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Fiscal Policy, Interest Rates and Risk Premia in Open Economy

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Abstract This paper reconsiders the effects of fiscal policy on long-term interest rates and sovereign spreads employing a *Factor Augmented Panel (FAP)* to control for the presence of common unobservable factors. We construct a real-time dataset of macroeconomic and fiscal variables for a panel of OECD countries for the period 1989-2009. We find that two global factors - the global monetary and fiscal policy stances - explain more than 60% of the variance in the long-term interest rates. The same two global factors play a relevant role also in explaining the variance of sovereign spreads, which in addition respond to global risk aversion. With respect to standard estimation techniques the use of the *FAP* reduces the importance of domestic fiscal variables in explaining long-term interest rates, while it emphasizes their importance in explaining sovereign spreads. Using the *FAP* framework we also analyse the cross-country differences in the propagation of a shock to global fiscal stance and global risk aversion. We find the effects of the former to be modest in large economies and strong in economies characterized by low financial integration and current account deficits. Changes in global risk aversion, instead, lead to higher spreads in countries with a high stock of public debt and weaker political institutions.

Keywords: Fiscal Policy; Sovereign debt; Interest rates; Sovereign spreads; Real time data; Cross-sectional dependence; Heterogeneous panels; Factor model.

JEL Classification Numbers: C10, E43, F42, F62, H68.

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1 Introduction

The global financial crisis and its adverse effects on the budget deficits of advanced economies have revived the debate on the link between fiscal policy and interest rates. The strong convergence observed among advanced countries' interest rates before the crisis came to a halt when the global recession provoked a substantial deterioration of sovereigns' fiscal positions. Financial markets then suddenly started to discriminate between borrowers. These developments seem to suggest that: (1) under increased capital market integration, interest rates and risk premia tend to follow global factors rather than domestic variables; (2) nonetheless, the effects stemming from fiscal policy can be large and substantial when sovereigns face a common adverse budgetary shock or an increase in global risk aversion. The objective of this paper is thus to analyse the impact of fiscal policy on sovereign interest rates in a broad panel of OECD countries, using a framework which can accommodate both the existence of common sources of fluctuations as well as heterogeneous responses to global shocks. In particular, we want to answer the following questions: In a context of high financial integration, do global factors matter more than domestic factors? And how do global factors affect the cost of borrowing?

In this paper we consider the effects of fiscal policy on both long-term interest rates and sovereign spreads, the latter being a better proxy for sovereign risk. We follow and expand the existing literature along two dimensions. Starting from the result according to which the relationship between fiscal policy and interest rates becomes statistically significant when using fiscal projections rather than actual data (Reinhart and Sack 2000, Canzoneri et al 2002; Gale and Orszag, 2004; Laubach 2009; Afonso 2010), we construct a real-time dataset based on macroeconomic projections collected from several vintages of the OECD economic outlook. The use of real time data serves two different purposes: (i) it takes into account the forward looking behaviour of financial markets; (ii) it avoids the possible reverse causality from interest rates to fiscal policy decisions which arises from the use of actual data. Collecting fiscal projections from an independent agency like the OECD rather than official government plans presents also a further advantage. As shown by Beetsma and Giuliodori (2010) and Cimadomo (2008), governments' released budget plans tend to be overly optimistic in terms of expected fiscal outcome; on the other hand, the forecasts released by an independent body such as the OECD are less prone to this 'optimistic bias'.

Our main contribution lies in the estimation strategy. Given the evidence of strong cross-country correlation in interest rates and sovereign spreads, we implement an estimation method called *Factor Augmented Panel*- originally developed by Giannone and Lenza (2008) - which explicitly accounts for the presence of unobserved global factors that affect interest rates simultaneously in all countries. By controlling for the presence of global factors this method allows us to estimate the effects of the idiosyncratic components of fiscal policy on interest rates and sovereign spreads. Moreover, it ensures unbiased estimates in case the effects of global shocks are heterogeneous across countries. Finally, it has the desirable property of allowing us to identify the global factors with observable data, and analyse the determinants of the cross-country differences of their effects on interest rates and sovereign spreads.

Overall, we find that using standard panel techniques provides results that are similar to those found in previous literature. However, once we implement the *Factor Augmented Panel* method to account for the presence of global factors, we find that the estimated effect of budget deficits on long-term interest rates becomes smaller in magnitude and insignificant, while the effect of public debt remains significant and of about 0.8 basis points for a 1% increase in the debt to GDP ratio. When studying the effects on sovereign spreads, instead, we find that with the *Factor Augmented Panel* estimator both public debt and primary deficit are significant and with the expected sign, with effects of 2.6 and 0.5 basis points respectively.

The *Factor Augmented Panel* technique also allows us to analyse in more detail the nature and the quantitative importance of the common factors. Our results show that long-term interest rates are mainly driven by two global factors, which explain more than 60% of their variance and can be interpreted as the aggregate fiscal and monetary policy stances of the countries in the sample. This suggests that the fiscal consolidations and the reductions of monetary policy rates in most of advanced economies in the nineties can explain the observed general decline and the convergence of long-term interest rates. However we also show that long-term interest rates respond heterogeneously to the aggregate fiscal stance. In particular, after an increase in the aggregate deficit long-term interest rates increase more in small peripheral countries or countries characterized by low financial integration or current account deficits.

Aggregate monetary and fiscal policy stances play an important role also in determining sovereign yield spreads, together with global risk aversion. We find that a shock on global risk aversion generates a response in sovereign spreads which is markedly different across countries, with sovereign spreads increasing more in countries with high stocks of public debt or weaker institutions.

Contrary to previous studies, we do not find evidence of non-linear effects of public debt and primary deficit, but we find that the effects of public deficits on sovereign spreads are time varying and increase during crisis periods.

We proceed as follows. In Section 2, we provide a brief review of the literature. In Section 3 we derive the estimating equations and explain the *Factor Augmented Panel* methodology. In Section 4 we discuss our dataset and its properties. In Section 5 we present and discuss results. In Section 6 we analyse the heterogeneity in the country specific responses to global shocks, while in Section 7 we do some robustness checks. Section 8 concludes.

2 Literature review

There is a vast empirical literature on the effects of fiscal policy on long-term interest rates and sovereign spreads but, despite the large production, the results are still mixed. In spite of the mixed results, we can identify few areas of consensus: (1) studies that employ measures of expected rather than actual budget deficits as explanatory variables tend to find a significant effect of fiscal policy on long-term interest rates (Feldstein, 1986; Reinhart and Sack, 2000; Canzoneri et al. 2002; Thomas and Wu 2006; Laubach, 2009); (2) the effect of public debt appears to be non-linear (Faini, 2006; Ardagna et al. 2007); (3) the effects of public debt are quantitatively smaller than those of public deficit (Faini, 2006; Laubach, 2009); (4) the effects of global shocks and in particular 'global fiscal policy' seem larger than domestic effect (Faini, 2006; Ardagna et al. 2007); (5) 'global risk aversion' is a strong determinant of sovereign spreads both in advance countries (Codogno et al., 2003, Geyer et al., 2004; Bernoth et al., 2004 and Favero et al., 2009) and in emerging markets (Gonzalez-Rosada and Levy- Yeyati, 2008; Ciarlone et al., 2009).

This paper estimates the effects of fiscal policy on interest rates and sovereign spreads in panel of 17 OECD countries. The papers more closely related to our work are Reinhart and Sack (2000), Chinn and Frankel (2007), Ardagna et al. (2007), Schuknecht et al. (2011). As Reinhart and Sack (2000) and Chinn and Frankel (2007) we use fiscal projections instead of actual data. The choice of the regressors, instead, closely follows Ardagna et al. (2007) for the long-term interest rates equation and Schuknecht et al. (2011) for the sovereign spreads equation[1].

Reinhart and Sack (2000) estimate the effects of fiscal policy in a panel of 19 OECD countries using annual fiscal projections from the OECD. They find that a one percentage increase in the budget deficit to GDP increases interest rates by 9 basis points in the OECD and by 12 basis points in the G7. The authors, however, do not consider the level of debt and do not control for global factors. Chinn and Frankel (2007) focus on Germany, France, Italy and Spain, while also considering evidence for UK, US and Japan. They focus on the effect of public debt and also use fiscal projections from the OECD. They find that the effect of public debt is significant only when they include the US interest rate as a proxy for the "world" interest rate. Ardagna et al. (2007) estimate the effects of fiscal policy in a panel of 16 OECD countries using yearly data, from 1960 to 2002, but do not use fiscal projections. They find that a one percentage increase in the primary fiscal deficit to GDP increases long-term interest rates by 10 basis points, a result similar to the one in Reinhart and Sack (2000). Contrary to Reinhart and Sack (2000), Ardagna et al. (2007) also control for the level of debt, finding evidence of non-linearity: interest rates increase if the level of debt to GDP is higher than 60%. They also include cross-sectional averages of the fiscal variables to control for the presence of global factors. They find that average debt and average deficit have statistically significant effects on long-term interest rates, with magnitudes between 20 and 60 basis points.

Schuknecht et al. (2011) analyse sovereign spreads at issuance in a panel of 15 EU countries. They find that a one percentage point increase in public debt with respect to the benchmark country, increases spreads by 0.23 basis points, and that a one percentage point increase in public deficit with respect to the benchmark country, increases sovereign spreads by 4 basis points. They observe that these magnitudes increased substantially during the global financial crisis. Sgherri and Zoli (2009) show a similar result. Looking at a sample of European countries they find that sovereign risk premia tend to co-move with a 'global risk' factor, and that financial markets become more concerned about fiscal fundamentals in periods of crisis.

Our main difference from the literature lies in the empirical strategy. We argue that to properly identify the effects of fiscal policy we need a robust framework that allows us to isolate idiosyncratic effects from common factors. While the previous literature has acknowledged the relevance of global shocks as a driver of national interest rates,

[1] Although we also include an indicator of liquidity constructed as in Gomez-Puig (2006).

they have constrained their effects to be homogeneous across countries. We show that this assumption might lead to biased and inconsistent estimates. Our empirical model follows the insights of recent literature that analyses cross-sectional dependence in large panel. Cross-sectional dependence[2] arises whenever the units of observations are simultaneously and heterogeneously affected by *common unobserved factors*. The recent econometric literature provides different methodologies to deal with this type of structure in the data (Bai, 2009; Pesaran, 2006). In this paper, we follow the methodology proposed originally by Giannone and Lenza (2008) in their study of the puzzle. They show that the high correlation between domestic savings and investments found in previous studies vanishes once the panel takes into account global shocks with heterogeneous transmission. In the next section we provide a more detailed explanation of the methodology.

3 Econometric specification and Estimation strategy

In this section we describe the *Factor Augmented Panel* technique and discuss its properties and estimation procedure. We derive the estimating equations for the long-term interest rates and sovereign spreads starting from a data generating process in which a set of global unobservable factors simultaneously determines interest rates and macroeconomic variables. This feature generates cross-sectional dependence in the data, which is evident in both long-term interest rates and sovereign spreads (see *Section 4*). In discussing the *FAP* we show - as in Giannone and Lenza 2008 - that standard estimation techniques are likely to yield biased estimates whenever the effects of global factors are truly heterogeneous across countries. In *Section 3.2* we discuss the estimation of the unobserved factors and refer the reader to *Appendix A* for more details.

3.1 The econometric model

Let r_{it} and x_{it} be respectively the long-term interest rate and a set of observable variables, with $(i = 1, \ldots, N; t = 1, \ldots, T)$. Most of the literature has estimated linear models of the type:

$$r_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it} \tag{1}$$

where the country intercepts α_i capture time invariant heterogeneity across countries. This is the equation estimated for example by Reinhart and Sack (2000) in a panel of 20 OECD countries. The estimates of the β coefficients are however unlikely to be informative of the effect of x_{it} on y_{it} if these are simultaneously determined by a set of unobserved global factors. This is the case for open and integrated economies, which suffer from common sources of fluctuations - such as common business cycle shocks. In fact, common shocks jointly determine the reaction of monetary and fiscal authorities and hence the level of interest rates. Following Giannone and Lenza (2008) we

[2]Following the terminology of Chudik, Pesaran and Tosetti (2011), we deal with *strong* instead of *weak* cross-sectional dependence.

therefore assume a factor structure of the type:

$$\begin{cases} r_{it} = \sum_{k=1}^{q} \lambda_{ki}^{r} f_{kt} + r_{it}^{ID} \\ x_{it} = \sum_{k=1}^{q} \lambda_{ki}^{X} f_{kt} + x_{it}^{ID} \end{cases} \tag{2}$$

in which observable quantities $\{r_{it}, x_{it}\}$ are a function of a set of q unobservable global factors $\left\{f_t^k\right\}_{k=1}^q$ with heterogeneous impact in each country $\left\{\lambda_{ki}^r, \lambda_{ki}^X\right\}_{k=1}^q$, $\forall i : 1, ..., N$.

Given this data generating process, an accurate estimate of the effect of macroeconomic and fiscal policy variables on interest rates should be based on the idiosyncratic components only:

$$r_{it}^{ID} = \alpha_i + \tau_t + \beta x_{it}^{ID} + u_{it} \tag{3}$$

Although equation (3) cannot be estimated because the idiosyncratic components $\left\{r_{it}^{ID}, x_{it}^{ID}\right\}$ are *unobservable*, we can use (2) to substitute the idiosyncratic component in (3) and rewrite the equation in terms of observable quantities and global factors:

$$\begin{aligned} r_{it} &= \alpha_i + \tau_t + \sum_{k=1}^{q} \left(\lambda_{ki}^r - \beta \lambda_{ki}^X\right) f_{kt} + \beta x_{it} + u_{it} \\ r_{it} &= \alpha_i + \tau_t + \sum_{k=1}^{q} \delta_{ki} f_{kt} + \beta x_{it} + u_{it} \end{aligned} \tag{4}$$

Taking explicitly into account the global factors $\left\{f_t^k\right\}_{k=1}^q$, (4) allows us to estimate the relationship between the idiosyncratic components of the variables of interest.

Consistent estimates of the common factors, allow an estimation of the β by standard panel techniques. In *Section 3.2* will show that these can be obtained *extracting principal components* from the set of observable variables of equation (4), $\{r_{it}, x_{it}\}_{i=1,...,N;t=1,...,T}$. This estimation technique goes under the name of *Factor Augmented Panel (FAP).*

When the data generating process is represented by the system in (2), we can obtain unbiased estimates of the coefficients β only if we allow the factors to have heterogeneous impact across countries ($\delta_{ki} \neq \delta_{kj}$). This aspect has been often ignored in previous studies. In fact, when tackling the issue of common unobserved factors the literature has mainly pursued three different paths. The first approach (Chinn and Frankel, 2007) consists of finding an a priori *observable* variable (or a subset of variables) which might affect contemporaneously the interest rates across countries, and introduce it directly in the panel:

$$r_{it} = \alpha_i + \beta x_{it} + \gamma z_t + \xi_{it} \tag{5}$$

where the variable (z_t) is the vector (or matrix) of identified common factors. The alternative approach consists of accounting for unobservable common shocks by introducing time effects. This would lead to the estimation of the following model (Ardagna et al. 2007):

$$r_{it} = \alpha_i + \tau_t + \beta x_{it} + \xi_{it} \tag{6}$$

This is equivalent to assuming that in each time period there is a common shock which affects homogeneously countries' interest rates. The third approach in the literature on sovereign spreads, is to include on the right hand side the control variables in deviation from their cross-sectional average (Beber et al. 2009) or a common benchmark (Schukneth et al. 2011):

$$r_{it} = \alpha_i + \beta(x_{it} - \overline{x_t}) + \xi_{it} \tag{7}$$

Differently from the *FAP* specification in (4), equations (5), (6) and (7) impose homogeneous effects of the global factors, represented either by the common regressors z_{it} or by the time effects τ_{it}. If however the unobserved factors have truly an heterogeneous effect across countries, then the country specific components will become part of the error terms. Therefore, if the factors are correlated with the observable variables - as implied by (2) - equations (5), (6) and (7) will suffer from endogeneity and produce biased estimates.

3.1.1 Equation for the Spreads

To derive an estimating equation for the spreads we follow the literature and start from a no-arbitrage condition, which links the return on a risky asset r_{it} to the return on a risk free asset r^B_{jt}, where the superscript B stands for *'Benchmark Country'*. Assuming for simplicity a zero recovery rate, the no-arbitrage condition can be written as:

$$(1 + r_{it})\, p_{it} = \left(1 + r^B_{jt}\right) + \theta_{it}\,(1 - p_{it}) \tag{8}$$

where $(1 - p_{it})$ is the probability of default and θ_{it} is the investors' time varying risk aversion, which is allowed to affect each country's interest rates differently. Rewriting (8) we obtain:

$$\left(r_{it} - r^B_{jt}\right) = \left(1 + r^B_{jt} + \theta_{it}\right) \frac{1 - p_{it}}{p_{it}} \tag{9}$$

We assume that the relative probability of default is a function of the idiosyncratic macroeconomic variables: $\frac{1-p_{it}}{p_{it}} = \alpha_i + \beta x^{ID}_{it}$ and that the risk aversion coefficient is proportional to an unobservable factor with country specific factor loadings: $\theta_{it} = \varphi_i f^{RP}_t$. Equation (9) can therefore be rewritten as:

$$\left(r_{it} - r^B_{jt}\right) = \alpha_i + \beta x^{ID}_{it} + \Psi_i f^{RP}_t + \alpha_i r^B_{jt} + \mu_{it} \tag{10}$$

with $\Psi_i = \varphi_i \alpha_i$, $\mu_{it} = \left\{\beta r_t^B x_{it}^{ID} + \beta \varphi_i x_{it}^{ID} f_t^{RP}\right\}$. We can now use (2) to obtain:

$$\left(r_{it} - r_{jt}^B\right) = \alpha_i + \beta x_{it} + \sum_{k=1}^{q} \Delta_{ki} f_{kt} + \Psi_i f_t^{RP} + \alpha_i r_{jt}^B + \mu_{it} \tag{11}$$

where $\Delta_{ki} = -\beta \lambda_{ki}^X$. Sovereign spreads are therefore driven by a set of observable variables $\{r_{it}, x_{it}\}$, a set of common factors $\left\{f_t^k, f_t^{RP}\right\}_{k=1}^q$, and an error term μ_{it}.

As for the equation for the long-term interest rates (4) also in this case we can estimate the set of unobservable factors by extracting principal components from the observable elements of equation (11).[3] Conditional on this new extraction of factors, the term μ_{it} can be considered an error term.[4] From equations (4) and (11) we can derive two estimating equations conditional on estimates of the unobservable factors and on the choice of the number of relevant factors to include. The next section explains how this can be done.

3.2 Estimation strategy

To obtain consistent estimates of the sets of unobservable factors we follow Giannone and Lenza (2008) and use principal components. This is a general procedure that can be applied whenever in a linear regression the variables have a factor structure. It consists of taking the entire set of dependent and independent variables for all the N cross sections and, after stacking them together in a single matrix, apply principal components.

To estimate for the factors in the equation for the long-term rates (4) we first collect all the variables $\{r_{it}, x_{it}\}_{i=1,..,N;t=1,...T}$ in a matrix W^r:

$$W^r = \left[r_{it}^1, ..., r_{it}^N; x_{it}^1, ..., x_{it}^N\right]$$

If the elements x_{it}^j have dimension $T * k$, the matrix W^r will be of dimension $T * (N(k+1))$.[5]

The Principal Component Analysis (PCA) of W^r produces set of $N(k+1)$ orthogonal vectors which are the eigenvectors obtained from the eigenvalue-eigenvector decomposition of the covariance matrix of W^r. The eigenvectors are linear combinations of the columns of W^r. However, under the assumptions that common factors

[3]see *Section 3.2.*

[4]Under the assumption of known factors, when taking expectations conditional on $\left\{x_{it}, r_t^B, f_{1t}, ..., f_{qt}, f_t^{RP}\right\}$ all the components of μ_{it} go to zero. To see this let us rewrite μ_{it} as follows:

$$\begin{aligned}
\mu_{it} &= \beta r_{jt}^B x_{it}^{ID} + \beta \varphi_i x_{it}^{ID} f_t^{RP} \\
&= \beta \left\{\sum_{k=1}^{q} \lambda_{kj}^{rB} f_{kt} + r_{jt}^{ID,B}\right\} x_{it}^{ID} + \beta \varphi_i x_{it}^{ID} f_t^{RP} \\
&= \sum_{k=1}^{q} \Omega_{kj} f_{kt} x_{it}^{ID} + \beta r_{jt}^{ID,B} x_{it}^{ID} + \beta \varphi_i x_{it}^{ID} f_t^{RP}
\end{aligned}$$

where the expression in the second line comes from the fact that $r_{jt}^B = \sum_{k=1}^q \lambda_{kj}^{rB} f_{kt} + r_{jt}^{ID,B}$. Given that the idiosyncratic components have zero mean and they are orthogonal to the extracted factors, when taking expectations conditional on $\left\{x_{it}, r_t^B, f_{1t}, ..., f_{qt}, f_t^{RP}\right\}$ the first and the last elements of μ_{it} go to zero. The second element is zero in expectations because it is the product of the idiosyncratic component of the interest rates of country j (the benchmark) and of the macroeconomic variables of country i, which are uncorrelated by construction. In fact, the idiosyncratic components of the variables are - by definition of the factor structure - netted out of cross-sectional dependence and therefore it must be the case that they are uncorrelated across countries.

[5]See *AppendixA* for more details on the elements of W^r.

are pervasive and that idiosyncratic shocks are not pervasive, the eigenvectors are a consistent estimate of the of the common factors, with consistency achieved as the dimensions of W^r increase. Of all the $N(k+1)$ eigenvectors extracted from W^r we keep the first q, which are the ones associated with the highest proportion of explained variance. This procedure ensures that the q factors are indeed those elements which explain the bulk of the correlation among all of our data series and are therefore responsible for their observed co-movements.

In our case the first two eigenvectors explain 66% of the panel variance, with the third one contributing for less than 10% (*Table 1*). Following Giannone and Lenza (2008) we therefore take into consideration only the first two factors. Using these two estimated vectors we can rewrite the equation for the long-term interest rates (4) as:

$$r_{it} = \alpha_i + \tau_t + \beta x_{it} + \delta_{1i}\widehat{f}_{1t} + \delta_{1i}\widehat{f}_{2t} + \omega_{it} \tag{12}$$

Notice that, while we allow the response to the common factors (δ_{ik}) to vary across country, we impose the coefficients β to be common to keep the results consistent with those obtained in previous studies. The economic interpretation of the estimated factors $\widehat{f}_{1t}$ and $\widehat{f}_{2t}$ is important for the scope of our analysis. In *Appendix A* we show that these two elements can be interpreted *respectively* as the *average monetary policy* and the *average fiscal policy stances* of the countries in our sample.

The same procedure can be employed to obtain the estimation of the unobserved factors for the equation of the spreads (11). We construct a matrix $W^{spreads}$ using the series of the spreads $\left(r_{it} - r^B_{jt}\right)$, the set of regressors x_{it} and the benchmark interest rates r^B_t.[6] The first two principal components from $W^{spreads}$ explain around 67% of the variance, with the third contributing for around 12% of the variance (*Table 1*), indicating that in this case we should take into consideration 3 factors. Consistently with our theoretical model, in *Appendix A* we show that these three components closely track the average monetary and fiscal policy stances and the VIX index, a commonly used measure of investors' risk aversion (see Habib and Stracca 2011).[7] In particular: the first factor, which contributes for about 45% of the variance is the average fiscal stance; the second one - contributing to around 22% - is the risk factor, and the third one is the average monetary policy stance. Plugging back these three elements into equation (11) yields the estimating equation for the spreads.

Although theoretically driven, equation (11) contains a large set of parameters to estimate because it has four elements with country specific coefficients (the three unobserved factors and the interest rate of the benchmark country). To preserve degrees of freedom, we let the coefficients vary across country-groups instead of by individual countries. Our preferred grouping of countries is: (i) EMU Countries; (ii) Nordic Countries; (iii) Others.[8] We perform an F test to check whether these coefficients are truly heterogeneous. While we strongly reject the null

[6] See *Appendix A*.

[7] VIX is the ticker symbol for the Chicago Board Options Exchange Market Volatility Index, a popular measure of the implied volatility of S&P 500 index options.

[8] The group of EMU countries contains: Austria, Belgium, Finland, France,Ireland, Italy, Netherlands and Spain; the Nordics include: Denmark, Norway and Sweden and the "Others" include: Australia, Canada and Japan. As explained in Section 4, Germany and USA drop out of the sample because they are used as benchmark countries.

hypothesis of equal coefficients on the first three factors, we accept it for the coefficients on r_t^B.[9] We can therefore estimate a more parsimonious specification:

$$\left(r_{it} - r_t^B\right) = \alpha_i + \beta x_{it} + \Delta_{1i}\widehat{f}_{1t} + \Delta_{2i}\widehat{f}_{2t} + \Psi_i \widehat{f}_t^{RP} + \psi r_t^B + \mu_{it} \tag{13}$$

Although having estimated elements in the regression introduces a further source of uncertainty, which normally requires to bootstrap the standard errors, we rely on the result by Giannone and Lenza (2008), Bai (2004) and Bai and Ng (2006) who show that with s relatively large number of countries there is no generated regressor problem.[10]

The *FAP* is however not the only methodology proposed in the literature. Other types of estimator developed to tackle the issue of common unobservable factors and cross-sectional dependence are Pesaran's (2006) Common Correlated Effect *CCE*, and Bai's (2009) Interactive Fixed Effects *(IFE)*. In *Section 7* we show that our main results are preserved if we employ these two alternative estimation techniques.[11]

4 Data description and properties

4.1 Data

We construct our real-time semi-annual dataset of macroeconomic and fiscal forecasts from the December and June issues of the OECD's *Economic Outlook, (EO)* , from 1989 to 2009. The countries included are 17: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Norway, Netherlands, Spain, Sweden, United Kingdom and United States.

In our dataset, the projected horizon of the forecast is always one year ahead. So for example, for the June and the December issue of each year t, we collect the projections for year $t+1$.[12] The June and the December issues of the *EO* release forecasts with different information sets. Following the terminology of Beetsma and Giuliodori (2008), the December issue contains a forecast related to the *planning* phase of the budget law, while the June issue contains a forecast related to its *implementation* phase. In spite of this difference, we pool them together to achieve higher degrees of freedom. However we checked that splitting the sample according to the June or December issue does not affect our main results.[13]

As for the construction of the dependent variables, we use realized interest rates. The two different dependent variables we use are: the ten years yield on sovereign bonds (r_{it}); and the yield spreads measured as the difference between the ten years yield and the yield on a risk-free asset of the same maturity $\left(r_{it} - r_{it}^B\right)$. We construct these variables using the values of the interest rates observed in the month after the release of the forecast: January for

[9] The null hypothesis that that all coefficients are equal is accepted with a P Value equal to 0.717.

[10] Bai (2003) and Bai and Ng (2006) show that factor scan be treated as known if the number of countries is larger than the square root of the sample size.

[11] More details on the *CCE* and the *IFE* estimators are included in *Appendix B*.

[12] Starting from 1996, the OECD publishes also projections for year $t+2$ in the December issue; for internal consistency, we only keep the one year ahead projection.

[13] Results are available upon request.

the December issue and July for the June issue. This approach is useful because the forecasts on fiscal variables are likely to take into account current market conditions and the level of interest rates. Under the assumption that financial markets are forward looking and are able to incorporate rapidly all the available information, sampling interest rates after the release of the forecasts reduce the problem of reverse causality. Data on interest rates are taken from Datastream (*Appendix C*).

To measure the yield spreads we need to define a benchmark. In general the literature on EMU countries uses the interest rate on German government Bunds as a benchmark. After the introduction of the common currency, the exchange rate risk among EMU countries has disappeared and Germany seems to have acquired the 'status' of safe haven (see Schuknecht et al. 2011). Outside the EMU area, instead, it is generally the US Treasury which is considered the risk free asset.

For non-EMU countries (and for the EMU countries in the years prior to 1999) however, we need to take exchange rate risk into account. Following Codogno et al. (2003) we use data on interest rate swaps and define the *exchange rate risk adjusted spreads as:*

$$\widetilde{\left(r_{it} - r_{jt}^{B}\right)} = \left(r_{it} - r_{jt}^{B}\right) - \left(sw_{it} - sw_{jt}^{B}\right) \tag{14}$$

where r_{it}, r_{jt}^{B}, are the interest rates on government bonds for country i and for the benchmark country j and sw_{it} and sw_{jt}^{B} are the interest rate swaps for the currency of those same countries.[14] Because the two benchmark countries drop out of the analysis and because of the limited availability of data on interest rate swaps, in the regression for sovereign spreads we have a balanced panel of 15 countries observed between 1997 and 2009.

As indicators of fiscal stance, we use the expected primary deficit ($pdef$) and the expected public debt ($debt$) all measured as shares of previous period GDP. [15] We use the primary deficit instead of the total deficit to avoid the problem of reverse causality (since total deficit contains also the total interest payments), while debt is measured as the total gross financial liabilities of the general government.[16] *Table 2* reports the descriptive statistics of the variables used in the analysis.

4.2 Properties

The importance of the cross-sectional correlation among our variables of interest can be observed when looking at the behaviour of long-term interest rates and sovereign spreads in our sample *(Figure 1 and 2).* We have grouped

[14]Swap contracts are transactions which take place between investment banks. Two banks agree to swap two stream of payments computed on a given principal: one stream will be computed on the basis of a fixed exchange rate, the other on the basis of a variable one - usually the six-month LIBOR. Because these contracts involve no principal repayment, there is no real default risk. There is however counterpart risk, but because banks which deal in interest rate swaps generally operate in all the major currencies, these idiosyncratic risks will wash out. Therefore, the interest rates charged by two swap contracts on different currency but with the same maturity should exactly capture the risk of fluctuations in the exchange rate.

[15]We also used current period GDP and trend GDP measured with a Hodrick-Prescott filter as a scaling variable obtaining similar results.

[16]A better measure could be the Net Financial Liabilities of the General Government. However, this measure is still subject to substantial harmonization problems since it is not yet established how to compare the value of governments' assets across countries. An even better measure would include contingent liabilities. However, there is an ever bigger issue on how to compare these items across countries. This is though an interesting area of future research.

the countries from the right in the following way: first are the Scandinavian countries (Norway, Sweden, Denmark); then the EMU countries (Finland, Ireland, Italy, Spain, Austria, Belgium, Netherlands, France, Germany); then the Anglo-Saxon countries (Australia, Canada, the UK) and finally Japan and the US. Long-term interest rates are higher at the beginning of the sample in all countries (*Figure 1*). From 1994, there appears to be a strong convergence, with an especially marked reduction of the interest rates in the peripheral EMU countries (Ireland, Italy, Spain). Nevertheless, the convergence is observed also outside the EMU. Interest rates remain low throughout the 2000 particularly so in Japan, and they begin to diverge only during the crisis. When we look at sovereign spreads we find a similar downward trend with more variability with respect to the long-term rates for countries outside the EMU (see *Figure 2*). For EMU countries it is evident the flattening of sovereign spreads after the introduction of the single currency. However, with the outburst of the financial crisis sovereign spreads increase markedly in all countries, with the exception of the Nordic countries.

This evidence is in line with the hypothesis that countries might be subject to the same shocks causing a co-movement in interest rates and risk premia. To verify the importance of common factors, we test for the presence of cross-sectional dependence in long-term interest rates, sovereign spreads and the macroeconomic variables of interest using Pesaran's (2004) CD test. For a panel of N countries, the test statistic is constructed from the combinations of estimated correlation coefficients. Under the null of *cross-sectional independence* the statistic is distributed as a standard Normal. For all the variables in our sample we find strong evidence of cross-sectional dependence (*Table 3*). We also conducted standard stationarity tests (*Table 4*). We first implement the Pesaran's (2007) test for panel unit root and we find indication that almost all the variables can be treated as stationary. There is mixed evidence with respect to the fiscal variables. We therefore implement the Moon and Perron's test (2004) which accounts for multi-factor structure, which gives evidence of stationarity for all the variables.[17] We thus conclude that all the variables in our panel can be treated as stationary.

5 Estimation results

5.1 Baseline model

In this section we discuss the results of the estimation of (12) and (13). The set of regressors x_{it} contains the OECD forecasts of public debt, primary deficit, real GDP growth. We augment equation (12), with the expected short term interest rate[18] and the expected inflation rate - to net out of the long-term interest rate the expectations on future monetary policy stance and the inflation premium. In equation (13) we include also a measure of liquidity (the ratio of the stock of public debt over the total debt of OECD countries)[19], the VIX index and a dummy variable for the introduction of the Euro to control for the flattening of sovereign spreads after the introduction of the single currency (as in Schuknecht et al. 2011).

[17] We were unable to implement the Pesaran, Smith and Yamagata (2008) test, given that our time series is too small.
[18] We also tried using the actual 3 months interest rate from Datastream obtaining very similar results.
[19] See Gomez-Puig 2006.

Tables 5 and *Table 6* summarize the results for equation (12) and (13). In each table, *columns 1 and 2* replicate the results from previous literature using standard panel techniques, while *column 3* presents the evidence from the FAP. For equation (12) we first estimate a specification including only country fixed effects α_i (*column 1-FE*), then a second one which includes also time fixed effects τ_t (*column 2-2FE*) and finally a third one which includes both fixed effects and estimated factors (*column 3-FAP*).[20] For equation (13), we first estimate a model where the independent variables are taken in deviation from the respective variable in the benchmark country (*column 1-FE*); we then estimate a model which takes the variable in level but includes also time fixed effects (*column 2-2FE*); finally, the last column reports the estimates from the FAP (*column 3-FAP*). For the specifications in columns 2 and 3 the VIX index drops out because of the presence of time fixed effects. At the bottom of each table we include, as a further specification test, the value of the *CSD* statistic, which is Pesaran's (2006) test for cross-sectional dependence[21] [22] applied to the residuals of the estimated equation.

[Table 5 here]

In *Table 5*, we show that the positive correlation between fiscal variables and long-term interest rates previously found in the literature is not robust to the introduction of general equilibrium effects. A standard FE estimator shows that a one percentage point increase in the expected primary deficit to GDP ratio increases interest rates by around 12 basis points, while a 1% increase in the expected debt to GDP ratio increases interest rates by around 1.4 basis points (column *1*). However, the large value of the CSD statistic (46.45) for the residual, indicates that the regression is misspecified.

Looking at *columns 2 and 3* we first notice the importance of accounting for common factors. For both estimators, the CSD statistic falls markedly compared to the FE, but the FAP performs better against the 2FE (-4.5 vs. -3.5). The response of long-term interest rates to idiosyncratic factors diminishes in both cases. When we allow for heterogeneous response to global shocks with the FAP (*column 3*) primary deficit becomes statistically insignificant, while the effect of public debt becomes strongly significant. As for the magnitude, the effect is smaller

[20] The country and time fixed effects are eliminated by means of a standard within transformation applied to the left hand side and *observable* right hand side variables - See Bai 2009

[21] This test is based on the following set of hypotheses:

$$\begin{cases} H_0 : \rho_{ij} = \rho_{ji} = corr(u_{it}, u_{jt}) = 0 \quad \text{for } i \neq j \\ H_1 : \rho_{ij} = \rho_{ji} \neq 0 \quad \text{for some } i \neq j \end{cases}$$

Given the estimated pairwise correlation coefficients of the residuals:

$$\widehat{\rho}_{ij} = \widehat{\rho}_{ji} = \frac{\sum_{t=1}^{T} \widehat{u}_{it}\widehat{u}_{jt}}{\left(\sum_{t=1}^{T} \widehat{u}_{it}^2\right)^{1/2} \left(\sum_{t=1}^{T} \widehat{u}_{jt}^2\right)^{1/2}}$$

Pesaran (2006) showed that the following statistic:

$$CSD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \widehat{\rho}_{ij} \right)$$

is distributed as a *Standard Normal.* The asymptotic distribution of the test statistic is however developed for $N > T$.

[22] We report the value of the statistic instead of the *p-value* because the asymptotic for this test is developed for $N > T$ and to our knowledge there is no test of residual cross-sectional dependence which does not rely on this assumption. Hence, because in our panel we have $T > N$ we prefer to report the value of the statistic and interpret the changes in its values across different specifications as the marginal impact of the introduction of common factors in correcting cross-sectional dependence.

than in the standard FE estimator (*column 1*): a 1% increase increase in public debt increases long-term interest rates by 0.8 basis points compared to the 1.4 of *column 1.* The coefficient on the short term interest rate also decreases significantly when using the FAP, indicating that, accounting for general equilibrium effects, long-term interest rates are less responsive to domestic monetary policy. The coefficient on GDP growth is positively signed and its estimated effect is around 10 basis points for a 1% increase in expected growth rate. Finally, we find a positive but not significant relation with expected inflation.

Table 6 shows the results for the equation (13):

[Table 6 here]

The first column of *Table 6* shows the results from the FE estimator: fiscal variables are both significant and of the expected sign, but the value of the *CSD* statistic points towards the presence of cross-sectional dependence. With the introduction of time effects, the value of the *CSD* statistic decreases and of the fiscal variables only public debt stays marginally significant (*column 2*). Finally, when we introduce the estimated common factors with the FAP (*column 3*) the *CSD* statistic decreases marginally[23] both public debt and primary deficit become statistically significant. Compared to the 2FE specification the coefficient on primary deficit doubles in magnitude, with an effect of 2.6 basis points. The coefficient on public debt, instead, remains of the same order of magnitude, with an effect of 0.5 basis points. Higher expected GDP growth and more liquid markets decreases sovereign spreads. The sign and significance of the EMU dummy variable are consistent with the evidence presented in *Figure 2* which showed that the introduction of the single currency induced a marked flattening in sovereign spreads. The interest rate of the benchmark country, instead is significant and with a negative sign. The latter result shows the safe haven status of the US and German bonds and is consistent with the evidence in Schukneth et al. (2011).

5.2 Time variation in the idiosyncratic components

In this section we check whether the importance of the idiosyncratic components has been changing over time. We expect that, with the progressive financial and economic integration among advanced economies, global factors become more important and thus reduce the impact of idiosyncratic policies. We are primarily interested in the time varying effect of public debt and primary deficits. However, in the equation for the long-term interest rates we also analyse the coefficient on the short term interest rate, to assess whether the sensitivity to own monetary policy has changed over time as indicated in *Section 5.1.* In the equation for sovereign spreads, instead, we also look at the coefficient on the interest rate of the benchmark country. Some studies on sovereign spreads (Manganelli and Wolswijk 2009) have in fact found a positive effect of the benchmark interest rate. Lower interest rates are associated with higher liquidity which, in normal times, causes a 'flight to returns' therefore depressing sovereign spreads. The last part of the sample includes the financial crisis and allows us to check for this effect.

[23] The small decrease in the value of the *CSD* statistic when going from the 2FE specification to the FAP specification can be due to the fact that when estimating equation (13) we allow the coefficients on the factors to vary across country groups instead than across countries. In *Section 7* we show that when increasing the number of country groups the *CSD* statistic does decrease in absolute value and our main results are preserved.

Practically, we re estimate (12) and (13) and perform rolling regressions on a window of 24 periods.[24] The results are presented in *Figure 3* and *Figure 4.*

[Figure 3 and 4 here]

Figure 3 shows the behaviour of the coefficients on primary deficit, public debt and short-term interest rates estimated from the equation for long-term interest rates. As expected, there seems to be a clear downward trend in the coefficients, indicating a progressive loss of importance of domestic policy variables. This is the case for both fiscal and monetary policy. Apart from the last spike relative to the period of the last financial crisis, the coefficient on the short term interest rate shows that central banks have been progressively losing effectiveness in stirring long-term rates. This evidence is consistent with that presented by Giannone et al (2009), who show how in the recent decades long-term interest rates have become more disconnected from country-specific monetary policy stances.

Figure 4 shows the results for the coefficients on public debt, primary deficit and the benchmark interest rate r_t^B estimated from the equation for sovereign spreads. The importance of idiosyncratic fiscal factors stays flat for most of the sample and then increases for the last observations. Consistently with the evidence presented by Sgherri and Zoli (2009), we find that in times of crisis markets attach higher weight to fiscal fundamentals when pricing risk. The coefficient on r_t^B is positive in the first part of the sample, while it turns negative in the last years. This shows that, in crisis times agents fly to safety and invest excess liquidity in risk free bonds, therefore depressing their yields and further increasing the interest rate spread of risky assets.

5.3 Are crisis episodes different?

This section analyses the impact of fiscal policy on sovereign risk during episodes of financial stress. *Figure 4* shows that the coefficients on primary deficit and public debt increase in magnitude in the last part of the sample. However we want to test whether this is a more general results that apply to other periods of crises. We therefore re-estimate the equation for sovereign spreads (13) interacting the idiosyncratic fiscal policy variables with dummy variables for crisis periods. The results are reported in *Table 7.*

[Table 7 here]

Our preferred specification uses a spline for expected debt and expected deficit, obtained interacting those two variables with two dummies, one which takes value of 1 during episodes of crisis and the other which takes value 1 otherwise. To define periods of crises we use both the dummy variable created by Laeven and Valencia (2008)- *columns 1 to 4* - and a dummy variable which takes value 1 only during the last two years of the sample 2008-2009 - *columns 5 to 8.* In *columns 1 and 5* we introduce a new explanatory variable, the *'Deficit Gap'* which we construct as the interaction between the stock of expected debt (scaled by GDP) and the difference between the expected

[24] Having 49 time periods, the size of the window is determined by having an equal split of the sample in the first regression.

deficit and the surplus that would stabilize the debt to GDP ratio, for given real interest rates and growth rates (Faini, 2006).[25] This variable captures the sustainability of the fiscal policy stance given the expected path of the economy. In times of crises, investors might perceive the required fiscal adjustments to be politically infeasible and hence they will start discounting for the probability that the government might renege on its debt. The results from *Table 7* indicate that both the 'deficit gap' and the simple budget deficits have a higher impact on sovereign spreads during crisis times. *Columns 1 to 4* show that coefficients on the 'deficit gap' goes from 2.1 to 3.8 basis points, while those on primary deficit more than double in magnitude going from 2.2 to 4.8 basis points. On the other hand, the coefficients on the level of public debt do not vary much, with values in the range of 0.4 and 0.5 basis points; moreover, we cannot reject the null of equality between those coefficients (bottom panel of *Table 7*). The results are very similar irrespective of the way we define episodes of financial crises (*columns 5-8 Table 7*). We also included interaction terms of the fiscal variables with the VIX index, but we did not find any significant result. However, we will show in *Section 6* that there exists a positive relationship between countries' stock of debt and the size of the country-specific response to an increase in the global risk factor f_t^{RP}.

5.4 Non-linear effects of fiscal variables

In this section we investigate the presence of non-linearities with respect to the fiscal variables, to check if the effects on interest rates and sovereign spreads are different at different thresholds of public debt and deficit (see for example Ardagna et al. 2007 or Schuknecht et al. 2011). We test different specifications: some which include the squared term of public debt and primary deficit, others which include the interaction between the fiscal variables and dummy variables equal to one or zero depending on whether debt and deficit are above or below their average value in each country.

[Table 8 and 9 here]

The results for the long-term interest rates (*Table 8*) show no evidence of non linearities. Squared terms of public debt and of primary deficit are never significant, and when included in the regression they decrease the level of significance of the linear terms as well (*Columns 1 and 2*). When we estimate the specification with the spline for the fiscal variables (*Columns 3 to 5*) we find that the coefficients on the level of public debt are remarkably stable at 0.8 basis points and remain statistically significant. Primary deficit, instead remains insignificant as in the baseline estimation (*Table 5*).

When we conduct similar tests for the spreads equation, we also fail to find robust evidence of non-linearity for the primary deficit. The specification in *Column 1* (*Table 9*) in fact shows that primary deficit is statistically significant when it is introduced as a squared term, while specifications in *Columns 3 and 5* show that the effect on risk premia goes from 3 to about 4.8 basis points when the primary deficit is larger than its long-run average,

[25] See the Appendix C.

but a t-test cannot reject the null hypothesis that the estimated coefficients for different levels of primary deficit are the same. For public debt, instead, we find no evidence of non linearity.

5.5 Discussion

The results so far indicate that, when we use the *FAP* estimation to account for heterogeneous responses to global shocks: (1) long-term interest rates remain positively related only to public debt; (2) both public deficits and debt instead affect positively sovereign spreads; (3) there is mild evidence of increased importance of primary deficits in determining sovereign spreads during crisis periods; (4) we fail to find statistical evidence of non-linear effects stemming from idiosyncratic fiscal policy. Our results stand partly in contrast with previous literature. In particular, past studies have found a significant effect of public deficits on long-term interest rates (Ardagna et al. (2007)). We argue that a likely explanation behind this difference is related to the robust estimation framework that we adopt in this paper. The effect of public debt on long-term interest rates is also smaller compared to previous estimates. Laubach (2009) for example, finds that a 1% increase in public debt to GDP leads to an increase in long-term interest rates by 3 to 4 basis points, while we find that the effects are less than 1 basis point. We argue that our results are consistent with the implications of theoretical model if we change the assumption on the degree of crowding-out. Laubach (2009) shows that, within the neoclassical growth model, under the assumption that roughly two-thirds of the increase in public debt is offset by domestic savings, a 1% increase in public debt to GDP leads to an increase in real interest rates by 2.1 basis points.[26] However, recent evidence on the Feldstein-Horioka regression by Giannone and Lenza (2008), show that less than one-fifth of savings in developed countries are retained for domestic investment. This evidence on the lower degree of crowding-out reconcile our estimates with theory, and generate effects of public debt on real interest rates in the range of 0.8 basis points (Table 5, *Column 3*).[27]

6 Effects of global shocks

In this section, we analyse quantitatively the importance of these elements. In particular, we focus on how shocks to the aggregate fiscal stance and to investors' risk aversion transmit to domestic long-term rates and sovereign rate spreads respectively. In terms of our estimating equations, we analyse the magnitude and the cross-country differences in the coefficients δ_{2i} in equation (12) and Ψ_i in equation (13).

The existing literature has already recognized the importance of these global effects. Faini (2006) for example, analyses the effect of a 'global fiscal expansion' for EMU countries; Ardagna et al. (2007) extend their sample to the OECD while Claeys et al. (2008) used a panel of 100 countries. In all cases, the effects are found to be statistically

[26] Following the discussion in Lubach (2009), the effect of 1% increase in public debt to GDP on interest rates is given by the formula:

$$(1-s)cs/k^2 \tag{15}$$

where *s=0.33* is the capita share on national income; *k=2.5* is the capital-output ration; *c=0.6* is the degree of crowding out.

[27] Assuming the parameter is *c=0.2* the estimated effect is 0.7 basis points.

significant and much larger than those of domestic fiscal shocks.[28] Likewise, the effects of global risk aversion have been largely underlined in studies of sovereign spreads (see for example Codogno et al. 2003, Geyer et al. 2004, Baldacci et al 2008, Attinasi et al. 2009, Barrios et al. 2009, Ciarlone et al 2009, Manganelli and Wolswijk 2009, Mody 2009, Sgherri and Zoli 2009). However, in these works the effects of global factors have always been assumed to be homogeneous across countries.

One important advantage of our approach is that we can analyse not only the relative magnitudes of the effects of idiosyncratic versus global shocks, but we can also study how the effects of global shocks differ across the countries in our sample. For instance, when global deficits increase we would expect interest rates to respond more in countries with relatively closer capital account, as they can only draw from the smaller pool of national savings instead that from the world market. Alternatively, interest rates might increase more in countries with large current account deficits. When global risk aversion increases, instead, we would expect investors to discriminate more carefully among countries, and ask higher returns to governments which are deemed to be less safe - either because of bad fundamentals or because of bad institutions.

To estimate the effects of these global factors we re estimate equations (12) and (13) replacing the estimated factors with their economic interpretation. As discussed in *Appendix A* we use the average expected primary deficit[29] and the average expected short term rate of the countries in our sample, plus the VIX index in the equation for the spreads. Moreover, in this second case we allow the coefficients Ψ_i to vary across countries instead of across country groups.

The first column of *Table 10* refers to the estimated value of the coefficients δ_{2i} in equation (12) and represent the effect on long-term interest rates of an increase in global fiscal stance. The same coefficients are also plotted in *Figure 5* for easier comparison across countries. We can see that the effects of an increase in global fiscal stance are quantitatively important and heterogeneous across countries. There seems to be a clustering of countries, with Ireland, Italy and Spain displaying the highest coefficients. For them, a one percentage point increase in average deficit increases nominal interest rates between 34 and 50 basis points. Positive effects are also observed for the group of the core EMU members (Austria, Belgium, Netherlands, France), the Nordic countries (Finland, Denmark, Sweden), and the Anglo-Saxons (UK and Australia). For these groups, however, the coefficients are about 50% smaller, ranging between 10 and 25 basis points, with the exception of Finland which reaches almost 30 basis points. The group of countries for which the estimated coefficients are the lowest is composed of the US, Norway and Germany, which are also the only countries for which the estimated coefficients are not statistically significant. These are countries that are either relatively 'large' (US, and Germany) and therefore more likely to behave as closed economies; or for which availability of capital is more driven by the exogenous variation in the price of oil

[28] Faini (2006) finds that the effects on interest rates of domestic fiscal policy shocks are rather small compared to those caused by a global fiscal expansion: a change in domestic surplus leads to a 5 basis points reduction of interest rates, while a change in the EMU surplus leads to a 41 basis points decrease in interest rates. Ardagna et al. (2007) obtain similar results for the OECD. They analyse the world fiscal stance as both the aggregate primary deficit and the aggregate debt. They find that, depending on the specification, the world deficit leads to increase in interest rates between 28 and 66 basis points, while world debt increases interest rates between 3 and 21 basis points. In both papers, the effects of global shocks are supposed to be homogeneous across countries.

[29] The theory would suggest to use the *world* fiscal stance as control. Here, we use instead the average fiscal stance in 17 advanced economies. We believe this provides a reasonable approximation (see also Ardagna et al.(2007) on the point).

and natural gas (Norway). Quantitatively, average deficit is by far more important than the idiosyncratic fiscal components. Its average effect is in fact around 21 basis points, which is more than ten times larger than the effect of an increase in idiosyncratic primary deficit.

[Figure 5 here]

Besides recognizing the quantitative importance of the effects of global fiscal stance, our framework allows us to investigate the driving factors behind their cross-sectional dispersion. *Figure 6* shows that there exists a relationship between the estimated coefficients and: (i) the level of capital markets integration measured by the Chin and Ito Index[30] (top panels of *Figure 6*); (ii) the initial level of long-term nominal interest rates and (iii) the size of the current account imbalances (bottom panels of *Figure 6*). This descriptive evidence provides an explanation of the dynamics of long-term interest rates. A global fiscal retrenchment, like the one which took place among industrialized countries at the beginning of the nineties, increases aggregate savings and therefore causes long-term interest rates to decrease. This reduction is facilitated by the progressive integration in the capital markets, which induces interest rates in different countries to converge to the 'world interest rate'. For this reason the effects are larger in countries where long-term interest rates were initially higher, or in countries which were initially more closed to foreign capital[31] However, the progressive financial integration can also have side effects and create elements of vulnerability which translate into higher long-term rates in case of a sudden increase in global deficit such as large current account imbalances. Global fiscal expansion would drain aggregate savings pushing up the 'world interest rate'. As a result of higher need for savings, investors will repatriate capital from abroad, therefore making savings scarcer in countries with large current account deficits. Finally, a global fiscal expansion can have larger effects on long-term rates also in countries which have relatively closer capital account as these can only access their national pool of resources.[32]

[Figure 6 here]

Fgure 7 reports the estimated coefficients Ψ_i which represent the country specific effect on sovereign spreads of an increase in global risk aversion (see also *column 2 of Table 10*). Even in this case there seems to be clusters of countries, with Ireland and Italy having the highest coefficient and the Nordic countries and the UK with a negative value. However for most countries the effects are quite large. For instance, Italy and Ireland during the crisis saw their interest rates surge respectively by 150 and 300 basis points over the German Bund. During the same period the VIX index increased by about 30 points, meaning that the country specific response to global risk aversion can account for respectively 25% and 40% of the total increase in their spreads.

[30] Chin and Ito (2009).

[31] High long term rates and low financial integration are most likely two sides of the same coin.

[32] In terms of our theoretical model - equation (4) - the responsiveness of the domestic interest rates to the global factors are given by $\delta_{ki} = \lambda^r_{ki} - \beta\lambda^X_{ki}$. This means that they are directly proportional to the responsiveness of the domestic interest rates to the global factors and inversely related to the responsiveness of the regressors x_{it}.For instance, a close capital account translates into a higher value of the coefficients λ^r_{ki} because an expansion of aggregate budget deficits would mean relatively higher excess demand of capital for countries that can only access their domestic capital markets.

Figure 8 provides an interpretation for the differences across these estimated coefficients, relating them to the soundness of the fiscal sector - in terms of the stock of accumulated debt - and to the quality of the government. The first plot shows that there exists a positive correlation between the average stock of debt to GDP and the estimated values of the Ψ_i coefficients. This is therefore a channel through which fiscal fundamentals interact non linearly with global risk aversion in the determination of sovereign spreads. The second and third plots of *Figure 7* show that the estimated coefficients on global risk aversion are also related to the quality of government, measured by: (i) the incidence of corruption - computed as an average between the World Bank indicator of 'control of corruption' and the corruption index of the International Country Risk Guide[33] and (ii) institutional quality - computed as the average of six indicators taken from the World Bank.[34] Indeed countries with poor institutional quality and corrupt governments are those which are harshly punished by markets in periods when investors are unwilling to take risks.

[Figures 7 and 8 here]

Overall, these results give us a key of interpretation for the observed behaviour of interest rates and sovereign spreads. The first piece of evidence *(Figures 5 and 6)* suggests that one of the explanations for the observed common downward trend of long-term interest rates over the years 1992 to 2000 is the common move of the governments of most industrialized countries towards fiscal discipline, which has increased aggregate savings. Macroeconomic vulnerabilities such as large current account deficits however, are likely to aggravate the increase in interest rates which would follow an aggregate increase in budget deficits (Giavazzi and Spaventa, 2010). The second piece of evidence - *Figures 7 and 8*- instead, shows that when uncertainty shakes financial markets the country-specific response of risk premia seems to depend mainly on investors' perception of the soundness of fiscal fundamentals and on institutional quality. High stocks of public debt and ineffective governments constitute a potent signal for investors about the inability - or at least the difficulty - for certain countries to implement the austerity packages that markets expect in periods of emergency.

7 Robustness checks

In this section we report the results from some robustness checks. The first check consists of replacing the factors estimated from principal components with what we found to be their economic interpretation. That is, we replicate the results of the third column in *Table 5 and 6* but instead of the estimated factors we use: the average expected deficit and the average expected short term interest rate in the equation for the long-term interest rates, plus the VIX index in the equation for the spreads. From an econometric perspective the consistent estimates of the unobservable common factors are the eigenvectors extracted from the matrices W^r and $W^{spreads}$. However,

[33] Because the two indices have different scale they have been standardized before averaging. Low value indicate high incidence of corruption.

[34] The six indicators are: 1) Voice and Accountability; 2) Political stability; 3) Government Effectiveness; 4) Regulatory quality; 5) Rule of law; 6) Control of corruption. As before the measures have been standardized before being averaged

replacing them with actual data can give us a proof of how good our interpretation of the unobserved factors is. The results for both the long-term interest rate equation and the spreads equation (*Columns 1 and 3 Table 11*) are remarkably similar to those obtained with the estimated factors (*Columns 2 and 4 Table 11*). The test statistic of cross-sectional dependence on the residuals is also similar. Hence, we conclude that replacing the factors with their observed counterparts has only a marginal effect on standard errors, rather than on the estimated coefficients. We interpret this result as a further validation of our interpretation for the estimated factors.

[Table 11 here]

The second robustness check we perform is a cross-validation. We check whether the results from our baseline specifications - *equations (12)* and *(13)* - are confirmed if we exclude from the estimation one country at a time. In the specification for the nominal interest rate (*Table 12*) we can notice that the primary deficit turns out to be significant once we exclude Canada, while public debt remains significant throughout and rather stable in magnitude. Public debt remains significant and stable also in the equation for the interest rate spreads (*Table 13*), but the primary deficit turns insignificant if we exclude Ireland from the sample.

[Table 12 and 13 here]

A third robustness check is to include as a further regressor in both equations the current account balance (scaled by GDP). Small open economy models predict current account deficits to have no effect on interest rates as they create an appreciation of the real exchange rate, which decreases domestic demand and corrects the current account imbalances. In analyses for sovereign spreads, instead, the current account balance is introduced as a further indicator of economic performance, which provides information about the ability to repay foreign debt. Higher current account deficits should therefore induce higher sovereign spreads (see Baldacci et al. 2008).

Before running the regressions we checked that the inclusion of the new regressor did not alter the behaviour of the extracted principal components. Results are reported in *Table 14*.

[Table 14 here]

The current account balance enters with a negative sign indicating that a higher deficit tends to increase nominal rates and spreads. However it is always far from being statistically significant and its inclusion does not affect the main results.

As a fourth robustness check we re-estimate our baseline equation using different techniques: Pesaran's (2006) *Common Correlated Effect (CCE)* and Bai's (2009) *Interactive Fixed Effects (IFE)*. As shown in *Appendix B*, the (CCE) estimator consists of introducing cross-sectional averages of the dependent and the independent variables in the equation. Since cross-country aggregates average out idiosyncratic components, for large cross-sectional dimensions they tend to approximate the common factors. Contrary to the *FAP* this method does not provide us with a direct estimate of the unobserved factors, which is something we are interested in. Bai (2009) instead, has recently suggested the use of an estimator called Interactive Fixed Effects (*IFE*) which combines standard OLS and principal components, and allows to specify the number of unobservable factors which one wants to control for. When we use these estimation techniques for long-term interest rates (*Table 15*, *Columns 1 to 3*), the *IFE* estimator seems more in line with the results from the *FAP,* while using the *CCE* we find slightly smaller coefficients for expected growth and expected debt and larger coefficients for other variables. When the same estimators are applied to the equation for the spreads[35] - *Columns 5 and 6* of the same table - we can notice that the coefficient on expected debt remains significant and very similar across the different methods. The other coefficients, instead, display more variation.

[Table 15 here]

We also checked whether our results are robust when we change the specification of equation (13) to get closer to the equation implied by our theoretical model (11). In *Section 3.1.1* in fact we showed that sovereign spreads are a function of 4 common factors: three unobservable plus the interest rate of the benchmark country r^B, all of them with country specific coefficients. To avoid running out of degrees of freedom we constrained the coefficients on r^B to be constant across countries and we let those on the other factors vary across 3 country groups (EMU, Nordics, Others). Here we relax this assumption and estimate different specifications in which we add a fourth country group that includes Italy, Spain and Ireland.[36] Results are reported in *Table 16.* Next to the baseline results (*Column 1*) we report three different specifications: one where we allow also the coefficients on r^B to change but we keep the number of groups to 3 (*Column 2*); one where we let only the coefficients on the 3 estimated factors change across the 4 country groups (*Column 3*); and finally one where all the coefficients on the 4 factors are allowed to vary across the 4 country groups.

Results for the fiscal variables are robust although increasing the number of groups marginally decreases the significance of the effect of primary deficits. In terms of cross-sectional dependence we can see that the *CSD* statistic decreases when introducing four country groups, indicating that allowing for country-specific effects is indeed important to correct for the cross-sectional dependence due to unobserved factors. If instead the effect of global shocks is homogeneous - as it is in our case for r^B - then allowing country-specific responses does not make a difference, as we can see by comparing the values of the *CSD* statistic between *Columns 1 and 2* and *Columns 3 and 4*.

[Table 16 here]

As further checks we repeated the estimations splitting the sample to consider separately data belonging to the June and to the December issues of the OECD forecasts and obtained similar results. We also checked for the presence of structural breaks after the introduction of the Euro in the equation for long-term interest rates

[35] In the IFE we imposed a number o factors equal to 3 to be consistent with the model derived in Section 3.

[36] The country groups are therefore: (i) EMU: France, Austria, Belgium, Netherlands, Finland (ii) Peripheral EMU: Italy, Ireland, Spain; (iii) Nordics: Norway, Sweden, Denmark; (iv) Others: UK, Canada, Australia, Japan.

using a spline regression analogous to that used to study the effects of financial crises (*Table 7*). There appears to be a break in the coefficient on the inflation rate, which is found to be positive and significant only for countries and periods not belonging to the EMU. We interpret this result as the 'credibility effect' due to the presence of an inflation averse Central Bank. Finally, we repeat our estimation of the equation for the spreads using the US interest rate as the only benchmark for all countries and obtained results which are similar to our baseline.

8 Concluding remarks

In this paper we tackled the issue of identifying the effects of fiscal policy on long-term interest rates and yield spreads for a panel of OECD countries. We use real time data on forecasts to limit issues of reverse causality and to better take into account the forward looking nature of the responses of financial markets. The strong correlation observed across interest rates and sovereign spreads in different countries justifies the use of an estimator which takes into account the presence of unobservable global factors. We use a *Factor Augmented Panel (FAP)*, an estimation procedure originally developed by Giannone and Lenza (2008). This methodology allows us to obtain consistent estimates of the parameters and to study the heterogeneity of the cross-country propagation of global shocks. We show that in general two unobserved factors can explain more than 60% of the variance in the data, both for bond yields and for sovereign spreads. We identified these factors to be the aggregate monetary policy and the aggregate fiscal policy stances. In addition, sovereign spreads depend also on global risk aversion, which accounts for about 12% of the panel variance.

Our results show that global factors are not only quantitatively relevant determinants of sovereign yields and spreads, but once introduced in the analysis, they also affect the importance of the idiosyncratic components. In the equation for the long-term interest rates, when using the *FAP* estimation method, the role of domestic fiscal policy variables is largely reduced: public debt is still significant, but contributes by only 1 basis point. On the other hand, when using the *FAP* to analyse sovereign spreads we find that, contrary to the results obtained with standard fixed effects estimators, both public debt and primary deficit are statistically significant and of the expected sign, contributing by 0.5 and 2.6 basis points respectively. In contrast to some of the previous literature we also find no evidence of non-linear effects of public debt, but we do find mild evidence of non linearity of primary deficit in determining risk premia. Moreover, we show that both primary deficit and measures of expected fiscal sustainability tend to be more important for sovereign yield spreads in periods of financial crises.

As for the role played by global factors we find that global supply of funds, represented by global monetary and fiscal policy stances plays a relevant role in affecting long-term interest rates. The effects of the global fiscal stance are by far quantitatively more important than domestic fiscal policy alone, and are significantly heterogeneous across countries. The magnitude of these effects ranges between 3 and 50 basis points with stronger effects for countries that were relatively less financially integrated, and that have large current account deficits. Similar degree of heterogeneity is found when we analyse the propagation of shocks to aggregate risk aversion on sovereign spreads.

Risk premia increase proportionately more for countries with higher stocks of public debt and weaker governments, with effects up to 2.5 basis points.

Our results provide an interpretation of the recent behaviour of interest rates and sovereign risk premia in advanced economies. While during the nineties the general movement towards fiscal consolidation and low monetary policy rates has contributed to low long-term interest rates and low sovereign spreads, during these last years the increase in countries' budget deficits and the collapse in market confidence have reversed this process. These shocks have triggered an heterogeneous increase in borrowing costs with peripheral countries or countries with fiscal or institutional vulnerabilities suffering proportionately more. Hence, even if financial integration reduces the impact of national policies on borrowing costs, changing in the global financial condition may expose more vulnerable countries to a sudden reversal of fortunes.

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9 APPENDIX A: Factor extraction and interpretation

The aim of this appendix is to provide more details on the extraction of the factors and present the evidence for their economic interpretation. As mentioned in *Section 3.2* we extract two sets of factors, the first one for the equation for the long-term interest rates and the second one for that of sovereign spreads. They are extracted from the variance covariance matrices of W^r and $W^{spreads}$ respectively.

The first matrix W^r contains the following elements:

$$W^r = \begin{bmatrix} r & stnr & infl & g & pdef & debt \end{bmatrix}$$

where - as mentioned in the paper - r is the $(T \times N)$ matrix of long-term interest rates, $stnr$ the matrix of expected short-term rates, $infl$ is the matrix of expected inflation rates, g that of expected real GDP growth rates and $pdef$ and $debt$ those of expected primary deficits and public debts respectively. The second set of factors - for the spreads equation - are instead extracted from a similar matrix $W^{spreads}$ which is constructed as:

$$W^{spreads} = \begin{bmatrix} r - r^B & stnr & infl & g & pdef & debt & r^B & VIX & liq \end{bmatrix}$$

The long-term interest rates r have been replaced by the sovereign spreads and the expected long-term interest rate of the benchmark country r^B. The VIX is the Chicago Board Options Exchange Market Volatility Index. Additionally we introduced a measure of liquidity (the ratio of government debt over the total debt of the OECD countries as in Gomez-Puig 2006), which is usually included as a control in an equation for the spreads.

A first important decision in our analysis is the determination of the number of factors to include in the regression. In the empirical literature on factor models, the determination of the number of factors has been a subject of intense research. For example, Forni and Riechlin (1998) propose a rule of thumb according to which one should retain the number of principal components that explains more than a certain fraction of the variance, while Bai and Ng (2002) present a formal test based on information criteria. In our case *Table 1* shows that in general the first two components extracted from W^r and $W^{spreads}$ explain a large proportion of the panel variance. In both cases the cumulated variance explained by the first two factors is around 66%. The third factor explains around 9% in the first case and 12% in the second case. Therefore, following the rule of thumb proposed by Giannone and Lenza (2008) we decide to include two factors in the equation for the long-term interest rates and three in the one for the spreads.

[Table 1 here]

Another important point is the economic interpretation of the common factors. To find it we follow economic intuition. It is plausible to think that in integrated capital markets the global factors driving the interest rates must be related to the global availability of funds. Aggregate supply of savings, is in turn affected by the aggregate fiscal stance - which is the "public" component of savings - and by aggregate monetary policy stance, which drives the availability of liquidity in the market. This intuition is well supported by the data.

In fact, as shown in *Figure 9*, the first two factors extracted from W^r are very much correlated with the average short term interest rate and with the average primary deficit.

[Figure 9 here]

Given that the extracted factors are standardized, we also standardize the short term interest rates and the deficits before computing the averages across countries. To give quantitative support to our interpretation, we then try to regress our estimated factors on the average short term rate and on the average deficit respectively. *Table 17* reports the results of this exercise. In both cases the constant term is close to zero and never significant, while the coefficient on the estimated factor is close to one. Moreover the R^2 indicates a very good fit.

[Table 17 here]

As shown in *Section 3* the factors extracted from $W^{spreads}$ should track average fiscal and monetary policy stances and a measure of risk aversion. *Figure 10* shows that this is indeed the case. The three plots show the three estimated factors against average deficit, the VIX index and average short term interest rate.

[Figure 10 here]

Again, by regressing our extracted factors on their proposed interpretation (*Table 18*) we obtain a good fit. The coefficients on the average deficit and the VIX index are close to one, while the coefficient on the average monetary policy is a bit lower. The fits in term of R^2 are good for the first two equations and only less so for the last one.

[Table 18 here]

We conclude that this methodology of extracting factors provides us with quantities whose interpretation is in line both with economic theory and with the theoretical derivation of the estimating equations (12) and (13).

10 APPENDIX B: Factor structure and Estimation techniques

Factor models of the type presented in the paper have been discussed in some recent theoretical work. Pesaran (2006) and Bai (2009) present alternative estimation techniques for econometric models with errors characterized by factor structure. Both of them assume a data generating process which can be summarized as follows:

$$y_{it} = A_i \Gamma_t' + x_{it}'\beta + e_{it} \tag{16}$$

$$e_{it} = \phi_i' F_t + \varepsilon_{it} \tag{17}$$

where the main equation (16) allows for two way fixed effects ($A_i = \begin{bmatrix} \alpha_i & 1 \end{bmatrix}$; $\Gamma_t = \begin{bmatrix} 1 & \gamma_t \end{bmatrix}$), the error term follows a factor structure (17) and the set of k regressors x'_{it} is supposed to be a function of M unobserved factors stacked in the vector F_t. As for the model presented in *Section 3.1*, the data generating process creates cross-sectional dependence both in the dependent variable - as a consequence of the factor structure of the error term - and of the regressors - as a consequence of their dependence on the factors.

The key issue is that in both cases the common factors are correlated with the regressors and are therefore a cause of endogeneity. Moreover, because their effect is heterogeneous across countries, they cannot be eliminated by means of a within transformation or with the introduction of time dummies. As pointed out by Giannone and Lenza (2008) and Bai (2009) in fact, it is the *heterogeneity* which implies a factor structure as, if factors had homogeneous effect on the dependent variable, the model would collapse into the usual time effects model ($\delta_t = \phi' F_t$).

Although starting from the same data generating process, the specifications presented by Bai (2009) and Pesaran (2006) differ in the way they model the correlation between the observable regressors x'_{it} and the M unobservable components F_t.

Bai (2009) deriving his *Interactive Fixed Effects Estimator (IFE)* assumes a functional form for the regressors like:

$$x_{it} = b' F_t + \phi'_i a + c\phi'_i F_t + \pi'_i \Phi_t + v_{it} \tag{18}$$

where the regressors are allowed to be correlated with the factor loadings alone or the factors alone, or simultaneously with both and where Φ_t is a set of q common factors which does not enter the y_{it} equation.

Pesaran (2006), instead, assumes the regressors to be function of the unobservable factors and loadings:[37]

$$x_{it} = b'_i F_t + v_{it} \tag{19}$$

Bai (2009) demonstrates that the model in (16) to (18) can be estimated with an iterative procedure which uses Principal Components and OLS. As a first step the variables need to be transformed using a within transformation to eliminate country and time fixed effects. Then, called $\dot{x}_{it}$and $\dot{y}_{it}$the transformed variables,[38] the model can be estimated by minimizing a simple sum of squared residuals:

$$SSR(\beta, F, \lambda) = \left[\sum_{t=1}^{T} \sum_{i=1}^{N} \left(\dot{y}_{it} - \dot{x}'_{it}\beta - \phi'_i F_t \right)^2 \right]$$

Dependent variable and regressors can be stacked in vector and matrices of dimension $(T * 1)$ and $(T * k)$ respectively, which are denoted in capital letters. Given an estimate of F_t, the OLS estimates for β and ϕ would be given

[37]Both formulation allow for individual specific or time specific components as well. Here we omit them for simplicity.

[38]This is the standard transformation for the within estimator in presence of two-way fixed effects:

$$\dot{z}_{it} = z_{it} - \overline{z}_{i\bullet} - \overline{z}_{\bullet t} + \overline{z}_{\bullet\bullet}$$

by:

$$\widehat{\beta}_{IFE} = \left(\sum_{i=1}^{N} \dot{X}_i' M_{\widehat{F}} \dot{X}_i \right)^{-1} \sum_{i=1}^{N} \dot{X}_i' M_{\widehat{F}} \dot{Y}_i \tag{20}$$

with the matrix $M_{\widehat{F}}$ defined as: $M_{\widehat{F}} = I_T - \widehat{F}\left(\widehat{F}'\widehat{F}\right)^{-1}\widehat{F}'$, where the hat indicates a consistent estimate. Conditional on estimates of β, instead, estimates of the factors F_t can be obtained using principal components:

$$\widehat{F}V_{NT} = \left[\frac{1}{NT} \sum_{i=1}^{N} \left(\dot{Y}_i - \dot{X}_i \widehat{\beta} \right) \left(\dot{Y}_i - \dot{X}_i \widehat{\beta} \right)' \right] \widehat{F} \tag{21}$$

where V_{NT} is the diagonal matrix of eigenvalues of the matrix WW':

$$WW' = \frac{1}{NT} \sum_{i=1}^{N} \left(\dot{Y}_i - \dot{X}_i \widehat{\beta} \right) \left(\dot{Y}_i - \dot{X}_i \widehat{\beta} \right)'$$

Iterating over (20) and (21) therefore can yield consistent estimates for β and F. Finally, the estimates for the factor loadings ϕ_i' are then given by: $\phi_i' = \frac{1}{T}\widehat{F}\left(\dot{Y}_i - \dot{X}_i\widehat{\beta}\right)$. Bai (2009) derives the asymptotic distribution of the estimator under different assumptions on the error term and presents a bias corrected version of the estimator which is to be used in presence of serial correlation or heteroskedasticity in the errors. The estimates reported in *Table 15* use the bias corrected version of the estimator.[39]

Pesaran (2006) instead, derived a consistent estimators for the parameters β - called *Common Correlated Effects Estimator (CCE)* - under the assumptions that the structural model is represented by (16) ,(17) and (19). He showed that under the assumption of stationarity of common factors and independence of the idiosyncratic shocks, a consistent estimator for the parameters β_i for country i is given by the following expression:

$$\widehat{\beta}_{iCCE} = \left(X_i' \overline{M}_w X_i \right)^{-1} X_i' \overline{M}_w Y_i$$

where X_i' and Y_i are the $(T * k)$ and $(T * 1)$ matrices of data and $\overline{M}_w$ is the matrix that isolates the component of the variables which is orthogonal to the cross-sectional averages of both the dependent and independent variables. In fact $\overline{M}_w$ is defined as:

$$\overline{M}_w = I_T - \overline{H}\left(\overline{HH}'\right)^{-}\overline{H}'$$

with the matrix $\overline{H}$ collecting the deterministic common effects Γ_i and the cross-sectional (weighted) averages of both the dependent variable Y_i and the set of regressors X_i :[40]

$$\begin{aligned} \overline{H} &= (\mathbf{\Gamma}, \overline{Z}) \\ \mathbf{\Gamma} &= (\Gamma_1, ..., \Gamma_T); \quad \overline{Z} = \left(\sum_{i=1}^{N} \omega_i Y_i, \sum_{i=1}^{N} \omega_i X_i \right) \end{aligned}$$

[39]For more details see Bai (2009) Section 7

[40]Following Pesaran (2006) we indicate with $\left(\overline{HH}'\right)^{-}$ the generalized inverse of $\overline{HH}'$.

In our case, given that N is large we set $\omega_i = \frac{1}{N}$. A single value for the β coefficients can be computed using a simple average of the $\widehat{\beta}_i$:

$$\widehat{\beta}_{CCE,MG} = \frac{1}{N}\sum_{i=1}^{N} \widehat{\beta}_{iCCE}$$

where MG stands for *"Mean Group"*. This is equivalent to estimating by OLS an equation augmented by the cross-sectional (weighted) averages of $\left(\overline{Y}_{\bullet t}, \overline{X}_{\bullet t}\right)$. The estimation of the parameters The logic behind this procedure is that as $N \to \infty$ cross-sectional averages should converge to the common factors because the average of the idiosyncratic components goes to zero as N increases. Hence, a regression that uses observable variables 'purged' by cross-sectional averages should be able to capture the effects of the idiosyncratic components only.

10.1 Equivalence of the structural models: FAP, CCE, IFE

It is easy to show that both the estimation strategies by Giannone and Lenza (2008) and Pesaran (2006) and Bai (2009) are somewhat equivalent in terms of the structural model they estimate.

We saw in *Section 3.1* that estimating the equation:

$$y_{it} = \alpha_i + \tau_t + \sum_{k=1}^{M} \delta_{ki} f_{kt} + \beta x_{it} + u_{it} \tag{22}$$

is equivalent to estimate the linear relationship between the unobservable idiosyncratic components of interest rates and macroeconomic variables once the factor structure of dependent variable and regressors is taken into account.

Now, note that the system (16) ,(17) ,(19) can be rewritten as:

$$y_{it} = A_i \Gamma_t' + \left(\beta b_i' + \phi_i'\right) F_t + \beta v_{it} + \varepsilon_{it} \tag{23}$$

$$= A_i \Gamma_t' + d_i' F_t + \zeta_{it} \tag{24}$$

$$x_{it} = b_i' F_t + v_{it} \tag{25}$$

which is very similar to our specification in (2). As before, if we suppose there exist a relationship between the two idiosyncratic components:

$$\zeta_{it} = \beta v_{it} + \omega_{it}$$

we can express it in terms of the observable variables by substitution:

$$y_{it} - A_i \Gamma_t' - d_i' F_t = \beta \left(x_{it} - b_i' F_t\right) + \omega_{it}$$

which can then be rewritten in the familiar form of our estimating equation (22) :

$$\begin{aligned} y_{it} &= A_i \Gamma_t' + \beta x_{it} + (d_i' - \beta b_i') F_t + \omega_{it} \\ &= A_i \Gamma_t' + \beta x_{it} + \delta_i' F_t + \omega_{it} \end{aligned} \tag{26}$$

A very similar expression can be obtained starting from equations (16) , (17) , (18).

11 APPENDIX C: Variables

Variable	Description	Source
r	Long-term nominal interest rate	Datastream
$\widetilde{\left(r_{it}-r_t^B\right)}$	$\left(r_{it}-r_t^B\right) - \left(sw_{it}-sw_t^B\right)$	Datastream
	Interest rate spread minus the difference in interest rate swaps over the same maturity	
$stnr$	One year ahead short-term (3-Month) interest rate	OECD
r^B	One year ahead long-term nominal interest rate of the benchmark country	OECD
$\inf l$	One year ahead GDP deflator inflation rate ($\ln(PGDP_{t+1}/PGDP_t)$)	OECD
g	One year ahead Growth rate of Real GDP	OECD
$pdef$	Government lending net of interest payments (NLG+YPEPG)	OECD
$debt$	Gross Government Financial Liabilities (GGFL)	OECD
liq	Ratio of government debt over the total government debt of OECD countries	OECD
VIX	Chicago Board Options Exchange Market Volatility Index	Datastream
$def\ gap$	$(gbal^* - gbal)$	
	with: $gbal^* = (rltr - g)\, debt$, and $gbal = -pdef$	
	and $rltr = ltr - inf$, and ltr is the one year ahead forecast for long-term rate	OECD

12 APPENDIX D: Tables and Figures

Table 1: **Principal Component Analysis**

		1st	**2nd**	**3rd**	**4th**	**5th**
long-term Int. Rate	Marginal	0.4702	0.1922	0.0962	0.0533	0.0356
	Cumulative	0.4702	0.6624	0.7585	0.8118	0.8474
Int. Rate Spreads	Marginal	0.4549	0.2158	0.1233	0.0663	0.0302
	Cumulative	0.4549	0.6706	0.794	0.8602	0.8904

The table reports the marginal and cumulative proportions of the explained variance by the first 5 principal components. The principal components are extracted respectively from: W^r, $W^{spreads}$

Table 2: **Summary Statistics**

	mean	sd	min	max
Ltr	5.9	2.3	0.8	14.5
Spreads	0.16	0.6	-1.83	2.65
Int Rate - Short	5.2	3	0.2	15.3
GDP Growth	2.4	1	-1.9	7.5
Inflation	2.5	1.1	-0.7	8.9
Def/GDP(-1)	-2.9	3.8	-20.2	11
Debt/GDP(-1)	70	29	12.1	199.8
Liquidity	4.2	7.6	0.2	36.4
VIX	20.3	7.2	12.1	41.8

The table reports the summary statistics of the dependent variables and the regressors used in the analysis.

Table 3: **CD Test**

Variable	CD-test	p-value	corr	abs(corr)
Ltr	74.16	0	0.948	0.948
Spreads	26.3	0	0.456	0.491
Int Rate - Short	60.65	0	0.913	0.913
Inflation	36.76	0	0.554	0.554
Growth	36.22	0	0.464	0.464
Def/GDP(-1)	43.04	0	0.552	0.58
Debt/GDP(-1)	20.53	0	0.264	0.411
Liquidity	22	0	0.332	0.595

Under the null hypothesis of cross-section independence CD N(0,1)

Table 4: **Panel Unit Root Tests**

	0 lag		1 lag		2 lags			
	CIPS	p-val	CIPS	p-val	CIPS	p-val	MP	p-val
Ltr	-5.31	0	-3.4	0	-2.94	0	-3.515	0
Spreads	-10.02	0	-6.84	0	-1.46	0.07	-8.965	0
Int Rate - Short	-5.12	0	-2.72	0	-2.21	0.01	-3.137	0
Inflation	-5.4	0	-3.52	0	-1.98	0.02	-4.878	0
GDP Growth	-9.81	0	-4.59	0	-4.21	0	-14.49	0
Def/GDP(-1)	-1.16	0.12	0.97	0.83	1.28	0.9	-1.81	0.03
Debt/GDP(-1)	0.6	0.72	1.6	0.94	1.96	0.97	-1.867	0.03
Liquidity	-4.04	0	-2.35	0	-5.79	0	-5.766	0

CIPS is the t-test for unit roots in heterogenous panels with cross-section dependence, proposed by Pesaran (2007). The lag refers to the order of the ADF regression. Null hypothesis assumes that all series are non-stationary. MP is the Moon and Perron (2004) panel unit root test based on two extracted factors from the variable. The lag order is selected automatically. Null hypothesis assumes all series are non-stationary.

Table 5: **Baseline Estimation, long-term Interest Rates**

LTR	(1) FE	(2) 2FE	(3) FAP
Int Rate - Short	0.763***	0.607***	0.397***
	[0.033]	[0.057]	[0.035]
GDP Growth	0.182***	0.023	0.100*
	[0.079]	[0.068]	[0.050]
Inflation	0.171**	0.151**	0.078
	[0.082]	[0.069]	[0.046]
Def/GDP(-1)	0.123***	0.061***	0.016
	[0.017]	[0.019]	[0.013]
Debt/GDP(-1)	0.014	0.004**	0.008***
	[0.008]	[0.002]	[0.002]
Observations	709	709	709
R-squared	0.853	0.958	0.979
Number of id	17	17	17
CSD	46.45	-4.58	-3.53
Country FE	yes	yes	yes
Time FE	no	yes	yes
Factors	no	no	yes

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variable is the long-term nominal interest rate. The independent variables are: expected short term interest rate; expected GDP growth; expected Inflation; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP and the Vix index. CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence. Column 1 reports the results from the FE; Column 2 reports the results from the 2FE and Column 3 reports the results from the FAP.

Table 6: **Baseline Estimation, Interest Rate Spreads**

SPREADS	(1) FE	(2) 2FE	(3) FAP
Irl - Benchmark	0.046	0.121	-0.257***
	[0.028]	[0.076]	[0.076]
Liquidity	-0.050	-0.038	-0.039
	[0.032]	[0.028]	[0.024]
Growth	-0.100***	-0.190***	-0.053
	[0.025]	[0.045]	[0.040]
Def/GDP(-1)	0.039**	0.013	0.026**
	[0.011]	[0.014]	[0.012]
Debt/GDP(-1)	0.007***	0.005*	0.005**
	[0.002]	[0.002]	[0.002]
Emu	0.235***	0.005	-0.227*
	[0.079]	[0.104]	[0.123]
VIX	0.009*		
	[0.004]		
Observations	390	390	390
R-squared	0.215	0.393	0.613
Number of id	15	15	15
CSD	12.26	-1.95	-1.77
Country FE	yes	yes	yes
Time FE	no	yes	yes
Factors	no	no	yes

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variable is the interest rate spread, adjusted for exchange rate risk as in Codogno et al (2003). The independent variables are: the expected long-term interest rate of the benchmark country (Germany for EMU countries and US for the rest); liquidity, measured as the ratio between the stock of sovereign debt and the total debt of OECD countries; expected GDP growth; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP, a dummy variable for the introduction of the EURO and the Vix index. CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence. Column 1 reports the results from the FE with the regressors expressed in deviation from the benchmark country; Column 2 reports the results from the 2FE and Column 3 reports the results from the FAP.

Table 7: **Non Linearities with Financial Crises - Interest Rate Spreads**

	Leven & Valencia Dummy Crisis				Only 2007 Crisis			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SPREADS	Def Gap	Debt	Def	Debt-Def	Def Gap	Debt	Def	Debt-Def
Ltr Benchmark	-0.261***	-0.262***	-0.260***	-0.262***	-0.263***	-0.261***	-0.258***	-0.261***
	[0.077]	[0.077]	[0.077]	[0.077]	[0.076]	[0.077]	[0.077]	[0.077]
Liquidity	-0.043*	-0.041*	-0.037	-0.041	-0.04	-0.04	-0.038	-0.039*
	[0.024]	[0.023]	[0.026]	[0.026]	[0.025]	[0.025]	[0.023]	[0.024]
Growth	-0.025	-0.038	-0.053	-0.038	-0.032	-0.047	-0.054	-0.048
	[0.039]	[0.037]	[0.040]	[0.036]	[0.042]	[0.040]	[0.041]	[0.040]
Def/GDP(-1)			0.025**				0.026**	
			[0.012]				[0.012]	
Debt/GDP(-1)	0.004*	0.004**			0.004**	0.005**		
	[0.002]	[0.002]			[0.002]	[0.002]		
No Crisis*(Def Gap)	0.021*				0.020*			
	[0.011]				[0.011]			
Crisis*(Def Gap)	0.038*				0.034**			
	[0.021]				[0.015]			
No Crisis*(Def/GDP(-1))		0.022**		0.022*		0.022*		0.022*
		[0.011]		[0.011]		[0.012]		[0.012]
Crisis*(Def/GDP(-1))		0.048**		0.048*		0.036**		0.036**
		[0.026]		[0.027]		[0.016]		[0.016]
No Crisis*(Debt/GDP(-1))			0.005**	0.004**			0.004**	0.005**
			[0.002]	[0.002]			[0.002]	[0.002]
Crisis*(Debt/GDP(-1))			0.005**	0.004*			0.005*	0.005*
			[0.002]	[0.002]			[0.003]	[0.002]
Emu	-0.243**	-0.233*	-0.226*	-0.233*	-0.243*	-0.232*	-0.224*	-0.232*
	[0.123]	[0.121]	[0.123]	[0.122]	[0.125]	[0.124]	[0.124]	[0.124]
Observations	390	390	390	390	390	390	390	390
R-squared	0.616	0.618	0.615	0.618	0.617	0.616	0.614	0.616
Number of id	15	15	15	15	15	15	15	15
CSD	-1.64	-1.69	-1.76	-1.55	-1.72	-1.78	-1.76	-1.59
Test	0.363	0.269	0.64	0.292	0.222	0.248	0.899	0.247
Test b				0.987				0.966
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Factors	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variable is the interest rate spread, adjusted for exchange rate risk as in Codogno et al (2003). The independent variables are: the expected long-term interest rate of the benchmark country (Germany for EMU countries and US for the rest); liquidity, measured as the ratio between the stock of sovereign debt and the total debt of OECD countries; expected GDP growth; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP and a dummy variable for the introduction of the EURO. We test a specification with a spline on the fiscal variables according to weather or not they are measured in a period of financial crisis. Specifically in Columns 1 to 4 the crisis periods are taken from the database of Laeven and Valencia (2008), while in Columns 5 to 8 the crisis period corresponds only to the last financial crisis (from the second semester of 2007). In Columns 1 and 5 we test a spline on the deficit gap (as defined in Appendix C); in Columns 2 and 6 we test a spline on the debt variable; in Columns 3 and 7 we test a spline on the deficit variable and in Columns 4 and 8 we test a spline on both the deficit and the debt variables. CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence. All results are obtained using the FAP. The "Test" and "Test b" rows report the p-value of the t-test on the splined coefficients.

Table 8: **Non Linearities with the Debt level - long-term Interest Rates**

LTR	(1) Def^2	(2) Debt^2	(3) Def	(4) Debt	(5) Def-Debt
Int Rate - Short	0.397***	0.396***	0.398***	0.397***	0.399***
	[0.035]	[0.034]	[0.035]	[0.034]	[0.034]
Growth	0.101*	0.101*	0.098*	0.099*	0.098*
	[0.050]	[0.050]	[0.051]	[0.050]	[0.051]
Inflation	0.079	0.076	0.076	0.077	0.075
	[0.046]	[0.048]	[0.046]	[0.046]	[0.046]
Def/GDP(-1)	0.020	0.016		0.016	
	[0.023]	[0.013]		[0.013]	
Debt/GDP(-1)	0.008***	0.006	0.008***		
	[0.002]	[0.006]	[0.002]		
(Def/GDP(-1))^2	0.030				
	[0.094]				
(Debt/GDP(-1)^2		0.001			
		[0.003]			
Def/GDP(-1) $<$ Def/GDP(-1)$_{AV}$			0.015		0.015
			[0.015]		[0.015]
Def/GDP(-1) $>$ Def/GDP(-1)$_{AV}$			0.004		0.004
			[0.024]		[0.024]
Debt/GDP(-1) $<$ Debt/GDP(-1)$_{AV}$				0.008**	0.008**
				[0.003]	[0.003]
Debt/GDP(-1) $>$ Debt/GDP(-1)$_{AV}$				0.008***	0.008***
				[0.003]	[0.003]
Observations	709	709	709	709	709
R^2	0.979	0.979	0.979	0.979	0.979
Number of id	17	17	17	17	17
CSD	-3.53	-3.53	-3.50	-3.52	-3.50
Country FE	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes
Factors	yes	yes	yes	yes	yes

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variable is the long-term nominal interest rate. The independent variables are: expected short term interest rate; expected GDP growth; expected Inflation; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP. We test different non linearities with respect to public debt: in Column 1 we introduced deficit squared; in Column 2 we introduced the debt squared; in Columns 3 to 5 we splined the fiscal variables according to whether their value is smaller or larger than the average value for each country. CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence. All results are obtained using the FAP.

Table 9: **Non Linearities with the Debt level - Interest Rate Spreads**

SPREADS	(1) Def^2	(2) Debt^2	(3) Def	(4) Debt	(5) Def-Debt
Ltr Benchmark	-0.252***	-0.260***	-0.259***	-0.257***	-0.259***
	[0.063]	[0.065]	[0.062]	[0.063]	[0.062]
Liquidity	-0.041	-0.036	-0.044	-0.043*	-0.048*
	[0.024]	[0.023]	[0.025]	[0.023]	[0.024]
Growth	-0.017	-0.051	-0.034	-0.053	-0.034
	[0.034]	[0.044]	[0.034]	[0.044]	[0.035]
Def/GDP(-1)	0.047**	0.026**		0.027**	
	[0.017]	[0.010]		[0.011]	
Debt/GDP(-1)	0.004**	0.006	0.004**		
	[0.002]	[0.004]	[0.002]		
$(\text{Def/GDP(-1)})^2$	0.161*				
	[0.084]				
$(\text{Debt/GDP(-1)})^2$		0.001			
		[0.001]			
Def/GDP(-1) $<$ Def/GDP(-1)$_{AV}$			0.030**		0.030**
			[0.010]		[0.010]
Def/GDP(-1) $>$ Def/GDP(-1)$_{AV}$			0.048**		0.048**
			[0.023]		[0.023]
Debt/GDP(-1) $<$ Debt/GDP(-1)$_{AV}$				0.004*	0.003*
				[0.002]	[0.002]
Debt/GDP(-1) $>$ Debt/GDP(-1)$_{AV}$				0.004*	0.004**
				[0.002]	[0.002]
Emu	-0.213*	-0.229*	-0.217*	-0.223*	-0.217*
	[0.108]	[0.112]	[0.110]	[0.112]	[0.111]
Observations	390	390	390	390	390
R^2	0.622	0.614	0.619	0.615	0.619
Number of id	15	15	15	15	15
CSD	-1.69	-1.80	-1.74	-1.84	-1.79
Country FE	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes
Factors	yes	yes	yes	yes	yes

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variable is the interest rate spread, adjusted for exchange rate risk as in Codogno et al (2003). The independent variables are: the expected long-term interest rate of the benchmark country (Germany for EMU countries and US for the rest); liquidity, measured as the ratio between the stock of sovereign debt and the total debt of OECD countries; expected GDP growth; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP and a dummy variable for the introduction of the EURO. We test different non linearities with respect to public debt: in Column 1 we introduced the primary deficit squared; in Column 2 we introduced the debt squared; in Columns 3 to 5 we splined the fiscal variables according to whether their value is smaller or larger than the average value for each country. CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence. All results are obtained using the FAP.

Table 10: **Effects of Global Shocks - Interest Rates Equation and Spreads Equation**

GLOBAL SHOCKS	**Int Rates Eq.**	**Spreads Eq.**
	(1)	(2)
	Av Def - δ_{2i}	VIX - Ψ_i
AUS	0.210***	0.002
	[0.08]	[0.009]
AUT	0.141**	0.017***
	[0.065]	[0.005]
BEL	0.174***	0.017***
	[0.066]	[0.005]
CAN	0.127*	0.012
	[0.073]	[0.009]
DEU	0.102	
	[0.065]	
DNK	0.141**	-0.008
	[0.066]	[0.008]
ESP	0.400***	0.016***
	[0.075]	[0.005]
FIN	0.302***	0.015***
	[0.075]	[0.005]
FRA	0.166***	0.010**
	[0.063]	[0.005]
GBR	0.237***	-0.003
	[0.074]	[0.009]
IRE	0.337***	0.026***
	[0.077]	[0.006]
ITA	0.497***	0.021***
	[0.075]	[0.006]
JPN	0.159**	0.007
	[0.073]	[0.012]
NLD	0.129**	0.011**
	[0.065]	[0.005]
NOR	0.065	-0.013*
	[0.074]	[0.008]
SWE	0.219***	-0.014*
	[0.083]	[0.008]
USA	0.071	
	[0.075]	
Observations	709	390
F-test	177.4***	102.1***

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The table reports the country specific coefficients on the factors of interest. Columns 1 reports the coefficients on the second factor in the long-term interest rates equation. The factor is proxied by the average budget deficit of the countries in the sample. Column 3 reports the coefficients on the second factor in the spread equation. The factor is proxied by the VIX index. "F-test" is the value of the F-statistic for the test of equality of coefficients.

Table 11: **- Factor Interpretation**

	LTR		**SPREADS**	
	(1)	(2)	(3)	(4)
Int Rate - Short	0.397***	0.418***		
	[0.035]	[0.036]		
Ltr Benchmark			-0.257***	-0.261***
			[0.076]	[0.091]
Liquidity			-0.039	-0.036
			[0.024]	[0.024]
GDP Growth	0.100*	0.112*	-0.053	-0.051
	[0.050]	[0.059]	[0.040]	[0.039]
Inflation	0.078	0.07		
	[0.046]	[0.046]		
Def/GDP(-1)	0.016	0.024*	0.026**	0.028**
	[0.013]	[0.013]	[0.012]	[0.012]
Debt/GDP(-1)	0.008***	0.008***	0.005**	0.004**
	[0.002]	[0.002]	[0.002]	[0.002]
Emu			-0.227*	-0.312***
			[0.123]	[0.113]
Observations	709	709	390	390
R-squared	0.979	0.979	0.613	0.614
Number of id	17	17	15	15
CSD	-3.53	-3.58	-1.77	-1.77
Country FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Factors	**PCA**	**Data**	**PCA**	**Data**

Robust standard errors in brackets

$***p < 0.01, **p < 0.05, *p < 0.1$

The dependent variables are the long-term nominal interest rate (Columns 1 and 2) and the interest rate spread adjusted for exchange rate risk as in Codogno et al (2003) (Columns 3 and 4). The independent variables from top to bottom are: expected short term interest rate; the expected long-term interest rate of the benchmark country (Germany for EMU countries and US for the rest); liquidity, measured as the ratio between the stock of sovereign debt and the total debt of OECD countries; expected GDP growth; expected Inflation; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP; a dummy variable for the introduction of the EURO. Columns 1 and 3 repeat the results in column 3 of Table 5 and Table 6 respectively. In Columns 2 and 4 the common factors have been replaced by their interpretation: average short term interest rate and average deficit for Column 2; average deficit, VIX index and average short term interest rate for Column 4. CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence.

Table 12: **Robustness - Cross-Validation, long-term Interest Rates**

LTR	All Sample	No AUS	No AUT	No BEL	No CAN	No DEU	No DNK	No ESP	No FIN
Int Rate - Short	0.397***	0.367***	0.399***	0.397***	0.411***	0.401***	0.404***	0.389***	0.391***
	[0.035]	[0.026]	[0.036]	[0.036]	[0.034]	[0.035]	[0.034]	[0.036]	[0.036]
GDP Growth	0.100*	0.104*	0.109*	0.094*	0.098	0.110**	0.112**	0.117**	0.057
	[0.050]	[0.051]	[0.052]	[0.051]	[0.057]	[0.049]	[0.052]	[0.048]	[0.035]
Inflation	0.078	0.072	0.079	0.081	0.087*	0.074	0.078	0.092*	0.095*
	[0.046]	[0.049]	[0.047]	[0.047]	[0.047]	[0.048]	[0.049]	[0.044]	[0.048]
Def/GDP(-1)	0.016	0.014	0.016	0.015	0.023*	0.015	0.018	0.017	0.013
	[0.013]	[0.012]	[0.013]	[0.012]	[0.012]	[0.013]	[0.013]	[0.014]	[0.013]
Debt/GDP(-1)	0.008***	0.009***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.003]
Observations	709	667	668	667	667	667	667	667	667
R-squared	0.979	0.98	0.979	0.979	0.979	0.979	0.978	0.978	0.978
Number of id	17	16	16	16	16	16	16	16	16
CSD	-3.53	-3.52	-3.9	-3.75	-3.42	-3.85	-3.61	-3.46	-3.37
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Factors	yes	yes	yes	yes	yes	yes	yes	yes	yes

	No FRA	No GBR	No IRE	No ITA	No JPN	No NLD	No NOR	No SWE	No USA
Int Rate - Short	0.397***	0.399***	0.392***	0.388***	0.393***	0.397***	0.397***	0.407***	0.406***
	[0.035]	[0.038]	[0.035]	[0.038]	[0.036]	[0.036]	[0.039]	[0.035]	[0.036]
GDP Growth	0.101*	0.09	0.1	0.094*	0.085	0.106*	0.108*	0.108*	0.095
	[0.051]	[0.053]	[0.062]	[0.053]	[0.051]	[0.051]	[0.054]	[0.053]	[0.056]
Inflation	0.077	0.088*	0.088	0.07	0.06	0.078	0.079	0.04	0.08
	[0.047]	[0.048]	[0.050]	[0.048]	[0.047]	[0.048]	[0.054]	[0.038]	[0.046]
Def/GDP(-1)	0.016	0.015	0.015	0.018	0.019	0.015	0.025	0.006	0.018
	[0.013]	[0.013]	[0.014]	[0.014]	[0.013]	[0.013]	[0.019]	[0.009]	[0.013]
Debt/GDP(-1)	0.008***	0.008***	0.008***	0.008***	0.009**	0.008***	0.008***	0.006***	0.008***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.002]	[0.002]	[0.001]	[0.002]
Observations	667	667	667	671	667	667	667	667	667
R-squared	0.978	0.979	0.979	0.978	0.98	0.979	0.98	0.979	0.98
Number of id	16	16	16	16	16	16	16	16	16
CSD	-4.12	-3.41	-3.39	-3.42	-3.5	-3.9	-3.53	-3.49	-3.56
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Factors	yes	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$

Table 13: **Robustness - Cross-Validation, Interest Rate Spreads**

SPREADS	All Sample	No AUS	No AUT	No BEL	No CAN	No DNK	No ESP	No FIN
Irl Benchmark	-0.257***	-0.253***	-0.263***	-0.258***	-0.296***	-0.259***	-0.256***	-0.260***
	[0.076]	[0.080]	[0.078]	[0.078]	[0.083]	[0.085]	[0.078]	[0.078]
Liquidity	-0.039	-0.034	-0.039	-0.038	-0.051*	-0.04	-0.042*	-0.039
	[0.024]	[0.023]	[0.024]	[0.024]	[0.026]	[0.024]	[0.025]	[0.024]
Growth	-0.053	-0.047	-0.05	-0.052	-0.052	-0.046	-0.055	-0.053
	[0.040]	[0.042]	[0.041]	[0.041]	[0.042]	[0.041]	[0.041]	[0.040]
Def/GDP(-1)	0.026**	0.026**	0.026**	0.026**	0.029**	0.027**	0.028**	0.027**
	[0.012]	[0.012]	[0.013]	[0.012]	[0.013]	[0.013]	[0.013]	[0.012]
Debt/GDP(-1)	0.005**	0.005**	0.005**	0.004**	0.004*	0.005**	0.005**	0.005**
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Emu	-0.227*	-0.216	-0.224*	-0.222*	-0.288**	-0.204	-0.227*	-0.228*
	[0.123]	[0.135]	[0.125]	[0.124]	[0.128]	[0.141]	[0.125]	[0.124]
Observations	390	364	364	364	364	364	364	364
R-squared	0.613	0.655	0.613	0.613	0.623	0.591	0.61	0.62
Number of id	15	14	14	14	14	14	14	14
CSD	-1.77	-1.77	-2.37	-2.41	-1.46	-1.43	-2.32	-2.24
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Factors	yes	yes	yes	yes	yes	yes	yes	yes

	No FRA	No GBR	No IRE	No ITA	No JPN	No NLD	No NOR	No SWE
Irl Benchmark	-0.258***	-0.236***	-0.240***	-0.267***	-0.217***	-0.265***	-0.277***	-0.231***
	[0.077]	[0.085]	[0.073]	[0.078]	[0.073]	[0.078]	[0.080]	[0.081]
Liquidity	-0.039	-0.033	-0.015	-0.025	-0.150***	-0.037	-0.047*	-0.043*
	[0.024]	[0.026]	[0.025]	[0.026]	[0.051]	[0.024]	[0.026]	[0.025]
Growth	-0.045	-0.071*	0.037	-0.065	-0.072**	-0.053	-0.056	-0.062
	[0.039]	[0.040]	[0.048]	[0.042]	[0.035]	[0.041]	[0.042]	[0.041]
Def/GDP(-1)	0.027**	0.021*	0.015	0.025*	0.023*	0.025**	0.035*	0.026**
	[0.012]	[0.013]	[0.011]	[0.013]	[0.013]	[0.012]	[0.021]	[0.013]
Debt/GDP(-1)	0.005**	0.005**	0.004**	0.004*	0.005***	0.004**	0.006**	0.005**
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.002]
Emu	-0.195	-0.17	-0.248**	-0.251**	-0.259**	-0.214*	-0.253*	-0.186
	[0.124]	[0.112]	[0.124]	[0.124]	[0.123]	[0.124]	[0.137]	[0.137]
Observations	364	364	364	364	364	364	364	364
R-squared	0.627	0.622	0.603	0.606	0.645	0.62	0.607	0.612
Number of id	14	14	14	14	14	14	14	14
CSD	-2.21	-1.72	-1.48	-1.64	-1.62	-2.32	-1.55	-1.59
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes	yes	yes
Factors	yes	yes	yes	yes	yes	yes	yes	yes

Robust standard errors in brackets
$* * *p < 0.01, * * p < 0.05, *p < 0.1$

Table 14: **Robustness - Introducing the CA Balance**

	LTR (1)	**SPREADS** (2)
Int Rate - Short	0. 398***	
	[0.034]	
Ltr Benchmark		-0.259***
		[0.076]
Liquidity		-0.040*
		[0.024]
Growth	0.099*	-0.054
	[0.050]	[0.040]
Inflation	0.067	
	[0.048]	
Def/GDP(-1)	0.011	0.023*
	[0.015]	[0.013]
Debt/GDP(-1)	0.008***	0.005**
	[0.002]	[0.002]
CA/GDP(-1)	-0.007	-0.006
	[0.006]	[0.007]
Emu		-0.253*
		[0.130]
Observations	709	390
R-squared	0.979	0.615
Number of id	17	15
CSD	-3.03	-1.76
Country FE	yes	yes
Time FE	yes	yes
Factors	yes	yes

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variables are the long-term nominal interest rate in Column 1 and the interest rate spread adjusted for exchange rate risk as in Codogno et al (2003) in Column 2. The independent variables from top to bottom are: expected short term interest rate; the expected long-term interest rate of the benchmark country (Germany for EMU countries and US for the rest); liquidity, measured as the ratio between the stock of sovereign debt and the total debt of OECD countries; expected GDP growth; expected Inflation; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP; current account balance as a share of previous period GDP and a dummy variable for the introduction of the EURO. CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence. All results are obtained using the FAP.

Table 15: **Robustness - FAP, CCE and IFE Estimators**

	LTR			**SPREADS**		
	(1)	(2)	(3)	(4)	(5)	(6)
	FAP	CCE	IFE	FAP	CCE	IFE
Int Rate - Short	0.397***	0.607***	0.349***			
	[0.035]	[0.057]	[0.112]			
Ltr Benchmark				-0.257***	-0.037	-0.295
				[0.076]	[0.073]	[0.566]
Liquidity				-0.039	-0.044*	-0.061
				[0.024]	[0.023]	[0.095]
Growth	0.100*	0.023	0.092	-0.053	-0.059	-0.028
	[0.050]	[0.068]	[0.253]	[0.040]	[0.040]	[0.068]
Inflation	0.078	0.151**	0.019			
	[0.046]	[0.069]	[0.277]			
Def/GDP(-1)	0.016	0.061***	0.019	0.026**	0.021	0.001
	[0.013]	[0.019]	[0.017]	[0.012]	[0.013]	[0.006]
Debt/GDP(-1)	0.008***	0.005**	0.005***	0.005**	0.004**	0.004***
	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]	[0.001]
Emu				-0.227*	-0.089	-1.525**
				[0.123]	[0.262]	[0.770]
Observations	709	709	709	390	390	390
R-squared	0.979	0.958	0.988	0.613	0.622	0.931
Number of id	17	17	17	15	15	15
CSD	-3.53	-3.6	-3.81	-1.77	-1.51	-2.25

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variables are the long-term nominal interest rate in Columns 1 to 3 and the interest rate spread adjusted for exchange rate risk as in Codogno et al (2003) in Columns 4 to 6. The independent variables from top to bottom are: expected short term interest rate; the expected long-term interest rate of the benchmark country (Germany for EMU countries and US for the rest); liquidity, measured as the ratio between the stock of sovereign debt and the total debt of OECD countries; expected GDP growth; expected Inflation; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP; a dummy variable for the introduction of the EURO. Columns 1 and 4 repeat the results in column 3 of Table 5 and Table 6 respectively. In Columns 2 and 5 we perform Pesaran's (2006) Common Correlated Effect estimator. In Columns 3 and 6 we perform Bais (2009) Interacted Fixed Effects estimator. CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence.

Table 16: **Robustness - Different Country Groups**

	3 Country Groups		**4 Country Groups**	
	(1)	(2)	(3)	(4)
		r^B	r^B	r^B
SPREADS	baseline	interacted	constrained	interacted
Ltr Benchmark	-0.257***		-0.255***	
	[0.076]		[0.075]	
Liquidity	-0.039	-0.038	-0.021	-0.023
	[0.024]	[0.024]	[0.023]	[0.023]
Growth	-0.053	-0.052	-0.011	-0.006
	[0.040]	[0.041]	[0.037]	[0.038]
Def/GDP(-1)	0.026**	0.025**	0.022*	0.022*
	[0.012]	[0.012]	[0.011]	[0.012]
Debt/GDP(-1)	0.005**	0.004**	0.004**	0.004**
	[0.002]	[0.002]	[0.002]	[0.002]
Emu	-0.227*	-0.379***	-0.213*	-0.100
	[0.123]	[0.140]	[0.125]	[0.123]
Observations	390	390	390	390
R^2	0.613	0.622	0.643	0.633
Number of id	15	15	15	15
CSD	-1.77	-1.76	-1.46	-1.47
Country FE	yes	yes	yes	yes
Time FE	yes	yes	yes	yes
Factors	yes	yes	yes	yes

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variable is the interest rate spread adjusted for exchange rate risk as in Codogno et al (2003). The independent variables from top to bottom are: the expected long-term interest rate of the benchmark country (Germany for EMU countries and US for the rest); liquidity, measured as the ratio between the stock of sovereign debt and the total debt of OECD countries; expected GDP growth; expected deficit as a share of previous period GDP; expected gross debt as a share of previous period GDP; a dummy variable for the introduction of the EURO. Column 1 replicates the baseline results of the FAP (Table 6, column 3): unobserved factors are interacted with 3 dummy variables for 3 country groups; in Column 2 we replicate the baseline estimation interacting also the expected long-term interest rate of the benchmark country with the 3 dummy variables for 3 country groups (as implied by the model in Section 3.1.1); in Column 3 we replicate the baseline interacting the factors with 4 country group dummy variables (Core EMU, Other EMU, Nordics, Others); in Column 4 we replicate the baseline estimation interacting also the expected long-term interest rate of the benchmark country with the 4 country group dummy variables (as implied by the model in Section 3.1.1). CSD is the Pesaran's (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence. All the results are obtained using the FAP.

Table 17: **Interpretation of the Factors - long-term Interest Rates**

LTR	(1) F1 ltr	(2) F2 ltr
Average IRS	0.979***	
	[0.0297]	
Average DEF		0.903***
		[0.0626]
Constant	3.31E-09	6.08E-09
	[0.0294]	[0.0619]
Observations	49	49
R-squared	0.959	0.816

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
In Column 1, the dependent variable is the first factor extracted from W^r while the independent variable is the average expected short term interest rate of the countries in the sample; In Column 2, the dependent variable is the second factor extracted from W^r while the independent variable is the average expected deficit of the countries in the sample.

Table 18: **Interpretation of the Factors - Interest Rate Spreads**

SPREADS	(1) F1 Spreads	(2) F2 Spreads	(3) F3 Spreads
Average DEF	0.892***		
	[0.0921]		
Vix		0.859***	
		[0.105]	
Average IRS			0.564***
			[0.169]
Constant	-4.44E-08	7.42E-08	-1.98E-08
	[0.0903]	[0.103]	[0.165]
Observations	26	26	26
R-squared	0.796	0.737	0.618

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
In Column 1, the dependent variable is the first factor extracted from $W^{spreads}$ while the independent variable is the average expected deficit of the countries in the sample; In Column 2, the dependent variable is the second factor extracted from $W^{spreads}$ while the independent variable is the VIX index. Finally in Column 3 the dependent variable is the third factor extracted from $W^{spreads}$ and the independent variable is the average expected short term interest rate of the countries in the sample.

Figure 1: **Long-Term Interest Rates 1990 - 2009**

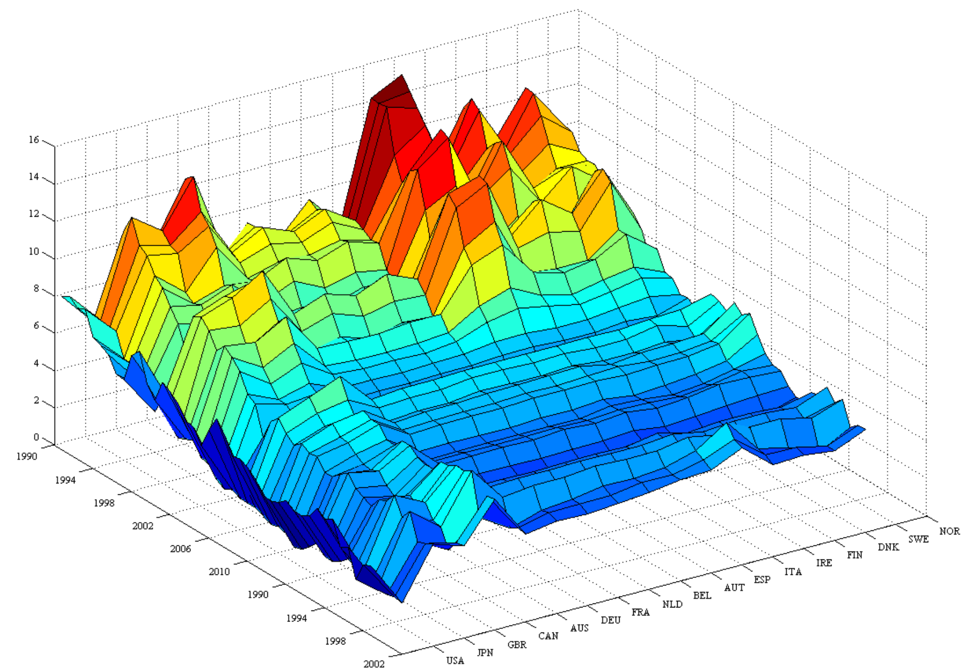

Figure 2: **Interest Rate Spreads 1997 - 2009**

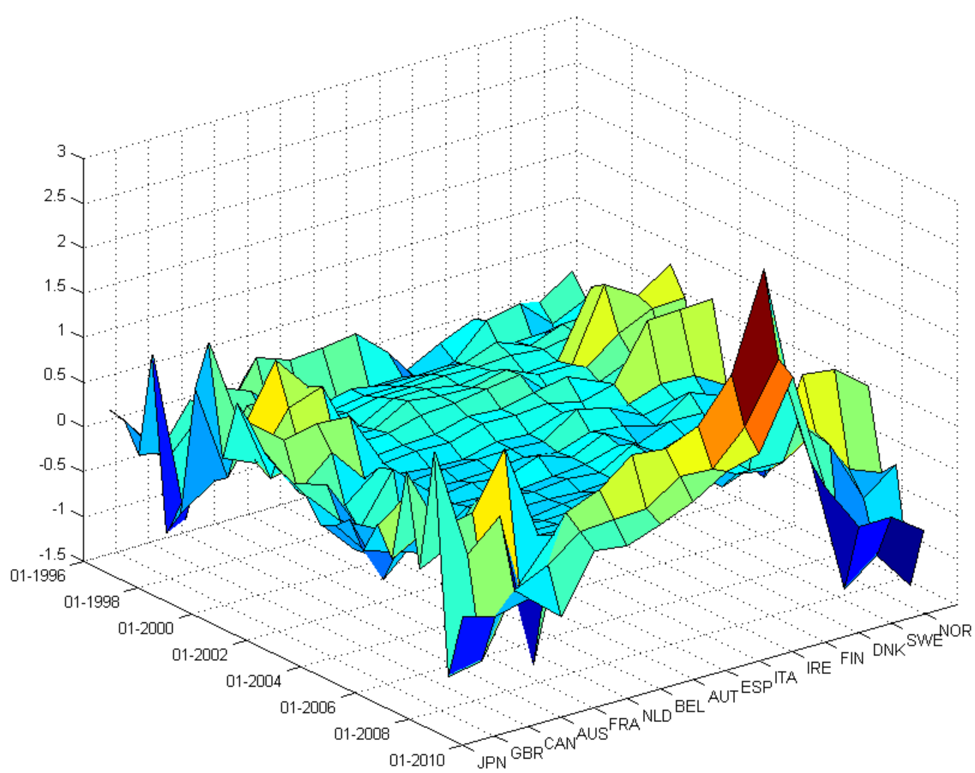

Figure 3: **Rolling Window Estimates - Long-Term Interest Rates**

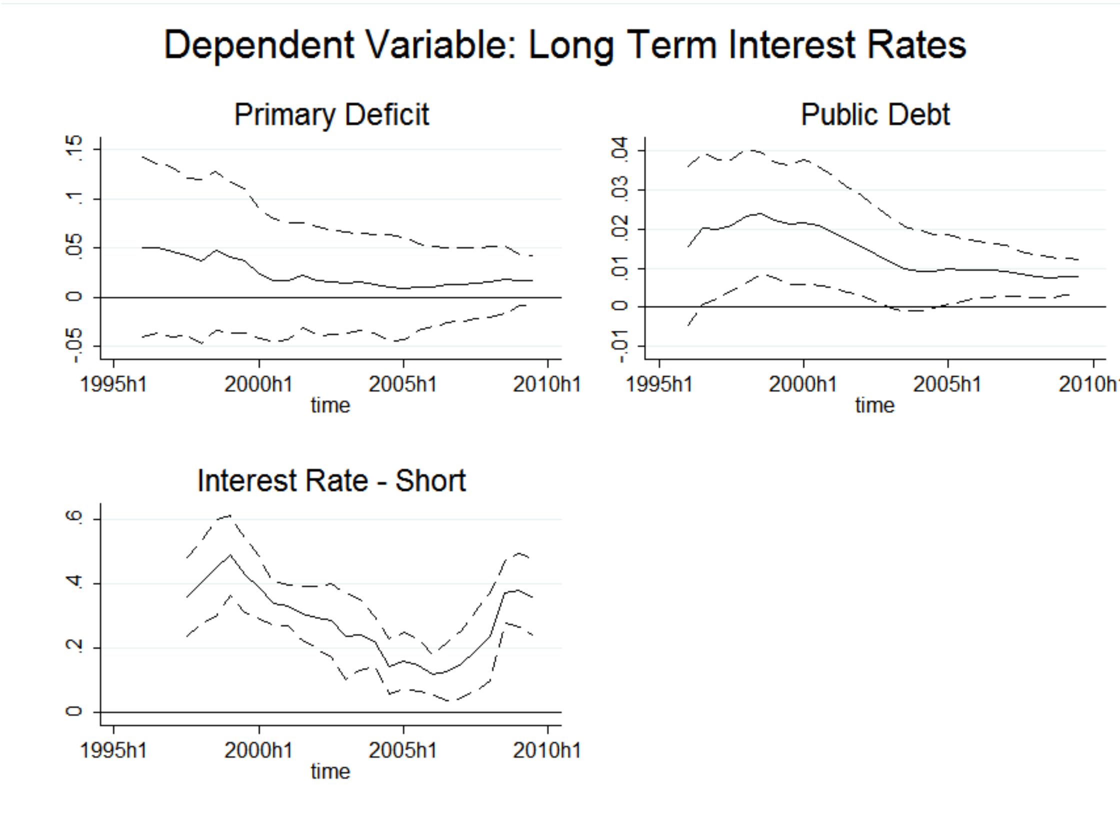

Figure 4: **Rolling Window Estimates - Sovereign Spreads**

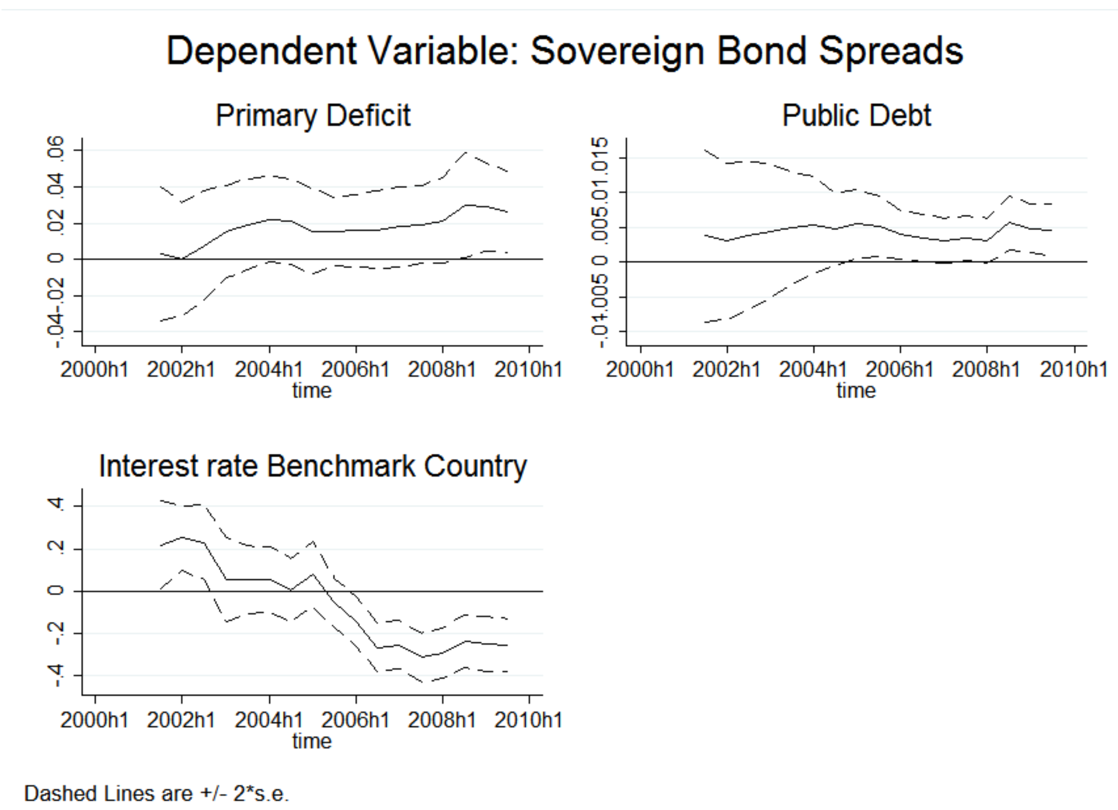

Figure 5: **Effects on Long-Term Interest Rates of a Global DeficitShock**

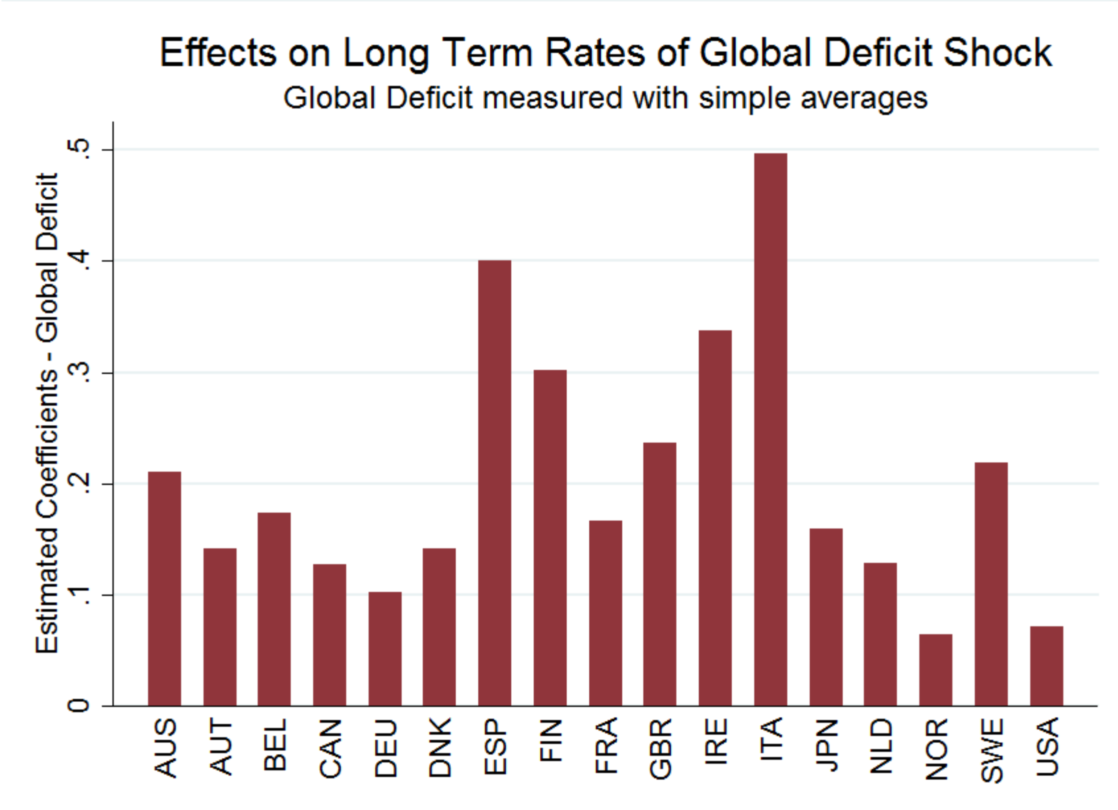

Figure 6: **Cross-Country Differences in the Effects of a Global Deficit Shock**

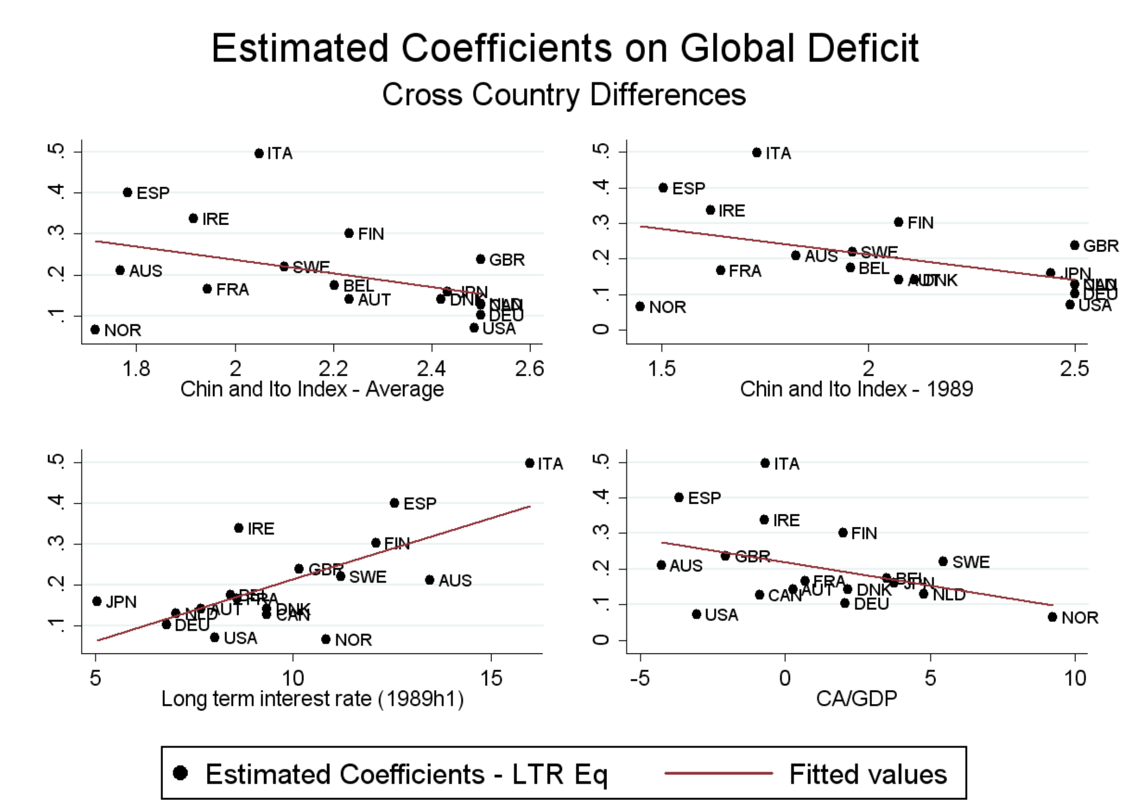

Figure 7: **Effects on Sovereign Spreads of a Global Risk Aversion Shock**

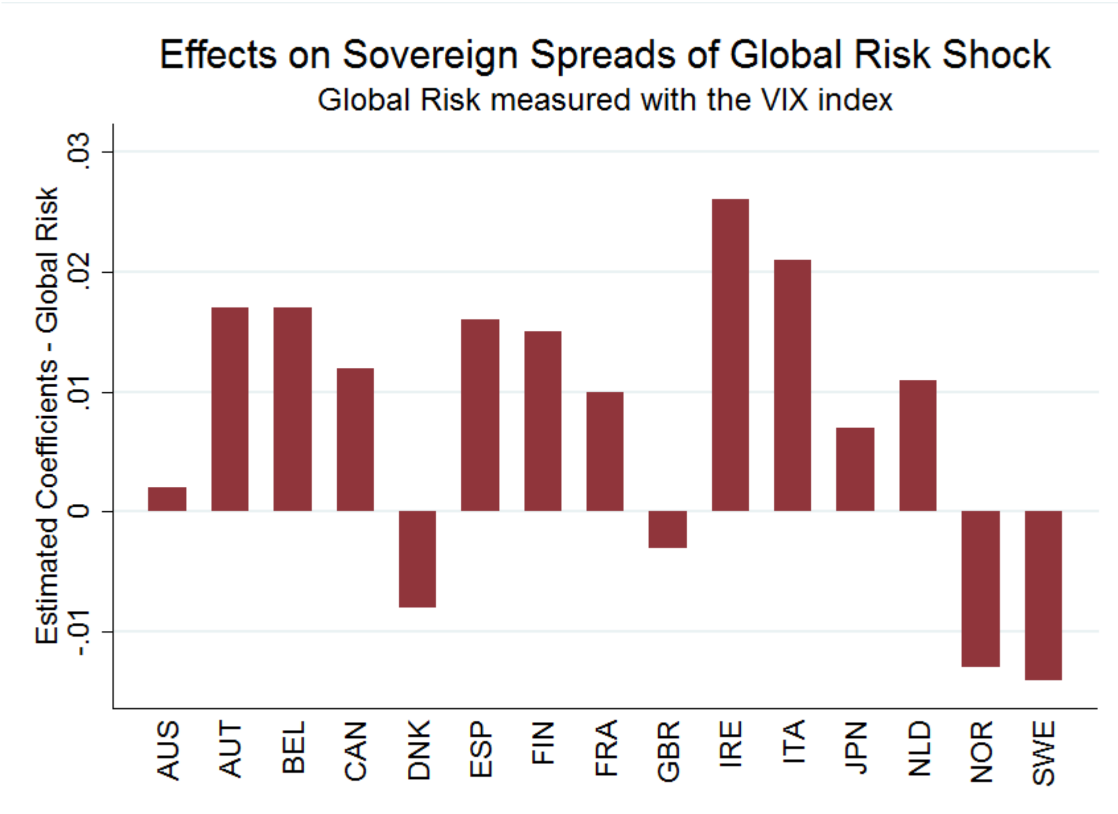

Figure 8: **Cross-Country Differences in the Effects of a Global Risk Aversion Shock**

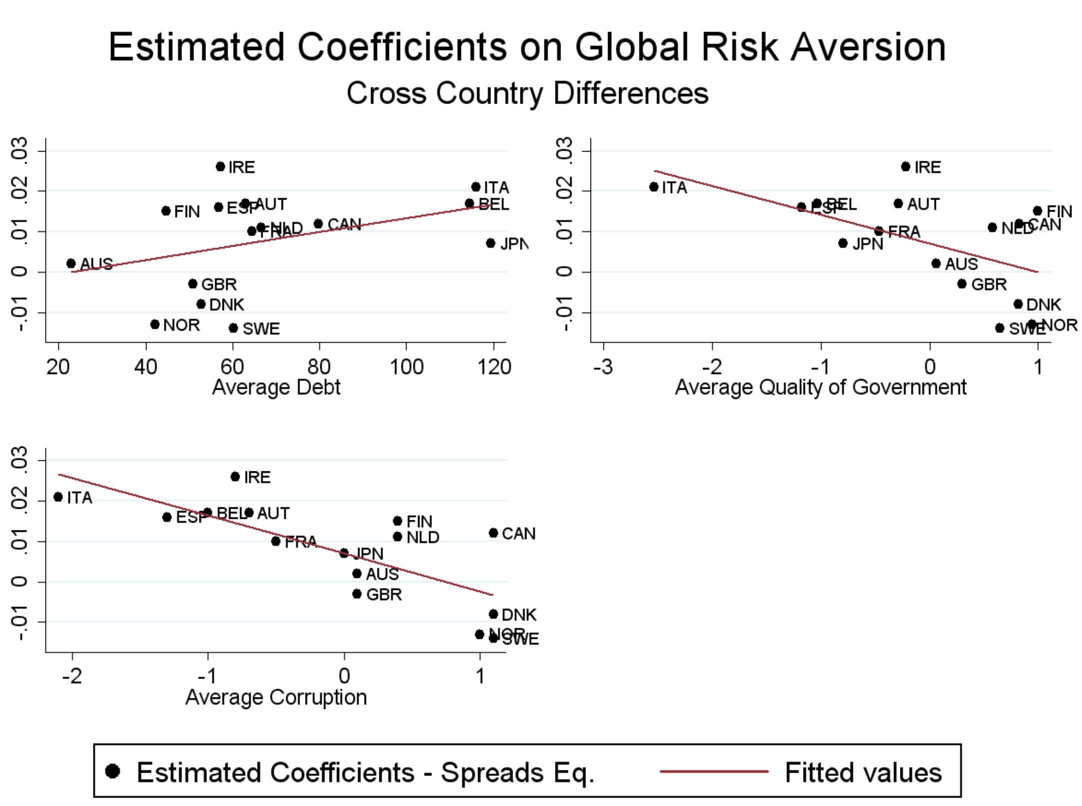

Figure 9: **Global Factors - extracted from** W^r

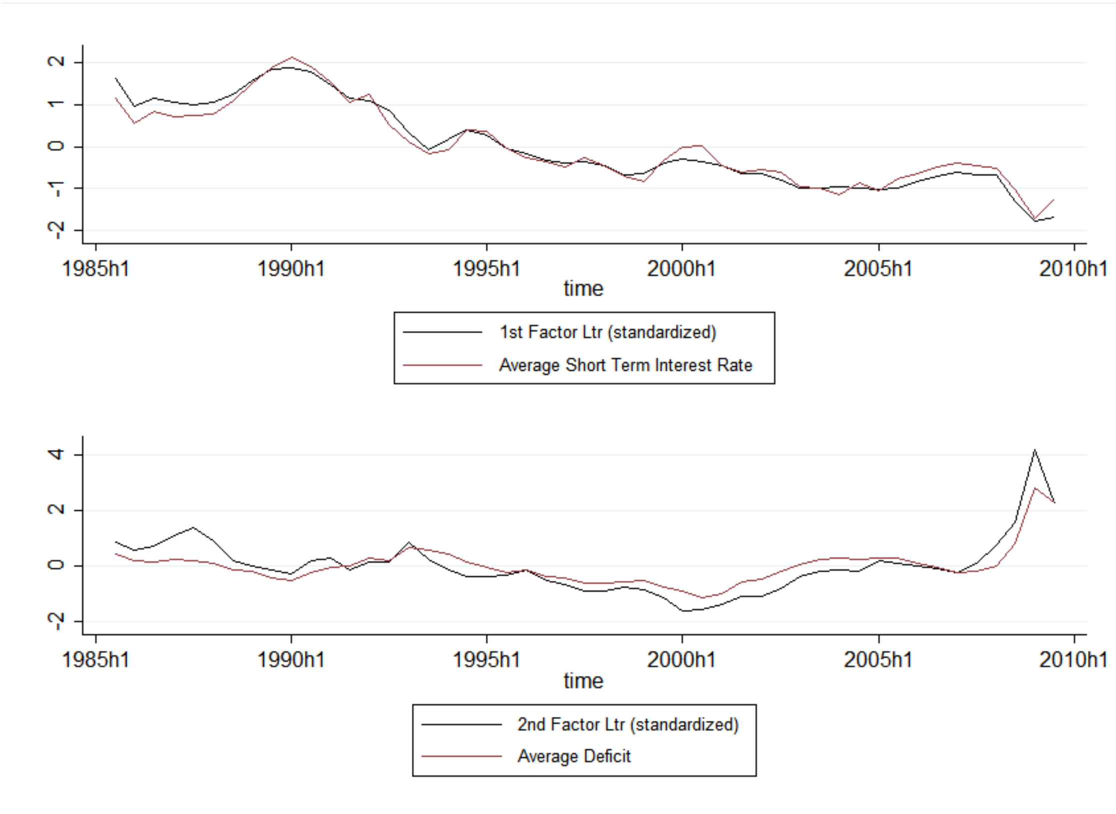

Figure 10: **Global Factors - extracted from** $W^{spreads}$