

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

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Presented at the International Conference in Economics,  
Universidade Portucalense, May 27th 2011

April 13, 2011

## Abstract

Public finances worldwide have been severely hit by the 2008-2009 Great Recession, stimulating the debate on the consequences of growing fiscal imbalances. Building on Paesani et al. (2006), this paper focuses on the USA, Germany and Italy over the 1983-2009 period and studies the effects of fiscal shocks and government debt accumulation on long-term interest rates, both nationally and across borders. Based on a theoretical framework, the empirical analysis disentangles permanent and transitory components of interest rates dynamics finding that sustained debt accumulation leads, at least temporarily, to higher long-term interest rates. This is particularly true for the Italian case. There is also evidence of significant cross-country linkages, mainly between Italy and the USA.

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

*JEL:* E6, H63.

# 1 Introduction

The 2008-2009 Great Recession had a severe impact on public finances worldwide, particularly for developed countries (see Table 1, Source: OECD Economic Outlook). Investigating the consequences of large government deficits and debts is one of the key issues in the ongoing policy debate.

Table 1: debt/GDP ratios in 2007 and 2010 for selected industrialized countries

COUNTRY	DEBT/GDP 2007	DEBT/GDP 2010
Belgium	84.2%	99.6%
Denmark	27.4%	44.6%
Finland	35.3%	52.3%
France	63.8%	85.1%
Germany	64.9%	77.9%
Greece	95.7%	125.3%
Ireland	25.0%	76.3%
Italy	103.5%	119.0%
Netherlands	45.5%	67.2%
Portugal	63.6%	84.9%
Spain	36.2%	63.4%
UK	44.7%	78.0%
USA	61.0%	89.7%

We aim at contributing to this debate by empirically investigating the effects of fiscal shocks and government debt accumulation on long-term interest rates, in a theoretically consistent way. The paper focuses on the USA, Germany and Italy: three among the principal issuers of government securities at the global level with different reputations in terms of fiscal discipline. In these countries public debt has significantly increased with respect to GDP, especially in the USA due to the massive 2009 fiscal stimulus plan. Building on Paesani et al. (2006), we investigate three specific issues. First, we study if domestic developments affecting the government debt/GDP ratio have an impact on nominal and real long-term interest rates and on the slope of the yield curve. 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 theoretical literature does not yield unambiguous predictions on how public debt should affect long-term bond yields. In a standard model, the short to medium-term effects depend on whether public debt crowds out private capital. Long-term interest rates rise if public debt reduces aggregate savings. This is prevented either if the private sector fully compensates the effect and keeps aggregate savings unchanged, or if the withdrawal of savings is substituted by capital inflows from abroad (see Ball and Mankiw 1995). The reaction of bond

yields also depends on whether public indebtedness has implications on future potential growth, a fact that may depend on the quality of the debt-financed fiscal policies and their impact on human and physical capital accumulation. In line with these and other transmission channels, the recent literature on fiscal consolidations has, e.g., strongly emphasized the different macroeconomic outcomes (and financial market reactions) of the expenditure versus revenue driven structure of the adjustment efforts (see Ardagna 2004). Finally, risk factors related to financial market have been put forward mainly to explain spreads in bond yields or premia. Again, the predictions are far from being univocal. High debt levels may imply more liquid markets for actively traded government debt securities and correspondingly a lower liquidity premium, but at the same time may lead to the perception of an increasing default risk, affecting interest rates in the opposite way. On balance, it seems to be largely an empirical question of how interest rates react to a deterioration of a countries fiscal position.

The empirical evidence on the issue includes a vast set of contributions, which differ along several dimensions: the countries of interest, the econometric methodology (single equation/VAR methods), and the nature of the fiscal variables employed to proxy the fiscal position (actual/projected debt/deficit). US-focused studies estimate the positive effect on long-term interest rates of a 1% increase in budget deficit to be in a range between 30 and 60 basis points (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 3-4 basis points (Engen and Hubbard 2004, Laubach 2009). On the other hand, Evans and Marshall (2007) - using data from 1959 to 2000 - do not find any significant effect of fiscal shocks on the US interest rates.

EU-based contributions are more scarce, and generally point towards increasing interest rates following deteriorating fiscal balances. Bernoth et al. (2006) 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. Chinn and Frankel (2007) find that a 1% increase in public debt leads to a 10-16 basis points increase in interest rates in France, Italy, Spain and in the UK (twice as much as the German case). 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 explanation they provide (pp. 126-127) for this finding, based on the portfolio theory (liquidity effect), is that "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". Interestingly, in the case of Italy, where the debt/GDP ratio has recently come close to 120% of GDP, they find a positive impact on long-term interest rates.

In this paper we investigate the effects of fiscal shocks and public debt accumulation on long-term interest rates in the three countries of interest, controlling for inflation, monetary policy and international linkages. The empirical analysis is mainly based on a Vector Error Correction - VEC - model including the debt/GDP ratio, inflation, the short and the long-term interest rates. We use a structural identification strategy based on a theoretical framework and on the common trends methodology to disentangle the permanent and the transitory stochastic components driving long-term interest rates and to assess the impact fiscal shocks and debt developments have on them.

The main findings of the paper can be summarized as follows. First, while fiscal developments mainly determine both the permanent and cyclical component of the long-term interest rate in Germany and the USA, in the case of Italy the monetary trend 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 a steeper yield curve. 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. Third, international linkages seems to connect the cyclical components of the US and the Italian long-term interest rates. On the other hand, the permanent components of the long-term interest rates of the three countries of interest do not share any common trend.

The rest of the paper is organized as follows. Section 2 discusses our theoretical background. Section 3 describes the econometric model and the identification strategy. Section 4 reports the results of the empirical analysis on each of the countries object of this study. Section 5 is devoted to the analysis of international linkages. Section 6 concludes and discusses the main policy implications of the analysis.

## 2 The theoretical background

This section provides a theoretical framework for our empirical investigation. Our intention is not to estimate the structural parameters of the model. Rather, we want to frame the main focus of our contribution - the empirical analysis - into a sound theoretical setting able to account for the structural relationships between the variables of interest. We therefore specify a simple and stylized dynamic stochastic general equilibrium model with no capital accumulation, two types of government bonds and portfolio adjustment costs. Note that due to presence of these frictions, the expectation hypothesis of the term structure no longer holds.

### 2.1 Households

The demand side is approximated by the presence of a representative infinitely-lived consumer whose preferences are defined over a consumption good ( $C_t$ ) and labour effort ( $N_t$ ), according to the utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \quad (1)$$

where  $E_t$  denotes the mathematical expectations operator conditional on the time- $t$  information set,  $\beta \in (0,1)$  is the discount factor,  $C_t$  and  $N_t$  indicate, respectively, aggregate consumption and labour effort.

The period utility function  $U(\bullet)$  is assumed to be strictly increasing in its first argument, strictly decreasing in the second and strictly concave, according to the following functional form:

$$U(C_t, N_t) = \vartheta_t \frac{C_t^{1-\gamma} - 1}{1-\gamma} - \frac{a_n}{1+\gamma_n} N_t^{1+\gamma_n} \quad (2)$$

where  $\gamma > 0$  is the intertemporal elasticity of consumption,  $\gamma_n > 0$  is the inverse of the Frisch elasticity of labour supply and  $a_n > 0$  a constant indicating the relative disutility of labour effort. The term  $\vartheta_t$  denotes a preference shock following an AR(1) stochastic process of the kind  $\vartheta_t = \rho^\vartheta \vartheta_{t-1} + \xi_t^\vartheta$  with  $-1 \leq \rho^\vartheta \leq 1$  and  $\xi_t^\vartheta \sim (0, \sigma_\vartheta^2)$ . Financial shocks  $\xi_t^\vartheta$  affect the marginal utility of consumption, the consumption/savings intertemporal decision and the demand for government securities.

The representative consumer's flow budget constraint in real terms is given by:

$$C_t + T_t + \frac{B_t^S}{P_t} + \frac{B_t^L}{P_t} (1 + AC) = \frac{W_t}{P_t} N_t + i_{t-1}^S \frac{B_{t-1}^S}{P_t} + i_{t-1}^L \frac{B_{t-1}^L}{P_t} \quad (3)$$

where  $T_t$  is lump-sum taxation,  $B_t^S$  and  $B_t^L$  are, respectively, short and long-term government bond paying gross returns equal to  $i_t^S$  and  $i_t^L$ .  $W_t$  is the nominal hourly wage, and  $P_t$  is the nominal price level.

In line with a consolidated literature (Tobin 1969, 1982, Andrès et al 2004, Zagaglia 2009), we include portfolio adjustment frictions, by assuming that it is costly for agents - in terms of output units - to adjust the ratio between long-term and short-term bond holding. These transactions costs are assumed to be quadratic and of the following form:

$$AC = \frac{\phi}{2} \left( \frac{B_t^L}{B_t^S} \right)^2 Y_t \quad (4)$$

We adopt this specification to capture the fact that long-term bonds are more risky to hold than Treasury bills.

The household's problem consists in choosing the optimal levels of consumption, labour effort, short-term and long-term nominal bond holdings in order to maximize the intertemporal utility function (1) subject to (3), and the usual transversality condition.

First order conditions on, respectively,  $C_t$ ,  $N_t$ ,  $B_t^S$  and  $B_t^L$  are:

$$\vartheta_t C_t^{-\gamma} = \lambda_t \quad (5)$$

$$\lambda_t \frac{W_t}{P_t} = a_n N_t^{\gamma_n} \quad (6)$$

$$\lambda_t \left( 1 - \phi \left( \frac{B_t^L}{B_t^S} \right)^3 Y_t \right) = \beta \lambda_{t+1} \frac{i_t^S}{\pi_{t+1}} \quad (7)$$

$$\lambda_t \left( 1 + \frac{3}{2} \phi Y_t \left( \frac{B_t^L}{B_t^S} \right)^2 \right) = \beta \lambda_{t+1} \frac{i_t^L}{\pi_{t+1}} \quad (8)$$

Combining (5) and (6) we get the labour supply curve:

$$\frac{W_t}{P_t} = \frac{N_t^{\gamma_n}}{\vartheta_t C_t^{-\gamma}} \quad (9)$$

Combining (5) and (7), and using the aggregate resource constraint  $Y_t = C_t + G_t$  - we obtain the Euler equation augmented with shock:

$$Y_t = \left[ \frac{\beta \frac{i_t^S}{\pi_{t+1}}}{\vartheta_t \left( 1 - \phi \left( \frac{B_t^L}{B_t^S} \right)^3 Y_t \right)} \right]^{-\frac{1}{\gamma}} E_t Y_{t+1} + (G_t - E_t G_{t+1}) \quad (10)$$

Combining (7) and (8) we obtain a relationship between  $i_t^S$  and  $i_t^L$  and their quantities:

$$i_t^L = \left[ \frac{1 + \frac{3}{2} \phi Y_t \left( \frac{B_t^L}{B_t^S} \right)^2}{1 - \phi \left( \frac{B_t^L}{B_t^S} \right)^3 Y_t} \right] i_t^S \quad (11)$$

Under perfect substitutability of financial assets ( $\phi = 0$ ), optimality conditions for the two bonds are identical, and  $i_t^L = i_t^S$ .

## 2.2 Firms

The supply side of the model economy is composed of a continuum of identical firms, each producing a variety  $i$  according to a simple constant returns to scale production function  $Y_t = N_t$ . We assume a Calvo-style nominal rigidity framework, where each period a fraction  $0 < \alpha < 1$  of goods prices remains fixed, while the remaining  $(1 - \alpha)$  are set optimally. Since all firms who get to change their prices face the same problem, the optimal price  $p_t^*$  is the same for every optimizing firm.

Firms who have the chance to change their price at time  $t$  face the following problem:

$$\max_{p_{it}} E_t \left[ \sum_{T=t}^{\infty} \alpha^{T-t} \Lambda_{t,T} \Pi (p_{it}, P_T, Y_T) \right] \quad (12)$$

where:

$\Lambda_{t,T}$  = stochastic discount factor between time  $t$  and  $T$ ;

$\alpha^{T-t}$  = probability that price chosen at time  $t$  (that is  $p_{it}$ ) will still be in place at time  $T$ ;

$\Pi (p_{it}, P_T, Y_T)$  = nominal profits.

First order condition of problem (12) is:

$$E_t \left\{ \sum_{T=t}^{\infty} \alpha^{T-t} \Lambda_{t,T} \frac{\partial \Pi (p_{it}, P_T, Y_T)}{\partial p_{it}} \right\} = 0 \quad (13)$$

Equation (13) - along with the usual expression for the general price index - represents the supply-side of the model.

Log-linear approximations of these two equations leads to the standard New Keynesian Phillips curve, which here is augmented with a  $AR(1)$  stochastic process shock representing an inflationary disturbance.

$$\pi_t = \beta E_t \pi_{t+1} + \lambda y_t + \eta_t \quad (14)$$

where  $\lambda = \frac{(1-\psi\beta)(1-\beta)}{\psi\beta} \left( \frac{\gamma Y}{C} + \gamma_n \right)$ , and  $\eta_t = \rho^\eta \eta_{t-1} + \xi_t^\pi$  with  $-1 \leq \rho \leq 1$  and  $\xi_t^\pi \sim (0, \sigma_{\eta_t}^2)$ .

## 2.3 Policy

### 2.3.1 Monetary policy

The monetary policy's instrument is the short-term interest rate  $i_t^S$ , which is set by the central bank according to a standard Taylor-rule such that:

$$i_t^S = i_t^* + \phi_\pi \pi_t + \phi_y y_t \quad (15)$$

$$i_t^* = \bar{i} + v_t \quad (16)$$

where  $\phi_\pi, \phi_y > 0$ ,  $\bar{i}$  is the steady-state short-term nominal rate, and  $v_t$  is the monetary trend - expressing monetary policy stance. The monetary trend evolves according to the following rule:

$$v_t = v_{t-1} + \xi_t^v$$

where  $\xi_t^v \sim (0, \sigma_v^2)$  is the monetary shock.

### 2.3.2 Fiscal policy

The government flow budget constraint in real terms can be expressed as:

$$\frac{B_t}{P_t} = \frac{B_t^S}{P_t} + \frac{B_t^L}{P_t} = i_t^S \frac{B_{t-1}^S}{P_t} + i_t^L \frac{B_{t-1}^L}{P_t} + \frac{(G_t - T_t)}{P_t} \quad (17)$$

where  $(T_t - G_t)$  is the budget primary surplus. Fiscal policy rule is specified in terms of total debt. We assume this to respond to a stochastic component  $\varphi_t$  expressing the fiscal policy stance, and to the business cycle through automatic stabilizers

$$B_t = \varphi_t - \phi_b y_t \quad (18)$$

$$\varphi_t = \varphi_{t-1} + \xi_t^\varphi \quad (19)$$

where  $\xi_t^\varphi \sim (0, \sigma_\varphi^2)$  is the fiscal shock. The bond/bill ratio is determined by the government debt manager on the basis of optimal issuance considerations (cost-risk minimization) which we take as exogenous.

Equations (10), (11), (14), (15) and (18) define our simple general equilibrium model. In this framework, two permanent shocks reflect fiscal and monetary policy ((15) and (18)), two transitory shocks come from the demand side of the model (through the Euler equation 10) and the supply-side (through the Phillips Curve 14). Equation (11) captures the idea of a term structure not depending on the expectation hypothesis.

Next section outlines our empirical strategy based on the above theoretical setting.

## 3 The econometric strategy

The following VEC model constitutes the basis of our investigation.

$$\begin{bmatrix} \Delta b_t \\ \Delta \pi_t \\ \Delta i_t^S \\ \Delta i_t^L \end{bmatrix} = \sum_{i=1}^{m-1} \Gamma_i \begin{bmatrix} \Delta b_{t-i} \\ \Delta \pi_{t-i} \\ \Delta i_{t-i}^S \\ \Delta i_{t-i}^L \end{bmatrix} + \Pi \begin{bmatrix} \Delta b_{t-1} \\ \Delta \pi_{t-1} \\ \Delta i_{t-1}^S \\ \Delta i_{t-1}^L \end{bmatrix} + \Omega \begin{bmatrix} Const \\ Trend \\ Seas.d. \\ I.d. \end{bmatrix} + \begin{bmatrix} \varepsilon_t^b \\ \varepsilon_t^\pi \\ \varepsilon_t^s \\ \varepsilon_t^l \end{bmatrix} \quad (20)$$

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

Based on our theoretical assumptions, we expect this model to contain two permanent and two transitory components. This implies a rank equal to 2 for the  $\Pi$  matrix, i.e. the presence of two cointegrating vectors ( $r = 2$ ) in the model. Structural identification is done according to the common trends methodology (Warne 1993, Mosconi 1998). Omitting the model 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  $\varepsilon_t$ . This is given by:



$$\begin{bmatrix} b_t \\ \pi_t \\ i_t^S \\ i_t^L \end{bmatrix} = \xi + C \sum_{i=1}^t \begin{bmatrix} \varepsilon_i^b \\ \varepsilon_i^\pi \\ \varepsilon_i^s \\ \varepsilon_i^l \end{bmatrix} + C^*(L) \begin{bmatrix} \varepsilon_t^b \\ \varepsilon_t^\pi \\ \varepsilon_t^s \\ \varepsilon_t^l \end{bmatrix} \quad (21)$$

where the matrix  $C = \beta_\perp [\alpha'_\perp (I - \Sigma_i \Gamma_i)^{-1} \beta_\perp] \alpha'_\perp$  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:

$$\begin{bmatrix} \varepsilon_t^b \\ \varepsilon_t^\pi \\ \varepsilon_t^s \\ \varepsilon_t^l \end{bmatrix} = B \begin{bmatrix} \xi_t^\varphi \\ \xi_t^v \\ \xi_t^\theta \\ \xi_t^\eta \end{bmatrix} \quad (22)$$

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

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

$$\xi + \Phi \sum_{i=1}^t \begin{bmatrix} \xi_i^\varphi \\ \xi_i^v \\ \xi_i^\theta \\ \xi_i^\eta \end{bmatrix} + \Phi^*(L) \begin{bmatrix} \xi_t^\varphi \\ \xi_t^v \\ \xi_t^\theta \\ \xi_t^\eta \end{bmatrix} \quad (23)$$

where the matrix  $\Phi$  contains the permanent component of the model, and the matrix polynomial  $\Phi^*(L)$  the cyclical (transitory) component. The assumption of orthonormal structural innovations places  $4(4+1)/2 = 10$  identification restrictions on  $B$ . In order to get exact identification,  $4(4-1)/2 = 6$  more restrictions are needed. Following Warne (1993), 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.

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  $\Phi$  (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  $\Phi_l$  or on the matrix  $\Phi_{01}^* = B'_\perp$ , which measures the simultaneous impact of permanent innovations. Imposing the neutrality assumption that the monetary trend 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), is equivalent to restricting to zero the  $(1,2)$  element of matrix  $\Phi_l$ . Finally,

the identification of the two transitory shocks requires imposing one additional restriction on the matrix  $\Phi_{02}^* = BU$  which measures the instantaneous impact of transitory shocks on the variable. Thus, we restrict to zero the simultaneous impact of the inflation shock, i.e. element (2,1) of matrix  $\Phi_{02}^*$ . The overall number of restrictions ( $4 + 1 + 1 = 6$ ) plus the 10 orthonormality restrictions guarantees the just identification of the structural model.

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  $i_t^L$  we have:

$$i_t^L = \delta_l + l_t^P + l_t^C \quad (24)$$

where  $\delta_l$  is a function of the initial condition and of the deterministic component of the model,  $l_t^P$  is the permanent stochastic component driving the long-term interest rate and  $l_t^C$  is the cyclical component. The latter can be further decomposed into the sum of the two cumulated permanent shocks according to the formula:

$$l_t^P = \Phi_{41} \sum_{i=1}^t \xi_i^\varphi + \Phi_{42} \sum_{i=1}^t \xi_i^\nu \quad (25)$$

where  $\Phi_{41}$  ( $\Phi_{42}$ ) is the element occupying the fourth row, first (second) column of matrix  $\Phi$  and  $\Phi_{43}$  and  $\Phi_{44}$  are restricted to zero. This decomposition makes it possible to understand to what extent the fiscal trend  $\sum \xi_i^\varphi$  and the monetary trend  $\sum \xi_i^\nu$  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:

$$l_t^C = \sum_{i=1}^t \Phi_{1,41}^* \xi_i^\varphi + \sum_{i=1}^t \Phi_{1,42}^* \xi_i^\nu + \sum_{i=1}^t \Phi_{1,43}^* \xi_i^\theta + \sum_{i=1}^t \Phi_{1,44}^* \xi_i^\eta \quad (26)$$

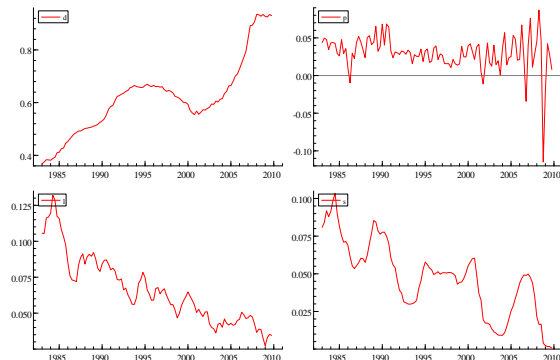
where  $\Phi_{i,41}^*$  is the element occupying the fourth row, first column of matrix  $\Phi_i^*$ . This decomposition makes it possible to understand to what extent each of the four stochastic elements included in the model contributes to determining the cyclical component of the long-term interest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

## 4 Country-by-country analysis

### 4.1 USA

Figure 1 depicts the US data. The debt/GDP ratio (upper left corner) increases until 1995, falls in the second half of the 1990s (the Clinton years, when government budget surpluses were attained), increasing again from 2001 onwards under the Bush Jr. and Obama administrations. The inflation graph (upper corner, right) shows an irregular seasonal pattern with few notable outliers, especially in the second half of the sample period. The short-term interest rate (lower left

Figure 1: The US data



corner) fluctuates irregularly around a downward trend. The long-term interest rate (lower right corner) follows a similar pattern.

We analyze the statistical properties of the data using a VEC model including an unrestricted constant and a linear trend, restricted to belong to the cointegration space. Standard information criteria and residual autocorrelation tests suggest choosing six lags. Seven impulse dummies are also included to account for as many outliers, identified on the basis of graphic and residual analysis.<sup>1</sup> Misspecification tests for residual autocorrelation, normality and heteroscedasticity indicate that the model is well specified.<sup>2</sup> Univariate tests (available on request) confirm this result. Table 2 reports the outcome of the Johansen trace cointegration test. The null hypothesis of two cointegrating vectors and two common trends is not rejected at the 5% confidence level, as expected on the basis of theoretical considerations.

Table 2. Johansen trace cointegration test, USA

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

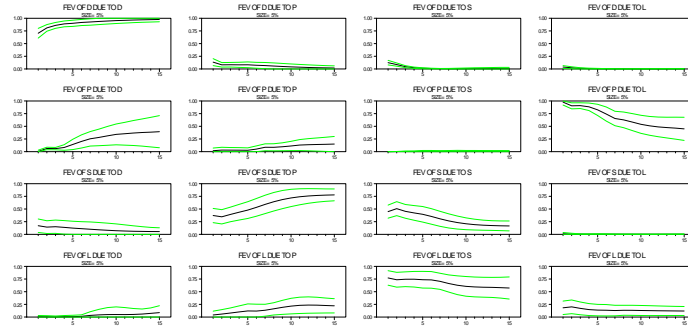
The degree of consistency between empirical and theoretical shocks can be established on the basis of Forecast Error Variance Decomposition (FEVD)

<sup>1</sup>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).

<sup>2</sup>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).

analysis. According to the graphs in the first column of Figure 2, the contribution of the fiscal shock  $\xi^\varphi$  to explaining the FEV of the debt/GDP ratio is close to 100%, it is marginally positive in the case of inflation, and close to zero for the two interest rates. The graphs contained in the second column conform with the neutrality assumption and with the close linkage between the monetary shock  $\xi^v$  and the short-term interest rate. The graphs in the third column show that the only significant contribution of the financial shock  $\xi^\theta$  is to the FEV of the two interest rates. Finally, the graphs of the fourth column conform with our identification of the fourth stochastic component as a transitory inflationary shock  $\xi^\eta$ .

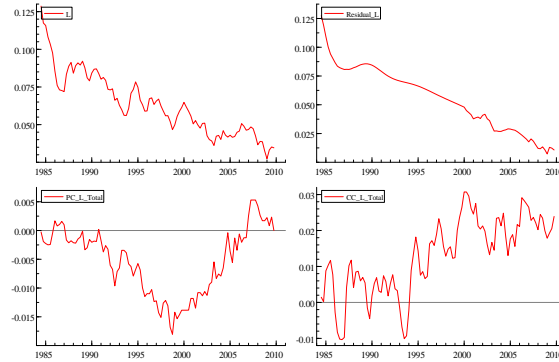
Figure 2: Forecast Error Variance Decomposition, USA



Note: column 1 (contribution of the first shock - permanent, fiscal trend  $\xi_t^\varphi$ ), column 2 (contribution of the second shock - permanent, inflationary trend  $\xi_t^v$ ), column 3 (contribution of the third shock - transitory, financial  $\xi_t^\theta$ ), column 4 (contribution of the fourth shock - transitory, inflationary  $\xi_t^\eta$ ).

Figure 3 portrays the graph of the US long-term interest rate (upper left panel) and of its three components as indicated by Equation (24) above. The element reflecting initial conditions plus deterministic components (upper left panel) captures 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. The permanent stochastic component (lower left panel), follows a downward trend between 1991 and 1999), an upward trend afterwards. The contribution of the cyclical stochastic component (lower right panel) fluctuates around zero until the second half of the 1990s, turning positive thereafter.

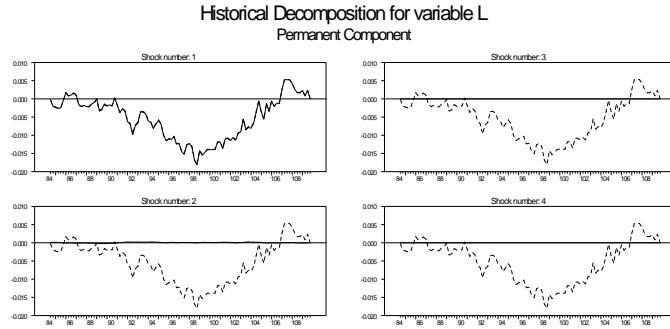
Figure 3: Decomposing the US long-term interest rate



Note: the decomposition is  $i_t^L = \delta_t + l_t^P + l_t^C$ .  $l$  (upper panel, left),  $\delta_t$  (upper panel, right),  $l_t^P$  (lower panel, left),  $l_t^C$  (lower panel, right).

As Figure 4 shows, the permanent stochastic component driving the long-term interest rate  $l_t^P$  is almost entirely determined by cumulated fiscal shocks of the  $\xi^\varphi$  type (upper left panel). The contribution is negative for most of the observation period, compatibly with the liquidity effect. The timing of the changes in slope and sign however are consistent with fiscal deterioration leading *ceteris paribus* to higher long-term interest rates.

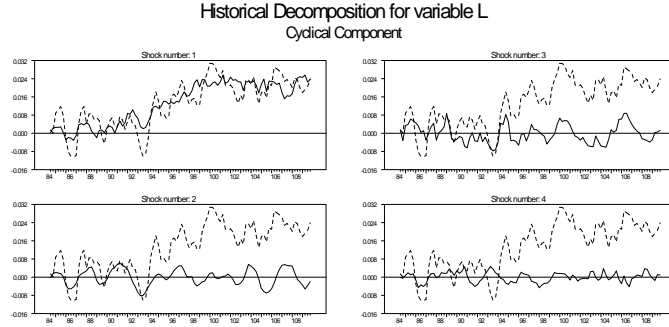
Figure 4: Permanent component of the US long-term interest rate



Note: The graph portrays  $\Phi_{41} \sum_{i=1}^t \xi_i^\varphi$  (solid line, upper left corner),  $\Phi_{42} \sum_{i=1}^t \xi_i^\nu$  (solid line, lower left corner), and their sum  $l_t^P$  (dashed line). See Equation 25. The two columns on the right show that the cyclical components do not concur in determining  $l_t^P$ .

Figure 5 decomposes the cyclical component driving the US long-term interest rate  $l_t^C$  into its main determinants. As the graph in the upper panel shows,  $l_t^C$  is mainly determined by the fiscal shock, with minor contributions from the monetary and inflationary shocks, especially in the second half of the sample period. The observed patterns again conform with the idea that long-term interest rates tend to increase (fall) during phases of steady fiscal deterioration (retrenchment). The direction of changes would be also 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.

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

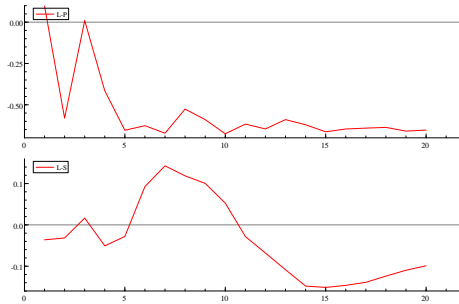


Note: The graph portrays  $\sum_{i=1}^t \Phi_{1,41}^* \xi_i^\varphi$  (solid line, upper left corner),  $\sum_{i=1}^t \Phi_{1,42}^* \xi_i^\nu$  (solid line, upper right corner),  $\sum_{i=1}^t \Phi_{1,43}^* \xi_i^\theta$  (solid line, lower left corner), and  $\sum_{i=1}^t \Phi_{1,44}^* \xi_i^\eta$  (solid line, lower right corner), plus their sum  $l_t^c$  (dashed line). See Equation 26.

Figure 6 contains the impulse responses of the real interest rate (obtained by subtracting the impulse response function of inflation to that of the long-term interest rate) in the upper 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) in the lower panel to an adverse fiscal shock equal to 1% of the debt/GDP ratio. This leads to the real interest rate falling by 13 basis points after five years. On the other hand 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.<sup>3</sup>

<sup>3</sup>As the US economy is hit by a recessionary shock, aggregate demand and real GDP contract, the budget deficit and government debt increase, the real interest rate falls.

Figure 6: Impact of a fiscal shock on the real long term interest rate (upper section) and on the slope of the yield curve (lower section), USA



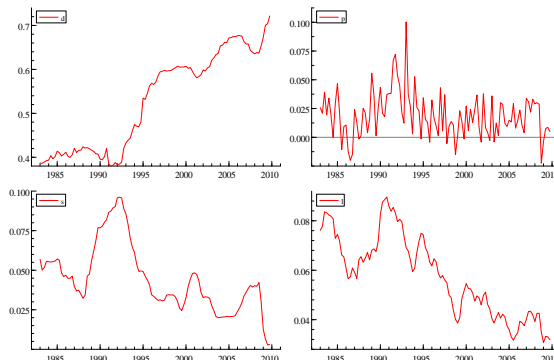
Summarizing the available evidence, and excluding the presence of any default risk in the case of the USA, our analysis shows that as public debt accumulates over time long-term interest rate tend *ceteris paribus* to be higher, both through permanent and cyclical stochastic components. However, the observed impact of a fiscal shock (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 inflationary fiscal stimuli.

## 4.2 Germany

Figure 7 depicts the graphs of the German data. The profile of the debt/GDP ratio (upper left corner) indicates the insurgence of major fiscal deterioration after 1992, due to the costs of the reunification. The inflation graph (upper right corner) shows an irregular seasonal pattern with few outliers. None of these variables appears to move along a linear trend. Both inflation and the short-term interest rate increase up to 1993, sharply falling thereafter. This reflects inflationary pressures unleashed by the German reunification, and the Bundesbank prompt intervention to extinguish them. The long-term interest rate has a more jagged profile. Indications of asynchronous movements between the inflation rate and the debt/GDP ratio emerge again at the end of the sample period (financial crisis).



Figure 7: The German data



A VEC model with unrestricted constant, 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.<sup>4</sup> Misspecification tests for residual autocorrelation, normality and heteroscedasticity indicate that the model is well specified.<sup>5</sup> Univariate tests (available on request) confirm this result.

Table 3 reports the result of the Johansen cointegration test. The hypothesis of two cointegrating vectors and two common trends is not rejected at the 5% confidence level, conforming with our theoretical framework.

Table 3. Johansen trace cointegration test, Germany

Trace	$p$ value	$H_0: r \leq$
96.13	[0.000]	0
54.78	[0.002]	1
24.65	[0.069]	2
7.90	[0.268]	3

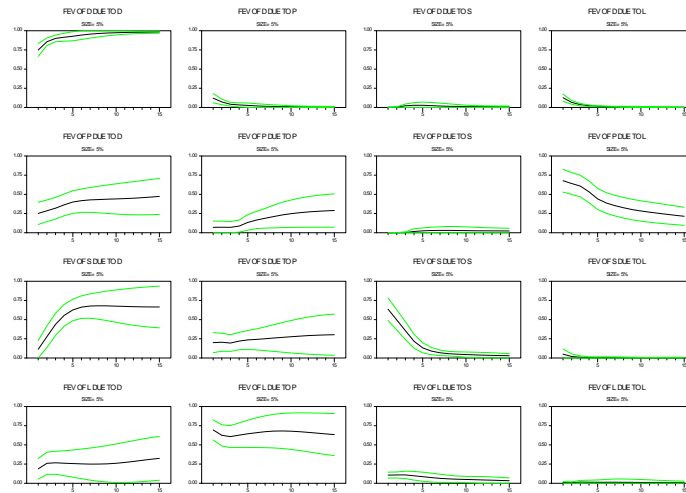
Figure 8 contains the Forecast Error Variance Decomposition (FEVD) graphics. Fiscal shocks explain entirely the FEV of the debt/GDP ratio. Their contribution is also significant in explaining the FEV of inflation and of the two interest rates, to a higher degree than in the case of the USA. The graphs contained in the second column are coherent with the neutrality assumption and with the second permanent stochastic component of the model being related to

<sup>4</sup>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).

<sup>5</sup>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).

nominal magnitudes. The graphs in the third column indicate that the only significant contribution of the third stochastic component of the model is to the FEV of the short-term interest rate. This is the only significant different with respect to FEVD in the US case. Finally, the graphs of the fourth column conform to our identification of the fourth stochastic component of the model as a transitory inflation shock.

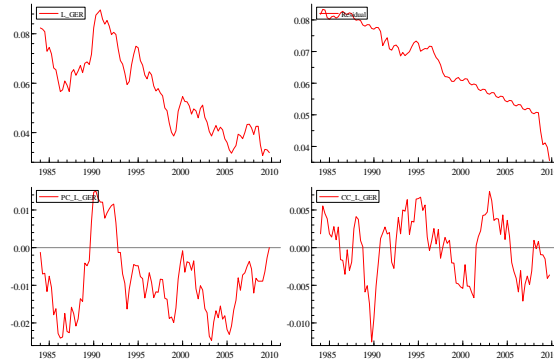
Figure 8: Forecast Error Variance Decomposition, Germany



Note: column 1 (contribution of the first shock - permanent, fiscal trend  $\xi_t^\varphi$ ), column 2 (contribution of the second shock - permanent, inflationary trend  $\xi_t^v$ ), column 3 (contribution of the third shock - transitory, financial  $\xi_t^\theta$ ), column 4 (contribution of the fourth shock - transitory, inflationary  $\xi_t^\eta$ ).

Figure 9 portrays the graph of the long-term interest rate (upper left panel) and of its three components. As shown in the upper right panel, the element reflecting initial conditions plus deterministic components captures the disinflation of the international and German economies and the effects of price stability under EMU (with the reunification break). The sharp drop at the end of the period can be attributed to the recent financial crisis having a particularly strong deflationary impact on Germany. The contribution of the permanent stochastic component to the level of the long-term interest rate is negative throughout the sample period with the notable exception of the reunification years (1989-1993), as if anticipating the subsequent sharp rise in the debt/GDP ratio. On the other hand, the contribution of the cyclical component has been oscillating during the sample period without showing a clear connection with the pattern of fiscal deterioration.

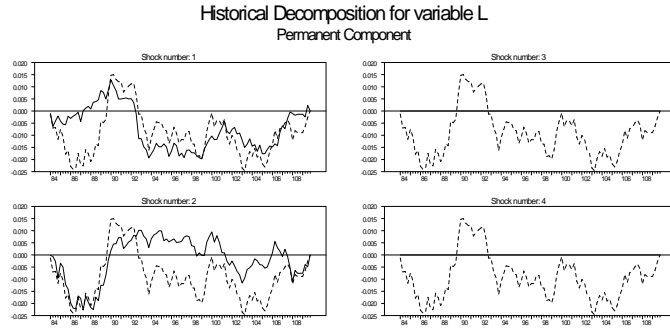
Figure 9: Decomposing the German long-term interest rate



Note: the decomposition is  $i_t^L = \delta_l + l_t^P + l_t^C$ .  $l$  (upper panel, left),  $\delta_l$  (upper panel, right),  $l_t^P$  (lower panel, left),  $l_t^C$  (lower panel, right).

Figure 10 decomposes the permanent stochastic component  $l_t^P$  (dashed line) into its two determinants: the fiscal trend (upper left panel) and the monetary trend (lower left panel). As the graphs indicate,  $l_t^P$  appears to be almost entirely explained by the fiscal trend from the beginning of the 1990s. The effects are prevalently negative, demonstrating the higher importance of a liquidity effect over a crowding-out effect. The fact that there was a positive push 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).

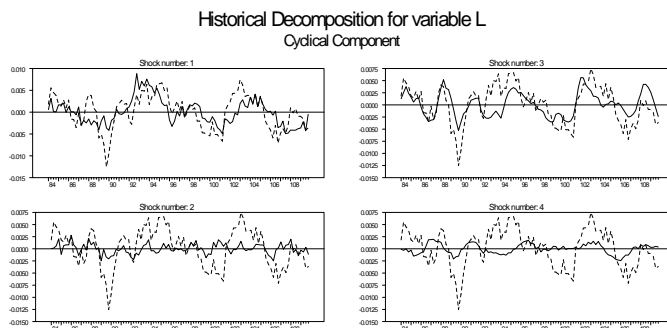
Figure 10: Permanent component of the German long-term interest rate



Note: The graph portrays  $\Phi_{41} \sum_{i=1}^t \xi_i^\varphi$  (solid line, upper left corner),  $\Phi_{42} \sum_{i=1}^t \xi_i^\nu$  (solid line, lower left corner), and their sum  $l_t^P$  (dashed line). See Equation 25. The two columns on the right show that the cyclical components do not concur in determining  $l_t^P$ .

Figure 11 portrays the cyclical stochastic component driving the German long-term interest rate (dashed line) and the relative contribution of the four structural shocks to its formation (solid lines). As the four graphs indicate, the cyclical component of the long-term interest rate is mainly determined by the first (fiscal developments) and the third structural stochastic component (transitory financial shock), with the contribution of the two nominal shocks being considerably less important. The relevance of this third stochastic component (transitory financial shock) is nevertheless more pronounced than what is observed in the US case.

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

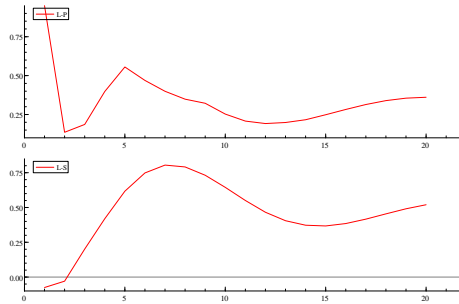


Note: The graph portrays  $\sum_{i=1}^t \Phi_{1,41}^* \xi_i^\varphi$  (solid line, upper left corner),  $\sum_{i=1}^t \Phi_{1,42}^* \xi_i^\nu$  (solid line, upper right corner),  $\sum_{i=1}^t \Phi_{1,43}^* \xi_i^\theta$  (solid line, lower left corner), and  $\sum_{i=1}^t \Phi_{1,44}^* \xi_i^\eta$  (solid line, lower right corner), plus their sum  $l_t^c$  (dashed line). See Equation 26.

Figure 12 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 (upper panel) and of the yield curve (lower 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 widens by 9 basis points after five years. Both effects are more persistent than those observed in the case of the US and might reflect a different market perception of the fiscal solidity of the two countries, or which is more likely a difference source for the fiscal shock. In the USA fiscal shocks may emanate 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.<sup>6</sup>

<sup>6</sup>As to the crowding-out effect Paesani et al. (2006, p. 28) note "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 impulse on the real interest rate should therefore also reflect some crowding-out of private capital acquisition through (partly extra-) budgetary financing requirements of the public sector".

Figure 12: Impact of a fiscal shock on the real long term interest rate (upper section) and on the slope of the yield curve (lower section), Germany

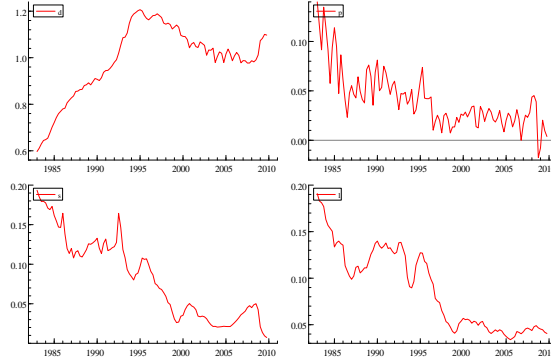


Summarizing the available evidence, and excluding the presence of any default risk effect in the case of Germany, as fiscal shocks cumulate over time, their impact on the long-term interest rate, especially through the permanent stochastic component, is compatible with interest rates increasing with the debt/GDP ratio. The positive impacts 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.

### 4.3 Italy

As Figure 13 shows, between 1980 and 1994 the Italian economy has been subject to an episode of major structural fiscal deterioration, pushing the debt/GDP ratio 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 an average of 5% up to 1997 and on a lower average after the start of the EMU, presenting an irregular seasonal pattern through the sample period. Both interest rates move along a declining trend. The 1992 spike in the short-term interest rate corresponds to the 1992 EMS crisis.

Figure 13: The Italian data



A VEC with unrestricted constant, restricted trend, and seasonal dummies is chosen as the statistical model to analyze the data. As to the optimal number of lags, the 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.<sup>7</sup> Misspecification tests for residual autocorrelation, normality and heteroscedasticity indicate that the model is well specified.<sup>8</sup> Univariate tests (available on request) confirm this result.

Table 4 reports the result of the Johansen cointegration test. The hypothesis of two cointegrating vectors and two common trends is not rejected at the 5% confidence level, as we expected on the basis of the theoretical considerations.

Table 4. Johansen trace cointegration test, USA

Trace	$p$ value	$H_0: r \leq$
76.89	[0.002]	0
43.26	[0.044]	1
18.38	[0.326]	2
3.74	[0.775]	3

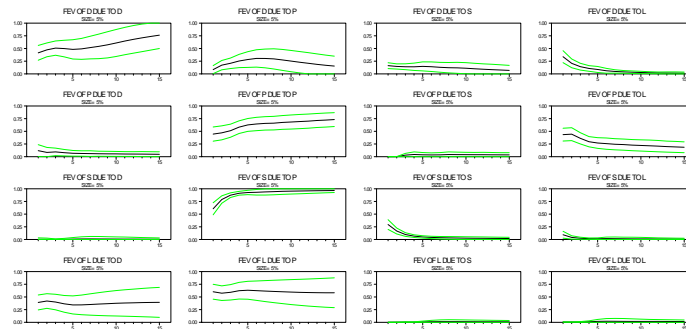
Figure 14 contains the FEVD graphics. As in the case of the other two countries, the graphs of first column indicates that fiscal shocks absorbs almost entirely the FEV of the debt/GDP ratio. Also, it contributes significantly to explain the FEV of the long-term interest rate (not the short-term one, though). According to the graphs in the second column, innovations to monetary shocks conform with the neutrality assumption and explain almost entirely the FEV of inflation and of the short-term interest rate from the fourth quarter onwards.

<sup>7</sup>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).

<sup>8</sup>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).

The impact on the debt/GDP ratio may be related to the specific composition of the Italian public debt and to the high share, over most of the sample period, of Treasury bills and medium-term indexed bonds (Missale 1999). The graphs in the third column indicate that the only significant contribution of financial shocks is to the FEVs of the short-term interest rate and of the debt/GDP ratio. Finally, the graphs of the fourth column conform to our identification of the fourth stochastic component of the model as a transitory inflation shock.

Figure 14: Forecast Error Variance Decomposition, Italy

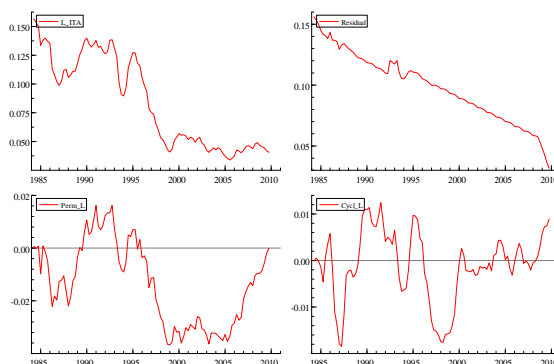


Note: column 1 (contribution of the first shock - permanent, fiscal trend  $\xi_t^\varphi$ ), column 2 (contribution of the second shock - permanent, inflationary trend  $\xi_t^v$ ), column 3 (contribution of the third shock - transitory, financial  $\xi_t^\theta$ ), column 4 (contribution of the fourth shock - transitory, inflationary  $\xi_t^\eta$ ).

Figure 15 portrays the graph of the long-term interest rate (upper left panel) and of its three components. As the figure shows, the element associated to initial conditions plus deterministic component 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. Again, 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. The contribution of the permanent stochastic component to the level of the long-term interest rate has been negative between 1983 and 1989, positive between 1990 and 1996, and again positive afterwards. No clear link between this pattern and that of fiscal deterioration appears. The contribution of the cyclical component shows a similar pattern, except that it is close to zero starting from 2000.



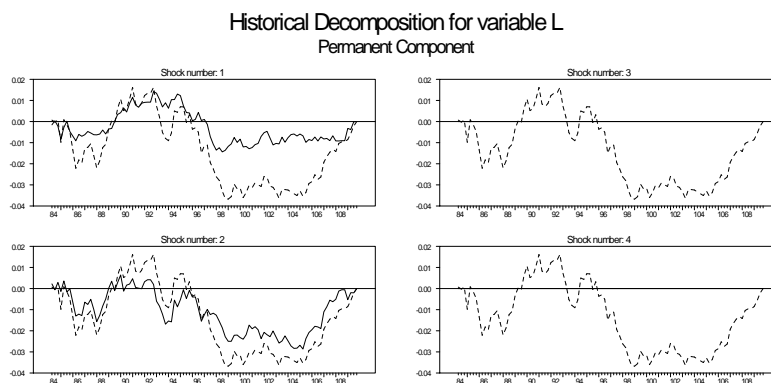
Figure 15: Decomposing the Italian long-term interest rate



Note: the decomposition is  $i_t^L = \delta_l + l_t^P + l_t^C$ .  $l$  (upper panel, left),  $\delta_l$  (upper panel, right),  $l_t^P$  (lower panel, left),  $l_t^C$  (lower panel, right).

Figure 16 decomposes the permanent stochastic component associated to the long-term interest rate (dashed line) into its two determinants: the fiscal trend (upper left panel) and the monetary trend (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.

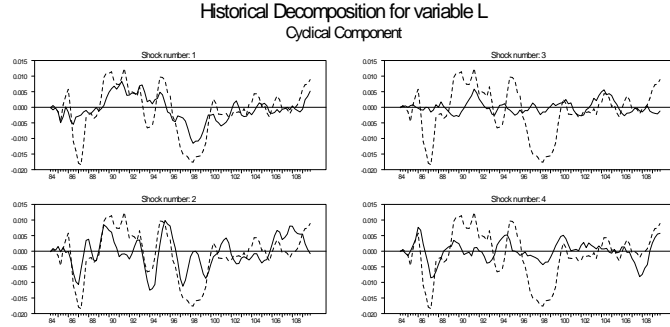
Figure 16: Permanent component of the Italian long-term interest rate



Note: The graph portrays  $\Phi_{41} \sum_{i=1}^t \xi_i^{\varphi}$  (solid line, upper left corner),  $\Phi_{42} \sum_{i=1}^t \xi_i^{\nu}$  (solid line, lower left corner), and their sum  $l_t^P$  (dashed line). See Equation 25. The two columns on the right show that the cyclical components do not concur in determining  $l_t^P$ .

Figure 17 portrays the cyclical stochastic component driving 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 permanent shocks (graphs on the left column) is more pronounced with respect to that of the other two components, and there is a high correlation between the development of the fiscal trend reflecting nominal bond issuance (i.e. the government financing requirement which should roughly correspond to fiscal deficits) and the cyclical part of long-term yields. 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.

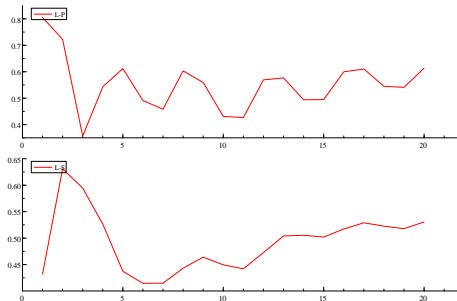
Figure 17: Transitory component of the Italian long-term interest rate



Note: The graph portrays  $\sum_{i=1}^t \Phi_{1,41}^* \xi_i^\varphi$  (solid line, upper left corner),  $\sum_{i=1}^t \Phi_{1,42}^* \xi_i^\nu$  (solid line, upper right corner),  $\sum_{i=1}^t \Phi_{1,43}^* \xi_i^\theta$  (solid line, lower left corner), and  $\sum_{i=1}^t \Phi_{1,44}^* \xi_i^\eta$  (solid line, lower right corner), plus their sum  $l_t^c$  (dashed line). See Equation 26.

Figure 18 contains the impulse responses of the real ex-post long-term interest rate on the upper panel, and of the yield curve in the lower panel, in response to adverse fiscal shocks. Both variables tend to increase as a consequence of an adverse fiscal shock equal to 1% of the debt/GDP ratio. The real long-term interest rate increases by 11 basis points after five years. A comparable increase (9 basis points) is observed for the differential between long and short-term interest rates.

Figure 18: Impact of a fiscal shock on the real long term interest rate (upper section) and on the slope of the yield curve (lower section), Italy



Summarizing the available evidence, the Italian analysis supports once again the positive impact of public debt on long-term interest rates. The impact of the fiscal trend 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 so-called "euro-dividend", namely the macroeconomic shield provided by the common currency against the effect of residual national fiscal imbalances on nominal variables (the imported credibility effect of the euro).

Still, there is evidence of a strong and positive impact of public debt 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 in the US and German case.

## 5 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 driving 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 effect of initial conditions, deterministic component and of cyclical stochastic elements has 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 possibility of short-term or transitory linkages between the series.

## 5.1 Long-term linkages

The Johansen trace cointegration test reported in Table 5 below indicates that the permanent components, respectively driving the US ( $i_{USA}^L$ ), German ( $i_{GER}^L$ ), and the Italian ( $i_{ITA}^L$ ) long-term interest rate do not share any stochastic element among themselves.

Table 5.  
Johansen trace cointegration test on  $l_{USA}^P$ ,  $l_{GER}^P$ ,  $l_{ITA}^P$

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.

## 5.2 Short-term linkages

The second step of the analysis of cross-country linkages consists in estimating a structural Vector Auto-Regressive (SVAR) model containing the three stationary cyclical components driving the US, German and Italian long-term interest rates, respectively labelled:  $l_{USA}^C$ ,  $l_{GER}^C$ ,  $l_{ITA}^C$ . 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.<sup>9</sup> The SVAR model is identified using the Cholesky structure reported in Table 6, with  $l_{USA}^C$  having a simultaneous impact on  $l_{GER}^C$  and  $l_{ITA}^C$ , and  $l_{GER}^C$  having a simultaneous impact on  $l_{ITA}^C$ .

Table 6. The matrix of simultaneous relationships

	$l_{USA}^C$	$l_{GER}^C$	$l_{ITA}^C$
$l_{USA}^C$	1.00	.	.
$l_{GER}^C$	-0.13 (0.11)	1.00	.
$l_{ITA}^C$	0.05 (0.13)	-0.04 (0.20)	1.00

Note: Standard errors in parenthesis.

As table 7 indicates, FEVD based on the SVAR model indicates that, as might be expected, in all of the three cases the domestic element is by far the

<sup>9</sup>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].

most important explanatory variable. After all, the previous analysis 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 FEV of  $l_{GER}^C$ . In the Italian case, the FEVD of  $l_{ITA}^C$  appears to be influenced more by  $l_{USA}^C$  than by  $l_{GER}^C$ .

Table 7. SVAR FEVD analysis

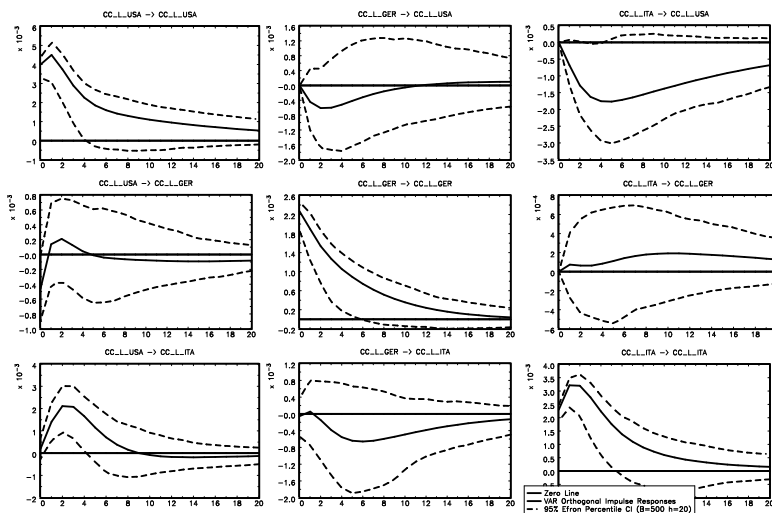
Qrts. ahead	$l_{USA}^C$ exp by $l^C$			$l_{GER}^C$ exp by $l^C$			$l_{ITA}^C$ exp by $l^C$		
	<i>USA</i>	<i>GER</i>	<i>ITA</i>	<i>USA</i>	<i>GER</i>	<i>ITA</i>	<i>USA</i>	<i>GER</i>	<i>ITA</i>
1	1.00	0.00	0.00	0.04	0.96	0.00	0.01	0.00	0.99
4	0.91	0.01	0.07	0.02	0.98	0.00	0.24	0.00	0.75
8	0.80	0.02	0.18	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

SVAR impulse response functions, depicted in Figure 19, provide additional evidence on the relationship between the three temporary components driving the three 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  $l_{ITA}^C$  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 19: Figure 19: SVAR impulse responses

JMulti Fri Feb 11 15:19:59 2011

VAR Orthogonal Impulse Responses



Having shown that the cyclical component driving each of the three interest rates is strongly dominated by fiscal developments in all countries, in a way consistent with fiscal deterioration leading to a higher temporary component (and by the transitory financial shock in Germany, and by the permanent inflationary trend in Italy), the previous impulse responses are consistent with the possibility of financial linkages between the USA and Italy, with a minor role played by Germany .

## 6 Conclusions

This paper is devoted to the analysis of the effects of fiscal shocks and public debt accumulation on both the long-term interest rates, controlling for inflation and monetary policy. Building on Paesani et al. (2006), we make use of both a theoretical setting and several empirical tools to analyze the effects of fiscal developments on long-term interest rates in three countries of interest: USA, Germany and Italy. The empirical analysis is mainly based on a structural Vector Error Correction (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 trend 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 the fiscal/financial/inflationary/nominal developments in explaining the 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 role of international linkages.

Our results are the following. We find that the fiscal trend plays a major role in driving interest rates' permanent and cyclical components in the USA and in Germany. In the Italian case, the monetary trend plays a non-negligible role as well. 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 term structure).

Finally, international linkages do not seem to matter in determining the permanent components 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 financial linkages between the USA and Italy.

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 - such as Italy - with a less consolidated tradition in public finance sustainability. Moreover, our results support those who question - in presence of loose fiscal policy - the general effectiveness of monetary policy strategies (such as the "quantitative easing") devoted to affect the longer maturities of the yield curve. Under such a perspective, fiscal discipline might be viewed as a necessary condition for monetary policy to successfully affect the yield curve.

## 7 References

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## 8 Data Appendix

### 8.1 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	$\Delta b$	4	$c = 0$	-2.11
$\pi$	9	c	-2.48	$\Delta \pi$	8	$c = 0$	-3.98
$i^S$	1	c, t	-3.35	$\Delta i^S$	0	c	-5.49
$i^L$	1	c, t	-3.79	$\Delta i^L$	0	c	-7.78
ADF	$c = 0$		-1.62				-1.94
ADF	c		-2.57				-2.86
ADF	c, t		-3.13				-3.41

## 8.2 Germany

Table A3: 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  $b = B/(\text{sum of 4 quarters } Y)$ , The short term interest rate  $i^S = (S/100)$ , the long term interest rate  $i^L = (L/100)$ , inflation  $\pi = 4 \cdot \Delta \log(P)$ . Unit root tests reported in table A6 are consistent with treating all the variables as  $I(1)$ .

Table A4. Unit root tests (1983:1-2009:4)

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

## 8.3 Italy

Table A5: 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  $b = B/(\text{sum of 4 quarters } Y)$ , 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 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 A6. Unit root tests (1983:1-2009:4)

	Lag	Det	ADF		Lag	Det	ADF
$b$	5	c	-2.43	$\Delta b$	4	c = 0	-2.28
$\pi$	4	c, t, sd	-3.96	$\Delta\pi$	2	c, sd	-9.69
$i^S$	1	c, t	-2.99	$\Delta i^S$	0	c	-8.41
$i^L$	4	c	-1.59	$\Delta i^L$	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