Euro bond spreads

SUMMARY

Spreads between euro area government bond yields are related to short-term interest rates, which are in turn related to market liquidity, to cyclical conditions, and to investors' incentives to take risk. In theory, lower interest rates are associated with lower degrees of risk aversion and smaller government bond spreads. Empirically, the Eurosystem's short-term interest rates are positively related to those spreads, which our econometric model finds to include significant and policy-relevant default risk and liquidity risk components.

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Economic Policy April 2009 Printed in Great Britain

What drives spreads in the euro area government bond market?

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1. INTRODUCTION

In the run-up to the European economic and monetary union (EMU), interest rate spreads of euro area 10-year government bonds against the German benchmark have declined dramatically. The decrease mainly reflected the introduction of the euro and the removal of exchange rate risks. However, developments in spreads after that are more puzzling. Developments in fiscal positions of euro area governments at first sight seem to offer only limited explanation for this: for instance, the years 2003–5 have seen rising deficits and debts but spreads reached their low point around 2004–5. Furthermore, while many governments made progress in reducing fiscal imbalances in 2006 and 2007, the start of the financial market turmoil in summer 2007 and its intensification in 2008 have caused spreads to rebound, to levels exceeding those observed in the early years of EMU.

Understanding what drives the developments in spreads is of interest to policymakers and practitioners alike. Given the size of most government debts, even small variations in bond prices may entail significant costs for the tax payer. Furthermore,

The authors wish to thank for providing useful comments three anonymous referees, Marco Lo Duca, Lorenzo Cappiello, Carsten Detken, Francesco Drudi, Reint Gropp, Philipp Hartmann, José Marín, Philippe Moutot, Frank Packer, José Luis Peydró-Alcalde and Ludger Schuknecht, as well as seminar participants at the European Central Bank, the Bank of England, the Hong Kong Monetary Institute and the 48th *Economic Policy* panel meeting. The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank or the Eurosystem.
The Managing Editor in charge of this paper was Giuseppe Bertola.

Economic Policy April 2009 pp. 191–240 Printed in Great Britain

government bonds play a crucial role in modern financial markets, for asset allocation and asset pricing purposes.

The existing literature is unanimous in finding that spreads of euro area government bond markets reflect liquidity and credit risks, and are mainly driven by a common factor. This common factor has been identified as an international risk aversion, typically proxied by the spreads of US corporate bonds over Treasury bonds. Although the statistical correlation between these variables continues to be high, the most interesting question – what drives changes in risk aversion and ultimately government bond spreads – remains unanswered.

In this paper, we argue that in normal times developments in risk aversion may be related to the level of short-term interest rates – and therefore to government bond spreads – via at least two channels. A first direct channel works through incentives on investment managers, as originally suggested by Rajan (2006). When interest rates are low, investors have greater incentives to take on risk, in order to improve the expected return on their investment. Vice versa, when interest rates are high investment managers may realize a sufficient return investing in safer assets. A second indirect channel works through the impact that interest rates have on the state of the economy. Since it is well known from the finance literature that risk aversion increases during economic slowdowns and decreases in expansions, if a tightening in monetary policy depresses real activity and lowers future levels of consumption, it will also increase investors' risk aversion. If investors take on less liquidity or credit risk in the government bond market when interest rates are high, spreads will widen, thus generating a positive correlation between interest rates and spreads.

Our empirical analysis confirms that spreads of euro area government bonds are indeed tightly related to the level of short-term interest rates set by the Eurosystem: an increase in interest rates is associated with a widening of spreads and conversely a tightening of monetary policy with a reduction in spreads. In practice it is difficult to disentangle the effects of interest rates from other potentially omitted factors that matter for spreads: short-term interest rates may be correlated with an omitted variable, which in turn is correlated with risk aversion or directly to the level of spreads. Our findings, however, are consistent with an emerging line of empirical research, showing that tight monetary policy decreases the willingness of investors to bear risks. Evidence already existed for equity and banking markets, but to our knowledge it is the first time that such a channel is considered to explain bond spreads. Furthermore, data on US corporate bonds show that a positive relationship between spreads and interest rates goes back at least to the 1960s. At the same time, the fact that risk aversion typically rises during crisis times (as investors fly to quality and safety) contributes to explain why spreads have reached their record levels during the 2007–8 financial turmoil.

We show with a series of tests that our main result is robust to alternative specifications, in particular to the introduction of non-linearities and to a different measure of fiscal soundness. Introduction of US corporate spreads as a control variable only marginally increases the explanatory power of our main regression and leaves unaltered the sign and significance of short-term interest rates. However, the fact that US corporate spreads do get a significant coefficient signals that spreads in the euro area government bond market are determined not only by local factors, but also by international ones. This is not surprising given the strong economic and financial linkages around the globe. Additional robustness checks are carried out with euro area and US corporate spreads, confirming that the level of short term interest rates is strongly linked to spread developments.

Our theoretical and empirical framework allows us also to decompose the spreads of euro area government bonds into a credit risk and a liquidity risk premium.[1] The credit risk premium measures the financial compensation investors demand to cover the risk that a government defaults and the investor would not receive back his full investment and interest. The liquidity risk premium instead measures the extra interest rate an investor requires to be compensated for bearing the risk of having to liquidate the security at a lower price with respect to the benchmark. Making this decomposition is essential for deriving policy implications: a large default risk premium is associated with market discipline and calls for improvements in the sustainability of public finances to be reduced, while a large liquidity premium may indicate incomplete bond market integration, pointing to the need for further harmonization of technical standards and bond issuance policies. Our findings suggest that market discipline is still working, with lower rated governments having to pay higher premiums. Nevertheless, liquidity risk premiums remain non-negligible. Their presence calls for the attention of policy-makers and market participants, who should step up efforts to bring to completion the ongoing process of financial integration.

The remainder of this article has the following structure. The next section describes the institutional set up within which the euro area government bond markets operate, with an emphasis on policy issues. Section 3 discusses the empirical and theoretical links between government bond spreads, risk premiums and short-term interest rates. Section 4 provides an exploratory data analysis, while Section 5 presents our main econometric results. Section 6 contains the robustness checks. Section 7 concludes, highlighting the main policy implications of the paper.

2. INSTITUTIONAL BACKGROUND

Understanding developments in spreads of euro area government bonds requires in the first place knowledge of the institutional set-up in which financial markets operate. Crucial elements of this setting include fiscal rules, no bail out provisions and the degree of financial integration. A common concern before the current turmoil

[1] Credit and default risks will be used interchangeably throughout the paper.

was that the introduction of fiscal rules, the lack of credibility of the no-bail-out provisions and the steady progress of financial integration had contributed to weakening market discipline in the euro area government bond market and were responsible for the overall reduction of spreads. This section provides some institutional background and discusses how spreads may be related to issues of market discipline, financial integration and the Stability and Growth Pact. A crucial point emerging from this debate is the need to quantify if and to what extent spreads after 1999 still reflect sustainability of public finances. We will provide an answer to this question in Section 5.

2.1. Market discipline and fiscal rules

Market discipline may be broadly defined as the influence exerted by market participants on governments by pricing different risks of default. Bonds of governments following unsound fiscal policies are characterized by higher default risks, for which investors want to be compensated by a higher yield. Governments have to take into account these higher financing costs when planning their fiscal policies. *Ceteris paribus*, market discipline provides a deterrent against unsound fiscal policies, and thus supports fiscal discipline. The fact that interest rates in the EMU seem to be only weakly linked to underlying fiscal developments has raised doubts about financial markets' ability to assess sustainability of public finances.

It is well known that markets reactions to a continuous deterioration in fiscal sustainability may be subdued within certain ranges of deficit and debt, but sizeable and abrupt in the aftermath of 'trigger events', such as a rating agency's decision to downgrade a country's debt (see, for instance, the Delors report). While higher interest rates after such an event help to discipline government finances, sudden and sharp changes in financial conditions may entail large macroeconomic costs.

To counter this, the Maastricht Treaty and the Stability and Growth Pact introduced rules to avoid 'excessive' deficits.[2] In particular, nominal deficits should remain below 3% of GDP and debt-to-GDP ratios should be below 60% or, if not, at least decline quickly towards that level. Deviations from these rules can lead to policy recommendations and, ultimately, to financial sanctions being imposed upon a country.[3]

Fiscal rules may enhance market discipline by giving guidance for monitoring fiscal developments and providing a 'common language' for investors (Mosley, 2003). Also, the requirement to provide more timely, comparable and comprehensive fiscal data – in response to the need for assessing compliance with the fiscal rules – enables financial market participants to price bonds using more reliable statistics.

[2] Incentives to run deficits may actually increase within a monetary union. See for instance Detken *et al.* (2004).

[3] This discussion focuses on the European fiscal framework, though it must be noted that there are also many national fiscal rules and institutions, especially since the start of EMU. See Debrun *et al.* (2008).

However, the effect of rules on market behaviour is theoretically ambivalent. Market reactions to breaches of the rules can be muted, on two – opposing – grounds. First, market participants may regard the Stability and Growth Pact as irrelevant or ineffective, in which case Brussels' decisions and recommendations on national public finances would have no impact on government bond yields. Second, a perfectly credible Stability and Growth Pact would immediately exercise a deterrent and correcting effect on national governments, thus causing markets to believe that any excess will be corrected promptly.[4] In the first case, fiscal rules have no effect on the monitoring behaviour by financial markets. In the second case, credible fiscal rules would make monitoring much easier, and market discipline would strengthen the discipline exerted via the fiscal rules. The large number of breaches of the rules of the Pact and a 2005 revision of the Pact that weakened the rules seem to support the first view. However, it also needs to be kept in mind that, at least when compared to country-experiences before EMU, public finances until 2007 were in a relatively good shape as no major derailments had taken place. Thus, in practice, it is hard to distinguish between these two opposing views.

2.2. Market discipline and financial integration

According to its mission statement, the Eurosystem (the European Central Bank (ECB) and the national central banks of countries that have introduced the euro) – notwithstanding the overriding objective of maintaining price stability – aims to promote European financial integration. Similarly, the European Commission has put great emphasis in creating an EU-wide level playing field in the financial sector. In particular, the Financial Services Action Plan, launched in 1999, constituted a major overhaul of the EU legislation for financial services, aimed at removing barriers to cross-border activities. At the same time, the Governing Council of the Eurosystem and the European Commission have reiterated on several occasions that euro area countries should comply with the provisions of the Stability and Growth Pact and consolidate their fiscal imbalances.

The steady and increasing process of financial integration of the euro area financial markets may have reduced the liquidity premium in government bond spreads as it has facilitated cross-border trade of securities. However, some observers fear that at the same time, increasing financial integration hampers the markets' ability to discriminate the quality of fiscal policies: the substantial convergence in yields brought about by the *de jure* and *de facto* integration of capital markets – the argument goes – is a sign that market participants no longer discriminate among bonds issued by different governments. Although such arguments are less in fashion today

[4] For US states, this has been empirically confirmed by Poterba and Rueben (2001), reporting evidence that in US states with tight anti-deficit rules, unexpected deficits lead to smaller interest rate increases than in states without such strict fiscal rules.

in view of the recent increase in spreads, if it were true that financial integration, by eliminating the disciplinary power of the markets, is the main driving force behind the reduction in spreads, EU policy-makers may be seen as pursuing conflicting strategies.

We argue instead that financial integration, rather than obstructing market discipline, is a necessary condition for markets to work properly and exert their disciplinary effect.

Market discipline is most effective in competitive and well-functioning markets. A first necessary condition for financial markets to price sovereign bonds correctly is that governments have access to the capital markets on the same terms as other borrowers (no preferential access), and in particular that each country will ultimately bear the full financial consequences of a default (no-bail-out). Any direct or indirect pressure to favour government debt securities would inevitably introduce pricing distortions, thus impairing the role of markets as a disciplinary device. The Maastricht Treaty explicitly recognizes the importance of these issues in Articles 101–103. Note that what matters for effects on interest spreads, however, is market participants' perception of the credibility of the no-bail-out clause, rather than its acknowledgment.

A second (and related) condition for market discipline to work is that the relevant markets are integrated, that is, that all agents with the same relevant characteristics operating in that market face a single set of rules, have equal access and are treated equally.[5] In general, financial integration contributes to bring financial markets closer to the ideal benchmark of perfect competition. Under these circumstances, market forces will provide an accurate assessment of the risk/return profile of each government bond, ultimately leading to an efficient allocation of funds to their most productive use, taking risk properly into account. There is little doubt that, by eliminating barriers to trade and creating a true level playing field, the process of financial integration has progressively increased the efficiency of European financial markets, bringing them closer to the ideal benchmark of perfect competition. According to this line of reasoning, the observed integration of government bond markets must have reinforced, if anything, any market-driven disciplinary effect.

3. RISK AVERSION, SHORT-TERM INTEREST RATES AND GOVERNMENT BOND SPREADS

A robust finding of the literature on euro area government bonds, starting with Codogno *et al.* (2003), is that spreads are driven by a single common factor. This common factor has been interpreted as an international risk aversion,

[5] See Baele *et al.* (2004) for a more formal definition of financial integration.

proxied by the spread between corporate bonds and government bonds (see Box 1 for a literature review). The literature, however, remains silent about the economic forces driving risk aversion. In this section we review the main empirical evidence and theoretical arguments explaining time-varying risk aversion. There are both direct and indirect channels linking the level of short-term interest rates with risk aversion. The existence of an additional risk-taking channel in the transmission of monetary policy is increasingly acknowledged by the academic literature and policy-makers (see, for instance, the review in ECB, 2008b and Borio and Zhu, 2008).

Box 1. Existing evidence for euro area government bonds

The behaviour of spreads in the euro area government bond market has been studied in several papers. It has been noticed that spreads – after the impressive convergence in the run up to the EMU – have not disappeared completely after the introduction of the euro. Furthermore, spreads tend to co-move over time. These stylized facts have prompted researchers to devise theoretical and empirical strategies to understand the determinants of such co-movements. See Pagano and Von Thadden (2004) for an early review of the literature.

Most studies include some pre-EMU years to have sufficient observations to obtain reliable estimates or to directly test for the impact of the euro. Removing the exchange rate component from interest rate spreads is a crucial, albeit controversial, step in the analysis. A common approach is to deduct from the interest rate spreads the difference between 10-year swaps in the currency of the country and the deutschemark as a measure of the exchange rate related premium. An alternative is to compare yields on bonds issued by different governments in the same currency, for example DM/euro or US dollars.

Codogno *et al.* (2003) have been among the first to study the problem. They find that yield differentials between government bonds can be explained by variations in international risk factors, proxied by the spread between the US corporate and government bonds. The results are obtained with simple regressions, where spreads are regressed against countries' deviation of debt-to-GDP ratios with respect to Germany and their proxy for the international risk premium. Geyer *et al.* (2004) arrive at a similar conclusion, using a more sophisticated theoretical and econometric set up. Specifically, they use a pricing model for EMU government bonds, where spreads are driven by an affine factor structure. The estimated factors, extracted with a state-space approach, are then regressed on a set of macroeconomic and financial variables. The authors find spread factors to be related to euro area corporate bond spreads. Like Codogno *et al.* (2003) they find that liquidity factors play a minor role. Unlike Codogno *et al.* (2003), they conclude that credit risk is a major driving force of systematic risk in EMU government yield spreads.

Bernoth *et al.* (2004) study the determinants of spreads using a database on EU Eurobonds issued between 1991 and 2002. The use of these data allows the authors to ignore any issue with exchange rate risks, which affect the time series starting before 1999. On the other hand, the Eurobond market may be characterized by different liquidity relative to national bond markets. In line with the papers discussed above, the authors find that spreads are affected by international risk factors (proxied in this case by the spread between BBB US corporate bonds and benchmark US government bonds), and reflect both positive default and liquidity risk premiums. The default risk premium is positively affected by debt and debt service ratios of the issuer country. The liquidity risk premium on the other hand has shrunk with the introduction of the euro.

The importance of liquidity is further scrutinized in a series of other papers. Gomez-Puig (2006) finds that a change in the market assessment of liquidity may be more important than credit risk in explaining the variation in spreads after the introduction of the euro. The results are obtained by regressing yield spreads (exchange-rate adjusted spreads before 1999) against several proxies for liquidity, such as bid-ask spreads and relative market size. Credit risk is controlled for using rating dummies. Jankowitsch *et al.* (2006) study liquidity by constructing sub-portfolios formed using individual bond data on alternative liquidity measures. They find that only the benchmark property appears to command a liquidity premium. In particular, more traditional liquidity measures, such as the on-the-run property, the issue size and bid-ask spreads, do not have a persistent price impact. More generally, they find that liquidity effects alone cannot explain the size of yield spreads across different issuers. Favero *et al.* (2009) propose a model with endogenous liquidity demand, where yield differentials increase as both liquidity and aggregate risk increase. The special feature of this model is that it predicts a negative dependence of spreads on the interaction between liquidity and risk. These predictions are confirmed by their empirical results based on daily data between 2002 and 2003. Beber *et al.* (2009), using transaction data from the MTS securities platform, conclude that normally credit risks explain the largest part of bond spreads, but in case of heightened market uncertainty, liquidity considerations gain in importance.

We summarize the main features of this literature in Table 1. The table highlights how the samples used in the analysis contain only a couple of years of post-EMU data. We will base instead our empirical analysis on a sample of 10 years of post-EMU data. Although it could still be argued that longer samples are needed to capture long-run, low frequency relationships, we have the longest sample used in this literature. In addition, since our analysis is based on post-EMU data, it is not contaminated by exchange rate risks.

A major feature emerging from our reading of the literature is the existence of a single common factor driving the spreads. This common factor has been interpreted as an international risk aversion, proxied by the spread between corporate bonds and government bonds. Although the statistical correlation with government bond spreads is extremely high, this interpretation seems unsatisfactory for at least two reasons. First, it is not clear why international risk factors should be best measured by US risk premiums and not, say, by euro area government bond spreads, or by some other omitted variable. In other words, why should the causality relationship go from US corporate spreads to euro area government bond spreads and not vice versa? Second, appealing to exogenous changes in investors' risk appetite to explain spreads in the euro area government bond market does not help us understand the behaviour of these spreads. If spreads are driven by changes in risk aversion, what drives then investors' risk appetite?

These questions are tackled in Section 3.

Table 1. Overview of recent studies on the liquidity and the default risk premium

	Sample	Countries	Conclusion
Codogno *et al.* (2003)	12/95–10/02	Euro\{GR,LU}	Spreads driven by US corporate spreads
Geyer *et al.* (2004)	01/99–05/02	{BE,ES,IT,AT}	Spreads driven by euro corporate spreads
Bernoth *et al.* (2004)	Eurobonds 1991–2002	Euro\{LU,NL}	Spreads driven by US corporate spreads
Favero *et al.* (2009)	01/01/2002–31/12/2003	Euro\{IE,GR,LU}	Spreads driven by US corporate spreads
Gómez-Puig (2006)	01/96–12/01	Euro\{GR,LU}	Liquidity premium increased after EMU
Jankowitsch *et al.* (2006)	01/99–03/01	{ES,FR,IT,NL,AT}	Liquidity not captured by traditional measures
Beber *et al.* (2009)	04/03–12/04	Euro\{IE,LU}	Spreads driven by credit risk, except in times of stress

Note: The notation 'Euro\{A,B}' indicates that the analysis covers all 12 euro area countries, with the exception of countries A and B.

3.1. Empirical evidence

Recently, a number of papers have found that the level of interest rates set by the central bank has a bearing on the willingness of investors to take on risk. Evidence exists for equity and banking markets. Interestingly, the link between interest rates and risk taking to our knowledge has not yet been explored for bond markets.

In the context of equity markets, Rigobon and Sack (2004) show that an increase in the short-term interest rate has a negative impact on stock prices. In principle, an unexpected tightening of monetary policy may lead to a decline in stock prices via three channels: (1) lower expected dividends; (2) higher expected real interest rates used to discount those dividends; (3) higher equity risk premiums. Although they are not able to identify which of these channels is driving prices, they do find that the negative impact is stronger on the Nasdaq index than on the S&P 500-index. Since Nasdaq is typically characterized by greater volatility (and hence greater risk) relative to the S&P500 index, this finding is consistent with investors asking for larger risk premiums when interest rates increase. Bernanke and Kuttner (2005) are able to shed some light on the mechanisms leading to such results using a different methodology. According to their decomposition, a sizeable portion of the reaction of equity prices to monetary policy is attributable to the effects it has on expected future excess returns. The implication of this result is that an increase in interest rates lowers stock prices by raising the equity risk premium. The authors offer two tentative explanations for this finding. First, restrictive monetary policy could directly increase the risk of holding stocks by increasing borrowing costs for quoted firms. Second, restrictive monetary policy could reduce the risk appetite of investors.

The impact of monetary policy on banks' lending behaviour has been studied by Jimenéz *et al.* (2007). They analyse a Spanish dataset which contains detailed information on virtually all loans granted by all credit institutions operating in Spain over a period of 22 years. They find that lower short-term interest rates result in banks granting more risky new loans, and that banks tend to soften their lending standards, when interest rates are low prior to loan origination, by lending more to borrowers with a bad credit history or with higher uncertainty. In addition, they find that the impact of monetary policy is quantitatively stronger than the impact of GDP growth on bank risk-taking. Their conclusion is that monetary policy affects banks' risk-taking behaviour, as well as the composition of credit in the economy. In a related paper, Ioannidou *et al.* (2007) reach similar conclusions using data on loans granted in Bolivia: a decrease in overnight rates increases the default risk of the loans granted by banks, yet banks decrease the loan spreads on these riskier loans. This result is consistent with a higher bank appetite for risk when monetary policy is more expansive.

Another piece of evidence linking monetary policy and risk taking behaviour is provided by Amato (2005). He studies the determinants of spreads on US credit default swaps, decomposing them into a risk premium and a default risk aversion component. He finds a strong relationship between default risk aversion and the real interest rate gap, which is interpreted as a direct measure of the stance of monetary policy. In particular, his results suggest that default risk aversion declined as the real federal funds rate fell further below the natural rate.

As to the corporate bond markets, several studies have introduced extensions to the model of Merton (1974) that links short-term interest rates to corporate bond spreads, without however explicitly addressing issues of risk aversion. The relation between interest rates and spreads in these models is a negative one, as the interest rate approximates the expected growth rate of the firm. Several authors have applied this framework to corporate bond spreads (see Collin-Dufresne *et al.*, 2001 and Van Landschoot, 2004 for the euro area). Although empirical outcomes confirm the negative relation between spreads and the interest rate level, this line of research focuses on changes in credit spreads, rather than their levels. As discussed by Bevan and Garzarelli (2000), using changes in credit spreads as the dependent variable implies a focus on their short-term dynamics and fails to account for longer-term equilibrium relationships. By adopting a cointegration methodology, the authors show that the relationship between credit spreads and interest rates is negative in the short run, but positive in the long run.

In the next sub-section we will describe possible theoretical channels through which monetary policy may affect sovereign bond spreads.

3.2. Theoretical links

In theory, the spread between two assets with the same cash flow should be zero only if those assets have identical risk-return characteristics. Since the introduction of the euro, spreads between government bonds reflect two types of risks: liquidity and credit risk. The credit risk premium measures the financial compensation investors demand to cover the risk that a government defaults and the investor would not receive back his full investment and interest. The liquidity risk premium instead measures the extra interest rate an investor requires to be compensated for bearing the risk of having to liquidate the security at a lower price with respect to the benchmark. In the Appendix we provide a formal theoretical decomposition of these two risks.

Given the finding of the literature that spreads are driven by a single time-varying common factor, theoretical explanations of government bond spreads must build on models which account for time-varying risk premia. In the finance literature, time-varying risk aversion is typically associated to the state of the economy. Risk aversion increases during economic downturns and decreases in periods of expansion. The basic intuition is the following. As the economy enters into a recession and people risk losing their job, investors will take less risk in financial markets, as their primary source of income is already at risk.

The academic literature has modelled this type of behaviour by introducing habits in the agent's utility function. In the Appendix, we show with a simple consumption-based model with habit formation how short-term interest rates may affect risk aversion by affecting the future state of the economy. In habit formation models *à la* Campbell and Cochrane (1999) agents become more risk averse during economic slowdowns because their (expected) consumption decreases relative to the established standard of living. Because consumers are afraid of a poor performance of assets during recessions as this may further depress consumption possibilities, the risk premium of riskier assets increases. In such a setting, if a tightening in monetary policy depresses real activity and lowers future consumption levels – as it would be implied by a standard new Keynesian model – it will also increase investors' risk aversion, increasing in this way the risk premiums associated to the riskier bonds. We use this model to derive the estimation equation underlying our empirical analysis.

Rajan (2006) suggests another mechanism linking interest rates and bond spreads, based on the incentive structure of investment managers. He argues that what is usually referred to as changes in risk aversion is more likely to reflect changes in the structure of incentives – and therefore in the behaviour – of agents. Investors nowadays channel their savings to the markets no longer exclusively through banks but increasingly also through mutual funds, insurance companies, pension funds, hedge funds and other forms of private equities. Rajan refers to the people managing these savings as 'investment managers'. In order for investors to effectively delegate the management of their wealth to these investment managers, they have to provide incentives, most commonly by remunerating their performance in comparison to similar managers and by the amount of assets under management. Since positive excess returns typically generate substantial inflows of funds, while negative returns generate milder outflows, the compensation structure of investment managers is convex in returns, that is, with strong upside potential and limited downside risk. Investment managers have therefore greater incentives to take on risk which is hidden from investors (such as tail risk) than in the past. This will boost their performance with very high probability and it will look like superior managing abilities. Catastrophic losses will occur only with very small probability and possibly only after the manager has left the company.

Monetary policy may substantially affect the incentives to take risk via the interest rates. To see how these incentives operate, Rajan considers the typical compensation contract for a hedge fund manager. The manager earns 2% of the value of the assets under management, plus a percentage of the annual returns on the investment. When interest rates are high, compensation will be high even investing in risk-free assets. On the other hand, when interest rates are low, managers will have the incentive to take on more risk because they can boost their compensation by increasing the expected return on their investment, and avoid withdrawals that decrease the asset value of their portfolio.[6]

If investors consistently follow this behavioural pattern, one would observe an increased demand for riskier assets when interest rates are low and a decreasing demand when interest rates are high. Rising prices imply lower expected returns, which could be erroneously attributed to changes in risk aversion, while it would simply be the response to incentives. This interpretation is consistent with the available empirical evidence in the context of equity and banking markets.

Loose monetary policy may also increase funding liquidity, allowing investors to more easily finance illiquid positions and hold them to maturity (Brunnermeier and Pedersen, 2008). As funding conditions tighten, investors become less willing to take on positions that require high, funding-intensive margins (i.e. large difference between the asset price and the collateral value). Lower funding liquidity may therefore induce lower market liquidity and higher liquidity premiums. This represents an additional link between interest rates and sovereign liquidity premiums.

It is hard in practice to empirically disentangle the proportion of spreads due to higher risk aversion and that due to incentives. Existing empirical evidence shows that a positive relationship between spreads and bond yields goes back at least to the 1960s (Bevan and Garzarelli, 2000), thus suggesting that risk shifting can only be part of the story. In addition, the considerable increase in spreads during the 2007–8 financial turmoil took place in an environment of increasingly loose monetary policy. While there might be a link between interest rates and incentives in normal times, the recent evidence indicates that in crisis times spreads react to the increased risk aversion triggered by the economic slowdown, rather than to incentives linked to the monetary policy.

At a more practical level, lower policy rates reduce the interest burden of heavily indebted governments. This in turn decreases their risk of insolvency, which investors may reward with lower interest rates on longer-term bonds, and therefore lower spreads. While such an argument might have some appeal in theory, there are some reasons to doubt its empirical relevance. First, spreads are time-varying also for those governments (such as France and the Netherlands) whose fiscal positions are comparable to Germany. Second, the part of government debt that is financed with short-term maturity (or longer-term maturity linked to a short-term interest rate) is relatively limited (around 18% for the euro area as a whole) and on

[6] Another example of 'risk shifting' is provided by insurance companies and pension funds which have long-term, fixed-rate commitments. With falling interest rates, managers may be forced to choose riskier investments, as otherwise they would be unable to face their commitments (unless they raise premiums or lower benefits). This applies more so nowadays than in the past as supervisors have strengthened solvency rules, requiring these institutions to act more quickly in case certain solvency thresholds are not met. On the other hand, with rising interest rates, relatively safe investments may be enough to face the liabilities. In that case, the institutional investors will take on less credit risk and rather invest in high-rated government bonds, which will also affect the liquidity premium. As long-term investors, they could also invest in illiquid markets to boost current performance on the expectation that liquidity in that market may increase in other circumstances.

a declining trend, at least before the crisis set in. Effects would be stronger if the yield curve would co-move with the short-term rate. All the same, it is hard to see why financial investors or rating agencies reassess their opinion on fiscal soundness solely on this basis.[7]

4. EXPLORATORY DATA ANALYSIS

In this section, we first describe the data used in our empirical analysis. Then, the key facts about the fiscal developments in euro area countries since the introduction of the euro are reported. Finally, we perform a preliminary data analysis to check whether these considerations are borne out by the data. Visual inspection suggests the existence of a strong low frequency relationship between spreads and interest rates. It also confirms that governments with lower ratings tend to pay, on average, higher yields.

4.1. Data

The dataset runs from January 1999 to April 2008. We exclude the period before the start of EMU from our analysis because data before that are not well comparable given that spreads contained some exchange rate risk. Furthermore, even if available, the convergence process towards 1999 may have caused some distortions, or even a regime shift. The analysis does not include the very recent financial crisis period, when interest rate spreads on some government bonds exceeded 100 basis points. The levels of risk aversion and uncertainty reached by financial markets during the second half of 2008 are unprecedented and have also affected very short-term money markets, as witnessed by the sharp increase of three and six month EURIBOR spreads.

We computed spreads for 10-year government and corporate bonds using daily yields data from Datastream. The empirical analyses of Sections 6 and 7 are based on monthly spreads computed as averages of daily spreads over each month. The lower frequencies used in the remainder of this section are computed as averages of daily data over the desired frequency.

For the analysis of corporate spreads, we used indices for 7 to 10-year corporate bonds for three rating categories, AAA, AA and A. We used the corresponding index for 7 to 10-year euro area and US government bonds to compute the spreads.

Data on public finances have been taken from the AMECO database of the European Commission, as at autumn 2007. Government bond ratings are taken from Standard & Poors.

[7] In explaining government debt ratings, the interest rate (spread) usually is not a relevant factor, as can be seen from the overview of studies in this area by Afonso *et al.* (2007).

4.2. Fiscal developments in the euro area since 1999

The average deficit in the euro area (for the 12 members in 2001) in the early years of EMU continued the downward trend observed before, when the decision of early EMU membership was made. From 5% of GDP in 1995, a balanced budget was reached in 2000, although with a substantial contribution that year from one-off receipts related to the sale of UMTS (Universal Mobile Telecommunications System) licences. After that, fiscal developments reversed on the back of deteriorating economic conditions and substantial fiscal loosening, mainly in the form of tax cuts, bringing the average deficit close to 3% of GDP in 2003 and 2004. Consolidation measures and economic tailwind again caused improvements, bringing back the deficit to 0.6% of GDP in 2007. Several countries have entered the excessive deficit procedure for surpassing the 3% deficit ceiling, sometimes for years in a row. Countries that at some point in time were in excessive deficit were France, Germany, Greece, Italy, the Netherlands, and Portugal (twice). Note that while this list includes many of the euro area countries with ratings below AAA, there are also some AAA-rated countries among them (France, Germany and the Netherlands). Figure 1 plots the development of ratings over the period 1999–2008 for the euro area countries in our sample, showing a wide variety in the rating levels and their trends.

Debt developments usually are seen as more relevant to assessing fiscal soundness than deficits, as a global indicator of the sustainability of public finances. On average in the euro area, debt ratios declined slightly, from 73% of GDP in 1998 to 69% in 2007. The decline was manifest in all countries except Germany, France, and Portugal. Yet, a few countries maintained rather high debt levels; six countries in the euro area still have a debt ratio above 60% of GDP, and in Italy it still surpasses the level of GDP.

The link between debt developments and interest rate spreads is shown in Figure 2, for 2007.[8] A clear correlation can be seen, with higher debt ratios reflected in higher yield spreads. However, the figure also shows that debt is not a perfect approximation of a country's financial soundness, witnessing for instance Belgium having a high debt ratio but a relatively low interest rate spread against Germany. Also, Portugal, France and Austria approximately have very similar debt ratios, but the interest rate spread for the first country is much higher.

Combining lower nominal interest rates and falling debt ratios, the interest payments of all euro area governments have fallen since the start of EMU, on average from 4.6% of GDP in 1998 to 3.0% in 2007. This took place especially in the initial EMU years due to refinancing of (pre-EMU) high-interest debt at substantially lower rates. Smaller countries in particular gained substantially, probably also reflecting the broadened investor's base.

[8] While it might be more accurate to compare interest rate spreads with the difference between a country's debt ratio and the German one, doing so for one particular year does not change the graph.

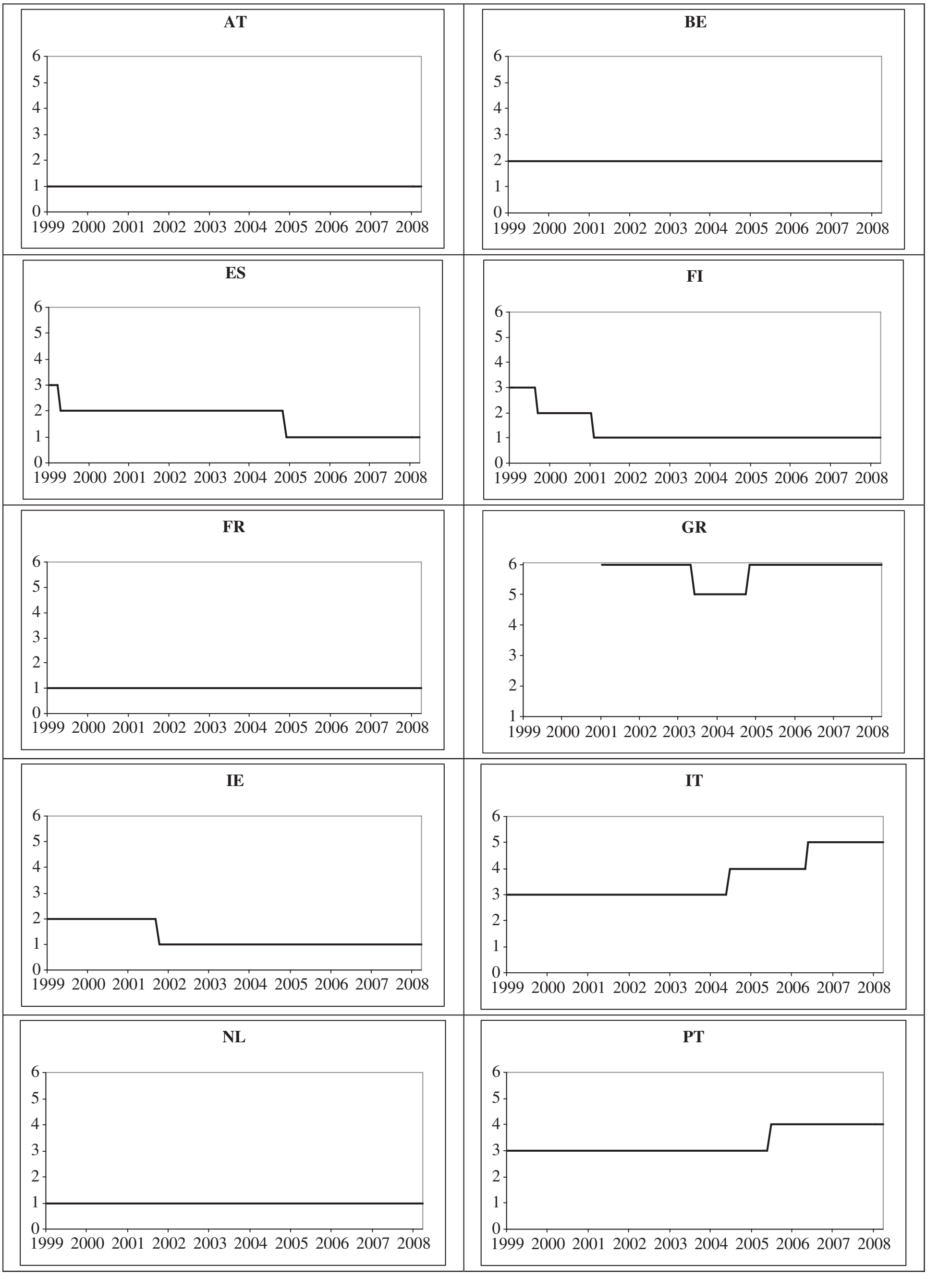

Figure 1. S&P rating evolution in euro area countries

Note: A '1' denotes the highest possible rating (AAA), larger numbers indicate subsequently lower rating classes. Germany has always been rated AAA.

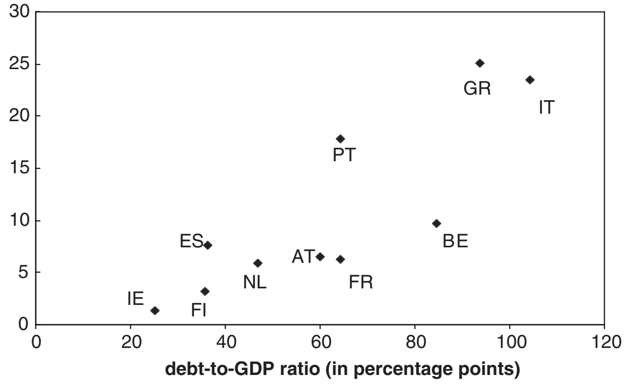

Figure 2. Interest rate spreads (basis points, 2007) and debt-to-GDP ratios

The improvement of fiscal balances that took place due to lower interest rates depends on the size of the debt affected, its maturity structure, and the use of hedging instruments. As indicated before, debt levels have come down as a percentage of GDP, though remaining high in some countries. Regarding maturities, some convergence can be observed over time, with maturities increasing in countries that previously had some difficulties in financing themselves long term. The largest part of government debt is financed with medium- to longer-term maturity securities. Tentative calculations (excluding swap effects) indicate that in 'normal' circumstances, interest rate changes will have a modest direct effect on public finances (between 0.05% and 0.1% of GDP deficit increase for a one percentage point increase of interest rates along the curve), though increasing over time as more new debt is issued and redeemed debt needs to be refinanced at the higher rates.

4.3. Evolution of euro area government bond spread since 1999

According to the arguments outlined in the previous section, spreads in the euro area government bond market ought to be related to the level of short-term interest rates. At the same time, for market discipline to work governments implementing unsound fiscal policies should be forced to pay higher spreads. The reason is that these governments face somewhat higher risks of default and investors need to be compensated for bearing such extra risk. It is important to stress that it is mainly the long-term sustainability of public finances (as opposed to short-term budget deficit fluctuations) that affects the probability of default and therefore accounts for the credit risk premium. A natural proxy for such long-term sustainability is given by the assessments provided by the leading rating agencies.[9] These ratings are more forward looking than debt- or deficit-to-GDP ratios, as they take into account not

[9] Ratings have been extensively used in the literature. See, for instance, Gomez-Puig (2006) for an application in the context of European government bond markets. Sironi (2003) uses ratings to test for market discipline in the European banking industry.

only the current fiscal position but also its expected development, implicit and/or contingent liabilities such as increasing ageing-related expenditures, as well as other factors such as the quality of the budget law, the political stability of the country, some of which are more judgemental in nature and difficult to quantify. In addition, ratings do play an important role in investors' portfolio decisions. With interest rate spreads between euro area government bonds being relatively limited compared to those in other bond market segments, cost-benefit analyses could lead investors to rely more heavily on external assessments, notably ratings, in making portfolios. A possible drawback of using rating assessments is that they usually change very slowly, and may therefore be seen as lagging behind fiscal developments. Available research, however, shows that government debt developments play an important role in shaping ratings assessments (see Afonso *et al.*, 2007).

It is important to highlight that this relationship is likely to be affected by short-term dynamics, which may lead to temporary price volatility due to country-specific supply and demand shocks. We should therefore expect this relationship to be stronger at lower frequencies, when high frequency idiosyncratic shocks are averaged out.

The four plots in Figure 3 confirm this intuition. We plot the average daily spread of 10-year euro area government bonds with respect to the 10-year German bond, together with the average main refinancing operations (MRO) minimum bid rate – that is, the interest rate decided by the Eurosystem – as of January 1999. The averages are taken over four different frequencies, monthly, quarterly, semi-annual and annual. It is obvious from the plots that at lower frequencies, the co-movement between spreads and interest rates becomes more pronounced, as short-term spread fluctuations are progressively averaged out.

Looking at correlations confirms the existence of a strong common component among the spreads and with MRO. Table 2 shows that correlations among monthly average spreads range from a minimum of 0.69 between Italy and the Netherlands to a maximum of 0.96 between Spain and Austria, covering the period starting January 1999 to April 2008. The overall average correlation is 0.84. The correlation between spreads and MRO instead ranges from a minimum of 0.67 for the Netherlands to a maximum of 0.86 for Portugal. The overall average correlation between spreads and MRO stands at 0.76.

We further confirm these stylized facts with a principal component analysis. Principal component analysis is a statistical method which is typically used to understand the characteristics of cross-sectional variation of a data set. In the extreme case of a set of independent series, all principal components contribute equally to explain the variance of the data set. At the other extreme, when all series are perfectly correlated, the first principal component can explain all the cross-sectional variation in the data. The first principal component for the data set containing all euro area monthly spreads explains 86% of the variance. This result is consistent with what has been previously found in the literature.

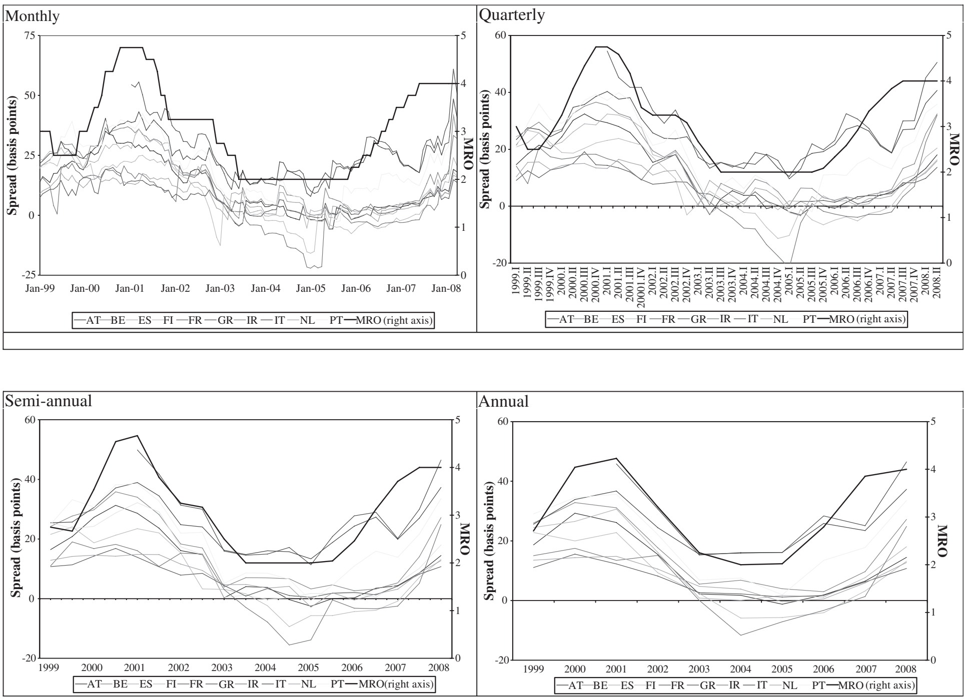

Figure 3. Average daily spreads and main refinancing operations minimum bid rate (MRO) at different frequencies (basis points)

Table 2. Correlations among monthly average spreads and MRO

	AT	BE	ES	FI	FR	GR	IE	IT	NL	PT
BE	0.92	1.00								
ES	0.96	0.94	1.00							
FI	0.87	0.86	0.88	1.00						
FR	0.87	0.92	0.88	0.84	1.00					
GR	0.84	0.86	0.86	0.77	0.84	1.00				
IE	0.76	0.79	0.75	0.77	0.83	0.78	1.00			
IT	0.79	0.84	0.81	0.73	0.82	0.95	0.73	1.00		
NL	0.83	0.87	0.82	0.84	0.87	0.74	0.75	0.69	1.00	
PT	0.92	0.90	0.91	0.81	0.87	0.90	0.78	0.90	0.82	1.00
MRO	0.78	0.74	0.79	0.73	0.81	0.81	0.69	0.82	0.67	0.86

To gauge a first impression of how liquidity and credit risk premiums vary over time, we construct 'factor mimicking portfolios' in the spirit of what people do in stock pricing. As we show in the Appendix, the yield differentials can be decomposed into differentials between expected payoffs, credit risk and liquidity risk premiums. If we assume that the probability of default is very low, expected payoffs will also be very low and the spreads will be driven mostly by credit and liquidity risk premiums. According to Equation (A7) in the Appendix:

$$Y_t^i - Y_t^b = h_t \sum_{n=1}^{N} z_{t,n-1}[(CP_{t+n}^b - CP_{t+n}^i) + (LP_{t+n}^b - LP_{t+n}^i)]. \quad (1)$$

Since German bonds are rated AAA, if we assume that any other AAA bond has the same probability of default as German ones, the spread over Germany of these bonds should reflect only liquidity risk and no credit risk:

$$Y_t^i - Y_t^b = h_t \sum_{n=1}^{N} z_{t,n-1}(LP_{t+n}^b - LP_{t+n}^i). \quad (2)$$

We construct the spread for AAA bonds, by averaging in each month the spreads of all AAA bonds. We call this the 'liquidity factor'.

To obtain an insight on credit risk premiums, we take differences in yields between AA+ bonds and AAA non-benchmark bonds. If these bonds have similar levels of liquidity, i.e. $LP_{t+n}^i = LP_{t+n}$ for all i, we obtain that these spreads should mainly reflect differences in credit risk premiums:

$$Y_t^i - Y_t^j = h_t \sum_{n=1}^{N} z_{t,n-1}(CP_{t+n}^j - CP_{t+n}^i) \quad (3)$$

where j is a AAA non benchmark bond and i is a AA+ bond. We call this the 'AA+ factor'. A similar computation is done for bonds rated AA or lower, to obtain the 'AA↓ factor'.

The resulting factors are plotted in Figure 4. As before, we plot these spreads together with the MRO. We continue to notice a correlation between spreads and MRO. The correlation is particularly striking between MRO and the spread of the 'liquidity factor'. Table 3 reports the correlations among the series plotted in the figure.

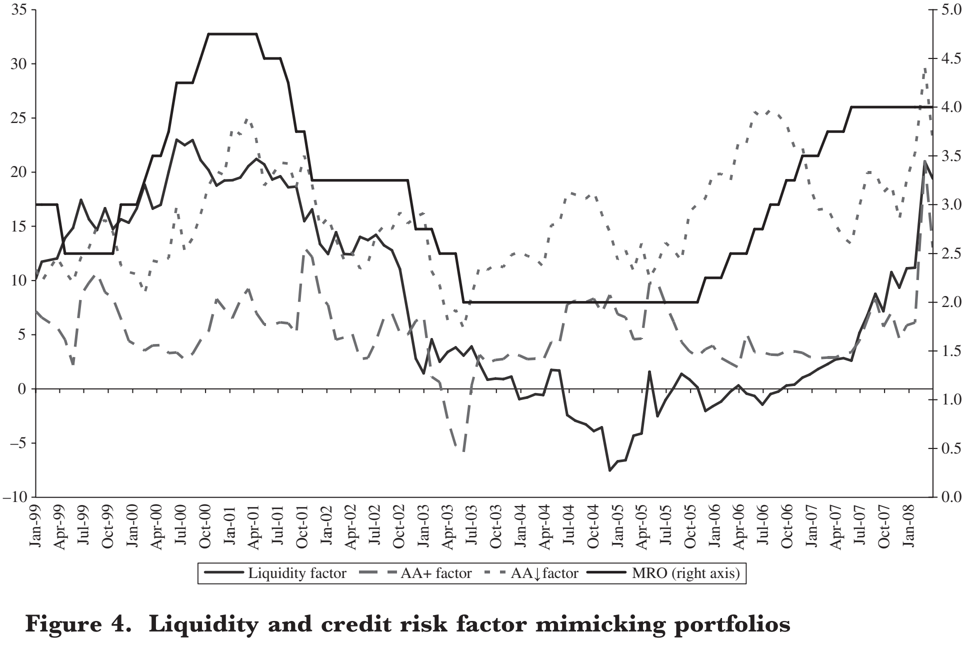

Figure 4. Liquidity and credit risk factor mimicking portfolios

Table 3. Correlations among 'factor mimicking portfolios'

	Liquidity factor	AA+ factor	AA↓ factor
AA+ factor	0.29		
AA↓ factor	0.10	0.43	
MRO	0.74	0.21	0.46

Note: The 'Liquidity factor' is computed as the average of all AAA spreads relative to Germany. The 'AA+ factor' is the average of the difference between yields of AA+ and AAA (excluding Germany) bonds. The 'AA↓ factor' is obtained with a similar computation.

5. EMPIRICAL EVIDENCE

As argued so far, since the introduction of the euro, spreads between government bonds reflect two types of risks: liquidity and credit risk. In addition, other *technical factors* (such as differences in taxation, or in the issuance, clearing and settlement procedures) may contribute to generate positive spreads, though these are expected to be rather small.

Measuring the magnitude of the premiums associated with these risks is important from a policy perspective. Significant default risk premiums may be the result of market disciplinary forces, and therefore call for improvements in the sustainability of public finances. Large liquidity premiums, on the other hand, may be a symptom of market fragmentation and require policies aimed at fostering the ongoing integration process. It is also important to quantify the extent to which spreads in the euro area government bond market are driven by interest rates. At times of loose monetary policy, the above argument would suggest an overall reduction in spreads, simply because risk aversion decreases or the incentives to take greater risks are higher. If governments were to interpret such a spread reduction as a sign of good fiscal policies, this could reduce the incentives of the governments to continue pursuing sound fiscal policies.

To check to what extent the level of interest rates is affecting spreads, we start by running the following regressions:

$$\Upsilon_t^i - \Upsilon_t^b = \alpha^i + \beta^i \cdot r_t + \varepsilon_t^i \tag{4}$$

where Υ_t^i and Υ_t^b denote the yield at time t of the 10-year government bond for country i and Germany, respectively, and r_t is the MRO minimum bid rate decided by the Governing Council of the Eurosystem every first Thursday of the month.[10]

This corresponds to running regression (A11) for each country, assuming h_t is constant and ignoring the distinction between credit and liquidity risk premiums. Table 4 reports the estimates together with the standard errors. Standard errors

[10] In this and the following specifications we have also tried to include as the dependent variable the real short-term interest rate. The results are virtually unchanged, as inflation rates have been very stable at around 2% since the introduction of the euro. This constant and low level of inflation is also reinforced by the firm anchoring of inflation expectations around the level consistent with the ECB's definition of price stability ('close to but below 2%'), as can, for instance, be derived from inflation-indexed bonds or consumer surveys. See, for example, ECB (2006).

Table 4. Regression output for a panel regression with fixed country effects

		AT	BE	ES	FI	GR	IE	IT	NL	PT
α^i	−6.56	−10.07	−6.22	−9.80	−11.19	0.85	−14.73	7.45	1.61	−8.26
	1.02	*1.56*	*1.64*	*1.70*	*2.05*	*2.52*	*2.43*	*1.20*	*1.08*	*1.96*
β^i	4.43	4.74	4.89	5.00	3.83	6.40	4.27	3.36	−0.26	6.77
	0.33	*0.51*	*0.54*	*0.54*	*0.57*	*0.95*	*0.73*	*0.39*	*0.32*	*0.55*
									R^2	0.66

Note: Estimated coefficients of $\Upsilon_t^i - \Upsilon_t^b = \alpha^i + \beta^i \cdot r_t + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

were computed using the 'White cross-section' option in EViews. This option gives standard errors which are robust to cross-equation contemporaneous correlations, as well as different error variances in each cross-section.

The estimates in the first column give the intercept and slope coefficient associated with the French spreads (which are taken as reference in the dummy regression). The coefficients associated with the individual country coefficients are country dummy coefficients. They therefore have to be summed to the coefficients in the first column to obtain the total country effect.

We notice that the coefficient associated with MRO is positive and strongly significant for France. For the other countries there is an always positive and significant additional effect for the slope (except for the Netherlands, whose coefficient does not seem to be significantly different from the French one).

Although these results already provide evidence in support of the maintained assumption that spreads are driven by interest rates, this regression does not permit to identify liquidity and credit risk premiums. We therefore run regression (A12), assuming constant h_t and accounting for the impact of different fiscal position by proxying them with ratings on central government bonds:

$$\Upsilon_t^i - \Upsilon_t^b = (\alpha^P + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \varepsilon_t^i \tag{5}$$

where $R_t^i = 1$ if the rating of country i at time t is equal to rating R and $R_t^i = 0$ otherwise. We include in the regression two rating dummies $R \in \{AA+, AA\downarrow\}$, where the category $AA\downarrow$ includes all the country observations which have a rating of AA or lower. We divided the ratings into three categories, AAA, AA+ and AA or lower, because otherwise there would not be enough cross-sectional variation to obtain meaningful estimates. All ratings are taken from Standard & Poor's.

The results are reported in Table 5.

The estimates have an analogue interpretation to those of the previous table. The first column gives the intercept and slope coefficient of the spreads for government bonds rated AAA. The second and third columns are the coefficients

Table 5. Regression output for a panel regression accounting for differences in rating across different government bonds

		AA+	AA↓
α	−14.56	6.07	8.53
	1.39	*1.94*	*1.14*
β	7.01	0.72	2.69
	0.50	*0.53*	*0.38*
		R^2	0.65

Note: Estimated coefficients of $Y_t^i - Y_t^b = (\alpha^P + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

associated with the dummy variables for the AA+ and the AA or lower categories.

We find confirmation that the interest rate is an important variable in explaining the spreads, entering again with a positive and strongly significant coefficient. The coefficient increases as the rating worsens, suggesting that a deterioration in a country's fiscal position increases the sensitivity of its spreads to the level of interest rates. The intercept increases as the rating decreases, implying an overall higher fiscal burden as a country's debt is downgraded. Interestingly, the R^2 associated with this regression is similar to the one associated with the previous regression with country fixed effects: the explanatory power of the cross-section taken across countries is roughly similar to the one taken across rating groups.

From this regression, we can derive estimates of liquidity and credit risk premiums under the identification conditions discussed in the Appendix (before Equation A12). Liquidity risk premiums are identified via AAA non-benchmark bonds: since these bonds have the same credit risk as the German ones, their spreads should contain no significant additional credit risk premium, but only a liquidity risk premium, reflecting the greater size of the German market and especially its very active futures market. An estimate of the liquidity premium is therefore given by:

$$LP_t = \hat{\alpha}^P + \hat{\beta}^P r_t \tag{6}$$

where the hat (^) denotes the estimated coefficient. This estimate quantifies the extra interest rate that governments with AAA rating have to pay with respect to Germany. Note that the dependence of the liquidity risk premium on the short-term interest rate remains consistent with the argument that monetary policy affects investors' risk taking behaviour: low levels of interest rates induce investors to take on more risk in general, which besides credit risk can also be liquidity risk.

Credit risk premiums, on the other hand, are identified via the rating dummies, and are measured by how much – in addition to the liquidity premium – countries with lower ratings need to pay to attract risk averse investors:

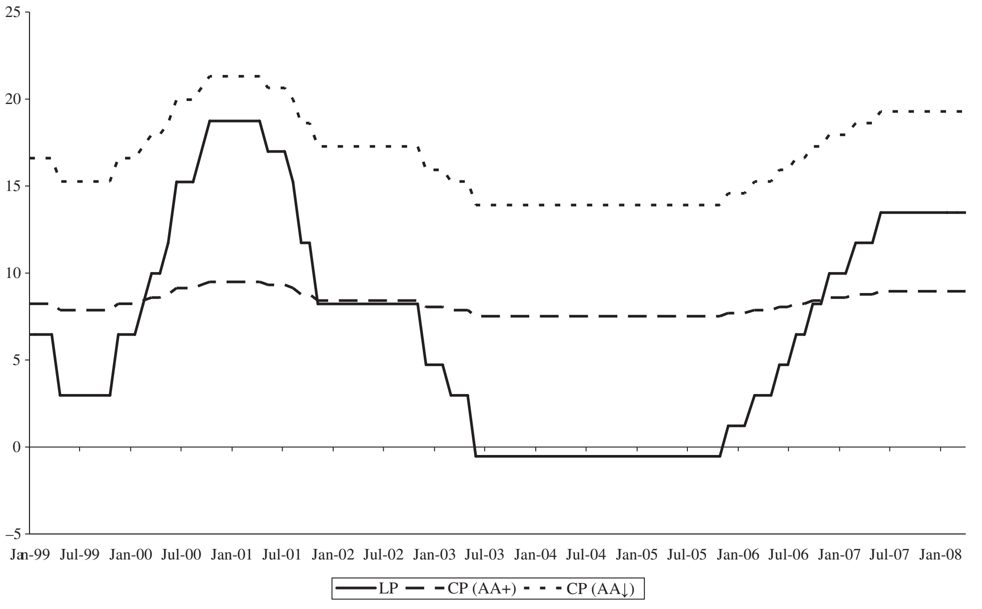

Figure 5. Liquidity and credit risk premiums decomposition (basis points)

$$CP_t^R = \hat{\alpha}^{d,R} + \hat{\beta}^{d,R} r_t \quad R \in \{AA+, AA\downarrow\}. \tag{7}$$

We report the estimates of both liquidity and credit risk premiums in Figure 5. The level of these premiums follows by construction closely the level of the interest rates set by the Eurosystem. We have argued in Section 3, and confirmed in the empirical analysis, that monetary policy does play a crucial role in determining the size of risk premiums.

Two interesting facts emerge from this figure. First, the liquidity premium is much more responsive to the level of interest rates. Not surprisingly, when interest rates are low and liquidity is abundant, liquidity does not seem to play a big role in explaining government bond spreads. On the other hand, when interest rates are high, liquidity risk premiums can explain almost up to a half of the total spread against Germany. This suggests that the greater liquidity enjoyed by the German bund thanks to its well-developed underlying futures market is able to command a sizeable premium. Policy makers may think of strategies aimed at increasing the liquidity of the other markets, as this would result in additional savings on behalf of governments and seems like a necessary step in the direction of a truly integrated European government bond market.

Second, it is not true – as some have argued – that the ongoing process of financial integration has eliminated the disciplinary effect that markets exert on governments: governments with lower ratings do pay on average a credit risk premium, which is increasing with the worsening of the fiscal situation.

6. ROBUSTNESS CHECKS

A direct test of the robustness of our results would be to draw a comparison with developments in government spreads in other monetary unions. Unfortunately, lack of data prevents us from conducting a similar exercise. This lack of data primarily reflects the institutional limits imposed by national governments on sub-national state finances, often in the form of a balanced (non-investment) budget. Consequently, debt ratios and new issuances of debt of lower governments generally are limited, notably for general-purpose bonds. Schuknecht *et al.* (2008) examine yield-at-issue of sub-national governments in Canada and Germany, including the pre-EMU period. As to Germany, they find that in EMU spread differentiation actually increased for states that are recipients of equalization schemes, which they relate to the reduced capacity of the German federal government to borrow. Spreads nevertheless remain limited, as are credit rating differences, reflecting the extensive equalization system, and a bail out-like obligation for mutual support between *Länder* and the federal government following a ruling of the Federal Constitutional Court in 1992.[11] A similar result applies to Canada, which also has an extended fiscal equalization scheme: net recipient states benefit from relatively low interest rate spreads.

In the remainder of this section we will check whether our results are robust to the imposed panel restrictions, to non-linearities, to the introduction of international risk factors commonly used in the literature, and to the use of debt to GDP ratios as proxies for fiscal sustainability. We will also check to what extent short interest rates are important drivers for euro area and US corporate bond spreads.

6.1. Testing panel restrictions

We first test whether the panel restrictions imposed in Table 5 are borne out by the data, by simply adding fixed effect coefficients to the panel regression (we had to impose a common country coefficient associated with MRO to avoid multicollinearity issues):

$$Y_t^i - Y_t^b = (\alpha^{i,P} + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \varepsilon_t^i. \tag{8}$$

Results are reported in Table 6.

Fixed effect coefficients are significant only for a few countries (Austria, Finland, Ireland and Portugal).[12] We see that the fit of the regression slightly improves, but the results remain qualitatively the same. The level of interest rates set by the Eurosystem continues to enter in a positive and strongly significant way in the regression. Furthermore, there is confirming evidence that markets do penalize countries with worse fiscal positions (to the extent that this is proxied by the debt rating).

[11] Indeed, Fitch Ratings on this account assigns the same rating as the Federal government (AAA) to all German states, while other rating agencies allow for some differentiation.

[12] The fact that the fixed effect coefficient for Portugal is high and negative is likely due to possible interaction effects with the dummies (recall that Portugal's rating belongs to the category AA↓).

Table 6. Regression output for a panel regression with fixed country effects and accounting for differences in rating across different government bonds

		AA+	AA↓	AT	BE	ES	FI	GR	IE	IT	NL	PT
α	−13.49	5.74	11.50	4.37	−1.26	−1.21	−2.59	−0.78	−4.89	−3.34	0.81	−8.68
	1.41	*2.65*	*1.98*	*0.63*	*1.59*	*0.96*	*0.78*	*1.74*	*0.92*	*1.53*	*0.30*	*1.63*
β	6.70	1.38	3.13									
	0.47	*0.54*	*0.34*									
											R^2	0.69

Note: Estimated coefficients of $\Upsilon_t^i - \Upsilon_t^b = (\alpha^{i,P} + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

6.2. Testing non-linearities

As shown in the Appendix, h_t depends positively and in a non-linear fashion on Υ_t^b. We approximate this dependence in Equation (A12) with the quadratic polynomial $h_t \approx \Upsilon_t^b + \beta_\Upsilon(\Upsilon_t^b)^2$ and run the following regression:

$$\Upsilon_t^i - \Upsilon_t^b = \chi + [\Upsilon_t^b + \delta(\Upsilon_t^b)^2][(\alpha^{i,P} + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t)] + \varepsilon_t^i. \qquad (9)$$

The results are reported in Table 7.

Adding the non-linear term significantly improves the fit of the regression (whose R^2 jumps from 69% to 76%), but does not change the overall picture: interest rates and rating dummies continue to be positive and strongly significant.

6.3. International risk factors

What about international risk factors as proxied by US spreads by Codogno *et al.* (2003)? We test directly for their significance by including in the regression analysis the interest rate swap spread as a control variable:

Table 7. Regression output for a panel regression accounting for non-linearities

		AA+	AA↓	AT	BE	ES	FI	GR	IE	IT	NL	PT
χ	47.41											
	6.98											
δ	−0.15											
	0.00											
α	−35.08	−0.85	5.10	2.46	2.16	1.08	−1.40	0.38	−2.34	−1.45	0.50	−5.33
	2.67	*1.30*	*1.10*	*0.47*	*0.83*	*0.54*	*0.47*	*0.90*	*0.55*	*0.78*	*0.21*	*0.89*
β	2.79	1.36	2.71									
	0.43	*0.28*	*0.39*									
											R^2	0.76

Note: Estimates of $\Upsilon_t^i - \Upsilon_t^b = \chi + [\Upsilon_t^b + \delta(\Upsilon_t^b)^2][(\alpha^{i,P} + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t)] + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

Table 8. Regression output for a panel regression accounting for international risk factors

		AA+	AA↓
α	−16.76	6.08	6.61
	1.16	*1.47*	*1.26*
β	4.27	0.15	3.03
	0.63	*0.42*	*0.41*
ψ	17.18		
	2.20		
		R^2	0.72

Note: Estimates for $\Upsilon_t^i - \Upsilon_t^b = (\alpha^P + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \psi x_t^{US} + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

$$\Upsilon_t^i - \Upsilon_t^b = (\alpha^P + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \psi x_t^{US} + \varepsilon_t^i \tag{10}$$

where x_t^{US} is the spread between 10-year fixed interest rates on US swaps and the yield on 10-year US government bonds (similar results are obtained using the US corporate bond spread, the alternative proxy for international risk aversion used by Codogno *et al.*).

Results are reported in Table 8.

We notice that the US swap spreads enter the regression with a strongly significant coefficient. However, the introduction of this control variable increases only slightly the overall fit of the regression (about 2%). Moreover, interest rate coefficients continue to remain positive and strongly significant. This signals that international factors may play a role in determining risk premiums: spreads in the euro area are determined not only by local factors, but also by international ones.

6.4. Debt to GDP ratios as proxies for fiscal sustainability

As indicated in Section 4, the use of assessments by rating agencies as a credit risk indicator may have certain drawbacks, such as capturing more factors than just the soundness of public finances. Therefore, we have re-estimated the equation using data on (general) government debt to GDP ratios rather than ratings.[13]

$$\Upsilon_t^i - \Upsilon_t^b = \alpha^i + \beta r_t + \psi^i (D_t^i / GDP_t^i - D_t^b / GDP_t^b) + \varepsilon_t^i. \tag{11}$$

The results, reported in Table 9, are qualitatively similar to those obtained in Section 5: the coefficient on short-term interest rate remains positive and strongly significant.

[13] Since fiscal data on debt is available only at annual frequency, to make results comparable with those of Tables 5 and 6 we incorporated it in the regression using yearly time dummies. That is, the dependent variable is still at monthly frequency and

$$D_t^i / GDP_t = \Sigma_{YEAR}(D_{YEAR}^i / GDP_{YEAR}) S_t^{YEAR},$$

where S_t^X is a monthly time dummy which takes value one in year X and zero otherwise.

Table 9. Regression output for a panel regression with fixed country effects and accounting for differences in debt ratios across countries

		FR	AT	BE	ES	FI	GR	IE	IT	NL	PT
α^i	−14.74		3.94	−11.73	15.39	28.57	21.15	−32.65	23.62	−15.43	23.52
	1.27		*0.83*	*2.03*	*1.19*	*2.89*	*2.70*	*5.01*	*1.94*	*4.35*	*1.71*
β	7.00										
	0.43										
ψ^i		−0.16	1.32	0.59	0.67	1.29	0.88	0.18	0.38	0.91	0.18
		0.37	*0.08*	*0.05*	*0.04*	*0.12*	*0.14*	*0.05*	*0.11*	*0.11*	*0.48*
										R^2	0.80

Note: Estimates of $Y_t^i - Y_t^b = \alpha^i + \beta r_t + \psi^i(D_t^i/GDP_t^i - D_t^b/GDP_t^b) + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

6.5. Evidence from euro area corporate bonds

To assess whether a positive relationship between interest rates and spreads holds for other bonds in general, we run a similar analysis on corporate bond indices, both from the euro area and from the United States.

Figure 6 plots the behaviour of euro area corporate bond spreads since 1999, together with the MRO. Indices were taken from Datastream for 7 to 10-year corporate bonds for three rating categories, AAA, AA and A. We used the corresponding index for 7 to 10-year euro area and US government bonds to compute the spreads. We observe an overall pattern similar to the one seen in Figure 3 for the euro area government bonds. Spreads tend to follow the overall level of interest rates, with high levels in 2000–1, lower levels from 2003 to 2006 and higher levels again towards the end of the sample. We notice a spike between 2002 and 2003 occurred in the aftermath of the Enron and other corporate scandals that shook the financial world. This spike, which is not present in the euro area government bond spreads, is likely to reflect a temporary uncertainty about the intrinsic worthiness of the corporate bonds. The increase in corporate spreads after the summer of 2007 following the subprime fiasco, instead, are considerably more pronounced than those of the government bond market, suggesting that flight to liquidity/quality phenomena tend to be more relevant in corporate than in government bond markets.

On average, spreads of corporate bonds are, as expected, slightly higher than those on government bonds of comparable ratings. This may be explained by the relatively higher liquidity of government bond markets, as well as by the fact that government bonds are usually perceived as safer than any other asset due to countries' taxing capability. Interestingly, corporate spreads have been rising since the beginning of 2006, in response to the increase in MRO. This increase is dwarfed by the big spike that occurred after the 2007 financial turmoil.

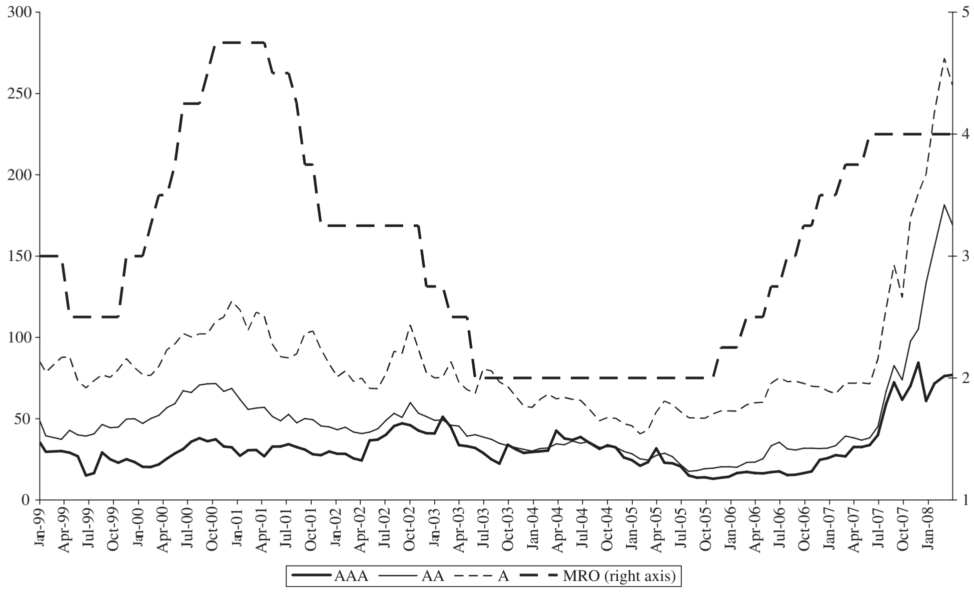

Figure 6. Average monthly spreads of 10-year euro area corporate bond indices (basis points)

Table 10 shows that correlation coefficients between the individual spreads and MRO are also high, although significantly lower than those observed for government spreads. As discussed above, correlations computed excluding the turmoil period confirm that temporary flight-to-quality phenomena are responsible for short-term breakdowns of correlations.

The close relationship between spreads and interest rate levels is further confirmed by running a panel regression similar to the one estimated for the government bond spreads:

$$\Upsilon_t^i - \Upsilon_t^b = (\alpha^P + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \varepsilon_t^i \qquad (12)$$

Estimates are reported in Table 11. The coefficient associated with the MRO continues to be positive and strongly significant. It also increases in a significant way for lower rated corporate bonds, suggesting that the lower the rating the higher the sensitivity of spreads to the interest rate set by the central bank. This result confirms what we found for the euro area government spreads.

Table 10. Correlations between 10-year euro area corporate bond indices and the MRO minimum bid rate

	AAA	AA	A
MRO			
Full sample	0.39	0.39	0.61
Excluding turmoil	0.24	0.77	0.83

Table 11. Regression output for a panel regression accounting for differences in rating across different 10-year euro area corporate bond indices

		AA	A
α^R	0.13	−0.19	−0.09
	0.04	*0.04*	*0.06*
β^R	0.06	0.11	0.20
	0.01	*0.02*	*0.03*
		R^2	0.59

Note: Estimates of $\Upsilon_t^i - \Upsilon_t^b = (\alpha^P + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

Since we observe that the period of financial turmoil may have triggered episodes of flight-to-quality which may have broken the relationship between interest rates and spreads, we re-estimate the panel regression including a crisis dummy for the period from August 2007 to the end of our sample (April 2008):

$$\Upsilon_t^i - \Upsilon_t^b = (\alpha^P + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \psi C_t + \psi^R R_t^i C_t + \varepsilon_t^i \tag{13}$$

where C_t is a time dummy which equals 1 for observations after August 2007 (Table 12).

We observe that the inclusion of the crisis dummy does not change in a qualitative significant way the sensitivity of spreads to MRO, and the coefficient associated with the crisis dummy is positive and strongly significant, indicating increasing spread differentiation in the turmoil period. Tellingly, the overall fit of the regression increases substantially, with the R^2 jumping from 59% to 85%.

Table 13 shows the results of including a crisis dummy in the government bond spreads regression. We notice that, unlike for the corporate bond spreads, the crisis dummy is never significant, and adds very little in terms of explana-

Table 12. Regression output for a panel regression for spreads of euro area corporate bond indices accounting for differences in rating and for the recent financial turmoil

		AA	A
α^R	0.21	−0.14	0.03
	0.02	*0.02*	*0.04*
β^R	0.02	0.09	0.15
	0.01	*0.01*	*0.01*
ψ^R	0.39	0.27	0.58
	0.03	*0.13*	*0.17*
		R^2	0.85

Note: Estimates of $\Upsilon_t^i - \Upsilon_t^b = (\alpha^P + \beta^P r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \psi C_t + \psi^R R_t^i C_t + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

Table 13. Regression output for a panel regression on euro area government bond spreads including a dummy for the recent financial turmoil (with fixed country effects and accounting for differences in rating)

		AA+	AA↓	AT	BE	ES	FI	GR	IE	IT	NL	PT
α	−13.94	5.53	11.62	4.37	−0.81	−1.02	−2.53	−0.62	−4.80	−3.20	0.81	−8.55
	1.51	*2.69*	*2.02*	*0.63*	*1.64*	*1.00*	*0.80*	*1.78*	*0.92*	*1.56*	*0.30*	*1.67*
β^R	6.88	1.35	3.04									
	0.53	*0.58*	*0.38*									
ψ^R	−1.33	−1.95	0.54									
	1.86	*1.78*	*1.44*									
											R^2	0.69

Note: Estimates of $\Upsilon_t^i - \Upsilon_t^b = (\alpha^{i,P} + \beta^{i,P} r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \psi C_t + \psi^R R_t^i C_t + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

tory power, as shown by the unchanged R^2. This evidence suggests that flight-to-quality phenomena are of an order of magnitude more important in the corporate bond market than in the government bond market. It may also reflect the relatively limited variation in ratings for euro area government bonds compared to corporate bonds, as well as lack of strong concerns about the liquidity of government bond markets.

6.6. Evidence from US corporate bonds

Finally, we look at the 10-year US corporate bond spreads, which are plotted together with the monthly federal fund rate in Figure 7. We notice here as well the impact of the corporate scandals in 2002 and of the recent financial turmoil. Crisis periods tend to trigger flight-to-quality effects, which result in an increase in corporate spreads, as investors move away from riskier assets and go into safer government bonds. We notice from the figure that US corporate bond spreads have been gradually increasing since the beginning of 2005, responding to the increase of the federal fund rate, before jumping after the summer of 2007.[14]

These overall trends are confirmed by the correlations reported in Table 14. We see that once we exclude the turmoil period, correlations between spreads and the Federal Funds Rate increase significantly, although they remain lower than those observed for euro area corporate bonds.

We run analogous regressions to those estimated for the euro area corporate bond spreads, with and without the crisis dummy. Results are reported in Tables 15 and 16.

[14] Existing contributions have already documented the existence of a positive relationship between spreads of investment grade bonds and the federal funds rates (Zhang, 2002) and long-term Treasury yield (Bevan and Garzarelli, 2000).

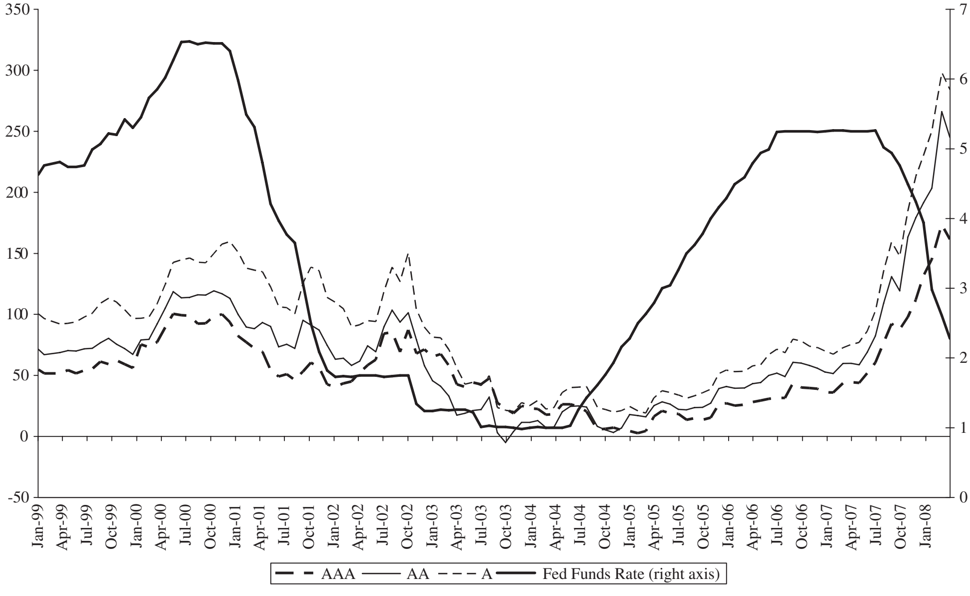

Figure 7. Average monthly spreads of 10-year US corporate bond indices (basis points)

Table 14. Correlations between 10-year US corporate bond indices and the Federal Funds Rate

	AAA	AA	A
Fed Funds Rate			
Full sample	0.33	0.40	0.36
Excluding turmoil	0.46	0.63	0.53

We broadly find confirmation of the results obtained for the euro area corporate bond spreads. First, the coefficient associated to the Federal Funds Rate is positive and strongly significant. Second, the sensitivity of the corporate bond indices to the Federal Funds Rate increases as the quality of the bonds deteriorates. Finally,

Table 15. Regression output for a panel regression accounting for differences in rating across different 10-year US corporate bond indices

		AA	A
α^R	0.31	−0.03	0.20
	0.06	*0.04*	*0.05*
β^R	0.06	0.05	0.05
	0.01	*0.01*	*0.01*
		R^2	0.23

Note: Estimates of $\Upsilon_t^i - \Upsilon_t^b = (\alpha^{i,P} + \beta^{i,P} r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

Table 16. Regression output for a panel regression for spreads of US corporate bond indices accounting for differences in rating and for the recent financial turmoil

		AA	A
α^R	0.28	−0.06	0.17
	0.05	*0.03*	*0.04*
β^R	0.05	0.04	0.05
	0.01	*0.01*	*0.01*
ψ^R	0.71	0.48	0.56
	0.13	*0.08*	*0.10*
		R^2	0.59

Note: Estimates of $\Upsilon_t^i - \Upsilon_t^b = (\alpha^{i,P} + \beta^{i,P} r_t) + \Sigma_R(\alpha^{d,R} R_t^i + \beta^{d,R} R_t^i r_t) + \psi C_t + \psi^R R_t^i C_t + \varepsilon_t^i$. Standard errors, reported in italics below the coefficient, have been computed using White's standard errors, robust to cross-equation contemporaneous correlations and to different error variances in the cross-section.

the crisis dummy is highly significant and considerably increases the overall fit of the regression, without significantly affecting the estimates of the other coefficients.

7. CONCLUSION

There is unanimous consensus in the literature that euro area government bond spreads are mostly driven by a single common factor, associated to a time-varying international risk aversion. In this paper we have argued that developments in risk aversion are related to the level of short-term interest rates, via at least two channels. First, low interest rates increase funding liquidity as well as the incentives of investment managers to take risk, in order to boost the return on their investments. Second, interest rates affect the state of the economy, which in turn is known to be related to agents' risk aversion. Lower interest rates are associated with lower degrees of risk aversion, and therefore with lower government bond spreads.

Our empirical analysis confirmed the existence of a positive relation between short-term interest rates as set by the Eurosystem and euro area government bonds spreads. We also find that the sensitivity of government bond spreads to short-term interest rates increases as the credit quality of the underlying bond deteriorates. These findings are relatively robust, being supported by evidence on the European and the US corporate bond markets, as well as by a series of robustness tests with alternative specifications. Nevertheless our findings do not rule out that other variables may also be important: short-term interest rates may be correlated with an omitted variable, which in turn is correlated with risk aversion or directly to the level of spreads. For instance, one of our robustness analyses shows that, besides short-term interest rates, international risk aversion (as proxied by spreads between 10-year US interest rate swaps and Treasury bonds) continues to play a role in determining euro area government bond spreads. A further analysis on the relevance of various mechanisms linking fundamentals, short-term interest rates and government bond spreads is required to shed more light on this.

A second contribution of this paper is to quantify how much of spread developments reflects the credit risk premium and how much the liquidity risk premium. While in the past, when interest rate spreads reached very low levels, doubts arose whether market discipline still operates in a fairly integrated financial market, our results clearly show that credit risk is priced in the euro area government bond markets, also in normal market circumstances. This implies that the possibilities and incentives for market participants to distinguish between the credit qualities of bonds of different governments have not vanished. Bond market operators demand a higher interest rate if there is a higher risk of default on account of unsustainable public finances as reflected in a lower credit rating. It is, of course, another question whether spreads are sufficiently high to encourage governments to make substantial changes to their fiscal course. At least in the short term, other (political) considerations may dominate budgetary choices.

Events since the start of the financial crisis in 2007 have reconfirmed the notion in the Delors report that market reactions may often be subdued, but sizeable and abrupt in some cases. Sharp increases in credit default swap rates for the bonds of most euro area governments signal potential sustainability problems, partly related to governments taking over financial liabilities of troubled banks. At the same time, it is hard to distinguish the impact of these fiscal considerations from the very high levels of risk aversion, which have caused unprecedented flights to liquidity and to quality.

Although euro area bond markets have already achieved a high degree of integration, liquidity risk is still a factor that is priced in by investors. Specifically, we find that the liquidity premium is rather responsive to the level of interest rates: liquidity premiums tend to be high when interest rates are high. From a policy perspective, this result implies that measures enhancing further integration would be desirable, as they would allow additional cost-savings on governments' interest payments. It is, however, important to ensure that such integration-promoting measures do not undermine the working of market discipline.

A case in point is the idea to coordinate the issuances of government bonds by national debt management agencies, as discussed by the Giovannini Group (2000) and SIFMA (2008). Various forms of closer coordination have been considered. One possibility is to issue a common debt instrument with several country-specific tranches. A more extreme proposal is the set-up of a European debt management agency issuing common euro area government bonds with a single interest rate, and distributing the receipts to the national governments. These forms of European coordination of public debt issuance would certainly contribute to bring to completion the ongoing process of market integration. By removing national distinctions, they would also eliminate liquidity premiums paid by non-benchmark countries. As a result, the euro area government bond market would become much closer to the US example with one issuer, large issue sizes and a large and liquid derivatives market based on these securities.[15] At the same time, however, such far-reaching co-ordination initiatives could eliminate markets' ability to exert discipline on individual governments. They could also infringe the no bail out provision agreed in the Maastricht Treaty, as governments would need to take over repayments of debt of another country in case that country enters into serious financial problems. Furthermore, depending on the countries participating in the initiative, virtuous governments could actually end up paying higher interest rates than before if their bonds are pooled with those of lower credit quality.

Policy initiatives aimed at tackling the current fragmentation of euro area government bond markets therefore need to balance gains in liquidity with the need to maintain market discipline. A less radical proposal allows only countries with equal ratings to have bonds issued by a common institution, with procedures in place in case of a revision in the rating of one of the countries, or setting up special funds guarantees in case of a default (see SIFMA, 2008).

Less controversial initiatives for promoting liquidity aim at a closer coordination of issuance calendars and convergence of tax regimes of government bonds income. While at EU level, interest income from government bonds is generally tax exempted for non-residents, differences in effective tax rates between countries may have an impact on the levels of bond spreads. There are additional technical aspects affecting spreads which should be addressed, such as differences in transactions costs when handling government securities, legal uncertainty on the application of certain tax provisions for foreign investors, and extra costs that international investors have to sustain when holding cross-border securities (for instance because of requirements that withholding tax can only be collected via local operators).

Discussion

Morten O. Ravn
European University Institute

This paper examines an interesting question and finds some intriguing answers to it. The authors investigate the time-series behaviour of return spreads on euro area government debt. Were these debt contracts perfect substitutes, there should be no spreads and spreads should not move over time. This evidently is not the case for the euro area despite the integration of financial markets within this area and despite the various restrictions on fiscal policy meant to limit or even eliminate

[15] See Dunne *et al.* (2006) for a comparison between the fragmented European sovereign debt market and the US Treasury market.

concerns about government debt sustainability. Instead, there are still sizeable government debt return spreads and these spreads are far from constant over time.

This observation begs one to ask what drives these spreads? This is the theme of the current paper. The authors show that there is a strong correlation between spreads and the common euro area interest rate and that bond issuers with lower debt ratings are more sensitive to changes in interest rates. The bond spreads are decomposed into 'liquidity risk', that is risk that is associated with holding an asset that is less liquid (in a broad sense) than another asset, and 'credit risk', that is risk associated with holding an asset for which there is a bigger chance that the issuer may not observe the debt contract. Most of the time-variation is due to the first of these components and this finding is interpreted in terms of movements in 'risk appetite'. Nevertheless, there is still some role for credit risk. The authors conclude that the former of these factors might be addressed by governments cooperating on bond issues.

These results are clearly policy relevant and they are interesting. The large variations in spreads on government debt issues are by themselves surprising given that there is no currency risk in the euro area (unless one seriously thinks that some member countries would leave the euro), that many of the euro bonds are issued in large quantities (which one would think should imply low liquidity risk), and that there is relatively little discussion of worries about government defaults (which should imply low credit risk). Perhaps there are other reasons why spreads move over time but surely these three must constitute the main candidates. Also, the idea that any member country would opt out of the euro within a foreseeable future seems rather far-fetched so one will have to agree that credit risk and liquidity risk are the two main contenders for explaining the time series evidence. And we are not talking about peanuts here. A government with an AA-government debt rating may have been paying a spread of up to 40 basis points over German debt. Thus, it seems that there is a real issue of concern here.

In my discussion I will touch upon a number of issues but at the end of the day, I think that the paper has identified some quite interesting results that other researchers may want to devote some attention to in the future.

Causality

The basic regression of the paper takes the spreads and regresses them on the short-term interest rate distinguishing between AA+ and AA-rated government debt. From this regression, the authors make a decomposition of the spreads into a liquidity premium basically associating the common impact of the interest rate to the liquidity factor while the credit premium is related to how much countries with lower than German rate government debt must pay.

One problem with this approach is that it assumes that the short-term interest rate is exogenous and that movements in the interest rate are unrelated to other factors that may potentially affect the spread. The assumption that short-term interest rates are exogenous is doubtful. A proper measure would instead be some estimate of 'monetary policy shocks', that is, movements in interest rates that are unrelated to factors to which the ECB reacts when setting the interest rate. Indeed it is perceivable that there are underlying factors that affect spreads and interest rates simultaneously and the results therefore may not be appropriate measures of the impact of interest rates on bond spreads. Central banks may, for example, react to the output gap (the deviation of output from some 'natural level') and to the extent that the output gap drives spreads, the estimates suffer from endogeneity of the interest rate. There would be straightforward ways of addressing this concern such as a system approach or even a two-step approach in which spreads are regressed on measures of identified monetary policy shocks. The authors neglect this problem so I would claim that a question mark still remains over the results and, in particular, over the importance of the liquidity premium.

Debt ratings

Another issue is related to the use of debt ratings. Debt ratings are important for the paper's results since it is the distinction between the ratings of different countries' government debt issues that allow for the decomposition into liquidity and credit risk. Yet, there are serious problems with the use of debt ratings.

First, debt ratings are notoriously unreliable. Credit ratings agencies cannot claim much success in forecasting (apart from at shorter horizons) the probability of default. This is true both for corporate debt and for sovereign debt. For that reason, market players probably look at more indicators than simple debt ratings when evaluating the credit worthiness of debt issuers. Therefore, to the extent that debt ratings are noisy indicators of credit risk, the results may underestimate the relative importance of credit risk.

Second, the debt ratings used by the authors are discrete. Therefore, any inframarginal movements in credit worthiness are not captured by these ratings and this would, again, tend to associate too large a fraction of the bonds spreads to the liquidity factor.

Third, and this is perhaps the most serious problem, credit ratings are endogenous. Suppose that credit rating agencies had estimated the same regression as the authors that relates the bond spreads to the interest rate. They would then observe a positive correlation between spreads and the short-term interest rate. Hence, they would tend to down-rate high debt countries when the interest rate rises. Therefore, the regressions in this paper would actually not be able fully to distinguish between the liquidity premium and the credit premium.

How might one deal with these problems? One alternative would be to adopt a slightly more structural approach attempting to estimate credit risk directly. One aspect of such an exercise is related to the next point.

Government debt sustainability

Section 6.4 of the paper introduces government debt to GDP ratio to the basic regression. The motivation for this is that 'credit risk indicators may have certain drawbacks'. Given my comments above, I certainly agree with this. However, I am less convinced that the authors' approach fully deals with these issues. A standard model of government debt dynamics suggests that the path of future government debt to GDP ratios given initial debt to GDP (heroically assuming a status quo situation) is determined by the deficit ratio and by the difference between the growth rate of GDP and the real return on government debt.

Two insights follow. First, it is not sufficient just to control for initial debt to GDP. The sustainability of the government debt to GDP ratio depends also on the deficit ratio and by the growth–interest rate differential. Second, the impact of changes in interest rates is very non-linear. Countries that are growing at low rates and have high deficits will be very sensitive to changes in interest rates while this should not be so for high growing countries or countries that are either running surpluses or low levels of deficits. Take Italy as an example. Over the recent past Italy has been growing at a rate of below 2% per year and has been running budget deficits of around (just below) 3% per year. Thus, increases in interest rates quickly lead to very high debt levels given that Italian government debt to GDP is already standard at 106% of annual GDP. This may partially help understanding the high importance of the liquidity premium since it might capture parts of this non-linearity although the regression analysis does not fully answer this given these two points.

Habit formation and risk appetite

To go back to the beginning, the central idea put forward by the authors is that their results are consistent with a risk appetite story. This story has it that changes in short-term interest rates affect future expected consumption growth (although one would think that it is the real interest rate that matters for consumption growth). Combine this with a model of habit formation (or Stone–Geary preferences) and you would get that increases in interest rates increase local risk aversion. Such increases in local risk aversion would make households less willing to hold more risky assets and assets with larger transactions costs.

This is an idea that has been explored quite extensively in the macro-finance literature. While there may not be consensus about its plausibility, the potential importance of habit formation for explaining variation in asset prices is certainly well recognized. I personally find the idea that households' preferences may be well described by habit formation quite compelling, and habit formation has been shown to be a powerful mechanism for explaining a host of issues in macroeconomics.

However, it is probably pertinent to point out that the habit formation story also has some problems. Otrok *et al.* (2002), for example, point out that habit formation models have problems accounting for the low frequency movements in asset prices when contrasted with the low frequency movements in the moments of consumptions. During the 20th century the persistence and mean of the US consumption growth rates have increased slightly over time while the variance of consumption growth rates has declined. Feed this into an asset pricing model with habit formation and it would predict a decline in the equity premium over time while the risk free rate should have increased. Yet, in US data, the risk free rate has declined and the equity premium has, if anything, increased slightly secularly. Thus, while the habit formation model performs well at high to medium frequencies, it seems less able to account for low frequency movements.

Thus, if one accepts the importance of the liquidity premium for explaining the time variation in government bond spreads, one might want to look further than habits for explanations of this. Nonetheless, habits may be a good way of accounting for the high to medium frequency movements in the data.

Summary

The authors have written an interesting and thought-provoking paper on the determinants of the time variation in euro area government bond spreads. Their results indicate that liquidity premia account for a large fraction of the time variation in the spreads but also that market mechanisms are at work through credit risk. I find it surprising that liquidity risk appears to be so important and I have provided several arguments for why the second factor may be underestimated by the authors but answers to this will need to come from future research into the issues studied by the authors.

David Thesmar
HEC Paris

This is a thought-provoking paper but I think the statistical results are a bit over-interpreted. Before going to the interpretations, let me first summarize the results. First, government bond spreads in the EMU are sensitive to movements in short interest rates: when short-run rates increase, so do spreads on sovereign debt, for both Germany and Greece. Second, this sensitivity is (slightly) higher for governments that have lower ratings (higher risk of default). These two pieces of evidence are based on simple OLS regressions run on monthly data on 1999–2008.

The authors have their own reading of these results. The short-run interest rate measures the future state of the economy: when it increases, the economy will deteriorate as monetary conditions will become tighter. This will make future sovereign debt repayments riskier cash flows, in particular if the country is already risky (= has a bad rating). Thus, the authors claim that they have found a good way (short-run interest rates) to measure the common risk factor (future state of the economy) that explains sovereign bond spreads. In addition, the fact that even German debt is sensitive to such fluctuations, while the risk of default seems negligible, certainly means that there must be an additional liquidity risk factor, in addition to the risk of default. Exposure to the liquidity factor being the same for all bonds, the difference across bonds has to come from exposures to future economic slowdown.

Saying that the short-run interest rate is a sufficient statistic for the future rate of growth of the economy is in my view a bit too fast. Other shocks may also happen than changes of the short-run interest rate (for instance, exchange rate, commodity prices, or fiscal deficit). A more direct approach could be to find a good predictor of future growth, and ask if this predictor explains well sovereign debt spreads. Ultimately, the authors could then check whether including the short interest rate does wipe out the growth predictor in credit spread regressions. Direct evidence of their claim is severely lacking.

Besides, the authors make the implicit assumption that the liquidity premium is the same for all bonds, but there is no reason to believe that this is true. One possibility is that liquidity of riskier bonds dries up more quickly than the liquidity of riskless bonds such as the German bund. Thus, the fact that bond spreads react more when the short-run interest goes up can simply be interpreted as evidence that the exposure to liquidity risk is stronger for bonds with lower ratings. Hence, the evidence provided in the paper does not prove at all that the short-run interest rate proxies for the future state of the economy. Liquidity risk may explain everything. One possible way out of this could be to look at bid-ask spreads directly, and show, for instance, that they are all affected to a similar extent by changes in the short-run interest rate. If that were true, this would give the reader confidence that something else (i.e. beyond liquidity) happens.

The authors have a particular story in mind when they argue that the current short-run interest rate proxies for future growth: they invoke habit formation. When growth slows down, people save less to maintain their habit. This reduces savings and pushes interest rates up. Recent finance literature on liquidity (Adrian and Shin, 2008; Brunnermeier and Pedersen, 2008) argues otherwise: an increase in interest rates reduces the ability of financial intermediaries to borrow and inject liquidity in the market. This increases bid-ask spreads and reduces prices (increases spreads). The habit formation story is plausible but not totally natural, and I miss an explanation of why it should be preferred to the other one (the paper does not propose any test). In fact, an even older literature in financial economics argues that there should be a flight to quality to well-rated bonds in case of liquidity risk (as is currently happening with US T-bills): thus an increase in short-run interest rates should result in spread widening for bonds with low ratings, and a narrowing for bonds with a high rating.

So we have three possible stories: habit formation, financial intermediary balance sheets, or flight to quality. Now, let's get back to the data, and see how much it can tell us. It spans a period of about 10 years, with basically one business cycle, so identification is difficult. The habit formation story strikes me as a business frequency kind of story, but since we have at most 1.5 business cycles in the data, I don't see how we can find any evidence of it. The flight to quality story is even worse, since it is typically triggered by a rare event such as the one we are currently experiencing on credit markets. We cannot test it either with the data at hand. The last one that seems easier to test with monthly data is the Adrian–Shin theory based on endogenous financial intermediary balance sheet (low interest rates allow them to lever up and provide liquidity). The response to shocks on short-run interest rates could show up at the monthly frequency.

On the basis of the evidence in the paper, the data appear consistent with the last of these explanations. My only quibble is that we need to be sure that such evidence is really identified on high frequency movements and not on long trends. To check on this, one could test for time series stationarity and control for potential co-integration. Getting the econometrics right here is important to help readers know what they should take away from the paper.

Panel discussion

Francesco Caselli opened the panel discussion asking for a clarification on the notion of liquidity risk in the paper, as liquidity risk in the sense of market thinness seems farfetched in large bond markets, where at most there can be some infra-marginal change in credit risk. He also noticed that while the paper quickly rules out exchange rate risk the possibility that some peripheral countries may be forced to leave the EMU is in some market participants' minds, and spreads may well take this possibility into account. Hans-Werner Sinn remarked that the relationship between spreads and risk premia needs to be clarified, as they are different things, and treating risk premium as an indicator of debt reliability is confusing. Indeed, an expectation of default is incorporated in interest rate differentials even if there is no risk premium. The authors replied that 'liquidity' in the paper refers to the risk that agents bear if they want to sell before expiration, which of course is affected by default risk. Abandonment of the common currency would be (partial) default on government obligations.

Ashoka Mody stressed that the common factor needs to be identified to interpret findings. In the United States there is a strongly negative relationship between the level of interest rates and changes in spreads, and a substantial literature tried to interpret its variation over time in terms of changes in monetary policy rules. Perhaps monetary policy is different in the EMU with respect to the United States in a way that explains the results, and understanding this point may be far more interesting than proposing an interpretation which is beyond what the data support.

The panel questioned the use of credit ratings and discussed other data issues. According to Richard Portes, the incompetence of rating agencies not only was manifest recently in private bonds, but generated plenty of earlier evidence of bad judgment on sovereign risk in Argentina and other crises. He also suggested having a look at CDS spreads, which seem to be a reasonable market estimate and are available up until fairly recent years. The authors pointed out that government bond ratings are not based on the same procedure as private bond ratings, and that CDS spreads are not available for very long periods and showed very little volatility. The authors also thought that default is a small concern in the euro government bond market, and that their theoretical framework is arguably a better explanation of recent increases in spreads even across very reliable debt instruments, such as French and German ones. Hans-Werner Sinn disagreed, noting that default cannot be simply ruled out: the case of Iceland and other recent events indicate that at least a few basis points can be explained by default risk. Richard Portes disagreed in turn, remarking that Iceland did not default on sovereign debt.

APPENDIX: A CONSUMPTION-BASED MODEL FOR BOND YIELD SPREADS

To understand the fundamental drivers of government bond spreads and arrive at an empirical specification, we use a simple consumption based model to express yield differentials in terms of credit and liquidity risk premiums. We proceed in steps. We first show how to express yield differentials in terms of price differentials. Next, we decompose the price of a bond in terms of the stochastic discount factor. Finally, we bring the two blocks together.

Expressing spreads in terms of price differentials

The yield Y_t^i of an N-period bond i is implicitly defined as the solution to the following equation:

$$P_t^i = \sum_{n=1}^{N} \frac{d_n^i}{(1 + Y_t^i)^n} \tag{A1}$$

where d_n^i is the payment of bond i in period n. Although there is no analytical expression for Y_t^i in terms of P_t^i, we can write $Y_t^i = f(P_t^i)$. From the definition of yield, it must be that $f'(P_t^i) \equiv \partial f(P_t^i)/\partial P_t^i < 0$ and $f''(P_t^i) \equiv \partial^2 f(P_t^i)/\partial (P_t^i)^2 > 0$. That is, there is an inverse and convex relationship between yields and prices of a bond. The yield differential between a bond i and a benchmark bond b is therefore:

$$\begin{aligned} Y_t^i - Y_t^b &= f(P_t^i) - f(P_t^b) \\ &\cong f'(P_t^b)(P_t^i - P_t^b) \end{aligned} \tag{A2}$$

where the approximation is obtained by applying a first order Taylor expansion around P_t^b. Since $f'(P_t^b) < 0$, we can rewrite the relationship between yield and price differentials as:

$$Y_t^i - Y_t^b \cong h_t(P_t^b - P_t^i) \qquad h_t \equiv -f'(P_t^b) > 0. \tag{A3}$$

Note that $\partial h_t / \partial P_t^b < 0$ because of the convexity properties of bonds. Therefore the lower the price P_t^b the higher the yield Y_t^b and the higher h_t. Even with constant or slow varying price differentials, the fact that h_t co-varies with Y_t^b implies that also the yield spreads co-vary with Y_t^b. This provides a mechanistic explanation linking the spreads to the level of yields.

Pricing bonds with a stochastic discount factor

The price of any asset can be expressed as $P_t^i = E_t(m_{t+1} x_{t+1}^i)$, where $x_{t+1}^i = d_{t+1}^i + P_{t+1}^i$, d_{t+1}^i is the coupon payment at time $t + 1$, $m_{t+1} = \beta u'(c_{t+1})/u'(c_t)$ and c_t is the level of consumption at time t (see for instance Cochrane, 2005). Exploiting the relationship $E(xy) = E(x)E(y) + \mathrm{cov}(x, y)$, we obtain:

$$P_t^i = \underbrace{E_t(m_{t+1})E_t(d_{t+1}^i + P_{t+1}^i)}_{\text{Expected payoff}} + \underbrace{\mathrm{cov}_t(m_{t+1}, d_{t+1}^i)}_{\text{Credit risk premium}} + \underbrace{\mathrm{cov}_t(m_{t+1}, P_{t+1}^i)}_{\text{Liquidity risk premium}}. \tag{A4}$$

The price of a bond is given by the future expected cash flow plus risk premiums. The credit risk premium is generated by the covariance between the next period dividend and the stochastic discount factor. The liquidity risk premium is due to the covariance between next period price and the stochastic discount factor. We call this liquidity risk premium as it arises from the uncertainty of the price when liquidating the asset next period. If an investor were to hold the bond until maturity, he would bear no liquidity risk.

In Equation (A4), we can substitute recursively for the prices and obtain:

$$P_t^i = \sum_{n=1}^{N} z_{t,n} E_t(d_{t+n}^i) + \sum_{n=1}^{N} z_{t,n-1} CP_{t+n}^i + \sum_{n=1}^{N} z_{t,n-1} LP_{t+n}^i \tag{A5}$$

where $z_{t,0} = 1$, $z_{t,k} \equiv \Pi_{j=1}^{k} E_t(m_{t+j})$ for $k \geq 1$, $CP_{t+n}^i \equiv \mathrm{cov}_t(m_{t+n}, d_{t+n}^i)$ and $LP_{t+n}^i \equiv \mathrm{cov}_t(m_{t+n}, P_{t+n}^i)$. Therefore the price of a bond is equal to its expected future cash flow plus the future credit and liquidity risk premiums.

To understand our definition of liquidity risk, it may be helpful to consider a simple case of a two-period bond, with no credit risk. Suppose the bond pays d_1 in period 1 and $d_2 + \bar{P}$ in period 2. Given that d_1 and $d_2 + \bar{P}$ are non-random (we assumed that there is no credit risk), the price of the bond can be shown to be:

$$P_0 = [z_{t,1} d_1 + z_{t,2}(d_2 + \bar{P})] + (d_2 + \bar{P})\mathrm{cov}_t(m_1, E_1(m_2)). \tag{A6}$$

The liquidity risk premium in this case is driven by the covariance between the stochastic discount factors in the two periods. However, this is not enough to give a yield differential between two bonds with no credit risk, but with different liquidity: since the risk premium depends only on the stochastic discount factors, the price must be the same for any bond with the same cash flow, and the yield differential must be zero. To obtain a bond specific liquidity premium, suppose there is a probability π^i that the bond i cannot be traded at time 1, with $\pi^i > 0$. This may be due, for instance, to market segmentation produced by the fact that the benchmark bond has a larger pool of investors (in the case of the German Bund this could be due to the existence of a large underlying futures market).[16] In this case, $P_1^i \leq P_1^b$ even if they have exactly the same payoff at time 2, implying $P_0^i < P_0^b$, where P^b is the price of the benchmark bond.

Spreads and risk premiums

Combining relationships (A3) and (A5), we can express yield differentials in terms of expected cash flows and risk premiums:

$$Y_t^i - Y_t^b \cong h_t \sum_{n=1}^{N} \left[z_{t,n} E_t(d_{t+n}^b - d_{t+n}^i) + z_{t,n-1}(CP_{t+n}^b - CP_{t+n}^i) + z_{t,n-1}(LP_{t+n}^b - LP_{t+n}^i) \right]. \tag{A7}$$

Since the probability of default of euro area government bonds is extremely low, the first term of the above expression is very close to zero.[17] According to our decomposition, time variation in yield spreads must therefore be driven by one of the following:

- changes in h_t – we saw that higher yields Y_t^b imply higher h_t and therefore higher spreads;
- changes in $z_{t,n}$ – the higher the rate at which one discounts future risk premiums, the lower the spreads;
- time variation in risk premiums.

To understand the fundamental sources of time variation in risk premiums, it is helpful to rewrite them in terms of the stochastic discount factor:

$$\begin{aligned} CP_{t+1}^b - CP_{t+1}^i &= \mathrm{cov}_t(m_{t+1}, d_{t+1}^b - d_{t+1}^i) \\ LP_{t+1}^b - LP_{t+1}^i &= \mathrm{cov}_t(m_{t+1}, P_{t+1}^b - P_{t+1}^i) \end{aligned} \tag{A8}$$

[16] Li and Primbs (2005), for instance, analyse the pricing implications of markets where the investor groups that trade in one market are a strict subset of the investor groups that trade in the other market.

[17] Note that this can still be consistent with a positive default risk premium: default may occur at times of very low consumption, i.e. at times of high marginal utility, and therefore command a high risk premium.

where $m_{t+1} = \beta u'(c_{t+1})/u'(c_t)$ measure the marginal rate at which the investor is willing to substitute consumption at time $t+1$ with consumption at time t. Time variation in risk premiums is due to time variation in the covariance between the stochastic discount factor and the differential payoffs of the bonds. To arrive at an empirical specification for yield spreads we must understand what drives these covariances.

Empirical specification

To fix ideas and arrive at a simple empirical specification, assume that the representative agent has the following utility function, $u(c_t - X_t) = [(c_t - X_t)^{1-\zeta} - 1]/(1-\zeta)$, $(\zeta > 0,\ \zeta \neq 1)$, where c_t is the real consumption at time t and X_t is a subjective reference level against which consumption is measured (here we follow the set up of Brandt and Wang, 2003). The defining feature of this utility function is that it yields a time-varying relative risk aversion $RRA_t \equiv \zeta c_t/(c_t - X_t)$. Define $\gamma_t \equiv \ln(RRA_t)$ and express the stochastic discount factor in terms of risk aversion and consumption growth, $m_{t+1} = \beta \exp\{\zeta(\gamma_{t+1} - \gamma_t - g_{t+1})\}$, where $g_{t+1} \equiv \ln(c_{t+1}/c_t)$. Brandt and Wang further assume that the log relative risk aversion depends on future consumption growth as $\gamma_{t+1} = \bar{\gamma} + \phi(\gamma_t - \bar{\gamma}) - \lambda(\gamma_t)\eta_{t+1}$, where $\eta_{t+1} \equiv g_{t+1} - E_t(g_{t+1})$ and $\lambda(\gamma_t)$ is a sensitivity function which measures the sensitivity of the agent's log risk aversion to future consumption growth and is parameterized as $\lambda(\gamma_t) = \exp\{\gamma_t\}/\zeta - 1$. This parameterization reflects the intuition that a more risk averse agent is also more responsive to changes in consumption levels. Conditioning on the information available at time t and assuming that the random variables of interest are jointly normal, application of Stein's lemma gives:

$$\mathrm{cov}_t(m_{t+1}, P^b_{t+1} - P^i_{t+1}) = \zeta E_t(m_{t+1})\mathrm{cov}_t(\eta_{t+1}, P^b_{t+1} - P^i_{t+1}) \cdot c_t/(c_t - X_t). \quad \text{(A9)}$$

The above expression shows that the liquidity risk premium depends on the level of consumption relative to the habit.

Combining this with Equation (A7), neglecting the expected payoff differential and assuming that the covariance terms and the expected discount factors are constant over time, we obtain:

$$Y^i_t - Y^b_t \cong h_t \sum_{n=1}^{N} (\theta^{i,P}_n + \theta^{i,d}_n) E_t[c_{t+n-1}/(c_{t+n-1} - X_{t+n-1})] \quad \text{(A10)}$$

where $\theta^{i,p}_n \equiv \zeta E_t(m_{t+n})\mathrm{cov}_t(\eta_{t+n}, P^b_{t+n} - P^i_{t+n})$ and $\theta^{i,d}_n \equiv \zeta E_t(m_{t+n})\mathrm{cov}_t\ (\eta_{t+n}, d^b_{t+n} - d^i_{t+n})$. Yield spreads depend on future levels of expected consumption, relative to the habit. As future levels of consumption decrease and approach the habit, risk aversion increases. In turn, higher levels of risk aversion command higher risk premiums and ultimately higher spreads. Brandt and Wang (2003) show that the model can be easily extended to cover the case of nominal consumption. In this case, an unexpected increase in inflation represents an additional channel which raises aggregate risk aversion.

In such a framework, if higher interest rates reduce expected levels of future income and consumption (as implied for instance by New Keynesian models), they also reduce investors' willingness to bear risk and increase the spreads of bond yields over the benchmark.[18] Taking a linear approximation of the link between expected consumption and interest rates (r_t), i.e. $\Sigma_{n=1}^{N}\theta_n^{i,P}E_t[c_{t+n-1}/(c_{t+n-1}-X_{t+n-1})] = \alpha^{i,P} + \beta^{i,P}r_t + \varepsilon_t^{i,P}$ and similarly for the term involving $\theta_n^{i,d}$:

$$Y_t^i - Y_t^b \cong h_t[\underbrace{(\alpha^{i,P} + \beta^{i,P}r_t)}_{\text{Liquidity risk premium}} + \underbrace{(\alpha^{i,d} + \beta^{i,d}r_t)}_{\text{Credit risk premium}}] + \varepsilon_t^i. \tag{A11}$$

This equation cannot be estimated as it is not identified. We can, however, arrive at an estimate of liquidity and credit risk premiums by imposing the following identification conditions:

1. All countries have the same liquidity risk premium, i.e. $\alpha^{i,P} = \alpha^P$ and $\beta^{i,P} = \beta^P$ for all i.
2. Countries with same rating as Germany pay no credit risk premium.
3. Countries with same rating R pay the same risk premium, i.e. $\alpha^{i,d} = \alpha^{d,R}$ and $\beta^{i,d} = \beta^{d,R}$ for all countries i rated R.

With these assumptions and denoting with R_t^i the dummy variable for the rating of country i at time t, we arrive at the following empirical specification:

$$Y_t^i - Y_t^b \cong h_t[\underbrace{(\alpha^P + \beta^P r_t)}_{\text{Liquidity risk premium}} + \underbrace{(\alpha^{d,R}R_t^i + \beta^{d,R}R_t^i r_t)}_{\text{Credit risk premium}}] + \varepsilon_t^i. \tag{A12}$$

The assumption that all countries have the same liquidity risk premium may appear overly restrictive. However, the microstructure of trading for government bonds in Europe suggests that liquidity conditions are not too dissimilar between countries. The trade of government bonds on electronic platforms (MTS) and the existence of primary dealers contribute to maintaining relatively narrow bid-ask spreads, at least in normal times (see Dunne *et al.*, 2006). Bid-ask spreads – which is the standard proxy for liquidity in the market microstructure literature – averaged in the 2004–7 period within the range of 0.03–0.06 for those countries with reliable data and show very little correlation with government bond spreads.[19]

[18] Constructing a business cycle model with habit persistence which is consistent with business cycle facts is not trivial. See Boldrin *et al.* (2001) for such an example where high interest rates can be negatively correlated with future output. Interest rates are only a possible channel through which future consumption can be affected. An alternative mechanism through which monetary policy actions affect risk premia is proposed by Alvarez *et al.* (2008).

[19] Data are based on Reuters information and have been corrected for outliers.

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