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SAFE HAVENS, PURGATORY, AND THE DAMNED

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Determinants of OECD countries' sovereign yields: safe havens, purgatory, and the damned*

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Résumé Dans ce papier, nous estimons les déterminants des écarts entre les taux souverains à 10 ans et le taux du swap de taux d'intérêt pour un échantillon de 22 pays de l'OCDE sur la période janvier 1999-décembre 2013, en utilisant plusieurs modèles. Notre modèle principal, à effets fixes, souligne le rôle crucial de la croissance du PIB, du déficit public et de la liquidité de la dette pour expliquer le niveau des écarts de taux, tandis que le ratio de dette publique sur PIB joue un rôle moindre. Nous constatons que nos résultats sont déterminés principalement par les observations sur les pays de la zone euro après le début de la crise de 2008, avec des écarts de taux observés dépassant significativement les valeurs estimées pendant la crise pour un certain nombre de pays de la zone euro. Nous soulignons également l'effet des politiques monétaires non conventionnelles, tandis que les soldes Target 2 sont utilisés pour les pays de la zone euro afin de refléter les inquiétudes sur la stabilité de la zone euro. Enfin, d'après notre modèle de cointégration, nous trouvons une relation de long terme entre l'écart de taux, le ratio de dette sur PIB et la croissance potentielle, avec un impact plus élevé de cette dernière variable.

Mots clés : taux d'intérêt ; écarts de taux souverains ; dette publique ; données de panel
Codes JEL : C23, E43, E44, G15

Abstract In this paper, we estimate the determinants of the spreads between the 10-year sovereign bond yields and the (interest rate) swap rate for a sample of 22 OECD countries over the January 1999-December 2013 period, using various models. Our main, fixed-effect, model highlights the crucial role of GDP growth, public deficit and debt liquidity in explaining the level of spreads, while the public debt-to-GDP ratio plays a lesser role. We find that our results are mainly driven by observations on euro area countries after the onset of the 2008 crisis, with observed spreads found to significantly exceed estimated values during the crisis for a number of euro area countries. We also shed light on the effect of unconventional monetary policies, while Target 2 balances are used for euro area countries in order to reflect concerns on the stability of the euro area. Finally, according to our cointegration model, we find a long-term relationship between the spread, the debt-to-GDP ratio, and potential GDP growth, with a larger impact of the latter variable.

Keywords: interest rates; sovereign spreads; public debt; panel data
JEL classification: C23, E43, E44, G15

Non-technical summary

The 2008/2009 financial crisis and, more importantly, the 2010/2012 euro area debt crisis have renewed the attention paid to the notion of sovereign yield spreads due to the deterioration of economic fundamentals in many countries and increased discrimination by investors between underwriting quality. In this paper, we shed light on the determinants of sovereign interest rates and spreads by using a panel of 22 OECD countries over the 1999-2013 period. We estimate the spread between the 10-year government bond rates and the (interest rate) swap rates in order to make rates comparable between countries. We try to disentangle the effects of economic and fiscal fundamentals, the impact of monetary policy, and the role of financial variables and risk aversion. This may allow us to determine whether the spreads observed during the crisis were excessive with regard to fundamentals.

To that aim, we estimate several models in order to take into account a large range of assumptions. Our main model includes country-specific intercepts in order to capture the unobserved characteristics of each country. This model shows the large impact of GDP growth and the general government balance: an increase in these variables results in a tightening of the spread between the 10-year government bond rates and the (interest rate) swap rates. Debt liquidity, measured by the bid-ask spread, plays a very large role as well: when the bid-ask spread increases by 1 basis point, which corresponds to a decline in liquidity, the spread between sovereign and swap rates widens by 10 basis points. By contrast, the debt-to-GDP ratio is found to have a lesser impact.

We then try to be more specific in our estimations by focusing on the latest crisis period and then on the euro area crisis. We find that our results are mainly determined by the observations after the onset of the 2008 crisis and on euro area countries. Whereas monetary policies mainly explain spreads before the crisis, credit and liquidity risks variables are found to have significant effects on the spreads from September 2008 onwards due to the crisis. We also try to assess the impact of unconventional monetary policies carried out from 2008 onwards and find a significant and negative impact on spreads for non-euro area countries, while results are more mixed for euro area countries. Finally, we use Target 2 balances between euro area countries as a variable reflecting the solidity of the euro area and concerns on redenomination risks: we find that when the Target 2 balance of a euro area country increases, which reflects a net creditor position of the country's central bank vis-a-vis the other central banks of the euro area, the spread tightens for this country.

We then introduce an AR(1) term in our main, fixed-effect, model in order to introduce some dynamics. We find that the autoregressive coefficient is not significantly different from 1: this raises the legitimate issue of the possible non-stationarity of the series. However, the results of the stationarity tests we perform are not clear-cut: we cannot strictly conclude that the data are non-stationary, but we cannot rule out this possibility either. We then assess the existence of a possible long term relationship between the different series, but the cointegration tests we perform are ambiguous too. We nevertheless estimate an error-correction model with the pooled mean group (PMG) estimator: we consider a specification where GDP potential growth and the debt-to-GDP ratio are regarded as long-term determinants of the spread, while the other explanatory variables are considered as short-term factors. We find that the speeds of adjustment to the long term relationship are negative: this supports the cointegration hypothesis. Moreover, GDP potential growth seems to have a much larger long-term impact on the spread than the debt-to-GDP ratio.

A comparison between spreads actually observed in July 2012 and the estimates of our three main models reveals that observed spreads in some euro area countries exceeded their estimated values significantly at that time, especially with regard to the results model based on long-term relationships. This suggests that spreads should converge towards their long-term value.

1 Introduction

The worldwide financial crisis that erupted in 2007/2008, and even more importantly, the euro area debt crisis that spread from Greece from 2010 onwards have entailed a renewed attention to the determinants of sovereign interest rates and the notion of yield spreads. Three factors contributed to this regained importance of sovereign yields:

i. the deterioration in public finances brought about by the financial crisis triggered increased market concerns on the solvency of several advanced states;

ii. investors discriminated more between sovereigns' fundamentals whereas the convergence process that had happened in the run-up to the euro creation and the worldwide "great moderation" in the 2000s decade had to a large extent abolished yield spreads, i.e. the difference between the interest rates paid by countries on their sovereign debts;

iii. the quantitative easing carried out by major central banks through very large asset purchases, including sovereign bond buying, blurred the price formation of sovereign bonds and changed the way monetary policy is transmitted to long-term interest rates.

Moreover, sovereign market developments have triggered policy measures as several euro area countries (Greece, Ireland, and Portugal) had to request an international bailout financial programme when their borrowing costs exceeded a certain threshold, usually estimated at 7% for the ten-year interest rate. In the case of Spain and Italy, the rise in their ten-year borrowing costs to levels deemed as unsustainable led the European Central Bank to set-up a new bond-buying programme in the summer 2012, called the "Outright Monetary Transactions" (OMT) programme.

In this context, there has been a very extensive body of literature on the determinants of sovereign bond yields and spreads. Papers analysed either the yields in levels or spreads compared to a benchmark rate, usually the US or the German 10-year rate. The methodology differed from one paper to another, and there has been no agreement in the literature on the relative weights of fundamental, monetary policy and financial variables in the determination of sovereign bond yields. Therefore, there remain unanswered questions as to whether interest rates on sovereign debts primarily represent investors' opinions on a country's solvency and growth prospect, the impact of monetary policy, or changes in investors' risk aversion. Moreover, there has been no agreement either in the literature on "equilibrium" yields and spreads as countries with similar levels of the public debt-to-GDP ratio may face very different sovereign bond yields. Papers have also faced difficulties in appropriately introducing variables specific to the euro area in models, such as the so-called redenomination risks or safe haven flows' determinants. Therefore, disentangling credit risk and liquidity risk has been a challenging task, further complicated by the redenomination risk premium for countries in a currency union.

In this paper, we decide to revisit the issue of sovereign bond spreads' main determinants by estimating the spreads between 10-year sovereign bond yields and the swap rate, by choosing a large sample of OECD countries, by comparing the results of different models based on fixed effects or error-correction estimators, and by introducing several variables that enable us to assess the new phenomena that are at stake in the formation of sovereign bond yields since the onset of the 2008 financial crisis, as compared to the previous period. Our main findings are that GDP growth, public deficit and debt liquidity play a crucial role in explaining the level of spreads, while the public debt-to-GDP ratio plays a lesser role. We find that our results are mainly driven by observations on euro area countries after the onset of the 2008 crisis, with observed spreads found to exceed estimated values during the crisis for a number of euro area countries.

We also shed light on the effect of unconventional monetary policies outside the Eurozone, while Target 2 balances are used for euro area countries in order to reflect concerns on the stability of the euro area. Finally, according to our cointegration model, we find a long-term relationship between the spread, the debt-to-GDP ratio, and potential GDP growth, with a larger impact of the latter variable.

The remainder of this paper is organized as follows. Section 2 presents a short literature overview and the contribution of this paper. Section 3 describes the data and discusses stylized facts resulting from simple descriptive statistics. Section 4 presents our static analysis model. Section 5 presents historic and geographic specificities. Section 6 discusses the stationarity issue and presents the cointegration model and its results. Section 7 presents a breakdown of countries on the basis of the results of our different models. Section 8 concludes.

2 Literature Review

There has been a very large literature on the determinants of sovereign bond yields. Papers usually estimate a fixed effect panel model introducing fiscal variables and control variables in order to take into account the unobserved individual characteristics of countries.

Usually, papers have found a significant relationship between government credit risks and sovereign bond yield spreads. They find that public debt-to-GDP ratios are seen by investors as the best indicator of governments' solvency: market participants require higher interest rates for bearing credit risks when they buy bonds of a government with a higher debt burden (Ardagna et al. (2007), Baldacci and Kumar (2010)). The role of sovereign credit ratings has been discussed but no consensus has been found in the literature (Manganelli and Wolswijk (2009), Afonso et al. (2012)) and the use of sovereign ratings as fiscal sustainability indicators has been criticized. Interestingly, a recent paper by D'Agostino and Ehrmann (2013) using forecast data from macroeconomic fundamentals from Consensus Economics finds a considerable time variation in the value of coefficients and that the countries' macroeconomic fundamentals play a much larger role in explaining the size of the spread with a benchmark country (the US or Germany) than the fundamentals of the benchmark country.

Due to the euro area debt crisis, euro area countries have received a great deal of attention in recent papers with bond yield spreads being estimated against the German rate, taken as a benchmark. Typically they have expanded the list of variables having an effect on sovereign bond spreads and have noted a shift in the determinants over time. A large number of papers have shed light on the impact of financial variables, more specifically of a single common factor interpreted as an international risk aversion indicator, building on the paper of Codogno et al. (2003). Contagion effects and safe haven flows have been found to have a significant effect on sovereign spreads (Caceres, Guzzo and Segoviano (2010), De Santis (2012)), but with no consensus as Giordano et al. (2013) found no evidence of pure contagion in explaining the sharp increase in sovereign spreads of euro area countries after the Greek crisis. A large part of the spreads observed for some countries during the euro area debt crisis has been found to be unexplained and higher than what could be justified by fundamentals (Di Cesare et al. (2012)), which suggests the presence of financial factors not captured by models, such as the risk of a euro area break-up and the redenomination risk that prevailed in financial markets during the peak of the euro debt crisis (2011-2012).

Other papers have more specifically analysed the effect of the monetary stance: Manganelli and Wolswijk (2009) have found a significant relationship between the level of short-term interest rates, investors' risk aversion and euro area government bond spreads, whereby lower short-term interest rates are associated with lower risk aversion which brings about lower government bond yield spreads through various channels (funding liquidity channel, state of the economy).

A smaller number of papers estimate dynamic panel models aimed at taking into account non-stationarity and cointegration relationships and constitute a very interesting avenue for research. Giordano et al. (2013) estimate long-run relationships between sovereign spreads in the euro area and economic fundamentals using a panel dynamic least square model; they find evidence of investors' increased attention to fundamentals since the onset of the crisis. Poghosyan (2012) estimates real bond yields by using a pooled mean group estimator allowing him to differentiate between long-run and short-run determinants of bond yields: he finds that in the long run, government bond yields increase by about 2 basis points in response to a 1 percentage point increase in government debt-to-GDP ratio and by about 45 basis points in response to a 1 percentage point increase in the potential growth rate.

The contribution of our paper is manifold. First, the choice of our dependent variable, namely the spread between the 10-year sovereign bond yield and the swap rate, enables us to include every country in the estimation, to avoid the need to exclude a benchmark country from the sample and to neutralise exchange rate effects; moreover, we use the Bloomberg fair value generic 10-year sovereign bond yield in order to get rid of the possible exogenous jumps in the sovereign yield rate when the benchmark security representative of the ten-year maturity changes. Second, our choice of large panel of OECD countries enables us to calculate a worldwide "equilibrium" estimate of the spread between the sovereign bond yield and the swap rate. Third, the use of monthly data allows us to better assess short term effects and to estimate coefficients with more precision in comparison with papers relying on quarterly or annual data. Fourth, our model is estimated using different methods (fixed effects, cointegration) in order to take into account a large set of assumptions. Fifth, the use of new variables linked to the current crisis (monetary quantitative easing indicators, redenomination risk in the euro area, safe haven effects) allows us to capture effects that are specific to the post-Lehman era in the model.

3 Data and descriptive statistics

3.1 The dependent variable

Our panel is composed of OECD countries. Our dependent variable is the spread between the 10-year sovereign bond yields and the swap rate in percentage points. The choice of this dependent variable is guided by different motives.

First, it has to be noted that yields of bonds denominated in different currencies are not directly comparable because of the presence of a foreign exchange rate factor. The most intuitive solution to take this factor into account consists in using spot and forward exchange rates. However, few satisfactory data are available on Bloomberg for 10-year forward exchange rates. Using the spread between the 10-year sovereign bond yields and the swap rate as our dependent variable appears to be a good way of circumventing the problem: indeed, this spread is not affected by any foreign exchange risk[1]. Moreover, choosing the spread between the 10-year sovereign bond yields and the swap rate as our dependent variable has a second advantage: it enables us to include every country in the estimation and to avoid the need to exclude a benchmark country from the sample. While the German rate is often taken as the benchmark to calculate sovereign spreads in the euro area, it may be interesting to estimate the theoretical value of the German rate predicted by its main determinants.

[1] See Appendix A for a demonstration inspired from Favero et al. (1997) and Gomez-Puig (2006). However, it has to be noted that the spread between the sovereign rate and the swap rate is immune to the foreign exchange rate risk only if the probability of occurrence of a credit event before the term of the swap is equal to 0. Indeed, if a credit event happens before the swap term, the buyer of the bond receives a financial flow in a foreign currency at a maturity for which he is not hedged.

As the rate representative of the sovereign bond yields, we take the Bloomberg 10-year generic fair-value sovereign bond yield, which is the rate resulting from an interpolation of the yields of current debt securities with maturities around the 10-year maturity. This rate has the advantage of avoiding possible exogenous jumps in the sovereign bond rate when the benchmark security representative of the ten-year maturity changes. The 10-year swap rate is the fixed rate that the buyer of the swap contract receives in exchange of the payment of the varying 6-month Libor rate[2] during the length of the contract, namely 10 years.

Both these variables change with an intraday frequency. However, we have chosen to express all the variables of our model with a monthly frequency in order to reconcile the frequencies of the original series we use (see below for further details): therefore, we calculated the monthly averages of the 10-year sovereign bond yields and of the 10-year swap rate, and then took the monthly value of the spread between the two.

Among OECD countries, we had to exclude five countries that do not issue 10-year bonds from our sample: Estonia, Iceland, Israel, Luxembourg, and Slovenia.

Figures 1 to 3 present the developments in the spread between the 10-year sovereign bond yields and the swap rate for three groups of countries: non euro area countries, euro area countries having entered an international bailout programme during the crisis; and euro area countries without any bailout programme. They show specific patterns for some euro area countries. A striking development has been the sharp increase in the spread of several euro area countries (Greece, Ireland, Italy, Portugal, Spain) from the onset of the 2008 financial crisis, with a peak reached by Greece in January 2012 at 47 points, and by Spain in July 2012 at 5.1 points. France experienced a much more moderate rise in the second half of 2011, while the spread for Germany remained negative over the whole period. Among non euro area countries, the spreads of the UK and the US remained negative most of the time but experienced a rise over the period, while the spread of Japan remained around 0.

Table 1 presents descriptive statistics on the spread between the 10-year sovereign bond yields and the swap rate for our sample of countries as a whole, confirming large differences between pre-Lehman and post-Lehman periods. The September 2008-December 2013 period is indeed characterized in comparison with the January 1999-August 2008 period by a higher mean of the spread and a much larger dispersion of observations, visible in a higher standard deviation and a broader gap between extreme values, suggesting a higher discrimination in credit underwriting by investors. While the average spread between the 10-year sovereign bond yields and the swap rate was negative over the 1999-August 2008 period, it turned positive over the September 2008-December 2013 period.

3.2 Explanatory variables

In our model, we introduce fiscal, macroeconomic, and financial variables, all extracted from Bloomberg, with different frequencies[3]. As a general rule, for variables with a frequency lower than a monthly frequency, we decided to apply the transformation which makes the most economic sense, namely we interpolated stock variables and variables in level (debt, government effectiveness index), converted growth rates into monthly growth rates with n-th-roots, and kept the same value for flow variables (deficit). Fiscal variables have an annual frequency and include the general government deficit as a percentage of GDP, the general government debt-to-GDP ratio in percentage, the general government debt in national currency converted into US dollar, and the World Bank Government Effectiveness Index. The general government deficit-to-GDP ratios are

[2]The 6-month Libor rate that is considered here is labelled in the currency of the studied country: Euribor for euro area countries, USD Libor for the United States, GBP Libor for the United Kingdom, etc...

[3]Due to problem with data access, we chose not to use forecasted data provided by Consensus Economics.

taken from the IMF and have an annual frequency; as the frequency of the data used in our model is monthly, we retain the annual value of the ratio and apply it to each month of the given year as interpolating a flow variable would make no sense. The general government debt-to-GDP ratio series is taken from the IMF for the sake of cross-country consistency; variables are interpolated from an annual to a monthly frequency. The general government debt in national currency converted into US dollar is taken from the IMF, using a frozen spot exchange rate at the start of the observation period (December 31, 1998) in order to neutralise the exchange rate effect; the series is interpolated; likewise for the World Bank Government Effectiveness Index (see Kaufmann et al. (2010)).

Macroeconomic variables have an annual, quarterly or a monthly frequency. They include potential GDP growth, actual GDP growth in volume, the current account balance as a percentage of GDP, the inflation rate, the month-on-month industrial production growth in volume, the month-on-month retail sales growth in volume, and business sentiment. Actual GDP growth in volume is taken from national statistics offices; it has a quarterly frequency, we thus convert the quarterly growth rate into a monthly growth rate by calculating the cubic root of 1 plus the quarterly growth. We do the same with potential GDP growth taken from the OECD and which as an annual frequency: we convert the annual growth rate into a monthly growth rate by calculating the 12th root of 1 plus the quarterly growth. The current account balance as a percentage of GDP is taken from the OECD and has a quarterly frequency; we apply quarterly values to each month of the given quarter. The inflation rate, the industrial production growth, and the retail sales growth are all taken from national statistics offices; the series have a monthly frequency and are seasonally-adjusted. Finally, business confidence indicators are taken from the European Commission (Economic Sentiment Indicator) for the EU countries, and from national statistics offices for the others.

Most of our financial variables have a daily frequency; we calculated the monthly averages of each of them before including them in our model. They include the Chicago Board Options Exchange SPX Volatility Index (VIX), the historical volatility of national stock market indices on a one-month rolling window as a percentage of the value of the index at the end of the rolling window, the historical volatility of national Morgan Stanley Capital International (MSCI) financials indices on a one-month rolling window as a percentage of the value of the index at the end of the rolling window. We also consider the bid-ask spreads on the 10-year generic government bond yields in percentage points: we take the average value on a 6-month rolling window, in order to smooth the jumps linked to changes in benchmarks. Our financial variables also include the central bank's policy rate, the overnight interbank rate, the 3-month interbank rate, the size of the central bank's balance sheet as a percentage of GDP. Three financial variables have frequencies which are lower than daily. For euro area countries, we take national central banks' net claims within the Target 2 system as a percentage of GDP, which are available at a monthly frequency. Bank asset returns as a percentage and banks' non-performing loan ratios are taken from the IMF Financial Soundness Indicators (FSI) database: they have a quarterly frequency, we thus had to apply quarterly values to each month of the given quarter.

Due to data limitations, we had to exclude seven other OECD countries from our sample: Chile, Hungary, South Korea, Mexico, New Zealand, Slovakia, and Turkey. Therefore, we end up with 22 countries composing our sample: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, UK, and USA. Table 2 summarizes the list and sources of the variables used in our model.

4 Static analysis

4.1 Baseline specification

4.1.1 Empirical model

We estimate a panel model composed of 22 countries with monthly variables over the January 1999-December 2013 period. The first empirical model that we consider is static: at this stage, we do not try to capture the dynamics of the spread between sovereign long-term bond yields and swap rates, and therefore we do not introduce any AR term in the specification. We try to assess the respective effects on sovereign bond yields of macroeconomic fundamentals, fiscal policy indicators and short-term financial conditions. Consequently, the model can be written as:

$$r_{it} = \alpha + \gamma_i + \beta_1 X^{(m)}_{it-3} + \beta_2 X^{(fs)}_{it-12} + \beta_3 X^{(ra)}_{it} + \beta_4 X^{(sh)}_{it} + \beta_5 X^{(l)}_{it} + \beta_6 X^{(mp)}_{it} + \delta_1 \mathbb{1}(IMF)_{it} + \delta_2 \mathbb{1}(month)_t + \varepsilon_{it} \quad (1)$$

where subscripts i and t respectively denote country i and time t. r_{it} is the spread between the 10-year sovereign bond yield and the swap rate, $X^{(m)}_{it}$, $X^{(fs)}_{it}$, $X^{(ra)}_{it}$, $X^{(sh)}_{it}$, $X^{(l)}_{it}$ and $X^{(mp)}_{it}$ are respectively macroeconomic, fiscal strength, risk aversion, safe haven effect, liquidity and monetary policy variables or vectors of variables[4]. Fiscal and macroeconomic variables are our main variables, the others stand for control. We also consider a vector of monthly dummy variables $\mathbb{1}(month)_t$ to control for potential seasonal behaviours in the regression. Finally, we introduce a country-specific dummy variable $\mathbb{1}(IMF)_{it}$ that is equal to 1 when the country is under an IMF-supported programme in the regression, in order to take into account the effect that the entry into such a programme may produce on sovereign long-term bond yields and the regime change associated with the interruption in market financing. The error term is assumed zero-mean, stationary and independent across countries but we allow for heteroskedasticity and autocorrelation. The empirical model is estimated using the Least Square Dummy Variable (LSDV) method, and the standard errors we compute are robust to heteroskedasticity and within-panel serial correlation. For our baseline estimation, we have chosen only one or two variables per $X^{(\ )}_{it}$ category for the sake of parsimony: including too many variables from the same category in the regression may cause multicollinearity problems. The chosen variables are:

- **A macroeconomic variable:** the series chosen for this category in our baseline estimation is GDP growth, lagged by three periods (i.e. one quarter) in order to avoid endogeneity problems. Theoretically, a positive relationship is expected from growth to interest rates[5]. However, it has to be recalled that our dependent variable is the spread between the 10-year sovereign bond yields and the swap rate. Consequently, a negative sign can be expected on the coefficient of this variable if a stronger economic situation translates into a lower yield required by investors on the sovereign debt with respect to purely monetary rates, as it strengthens the general government financial accounts and its solvency.

[4]Most of the $X^{(\ )}_{it}$ terms are country-specific, which is the reason why we have indexed them with both i and t. However, some of these terms may be common across countries.

[5]This can be illustrated through a very simple two-period model, in which the representative consumer's utility maximization problem is $max\ \ u(c_t) + \beta\mathbb{E}[u(c_{t+1})]$ subject to $c_t + \frac{c_{t+1}}{1+r_t} = w_t$ where c_t, w_t and r_t respectively stand for consumption, income and interest rate at time t. Using a CRRA utility function and proxying the consumption growth $\frac{c_{t+1}-c_t}{c_t}$ by the output growth rate g_t, one can find at the steady state the linearized relationship $r = \sigma g + \theta$ where σ is the relative risk aversion parameter of the CRRA utility function and θ is such that $\beta = \frac{1}{1+\theta}$.

- **Fiscal strength variables:** this category includes the public finance indicators aimed at capturing the solvency of every general government of our sample. These variables are the general government debt-to-GDP ratio and the general government budget balance as a percentage of GDP. These two variables are introduced into the regression with a 12-month lag for two reasons. First, this limits endogeneity problems and thus concerns about possible reverse causation between the current sovereign bond yields and fiscal indicators: a higher rate on the sovereign debt translates into a higher debt service, deteriorates the fiscal balance and thus may increase the general government debt in a contemporaneous fashion. Second, fiscal indicators related to a given year are known with a lag which may comprise several months: they are thus deemed to have an effect on sovereign market yields with a delay. We expect a positive relationship between the public debt-to-GDP ratio and our dependent variable as a higher debt increases credit risks and the yield required by investors to hold such a debt. Conversely, we expect a negative relationship between the general government fiscal balance ratio and the sovereign rate as a higher fiscal balance implies lower credit risks.

- **A risk aversion variable:** the series chosen for this category is the Chicago Board Options Exchange Volatility Index (VIX index), an indicator for worldwide risk aversion. The expected sign of the risk aversion indicator coefficient is ambiguous depending on the status of the sovereign debt perceived by the market: on the one hand, higher risk aversion may reduce the sovereign yield if sovereign debt benefits from safe haven flows and substitution effects from other financial assets; on the other hand, it may increase the sovereign yield if the sovereign debt of the country concerned is considered as a risky asset.

- **A safe haven effect variable:** we introduce the World Bank Government Effectiveness Index into the regression in order to partially capture "flight to quality" phenomena (see Kaufmann et al. (2010) for further details). We suppose that the quality of policy formulation and implementation, as well as the credibility of the government's commitment to such policies are particularly taken into account by investors during stress periods. As the value of the indicator is increasing with the government effectiveness, we expect a negative sign on the coefficient of the variable: the higher the government effectiveness, the safer the country is perceived by market participants, and the lower the yield required on the sovereign debt.

- **A liquidity variable:** we consider the Bid-Ask spread on the long-term sovereign bonds of every country of our sample, i.e. the liquidity variable that is the most widespread in the literature. We expect a positive relationship between the bid-ask spread and our dependent variable: the larger the bid-ask spread, the lower the liquidity of the security, and the higher the interest rate on the sovereign debt, since a liquidity premium is required.

- **A monetary policy variable:** we choose the 3-month LIBOR rate as a variable reflecting the monetary policy stance in each country of the sample[6]. The expected effect of this rate on the dependent variable, which is built as the difference between the 10-year government bond yield and the 10-year swap rate, is ambiguous, since it depends on the respective impact of monetary policy on the two terms.

The expected signs of all the coefficients are summed up in Table 3, Column 1.

[6]It has to be noted that the Libor rate may be affected by disruptions in the interbank market in some periods, such as in the period that followed Lehman Brothers' bankruptcy. In such periods, it may not reflect the monetary stance appropriately. That is why we replaced the Libor rate by the central bank's policy rate in an alternative specification as a robustness check (see below).

4.1.2 Results

The estimation results are displayed[7] in Table 3, Column 2. Overall, most of the coefficients have the expected signs, even though the general government debt-to-GDP ratio coefficient is not significant. Moreover, the results of the baseline specification show that the macroeconomic fundamentals (GDP growth and fiscal balance), the government effectiveness index, liquidity, the VIX index, and the LIBOR rate have the most significant effects on the spread between long-term government bond yields and the swap rate. More precisely, a 1-percentage point increase in the quarterly GDP growth rate is associated with a 6 basis-point tightening of the spread[8]; a 1-point-of-GDP increase in the budget balance, with a 5 basis-point tightening of the spread; a 1-basis point widening of the bid-ask spread, with a 10-bp widening of the rate spread; and a 1-point increase in the LIBOR rate, with a 6-bp narrowing of the spread. The negative coefficient on the World Bank Government Effectiveness Index demonstrates that the robustness of countries' institutions has a significant impact on the spread. The significant and positive VIX coefficient indicates that sovereign bonds may be perceived as risky assets since their yields on average increase during stress periods: when the VIX increases by 10 points, the spread widens by 5 bp. The significant and negative coefficient of the LIBOR rate shows that the 10-year swap rate is more impacted by monetary policy than the 10-year government bond yield. Finally, the IMF dummy is not significant and the coefficients of the other variables remain qualitatively unchanged when we run the regression without this dummy.

4.2 Main variants

As robustness checks, we present alternative specifications. As in the baseline case, monthly dummies are included in the regression as control variables but we do not display the coefficients obtained for these regressors. The expected signs for the coefficients on the different variables mentioned in this section are summed up in Table 3, Column 1.

Macroeconomic variables We consider a variant with a higher number of macroeconomic variables than in our baseline estimation. We replace GDP growth by two variables which are available at a higher frequency, namely the industrial production growth and the retail sales growth. They are respectively proxies for investment and consumption, two components of GDP, and can be expected to have a more immediate effect on general government bond yields than GDP growth. Moreover, we add a Business Confidence Index, a leading indicator which is carefully watched by market participants as it displays more forward-looking information than GDP growth. We expect a negative sign on the coefficient of this variable, which reflects the economic strength. We also introduce the inflation rate in the regression: as for monetary policy, the expected effect of the inflation rate on the dependent variable, which is built as the difference between the 10-year government bond yield and the 10-year swap rate, is ambiguous, since it depends on its respective impact on each of these two terms. Every macro variable is lagged by one period to avoid endogeneity problems. The results of this estimation are displayed in Table 3, Column 3. The coefficients on the Business Confidence Index, the industrial production growth and retail sales growth are negative as expected, even though only the retail sales growth is significant. The inflation rate coefficient is negative and not significant. The debt ratio becomes (weakly) significant while the Libor rate and VIX index no longer are. The results obtained for the other variables are qualitatively similar to those of the baseline.

[7] None of the monthly dummies is individually significant at the 10 percent level but a simple Fisher test shows that they are jointly significant. Therefore, we kept them in the regression as control variables but we do not display the coefficients obtained for these regressors. It should be noted that the results are virtually unchanged if we run the regression without these monthly dummy variables.

[8] It has to be recalled that the figure displayed in Table 3 is relative to a monthly GDP growth rate.

Fiscal Strength variables We consider the specification in which the sovereign rating replaces the general government debt-to-GDP ratio and the general government balance ratio as the only fiscal strength variable. We build a sovereign rating index as the average of numerical values of the ratings granted by the three major rating agencies (Standard and Poor's, Moody's and Fitch), using a scale in which low values are associated with good ratings (1 corresponding to an AAA rating, and 22 to default). Therefore, the coefficient on this variable is expected to be positive: the lower the numerical value associated to the rating (i.e. the better the rating), the lower the sovereign long-term bond yields. The variable is lagged by one period due to endogeneity concerns. Estimation results are displayed in Table 3, Column 4. The rating coefficient is extremely significant and has the expected sign: a one-notch downgrade by one of the 3 rating agencies is associated with a 11-bp widening of the spread. The results obtained for the other variables are very similar to those obtained in the baseline estimation, even though the bid-ask spread is a bit less significant than before.

Liquidity variables Theoretically, the potential effect of the size of public debt on sovereign yields is ambiguous. On the one hand, a large public debt level can be perceived by market participants as a fiscal vulnerability variable. On the other hand, investors looking for liquidity may favour the sovereign debts displaying a deep market: therefore, a large public debt can also be viewed positively by market participants. Up to now, we have not tried to capture this second effect: when introduced in the regression, the 12-month lagged general government debt-to-GDP ratio is associated with a positive coefficient and consequently, this regressor should be rather considered as a credit risk variable. However, this coefficient is not significant, which may indicate that this variable captures fiscal vulnerability and liquidity effects simultaneously. In order to distinguish these effects, we replace the Bid-Ask spread, our baseline liquidity variable, by the total amount of public debt, expressed in USD trillions, using a frozen exchange rate in order to neutralise exchange rate effects and with a 12-month lag to circumvent endogeneity problems. Consequently, the alternative specification that we consider includes two public debt variables among its regressors: the general government debt-to-GDP ratio as a fiscal vulnerability variable and the total amount of public debt (in USD trillions) as a liquidity variable. Multicollinearity problems are avoided through the different units in which these two variables are expressed. Estimation results are displayed in Table 3, Column 5. Interestingly, both the general government debt-to-GDP ratio and the total amount of public debt (in USD trillions) coefficients have the expected signs but none of them is significant, albeit close to the significance at the 10% level. The other coefficients remain qualitatively the same.

Risk Aversion variables We consider an alternative specification in which the VIX is replaced as the risk aversion variable by the national stock market volatility. We thus substitute a country-specific risk aversion measure for a global risk aversion indicator. Estimation results are displayed in Table 3, Column 6. This substitution changes virtually nothing to the results, which may suggest a high correlation between national stock market volatility levels and the US stock market implicit volatility.

Safe-Haven Effect variables We consider the specification in which the current account replaces the World Bank Government Effectiveness Index as the variable used to capture safe-haven phenomena. We expect a negative coefficient on this variable: a large current account surplus should be associated with low sovereign long-term bond yields since the public debt of a country in such a situation is regarded as a safe asset by market participants because it reflects an improvement in the country's external position and solvency. However, the results we obtain (not shown) are disappointing: the coefficient on the current account is positive but not significant, while the other coefficients are extremely similar to those of the baseline estimation. Therefore, the current account seems to be less reliable than the World Bank Government Effectiveness Index as a safe-haven effect variable.

Monetary Policy variables We successively use the overnight interbank rate and Central Banks' policy rates instead of the 3-month LIBOR as the monetary policy variable. The results we obtain (not shown) are very similar to our baseline estimate.

Overall, it can be noticed that the qualitative results of our baseline estimate are robust to changes in the regressors: therefore, the main conclusions we have drawn from our baseline estimation are confirmed.

5 Historic and geographic specificities

Up to now, we have followed a strict LSDV approach, in which the coefficients on the different regressors are not allowed to change through the period nor across the countries. This kind of reasoning is appropriate if one wishes to determine the average impact of the different variables on the spread between the 10-year sovereign bond yield and the swap rate, but we now want to consider specifications that are more adapted to take into account the specificities of some periods or geographic zones. Two strategies can be considered: we can either keep the same panel as before and allow for time-varying or area-varying coefficients, or restrain our sample to countries and periods we are particularly interested in.

5.1 A flexible LSDV approach

In this section, we consider estimates which allow for time-varying or area-varying coefficients. This kind of method allows us to keep the same sample as before and is therefore as general as the LSDV approach we used previously, but a bit more flexible. We consider three different types of specifications: the first one allows for time-varying coefficients, the second one allows for geographic area-specific coefficients and the third one takes into account both specificities.

5.1.1 Impact of the crisis

It can be noticed in Figures 1 to 3 that many countries experienced a radical change in the evolution of the spread between the 10-year sovereign bond yield and the swap rate in the second half of 2008. Therefore, we may suppose that the sensitivity of our dependent variable to the regressors has changed since the onset of the financial crisis. In order to take this phenomenon into account, we consider a specification that allows the coefficient on each variable to change as from September 2008[9]. More precisely, this specification can be written as:

$$\begin{aligned} r_{it} =& \mathbb{1}(t < sept2008)(\beta_1' X_{it-3}^{(m)} + \beta_2' X_{it-12}^{(fs)} + \beta_3' X_{it}^{(ra)} + \beta_4' X_{it}^{(sh)} + \beta_5' X_{it}^{(l)} + \beta_6' X_{it}^{(mp)}) \\ &+ \mathbb{1}(t \geq sept2008)(\beta_1'' X_{it-3}^{(m)} + \beta_2'' X_{it-12}^{(fs)} + \beta_3'' X_{it}^{(ra)} + \beta_4'' X_{it}^{(sh)} + \beta_5'' X_{it}^{(l)} + \beta_6'' X_{it}^{(mp)} + \alpha'') \\ &+ \alpha + \gamma_i + \delta_1 \mathbb{1}(IMF)_{it} + \delta_2 \mathbb{1}(month)_t + \varepsilon_{it} \end{aligned}$$

where $\mathbb{1}(t < sept2008)$ (resp. $\mathbb{1}(t \geq sept2008)$) is a time dummy equal to 1 before (resp. as from) September 2008 and 0 otherwise (see section 4.1 for further details on the notations). Our results are displayed in Table

[9] We have chosen this date because it corresponds to the bankruptcy of Lehman Brothers and approximately coincides with the beginning of the spread's widening for many countries of our panel. Choosing another month of the same period would lead to very similar results.

4[10]. Column 1 is a reminder of our baseline estimation's results, Column 2 and Column 3 respectively display the pre-Lehman and post-Lehman coefficients (i.e. respectively the β'_k and β''_k terms of the regression) while Column 4 contains the difference between the pre-Lehman and post-Lehman values of the coefficients[11]. Overall, we notice that the bursting of the crisis translates into a nearly 1.2-point widening of the spread between the 10-year sovereign bond yield and the swap rate. Moreover, the sensitivity of our dependent variable to the regressors has dramatically increased since September 2008. Before that date, only GDP growth, the government budget balance, the liquidity variable (the bid-ask spread) and the monetary rate variable (the Libor) have a noticeable impact on the spread, while the World Bank Government Effectiveness Index have become significant only after the onset of the crisis. The absolute value of the coefficient on government budget balance has also increased significantly. Overall, the sensitivity of the dependent variable to all the regressors displays a radical shift in September 2008, which is particularly spectacular for GDP growth, the government budget balance and the World Bank Government Effectiveness Index: this shows that investors have become more sensitive to credit quality indicators after the crisis and more prone to risk aversion.

5.1.2 A Eurozone specific process?

The recent Eurozone crisis may suggest that the spread between the 10-year sovereign bond yield and the swap rate follows a process that is different for European countries from the one observed for the other countries of the sample. In particular, Figures 1 to 3 show specific patterns for some euro area countries such as Greece, Ireland, Italy, Portugal or Spain. Therefore, we consider a specification that allows the coefficient on each variable to change depending on whether the country considered belongs to the Eurozone or not. More precisely, this specification can be written as:

$$\begin{aligned} r_{it} =& \mathbb{1}(i \in Eurozone)(\beta'_1 X^{(m)}_{it-3} + \beta'_2 X^{(fs)}_{it-12} + \beta'_3 X^{(ra)}_{it} + \beta'_4 X^{(sh)}_{it} + \beta'_5 X^{(l)}_{it} + \beta'_6 X^{(mp)}_{it}) \\ &+ \mathbb{1}(i \notin Eurozone)(\beta''_1 X^{(m)}_{it-3} + \beta''_2 X^{(fs)}_{it-12} + \beta''_3 X^{(ra)}_{it} + \beta''_4 X^{(sh)}_{it} + \beta''_5 X^{(l)}_{it} + \beta''_6 X^{(mp)}_{it}) \\ &+ \alpha + \gamma_i + \delta_1 \mathbb{1}(IMF)_{it} + \delta_2 \mathbb{1}(month)_t + \varepsilon_{it} \end{aligned}$$

where $\mathbb{1}(i \in Eurozone)$ (resp. $\mathbb{1}(i \notin Eurozone)$) is a dummy equal to 1 for countries that belong to (resp. do not belong to) the Eurozone and 0 otherwise (see section 4.1 for further details on the notations). Our results are displayed in Table 5: Column 1 is a reminder of our baseline estimation's results, Column 2 and Column 3 respectively display the non-Eurozone and Eurozone coefficients (i.e. respectively the β''_k and β'_k terms of the regression) while Column 4 contains the difference between the non-Eurozone and Eurozone values of the coefficients[12]. The result is striking: for non-Eurozone countries, three variables only are significant, namely GDP growth, the general government balance, and the monetary rate variable (the

[10] Once again, we do not display the coefficients on monthly dummies for the sake of clarity. The standard errors we compute are robust to heteroskedasticity and within-panel serial correlation. This will be the case for all the regressions undertaken in this part.

[11] We also display robust standard errors for Column 4 coefficients, which correspond to the β'''_k terms of the regression:

$$\begin{aligned} r_{it} =& \mathbb{1}(t \geq sept2008)(\beta'''_1 X^{(m)}_{it-3} + \beta'''_2 X^{(fs)}_{it-12} + \beta'''_3 X^{(ra)}_{it} + \beta'''_4 X^{(sh)}_{it} + \beta'''_5 X^{(l)}_{it} + \beta'''_6 X^{(mp)}_{it} + \alpha''') \\ &+ \beta'_1 X^{(m)}_{it-3} + \beta'_2 X^{(fs)}_{it-12} + \beta'_3 X^{(ra)}_{it} + \beta'_4 X^{(sh)}_{it} + \beta'_5 X^{(l)}_{it} + \beta'_6 X^{(mp)}_{it} + \alpha + \gamma_i + \delta_1 \mathbb{1}(IMF)_{it} + \delta_2 \mathbb{1}(month)_t + \varepsilon_{it} \end{aligned}$$

[12] We also display robust standard errors for Column 4 coefficients, which correspond to the β'''_k terms of the regression:

$$\begin{aligned} r_{it} =& \mathbb{1}(i \in Eurozone)(\beta'''_1 X^{(m)}_{it-3} + \beta'''_2 X^{(fs)}_{it-12} + \beta'''_3 X^{(ra)}_{it} + \beta'''_4 X^{(sh)}_{it} + \beta'''_5 X^{(l)}_{it} + \beta'''_6 X^{(mp)}_{it}) \\ &+ \beta''_1 X^{(m)}_{it-3} + \beta''_2 X^{(fs)}_{it-12} + \beta''_3 X^{(ra)}_{it} + \beta''_4 X^{(sh)}_{it} + \beta''_5 X^{(l)}_{it} + \beta''_6 X^{(mp)}_{it}) + \alpha + \gamma_i + \delta_1 \mathbb{1}(IMF)_{it} + \delta_2 \mathbb{1}(month)_t + \varepsilon_{it} \end{aligned}$$

Libor). When we turn to the euro area countries, the World Bank Government Effectiveness Index and the Bid-Ask Spread become highly significant and the significance of the general government balance variable increases markedly. Overall, the sensitivity of our dependent variable to the credit quality regressors is larger for Eurozone countries than in the case where all the countries are pooled together: this suggests that the sign and significance of the coefficients in our baseline estimation are mainly driven by the behaviour of the spread between the 10-year sovereign bond yield and the swap rate for Eurozone countries.

5.1.3 Taking both geographic and time specificities into account

We would like to further explore the approach that we have adopted in this section, crossing both our time-varying and area-varying methodologies. In order to do so, we consider the following specification (see above for further details on the notations):

$$\begin{aligned}
r_{it} =& \mathbb{1}(t < sept2008).\mathbb{1}(i \notin Eurozone)(\beta_1' X_{it-3}^{(m)} + \beta_2' X_{it-12}^{(fs)} + \beta_3' X_{it}^{(ra)} + \beta_4' X_{it}^{(sh)} + \beta_5' X_{it}^{(l)} + \beta_6' X_{it}^{(mp)}) \\
&+ \mathbb{1}(t < sept2008).\mathbb{1}(i \in Eurozone)(\beta_1'' X_{it-3}^{(m)} + \beta_2'' X_{it-12}^{(fs)} + \beta_3'' X_{it}^{(ra)} + \beta_4'' X_{it}^{(sh)} + \beta_5'' X_{it}^{(l)} + \beta_6'' X_{it}^{(mp)}) \\
&+ \mathbb{1}(t \geq sept2008).\mathbb{1}(i \notin Eurozone)(\beta_1''' X_{it-3}^{(m)} + \beta_2''' X_{it-12}^{(fs)} + \beta_3''' X_{it}^{(ra)} + \beta_4''' X_{it}^{(sh)} + \beta_5''' X_{it}^{(l)} + \beta_6''' X_{it}^{(mp)} + \alpha''') \\
&+ \mathbb{1}(t \geq sept2008).\mathbb{1}(i \in Eurozone)(\beta_1'''' X_{it-3}^{(m)} + \beta_2'''' X_{it-12}^{(fs)} + \beta_3'''' X_{it}^{(ra)} + \beta_4'''' X_{it}^{(sh)} + \beta_5'''' X_{it}^{(l)} + \beta_6'''' X_{it}^{(mp)} + \alpha'''') \\
&+ \alpha + \gamma_i + \delta_1 \mathbb{1}(IMF)_{it} + \delta_2 \mathbb{1}(month)_t + \varepsilon_{it}
\end{aligned}$$

Our results are displayed in Table 6: Column 1 is a reminder of our baseline estimation's results, Columns 2, 3, 4 and 5 respectively display pre-Lehman coefficients in non-Eurozone countries, pre-Lehman coefficients in Eurozone countries, post-Lehman coefficients in non-Eurozone countries and post-Lehman coefficients in Eurozone countries (i.e. respectively the β_k', β_k'', β_k''' and β_k'''' terms of the regression). This estimate allows us to operate a fine analysis of the variables' impact on the spread between the 10-year sovereign bond yield and the swap rate. Before the crisis, our regressors have almost no noticeable impact on the dependent variable, which is mainly driven by monetary rates. As from the onset of the crisis, credit quality variables such as the government budget balance and the World Bank Government Effectiveness Index, and GDP growth have become significant for both kinds of countries, while our liquidity variable (the Bid-Ask spread) significantly affects the dependent variable for Eurozone countries only. Conversely, the Libor rate has a significant and negative effect on the spread for non-euro area countries after the onset of the crisis while it is insignificant for euro area countries. The coefficient on the VIX is significant too, but it does not have the same sign for both categories of countries: it is positive for non-Euro area countries, whose debt may be regarded as risky assets in the post-Lehman environment, whereas it is negative for Eurozone countries, which is a surprising result that has to be further investigated. In fact, it has to be noticed that Eurozone spreads between the 10-year sovereign bond yield and the swap rate experienced an average 2.5-point widening during the whole post-Lehman era. However, this period could be schematically divided into two parts. The first one (2008-2009) saw a skyrocketing increase in the VIX index, while the Eurozone spreads experienced very moderate movements. On the other hand, the second part (2010-2013) of the post-Lehman period corresponds to relatively lower levels of VIX and a large widening of the spread between the 10-year sovereign bond yield and the swap rate for so-called peripheral European countries. This phenomenon may explain the combination of a negative correlation that we find between the VIX index and the relative level of Eurozone spreads and the average 2.5-point premium that we measure for the whole post-Lehman era.

In conclusion, our regressors have the strongest explanatory power for Eurozone countries after September 2008. The high value and significance we find for all the coefficients suggest that our baseline estimation is mainly driven by the points that belong both to this geographic area and this period.

5.2 Restrained samples

In this section, we use samples that are tighter from the geographic or the historic point of view than those we have used so far. This strategy has several advantages. First, we can focus on phenomena whose impact is limited in time and space. Second, it allows us to study variables that cannot be used when the full sample is considered, either because the data are incomplete or because these regressors are supposed to affect our dependent variable only for some countries and during some periods.

5.2.1 Taking unconventional monetary policies into account

One of the main features of the post-Lehman environment is the implementation of unconventional monetary policies by the main central banks worldwide. The Federal Reserve and the Bank of England respectively launched their first quantitative easing programmes in December 2008 and March 2009, while the ECB announced its long term refinancing operations in December 2011 and February 2012. All these decisions translated into spectacular expansions of the size of central banks' balance sheets. None of the variables we have used up to now allows us to capture the potential impact that these unconventional monetary policies may have had on the spreads between the 10-year sovereign bond yield and the swap rate.

In order to estimate this effect, we consider a sample of observations that begins in October 2008 and that includes all the countries of our sample. We add the size of the central bank's balance sheet, expressed as a percentage of GDP, to our baseline specification. Moreover, we take the specificities of the Eurozone's structure into account: unlike conventional monetary policy tools, we suppose that the expansion of the size of ECB's balance sheet due to the LTROs may have had different effects on the spread between the 10-year sovereign bond yield and the swap rate for the different countries of the Euro Area. Therefore, we allow the coefficient on the central bank's balance sheet to vary across Eurozone countries, while only one value is allowed for non-Eurozone countries, in which unconventional monetary policies are supposed to have the same impact on the spread between the 10-year sovereign bond yield and the swap rate. The results of our estimation are displayed in Table 7: Column 1 displays the coefficients we get when our baseline specification is applied to the restrained sample, while Column 2 displays the results obtained with the specification that includes the size of the central bank's balance sheet[13].

We find that unconventional monetary policies have had a significant effect on the spread between the 10-year sovereign bond yield and the swap rate. On the one hand, a 1-GDP-percentage-point expansion of the central bank's balance sheet has been in average associated with a 1.2-basis-point tightening of the spread for non-euro area countries. On the other hand, the coefficients on ECB's balance sheet vary a lot across Eurozone countries, which explains why the effect of this variable is insignificant at the level of the euro area as a whole: the ECB's balance sheet size does not have a significant effect for 5 countries considered as "core countries" (Austria, Finland, France, Germany, the Netherlands), plus Portugal; it has a significant and negative effect as expected for one country only (Ireland) and a significant but unexpectedly positive effect for 4 countries (Belgium, Greece, Italy, and Spain). Therefore, our intuition that ECB's LTROs have had very different effects on the spread between the 10-year sovereign bond yield and the swap rate for the different countries of the Euro Area is confirmed. Eventually, it has to be noticed that a credit quality variable (the government effectiveness index), the VIX index and the Libor rate are no longer significant during this period.

[13]For the sake of clarity, we do not display the country-specific coefficients on the size of ECB's balance sheet in Table 7, but they are shown in Annex B.

5.2.2 Flight-to-quality phenomena in Europe

We now want to further investigate the phenomena that have taken place in Europe since the beginning of the crisis. In order to do so, we consider a sample of observations that starts in October 2008 and that includes only the eleven Eurozone countries of our sample[14]. The coefficients we obtain when we apply the specification that includes the size of the ECB's balance sheet to this restrained sample are displayed in Table 7, Column 3. It has to be noticed that the World Bank Government Effectiveness Index is not significant. Said differently, applying the specification to the restrained sample does not allow us to correctly capture flight-to-quality phenomena and safe-haven flows that have occurred in Europe since the outburst of the crisis. However, the R^2 increases markedly in this specification, which confirms that our model has a higher explanatory power for a sample restrained to euro area countries.

In order to appropriately capture flight-to-quality phenomena in the euro area, we replace the World Bank Government Effectiveness Index by TARGET2 balances of the different countries of the Eurozone, expressed as percentages of each country GDP. TARGET2 balance of a country corresponds to the net creditor position of the central bank of this country *vis-à-vis* the central banks of the other countries of the Eurosystem. Consequently, the TARGET2 system can be taken as a "shadow" foreign exchange market within the Eurozone and TARGET2 balances may therefore be considered as a flight-to-quality indicator, in particular in the recent period, potentially capturing the concerns that arose on a possible euro area break-up (the so-called "redenomination risk"). Moreover, it can be considered as a banking sector vulnerability variable, allowing us to capture the negative feedback loop between banking and sovereign risks that was observed during the crisis[15]. The results obtained with this new specification are displayed in Table 7, Column 4. We find a significantly negative coefficient on the TARGET2 variable: more precisely, a 1-GDP-percentage point increase in the TARGET2 balance of a country leads to a 4-basis-point tightening of the spread between the 10-year sovereign bond yield and the swap rate. Therefore, the TARGET2 balance appears as a more performing "flight-to-quality variable" than the World Bank Government Effectiveness Index when we restrain our estimation to the recent period in the Eurozone.

6 Dynamic analysis

6.1 Autoregressive specification

We now want to introduce some dynamics in the model. In order to do so, we introduce an AR(1) term in equation (1), which consequently becomes:

$$\begin{aligned} r_{it} = \alpha + \gamma_i + \rho r_{it-1} + \beta_1 X^{(m)}_{it-3} + \beta_2 X^{(fs)}_{it-12} + \beta_3 X^{(ra)}_{it} + \beta_4 X^{(sh)}_{it} + \beta_5 X^{(l)}_{it} + \beta_6 X^{(mp)}_{it} \\ + \delta_1 \mathbb{1}(IMF)_{it} + \delta_2 \mathbb{1}(month)_t + \varepsilon_{it} \end{aligned} \quad (2)$$

where subscripts i and t respectively denote country i and time t (see section 4.1 for further details on the notations). This type of equation is widespread in the literature (see, among others, Halleberg and Wolff

[14] Namely Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain.

[15] Alternatively, we tried to capture this negative feedback loop between banking and sovereign risks by estimating an instrumental variable model in which we introduced the volatility of MSCI indices for national financial institutions as an explanatory variable of the spread between 10-year sovereign rates and the swap rates. We chose the non-performing loan rate and banks' asset returns as instruments: however, the model did not provide satisfactory results.

(2008), Attinasi et al. (2009), Afonso et al. (2012) and Giordano et al. (2013)). We estimate with the LSDV model[16] the specification in which the $X_{it}^{(\ )}$ variables are the same as in the baseline case.

The results of this estimation[17] present two main features. First, the introduction of the AR(1) term is associated with a spectacular decrease in the significance of all the other explanatory variables. Second, the ρ coefficient is highly significant and its value is not significantly different from 1 at the 5%-level. This high persistence of the sovereign long-term bond yield spread raises the legitimate question of the possible non-stationarity of the series. The next section is devoted to this issue.

6.2 Stationarity concerns and long-run relationship estimation

6.2.1 Testing for unit roots

We now want to address possible stationarity concerns that may be linked to the existence of long-term relationships between our variables. To that end, we perform panel unit-root tests on our sovereign long-term bond yield spreads, but also on the other variables that we use in our baseline estimation. We perform panel unit-root tests on our sovereign long-term bond yield spreads, but also on the other variables that we use in our baseline estimation. We consider two different types of panel unit-root tests: a Levin, Lin and Chu (LLC) test and a Fisher-type ADF test[18].

Overall, the results are not clear-cut. Not only are the results of both tests sometimes different, but they also depend on the number of lags and the exogenous regressors that we include in the test specification (see Annex C for further details). Moreover, the unit-root tests may be disrupted by the fact that some of the series we use have an initial frequency lower than monthly. Consequently, we cannot strictly conclude that the data are non-stationary, but we cannot rule out this possibility either. We now present the consequences of the potential non stationarity of the series on the results we presented in part 4.

6.2.2 Estimation under non-stationarity

As recalled in Giordano et al. (2013), the issues raised by non-stationarity in panel data, although different from those of the pure time series case, dramatically depend on the existence of a cointegration relationship between the dependent and explanatory variables. Therefore, we have to perform a cointegration test on the data: if the test allows us to conclude that there is no cointegration relationship between the dependent and explanatory variables, we can rely on the results presented in part 4, while a DOLS estimator *à la* Stock and Watson (1993) has to be estimated in the opposite situation. The results of the Kao test we use are not clear cut and highly depend on the number of lags that we include in the ADF equation aiming at testing for stationarity of the residuals (see Annex D for further details). Therefore, the test does not allow us to conclude either that there is non-cointegration nor cointegration.

[16] Since Nickell (1981), it is well known that the LSDV estimator is biased when used in dynamic panels. Nevertheless, this bias tends to 0 as T tends to infinity. Using Monte-Carlo simulations, Judson and Owen (1999) show that LSDV remains one of the best estimators in terms of Root Mean Square Errors for panels in which T is large with respect to N. Since this is precisely the case of our sample, we still use the LSDV method to estimate the dynamic version of our empirical model.

[17] For the sake of parsimony, results are not displayed. However, they are available on request.

[18] These two tests assume under the null hypothesis that each cross-section data follow a unit-root process. Under the alternative, however, the LLC test assumes that the persistence parameters are common across cross-sections, while the Fisher-ADF test allows the persistence parameters to vary freely across cross-sections (see Annex C for further details).

Consequently, we have to bring the results of LSDV and DOLS estimators face to face. We perform a DOLS estimation[19] with the same explanatory variables as in our baseline LSDV estimate. The results[20] are qualitatively similar to those obtained with the LSDV method: in particular, the coefficients have the same sign and order of magnitude. Overall, this new estimation does not modify the general conclusions brought by our previous results.

6.3 An error correction model

Up to now, we have studied the impact of the potential non-stationarity of the data on our first results. In this last section, this potential unstationarity is not seen anymore as a disturbance: quite the opposite, we try to take advantage of it, by considering an error correction model[21]. This kind of models gives the possibility to distinguish short-run determinants of the spread between the 10-year sovereign bond yield and the swap rate from long-term factors. More specifically, we follow Poghosyan (2012) and consider the pooled mean group (PMG) estimator of Pesaran et al. (1999), which is a panel data version of the error-correction model.

The PMG estimator has several advantages for the purpose of our analysis. First, it allows differentiating between long-run and short-run determinants of the spread between the 10-year sovereign bond yield and the swap rate. Second, the PMG estimator pools coefficients on long-run factors: indeed, the relationship between the spread and its long-term determinants should not vary from country to country. However, unlike the LSDV estimator, it is flexible enough to allow country-specific variations in short-run coefficients. This in turn allows a differentiated response to changes in short-term factors depending on country-specific characteristics. Finally, the PMG specification can be tested against a more flexible mean-group (MG) estimator that enables both long-term and short-term coefficients to vary across countries using a Hausman test.

We consider a parsimonious PMG specification in which only two variables are considered as long-term determinants, namely the annual potential GDP growth, and the debt-to-GDP ratio lagged by twelve periods[22]. Moreover, we retain the following short-term factors: the (actual) GDP growth lagged by three periods, the debt-to-GDP ratio and the general government budget balance both lagged by twelve periods, the World Bank Government Effectiveness Index, the VIX index, the Bid-Ask spread, the 3-month LIBOR rate, and the IMF dummy, i.e. exactly the same variables as in our baseline LSDV specification. Finally, the empirical specification we consider takes the following classical ECM form:

$$\Delta r_{it} = \phi_i(r_{it-1} - \beta^{LR} LR_{it-1}) + \beta_i^{SR} \Delta SR_{it} + \varepsilon_{it} \tag{3}$$

where the dependent variable Δr_{it} is the change in the spread between the 10-year sovereign bond yield and the swap rate, while LR_{it-1} and ΔSR_{it} respectively are the long-term determinants (namely the annual potential GDP growth and the debt-to-GDP ratio) and the change in the short run factors (listed above). It has to be noticed that the long-term relationship (between brackets) does not vary across countries, while the coefficients on short-term determinants β_i^{SR} and the speed of adjustment to the long-term equilibrium

[19]We estimate the DOLS equation with $p = 2$, where p is the number of leads and lags used in the equation (see Annex D for further details on the notation), but the results do not vary much when another value of p is used.

[20]For the sake of parsimony, results are not displayed. However, they are available on request.

[21]However, one has to keep in mind that the results presented in this section must be very cautiously interpreted, as neither the stationarity nor the cointegration tests that we have led are clear-cut.

[22]It could be argued that the general government budget balance should also be regarded as a long-term factor. However, this would raise multicollinearity concerns, since the first difference of the debt-to-GDP ratio, which is one of the short-term factors we consider (see below in the text), also appears in the specification.

ϕ_i depend on the country that is considered; this is an important property of the PMG estimator that we have already mentioned.

The results are presented in Table 8. Both long-term determinants are highly significant and have the expected sign. The significance of the debt-to-GDP ratio is a noticeable difference with the results of our baseline LSDV estimator. Moreover, the respective impacts of our two long-term determinants on the spread between the 10-year sovereign bond yield and the swap rate do not have the same magnitude: while an increase in the debt-to-GDP ratio is associated with quite a small (but significant) widening in the spread (a 10-point increase in the debt-to-GDP ratio is associated with a 7-bp widening of the spread), the annual potential GDP growth seems to play a larger role since a 1-point increase in the annual potential GDP growth is associated with a 10-bp tightening of the spread[23]. Regarding the short-term factors[24], the variables that seem to have the largest effect on average are GDP growth, the debt-to-GDP ratio (the coefficients on both variables have the same sign as their long-run counterparts) and the LIBOR rate. Interestingly, the debt-to-GDP ratio seems to have an impact on the spread between the 10-year sovereign bond yield and the swap rate that is higher in the short run than in the long run. Moreover, it is worth noting that the speed of adjustment, although quite small (7% of the distance to long-term equilibrium is automatically reduced within a month), is significant and has the expected negative sign. Furthermore, none of the 22 country-specific speeds of adjustment (not shown but available on request) is significantly positive, which tends to strengthen the error correction hypothesis. Finally, the poolability of coefficients on long-term factors is not rejected by the Hausman test, supporting the use of the PMG estimator.

In conclusion, several elements of our results tend to support the ECM model that we use. We find that potential output growth and debt-to-GDP ratio both have a significant effect on the spread between the 10-year sovereign bond yield and the swap rate in the long run: while the impact of debt-to-GDP ratio remains modest, the potential output growth seems to play a larger role.

7 Safe havens, purgatory, and the damned

Figure 4 shows the difference between the spread between our dependent variable observed in July 2012, at the peak of the euro area debt crisis, for the same sample of countries as the ones presented in Charts 1-3 and the spreads estimated by three of our models: LSDV baseline, time- and area-flexible estimator, and PMG. Therefore, Figure 4 displays the part of the spreads that our models does not capture or, said differently, the residuals of the equations. For six countries (Germany, Greece, Italy, Portugal, Spain, and the UK), the signs of these residuals are the same in the three cases: this shows that all the models give the same diagnostic, albeit the order of magnitude of the residuals can vary. Overall, the graph shows three different groups of countries in July 2012: first, Ireland, Germany, Japan, the UK and the US, for which the observed spread is below the estimated spread (except for Ireland with the PMG estimator); second, France, for which observed and estimated spreads are close to each other; and third, Portugal, Spain, Italy, and Greece, for which the observed spread is significantly above the estimated spread (by 97 to 718 bp with the baseline LSDV estimator). However, for Greece, the estimated spread ends in June 2011 since the Greek statistics office has no longer published quarterly seasonally-adjusted GDP series since March 2011. It has to be noted that the differences between the LSDV estimator results and the time and area flexible

[23] It has to be noticed that our results differ a bit from those of Poghosyan (2012) both in terms of signs and magnitude of the coefficients. First, Poghosyan found a positive sign on the coefficient of potential growth. Second, Pogosyan found higher coefficients on both potential growth (0.65) and the debt-to-GDP ratio (0.01). However, it should be kept in mind that the two papers do not have the same dependent variables as Poghosyan estimates real long-term sovereign yields.

[24] Once again, the coefficients on short-term factors as well as the speed of adjustment vary across countries. Therefore, the coefficients that are displayed in Table 8 for each one of these terms are averages of the country-specific coefficients.

estimator results are moderate, whereas the PMG estimator provides quite large differences for the euro area peripheral countries, for which the actual spreads are found to be much higher than the estimated spreads with the PMG estimator. However, the different models can be viewed as complementary: while the LSDV and the flexible estimators provide estimates based on short-term determinants, the PMG estimator results show that given long-term determinants, current spreads are notably excessive in some euro area countries and should converge towards their long-term value.

8 Conclusion

In this paper, we estimated the determinants of the spreads between 10-year sovereign rates and the interest rate swap rate for a sample of 22 OECD countries over the January 1999-December 2013 period, using various models. Our main, fixed-effect, model highlights the crucial role of GDP growth, public deficit, and debt liquidity in explaining the level of spreads, while the public debt-to-GDP ratio plays a lesser role. We find that our result are mainly driven by observations on euro area countries after the onset of the 2008 crisis, with observed spreads found to significantly exceed estimated values during the crisis for a number of euro area countries. We also shed light on the effect of unconventional monetary policies outside the Eurozone, while Target 2 balances are used for euro area countries in order to reflect concerns on the stability of the euro area. Finally, according to our cointegration model, we find a long-term relationship between the spread, the debt-to-GDP ratio, and potential GDP growth, with a larger impact of the latter variable.

An important contribution of our paper results from the comparisons between the estimates of different models and the introduction of crisis-specific variables. In our opinion, our results make the case for a form of insurance between countries within a currency union in order to avoid unjustified and excessive risk premia in stress times, in the form of Eurobonds. This option seems to have a potentially higher impact on sovereign yields than unconventional monetary policies which had a differentiated effect on euro area countries during the crisis.

Further ways of research lie in better capturing the negative feedback loop between sovereign and banking risks that represented a major feature of the financial crisis that erupted in 2008. Such an interaction might be accounted for by a structural VAR model. We leave this question for a future paper.

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Tables and Figures

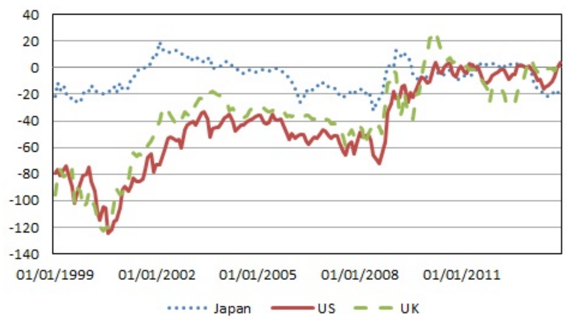

Figure 1: Non euro-area countries: Spread between the 10-year government bond rate and the swap rate (in bp).

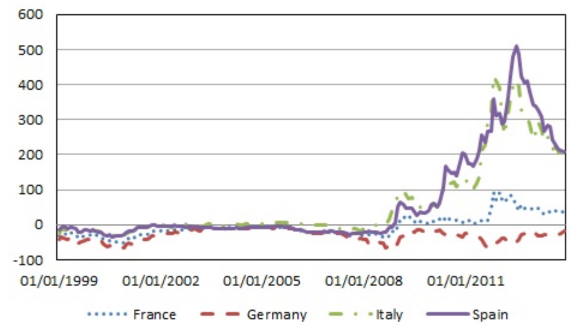

Figure 2: Euro-area non-programme countries: Spread between the 10-year government bond rate and the swap rate (in bp).

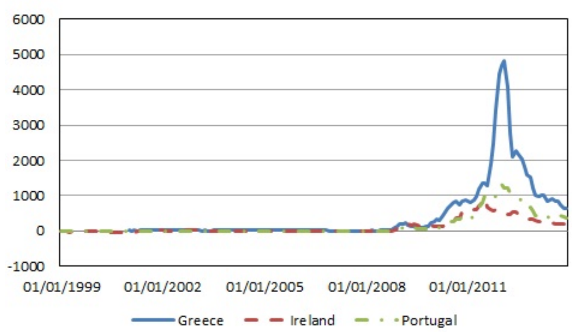

Figure 3: Euro-area programme countries: Spread between the 10-year government bond rate and the swap rate (in bp).

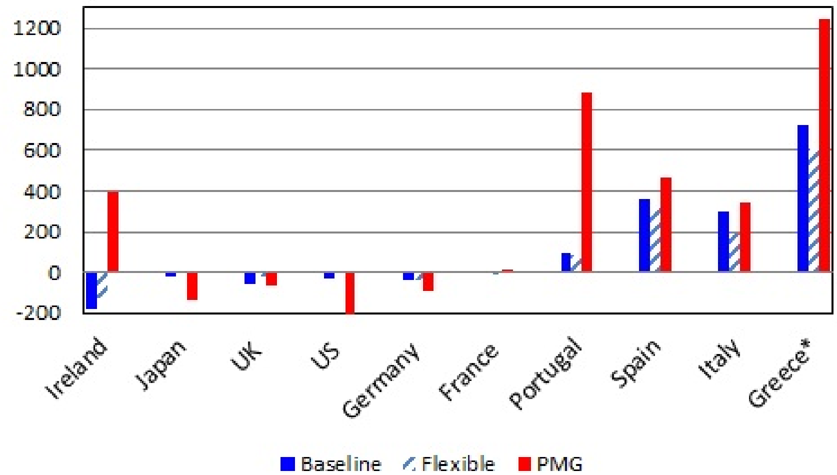

Figure 4: Difference between observed and estimated spreads, in bp (July 2012 except Greece, June 2011)

Table 1: Descriptive statistics on the spread between the 10-year sovereign bond yields and the swap rate for our sample of countries (in percentage points)

	Whole period	Jan 99 - Aug 08	Sep 08 - Dec 13
Mean	0.22	-0.22	1.01
Max.	48.27	3.59	48.27
Min.	-1.52	-1.24	-1.52
Standard dev.	2.30	0.35	3.67
Obs.	3,919	2,511	1,408

Table 2: List and sources of variables used in our model

Variables	Source	Frequency conversion
Dependent variable		
10-year generic fair-value government bond yield	Bloomberg	Monthly average of daily values
10-year interest rate swap rate	Bloomberg	Monthly average of daily values
Fiscal variables		
Government Effectiveness Index	World Bank	Linear interpolation from an annual to a monthly frequency
General government balance as a percentage of GDP	IMF	Annual value applied to each month of a given year
General government debt as a percentage of GDP	IMF	Linear interpolation from an annual to a monthly frequency
General government debt in USD	IMF	Converted from national currency into USD using a frozen exchange rate on 31/12/1998 Linear interpolation from an annual to a monthly frequency
Sovereign rating Index	Rating agencies	Monthly frequency
Macroeconomic variables		
Real GDP Growth	National statistics offices	Converted from a quarterly to a monthly frequency using a cubic root
Inflation rate	National statistics offices	Monthly frequency
Industrial Production Growth	National statistics offices	Monthly frequency
Retail Sales Growth	National statistics offices	Monthly frequency
Business sentiment	National statistics offices/ European Commission	Monthly frequency
Potential GDP Growth	OECD	Converted from an annual to a monthly frequency using a 12th root
Current account balance as a percentage of GDP	OECD	Quarterly value applied to each month of a given quarter
Financial variables		
VIX Index	Bloomberg	Monthly average of daily values
Historical volatility of national stock market indices	Bloomberg	Average of the standard deviations of national stock market indices on a one-month rolling window as a percentage of the value of the index
Bid-Ask spread on the 10-year in percentage points generic government bond yields	Bloomberg	Monthly average of daily values on a 6-month rolling window
Central bank's policy rate	Bloomberg	Monthly average of daily values
Overnight interbank rate	Bloomberg	Monthly average of daily values
3-month interbank rate	Bloomberg	Monthly average of daily values
Size of the Central Bank's Balance Sheet as a percentage of GDP	Bloomberg	Monthly average of daily values
Central banks' net claims within the Target 2 System as a percentage of GDP	Bloomberg	Monthly frequency

Table 3: Regression results (static analysis)

	(1) Expected Signs	(2) Baseline	(3) Macro	(4) Fiscal	(5) Liquidity	(6) Risk
Macroeconomic Variables						
GDP Growth	-	-0.170** (0.084)		-0.134* (0.074)	-0.218*** (0.081)	-0.154** (0.074)
Business Confidence	-		-0.097 (0.059)			
Inflation Rate	?		-0.004 (0.030)			
Industrial Production Growth	-		-0.005 (0.004)			
Retail Sales Growth	-		-0.015** (0.006)			
Fiscal Strength Variables						
General Govt Debt-to-GDP Ratio	+	0.005 (0.004)	0.013* (0.007)		0.013 (0.009)	0.004 (0.004)
Govt Budget Balance	-	-0.052*** (0.016)	-0.061* (0.032)		-0.068*** (0.024)	-0.053*** (0.015)
Sovereign Rating	+			0.334*** (0.065)		
Safe Haven Effect Variable						
Government Effectiveness	-	-0.747*** (0.217)	-0.796** (0.341)	-0.611*** (0.204)	-1.236*** (0.351)	-0.694*** (0.202)
Risk Aversion Variables						
VIX	?	0.005** (0.002)	0.004 (0.003)	0.006** (0.002)	0.005** (0.002)	
Stock Market Volatility	?					0.064*** (0.017)
Liquidity Variables						
Bid-Ask Spread	+	9.974*** (2.261)	9.879*** (0.625)	7.236*** (2.343)		9.967*** (2.239)
Total Amount of Public Debt (trillion USD)	-				-0.120 (0.078)	
Monetary Policy Variable						
LIBOR	?	-0.062*** (0.024)	-0.023 (0.043)	-0.108*** (0.021)	-0.015 (0.031)	-0.067*** (0.023)
Dummy IMF	?	1.655 (1.117)	2.628 (1.865)	0.993 (0.791)	3.221* (1.598)	1.663 (1.104)
Observations		3,797	3,045	3,743	3,889	3,797
R^2		0.77	0.88	0.81	0.65	0.77

*Note: LSDV estimates. Monthly dummies are included in the regression but we do not display the coefficients for these regressors. Standard errors robust to heteroskedasticty and within panel serial correlation in parentheses. The asterisks ***,** and * indicate significance at the 1%, 5% and 10% level respectively.*

Table 4: Regression results (time specificities)

	(1) Baseline	(2) Pre-Lehman	(3) Post-Lehman	(4) Difference
Macroeconomic Variable				
GDP Growth	-0.170**	0.077**	-0.302**	-0.379***
	(0.084)	(0.036)	(0.117)	(0.124)
Fiscal Strength Variables				
General Govt Debt-to-GDP Ratio	0.005	-0.003	-0.002	0.001
	(0.004)	(0.005)	(0.005)	(0.003)
Govt Budget Balance	-0.052***	-0.038**	-0.072***	-0.033***
	(0.016)	(0.015)	(0.015)	(0.011)
Safe Haven Effect Variable				
Government Effectiveness	-0.747***	-0.347	-1.412***	-1.064***
	(0.217)	(0.254)	(0.259)	(0.220)
Risk Aversion Variable				
VIX	0.005**	-0.000	0.008	0.008
	(0.002)	(0.002)	(0.006)	(0.007)
Liquidity Variable				
Bid-Ask Spread	9.974***	15.405**	10.287***	-5.118
	(2.261)	(6.370)	(2.139)	(7.890)
Monetary Policy Variable				
LIBOR	-0.062***	-0.081***	-0.151**	-0.070
	(0.024)	(0.019)	(0.059)	(0.061)
Dummy Crisis			1.542**	
			(0.630)	
Dummy IMF	1.655		1.283	
	(1.117)		(1.089)	
Observations	3,797		3,797	
R^2	0.77		0.82	

*Note: LSDV estimates. Columns 2 and 3 coefficients come from the same regression. Column 4 displays the difference between Column 2 and Column 3 coefficients. See section 5.1.1 for further detail. Monthly dummies are included in the regressions but we do not display the coefficients for these regressors. Standard errors robust to heteroskedasticty and within panel serial correlation in parentheses. The asterisks ***,** and * indicate significance at the 1%, 5% and 10% level respectively.*

Table 5: Regression results (geographic specificities)

	(1) Baseline	(2) non-Eurozone	(3) Eurozone	(4) Difference
Macroeconomic Variable				
GDP Growth	-0.170**	-0.072**	-0.345**	-0.274
	(0.084)	(0.034)	(0.158)	(0.162)
Fiscal Strength Variables				
General Govt Debt-to-GDP Ratio	0.005	0.002	-0.001	-0.003
	(0.004)	(0.002)	(0.014)	(0.014)
Govt Budget Balance	-0.052***	-0.017*	-0.064***	-0.046*
	(0.016)	(0.008)	(0.022)	(0.023)
Safe Haven Effect Variable				
Government Effectiveness	-0.747**	0.205	-0.781***	-0.986***
	(0.217)	(0.215)	(0.222)	(0.310)
Risk Aversion Variable				
VIX	0.005**	0.004	0.006	0.002
	(0.002)	(0.003)	(0.004)	(0.004)
Liquidity Variable				
Bid-Ask Spread	9.974***	-1.463	8.131**	9.593*
	(2.261)	(3.587)	(3.111)	(4.750)
Monetary Policy Variable				
LIBOR	-0.062***	-0.057***	-0.143***	-0.087
	(0.024)	(0.017)	(0.054)	(0.056)
Dummy IMF	1.655	-2.618		
	(1.117)	(1.882)		
Observations	3,797		3,797	
R^2	0.77		0.81	

*Note: LSDV estimates. Columns 2 and 3 coefficients come from the same regression. Column 4 displays the difference between Column 2 and Column 3 coefficients. See section 5.1.2 for further detail. Monthly dummies are included in the regressions but we do not display the coefficients for these regressors. Standard errors robust to heteroskedasticty and within panel serial correlation in parentheses. The asterisks ***,** and * indicate significance at the 1%, 5% and 10% level respectively.*

Table 6: Regression results (time and geographic specificities)

	(1) Baseline	(2) pre-Lehman non-Eurozone	(3) pre-Lehman Eurozone	(4) post-Lehman non-Eurozone	(5) post-Lehman Eurozone
Macroeconomic Variable					
GDP Growth	-0.170**	0.011	-0.024	-0.061*	-0.556**
	(0.084)	(0.068)	(0.079)	(0.034)	(0.238)
Fiscal Strength Variables					
General Govt Debt-to-GDP Ratio	0.005	-0.001	-0.014	-0.003**	-0.017
	(0.004)	(0.001)	(0.012)	(0.001)	(0.020)
Govt Budget Balance	-0.052***	-0.007	-0.006	-0.021***	-0.094***
	(0.016)	(0.008)	(0.035)	(0.004)	(0.022)
Safe Haven Effect Variable					
Government Effectiveness	-0.747***	0.075	0.300	-0.679***	-1.102***
	(0.217)	(0.170)	(0.264)	(0.220)	(0.353)
Risk Aversion Variable					
VIX	0.005**	-0.004	0.002	0.009***	-0.023**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.010)
Liquidity Variable					
Bid-Ask Spread	9.974***	3.698*	0.617	-3.195	8.256***
	(2.261)	(1.988)	(6.818)	(2.220)	(2.274)
Monetary Policy Variable					
LIBOR	-0.062***	-0.065***	-0.056**	-0.108***	-0.006
	(0.024)	(0.012)	(0.022)	(0.019)	(0.056)
Dummy Crisis				1.250***	3.099*
				(0.334)	(1.725)
Dummy IMF	1.655	-0.221*			
	(1.117)	(0.117)			
Observations	3,797	3,797			
R^2	0.77	0.88			

*Note: LSDV estimates. Columns 2, 3, 4 and 5 coefficients come from the same regression. See section 5.1.3 for further detail. Monthly dummies are included in the regressions but we do not display the coefficients for these regressors. Standard errors robust to heteroskedasticty and within panel serial correlation in parentheses. The asterisks ***,** and * indicate significance at the 1%, 5% and 10% level respectively.*

Table 7: Regression results (restrained samples)

	(1)	(2)	(3)	(4)
Macroeconomic Variable				
GDP Growth	-0.248**	-0.164***	-0.321***	-0.244***
	(0.101)	(0.057)	(0.103)	(0.055)
Fiscal Strength Variables				
General Govt Debt-to-GDP Ratio	0.003	0.006	-0.007	-0.006
	(0.016)	(0.009)	(0.020)	(0.015)
Govt Budget Balance	-0.075***	-0.036**	-0.038*	0.013
	(0.019)	(0.017)	(0.021)	(0.027)
Safe Haven Effect Variables				
Government Effectiveness	-1.655	-2.288	-3.524	
	(2.318)	(1.994)	(2.408)	
TARGET2 Balance				-0.043***
				(0.011)
Risk Aversion Variable				
VIX	0.001	-0.001	-0.028	-0.033*
	(0.010)	(0.008)	(0.016)	(0.016)
Liquidity Variable				
Bid-Ask Spread	9.101***	11.125***	10.279***	10.470***
	(2.116)	(1.451)	(1.268)	(1.327)
Monetary Policy Variables				
LIBOR	-0.001	0.045	0.137	0.182*
	(0.091)	(0.077)	(0.111)	(0.102)
Central Bank's Balance Sheet (non-Eurozone countries)		-0.012***		
		(0.004)		
ECB's Balance Sheet		cf. Annex B	cf. Annex B	cf. Annex B
Dummy IMF	1.398	1.753	3.070**	2.279
	(1.183)	(1.173)	(1.345)	(1.340)
Observations	1,356	1,259	643	643
R^2	0.87	0.92	0.95	0.95

*Note: LSDV estimates. Monthly dummies are included in the regression but we do not display the coefficients for these regressors. For the sake of clarity, the country-specific coefficients on the size of ECB's balance sheet are shown in Annex B. Standard errors robust to heteroskedasticty and within panel serial correlation in parentheses. The asterisks ***,** and * indicate significance at the 1%, 5% and 10% level respectively.*

Table 8: Regression results (Pooled Mean Group estimator)

	(1)
Long Term Determinants	
Potential GDP Growth	-1.179***
	(0.315)
General Govt Debt-to-GDP Ratio	0.007***
	(0.002)
Speed of adjustment	-0.071***
	(0.010)
Short run determinants	
GDP Growth	-0.026**
	(0.012)
General Govt Debt-to-GDP Ratio	0.045***
	(0.017)
Govt Budget Balance	-0.004
	(0.006)
Government Effectiveness	0.655***
	(0.250)
VIX	0.000
	(0.001)
Bid-Ask Spread	4.597***
	(1.558)
LIBOR	-0.084***
	(0.015)
Dummy IMF	0.041
	(0.038)
Observations	3,775
p-value of the Hausman test	0.55

*Note: Estimation is performed using the PMG estimator of Pesaran et al. (1999). The reported short-run coefficients and the speed of adjustment are simple averages of country-specific coefficients.The asterisks ***,** and * indicate significance at the 1%, 5% and 10% level respectively. H_0 (Hausman test): difference in long-run coefficients not systematic.*

Appendices

A Taking the foreign exchange rate factor into account

The yield of a national currency-denominated country k's sovereign bond depends on the currency held by the buyer. For instance, an investor who holds currency l has to convert it into currency k, buy the bond and do the reverse conversion at maturity. Consequently, if $i_k(l)$ is the yield of a country k's sovereign bond from the point of view of an investor who holds currency l, we have:

$$1 + i_k(l) = (1 + i_k) \, . \left(\frac{\mathbb{E}[S_T(l/k)]}{S_0(l/k)} \right)^{1/T} \tag{4}$$

where T is the bond maturity, $S_t(l/k)$ is the exchange rate from currency k to currency l at date t and $i_k = i_k(k)$. As we have already noticed, few satisfactory data are available on Bloomberg for $\mathbb{E}[S_{10y}(l/k)]$, which is a forward exchange rate, because 10-year exchange rate forwards are not liquid. Therefore, (4) cannot be used to modify the sovereign yields of our panel in order to take the foreign exchange rate factor into account.

Following Favero et al. (1997) and Gomez-Puig (2006), we have decided to circumvent this problem by using the 10-year interest swap rate in each currency: we make the key assumption that swap rates are foreign exchange risk-free, that is to say $is_k(l) = is_l$, where is_l is currency l 10-year swap rate and $is_k(l)$ is currency k 10-year swap rate from the point of view of a currency l holder. Said differently, we assume that it is equivalent for a currency l holder to buy a currency l 10-year interest rate swap, or to convert currency l into currency k, buy a currency k 10-year interest rate swap and do the reverse conversion at maturity. Consequently:

$$\left(\frac{\mathbb{E}[S_T(l/k)]}{S_0(l/k)} \right)^{1/T} = \frac{1 + is_l}{1 + is_k} \tag{5}$$

Substituting (5) into (4), we now have a simple formula to convert country k sovereign interest rates into yields from currency l holders' point of view:

$$1 + i_k(l) = (1 + i_k). \left(\frac{1 + is_l}{1 + is_k} \right)$$

The linearized version of this equality is:

$$i_k(l) = i_k + is_l - is_k$$

It can now be easily shown that, contrary to the sovereign yield i_k, the spread $i_k - is_k$ does not depend on the currency held by the investor.[25] **Therefore, the spread between the 10-year sovereign bond yield and the swap rate is not affected by any foreign exchange risk**. Finally, we check wether the loglinearized version of (5) holds, in order to validate our reasoning: the results obtained for the few data available on Bloomberg are satisfactory.

[25] $\forall l$, $i_k(l) - is_k(l) = i_k + is_l - is_k - is_l = i_k - is_k$.

B Annex to Table 7: Country-specific coefficients on ECB's balance sheet

	(2)	(3)	(4)
Austria	-0.034	-0.059	-0.024***
	(0.034)	(0.038)	(0.007)
Belgium	0.037**	0.012	0.028***
	(0.017)	(0.012)	(0.008)
Finland	-0.014	-0.033	0.091**
	(0.013)	(0.017)	(0.035)
France	-0.000	-0.014	0.029**
	(0.030)	(0.031)	(0.012)
Germany	-0.004	-0.008	0.048**
	(0.010)	(0.016)	(0.017)
Greece	0.702***	0.355	0.464
	(0.255)	(0.276)	(0.291)
Ireland	-0.346***	-0.343**	-0.377***
	(0.107)	(0.148)	(0.122)
Italy	0.213***	0.205***	0.133***
	(0.012)	(0.018)	(0.021)
The Netherlands	0.006	-0.001	0.063**
	(0.016)	(0.021)	(0.024)
Portugal	-0.116	-0.177	-0.198
	(0.117)	(0.127)	(0.132)
Spain	0.278***	0.307***	0.150***
	(0.036)	(0.064)	(0.035)

*Note: LSDV estimates. Standard errors robust to heteroskedasticty and within panel serial correlation in parentheses. The asterisks ***,** and * indicate significance at the 1%, 5% and 10% level respectively. See Table 7 for further details.*

C Results of the stationarity tests

We perform two different types of panel unit-root tests on the data.

- The LLC test, proposed by Levin, Lin and Chu (2002), consider the following basic ADF specification:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + \delta_i X_{it} + \varepsilon_{it}$$

  where y_{it} is the variable of interest and X_{it} a set of exogenous variables which can include fixed effects or individual trends. This term may also be omitted. The null and alternative hypotheses for the test may be written as:

$$H_0 : \alpha = 0 \qquad H_a : \alpha < 0 \ .$$

  LLC is said to be a test with a common unit root process since α is constant across cross-sections.

- The Fisher-type ADF test combines the p-values from individual unit root tests to obtain an overall statistic. This procedure, which uses Fisher's (1932) results, has been proposed by Maddala and Wu (1999) and by Choi (2001). If the individual ADF specifications are noted:

$$\Delta y_{it} = \alpha_i y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + \delta_i X_{it} + \varepsilon_{it}$$

  where the notations are similar to those we used in the previous paragraph, the null and alternative hypotheses for the test may be written as:

$$H_0 : \forall i \ \ \alpha_i = 0 \qquad H_a : \exists i \ \ \alpha_i < 0 \ .$$

  As opposed to the LLC test, the Fisher-type ADF test is said to be a test with individual unit root processes.

We perform these two tests on the series of the baseline estimation. We consider several specifications: the number of lags p_i to be included in the ADF specification, which can vary across cross-sections, is either fixed to a predetermined value (1 or 3) or automatically chosen for each cross-section following an information criterion (BIC). We also carry out the tests with different sets of exogenous variables included in the ADF specifications.

The exogenous variables that we chose to include in the ADF specifications have a direct impact on the type of non stationarity that is assumed under the null hypothesis. As recalled in Phillips and Moon (2000), the inclusion of a fixed-effect in the ADF specification results under the null hypothesis in individual specific deterministic trends in the data. For example, if we consider the simplest ADF specification ($p_i = 0$) with an individual fixed-effect under the null, recursive substitution leads to:

$$\begin{aligned} \Delta y_{it} &= \gamma_i + \varepsilon_{it} \\ y_{it} &= \gamma_i t + \sum_{k=1}^{t} \varepsilon_{ik} + y_{i0} = \gamma_i t + W_{it} \end{aligned}$$

where W_{it} is a random walk, i.e. a pure unit root process. Similarly, the inclusion of both a fixed effect and an individual trend in the ADF specification results under the null hypothesis in individual quadratic time polynomials in the data, while including no exogenous regressor in the ADF specification results under the null in a pure random walk.

Looking closely at the data, the type of non stationarity that has to be assumed under the null hypothesis is not obvious. The general government debt-to-GDP ratio seems to be the only series that may display cross-section specific quadratic time polynomials. Therefore, we perform the tests under both *fixed effect* and *fixed effect and individual trend* specifications for this series. For all the other variables of our baseline, we perform the tests under both *no exogenous regressor* and *fixed effect* specifications. The results (displayed below) are not clear-cut and depend, in particular, on the number of lags introduced in the ADF specification: the tests do not allow us to conclude either that there is non-stationarity nor stationarity.

		No exogenous regressor			Individual fixed-effects		
	Number of lags included in the test specification	BIC	1	3	BIC	1	3
Spread between sovereign long-term bond yield and the swap rate	LLC	*0.000*	*0.000*	*0.000*	*0.598*	*0.409*	*0.636*
	Fisher-ADF	*0.000*	*0.000*	*0.000*	*0.005*	*0.005*	*0.004*

p-values of the stationarity tests.
LLC: *H_0: unit root (common unit root process).*
Fisher-ADF: *H_0: unit root (individual unit root processes).*

		No exogenous regressor			Individual fixed-effects		
Number of lags included in the test specification		BIC	1	3	BIC	1	3
GDP Growth	LLC	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	Fisher-ADF	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Govt Budget Balance	LLC	*0.004*	*0.004*	*0.004*	*0.652*	*0.643*	*0.625*
	Fisher-ADF	*0.366*	*0.365*	*0.363*	*0.797*	*0.775*	*0.725*
Government Effectiveness	LLC	*0.008*	*0.009*	*0.009*	*0.362*	*0.247*	*0.222*
	Fisher-ADF	*0.608*	*0.633*	*0.632*	*0.630*	*0.385*	*0.284*
VIX	LLC	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	Fisher-ADF	*0.007*	*0.000*	*0.008*	*0.000*	*0.000*	*0.000*
Bid-Ask Spread	LLC	*0.000*	*0.000*	*0.000*	*0.304*	*0.000*	*0.080*
	Fisher-ADF	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
LIBOR	LLC	*0.000*	*0.000*	*0.000*	*0.408*	*0.612*	*0.416*
	Fisher-ADF	*0.001*	*0.001*	*0.013*	*0.769*	*0.921*	*0.759*

p-values of the stationarity tests.
LLC: H_0*: unit root (common unit root process).*
Fisher-ADF: H_0*: unit root (individual unit root processes).*

		individual fixed-effects			Individual fixed-effects and trends		
Number of lags included in the test specification		BIC	1	3	BIC	1	3
General Govt Debt-to-GDP ratio	LLC	*0.001*	*0.002*	*0.005*	*0.000*	*0.000*	*0.000*
	Fisher-ADF	*0.926*	*0.927*	*0.947*	*0.528*	*0.542*	*0.648*

p-values of the stationarity tests.
LLC: H_0*: unit root (common unit root process).*
Fisher-ADF: H_0*: unit root (individual unit root processes).*

D Results of the cointegration tests

The issues raised by non-stationarity in panel data, although different from those of the pure time series case, dramatically depend on the existence of a cointegration relationship between the dependent and explanatory variables:

- If there is no cointegration relationship, Phillipps and Moon (2000) show that LSDV estimators, such as those we used in section 4, deliver consistent estimates of the long-run average relationship between the dependent and the explanatory variables, in contrast with the pure time series case in which such a regression would be referred to as being "spurious".
- If there is a cointegration relationship, Kao and Chiang (2000) advise to use a DOLS estimator *à la* Stock and Watson (1993) such as:

$$
\begin{aligned}
r_{it} = {} & \alpha + \gamma_i + \beta_1 X_{it}^{(m)} + \beta_2 X_{it}^{(fs)} + \beta_3 X_{it}^{(ra)} + \beta_4 X_{it}^{(sh)} + \beta_5 X_{it}^{(l)} + \beta_6 X_{it}^{(mp)} \\
& + \sum_{k=-p}^{p} \left[\eta_{1k} \Delta X_{it+k}^{(m)} + \eta_{2k} \Delta X_{it+k}^{(fs)} + \eta_{3k} \Delta X_{it+k}^{(ra)} + \eta_{4k} \Delta X_{it+k}^{(sh)} + \eta_{5k} \Delta X_{it+k}^{(l)} + \eta_{6k} \Delta X_{it+k}^{(mp)} \right] \\
& + \delta_1 \mathbb{1}(IMF)_{it} + \delta_2 \mathbb{1}(month)_t + \varepsilon_{it}
\end{aligned}
$$

We use a Kao cointegration test, a residual-based approach inspired from Engle and Granger (1986): first, a LSDV regression is run, then the stationarity of the residuals is tested using a Fisher-type ADF test. The results (displayed below) are not clear-cut and depend on the number of lags introduced in the ADF specification: the tests do not allow us to conclude either that there is non-cointegration nor cointegration.

Number of lags included in the ADF specification	1	2	3	4
t-stat	-2.032	-2.509	-0.456	-0.926
p-value	*0.021*	*0.006*	*0.324*	*0.177*

H_0*: no cointegration.*

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