WHAT EXPLAINS THE SURGE IN EURO AREA SOVEREIGN SPREADS DURING THE FINANCIAL CRISIS OF 2007-09?

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ABSTRACT

This paper explains the determinants of widening sovereign bond yield spreads vis-à-vis Germany in selected euro area countries during the period end-July 2007 to end-March 2009, when the financial turmoil developed into a full-blown financial and economic crisis. Emphasis is given to the role of fiscal fundamentals and government announcements of substantial bank rescue packages. The paper finds that higher expected budget deficits and/or higher government debt ratios relative to Germany contributed to higher government bond yield spreads in the euro area during the analyzed period. More importantly, the announcements of bank rescue packages have led to a re-assessment, from the part of investors, of sovereign credit risk, first and foremost through a transfer of risk from the private financial sector to the government.

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1. INTRODUCTION

Since September 2008, for most euro area countries the long-term government bond yield spreads to Ger-

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many have widened markedly. Since the starting of the Economic and Monetary Union (EMU) and until the first half of 2008, bond yields of EMU governments' debt had generally been relatively close. Over this period, the average bond spread of 10-year sovereign bonds, relative to the benchmark German bund, had been about 16 basis points (bps).[1] For the Greek 10-year sovereign bonds, the spread to the benchmark German bund had been on average just about 30 bps. After the intensification of the financial crisis in September 2008, government bond yields differentials relative to Germany have increased dramatically for most euro area countries (in March 2009 the average spread between the Greek government bond and the German bund was about 270 bps).

This unprecedented surge in sovereign bond yield spreads reflected increasing concerns in financial markets about some governments' capacity to meet their future debt obligations. In addition to a higher cost of borrowing, the increase in sovereign bond yield spreads may signal that investors are less willing to provide funding to sovereign borrowers. In the extreme, this would threaten the latter's ability to access capital markets. The economic literature on the determinants of long-term government bond yields, has found evidence of the market-based fiscal discipline hypothesis according to which financial markets ask a higher default premium to countries that borrow excessively (Goldstein and Woglom 1991; Bayoumi et al. 1995).

The widening of sovereign bond spreads vis-à-vis Germany was interpreted by many observers as a welcome reassessment and differentiation of country risks. This is also understandable in the context of the Euro-

[1] This average is computed for the period January 2000 to July 2008 using daily 10-year sovereign bond yield spreads relative to Germany. Greece is included in the sample only since January 2001, the year of EMU accession. The data source is Bloomberg.

pean fiscal framework. The Stability and Growth Pact not only hinges upon the concept of peer pressure, i.e. that European countries among themselves "urge" countries with excessive deficits to correct them, but also on the idea that financial markets exert pressure, as well, via higher bond risk premia. This differentiation of country risk across the euro area was virtually absent before the financial crisis.

This paper provides an empirical analysis of the determinants of long-term government bond yield spreads for selected euro area countries over the period from 31 July 2007 to 25 March 2009. In this way, the analysis captures developments in bond spreads since the early stages of the financial crisis, when its consequences for the euro area appeared limited to a few banks, up to its intensification, when uncertainty in financial markets heightened considerably. Indeed, in the euro area, the first signs of the crisis were felt since end-July 2007, when the German government rescued the Deutsche Industriebank (IKB) due to its exposure to the US subprime mortgage market.

Largely following the literature, this paper looks at the main determinants of long-term government bond spreads, such as: (i) a country's credit risk, as captured in particular by the relative soundness of its expected fiscal position; (ii) international risk aversion, which in times of heightened uncertainty could be higher for some euro area countries than for others; and (iii) market liquidity risk, which may be related to the relative size of sovereign bond markets. In addition, given the particular nature of the financial crisis period covered in this paper, our empirical analysis investigates whether government announcements of substantial bank rescue packages have contributed to the widening of sovereign bond yield spreads and to a transfer of credit risk from the private financial sector to the public sector.

The paper is structured as follows. Section 2 provides a brief review of the literature on the determinants of sovereign bond yield spreads. Section 3 presents stylized facts on the developments in long-term government bond yields, gives details about data construction and sources and shows descriptive statistics for our main variables of interest. Section 4 describes the basic empirical model and its extensions, presents the empirical results, and discusses the model's goodness-of-fit and various robustness checks. The last part presents the conclusions and areas of future research.

2. LITERATURE REVIEW

The literature on the determinants of government bond yield spreads lists several factors influencing the risk premia paid by governments relative to the benchmark government bond. First, sovereign bond spreads are influenced by a country's creditworthiness as reflected by its fiscal and macroeconomic position (the so-called "credit risk"). Second, liquidity risk, i.e. the size and depth of the government's bond market, plays a role. Third, government bond spreads reflect international risk aversion, i.e. investor sentiment towards this asset class for each country. Finally, and related to credit risk, the effect of announcements, for example, macroeconomic news/surprises or fiscal policy events (e.g. government plans) might also play a role in the development of sovereign bond spreads. Since the analysis in this paper covers the period from the beginning of the crisis in financial markets (i.e. August 2007) until the end of March 2009, that is, the period during which the (presumed) sovereign yield differentiation based on countries' credit risk intensified, this review focuses on the role of credit risk and announcements.

For developed countries, a range of empirical literature has found a significant impact of ***fiscal variables*** on risk premia, in particular with regard to the level of public debt. For the U.S., a seminal paper by Goldstein

and Woglom (1992) finds evidence that the debt level of U.S. states has a positive impact on their bond yield relative to that of other states. Further evidence in this direction was provided by Bayoumi et al. (1995) and Poterba and Rueben (1999). Regarding the fiscal deficit, Laubach (2009) estimates the effect of the five-year ahead projection of the U.S. government deficit, as provided by the Office of Management and Budget, on the level of the five year ahead real Treasury yield. He finds a significant impact of deficits and debt on long-term interest rates, isolating the effects of the business cycle and associated monetary policy actions. However, he finds no evidence that yield spreads between corporate and sovereign bonds (as a proxy for changes in the sovereign risk) are systematically related to expected fiscal balances. Finally, for the OECD countries, Alesina et al. (1992) analyze the yield differential between sovereign and corporate bonds and find that it depends positively on the public debt level.

For European and, in particular, EMU countries, several studies tend to point to a significant impact of government debt and (not quite unambiguously) deficit on sovereign bond spreads.[2] Faini (2006) finds a significant effect of fiscal deficit and debt levels on the aggregate EMU interest rate level, as well as on sovereign bond spreads in a model with identical slope coefficients across countries. Bernoth et al. (2004) find that fiscal fundamentals, as proxied by the budget balance or the government debt, have a significant impact on sovereign bond spreads for a pooled sample of 13 EU countries. Similar results are obtained by Hallerberg and Wolff (2006) using fixed effects panel estimations. With a similar econometric approach Bernoth and Wolff (2008) focus on the accuracy of government-reported fiscal data and find a spread-reducing impact

[2] For a literature review and empirical investigation of government bond spreads in emerging markets using expected fiscal positions see Nickel et al. (2009).

of fiscal transparency in addition to a positive impact of deficits but not debt. Codogno et al. (2003) in their Seemingly Unrelated Regressions analysis (SUR) of government bond spreads, use public debt as the only proxy for a country's fiscal position and find that only for Italy and Spain fluctuations in yield differentials can be attributed to domestic fiscal fundamentals, whereas for the other countries in the sample (e.g. Belgium, France and Portugal) international risk-related factors seem to matter more. By contrast, assuming that it is expected fiscal developments rather than past outcomes that matter for investment decisions, Heppke-Falk and Hüfner (2004) analyze whether *expected* budget deficits, derived from the Consensus Forecasts, have an impact on interest rate swap spreads of France, Germany and Italy. Using a SUR framework, they find no such evidence for the period 1994-2004. However, they find that since July 1997 (after the Stability and Growth Pact had been signed) market discipline (i.e. markets' sensitivity to public finance outcomes) increased in Germany and France (but not in Italy) and for Germany also after the start of EMU in 1999. Manganelli and Wolswijk (2009) find that in the euro area, bond spreads are largely driven by the level of short-term interest rates (i.e. common international risk), while credit risk and liquidity risk still matter in EMU. More recently, Balli et al. (2010) have investigated the role of fiscal variables in affecting investors' willingness to hold bonds in the euro area market, following creation of the EMU. They find that investors seem to take into account debt-to-GDP differentials across euro area countries when pricing the bonds issued by these entities. In particular, they argue that since fiscal vulnerability differs across member countries, investors from high default risk countries may benefit from diversifying their bond portfolio holding in low default risk countries.

Finally, event study analyses have shown that ***announcements***, for example of macroeconomic data, have a discernable impact on government bond spreads,

especially on shorter-term horizons. Existing papers applied to the euro area government bond markets, find that US data releases not only affect US markets but also exert a significant effect on European bond markets. In a dynamic model of intra-day bond returns for long - term German government bonds, Andersson et al. (2006) use announcements of euro area, German, French and Italian macroeconomic releases, in addition to US announcements, and find significant effects on the prices of long term bonds. Similarly, Balli (2009) uses macroeconomic and monetary policy announcements released in the U.S., Germany and the euro area as a common shock factor to assess financial integration among government bond markets in the euro area. The author finds that common macroeconomic announcements are important factors in explaining the yield differential among euro benchmark government bonds. Ehrmann and Fratzscher (2005) assess the impact of central bank communication on asset prices, including euro area government bond yields. They find evidence that financial markets' response to central bank communication differs depending on the circumstances under which committee members address the public. The most consistent finding across central banks is that markets respond more strongly to communication prior to interest rate changes. Codogno et al. (2003) find that fiscal announcements about the initiation of excessive deficit procedures for Germany and Portugal have affected bond spreads only for Portugal. By contrast, Afonso and Strauch (2004) show that there is no persistent and systematic reaction of the default risk premium to the identified fiscal policy events during 2002, even if some specific events had a significant and temporary impact on swap spreads.

As to the role of other factors, such as the ***liquidity risk premium***, the literature does not provide clear-cut evidence on its relative importance versus credit risk for sovereign bond markets. Compared to studies that emphasize credit risk, several papers, such as Gomez-Puig

(2006) and Beber et al. (2009) find that liquidity risk is a highly relevant (even the most important) factor in explaining sovereign bond spreads after the introduction of the euro and in times of heightened uncertainty respectively.

The role of a common ***international risk factor***, as one of the main explanatory variables for sovereign spreads, is underlined in several studies, such as Codogno et al. (2003), Geyer et al. (2004), Barrios et al. (2009), Sgherri and Zoli (2009). The international risk factor is found to have a larger impact in countries with high government debt ratios (Codogno et al. 2003) and to magnify the impact of fiscal variables on yield spreads in crisis times (Haugh et al. 2009; Barrios et al. 2009).

To conclude, the review of the empirical literature provides, on balance, evidence for a significant impact of fiscal fundamentals in explaining sovereign bond spreads in normal economic times. The role of fiscal announcements is less well analyzed and the existing evidence is weak. This paper contributes to the existing empirical literature by looking at the impact of these factors during the economic and financial crisis that has hit the euro area and the world markets since September 2008.

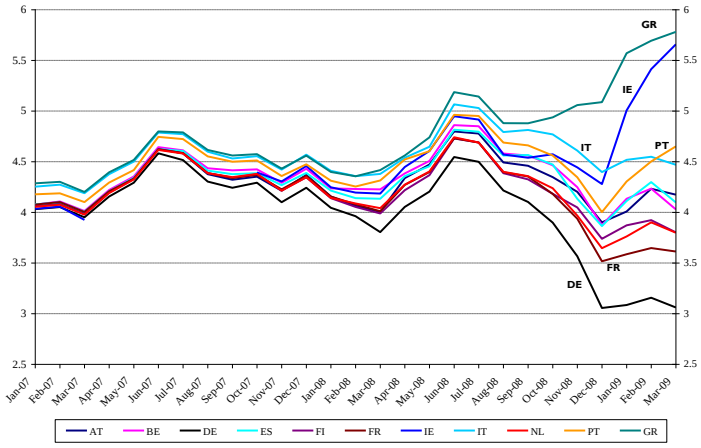
3. STYLIZED FACTS AND DATA DESCRIPTION

Our empirical analysis covers the period from end-July 2007, when the first signs of increasing turmoil in global financial markets became visible, until about end-March 2009.[3] The dependent variable is the daily 10-year government bond yield spreads relative to Germany for the following ten euro area countries: Aus-

[3] This was the time when we finalised the collection of our dataset; it also coincided with the period the financial markets started to gradually stabilise.

tria, Belgium, Finland, France, Greece, Ireland, Italy, the Netherlands, Portugal and Spain.[4]

Chart 1. Ten-year government bond yields of euro area countries (monthly averages; percentages per annum; January 2007-March 2009)



Source: Bloomberg and authors' calculations.

Since the start of stage three of the EMU[5] and until the onset of the financial crisis, 10-year government bond yields for euro area countries converged and differentials vis-à-vis Germany became very low. Since September 2008, when the financial turmoil intensified, spreads started to widen considerably, as shown in Chart 1. In particular, countries such as Greece and Irel-

[4] The remaining euro area countries (i.e. Cyprus, Luxembourg, Malta, Slovakia, and Slovenia) are not included in the analysis for two main reasons. First of all, information on 10-year government bond yields is not readily available for these euro area countries as their government bond markets are relatively small. Secondly, the countries included in the analysis are those that have announced bank rescue packages to support the banking sector since September 2008. The construction of the dependent variable is in line with existing empirical studies (Codogno et al. 2003; Manganelli and Wolswijk 2009).

[5] The tightening of sovereign bond spreads was mainly associated to the lower liquidity premia being asked by markets as a result of the increasing integration of financial markets.

and experienced the largest increase in their bond spreads, followed by Portugal, Italy, Belgium, Austria and Spain (Table 1).

Table 1. 10-yr government bond spreads: descriptive statistics (31/07/2007 to 25/03/2009; bps)

Country	Mean	St. dev.	Min	Max
Greece	93	80	26	300
Ireland	74	74	14	284
Italy	67	41	24	159
Portugal	57	39	20	176
Austria	37	34	5	137
Spain	41	33	8	128
Belgium	44	30	11	138
Finland	28	25	7	89
Netherlands	28	22	7	87
France	24	15	6	63

Sources: Bloomberg and authors' calculations.

As already introduced in the literature review section, long-term government bond yield spreads are likely to depend on three sets of factors: (i) countries' credit risk, as captured particularly by indicators of fiscal positions; (ii) markets' liquidity risk, and (iii) degree of international risk aversion.

3.1. CREDIT RISK VARIABLES

The most commonly used indicators of a country's fiscal position are the general government debt and deficit ratio. Several papers also use the debt service ratio, interest payments as a share of GDP (Bernoth et al. 2004), a country's credit rating (Manganelli and Wolswijk 2009), and in some cases dummies on fiscal announcements (Afonso and Strauch (2004). Our analysis looks at the role of a country's fiscal position in determining its bond spreads vis-à-vis Germany, but also at whether the announcement of broad based bank rescue packages had some effects on investor's assessment of credit risk (i.e. we control for the announcement effect).

However, unlike most previous studies for the euro area[6], our analysis does not use historical fiscal data, but the *expected* general government budget balance and debt ratios. These variables are taken from the European Commission Forecasts that are released on a bi-annual basis. For each country, we compute the average for a 2-year period of the expected budget balance and debt ratio, using the European Commission forecasts available at each point in time, and we take differences vis-à-vis Germany. In this way, our explanatory variables are consistent with the specification of the dependent variable.[7] Since a worsening of the expected fiscal position (i.e. higher expected deficits and/or higher expected debt ratios) could signal to investors increasing risks to the sustainability of a country's fiscal policy, in our analysis the expected sign on the expected general government budget balance is negative and the expected sign on the expected debt ratio is positive.

The rationale for including expected rather than historical fiscal data in our analysis relies on the assumption that at each point in time investors form their expectations about a country's fiscal position on the basis of the available information at that time. Given its prominent role in the application of the EU fiscal surveillance framework, we assume that investors use the European Commission's forecast as a reliable source of information to form their expectations.

A potential drawback of these data is their low frequency (bi-annual) as opposed to the high frequency of our dependent variable. An alternative approach would

[6] Several studies, such as Heppke-Falk and Huefner (2004), Haugh et al. (2009), Barrios et al. (2009), Sgherri and Zoli (2009), use expected fiscal variables in explaining sovereign bond spreads in the euro area.

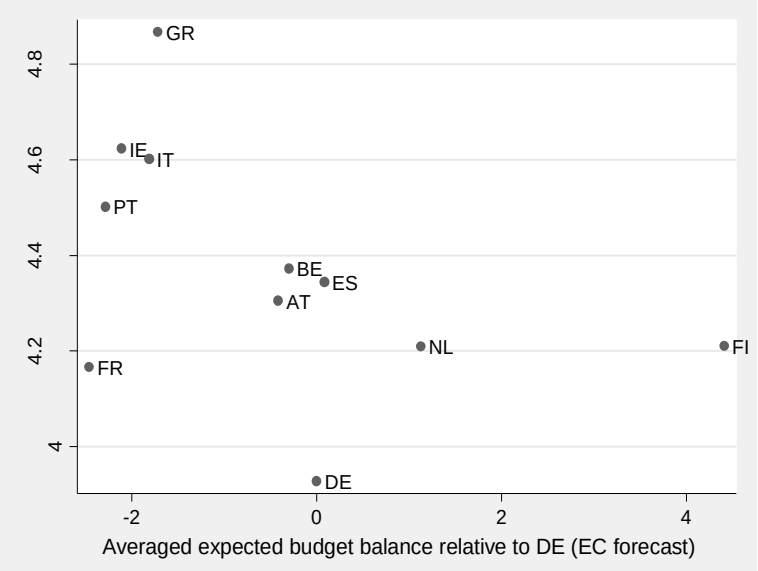
[7] In our daily database the value of the budget balance (debt ratio) is updated every time new forecasts are published by the Commission.

be to use fiscal forecasts released on a monthly basis by professional forecasters, e.g. the Consensus Forecast is an example. However, since not all countries in our sample are covered in these monthly forecasts, this approach would limit the scope of our analysis.

Chart 2 plots the ten-year government bond yield spreads over Germany for the euro area countries under consideration against their *expected* budget balance relative to Germany, both variables averaged over the period of our analysis. The chart shows that countries that are expected to have a less favorable budget balance compared to Germany have experienced larger bond yield differentials. France and Finland are outliers in this respect. France has experienced only a slight increase in its ten-year government bond yield differential to Germany despite its higher budget deficit. This may be explained by the relatively lower liquidity premium that France may benefit from compared with other countries under consideration, as well as lower perceived vulnerability to the financial turmoil. In the case of Finland, the opposite holds. In spite of a very favorable expected fiscal position vis-à-vis Germany, the spread between the Finnish and the German bonds has not declined sensibly. This may be due to the relatively shallow government bond market in Finland, which induces investors to price in a higher liquidity premium.

Interestingly, with the exception of Ireland, the countries that experienced the largest increase in their sovereign bond yield spreads (see also Table 1 and Chart 1), are those that entered the crisis with high deficits (and debt ratios). By contrast, as it will be shown below (see Table 2), the size of the bank rescue packages announced by the individual countries had no significant impact on the widening of bond spreads. Therefore, the crisis seems to have triggered a *flight to quality effect* whereby investors started to discriminate among sovereign borrowers on the basis of their fiscal outlook.

Chart 2. 10-year government bond yield spreads of euro area countries over Germany and the expected budget balance relative to Germany (average 31/07/2007 to 25/03/2009)



Sources: Bloomberg, European Commission and ECB staff calculations.
Note: For each country, the average expected budget balance for 2007, 2008 and 2009 is computed using vintages of the European Commission forecasts available at each point in time.

Given the particular nature of the period of financial crisis covered in our analysis, we expect that the *announcements* of *bank rescue packages* may have also affected investors' perceptions of euro area countries credit risk.[8] To capture this announcement effect, we construct a country dummy variable which equals 0 before the date of the announcement and 1 as of that date. We assume that investors may have interpreted the governments' decision to support the banking sector as an indicator of future higher fiscal burden, thus asking

[8] We do not consider the fiscal stimulus packages to boost aggregate demand announced by euro area governments. Their effect on the fiscal variables would already be captured by the expected budget deficits and debt ratios, given their direct statistical recording, thus making the two sets of variables strongly correlated.

higher premia on their debt. Therefore, the expected sign on the dummy variable is positive.

Bank rescue packages were directed at banks experiencing liquidity and/or solvency problems. Financial support schemes included: (i) government guarantees for interbank lending and new debt issued by banks; (ii) the recapitalization of financial institutions in difficulty; (iii) asset relief schemes and (iv) higher retail deposit insurance. These support measures were announced in the aftermath of the default of Lehman Brothers, between end-September and end-October 2008. Although all countries acted within the common guidelines setup by the European Action Plan[9], the timing of adoption of the measures differed across countries and it was not clear a priori whether all of them would provide such support, or what its precise shape would be. Ireland, for example, announced its blanket guarantee scheme on all deposits and debts of both domestic banks and foreign subsidiaries well ahead of the European Action Plan. Furthermore, whereas some countries adopted broad-based schemes consisting of both guarantees and recapitalization measures (Germany, Austria, Greece, Spain, France and the Netherlands), some other (Belgium, Luxembourg) did not announce a general scheme, but carried out *ad hoc* interventions to support individual institutions. Therefore, by recording the exact date of announcement of the government support measures, our dummy variable is able to capture the announcement effect related to the adoption of bank rescue packages by each country in our sample.

The amount of resources committed varied across countries to a great extent. Ireland, for example, announced a guarantee scheme of €400 billion, including the retail bank deposit guarantee, which amounts to more than 200% of its GDP. Countries such as the

[9] The concerted European action plan of the euro area countries was adopted on 12 October 2008.

Netherlands, Austria and Germany committed resources above 20% of their GDP. Overall, the total amount of resources committed to bank rescue packages between mid-September and mid-October 2008 amounted to about 23% of the euro area GDP.

Table 2. Bank rescue packages (as % of country GDP)

Country	Date of (first) announcement	Cumulative recapitalization	Cumulative guarantees*
AT	13/10/08	5.0	26.0
BE	26/09/08	5.1	74.0
DE	06/10/08	3.5	19.0
ES	07/10/08	2.8	9.1
FI	20/10/08	2.1	26.4
FR	30/09/08	2.0	16.4
GR	15/10/08	5.2	6.0
IE	29/09/08	5.0	259.0
IT	08/10/08	3.0	-
NL	26/09/08	18.0	33.7
PT	13/10/08	2.3	11.9

Note: The table reflects the cumulative amounts of bank rescue packages as released in some countries in subsequent announcements.
*Includes retail deposit guarantees.
Source: Authors' calculations.

Using information available on the size of the bank rescue packages we construct two additional variables, namely: the *size of recapitalization* and the *size of guarantees*. For each country in the sample we record the size of bank rescue packages as initially announced by governments between end-September and end-October 2008, separately for bank recapitalizations and guarantees.[10] To these amounts we add any individual operations announced outside the packages over the period between 31 July 2007 and 25 March 2009. Therefore, for each day (or month) of the sample period, the value of the variable is the cumulative amount of bank

[10] For Italy, we consider the size of government guarantees as percent of GDP to be zero.

rescue measures announced until that moment, expressed as percent of the respective country's GDP.

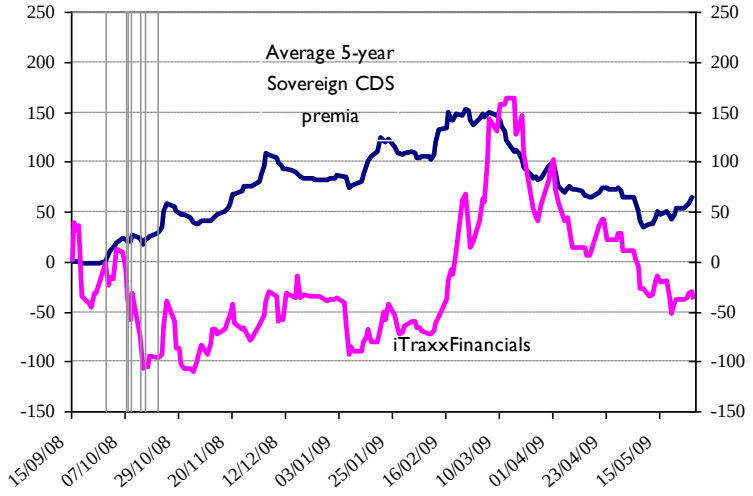
Concurrent to the announcement of bank rescue packages, pressures on the financial sector seemed to have eased whereas the opposite occurred at the general government level. This was felt through a sharp increase in sovereign credit default swap (CDS) premia for most euro area countries, whereas the CDS premia for European financial corporations (i.e. those covered by the iTraxx financial index)[11], reversed their upward trend and started to decline. Chart 3 illustrates these developments and depicts the cumulative changes since mid-September 2008 in average five-year sovereign CDS premia for 11 euro area countries and in the CDS premia for European financial institutions covered by the iTraxx index.

Until end-September 2008 average sovereign CDS premia had been very low and stable. The dramatic rise in CDS premia for most euro area countries after the announcements of bank rescue packages, broadly coinciding with the Irish guarantee scheme (29 September 2008) and the fact that they remained at elevated levels for a prolonged period of time points to a reassessment of countries' credit risk. At the same time, CDS premia for financial institutions declined. All in all this would suggest that the broad-based bank rescue packages have alleviated some credit risk in the banking sector and brought about a transfer of credit risk from the private financial to the public sector. Our empirical analysis tests the *credit risk transfer hypothesis* through the impact of the announcement of bank rescue packages on the difference between *sovereign CDS premia* and *CDS*

[11] The iTraxx financial index contains the CDS spreads of 25 European financial institutions, including institutions from the United Kingdom and Switzerland. The CDS premia represent the cost of insuring against the event of default of sovereign debt and corporate financial debt respectively.

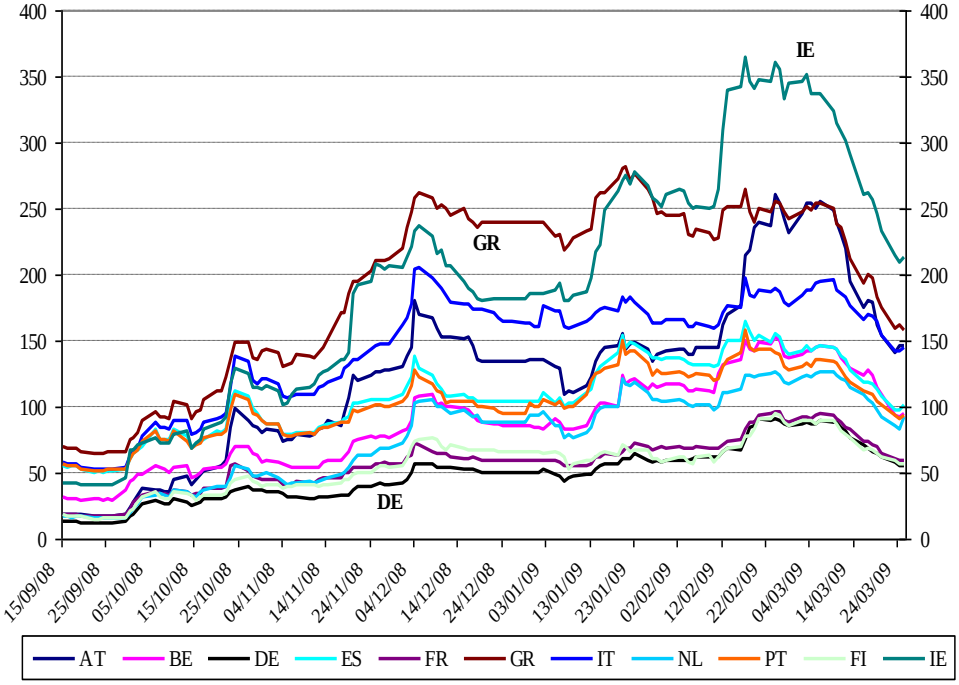
premia for European financial corporations. Under this hypothesis, the announcement of bank rescue packages should lead to a widening of the difference between the sovereign and the corporate CDS premia. Daily CDS data are from Bloomberg. Since we look at premia rather than spreads, Germany is also part of the analysis. A closer look at developments in CDS premia during the period of the analysis shows that they have differed quite substantially across countries. On the one hand, CDS premia for Ireland, Greece, Austria and Italy experienced high volatility and rose to above 200 bps at the peak of the financial crisis. On other hand, CDS premia for Germany, France and Finland were much less volatile (see Chart 4 and Table 3).

Chart 3. Cumulative changes in average five-year sovereign CDS premia for euro area countries and iTraxx financial index (15 September 2008- 25 March 2009; bps)



Sources: Datastream and ECB staff calculations.
Note: The vertical bars indicate the dates on which bank rescue packages were announced in euro area countries.

Chart 4. Sovereign CDS premia (levels) for euro area countries (bp), daily data 15 September 2009 to 25 March 2009



Source: Bloomberg.

Table 3. 5-year sovereign CDS premia: descriptive statistics (31/07/2007 to 25/03/2009; bps)

Country	Mean	St. dev.	Min	Max
Ireland	78	94	4	365
Greece	91	81	15	282
Austria	48	64	2	260
Italy	71	57	16	205
Spain	57	40	6	165
Belgium	42	38	5	153
Portugal	56	37	12	157
Netherlands	32	37	3	126
Finland	39	26	11	94
France	26	25	2	97
Germany	22	22	2	91

Source: Bloomberg and authors' calculation.

3.2. LIQUIDITY RISK VARIABLE

Liquidity factors also play a role in determining sovereign bond spreads. High liquidity is usually associated with lower yields in equilibrium, as more liquid bonds can be traded more easily, thus carrying lower transaction costs. Liquidity conditions can vary across sovereign issues depending on the trading volumes, the amounts of bonds outstanding, the trading activity of market makers and the efficiency of the secondary market.

Measures of liquidity differ widely across studies. Bid/ask spreads are often used as a measure of the cost incurred by investors in unwinding an asset position. Trading volumes, turnover ratios and trading intensity are used as measures of how frequently a given asset is traded in the market in a given period. Finally, a less traditional measure of liquidity is the amount of outstanding government debt which represents a measure of market depth. Codogno et al. (2003) use three different measures of liquidity (i.e. bid/ask spread, trading volume and turnover ratio) and find that trading volumes are the best performing liquidity indicator. Bernoth et al. (2004) use the size of government bond markets (i.e. the amount of debt issued by a country as a share of total debt in the EU) as an indicator of liquidity and find a significant effect of this variable on the yield differentials of euro area countries. Similarly, Gómez-Puig (2006) uses bid/ask spread and the overall outstanding volume of sovereign debt as measures of liquidity and finds that both measures played a role in the widening of sovereign bond spreads since the EMU. However, according to some authors the main drawback of the bid/ask spread measure is that it is not truly exogenous, as they depend on some features of the marketplace where they are determined (Dunne et al. 2006).

In line with Bernoth et al. (2004) and Gómez-Puig (2006), our analysis includes a proxy for liquidity ex-

pressed as the size of the government bond markets (i.e. the amount of gross government debt issuance). For each country in the sample, total debt issuance is taken as a share of the euro area bond market and the difference to the German ratio is computed. Since better liquidity conditions in the government bond market are expected to lead to lower yields, our liquidity proxy is expected to have a negative sign. Data are available on a quarterly basis and are taken from the ECB Securities Issues Statistics. As an alternative measure for liquidity, in line with Codogno et al. (2003), we also use traded volumes of total government securities maturing at 9- to 11-years, relative to Germany, which are available from Datastream at a monthly frequency. However, this variable has a weak or no significance in our model, while the sign stays the same as in the case of gross government debt issuance.

3.3. INTERNATIONAL RISK AVERSION

A common finding of the empirical literature is that besides country specific factors, sovereign bond spreads are driven by a single-time varying common factor, which is typically associated with shifts in international risk appetite. A proxy for international risk aversion frequently used in the literature, is the spread between the yield on AAA US corporate bonds and the yield on the 10-year US government bonds (Codogno et al. 2003; Manganelli and Wolswijk 2009). A widening of the spread is meant to capture shifts in investors' preferences from the riskier private sector assets towards safer government bonds. Other studies (e.g. Sgherri and Zoli 2009) estimate the common risk factor by using a simple asset pricing model.

Following Codogno et al. (2003) our measure for international risk aversion is computed as the spread between the US AAA corporate bonds and the US 10-year sovereign bonds. In line with other studies we expect a positive sign for this variable in our analysis.

Table A1 in Appendix 1 summarizes the variables in our dataset.

4. THE EMPIRICAL MODEL AND RESULTS

This section introduces a simple estimation model to analyze the determinants of sovereign bond spreads and to assess whether a transfer of risk from the private financial to the public sector occurred as result of government intervention to support the banking sector. Moreover, we gauge the predictive power of the model by quantifying the relative contributions of our main explanatory variables to the change in sovereign bond spreads during the period of analysis.

4.1. THE BASIC MODEL

Given the high persistency in our dependent variable - the level of bond yield spreads today depends also on past values - our preferred specification is a dynamic panel model. Moreover, we estimate the model using both daily and monthly data as a robustness check and in an attempt to mitigate persistency in the dependent variable. Hence, the following empirical model (Equation (1)) is used to explain 10-year government bond yield spreads over Germany (*spread*) in ten euro area countries.

$$spread_{it} = \alpha + \rho\ spread_{it-1} + \beta_1 (ANN)_{it} + \beta_2 E(FISC)_{it} + \beta_3 Intl.Risk_t + \beta_4 LIQ_{it} + \varepsilon_{it} \quad (1)$$

ANN is our country dummy variable on the announcements of bank rescue packages[12]; *E(FISC)* de-

[12] The variables included in equation (1) are specified in terms of differentials to Germany. However, the ANN variable can not be defined as a differential to Germany being based on calendar dates. Therefore, to ensure consistency in the model specification, in the construction of the dummy variable ANN, we dropped the dates of the announcement of bank rescue packages by Germany.

notes governments' expected fiscal positions, as given by the general government balance and/or gross government debt in percent of GDP, relative to Germany; *Intl.Risk* is our proxy for international risk aversion; *LIQ* is a proxy for liquidity of euro area governments' bond markets; ε_{it} is the error term.

The empirical methodology uses the Feasible Generalized Least Squares (FGLS) estimator, corrected for heteroskedasticity across panels and panel-specific AR(1) autocorrelation. Using panel specific autocorrelation allows the pattern of the regression residuals to differ by country. Potential cross-section dependence stemming from common factors is to be explained by our measure of international risk aversion (further checks for any remaining cross-sectional dependence are presented in the section on robustness checks). The FGLS estimator is well fitted to deal with serial correlation problems in samples with small number of cross-sectional units and long time series, and is thus preferred to the classical Arellano/Blundell-Bond (GMM) estimators for dynamic panels (as it will be shown in the robustness checks section, the Blundell-Bond estimator is used, as well, for the regression with monthly data).

The model is estimated using daily, as well as monthly averages for the dependent variable for the period from 31 July 2007 to 25 March 2009. Estimation results of Equation (1) are shown in Table 4 below. For both time frequencies model 1 includes the expected budget balance and expected government debt, model 2 includes only the expected budget balance and model 3 only the expected government debt.

The first lag of the dependent variable is highly significant and is indicative of the high persistency in spreads even when monthly frequencies are used, though the size of the coefficient is slightly smaller in the latter case. However, we find that past values alone

do not explain the widening of bond yield spreads over the period of our analysis. Our estimates show that a higher expected budget balance and/or higher expected government debt relative to Germany is on average associated with higher government bond yield spreads for the euro area countries in our sample.

Moreover, the expected budget balance is robust to all specifications and its coefficient increases substantially when monthly frequencies are used. The expected government debt is less robust with monthly data, as it loses significance when used together with the budget balance in the regression equation. This suggests that in periods of heightened economic uncertainty, the expected fiscal deficit seems to have a larger impact on the movements in sovereign bond spreads.

Table 4. Panel regression to explain 10-year government bond yield spreads over Germany

Variables	Daily data			Monthly data		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Spread (t-1)	0.9829***	0.9851***	0.9842***	0.9714***	0.9716***	0.9704***
ANN	0.0046**	0.0039*	0.0049**	0.0438*	0.0429*	0.0582**
Exp. budget bal.	-0.0007**	-0.0010***	-	-0.0157***	-0.0157***	-
Exp. gov. debt	0.0001**	-	0.0001***	0.0001	-	0.0008**
Intl.Risk	0.0041***	0.0037***	0.0035***	0.0312**	0.0314**	0.0262*
Liquidity (GDI)	-0.0037***	-0.0033***	-0.0028***	-0.0322***	-0.0321***	-0.0233***
_cons	0.0024*	0.0016	0.0025*	-0.0048	-0.0052	0.0074
Number obs. (N)	4212	4212	4212	196	196	196

Note: The dependent variable is $spreads_{it}$. The dependent variable and the explanatory variable *Intl.Risk* are expressed in percentage points. The abbreviations for the explanatory variables are explained in the text above (*Exp. budget bal.* and *Exp. gov. debt* denote the expected budget balance and, respectively, gross government debt).
Countries included in the analysis: Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain. The table shows the estimated coefficients and their significance level (*10%; **5%, ***1%).

Liquidity risk is found to play a role as government bond yield spreads seem to be lower the higher the liquidity in the government bond market. Similarly, the

higher the international risk aversion the higher sovereign bond yield spreads.

Turning to the announcements of bank rescue packages, our estimates show that the government announcements to support the banking sector have increased, on average, the perceived risk of government borrowing compared with Germany. The size of the coefficient increases when the model is estimated using monthly frequencies, although its significance is lower in this case, especially when used in conjunction with the budget balance (model 1+2). The results remain robust if we restrict the period of the analysis to start from September 2008 instead of end-July 2007. Interestingly, the regression results also remain unaffected if Ireland is excluded from the panel. This evidence shows that investors' discrimination across sovereign borrowers was triggered by the governments' *credible commitment* to extend support to the banking sector. Investors may have anticipated that governments would provide as much support as needed to shore up ailing banks regardless of the amounts explicitly announced in the first place (i.e. in case of systemic banking risk, significant implicit guarantees may add-up to the explicit ones).

This evidence is supported if we investigate the impact of the announced size of bank rescue operations on investors' perception of euro area governments' borrowing risk relative to Germany. To this purpose we replace the *ANN* variable in Equation (1) with the two *Size* variables taken as differences relative to Germany and we drop expected government debt which reflects part of the impact from bank recapitalization operations. Table 5 below presents the estimation results when the model is run using monthly frequencies.

When Equation (1) is estimated including the size of the packages, the significance of the expected budget balance remains unaffected, whereas the impact of the new variables is less conclusive. When daily data are

used we find that the size of both government guarantees and bank recapitalizations has no impact on government bond yield spreads. When monthly data are used (i.e. those reported in Table 5), we find that the relative size of guarantees extended by governments to the banking sector has contributed to the widening of sovereign bond yield spreads for the period of our analysis. However, this result is driven by Ireland, which is an extreme outlier in terms of the size of guarantees to the banking sector. If we eliminate Ireland from the panel, then the relative size of guarantees is not significantly related to the widening of government bond yield spreads. The size of recapitalizations is weakly significant only when included separately in the regression equation.

Table 5. Panel regression to explain spreads using the size of bank rescue packages

Variable (Monthly data)	m1 Dynamic panel Recap. + Guarantee	m2 Dynamic panel Guarantee	m3 Dynamic panel Recap.	m4 Dynamic panel Recap. + Guarantee (excl. IE)
Spread (t-1)	0.9660***	0.9672***	0.9643***	0.9517***
Size recap.	0.0021	-	0.0031	0.0025
Size guarantee	0.0005***	0.0006***	-	-0.0008
Exp budget bal	-0.0161***	-0.0141***	-0.0203***	-0.0129***
Int'l Risk	0.0445***	0.0461***	0.0464***	0.0488***
Liquidity (GDI)	-0.0325***	-0.0302***	-0.0380***	-0.0307***
_cons	-0.0191*	-0.0220**	-0.0194*	-0.0202*
No. of observations	196	196	196	179

Note: The dependent variable is $spreads_{it}$. The abbreviations for the explanatory variables are explained in the text above ("Size recap." represents the cumulative size of bank recapitalization; "Size guarantee" represents the cumulative size of bank guarantee, both as % of GDP and relative to the size of packages extended by Germany). Model m1 includes both variables Size recap. and Size guarantee; m2 includes only Size guarantee; m3 includes only Size recap. and m4 includes both variables but excludes Ireland from the sample, while m1 - m3 are run on the entire sample. The table shows the estimated coefficients and their significance level (*10%; **5%, ***1%).

The absence of, or at best weak, correlation between the size of bank rescue packages announced by the

countries in our sample and the widening in sovereign bond yield spreads is not surprising. As discussed in Section III, with the exception of Ireland, the countries that experienced the highest volatility and the largest increase in their bond spreads are not those that have committed the largest amount of resources to the bank rescue packages. The evidence presented in this section is that a country's expected fiscal position matters for investors' perception of its credit risk. It can be argued that the size of bank rescue packages depends, on average, on the country's fiscal room for maneuver: countries with limited fiscal space committed relatively less resources for the purpose of broad-based rescue packages.[13]

To conclude, investors seem to have reacted on average more forcefully to the announcement of financial support whereas they have been less responsive to the size of the packages, except in the case of Ireland whose package size was extremely large.

4.2. THE CREDIT RISK TRANSFER HYPOTHESIS

As discussed in Section III, the announcements of broad-based bank rescue packages may have signaled to investors the governments' commitment to take over part of the risks and liabilities from ailing financial institutions. This may have led to a reassessment of sovereign credit risk vis-à-vis the private financial sector, possibly reflected in an increase in the sovereign CDS premia and a decrease (or lower increase) in CDS premia of the private financial sector. To test this hypothesis, we regress the differential between sovereign CDS

[13] Moreover, a fixed effect estimate of the size of bank rescue packages on the historical values of government debt and deficit shows indeed that both the size of budget deficits and the amount of government debt have a negative and significant impact on the size of the rescue package.

premia and the iTraxx financials over the same variables as in Equation (1), but the proxy for liquidity in the government bond market, as CDS premia does not incorporate a liquidity risk premium. Table 6 below shows the results using a dynamic panel model and a fixed effects model (FE) for all eleven countries of the euro area considered, including Germany. We find evidence of the transfer of credit risk hypothesis as the estimated coefficient of the *ANN* variable is positive and highly statistically significant across all model specifications, meaning that the announcement of bank rescue packages led to a widening of the differential between the sovereign and the private financial CDS premia for the period of analysis. This evidence is confirmed when we run two separate regressions having sovereign CDS premia and iTraxx financials as dependent variables respectively. We find that the coefficient of the *ANN* variable is positive in the regression explaining sovereign CDS, implying an increase in the sovereign credit risk as a result of the announcements, and it is negative in the regression explaining iTraxx, implying a reduction of risk for the financial corporate sector.

On the other hand, the *Intl.Risk* variable has a negative and significant coefficient. We interpret this as an indication that, all other factors constant, higher international risk aversion hit more forcefully the creditworthiness of the European financial sector than that of the euro area governments. Again, if we run two separate regressions on sovereign CDS premia and iTraxx financials as dependent variables, we find that the coefficient of the *Intl.Risk* variable is positive in both regressions but its size is much larger in the regression explaining iTraxx financials.[14]

Finally, the *ANN* variable also seems to have had a higher economic impact compared with the international risk aversion (the coefficient of *ANN* is higher than

[14] Results are available upon request.

that of *Intl.Risk* across all specifications). This implies that the net effect of the two factors has been a higher relative increase of risk in the government sector vis-à-vis the private financial sector.

Table 6. Panel regression to explain the transfer of risk from the private banking sector to the government

Variables	Daily		Monthly	
	Model 1 (Dynamic)	Model 2 (FE)	Model 1 (Dynamic)	Model 2 (FE)
(CDS gov – ItraxxFin) $_{(t-1)}$	0.9851***	-	0.6065***	-
ANN	0.0253***	0.5278***	0.6023***	0.7479***
Exp. budget bal.	-0.0000	-0.0905***	-0.0303***	-0.1037***
Intl. Risk	-0.0116***	-0.2662***	-0.2920***	-0.4655***
Time trend	-	0.0005***	-	0.0242**
Country dummies	-	Included	-	Included
_cons	0.0103***	-0.0995***	0.2159***	0.271
Number obs. (N)	4449	4492	210	221
R-sq adj.		0.35		0.41

Note: The dependent variable is the difference between sovereign' Credit Default Swap (CDS) premia and CDS premia for iTraxx financials ($CDSgov_{it} - ItraxxFin_{t}$). Countries included in the analysis: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain. In this analysis, the expected budget balance is expressed as % of GDP (value by country) and not in spreads to Germany. Therefore, unlike in Table 4 above, the ANN variable also includes the bank rescue package announced by Germany.
The table shows the estimated coefficients and their significance level (*10%; **5%, ***1%).

4.3. PREDICTIVE POWER AND RELATIVE CONTRIBUTION OF FACTORS

In this section, we gauge the predictive power of our basic model and attempt to measure the relative contributions of our main regressors to the change in spreads, both on average for the panel and for each country separately. When computing the relative contributions, we transfer the first lag of the dependent variable to the LHS of Equation (1), thus broadly explaining the contribution of our variables of interest (fiscal variables;

liquidity risk and international risk aversion) to the *change* in sovereign bond yield spreads.[15]

Thus, for country *i* the *contribution* to the change in spread of each variable is calculated as the product between the average value of that variable across time for country *i*, and its coefficient estimate from Table 4, dynamic model 1 (daily). The *relative contribution* of each variable is then calculated as the ratio between the absolute value of the contribution (as calculated above) and the sum of the absolute value of the contributions of all (statistically significant) variables in the model.[16]

For example, the relative contribution of the *ANN* variable is calculated as follows:

$$ANN\ rel\ contr_i = \frac{\left|\hat{\beta}_1\right| * \left|\overline{ANN_t}\right|_i}{\left|\hat{\beta}_1\right| * \left|\overline{ANN_t}\right|_i + \left|\hat{\beta}_2\right| * \left|\overline{E(bal)_t}\right|_i + \left|\hat{\beta}_3\right| * \left|\overline{E(debt)_t}\right|_i + \left|\hat{\beta}_4\right| * \left|\overline{Liq_t}\right|_i + \left|\hat{\beta}_5\right| * \left|\overline{Int.Risk_t}\right|_i} \quad (2)$$

where $\left|\hat{\beta}_1\right|$ represents the regression coefficient of the variable *ANN* in model 1 (daily) (i.e. 0.0046) taken in absolute value; $\left|\overline{ANN_t}\right|_i$ is the average value over time of the variable *ANN*, taken in absolute value, for each country *i*. The other four variables (i.e. expected budget balance, expected gross government debt, the liquidity proxy and international risk aversion), as well as their corresponding coefficients, are expressed in a similar manner.

Table 7 summarizes these results. Column 2 represents the actual values of the dependent variable ($spreads_{it}$) averaged over the period of the analysis,

[15] More specifically, we assume that $y_{it} - \rho y_{it-1} \cong \Delta y_{it}$. In the analysis we only include those explanatory variables that are statistically significant.

[16] We follow the methodology in Beber et al. (2009).

while column 3 shows the averaged predicted values. The predictive power of the basic model is very high for the sample as a whole (up to the 1/100th basis point). By country, the predictive power of the model is also large, differences being in the range of 1/10th basis point - the largest difference seems to be for Finland, about 2 basis points, while for Greece and Ireland, the difference is about 1 basis point.

Table 7.Predictive power of the basic model and relative contributions of the explanatory factors

Country	Actual spreads	Predicted spreads	Maximum relative contribution of the main factors in explaining the daily change in sovereign spreads over Germany (%)				
			Ann. financial packages	Expected fiscal bal. over DE	Expected gov. debt over DE	Liquidity proxy	Intl. risk aversion
AT	0.3743	0.3763	12.3	2.8	4.7	4.5	75.7
BE	0.4427	0.4443	10.1	1.5	14.3	16.9	57.2
ES	0.4139	0.4124	9.9	0.6	19.3	11.0	59.2
FI	0.2802	0.2999	7.8	19.5	19.9	3.0	49.9
FR	0.2374	0.2375	6.6	8.9	1.2	42.6	40.7
GR	0.9318	0.9229	8.9	8.5	20.7	6.5	55.5
IE	0.7397	0.7306	9.8	10.2	21.7	2.2	56.1
IT	0.6718	0.6678	6.4	6.2	19.6	29.2	38.6
NL	0.2795	0.2794	8.8	5.3	12.6	19.8	53.5
PT	0.5701	0.5695	11.3	14.1	1.7	3.5	69.5
average sample-DE	**0.4942**	**0.4940**	**9.2**	**7.7**	**13.6**	**13.9**	**55.6**

Note: The results presented are obtained based on the dynamic Model 1 with daily data (see column 2 of Table 1 for details of the model and estimated coefficients).

For the whole panel, the average factor contribution is calculated by averaging the values of the explanatory variables both across time and countries. According to these calculations, our explanatory variables have contributed, on average, to the daily change in sovereign bond spreads in the sample in the following maximum proportions: 56% the international risk aversion; 21% the expected fiscal position (i.e. expected budget bal-

ance and expected debt ratio), 14% the liquidity proxy, and 9% the announcement of bank rescue packages. We consider these proportions as being the maximum since other uncontrolled explanatory factors may also play some additional role.[17] Hence, international risk aversion seems to be the largest relative contributor to the widening of spreads during the period covered by our analysis. This period has indeed been characterized by high investors' uncertainty and our proxy of international risk seems to capture this effect quite well. In particular, international risk aversion seems to matter more for countries with weaker fiscal positions.[18] The fiscal indicators and the fiscally-related factors, i.e. the *ANN* variable, contribute for about one third to the widening in sovereign bond yield spreads and seem to play a more important role than the liquidity factor. The expected debt-to-GDP ratio relative to Germany, though having a small regression coefficient, seems to be the largest contributor (about one third) among our proxies for country creditworthiness during the period of the analysis.

Turning to country specific results, the expected fiscal position (i.e. expected budget balance and debt ratio) have contributed the most to the change of sovereign bond spreads for Finland (up to 39%), followed by Ireland (up to 32%), Greece (29%) and Italy (up to 26%). The announcements of bank rescue packages have contributed up to 12% to the change in the sovereign bond yield spread in Austria, 11% in Portugal and about 10%

[17] We did not include the constant in the calculation of the relative factor contributions (in the denominator of the formula used above) since it was not significant at 5% level (the constant is mostly not significant across the dynamic panel models used).

[18] When we estimate our model including the interaction terms between the international risk aversion indicator and both expected deficit and expected debt relative to Germany, we find that *ceteris paribus* the impact of international risk aversion on sovereign bond yield spreads is slightly higher for countries with higher expected debt and higher expected deficit.

in Belgium, Spain and Ireland. The large contribution of the *ANN* variable in the case of Austria may reflect possible market concerns regarding future liabilities given the country's exposure to the Eastern and Central European banking sector. This conjuncture is also buttressed by the fact that Austria is the country in which the international risk aversion seems to have played the largest role in explaining the change in sovereign spreads compared to the other countries in the sample.

As regards the liquidity variable, it is found to be, by far, the largest contributor to the developments of sovereign bond spreads in France (up to 43%). Corroborated by the relatively low international risk aversion, this result is in line with Codogno et al. (2003), which found that France was the only country where the liquidity risk proved to be more important than the international risk factor. Other countries in which our liquidity proxy had a high contribution in explaining the change in the dependent variable are Italy (up to 29%), the Netherlands (20%) and Belgium (up to 17%).

To conclude, the results in this section reveal a high explanatory power of our basic model and help gauging the relative contribution of factors in explaining the widening of sovereign bond spreads in the euro area.

4.4. ROBUSTNESS CHECKS

In this section, we perform several robustness checks of our results. First, we investigate the robustness across various estimation techniques. Second, for the results with daily data, we control for the impact of other type of announcements, such as the release of lead indicators and main macroeconomic variables for the euro area, Germany, France, Italy and the U.S. Third, we control for other potentially omitted variables, such as expected external imbalances, expected economic growth rate, and the short term interest rate in the euro area as given by ECB's main refinancing rate.

4.4.1. ROBUSTNESS ACROSS ESTIMATION TECHNIQUES

Our results remain robust when we apply different estimation techniques to Equation (1) as well as when we specify our model in static rather than dynamic form.

An alternative estimator for dynamic panel data is the Blundell-Bond (system GMM) estimator. Since the system GMM estimator[19] is more adequate for highly persistent dependent variables with a short time dimension, we applied it only to our monthly data and found that the results were robust. Moreover, the significance of the announcement variable increases to 1% when this model is used (see Table A2.3, model m2 in Appendix 2). We also use the fixed effects estimator to control for country specific characteristics, while also correcting for serial autocorrelation (see model m4 with the Newey estimator in Tables A.2.1 and A.2.2). This allows us to compare our results with other studies in the literature using pooled OLS or fixed effects estimators. To account for any cross-sectional dependence potentially left unexplained by our common factor variable (international risk aversion), we also use the Driscoll-Kraay estimator[20] with fixed effects, which produces standard errors robust to disturbances being heteroskedastic, au-

[19] The system GMM estimator (Blundell-Bond 1998) is used when the dependent variable is highly persistent since its lag is not a good instrument for the first-difference. Compared to the Arellano-Bond estimator (difference GMM), the system GMM estimates an additional level equation (in a system of equations, hence its name) using lagged differences as instruments for levels. These estimation methods assume that there is no second order (or higher) autocorrelation in the error term. In the case of our data, this condition is met when we use both the first and second lag of the dependent variable as explanatory variables.

[20] As implemented in Stata using the command xtscc (for more details, see Hoechle (2007)). We thank an anonymous reviewer for suggesting the use of this estimator.

tocorrelated up to a certain lag (lag five is used in our case) and cross-sectional dependent. The results (shown under model m5 in Tables A.2.1 and A.2.2) for the fixed-effects static model indicate that the statistical significance of our main explanatory variables is preserved.

One potential problem with our data results from the use of mixed time frequencies. In particular, our main variables of interest – expected fiscal balance and debt – change only little over time within each cross-sectional unit. First, as explained in Section II, we were faced with the trade-off between using higher-frequency fiscal data available from private forecasters, but limit dramatically the number of countries included in the analysis, or employing the European Commission forecasts, available for each country at a lower time frequency. The latter choice seems more appropriate to capture the developments in the euro area.

Second, since we use forward-looking fiscal variables, which capture the signal to investors on future sovereign credit risks, we cannot interpolate our data for lower frequencies (e.g. monthly fiscal data to be used in our alternative monthly analysis), as done in some studies using historical data.[21] This method would artificially introduce new signals to investors related to the release of fiscal data. Hence, the economic interpretation of the statistical incidence of lower frequency-variables is related, in this case, to the signaling power of forward-looking event variables.

Third, as a robustness check in the static model, we proceed to correcting the empirical results for the lower time frequency of our fiscal variables. The fact that the expected fiscal balance and government debt change only little over time within each cross-sectional unit may induce (positive) serial correlation. This produces a

[21] See for instance Alexopoulou et al. (2009).

(downward) bias to the standard errors estimated with OLS. The problem is partly[22] mitigated when the (feasible) generalized least square (GLS) estimator is used with a correction for the autoregressive process. In general, observations may be correlated in some unknown way for the period in which our fiscal variables do not change. In the presence of such clusters, OLS estimates are still unbiased, but standard errors may be affected. To address this problem, we construct a daily time identifier matching the dates of change in the expected fiscal variables. We use this new variable to cluster the standard errors, thus capturing potential correlation between observations within the same time cluster. Results are shown under models m3 of Tables A2.1 and A2.2, Appendix 2 (robust and cluster-corrected standard errors) and illustrate that our fiscal variables (expected budget deficit and debt ratio) remain highly statistically significant. We also use a cross-sectional "country" identifier to check the robustness of our *Intl.Risk* variable, which is common across countries (and varies daily across time). Clustering by country yields similar results as above, with the *Intl.Risk* again highly statistically significant (at 1%).[23]

The conclusion of these robustness tests is that the explanatory variables of interest - the expected fiscal position and the announcement of bank rescue packages - remain robust across various estimation techniques. In addition, the very good explanatory power of the model is also confirmed by the high goodness of fit measures

[22]This is a usual corrective approach employed, for instance, in the "difference-in-difference" empirical literature, in which a treatment variable is kept constant within the cross-sectional units before and after the event. Yet, Bertrand at al. (2004) show that the estimator has only limited capacity to correct the serial correlation problem in a difference-in-difference specification. Wooldridge (2003) recommends the GLS estimator in order to exploit the presence of unobserved cluster effects in the error term when the number of groups is large.

[23] Results available upon request.

(as given by the *adjusted R-square* in the pooled OLS model and the *R-square within* in the fixed effects model of about 70%). The results are presented in Appendix 2.

4.4.2. CONTROLLING FOR MACROECONOMIC NEWS EVENTS

We also control whether during the period of our analysis investors' perception of sovereign risk has been driven by other types of announcements. The release of macroeconomic data and other lead indicators is likely to affect investors' perception of sovereign risk in the short run, especially on a daily basis. To control for the impact of these events, we collected the dates of macroeconomic announcements during the period of our analysis following Andersson et al. (2006). They investigate the intra-day impact on bond yield spreads in the euro area of a series of macro indicators released for the euro area, Germany, France, Italy and the U.S.

We use the indicators that were found statistically significant in the above mentioned study and add several other indicators, which are all listed in Appendix 3. Given the low frequency of most macroeconomic data releases, we cannot control directly in the regression equation for the surprise effect of the macroeconomic announcements (the difference between the actual data and the median expected by the market, available from Bloomberg); this would reduce our daily sample size from over four thousand to about 40 observations. Hence, we net-out the impact of macroeconomic announcements by estimating Equation (1) (excluding the lagged dependent variable[24]) on a sample that excludes:

[24] We do not use the dynamic model since the first lag of the dependent variable may also be eliminated together with the macroeconomic events and results may not comparable (in addition, we would lose a large number of observations). Hence, all models are estimating using fixed effects (FE). Model m1 in column 1 of Ta-

(i) the days of announcements (model m2 in Table A2.4, Appendix 2) and (ii) the first day following each announcement (model m3 in the same table). By eliminating the days of (or following) macro data releases, our conclusions do not change: the variables of interest that may be affected - the announcement of bank rescue packages, as well as the fiscal positions, remain highly statistically significant and have the same sign. Moreover, the sizes of their coefficients increase slightly, which may be an indication of the fact that the macro announcements do not interfere with the impact of the fiscal variables (as found in Andersson et al. (2006), the bulk of the impact may be intra-day).

4.4.3. CONTROLLING FOR OTHER EXPLANATORY VARIABLES

We also control for additional macroeconomic fundamentals and policy variables that may have an impact on sovereign bond spreads and check whether our variables of interest remain robust. The additional macroeconomic fundamentals that we use are the expected economic growth rate and a proxy for the expected external imbalances (the saving-investment balance of the private sector as a share of GDP). Both variables are calculated following the same procedure as previously used, i.e. the average over the current and the next year as projected in the European Commission's forecast, relative to that for Germany. For the policy variable, we investigate the impact of the short term interest rate, as proxied by the ECB's main refinancing operations rate for the period of our analysis.

Table A2.5 in Appendix 2 shows the estimation results of our basic dynamic panel model to which we add the new variables separately: the expected S-I balance of the private sector in model m1; the expected real

ble A2.4, Appendix 2, is the FE model with the whole sample shown for comparison.

GDP growth rate in model m2 and the ECB policy rate in model m3.

The results of these tests show that our explanatory variables of interest remain statistically significant even when we control for additional variables. The expected economic growth rate does not seem to have had an impact on the widening of spreads, whereas larger expected external imbalances (i.e. higher current account deficits) are associated to higher sovereign bond yield spreads for the period of our analysis. On the other hand, the ECB policy rate is highly statistically significant and has a positive sign, i.e. a lower reference interest rate has contributed to lowering sovereign spreads in the euro area. This result is in line with that found in Manganelli and Wolswijk (2009) for the period January 1999 to April 2008.

5. CONCLUSIONS AND AREAS FOR FUTURE RESEARCH

Since the intensification of the financial crisis in September 2008 up to end-March 2009, long-term government bond yield spreads relative to Germany have increased dramatically for most euro area countries. In March 2009 the spread between the Greek and the German government bonds was almost 270 bps from about 30 bps, the average spread after Greece's accession to EMU.

In line with the existing empirical literature, this paper finds that sovereign bond yield spreads in the euro area reflect concerns about a country's credit risk and liquidity risk as well as higher international risk aversion. Higher expected budget deficits and/or higher expected government debt relative to Germany have contributed to higher government bond yield spreads in the euro area over the period end-July 2007 to end-March 2009. The results are robust if we restrict the period of analysis to after the crisis has intensified, i.e. the period

from end-August 2008 to end-March 2009. The expected budget balance seems to be more robust than the expected debt across the various specifications. We interpret this result as pointing to a greater relevance of the fiscal deficit in shaping investors expectations in periods of heightened uncertainty.

In addition to standard measures of government creditworthiness we also take into account the impact that the announcements of bank rescue packages have had on government bond yield spreads. Interestingly, we found that the government commitment to support ailing financial institutions led to a re-assessment of sovereign credit risk from the part of investors, through a transfer of risk from the banking sector to the government. Moreover, we also find that this perception is not influenced by the amount of resources explicitly committed by governments to the bank rescue packages. The size of rescue packages does not have, on average, a statistically significant effect on sovereign bond yield spreads, especially when Ireland is excluded from the analysis. In our view, this can be explained by the fact that investors' discrimination among sovereign borrowers was triggered by governments' *credible commitment* to extend support to the banking sector, and not by the mere size of this support. Investors' perceptions may have been driven by expectations that governments would provide as much support as needed to shore up ailing banks regardless of the amounts explicitly announced in the first place.

The liquidity of government bond markets has also played a role in the widening of sovereign bond yield spreads. Countries with a more liquid bond market seem to enjoy relatively lower bond yield spreads during periods of financial turmoil. Finally, and in line with the existing empirical literature, we also found that international risk aversion is an important factor in explaining sovereign bond yield spreads.

Our findings are robust to the use of different time frequencies (daily and monthly), various estimation techniques, and to the inclusion of additional control variables. In this respect, we also found that the reduction in the ECB main refinancing operations rate contributed significantly to narrowing sovereign bond spreads for the period under consideration. In line with Manganelli and Wolswijk (2009) we interpret this variable as capturing (*inter-alia*) risk aversion in the euro-area. Similarly, private external imbalances relative to Germany have an influence on sovereign bond spreads, whereas the expected economic growth rate does not seem to matter for the period covered in our analysis. Controlling for other types of announcements, such as the release of macroeconomic data and lead indicators for the euro area, Germany, France, Italy and the U.S., does not change our conclusions regarding the impact of announcements of bank rescue packages on sovereign spreads.

Our model has a very high predictive power of both average and country-specific sovereign bond spreads in the sample. Using the (average) coefficient estimates from the basic model over the period from 31 July 2007 to 25 March 2009, we calculate the relative contribution of each explanatory variable in our sample to the daily change in average sovereign bond spreads both for each country and for the whole sample. This allows us to gauge the relative importance of each factor in explaining movements in sovereign bond spreads. For the sample as a whole we find that each explanatory variable contributes to the change in daily sovereign bond yield spreads in the following maximum proportions: 56% the international risk aversion; 21% the expected fiscal position (expected budget balance and debt), 14% the liquidity proxy, and 9% the announcement of bank rescue packages. The large relevance of international risk aversion for changes in sovereign bond yield spreads can be explained by the extraordinary severeness of the financial crisis during the period of our analysis. More-

over, the fact that fiscally-relevant variables account for about one-third of the movements in euro area sovereign spreads during the financial crisis points to the importance of preserving the public's trust in the soundness of public finances. This is essential to anchor market expectations about a government ability to meet its future debt obligations. Therefore, an important lesson from the financial crisis is that countries should consolidate during good economic times in order to build a "fiscal cushion" that provides sufficient room for maneuver during an economic downturn or a crisis. Many euro area countries failed to do so and entered the crisis with high fiscal deficits and debt ratios and thus, limited the scope of their fiscal actions at a time when it was needed the most.

Future lines of research could focus on the role of country-specific financial sector vulnerabilities in explaining sovereign bond spreads. A more in depth analysis of the impact of monetary policy announcements could provide a comprehensive view of the drivers of euro area sovereign bond spreads in crisis times. Finally, extending the econometric analysis to assess the developments of bond spreads on a country-by-country basis could provide additional insights as to the specific role of fiscal variables.

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APPENDIX 1. DATA DESCRIPTION

Table A1: Data definition, frequency and source

Variable	Definition	Frequency	Source
10-yr government bond yields	Current yield on 10-year government bonds	Daily	Bloomberg
10-yr government bond spreads	Differential in the current government bond yield vis-à-vis the German Bund	Daily	Authors' calculations based on government bond yields data
Government CDS premia	Cost of ensuring against the default of government debt	Daily	Bloomberg
iTraxx Financials Senior	CDS Index covering 25 European financial institutions including the UK and Switzerland	Daily	Bloomberg
International risk aversion	Differential between US AAA corporate bond yields and US 10-year government bond yields	Daily	Bloomberg
Announcement of bank rescue packages	=1 since the day of announcements of broad-based bank rescue packages =0 before	Daily	Authors' calculation
Size recapitalization	Cumulative size of bank recapitalizations	Daily	Authors' calculation
Size guarantee	Cumulative size of bank guarantees.	Daily	Authors' calculation
Liquidity	Gross government debt issuance at all maturities as share of total euro area issuance vis-à-vis Germany	Quarterly	ECB Securities Issues Statistics
Expected government budget balance	Differential in the projected government budget balance vis-à-vis Germany	Biannual	EC Commission forecasts, different vintages. All variables expressed as ratio to country GDP
Expected government debt	Differential in the projected government vis-à-vis Germany	Biannual	

APPENDIX 2. RESULTS OF ROBUSTNESS TESTS

1. ROBUSTNESS ACROSS ESTIMATION TECHNIQUES

Table A2.1: Panel with daily data using *Exp. budget bal*

Variable	m1 Dynamic panel XTGLS	m2 Pooled OLS, robust SE	m3 Pooled OLS robust and clustered SE	m4 FE, AR(2) robust SE (Newey)	M5 FE, Driscoll-Kraay SE
Spread (t-1)	0.9851***	-	-	-	-
Ann Fin Pack	0.0039*	0.2999***	0.2999**	0.3328***	.2899***
Exp budget bal	-0.0010***	-0.0695***	-0.0695**	-0.0572***	-.0566***
Int'l Risk	0.0037***	0.0871***	0.0871	0.0816***	.2401***
Liquidity (GDI)	-0.0033***	-0.1591***	-0.1591*	-0.2875***	-.2499***
time_id	-	0.0012***	0.0012**	0.0013***	-
dummy_BE	-	-	-	0.2132***	Included
dummy_ES	-	-	-	0.1464***	Included
dummy_FI	-	-	-	0.1651**	Included
dummy_FR	-	-	-	0.3544***	Included
dummy_GR	-	-	-	0.5169***	Included
dummy_IE	-	-	-	0.1579***	Included
dummy_IT	-	-	-	0.6443***	Included
dummy_NL	-	-	-	0.1832***	Included
dummy_PT	-	-	-	0.0822***	Included
_cons	0.0016	0.025	0.025	-0.1547***	.0677***
Number obs. (N)	4212	4222	4222	4222	4222
R-sq adj./within		0.67	0.67	0.72	0.69

Table A2.2: Panel with daily data using *Exp. gov. debt*

Variable	m1 Dynamic panel XTGLS	m2 Pooled OLS, robust SE	m3 Pooled OLS robust and clustered SE	m4 FE, AR(2) robust SE (Newey)	M5 FE, Driscoll-Kraay SE
Spread (t-1)	0.9842***	-	-	-	-
Ann Fin Pack	0.0049**	0.3714***	0.3714**	0.3313***	.2887***
Exp gov. debt	0.0001***	0.0074***	0.0074**	0.0243***	.0235***
Int'l Risk	0.0035***	0.0650***	0.0650	0.0755***	.2388***
Liquidity (GDI)	-0.0028***	-0.1951***	-0.1951*	-0.3141***	-.2743***
time_id	-	0.0014***	0.0014***	0.0014***	-
dummy_BE	-	-	-	-0.3812***	Included
dummy_ES	-	-	-	0.6323***	Included
dummy_FI	-	-	-	0.5387***	Included
dummy_FR	-	-	-	0.3520***	Included
dummy_GR	-	-	-	0.2441	Included
dummy_IE	-	-	-	0.8693***	Included
dummy_IT	-	-	-	-0.3356*	Included
dummy_NL	-	-	-	0.4487***	Included
dummy_PT	-	-	-	0.0217	Included
_cons	0.0025*	0.0956***	0.025	-0.0042	.1449***
Number obs. (N)	4212	4222	4222	4222	4222
R-sq adj.		0.69	0.69	0.73	0.70

Note for tables A2.1 and A2.2: The dependent var. is $spreads_{it}$. The abbreviations for the explanatory variables are explained in the text. Countries included in the analysis: Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal and Spain. The time frame is 31.07.2007 – 25.03.2009. The table shows the estimated coefficients and their significance level (*10%; **5%, ***1%). In model m3, standard errors (SE) are robust and cluster-corrected according to a time id matching the dates of change in the expected fiscal variables to account for their different time frequency (Clustering by country id yields similar results (available upon request), only that the Intl. Risk variable remains highly statistically significant (at ***). Clustering by country is the relevant methodology for the robustness of Intl. Risk, which is common across countries (and varies daily only across time).

Table A2.3: Panel regression with *monthly* data

Variable	m1 Dynamic panel XTGLS	m2 Dynamic panel Blundell-Bond (system GMM)
Spread (t-1)	0.9714***	1.1656***
Spread (t-2)	-	-0.2374***
Ann Fin Pack	0.0438*	0.0840***
Exp budget bal	0.0157***	-0.0207**
Exp gov. debt	0.0001	0.0019*
Int'l Risk	0.0312**	0.0330**
Liquidity (GDI)	-0.0322***	-0.0544***
_cons	-0.0048	0.0121
Number obs. (N)	196	186
AR test (Ho= no AR)		
AR(1) p-value		0.0146
AR(2) p-value		0.2244
AR(3) p-value		0.3560

Note: The second lag of the dependent variables is included in m2 to satisfy the AR condition of no second order correlation (excluding it would bring the p-value of the AR(2) test at 0.0731).

2. ROBUSTNESS CHECKS EXCLUDING MACROECONOMIC NEWS EVENTS

Table A2.4: Panel regression with daily data using *Exp. budget bal.*

Variable	m1 FE (Newey) Whole sample	m2 FE (Newey) No macro. events at time t	m2 FE (Newey) No macro. events at time t+1
ANN	0.3328***	0.3816***	0.3238***
Exp. Budget Bal.	-0.0572***	-0.0735***	-0.0547***
Int'l Risk	0.0800***	0.0700*	0.0400
Liquidity (GDI)	-0.2875***	-0.3173***	-0.2947***
Time trend	0.0013***	0.0014***	0.0016***
Country dummies	included	included	included
_cons	-0.1546***	-0.1588***	-0.1610***
Number obs. (N)	4222	1147	1018
R-sq	0.72	0.72	0.70

Note: All three models are estimated using fixed effects (FE). Model m1 is the FE model with the whole sample shown for comparison. Model m2 excludes the days of macroeconomic announcements, while model m3 excludes the first day following each announcement.

3. ROBUSTNESS CHECKS: CONTROLLING FOR OTHER EXPLANATORY VARIABLES

Table A2.5: Dynamic panel regression with daily data

Variable	m1 CAB private sector	m2 GDP growth rate	m3 ECB policy rate
Spread gov (t-1)	0.9816***	0.9829***	0.9865***
ANN	0.0052**	0.0045*	0.0085***
Exp. budget bal.	-0.0006**	-0.0009***	-0.0006**
Exp. gov debt	0.0001***	0.0001***	0.0001*
Liquidity (GDI)	-0.0037***	-0.0035***	-0.0033***
Int'l risk	0.0040***	0.0041***	0.0037***
Exp private CAB	-0.0002**	-	-
Exp GDP growth	-	0.0014	-
ECB policy rate	-	-	0.0035***
_cons	0.0017	0.0019	-0.0124**

Note: The expected private current account balance (CAB) and GDP growth rate are also expressed in relative terms to Germany and are calculated using the same methodology as the one for the fiscal variables (source of data: European Commission Forecast). ECB policy rate is the main refinancing operations rate for the period under analysis (31.07.2007 – 25.03.2009)

APPENDIX 3.
OTHER ANNOUNCEMENTS OF MACRO-ECONOMIC DATA AND LEAD INDICATORS

(released during 31/07/2007 – 25/03/2009)

US activity and employment
US GDP advance
US GDP final
US industrial production
US initial jobless claims
US retail sales
US factory orders
US durable goods orders

US Forward-looking
US University of Michigan consumer sentiment Index
US ISM manufacturing confidence US
US ISM non-manufacturing confidence
US Chicago PMI
US consumer confidence
US Philadelphia Fed index

US prices
US consumer price index

Euro area activity and employment
EA industrial production
EA GDP
EA retail sales
EA unemployment

Euro area Forward-looking
EA business confidence
EA consumer confidence

Euro area prices
EA HICP

National Activity and Employment
DE industrial production
DE GDP
DE unemployment
FR industrial production
FR GDP
FR unemployment
IT industrial production
IT unemployment

National forward-looking
ZEW economic sentiment DE
IFO business confidence DE
IFO expectations DE
FR business confidence
IT business confidence

National prices
DE consumer price index
FR consumer price index
IT consumer price index