cointegration analysis in RATS. Venezia: Libera Editrice Cafoscarina.

[26] Paesani, P., Kremer, M., Strauch, R. (2006). Public debt and long-term interest rates. The case of Germany, Italy and the USA. ECB working paper 656.

[27] Quah, D. (1992). The relative importance of permanent and transitory components. Identification and some theoretical bounds. Econometrica 60(January), 107-118.

[28] Reinhart, C.M., Rogoff, K.S. (2010). Growth in a time of debt. American Economic Review: Papers & Proceedings 100:2, 1-9.

[29] Stock, J.H., Watson, M.W. (1988). Testing for common trends. Journal of the American Statistical Association 83(December), 1097-1107.

[30] Thomas, L.B., Wu, D. (2009). Long-term interest rates and expected future budget deficits: evidence from the term structure. Applied Economics Letters 16(4), 365-368.

[31] Tsay, R.S. (1998) Testing and modeling multivariate threshold models. Journal of the American Statistical Association 93(443), 1188-1202.

[32] Von Hagen, J., Strauch, R. (1999). Tumbling giant: Germany's fiscal experience with the Maastricht criteria. In: D. Cobham and G. Zis (eds.) From EMS to EMU, London: Macmillan, 70-93.

[33] Warne, A. (1993). A common trends model: Identification, estimation and inference. Papers 555, International Economic Studies.

7 Appendix A: The Data

7.1 USA

Table A1: Quarterly data

Code	Description	Label
US & WB data	Total government debt	B
IFS..11199B.CZF...	GDP sa	Y
IFS..11164...ZF...	Consumer prices	P
IFS..11160C..ZF...	Treasury bill rate	S
IFS..11161..ZF...	Government bond yield	L

Sources: International Monetary Fund International Financial Statistics, US Bureau of Public Debt, World Bank Quarterly External Debt Statistics.

The time series used in the empirical analysis are obtained by appropriate transformation of the original dataset. Government debt/GDP ratio b = B/Y. The short term interest rate i^S = (S/100), the long term interest rate i^L = (L/100), inflation $\pi = 4*\Delta\log(P)$.

Augmented unit root tests are calculated on the variables in levels and first differences. Results are reported in table A2 below. According to unit root tests all the variables can be treated as $I(1)$ in levels. The long term interest rate, however, is borderline stationary.

Table A2. Unit root tests (1983:1-2009:4)

	Lag	Det	ADF		Lag	Det	ADF
b	5	c	-1.28	Δb	4	c = 0	-2.11
π	9	c	-2.48	$\Delta\pi$	8	c = 0	-3.98
i^S	1	c, t	-3.35	Δi^S	0	c	-5.49
i^L	1	c, t	-3.79	Δi^L	0	c	-7.78
				10%			5%
ADF	c = 0			-1.62			-1.94
ADF	c			-2.57			-2.86
ADF	c, t			-3.13			-3.41

Table A3. Johansen trace cointegration test

Trace	p value	H0: $r \leq$
81.67	[0.001]	0
42.86	[0.049]	1
15.48	[0.542]	2
6.89	[0.366]	3

7.2 Germany

Table A4: Quarterly data

Code	Description	Label
Official German data & BIS	Total government debt	B
IFS..13499B.CZF...	GDP sa	Y
IFS..13464.D.ZF... & 13464...ZF...	Consumer prices	P
IFS..13460B..ZF...	Treasury bill rate	S
IFS..13461..ZF...	Government bond yield	L

Sources: International Monetary Fund International Financial Statistics, Bundesbank, Bank for International Settlements.

The time series used in the empirical analysis are obtained by appropriate transformation of the original dataset. Government debt/GDP ratio $b = $ B/(sum of 4 quarters Y), The short term interest rate i^S = (S/100), the long term interest rate i^L = (L/100), inflation π = 4*Δlog(P).. Unit root tests reported in table A6 are consistent with treating all the variables as $I(1)$.

Table A5. Unit root tests (1983:1-2009:4)

	Lag	Det	ADF		Lag	Det	ADF
b	4	c, t	-3.13	Δb	3	c = 0	-2.01
π	2	c, sd	-3.48	$\Delta\pi$	2	c, sd	-9.79
i^S	1	c	-1.48	Δi^S	0	c = 0	-5.40
i^L	4	c	-1.29	Δi^L	3	c = 0	-4.98
				10%			5%
ADF	c = 0			-1.62			-1.94
ADF	c			-2.57			-2.86
ADF	c, t			-3.13			-3.41

Table A6. Johansen trace cointegration test

Trace	p value	H0: $r \leq$
96.13	[0.000]	0
54.78	[0.002]	1
24.65	[0.069]	2
7.90	[0.268]	3

7.3 Italy

Table A7: Quarterly data

Code	Description	Label
IFS..136c63..CG... & BdI	Total government debt	B
IFS..13699B.CZF...	GDP sa	Y
IFS..13664...ZF...	Consumer prices	P
IFS..13660B..ZF...	Treasury bill rate	S
IFS..13661..ZF...	Government bond yield	L

Sources: International Monetary Fund International Financial Statistics, Statistical Bulletin Banca d'Italia.

The time series used in the empirical analysis are obtained by appropriate transformation of the original dataset. Government debt/GDP ratio $b = \text{B}/(\text{sum}$ of 4 quarters Y), The short term interest rate $i^S = (\text{S}/100)$, the long term interest rate $i^L = (\text{L}/100)$, inflation $\pi = 4*\Delta\log(\text{P})$.. Augmented unit root tests are calculated on the variables in levels and first differences. Results are reported in table A4 below. According to unit root tests all the variables can be treated as $I(1)$ in levels. Inflation, however, is borderline stationary (strong trend stationarity).

Table A8. Unit root tests (1983:1-2009:4)

	Lag	Det	ADF		Lag	Det	ADF
b	5	c	-2.43	Δb	4	c = 0	-2.28
π	4	c, t, sd	-3.96	$\Delta\pi$	2	c, sd	-9.69
i^S	1	c, t	-2.99	Δi^S	0	c	-8.41
i^L	4	c	-1.59	Δi^L	3	c = 0	-5.71
				10%			5%
ADF	c = 0			-1.62			-1.94
ADF	c			-2.57			-2.86
ADF	c, t			-3.13			-3.41

Table A9. Johansen trace cointegration test, USA

Trace	p value	H0: $r \leq$
76.89	[0.002]	0
43.26	[0.044]	1
18.38	[0.326]	2
3.74	[0.775]	3

Alma Mater Studiorum - Università di Bologna
DEPARTMENT OF ECONOMICS

Strada Maggiore 45
40125 Bologna - Italy
Tel. +39 051 2092604
Fax +39 051 2092664
http://www.dse.unibo.it