Expected fiscal policy and interest rates 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 cross sectional dependence. 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. 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. We find the effects of the former to be modest in large economies and strong in economies characterized by low initial financial integration. Changes in global risk, instead, are found to lead to higher spreads in countries with a high stock of public debt and weaker political institutions. Overall our results are consistent with the evidence coming from the ongoing crisis.

Keywords: Real time data; Fiscal Policy; Interest rates; 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 deficits. Financial markets then suddenly started to discriminate between borrowers. These developments seem to suggest that: 1) under increased capital market integration, interest rates 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 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 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 what is the role of fiscal policy in determining the divergence in interest rates and risk premia that we observe in times of distress?

To answer these questions we conduct a parallel analysis using two different dependent variables: the 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. We start from the quite established result according to which the relation between fiscal policy and interest rates becomes statistically significant when using fiscal projections rather than actual data (Reinhart and Sack 2000, Canzoneri, Cumby and Diba, 2002; Gale and Orszag, 2004; Laubach 2009; Afonso 2009). Hence, 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 different purposes: i) it is meant to take into account the forward looking behaviour of financial markets; ii) it avoids possible simultaneity problems arising from the use of actual data. Collecting fiscal projections from an independent agency like the OECD rather than official government plans is motivated by the evidence presented in Beetsma and Giuliodori (2010) and Cimadomo (2008). The authors show how governments' released budget plans tend to be overly optimistic in terms of expected fiscal outcome. Thus, the forecasts released by the OECD are less prone to this "optimistic bias".

Our main contribution is however methodological. We implement a new estimator which takes explicitly into account the cross sectional dependence across the units of the panel induced by the presence of global factors and allows for country specific responses to these common shocks. The methodology (*Factor Augmented Panel*), originally developed by Giannone and Lenza (2008), consists of estimating the unobserved common factors from the data by means of principal components and plugging them back into the equation, interacting them with country fixed effects. Recent econometric literature (Pesaran, 2006, Bai, 2009) shows that not accounting for these effects in panel data can give rise to biased and inconsistent estimates.

Overall, we find that using standard panel techniques provides results that are similar to those found in previous literature: the estimated effect of a 1% increase in budget deficits on long term yields is about 10 basis points;

and 1 basis point for a 1% increase in public debt. However, once we account for cross sectional dependence, the estimated effect on long term yields of budget deficits becomes smaller in magnitude and insignificant, while the effect of public debt remains unchanged. When studying the effects on sovereign spreads, instead, we find that while with a standard fixed effects estimator fiscal variables appear with the wrong sign, when correcting for cross sectional dependence both public debt and primary deficit turn out significant and with the expected sign. Moreover the effect primary deficit doubles in value, from 1.3 to 2.6 basis points.

The methodological framework employed allows us to analyse in more details the nature and the quantitative importance of common unobservable factors. Consistently with economic theory our results show that in a sample of highly integrated economies long term interest rates are mainly driven by global factors. Two of them, which we interpret as the countries' aggregate monetary and fiscal policy stances explain more than 60% of the panel variance. Following an aggregate fiscal expansion, however, interest rates responds in an heterogeneous manner, with higher increases in small peripheral countries or countries characterized by low initial financial integration.

The same two factors also play an important role in determining sovereign yield spreads which, in addition, are also driven by global risk. Differences in fiscal fundamentals and institutional quality determine the cross country divergence of sovereign spreads following a shock to global risk. In particular, risk premia increase proportionately more for countries with higher stocks of public debt and where, on top of that, governments are perceived to be less effective and transparent. Our results overall confirm the evidence coming from the ongoing debt crisis: a global shock to aggregate fiscal policy or a collapse in market confidence determine an heterogeneous increase in borrowing costs and countries with fiscal or institutional vulnerabilities bear larger increases. Similarly, the common movement towards fiscal austerity in advanced countries and the low levels of global risk help to explain the convergence in interest rates and sovereign spreads which took place in advanced countries during the nineties. Finally, contrary to previous studies, we do not find evidence of non linear effects of public debt. However we find that the in periods of financial distress the effects of primary deficit on sovereign spreads tend to be larger and so are the effects of expected fiscal sustainability, proxied by the difference between debt stabilizing deficit and projected deficit.

We proceed as follows. In Section 2, we provide a brief review of the literature. In Section 3 we explain the methodological framework. In Section 4 we discuss our dataset and its properties. In Section 5 we present estimation results. In Section 6 we analyse the effect of fiscal policy spillovers, while in Section 7 we do some robustness checks. Section 8 concludes.

2 Literature Review

There is a large empirical literature on the effects of fiscal policy on interest rates. Despite the large production, the results are still mixed. A large body of the literature is based on US data, but an increasing number of studies is also based on European and OECD data. As reported by Gale and Orszag (2003) in their survey of existing work, out of 59 papers reviewed, 29 found a significant positive effect, 11 had mixed results, while 19 found a predominantly insignificant effect. 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 interest rates (Feldstein, 1986; Reinhert and Sack, 2000; Canzoneri et al. 2002; Laubach, 2009); 2) the effect of public debt appear 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 spillover effects of fiscal policy seem larger than domestic effect (Faini, 2006; Ardagna et al. 2007); 5) the effects found in cross country studies are smaller than those found in single country studies.

The papers more closely related to our work are Reinhart and Sack (2000), Chinn and Frankel (2005) and Ardagna et al. (2007). Reinhart and Sack (2000) estimate the effects of fiscal policy in a panel of 19 OECD countries using annual fiscal projections from the OECD. The authors 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 though do not consider the level of debt and do not control for global factors. Chinn and Frankel (2005) focus on Germany, France Italy and Spain, while also considering evidence for UK, the US and Japan. They use the expected debt rather than the expected deficit and also use projections from the OECD. They find mixed evidence about the effects of expected debt, but the results seem to be significant once 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 with annual actual data, from 1960 to 2002. 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 that the results are non linear: interest rates increase for debt to GDP level above 60%. Moreover, the authors control for global factors by including cross-sectional averages of explanatory variables. They find that average debt and deficits have significant (spillover) effects on interest rates, but domestic variables still affect interest rates while controlling for global factors.

Similar lack of agreement can be found in studies that analyse sovereign bond spreads. Here, while the literature seems to converge in identifying the most relevant elements - credit risk, liquidity and global markets conditions - it is way less unanimous when it turns to evaluate their relative importance. For example Codogno et al. (2003), Geyer et al. (2004); Bernoth et al. (2004) and Favero et al. (2009) find that global risk aversion - proxied by US or Euro area corporate spreads - is the main driver of sovereign spreads[1]. Beber et al. (2009) instead show that credit quality seems to be the most important variable, with liquidity acquiring more relevance in periods of high uncertainty. Global factors have usually been identified with global liquidity - proxied by the US short term interest rate - and with investors' risk aversion - measured either with the VIX index or with the US corporate spread. A study which is similar to ours in the estimation of global factors is Ciarlone et al (2009). Using principal component analysis they identify the VIX as the most important factor in explaining the variation of emerging

[1]See Manganelli and Wolswijk (2009).

markets spreads. Differently from their approach, however, we include factor analysis with the specific goal of tackling cross sectional correlation.

As for the choice of regressors, we follow Reinhart and Sack (2000) and Chinn and Frankel (2005) and use fiscal projections instead of actual data. On the other hand, we follow Ardagna et al. (2007) in adopting their empirical specification. However, our main difference from these papers lies in the methodology. In fact, our starting point is to recognize that interest rates are mainly driven by unobserved common factors, and that these factors affect each unit in the panel differently. The econometric literature provides different methodologies to correct for cross-sectional dependence (Bai, 2009; Pesaran, 2006). Here, we follow the methodology proposed originally by Giannone and Lenza (2008) in their study of the Feldstein-Horioka puzzle. They show that the high correlation between domestic savings and investments found in previous studies vanishes once the panel takes into account this factor structure approach. They attribute the high correlation between domestic saving and investment previously found in the literature as a result of a misspecified regression. This approach looks particularly suited to our case as it also allows us to study the heterogeneity in countries' responses to a shock to the global factors.

3 Methodology

While the theory acknowledges that in financially integrated economies global factors are key in determining interest rates, empirical results have proven inconclusive. Some authors have found that idiosyncratic factors play a minor role (Ford and Laxton, 1999; Faini, 2006) while others have found that domestic conditions are instead very relevant (Ardagna et al. 2007; Chinn and Frankel, 2007).

In this section we propose to approach the question with the help of a new methodology originally introduced by Giannone and Lenza (2008), which is meant to isolate pure idiosyncratic shocks from global factors. Starting from the assumption that both interest rates and macroeconomic variables are moved by a set of common factors, we derive our estimating equations - one for the long term interest rates and one for sovereign spreads. We also show that the methodologies previously used in the literature might not be robust since they fail to properly take into account the country specific response to global shocks.

3.1 The econometric model

Let's assume that the interest rate is r_{it} for $(i = 1, \ldots, N; t = 1, \ldots, T)$ and x_{it} is a set of regressors for $(i = 1, \ldots, N; t = 1, \ldots, T)$. A standard approach to the analysis of the effects of fiscal policy on interest rates with panel data would resolve to the estimation of the following model:

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

where some form of heterogeneity across countries is allowed by introducing time-invariant country characteristics in the form of fixed effects (α_i). This is the equation estimated by Reinhart and Sack (2000) in a panel of 20 OECD countries. This model however, is likely to suffer from cross sectional dependence since it does not take into account the presence of unobserved factors which are common to all countries. Open and integrated economies, in fact, are very much likely to have common sources of fluctuations - such as common business cycle shocks - which jointly determine the reaction of monetary and fiscal authorities and hence the level of interest rates. As pointed out by Eaton (2000) and Giannone and Lenza (2008), these general equilibrium effects play a relevant role in explaining the correlation between macroeconomic variables and interest rates. Following the analysis by Giannone and Lenza (2008), we therefore assume for our variables a factor structure of the type:

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

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

A general relationship between interest rates and macroeconomic variables net of the general equilibrium effects would take the form:

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

however, because the idiosyncratic components are unobservable, the equation above cannot be estimated from the data. Using (2) we can rewrite (3) in terms of observable quantities and global factors:

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

By taking explicitly into account the global factors $\{f_t^k\}_{k=1}^M$, (4) allows to estimate the relationship between the idiosyncratic components of the variables of interest. Hence consistent estimates of the β can be obtained by standard OLS conditional on consistent estimates of the common factors. *Section 3.2* will describe how such estimates can be obtained from the data. This estimation technique goes under the name of *Factor Augmented Panel (FAP)*.

From an econometric perspective it is important to notice that when the data generating process is given by (2) standard estimation techniques might lead to incorrect results. When tackling the issue of common unobserved factors the literature has mainly pursued two different paths. A first approach (Breedon et al. 1999; Chinn and Frankel, 2005) is to find an a priori *observable* variable (or a subset of variables) which might affect contemporaneously the interest rates across countries, and introduce them directly in the panel, so that the regression model becomes:

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

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

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

where the time dummy (τ_t) is equivalent to assuming that in each time period there is a common shock which affects homogeneously countries' interest rates. Precisely because both (5) and (6) impose homogeneous effects of the global factors, they are likely to produce biased estimates. To see this suppose that the effect of the common factors in (4) was homogeneous. Then the equation would collapse to the standard two way fixed effects estimator: the unobservable factors would be proxied by either any variable z_t common across countries, or by simple time effects. If on the other hand common factors do have an heterogeneous effect across countries, then neither common regressors nor time dummies would absorb the effect of the factors, which will then become part of the error term. However, if the unobservable factors are correlated with the elements in x_{it} - as implied by (2) - then estimating (5) or (6) would produce biased results.

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 a return on a risk free asset r_{jt}^B where the superscript B stands for *"Benchmark Country"*. Assuming for simplicity a zero recovery rate, the no arbitrage condition can be written as:

$$(1 + r_{it})\, p_{it} = \left(1 + r_{jt}^B\right) + \theta_{it}\,(1 - p_{it}) \tag{7}$$

where $(1 - p_{it})$ is the probability of default and θ_{it} is investors' risk aversion, which is allowed to affect each country's interest rates differently. Rewriting the equation to have the yield spreads on the left hand side we obtain:

$$\left(r_{it} - r_{jt}^B\right) = \left(1 + r_{jt}^B + \theta_{it}\right) \frac{1 - p_{it}}{p_{it}}$$

Let's assume now that the probability of default is a function of the idiosyncratic macroeconomic variables: $\frac{1-p_{it}}{p_{it}} = \alpha_i + \beta x_{it}^{ID}$ and that the risk aversion coefficient is in fact proportional to an unobservable factor with country specific factor loadings: $\theta_{it} = \varphi_i f_t^{RP}$. The equation above then can be rewritten as:

$$\left(r_{it} - r_{jt}^B\right) = \left(1 + r_{jt}^B + \varphi_i f_t^{RP}\right)\left[\alpha_i + \beta x_{it}^{ID}\right]$$

Solving the equation and grouping terms together yields:

$$\left(r_{it} - r_{jt}^{B}\right) = \alpha_i + \beta x_{it}^{ID} + \Psi_i f_t^{RP} + \alpha_i r_{jt}^{B} + \mu_{it} \tag{8}$$

with $\Psi_i = \varphi_i \alpha_i$, $\mu_{it} = \left\{\beta r_t^B x_{it}^{ID} + \Phi_i x_{it}^{ID} f_t^{RP}\right\}$ and $\Phi_i = \beta\varphi_i$.

We can now substitute out x_{it}^{ID} using (2) and, without loss of generality, set $M = 2$ to obtain:

$$\left(r_{it} - r_{jt}^{B}\right) = \alpha_i + \beta x_{it} + \Delta_{1i} f_{1t} + \Delta_{2i} f_{2t} + \Psi_i f_t^{RP} + \alpha_i r_{jt}^{B} + \mu_{it} \tag{9}$$

where $\Delta_i^1 = -\beta\lambda_{1i}^X$ and $\Delta_i^2 = -\beta\lambda_{2i}^X$. Sovereign spreads are therefore driven by a set of observable variables, a set of common factors and a nuisance parameter. The term μ_{it} can be considered an error term because - under the assumption of known factors - when taking conditional expectations on both sides of (9) all its components converge to zero. To see this let's rewrite μ_{it} as follows:

$$\begin{aligned}
\mu_{it} &= \beta r_{jt}^B x_{it}^{ID} + \Upsilon_i x_{it}^{ID} f_t^{RP} \\
&= \beta\left\{\lambda_{1j}^{rB} f_{1t} + \lambda_{2j}^{rB} f_{2t} + r_{jt}^{ID,B}\right\} x_{it}^{ID} + \Phi_i x_{it}^{ID} f_t^{RP} \\
&= \Omega_j f_{1t} x_{it}^{ID} + \Omega_j f_{2t} x_{it}^{ID} + \beta r_{jt}^{ID,B} x_{it}^{ID} + \Phi_i x_{it}^{ID} f_t^{RP}
\end{aligned}$$

where the expression in the second line comes from the fact that $r_{jt}^B = \lambda_{1j}^{rB} f_{1t} + \lambda_{2j}^{rB} f_{2t} + r_{jt}^{ID,B}$. Given that the idiosyncratic components have zero mean and they are orthogonal to the factors, when taking expectations conditional on $\left\{x_{it}, r_t^B, f_{1t}, f_{2t}, f_t^{RP}\right\}$ the first two elements of μ_{it} will converge to zero. So will the third one. This is 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. Finally, the last element will converge to zero if the idiosyncratic components of the macroeconomic variables are uncorrelated with the factor that drives the risk premia f_t^{RP}. The method of extraction of the factors f_{1t} and f_{2t} ensures that this condition is respected. In fact, if the risk factor was strongly correlated with the idiosyncratic components, then it would appear as one of the factors of the set $\left\{f_t^k\right\}_{k=1}^M$. Hence, if we do not find a quantity which is interpretable as global risk when we extract the set of global factors $\left\{f_t^k\right\}_{k=1}^M$ that determine $\{r_{it}, x_{it}\}_{i=1,\dots N; t=1,\dots t}$, then we can be reasonably sure that there is no correlation between f_t^{RP} and x_{it}^{ID}. More details on the extraction of the factors and their interpretation are presented in the next section and in *Appendix A*. From an practical point of view, this assumption is reasonable especially given that when analysing sovereign spreads we exclude from our sample the two benchmark countries - US and Germany - which, because of their size, might influence global risk with an unexpected change in their macroeconomic fundamentals.

3.2 Estimation Strategy

To estimate the unobservable common factors we closely follow Giannone and Lenza (2008) and obtain them by means of principal components. This is a very general procedure and can be applied whenever in a linear regression the variables are supposed to have a factor structure. It consists of taking all the set of dependent and independent variables for all the N cross sections and, after stacking them in a single matrix, apply principal components. Hence, to find an estimate of the factors in (4) we start from the representation in (2) and collect all the variables $\{r_{it}, x_{it}\}_{i=1,..,N;t=1,...T}$ in a big matrix W^r defined as:

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

In terms of W the system (2) can be represented in the following way:

$$W^r = F\Lambda + W^{r,id}$$

where F is the $T \times M$ matrix of common factors, Λ is the matrix of factor loadings and $W^{r,id}$ is the idiosyncratic component. Under the assumptions that common factors are pervasive and that idiosyncratic shocks are not pervasive, the matrix of common factors F can be consistently estimated by the eigenvectors extracted from the variance covariance matrix of W. In fact, under these conditions consistency is achieved as the number of series and the number of observations increase. Moreover these estimates are robust to some form of non stationarity in the data (Giannone and Lenza 2008). Of all the M eigenvectors we keep the first $q < M$ which are associated with the largest q eigenvalues.

This procedure ensures that the extracted factors are indeed those elements which explain the bulk of the correlation among all of our data series and are therefore responsible for their co-movements. *Table 1* shows that the first two principal components explain 66% of the panel variance, with the third one contributing for less than 10%. Following Giannone and Lenza (2008) we therefore take into consideration only the first two factors. In *Appendix A* we show that the two factors extracted using the matrix W^r track respectively the average monetary and fiscal policy stances of the countries in our sample. Once obtained consistent estimates we can use them into the equation (4):

$$r_{it} = \alpha_i + \tau_t + \beta x_{it} + \delta_{1i}\widehat{f}_{1t} + \delta_{1i}\widehat{f}_{2t} + \omega_{it} \tag{10}$$

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.

To estimate the equation for the spreads (9) we need the factors $\left\{\widehat{f}_{1t}, \widehat{f}_{2t}\right\}$ and a consistent estimate of the risk factor f_t^{RP}. Much of the empirical literature on sovereign spreads usually approximates global risk using the VIX index[2]. Here we adopt a more agnostic approach and proceed to the extraction of the common factors exactly as before. We construct a matrix called $W^{spreads}$ which contains the the same elements x_{it} of the matrix W^r but where, to be consistent with the methodology, we substitute the elements r_{it} with the spreads $\left(r_{it} - r^B_{jt}\right)$ and include also the benchmark interest rates r^B_{jt}. In *Appendix A* we show that, again, the first two principal components extracted using $W^{spreads}$ explain around 67% of the variance, with the third component still contributing for around 12% of the variance. Consistently with our theoretical model, the three extracted components track very closely the average monetary and fiscal policy stances and the VIX index. In particular: the first factor, which contributes for about 45% of the variance is the average fiscal stance; the second one - contributing by around 22% - is the risk factor, and the third one is the average monetary policy stance. Plugging back these elements into (9) yields the estimating equation for the spreads.

Although faithful to the theoretical derivation, equation (9) contains a very large set of parameters as it has four elements with country specific coefficients - the three latent factors and the interest rate of the benchmark country. To avoid running out of degrees of freedom we therefore let the coefficients vary across country-groups instead than by individual countries. Our preferred grouping of countries is: (i) EMU Countries; (ii) Nordic Countries; (iii) Others[3]. Moreover we perform a standard F test to check that these coefficients are truly heterogeneous. While the hypothesis of heterogeneity is strongly accepted for the coefficients on the first three factors, it is rejected for the coefficients on r^B_t, which are therefore treated as homogeneous[4]. Hence, the equation for the spreads takes the from:

$$\left(r_{it} - r^B_t\right) = \alpha_i + \beta x_{it} +_{it} \Delta_{1i}\widehat{f}_{1t} + \Delta_{2i}\widehat{f}_{2t} + \Psi_i \widehat{f}^{RP}_t + \psi r^B_t + \mu_{it} \tag{11}$$

A further methodological point is worth mentioning: normally, having estimated elements in the regression would introduce a further source of uncertainty, which would require bootstrapped standard errors. However, we rely on the result by Giannone and Lenza (2008), Bai (2003) and Bai and Ng (2006) according to which when the number of countries is not too small relative to the sample size there is no generated regressor problem[5].

Before turning to the description of the data, it is important to notice that this is not the only methodology proposed by the literature to tackle cross-sectional dependence. Other strategies can be found in Pesaran (2006) and Bai (2009). In particular, Pesaran (2006) has proposed an estimator called the Common Correlated Effects (CCE), which 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. While this method is simple and intuitive, we believe its shortcoming is that it does not provide us with a direct estimate of what the common factors are, which is

[2]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. It shows the market's expectation of 30-day volatility.

[3]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.

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

[5]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.

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. More details on these two alternative estimation techniques are given in *Appendix B.* In *Section 7* we will show that the main results from our equations (10) and (11) are robust to the choice of the estimator.

4 Data description and properties

4.1 Data

Our data are taken from a real-time semi-annual dataset of macroeconomic and fiscal forecasts of OECD countries, based on the December and June issues of the OECD's *Economic Outlook* , 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.

Since we are interested in isolating the effects of fiscal policy on interest rates and spreads, we should be using long term fiscal projections as regressors and expected interest rates for left hand side variables. As noted by Laubach (2009), long-horizon projections of fiscal policy and interest rates are presumed to be little affected by the current state of the business cycle. Unfortunately, these data are not available for a large group of countries. In our dataset, the projected horizon is either one or two years ahead. In particular, in the editions from 1989 to 1994, the Outlook publishes in year t the projections for year $t+1$, both in the June and December issue. Starting from 1996, the OECD publishes also projections for year $t+2$ in the December issue, while the June issue contains only the projection for the year $t+1$. Therefore we have: one year ahead projections for the June issue and for December issue between 1989 and 1994; two years ahead projections for the December issue from 1996 to 2009. While these forecasts embody different information sets, 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[6].

Another relevant point is the choice of the dependent variables. Since we are not able to gather data on historical forward rates for a large group of countries we use realized interest rates. For the purpose of our analysis we use two different dependent variables: the ten years yield on sovereign bonds (r); 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 $\left(r - r^B\right)$. We construct these variables using the values of the interest rates observed in the month after the release of the forecast: the January one for the December issue and the July one for the June issue. This approach is useful because the forecasts on fiscal variables are likely to take into account current markets conditions and the level of interest rates, so that measuring interest rates after the release of the forecasts reduces the problem of reverse causality. Furthermore, it only involves the reasonable assumption that financial markets are forward looking and are able to incorporate rapidly all the available information. Data on interest rates are taken from Datastream as

[6]Results are available upon request.

shown in *Appendix D*.

To measure the yield spreads we need to define a country to use as a benchmark. In general the literature that considers only EMU countries, uses as a benchmark the interest rate on German government Bunds. This is justified by the fact that inside the EMU countries since 1999 the exchange rate risk has disappeared and Germany seems to have acquired the "status" of safe haven (see Schuknecht et al. 2011). Hence the differences between the interest rates on government bonds and the German counterpart well proxy the risk premium. Outside the EMU area, instead, it is generally the US which is considered the risk free asset. Because in our sample we have both EMU and non EMU countries, we measure the sovereign spreads with respect to two different benchmarks: we use the US for non EMU countries and we use Germany for EMU countries. We believe this approach to be preferable to that of a single benchmark because it allows us to take advantage of having a set of countries with a single currency and for which no adjustment for exchange risk is required. This gives us more confidence as for the meaning of the spread as a pure risk premium.

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

$$\left(\widetilde{r_{it} - r_{jt}^B}\right) = \left(r_{it} - r_{jt}^B\right) - \left(sw_{it} - sw_{jt}^B\right) \tag{12}$$

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[7]. Because the two benchmark countries drop out of the analysis and because of the availability of data on interest rate swaps, in the regression for sovereign spreads we have a balanced panel of 15 countries observed between 1997h1 and 2009h2.

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[8]. We use primary deficit instead of total deficit to avoid the problem of reverse causality. As a measure of debt, we use the total gross financial liabilities of the general government[9]. Since it is not clear whether stocks or flows are more important and since the stock of debt represents the cumulated deficits (credit risk) we introduce both indicators throughout the estimation. *Table 2* reports the descriptive statistics. In the next section we provide some exploratory analysis to recognize the importance of common factors in the behaviour of interest rates.

[7]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.

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

[9]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.

4.2 Properties

The importance of cross sectional correlation of the interest rates can be easily observed by visual inspection. *Figures 1 and 2* represent the behaviour of long term interest rates and sovereign spreads in our sample. We have grouped 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. By looking at *Figure 1* which shows the behaviour of the long term rate, we notice that interest rates are higher at the beginning of the sample both in the EMU countries and outside. Starting after 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 EMU: throughout the 2000s, interest rates remain low particularly so in Japan, and they begin to diverge only during the crisis. *Figure 2* reports the cross section of sovereign spreads. We use the same ordering of countries, without the benchmark countries US and Germany which drop out of the sample. We can notice a similar common downward trend, but there seems to be somewhat more idiosyncracy with respect to nominal rates for countries outside the EMU. 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 almost all sovereign spreads jump steeply upwards, with some minor exceptions for the Nordic countries.

This evidence supports the hypothesis that with higher macroeconomic and financial integration countries might be subject to the same shocks causing a co-movement in interest rates and risk premia. In order to verify statistically the importance of common factors, we test for the presence of cross sectional dependence both for the dependent and independent variables using Pesaran's (2006) CSD test. We report the results for all the variables in our sample in *Table 3*. Under the null of *independence* the statistic is distributed as $CSD \sim N(0, 1)$, which implies that for all our variables there is a strong evidence in favour of cross sectional dependence. Before turning to the estimation, we briefly comment on the results on the stationarity tests, which we report in *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 multifactor structure, and we are able to reject the null of unit root[10]. We thus conclude that all the variables in our panel can be treated as stationary.

[10] We were unable to implement the Pesaran, Smith and Yamagata (2008) test, given that our time series is too small.

5 Estimation Results

5.1 Baseline Model

We now turn to the estimation. Once extracted the factors from the data, we estimate the theory implied equations (10) and (11) using the following specifications:

$$r_{it} = \alpha_i + \tau_t + \beta X_{it} + \xi q_{it} + \delta_{1i}\widehat{f}_{1t} + \delta_{1i}\widehat{f}_{2t} + \omega_{it} \quad (13)$$

$$\left(\widetilde{r_{it} - r_t^B}\right) = \alpha_i + \tau_t + \beta X_{it} + \zeta z_{it} +_{it} \Delta_{1i}\widehat{f}_{1t} + \Delta_{2i}\widehat{f}_{2t} + \Psi_i \widehat{f}_t^{RP} + \psi r_t^B + \mu_{it} \quad (14)$$

where $\left(\widetilde{r_{it} - r_t^B}\right)$ are the spreads corrected for exchange rate risk as discussed in the previous section. The set of regressors X_{it} contains the main variables of interest - the OECD forecasts of public debt, primary deficit, real GDP growth and the VIX index - while the vectors q_{it} and z_{it} are vectors of controls. In particular, in the baseline estimation q_{it} contains the expected short term interest rate[11] 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. The vector z_{iz} instead contains a measure of liquidity (the ratio of the stock of public debt over the total debt of OECD countries) and a dummy variable for the introduction of the Euro to control for the break in the trend of sovereign spreads in EMU countries after 1999. For both equations we estimate first a specification including only country fixed effects (α_i), then a second one which includes also time fixed effects (τ_i) and finally a third one which includes both fixed effects and estimated factors (the *Factor Augmented Panel*). When estimating the second and third specification the VIX index drops out of the analysis as it is country invariant.

The results are reported in *Tables 5 and 6.* The first column of both tables reports the results for the specification with one way fixed effects; the second one introduces also time fixed effects and the third column reports the results from the *Factor Augmented Panel Estimator (FAP).* Moreover, *Table 6* shows three more columns where we follow some of the literature on sovereign spreads (see for example Codogno et al. 2003) and include the first lag of the dependent variable. In this case the regression is estimated using the Arellano and Bond estimator for dynamic panels.

At the bottom of each table we report the value of the *CSD* statistic, which is Pesaran's (2006) test for residual cross-sectional dependence[12]. 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

[11] We also tried using the actual 3 months interest rate from Datastream obtaining very similar results.

[12] 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:

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

does not rely on this assumption. In our case any *p-values* are therefore likely to give a wrong indication of residual cross sectional dependence. Nonetheless we can interpret the variation in the value of the statistic across different specifications as the marginal impact of the introduction of common factors in correcting cross correlation.

We start by looking at *Table 5:*

[Table 5 here]

The results obtained from FE indicate a positive correlation between fiscal variables and long term interest rates: 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. The results are in line with those obtained in the literature (Ardagna et al., 2007), except that, contrary to the authors, we find that the coefficient on expected public debt is correctly signed. This may be a direct consequence of using fiscal projections rather than actual data, which reduces the problem of endogeneity. The VIX index, however, comes out with a negative sign. The value of the CSD statistic is very high indicating high residual cross sectional dependence, and the importance of accounting for unobserved common factors. The 2FE and the FAP results corroborates this intuition, as for both estimator the CSD statistic falls markedly (from above 40 to -3.5), with a better performance of the FAP against the 2FE (-3.5 vs. -2.5). We interpret this as evidence in favor of the FAP to better tackle cross sectional dependence. The 2FE shows that the impact of fiscal variables - despite staying statistically significant - decreases in magnitude with the effects being of 6 basis points for primary deficit and 0.4 basis points for public debt. If we look at the FAP we see that only the coefficient on public debt remains significant but with a slightly stronger effect of around 1 basis point.

The expected short term interest rate is always positive and significant across all the specifications, but the magnitude of the coefficients decreases significantly when using the FAP, indicating that the sensitivity of interest rates to own monetary policy development is smaller in an open economy setting. 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, indicating that for a 1% increase in expected inflation, investors require a premium of around 8 basis points.

Table 6 shows the results for the spreads equation:

[Table 6 here]

Looking at the first column we can see that with a simple FE estimator fiscal variables turn out of the wrong sign: both public debt primary deficit are negative and the latter is also statistically significant. This puzzling finding disappears when including common factors. With the 2FE estimator, however, none of the fiscal variables

Pesaran (2004) 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 $T < N$.

is statistically significant, but when we estimate the FAP both public debt and primary deficit turn out significant at the 5% level. It is interesting to note also that when passing from the 2FE to the FAP specification, while the effect of public debt remains stable, the coefficient on primary deficit doubles in magnitude from 1.3 to 2.5 basis points. We interpret this as again a clear sign of the importance of accounting for global factors.

Growth and liquidity have a negative sign as higher expected GDP growth decreases the probability of default while more liquid markets tend to decrease the liquidity premium, which is normally considered a component of the risk. 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 always significant and with a negative sign.

The last 3 columns of *Table 6* show that these results are robust to the introduction of the lag of the dependent variable as an additional regressor. Interestingly, though, when estimating the FAP specification (column 6) the lag of the dependent variable loses significance, while the coefficients for the other variables remain very close - in terms both of significance and of magnitude - to those obtained in column 3. This shows that the strong persistence in interest rate spreads is in reality induced by unobserved factors: if in fact unobserved factors display persistence, then omitting them from the estimation will generate serial correlation with the error terms which then generates serial correlation in the dependent variable.

5.2 Non linear effects of public debt

So far we have shown that, when we account for cross-sectional dependence, public debt remains the only fiscal variable that is consistently correlated with long term interest rates, while both debt and primary deficit remain significant when explaining sovereign spreads. In particular, a one standard deviation increase in public debt (which has an average value of 30% in the sample) increases nominal interest rates by around 24 basis points and spreads by around 15 basis points. A one standard deviation increase in public deficit (which averages around 4%), instead, increases sovereign spreads by about 10 basis points. Since the literature (see for example Ardagna et al. 2007 or Schuknecht et al. 2011) points out that the effects of public debt on interest rates may be different at different levels of public debt, in this section we investigate more in details the possibility of non-linearities. The results are reported in *Tables 7 and 8*. In each table, we include different specifications: a squared term of the debt level, splines for values of debt above and below the median (66% of GDP) and splines for values of debt above and below the 75th percentile (83% of GDP). In the equation for the spreads we also test a different specification where we interact the fiscal variables with the VIX index. In fact, there exist evidence (Baldacci et al 2008 and Codogno et al. 2003) that fiscal factors tend to be more important in explaining sovereign risk during periods of financial distress.

[Table 7 and 8 here]

Overall, we fail to find any significant non linear effect, and the results are similar to the one obtained in the baseline equations. *Table 7* shows that when including the quadratic term on public debt, the coefficient on public debt ceases to be statistically significant and in the other specifications the coefficients for different levels of debt are always very similar[13]. Same flavour have the results in *Table 8* where we repeat the analysis for the equation for sovereign spreads: the squared coefficient on debt level does not turn out to be significant and the coefficients on different levels of public debt are not statistically different from each other. Finally, columns 4 to 6 of *Table 8* report the results when we tested the non linearity with the VIX index. We included three different specifications: one where the VIX is interacted only with the debt level (column 4), one where it is interacted only with the primary deficit (column 5) and one where we introduce both interaction terms (column 6). Interestingly, not only interaction terms are never significant, but introducing the VIX interacted with a fiscal variable makes also that same variable lose significance.

These results show that the non linearities previously found in the literature can be related to the omission of the common factors. The non linear effect of debt level on long term interest rates, for instance, can be driven by the omission of the aggregate deficit factor. Because of the correlation which exists between average deficit and country specific debt levels, omitting the former would most probably artificially increase the importance of high levels of public debt. A similar argument can be followed for the non linear effects between fiscal fundamentals and the VIX index. Our framework shows that global risk is one of the common drivers of sovereign spreads. Hence, because the FAP technique allows the impact of global factors to be different across countries, failing to find a significant non linearity between fiscal variables and the VIX might signal that fiscal fundamentals are correlated with the country specific coefficients on the global risk factor. In *Section 6* we will show that this is indeed the case.

5.3 Time Variation in the idiosyncratic components

In this section we investigate whether the importance of the idiosyncratic components has been changing over time. In theory we would expect that, with the progressive financial and economic integration among advanced economies, global factors might become more and more important over time in the explanation of interest rates, therefore reducing the impact of country specific policies. To achieve this goal we re estimate (13) and (14) and perform rolling regressions. The results are presented in *Figure 3* and *Figure 4*.

[Figure 3 and 4 here]

The first figure shows the behaviour of the coefficients on primary deficit, public debt and short 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 both for 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

[13] And not statistically different from each other.

central banks have been progressively losing effectiveness in stirring long term rates. This evidence is consistent with that presented by Giannone Lenza and Riechlin (2009), who showed 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 debt, deficit and the benchmark interest rate r_t^B in the equation for the spreads. Interestingly it seems that the importance of idiosyncratic fiscal factors stays flat for most of the sample and then increases markedly for the last observations. This seems to indicate that in times of crisis markets look closer at fiscal fundamentals when pricing the risk. The pattern of the coefficient on r_t^B seems also worth some comments: while it is positive in the first part of the sample, it turns negative in the period of the crisis. In tranquil times, when the benchmark interest rate falls - therefore increasing the liquidity in the market - investors look for returns and shift to riskier assets. This tends to reduce their long term rates and depresses the spreads on risk free bonds. In crisis times, instead, investors fly to safety investing excess liquidity in risk free bonds, therefore depressing their yields and further increasing the interest rate spread of risky assets.

5.4 Are crisis episodes different?

Following up from the evidence collected using rolling regressions, this section wants to investigate whether the impact of fiscal policy on sovereign risk changes during episodes of financial stress. The latest financial crisis seems in fact to suggest that fiscal policy choices still play a significant role in determining sovereign spreads. Visually, this seems to be confirmed by the results in *Figure 4* where the coefficients on primary deficit and public debt increase in magnitude in the last part of the sample. However we want to test statistically this claim, given that in crisis periods spreads will be driven up also by the increase in two of the unobserved components: global risk and aggregate deficits. In this section we therefore re-estimate (14) interacting the idiosyncratic fiscal policy variables with dummy variables for crisis periods. The results are reported in *Table 9.*

[Table 9 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 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 in *Table 9* - 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 - following Faini (2006) - we construct as the difference between the surplus that, for given real interest rates and growth rates, stabilizes the debt to GDP ratio and the actual government budget balance[14]. We believe this is a more appropriate variable than public debt to detect the impact of fiscal policy on risk premia. Public debt is in fact a *stock* variable which represents the cumulation of past deficit. Risk premia arise when investors foresee a future *unsustainable* path for public debt; that is, they fear that the sovereign will not be able to repay interests given

[14] See the Appendix D for more details.

the expected path of future revenues. In fact, a sovereign may be able to repay interests on the current cumulated stock of debt, but may be suddenly perceived to be unable to pay interests on future expected debt. Therefore, it is important to look at expected variation in the stock of debt, and in particular, on the effort required (in terms of future revenue) to repay the future debt. As the latest crisis has shown, risk premia may not be necessarily related to the level of public debt. Ireland and Spain started in fact from a very low level of debt, but what seemed to matter for investors were their expectations about the ability of these countries to finance future debt, given that they both suffered from huge adverse effects of asset price collapse. To sketch the idea, in *Appendix D* we provide a simple formalization on how this variable is related to risk premia. Results from columns 1 and 5, indeed show that the deficit gap is a significant determinant of sovereign spreads and its importance is higher in times of financial distress. However, the difference between the two coefficients is not statistically significant.

Columns 2 to 4 and 6 to 8 show that evidence of non linearity exists also with respect to primary deficit. In fact, contrary to the coefficient on public debt, the effect of primary deficit passes from 2.2 basis point in normal times to 4.8 basis points during financial crises. However, from a statistical point of view we cannot reject the null of equality between those coefficients. The results are very similar irrespective of the way we define episodes of financial crises.

6 Fiscal Policy Spillovers

A final part of our analysis concerns the importance of common factors. We have seen so far that nominal interest rates and sovereign spreads seem to be driven by global factors which closely resemble global monetary policy, global fiscal policy and - for the spreads - investors' risk aversion. In this section we analyze quantitatively the importance of these elements. In particular, we concentrate on how shocks to the aggregate fiscal stance and risk aversion transmit to domestic interest rates and interest rate spreads respectively; which is we analyze the coefficients δ_{1i} in (13) and Ψ_i in (14). The study of these elements can help us shed some light on the dynamics of the interest rates and sovereign spreads observed during the recent crisis, which was characterized by a simultaneous increase in advanced countries' budget deficits and in investors' risk aversion.

Theoretically, in a group of integrated economies global fiscal stance is likely to affect interest rates because it changes the amount of savings available: if all governments increase spending together, this affects the aggregate savings schedule and thus the equilibrium interest rate; hence, because of capital markets integration, interest rates in all countries will follow. Similarly, when markets enter periods of distress, investors will tend to move their capitals towards safer assets: global demand for safer assets increases as riskier assets are offloaded. This depresses the interest rates paid by "safe havens" and increases those paid by other countries, therefore widening the spreads.

The literature has already recognized the importance of these effects. Faini (2006) for example, analyzes the extent of fiscal spillovers for the EMU, a deeply integrated economic area. Ardagna et al. (2007) consider the importance of fiscal spillovers in the OECD. Recently, Claeys et al. (2008) analyze the effects of spillovers in a panel of 100 countries. In all cases, the quantified effects are economically strong and statistically significant, with fiscal spillovers dominating quantitatively domestic crowding-out effects[15]. 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).

One important advantage of our approach, though, is that we can analyze not only the relative magnitudes of idiosyncratic versus common components, but we can also study how the effects of common factors differ across the countries in our sample. For instance, when aggregate deficits increase we would expect interest rates to respond more in countries with relatively closer capital account, as they can draw from a smaller pool of savings. Alternatively, interest rates might increase more in countries where there is a larger share of foreign capital. Using the spreads equation, instead we test whether when global risk aversion increases investors start discriminating across countries, asking higher returns to governments which are deemed less safe - either because of bad fundamentals or because of bad institutions.

An issue arising from the estimation of fiscal policy spillovers is how to approximate the aggregate fiscal stance. *Appendix A* shows that the simple average of primary deficits of the countries in the sample is very similar to the second common factor; however, a “pure” spillover measure would require to exclude the own country's fiscal stance from the average. As such, to check the robustness of our results, we confront the coefficients obtained using the average deficit with those obtained using the ”corrected” average deficit, which for each country is the average deficit of all the other $N-1$ countries[16]. To measure spillover effects from global risk, instead, we substitute the factor f_t^{RP} in the spreads equation with the VIX index (see *Appendix A*) and we allow the coefficients Ψ_i to vary across countries instead than across country groups.

We report the results in *Table 10* and *Figures 5, 6 and 8.* The vertical bars report the same estimated coefficients presented in *Table 10* but allow for easier comparison across countries. From *Figure 5 and 6* we can see that the magnitude of the country specific coefficients on the global fiscal stance are very similar irrespective of the way they are estimated - i.e. using simple or ”corrected” averages - and the ranking of the coefficients across countries remains the same. Interestingly, 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 way lower, 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 spillover

[15] Faini (2006) finds that while domestic policy bears an effect on interest rates, these are rather small compared to the spillover effects: 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 analyze 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 coefficients for spillovers are homogeneous across countries.

[16] 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).

coefficients are lower is composed of the US, Norway and Germany, which are also the only countries for which the spillover 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 and natural gas (Norway). Quantitatively global deficit is by far more important than the idiosyncratic fiscal components. The average spillover coefficient is in fact around 21 basis points, which is more than ten times larger than the coefficient on idiosyncratic primary deficit. Because the average primary deficit during the crisis period has increased by around 6 percentage points, it means that it could have generate increases in long term rates of up to 2 percentage points, everything else equal[17].

[Figures 5 and 6 here]

Besides recognizing the quantitative importance of the spillovers from global fiscal stance, our framework allows us to investigate the driving factors behind their cross sectional dispersion. In (4) we showed that the spillover coefficients can be expressed as $\delta_{ki} = \lambda^r_{ki} - \beta\lambda^X_{ki}$ meaning 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}. It is therefore likely that the spillover coefficients will be higher in countries with less integrated capital markets. A close capital account, in fact, translates into a higher value of the coefficients λ^r_{ki} in that an expansion of aggregate budget deficits means relatively higher excess demand of capital for countries that can only access their domestic capital markets. Another possible explanation is the presence of high current account deficits. In terms of our structural model, a large share of foreign capital can translate - as for the degree of openness - into high values of the λ^r_{ki} coefficients. If in fact global fiscal expansions take place in periods of recessions when investors also pull out capital from abroad, then running a high current account deficit might aggravate capital scarcity and induce higher increase in interest rates. Besides, if current account deficits represent scarce competitiveness of national products, it can be the case that an aggregate fiscal expansion only translates into higher imports and hence it lowers domestic growth. In terms of (4) this would mean a negative value for the coefficient λ^X_{ki} and therefore higher δ_{ki}. To proxy capital account openness we use both a *de jure* and a *de facto* measure: for the first one we take values of the Quinn and of the Chin and Ito indices as of the beginning of period[18], and for the second one the value of the long term nominal interest rates again measured at the beginning of the period. *Figure 7* shows that the spillover coefficients seem indeed correlated with initial capital account openness - with stronger correlation with the de facto measure - and the size of current account imbalances.

[Figure 7 here]

Figures 8 and 9, instead, plot the estimated coefficients of the country specific responses to the global risk aversion factor (Ψ_i). Even in this case there seems to be clusters of countries, with Ireland and Italy having the highest values and the Nordic countries and the UK with a negative value. Even in this case the sizes of the

[17] Of course in reality this effect has been counterbalanced by the considerable easying of global monetary policy stance.
[18] Quinn (1997), Chin and Ito (2009).

coefficients are very important. For instance, Italy and Ireland during the crisis saw their interest rates surge by 150 and 300 basis points over the German Bund. Over the same period the VIX index increased by about 30 points, meaning that the spillover from global risk can account for respectively 25% and 40% of the total increase in their spreads. The cross sectional dispersion in the coefficients seems to be mostly related to the level of public debt and to the quality of the government *(Figure 9).* The first finding is directly connected with the results in *Section 5.2,* where we showed that for the spreads equation we do not find evidence of non linearity between fiscal variables and the VIX index. Because the effect of a shock on global risk aversion is larger in countries with worse fiscal fundamentals, it is likely that in a standard fixed effects regression, this would show up as a significant interaction term between fiscal variables and a measure of risk aversion.

The quality of the government is proxied by: (i) the incidence of corruption[19]; (ii) the institutional quality[20] and (iii) the "deficit surprise". The "deficit surprise" is a measure which indicates by how much governments have on average been disappointing agents' forecasts during periods of economic contraction. As Buiter (2010) points out, in fact, "the best guide to future primary surpluses is the government's capacity of generating primary surpluses when doing so was not easy". It is measured as the average difference between the forecast of the deficit made at time $t-1$ for time t and the realized deficit at time t during periods of recessions. Recessions are identified with periods of negative output gap, which is computed passing a standard Hodrick Prescott filter on quarterly data for real GDP[21]. We interpret it as an indication of how much agents perceive a government to be fiscally "responsible" and "reliable" during bad times.

[Figures 8 and 9 here]

These results provide us with a novel interpretation for the cross sectional dispersion of interest rates. The first piece of evidence - *Figures 5, 6 and 7* - suggests that the common downward trend of interest observed between 1992 and 2000 can be explained by the move of most countries towards fiscal discipline, which has increased aggregate savings. Stronger convergence - facilitated for some countries by the accession to the Euro - has taken place for countries initially less financially integrated. However, whenever this has translated into the build up of macroeconomic vulnerabilities like large current account imbalances (Giavazzi and Spaventa, 2010), the price to pay after a fiscal shock of the opposite sign is proportionately higher. The second piece of evidence - *Figures 8 and 9* - instead, shows that, when uncertainty shakes financial markets the dispersion in risk premia seems to depend mainly on investors' perception of governments' quality. The presence of a "deficit bias" mirrored by high stocks of public debt or by deficits which in bad times systematically exceed forecasts, and the presence of ineffective and corrupt governments can be interpreted by investors as a strong signal of the inability to implement the austerity packages that markets expect in periods of emergency.

[19] This is the average between the World Bank indicator of "control of corruption" and the corruption index of the International Country Risk Guide; low value indicate high incidence of corruption. Because the two indices have different scale they have been standardized before averaging.

[20] This is the average of the six World Bank indicators of quality of governance: 1) Voice and Accountability; 2) Political stability; 3) Government Effectiveness; 4) Regulatory quality; 5) Rule of law; 6) Control of corruption.

[21] We excluded Norway given that the difference between the forecasted and the realized deficit is very likely to depend on the exogenous variation in oil and natural gas prices.

7 Robustness Checks

In this section we report the results from some robustness checks aimed at validating our results. 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 deficit and the average short term interest rate in the equation for the long term interest rates, plus the VIX index in the equation for the spreads. The results are reported in *Table 11*. Columns 1 and 3 report the results obtained with the *FAP* (from *Table 5 and 6*) to facilitate the comparison.

[Table 11 here]

This table shows that the main results are robust once we replace the interpretation of the factors. There is no significant change in the magnitude of the coefficients, although there are some minor changes in the significance of the fiscal variables. For example, in the equation for the long term interest rate, the primary deficit turns to be marginally significant when the factors are replaced with actual data. The test statistic of cross sectional dependence on the residuals is also very similar. Overall, we conclude that the minor effect of replacing the factors with their observed counterparts is seen on the standard errors, rather than on the coefficients. We interpret this result as a further validation of our interpretation for the estimated factors.

The second robustness check we perform is a cross-validation. We check whether results are confirmed once we exclude one country at a time from the panel. *Table 12* and *Table 13* show the results. In the specification for the nominal interest rate 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, 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 the current account balance (scaled by GDP) as additional regressor. 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)*. The first three columns of *Table 15* show that when estimating the specification for long term interest rates, 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[22] - 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. On the other hand, the other coefficients display more variation.

[Table 15 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, obtaining similar results. We also checked for the presence of structural breaks after the introduction of the Euro using a spline regression analogous to that used to study the effects of financial crises (*Table 9*). Interestingly, in the equation for the nominal interest rates 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 the estimation of the equation for the spreads using the US interest rate as the only benchmark for all countries obtaining very similar results.

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. To appropriately consider the cross sectional dependence across countries' interest rates we use a factor augmented panel *(FAP)* as in Giannone and Lenza (2008). This methodology on one hand allows us to obtain consistent estimates of the parameters and, on the other, it allows us 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 by global risk aversion, which accounts for about 12% of the panel variance.

Our results show that global factors are not only quantitatively relevant, 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 explain 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

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

points respectively. Contrary to previous literature we also find no evidence of non-linear effects of fiscal policy, but we do find that primary deficit has a stronger effect in determining risk premia in periods of financial distress. In particular, we show that sovereign yield spreads in periods of financial distress respond stronger to the *deficit gap*, which is the distance between the projected deficit and the debt stabilizing primary balance.

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. In particular the effects of a global fiscal expansion are by far quantitatively more important than domestic fiscal policy alone, and are significantly heterogeneous across countries. The magnitude of these spillover effects ranges between 3 and 50 basis points with stronger effects for countries characterized by that were relatively less financially integrated at the beginning of the sample, 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.

These results show us that in open and integrated economies a profligate fiscal policy does not translate directly into higher borrowing costs when the stimulus is country specific. As interest rates are determined on the world markets, free riding on other countries' fiscal discipline is indeed feasible, but can be dangerous and short lived. In fact, fiscal profligacy ultimately leads to a build up of public debt which still has positive effect on interest rates. Moreover, high stocks of public debt constitute an evident element of vulnerability in that heavily indebted countries end up facing higher risk premia whenever markets are struck by a sudden lack of confidence. Interestingly this is also the case for countries with weaker or more corrupt governments or which in the past have consistently surprised investors with higher than expected budget deficits.

Our results provide an interesting interpretation of the recent behaviour of interest rates and sovereign risk in advanced economies: while the general movement towards fiscal consolidation and lower interest rates of the nineties has contributed to low long term interest rates and low sovereign spreads, this can come suddenly to an end after a global shock to aggregate fiscal policy or a collapse in market confidence. This would promptly trigger an heterogeneous increase in borrowing costs with more peripheral countries or countries with fiscal or institutional vulnerabilities suffering proportionately more. Therefore, even if financial integration helps in part to decouple interest rates from national policies, governments misbehaviour does not seem to be left unpunished by markets. As the latest financial crisis has been drastically showing, this is especially true during periods of financial stress when market participants carefully scrutinize governments to assess the possibility that they will honour their obligations in the near future.

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9 APPENDIX A: Factor extraction and interpretation

The aim of this section is to show the results from the principal component analysis and provide the evidence for the interpretation of the factors. As mentioned in *Section 3.2* we extract the first set of factors from a matrix W^r which contains long term interest rates r_{it} and the set of k regressors x_{it} for all countries. Hence, with a balanced panel of N countries, observed for T periods, the matrix W^r will be of dimension $(T \times (N \times (k+1)))$. In our case W^r contains the following elements:

$$W^r = \left[\begin{array}{ccccccc} r & stnr & \inf l & g & pdef & debt & VIX \end{array} \right]$$

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, $\inf l$ 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. VIX is the Chicago Board Options Exchange Market Volatility Index, a popular measure of uncertainty. The second set of factors - for the spreads equation - are instead extracted from a similar matrix $W^{spreads}$ which is constructed as:

$$W^{spreads} = \left[\begin{array}{ccccccccc} r - r^B & stnr & \inf l & g & pdef & debt & r^B & VIX & liq \end{array} \right]$$

The long term interest rates r have been replaced by the sovereign spreads and the interest rate of the benchmark country r^B. Additionally we introduced a measure of liquidity (the ratio of government debt over the total debt of the OECD countries), which is usually included as a control in an equation for the spreads.

An important point 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 very large fraction 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. Such a high portion of explained variance mean that the cross sectional correlation is indeed relevant in explaining the behaviour of our dependent variables, and it points towards the presence of a small number of global shocks.

[Table 1 here]

A second important point is the economic interpretation of the common factors. To find it we let ourselves guide by 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, in turn will be 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 10*, 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 10 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 16* reports the results of this exercise. We can see that in both cases the constant term is very close to zero and never significant, while the coefficient on the estimated factor is pretty close to one. Moreover the R^2 indicates a very good fit.

[Table 16 here]

From what we said in *Section 3*, the factors extracted from $W^{spreads}$, which have to be used in equation (11), should closely tack average fiscal and monetary policy stances - again - and a proxy for risk aversion. *Figure 11* shows that this is indeed the case. The three plots in fact show the three estimated factors against average deficit, the VIX index and average short term interest rate.

[Figure 11 here]

Again, by regressing our extracted factors on their proposed interpretation (*Table 17*) we obtain a pretty good fit. The coefficients on the average deficit and the VIX index are pretty 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 17 here]

Overall 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 (10) and (11) .

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:

$$y_{it} = A_i\Gamma_t' + x_{it}'\beta + e_{it} \tag{15}$$

$$e_{it} = \phi_i' F_t + \varepsilon_{it} \tag{16}$$

where the main equation (15) 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 (16) 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 baseline equations, 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:

$$x_{it} = b' F_t + \phi_i' a + c\phi_i' F_t + \pi_i' \Phi_t + v_{it} \tag{17}$$

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[23]:

$$x_{it} = b_i' F_t + v_{it} \tag{18}$$

Bai (2009) demonstrates that the model in (15) to (17) can be estimated with an iterative procedure, which is robust to weak dependence across both i and t of the error component ε_{it} and which does not need to assume stationarity in both factors F_t and factor loadings ϕ_i'.

First the variables needs to be transformed to eliminate country and time fixed effects by means of a within transformation. Then, called $\dot{x}_{it}$and $\dot{y}_{it}$the transformed variables[24], the model can be estimated by minimizing a

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

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

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

simple sum of squared residuals:

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

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

$$\widehat{\beta}_{IFE} = \left(\sum_{i=1}^{N} \overset{\bullet}{X}'_i M_{\widehat{F}} \overset{\bullet}{X}_i \right)^{-1} \sum_{i=1}^{N} \overset{\bullet}{X}'_i M_{\widehat{F}} \overset{\bullet}{Y}_i \tag{19}$$

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 $\widehat{\beta}$ estimates of the unobserved factors can be obtained using principal components:

$$\widehat{F}V_{NT} = \left[\frac{1}{NT} \sum_{i=1}^{N} \left(\overset{\bullet}{Y}_i - \overset{\bullet}{X}_i\widehat{\beta} \right) \left(\overset{\bullet}{Y}_i - \overset{\bullet}{X}_i\widehat{\beta} \right)' \right] \widehat{F} \tag{20}$$

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

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

Iterating over (19) and (20) therefore can yield estimates for $\widehat{\beta}$ and $\widehat{F}$. Finally, the estimates for the factor loadings ϕ'_i are then given by: $\phi'_i = \frac{1}{T}\widehat{F}\left(\overset{\bullet}{Y}_i - \overset{\bullet}{X}_i\widehat{\beta} \right)$. 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 this paper use this last specification of the estimator[25].

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 (15) , (16) and (18). In particular, he showed that under the assumption of stationarity of common factors and independence of the idiosyncratic shocks, the CCE estimator for β is given by the following expression:

$$\widehat{\beta}_{CCE} = \left(\sum_{i=1}^{N} \theta_i X'_i \overline{M}_w X_i \right)^{-1} \sum_{i=1}^{N} \theta_i X'_i \overline{M}_w Y_i$$

where X'_i and Y_i are the $(T*k)$ and $(T*1)$ matrices of data, θ_i is a country specific weight 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

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

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[26]:

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

This is equivalent to estimating by OLS an equation augmented by the cross sectional averages of $\left(\overline{Y}_{\bullet t}, \overline{X}_{\bullet t}\right)$, the logic being that by filtering the individual specific variables by means of cross-section aggregates so that as $N \to \infty$, these can purge the effect of the common factors.

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

It is moreover easy to demonstrate 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:

$$y_{it} = \alpha_i + \tau_t + \sum_{k=1}^{M} \delta_{ki} f_{kt} + \beta x_{it} + u_{it} \tag{21}$$

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 $(15), (16), (18)$ can be rewritten as:

$$\begin{aligned} y_{it} &= A_i \Gamma_t' + (\beta b_i' + \phi_i') F_t + \beta v_{it} + \varepsilon_{it} && (22) \\ &= A_i \Gamma_t' + d_i' F_t + \zeta_{it} && (23) \\ x_{it} &= b_i' F_t + v_{it} && (24) \end{aligned}$$

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

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

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

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 (21) :

$$\begin{aligned} y_{it} &= A_i\Gamma_t' + \beta x_{it} + \left(d_i' - \beta b_i'\right)F_t + \omega_{it} \\ &= A_i\Gamma_t' + \beta x_{it} + \delta_i' F_t + \omega_{it} \end{aligned} \qquad (25)$$

11 APPENDIX C: Deficit Gap

Imagine that a risk neutral investor prices the interest rate according to the following condition

$$r(1-p) = r^*$$

where r is the domestic interest rate, p is the probability of default and r^* is a benchmark rate. The default probability will determine the possible size of the risk premium, and will be related to the deficit gap in the following way:

$$p = p_1 \text{ if } gbal^* - gbal < k$$

$$p = p_2 \text{ if } gbal^* - gbal > k$$

with $p_1 < p_2$ and where $gbal^*$ is the government balance that stabilizes the debt to GDP ratio and $gbal$ is the actual government balance. So if the required adjustment is perceived as large, there will be risk premia, while it will not affect interest rates if the deficit needed to stabilize the debt is not too high. The interest rates are thus subject to multiple equilibria.

12 APPENDIX D: 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
$\inf l$	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

13 APPENDIX E: 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: **CSD 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**

	(1)	(2)	(3)
LTR	FE	2FE	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]
VIX	-0.013**		
	[0.006]		
Observations	709	709	709
R-squared	0.853	0.958	0.979
Number of id	17	17	17
CSD	46.45	-3.58	-2.53
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 Pesarans (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**

	(1)	(2)	(3)	(4)	(5)	(6)
SPREADS	FE	2FE	FAP	FE	2FE	FAP
L.spreads				0.382***	0.388***	0.063
				[0.078]	[0.100]	[0.086]
Irl - Benchmark	0.105***	0.121	-0.257***	0.096***	0.256***	-0.237***
	[0.035]	[0.076]	[0.076]	[0.029]	[0.053]	[0.066]
Liquidity	0.031	-0.038	-0.039	0.014	-0.037*	-0.038*
	[0.028]	[0.028]	[0.024]	[0.029]	[0.021]	[0.021]
Growth	-0.143***	-0.190***	-0.053	-0.070**	-0.107***	-0.048
	[0.039]	[0.045]	[0.040]	[0.035]	[0.023]	[0.035]
Def/GDP(-1)	-0.022**	0.013	0.026**	-0.012	0.012	0.025**
	[0.010]	[0.014]	[0.012]	[0.008]	[0.010]	[0.010]
Debt/GDP(-1)	-0.001	0.005*	0.005**	-0.002	0.003	0.004***
	[0.003]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Emu	0.229***	0.005	-0.227*	0.196***	0.132	-0.221**
	[0.063]	[0.104]	[0.123]	[0.069]	[0.083]	[0.096]
VIX	0.008**			0.005*		
	[0.003]			[0.003]		
Observations	390	390	390	387	387	387
R-squared	0.18	0.393	0.613			
Number of id	15	15	15	15	15	15
CSD	9.32	-1.95	-1.77	23.73	14.71	-1.62
Country FE	yes	yes	yes	yes	yes	yes
Time FE	no	yes	yes	no	yes	yes
Factors	no	no	yes	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 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 Pesarans (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. Columns 4 to 6 introduce the lag of the dependent variable and the estimates are obtained using GMM (Arellano and Bond 1991).

Table 7: **Non Linearities with the Debt level - Long Term Interest Rates**

LTR	(1)	(2)	(3)
Int Rate - Short	0.396***	0.396***	0.399***
	[0.034]	[0.034]	[0.034]
GDP Growth	0.101*	0.101*	0.100*
	[0.050]	[0.049]	[0.051]
Inflation	0.076	0.078	0.075
	[0.048]	[0.047]	[0.046]
Def/GDP(-1)	0.016	0.016	0.016
	[0.013]	[0.013]	[0.012]
Debt/GDP(-1)	0.006		
	[0.006]		
$(\text{Debt}/(\text{GDP}(-1))^2$	0		
	[0.000]		
Debt/GDP(-1) $<$ 50%		0.007**	
		[0.003]	
Debt/GDP(-1) $>$ 50%		0.008***	
		[0.002]	
Debt/GDP(-1) $<$ 75%			0.006***
			[0.002]
Debt/GDP(-1) $>$ 75%			0.008***
			[0.002]
Observations	709	709	709
R-squared	0.979	0.979	0.979
Number of id	17	17	17
CSD	-3.53	-3.55	-3.52
Country FE	yes	yes	yes
Time FE	yes	yes	yes
Factors	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 debt squared; in Column 2 we splined the debt variable according to whether the debt to GDP is lower or higher than the median of the entire sample; in Column 3 we splined the debt variable according to whether debt to GDP is lower or higher than the 3rd quartile of the entire sample. CSD is the Pesarans (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 8: **Non Linearities with the Debt level - Interest Rate Spreads**

	Non Linearity with Debt			Non Linearity with Vix		
SPREADS	(1)	(2)	(3)	(4)	(5)	(6)
Ltr Benchmark	-0.260***	-0.261***	-0.255***	-0.257***	-0.258***	-0.258***
	[0.076]	[0.077]	[0.077]	[0.075]	[0.076]	[0.075]
Liquidity	-0.036	-0.04	-0.041*	-0.036	-0.039	-0.036
	[0.026]	[0.025]	[0.024]	[0.023]	[0.024]	[0.023]
Growth	-0.051	-0.054	-0.054	-0.052	-0.044	-0.043
	[0.039]	[0.040]	[0.040]	[0.040]	[0.041]	[0.041]
Debt/GDP(-1)	0.006*			0.003	0.005**	0.003
	[0.004]			[0.003]	[0.002]	[0.003]
$(\text{Debt}/(\text{GDP}(-1))^2)$	0					
	[0.000]					
Def/GDP(-1)	0.025**	0.027**	0.026**	0.028**	0.012	0.014
	[0.012]	[0.012]	[0.012]	[0.013]	[0.014]	[0.014]
Emu	-0.232*	-0.232*	-0.227*	-0.222*	-0.228*	-0.223*
	[0.124]	[0.123]	[0.123]	[0.123]	[0.123]	[0.123]
Debt/GDP(-1) $<$ 50%		0.005*				
		[0.003]				
Debt/GDP(-1) $>$ 50%		0.005**				
		[0.002]				
Debt/GDP(-1) $<$ 75%			0.004*			
			[0.002]			
Debt/GDP(-1) $>$ 75%			0.005**			
			[0.002]			
Debt/GDP(-1)*Vix				0		0
				[0.000]		[0.000]
Def/GDP(-1)*Vix					0.001	0.001
					[0.001]	[0.001]
Observations	390	390	390	390	390	390
R-squared	0.614	0.614	0.614	0.616	0.615	0.618
Number of id	17	17	17	17	17	17
CSD	-1.8	-1.8	-1.76	-1.77	-1.78	-1.78
Country FE	yes	yes	yes	yes	yes	yes
Time FE	yes	yes	yes	yes	yes	yes
Factors	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 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 debt squared; in Column 2 we splined the debt variable according to whether the debt to GDP is lower or higher than the median of the entire sample; in Column 3 we splined the debt variable according to whether debt to GDP is lower or higher than the 3rd quartile of the entire sample; in Columns 4 to 6 we interacted the fiscal variables expected deficit and expected debt with the Vix index. CSD is the Pesarans (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 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
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 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; 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 Pesarans (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 10: **Spillover Coefficients - Interest Rates Equation and Spreads Equation**

SPILLOVERS	Int Rates Eq.		Spreads Eq.
	(1) Av Def (simple av.)	(2) Av Def (corr av.)	(3) VIX
AUS	0.210***	0.211***	0.002
	-0.08	-0.081	-0.009
AUT	0.141**	0.140**	0.017***
	-0.065	-0.065	-0.005
BEL	0.174***	0.172***	0.017***
	-0.066	-0.067	-0.005
CAN	0.127*	0.132*	0.012
	-0.073	-0.075	-0.009
DEU	0.102	0.1	
	-0.065	-0.066	
DNK	0.141**	0.142**	-0.008
	-0.066	-0.067	-0.008
ESP	0.400***	0.419***	0.016***
	-0.075	-0.078	-0.005
FIN	0.302***	0.315***	0.015***
	-0.075	-0.077	-0.005
FRA	0.166***	0.165***	0.010**
	-0.063	-0.063	-0.005
GBR	0.237***	0.243***	-0.003
	-0.074	-0.076	-0.009
IRE	0.337***	0.338***	0.026***
	-0.077	-0.079	-0.006
ITA	0.497***	0.520***	0.021***
	-0.075	-0.076	-0.006
JPN	0.159**	0.164**	0.007
	-0.073	-0.073	-0.012
NLD	0.129**	0.125*	0.011**
	-0.065	-0.066	-0.005
NOR	0.065	0.06	-0.013*
	-0.074	-0.075	-0.008
SWE	0.219***	0.216**	-0.014*
	-0.083	-0.086	-0.008
USA	0.071	0.069	
	-0.075	-0.077	
Observations	709	709	390
F-test	177.4***	176.6***	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 and 2 report the coefficients on the second factor in the interest rates equation. The factor is proxied by the average budget deficit of the countries in the sample Column 1 and by the average which excludes own country deficit. 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: **Robustness - 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	-2.05	-2.05
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 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 Pesarans (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**

	(1) **LTR**	(2) **SPREADS**
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

Robust standard errors in brackets
$***p < 0.01, **p < 0.05, *p < 0.1$
The dependent variables are the long term nominal interest rate Column 1 and the interest rate spread adjusted for exchange rate risk as in Codogno et al (2003) Column 2. The independent variables from top to bottom are: expected short term interest rate; the 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 Pesarans (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 Columns 1 to 3 and the interest rate spread adjusted for exchange rate risk as in Codogno et al (2003) Columns 4 to 6. The independent variables from top to bottom are: expected short term interest rate; the 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 Pesarans (2006) Common Correlated Effect estimator. In Columns 3 and 6 we perform Bais (2009) Interacted Fixed Effects estimator. CSD is the Pesarans (2004) statistic to detect cross-sectional dependence; the statistic is distributed as a normal under the null of cross-sectional independence.

Table 16: **Interpretation of the Factors - Long Term Interest Rates**

	(1)	(2)
LTR	F1 ltr	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 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 deficit of the countries in the sample.

Table 17: **Interpretation of the Factors - Interest Rate Spreads**

	(1)	(2)	(3)
SPREADS	F1 Spreads	F2 Spreads	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 interest 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 short term interest rate of the countries in the sample.

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

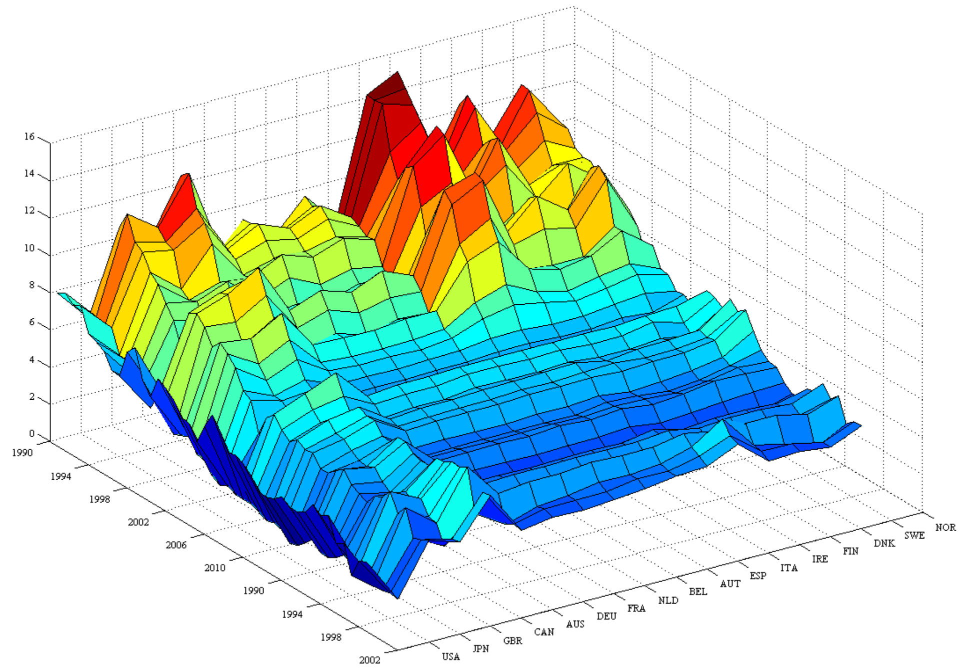

Figure 2: **Interest Rate Spreads 1997 - 2009**

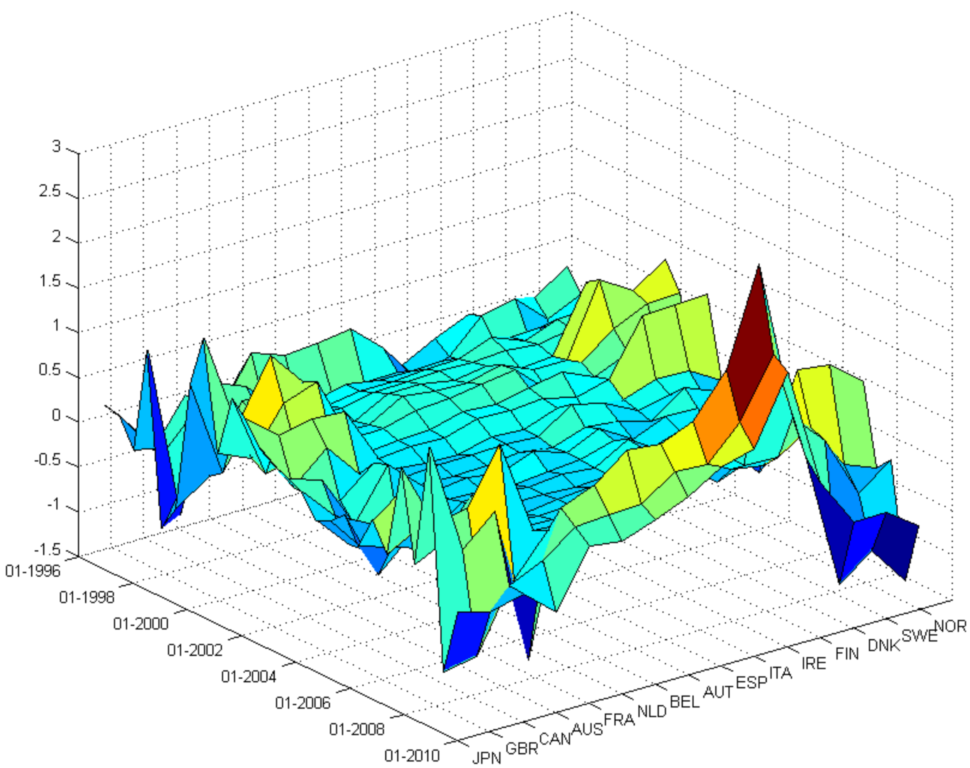

Figure 3: **Rolling Window Estimates - Long Term Interest Rates**

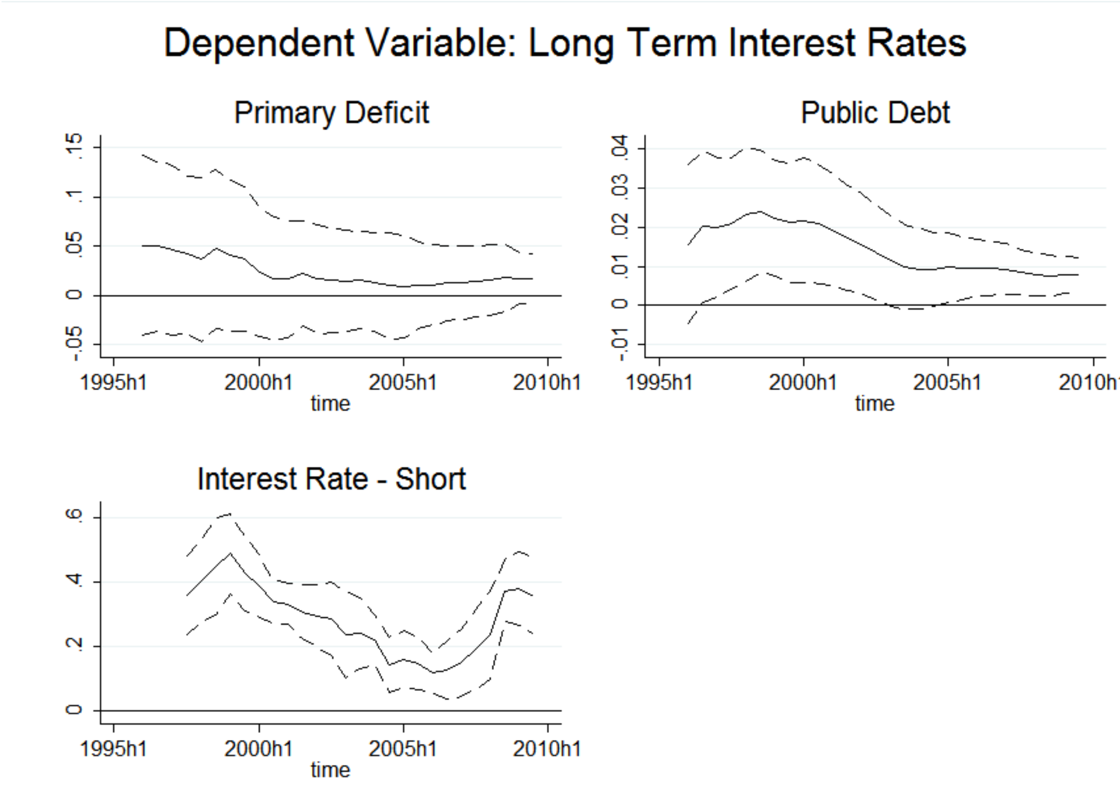

Figure 4: **Rolling Window Estimates - Sovereign Spreads**

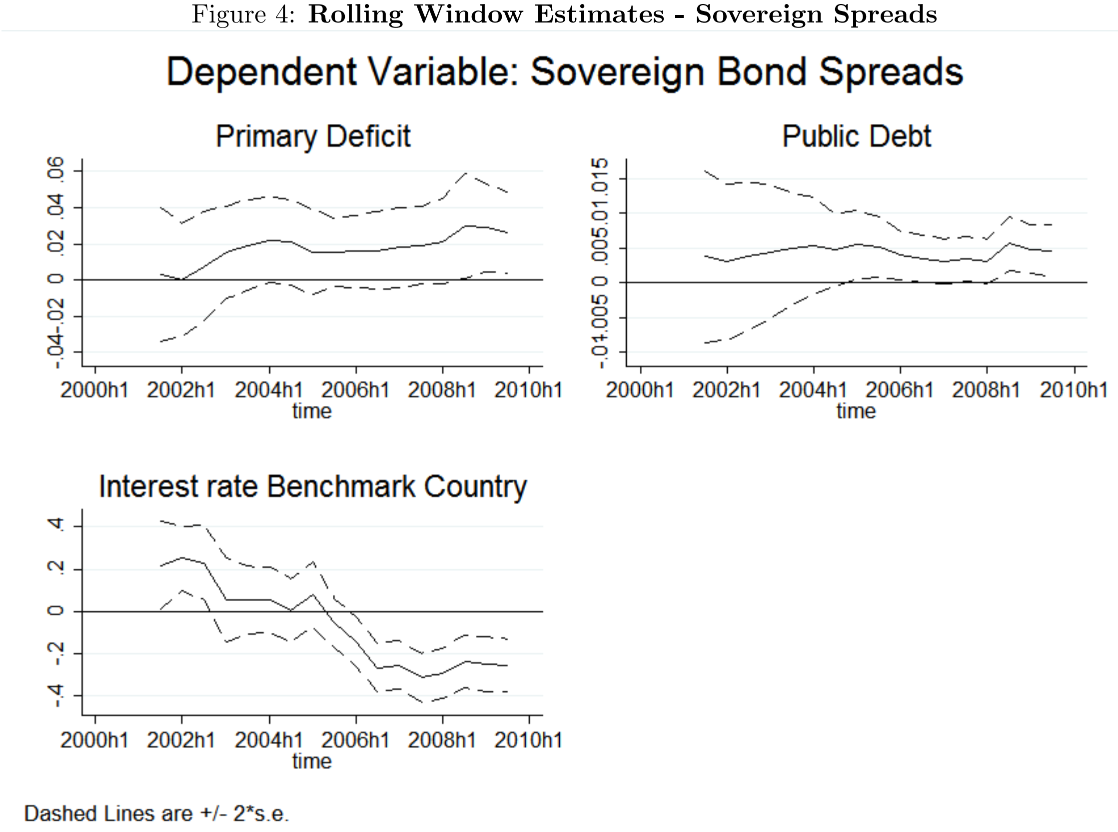

Figure 5: **Spillover Coefficients - Global Deficit, using simple averages**

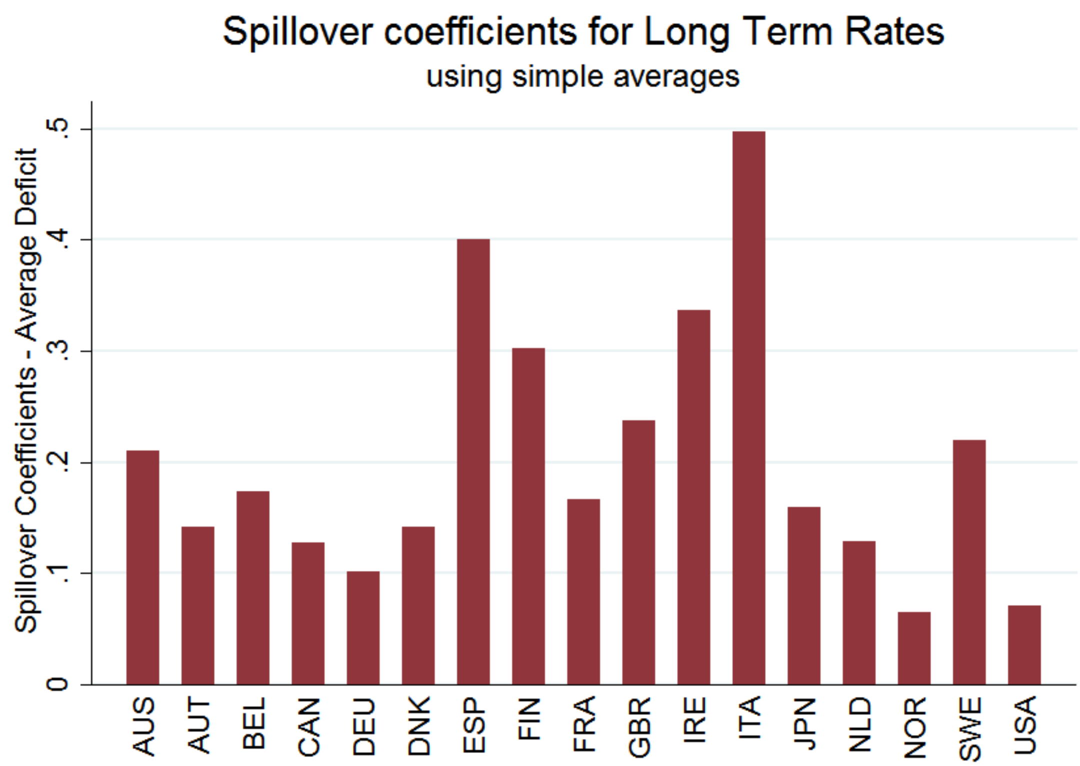

Figure 6: **Spillover Coefficients - Global Deficit, using corrected averages**

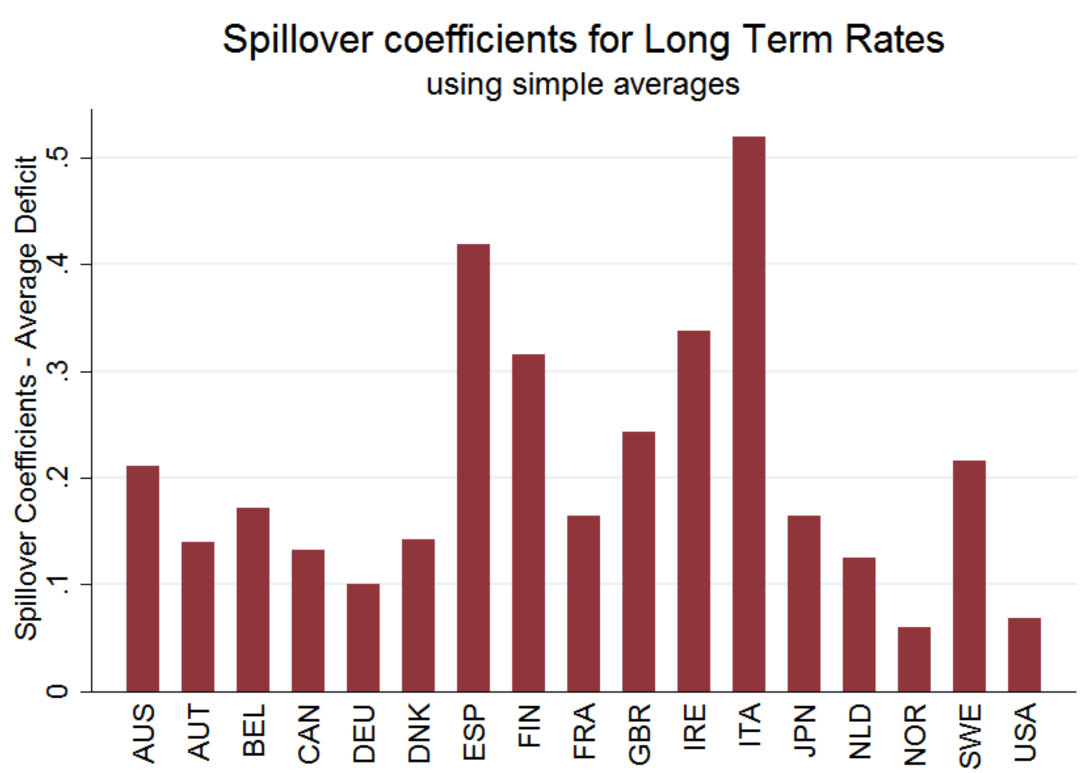

Figure 7: **Interpretation of the Spillover Coefficients - Global Deficit**

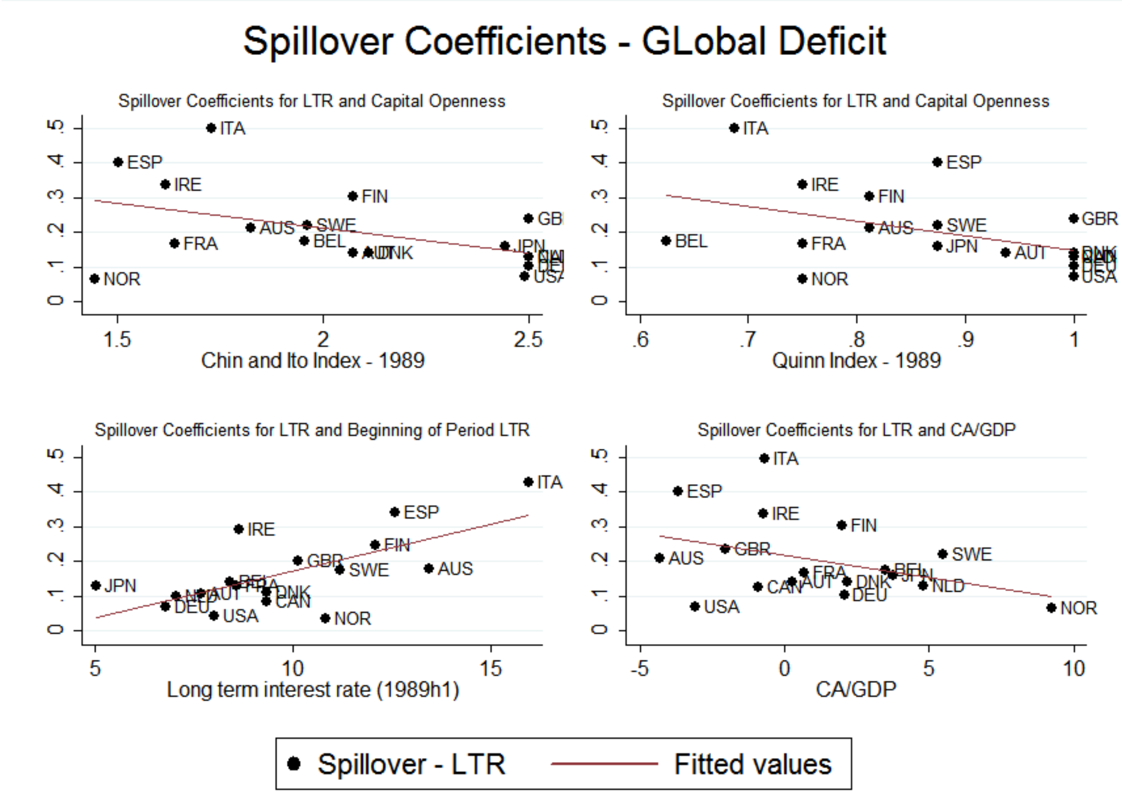

Figure 8: **Spillover Coefficients - Global Risk**

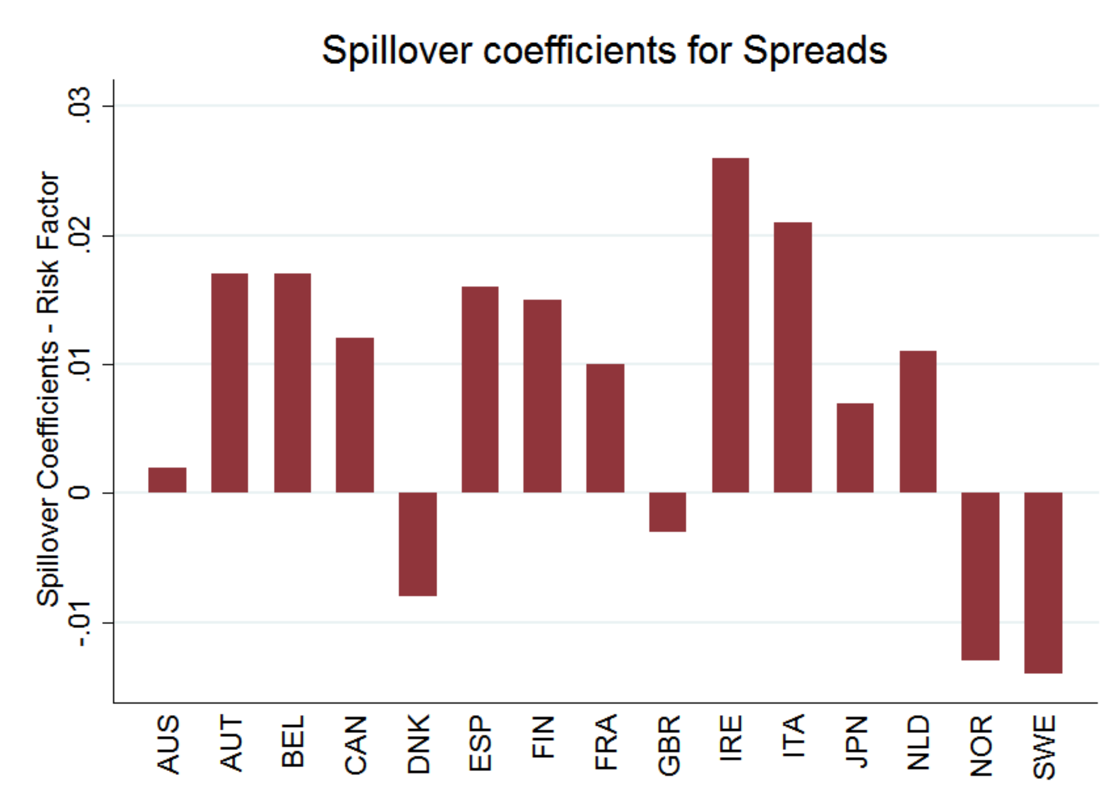

Figure 9: **Interpretation of the Spillover Coefficients - Global Risk**

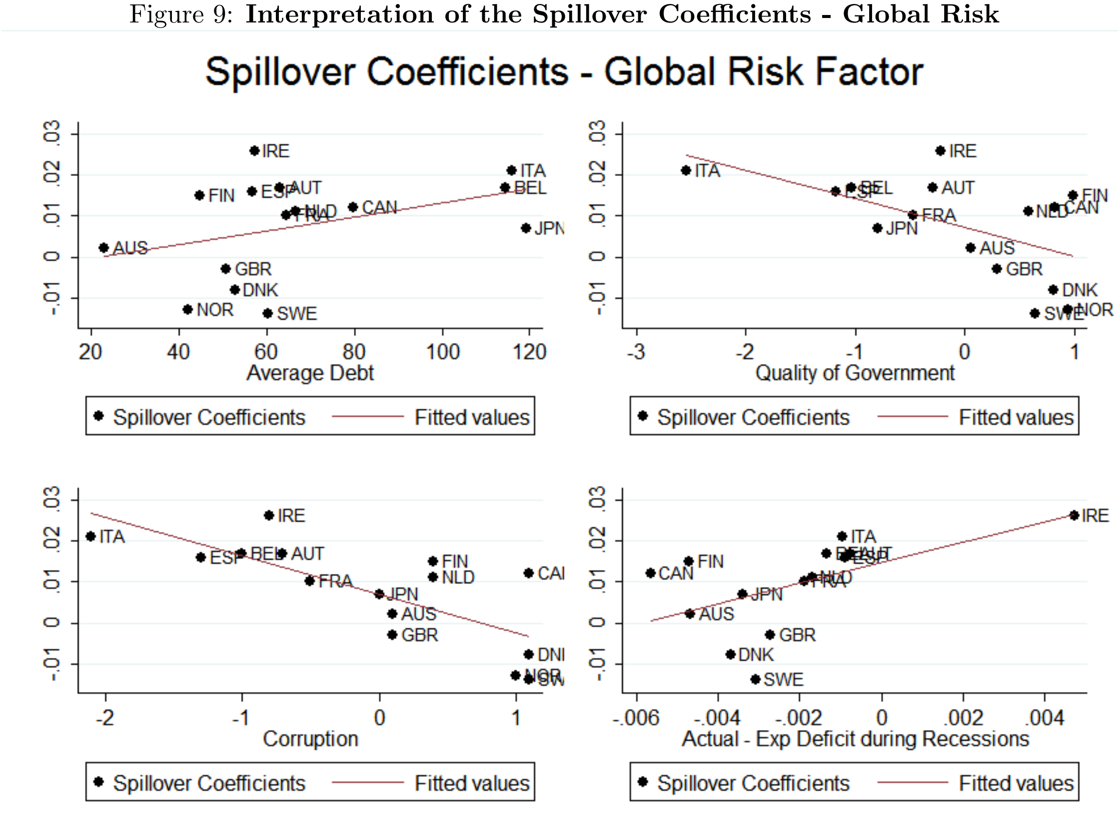

Figure 10: **Global Factors - extracted from** W^r

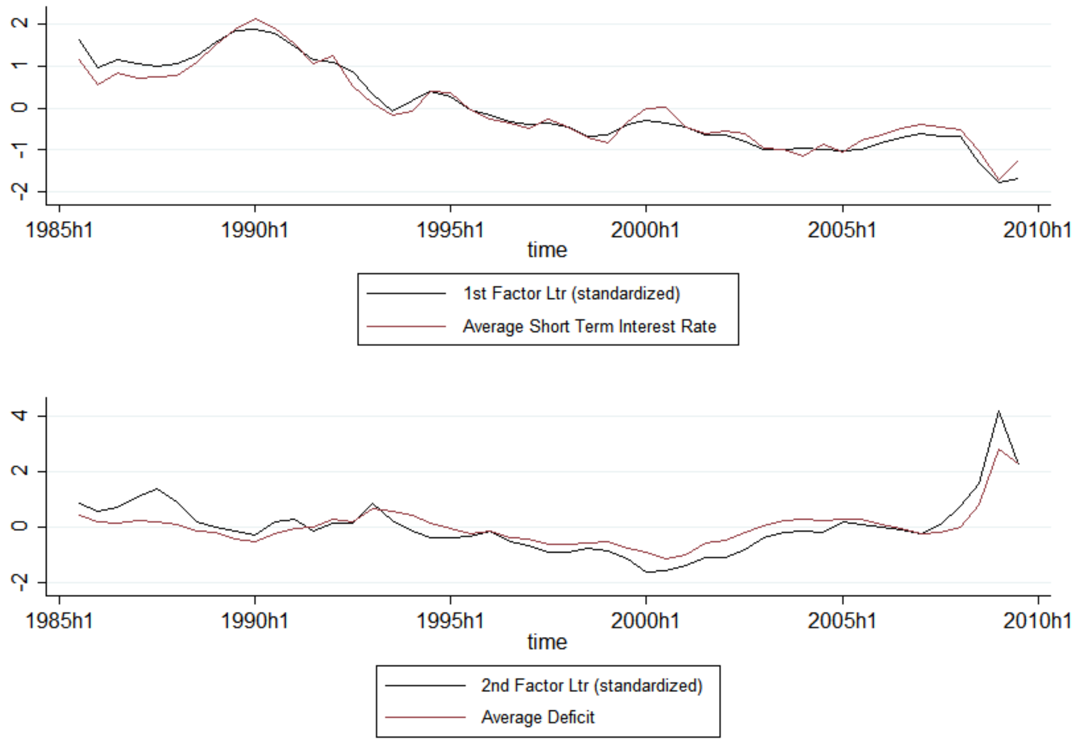

Figure 11: **Global Factors - extracted from** $W^{spreads}$