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## Determinants of euro-denominated corporate bond spreads

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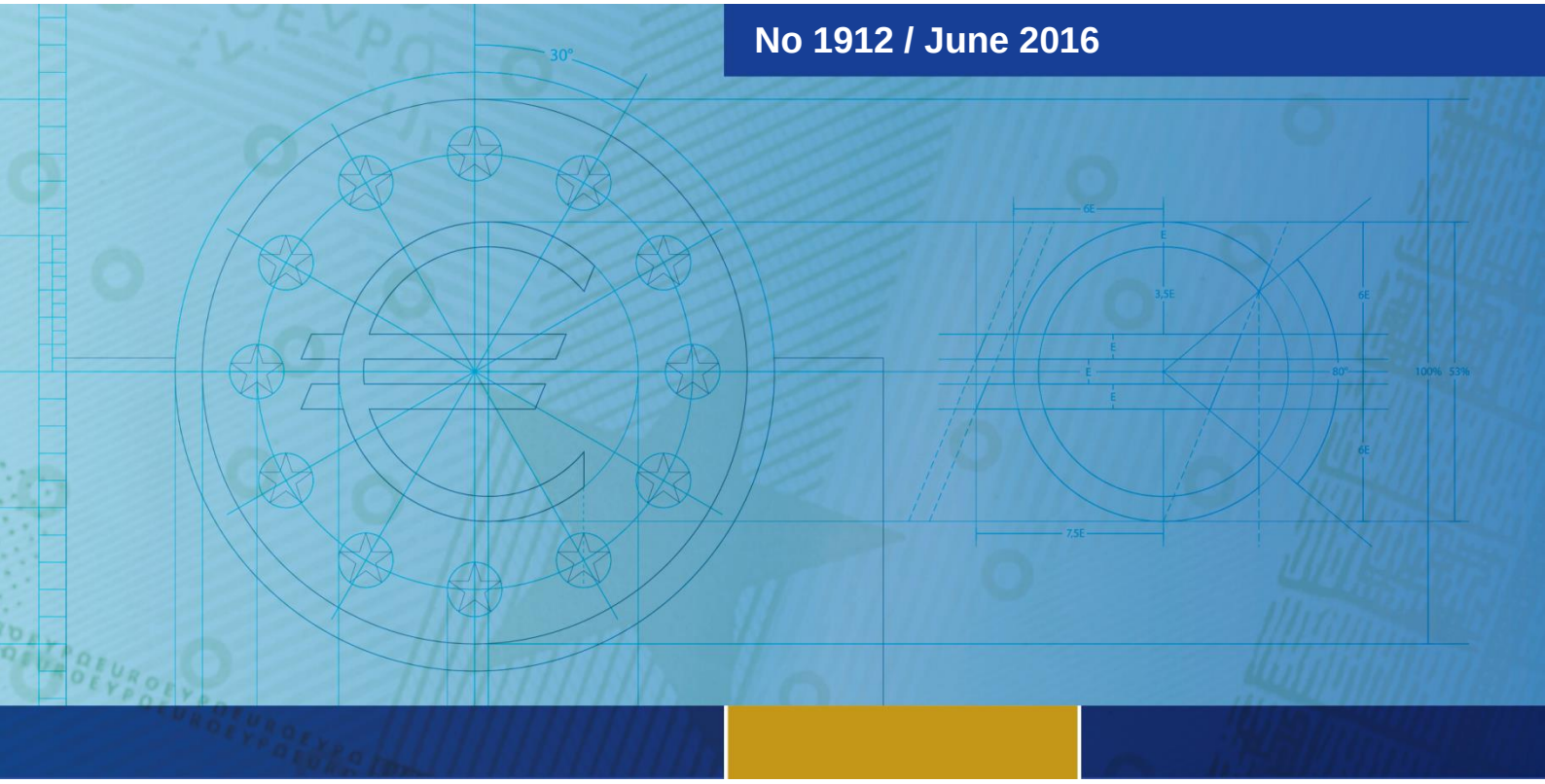

**Abstract**

This paper computes time-varying indicators of the relative importance of different credit spread determinants, including rating, sector and country attribution as well as the coupon rate, maturity and liquidity on the basis of the comprehensive dataset of individual bonds. Additionally, it decomposes variances of rating-specific (country- and sector-specific) spread indices into the impacts of explanatory variables. Both cross-sectional and time series analyses confirm that the rating effect was the major driver of corporate bond spreads during the pre-crisis period, while the recent financial crisis was characterised by increased cross-country and cross-sector heterogeneity. The sector effects in corporate spreads together with the rating effects for high-rated and low-rated bonds are found to be more closely linked to default rates and stock indices, whereas the common effect also to be linked to business cycle conditions. The dataset also allows documenting a break-up in the existence of country ceilings for corporate bond ratings during the crisis.

JEL classification: G12, C21, C22, E44
Keywords: corporate bond spreads, credit risk

## Non-technical summary

The euro-denominated corporate bond market, which still lags its US counterpart both in terms of absolute value and relative to the size of the economy, has undergone substantial changes during the last two decades, which include not only growth of its outstanding volume, but also significant changes in its decomposition. Corporate bond spread indices, which are traditionally used to comprise market developments by means of a single statistics, could provide a misleading picture. Currently available indices for euro-denominated corporate bonds differentiate only between various ratings of issues, thus, they mask the heterogeneous developments in corporate bond spreads across individual countries as well as different industrial segments of the market. At the same time, any euro area country-specific or industry-specific corporate bond index does not account for significant changes in rating decomposition, occurred during the last decade. Moreover, most of euro-denominated corporate bond indices include non-European euro-denominated bonds as well as bonds with embedded special features; they also mix bonds with different maturities and coupons. Therefore, our analysis of factors affecting credit spreads is based on the comprehensive dataset of the most representative individual bonds. This dataset allows us to describe the substantial changes in rating, country and sector decompositions of the euro-denominated investment grade corporate bond market and the cross-country heterogeneity in downgrading and upgrading processes. I document that an overpricing of sovereign risk during the euro area sovereign debt crisis led to a counterintuitive break-up of the existence of country ceilings for corporate bond ratings in all countries in our sample, except Germany and the Netherlands, and even to the sharp declines of sovereign ratings in some countries under stress to the levels of the minimal investment grade corporate ratings in these countries.

This paper examines the relative importance of the corporate bond spreads determinants, such as rating, country of risk, industry, a coupon rate, liquidity and time to maturity. The analysis shows that before 2007, the rating effect was the major driver of corporate bond spreads, while the recent episode of the financial crisis was characterised by the increased cross-country and cross-industry heterogeneity. The time series of the rating, country and sector effects together with the proportion of cross-sectional variance, explained by these effects, indicate the time-varying pattern of market segmentation. Subsequently, I continue to investigate the relative importance of the credit spreads determinants for the volume-weighted country, rating and sector corporate spread indices as well as the country-sector-specific spread indices. During the pre-crisis period, the rating effect was the most dominant for all types of indices. Afterwards, during the period of financial crisis, the dominance of the rating effect becomes less pronounced and the heterogeneity in country corporate spread indices increases.

The empirical exercise confirms that most of the determinants of credit spreads suggested by theoretical and empirical studies (business cycle conditions, information contained in default rates, returns and volatilities of stock indices, real interest rates and the slope of the risk-free yield curve) are important for the common factor in credit spreads, affecting all bonds identically, and the coefficient describing the term premia in corporate spreads and responsible for the steepness of the corporate spread curve. The sector effects together with the rating effects for high-rated and low-rated bonds can be explained rather well using the information contained in default rates and stock prices. By contrast, the rating effects for bonds in the middle segment of a rating scale has a lower proportion of variance explained and requires information about cyclical component of economic environment. The country effects in general are more closely linked to the country-specific default rates and returns on aggregate stock indices.

## 1. INTRODUCTION

Monitoring corporate bond markets is important for monetary policy, because the markets affect the link between the central banks' policy rates and the corporate sector's cost of funds. Moreover, corporate bond yields provide a timely and forward-looking measure of the general business climate. The euro area corporate bond market is relatively young compared to the government bond market and still smaller than in the US, both in absolute value and relative to the size of the economy. Market-based debt funding remains a comparatively minor source of external financing for euro area firms non-financial corporations. However, in the last couple of years, the net issuance of corporate bonds in countries less affected by financial tensions has increased and market–based financing has been substituting for bank-based financing to a certain extent.

This paper relates to the extensive branch of literature that analyses the variables affecting the behaviour of credit spreads. Empirical studies have underlined the difficulties of theoretical corporate bond spread models in explaining the observed spreads. However, even those empirical studies that avoid being based on certain theoretical models of credit spreads and instead use a data-driven approach to account for a rich set of inputs, such as taxation, liquidity, default loss and business cycle conditions, explain only some fraction of variance in corporate bond spreads. This fact led to the emergence of the "credit spread puzzle" concept in corporate finance (see the literature overview in Christensen, 2008).

The purpose of the current paper is to examine the factors driving credit spreads, defined as the difference between the corporate bond yields and the risk free rate of exactly the same maturity. On the basis of cross-sectional regression I, first, distinguish between the impact of individual bond characteristics and systematic risk factors as well as term-premia in corporate bonds. Second, I inspect the time-variation in the relative importance of different drivers of corporate spreads and quantify the time-variation in market segmentation. Third, I decompose variances of rating-specific (country- and sector-specific) spread indices into the impacts of explanatory variables and compare the output of the cross-sectional and time-series analysis. Finally, I consider the determinants of the components of credit spreads, such as the common factor, the country, rating and sector effects, etc.

The analysis of overall trends in corporate euro-denominated bond spreads is often based on corporate bond indices. This might provide misleading results due to several reasons.[2] To avoid this issue, the current paper exploits a comprehensive dataset of the most representative individual euro-denominated investment grade bonds without embedded special features. In addition, taking into account that the pricing of the euro-area sovereign bonds was contaminated by the sovereign debt crisis, I refine the traditional measure of corporate spreads with respect to government bond yields and use the swap curve to proxy the euro-area risk-free rate. The dataset also permits to construct a refined proxy of liquidity, defined as the bid-ask spread scaled by the mid-yield.

[2] Currently available indices for euro-denominated corporate bonds differentiate only between various ratings of issues, thus, they mask the heterogeneous developments in credit spreads across individual countries-of-risk as well as different industrial segments of the market. Moreover, substantial downgrading process has changed the rating decomposition of the overall market and its country or industry components; therefore, the interpretation of the values of any country-specific or industry-specific corporate bond index will be inaccurate without considering changes in its rating decomposition. Besides, most of euro-denominated corporate bond indices include non-European bonds; hence, the interpretation of the overall index might be biased, when the pricing of the domestic and the oversee issues decouples. Indices also mix bonds with different maturities and coupons, thus, they do not distinguish properly between risk- and term-premia. Also, indices include corporate bonds with special features (callable, putable, etc), which prices embed different credit risk characteristics.

This comprehensive dataset allows me to describe the changes in the rating, country and industry decomposition of the euro-denominated investment grade corporate bond market in between 1997 and 2014 (see Section 2). I document cross-country heterogeneity during the various sequences of downgrades and upgrades together with a pronounced impact of the sovereign debt crisis on the changes in sovereign and corporate ratings. In particular the sovereign debt crisis led to a break-up of country ceilings for corporate bond ratings in all countries in our sample, except for Germany and the Netherlands. Moreover, sovereign ratings declined sharply in some countries that faced sovereign debt stress: they fell below the weighted average of corporate bond ratings and even reached the levels of minimum investment grade corporate ratings.

Considering the cross-section of corporate bonds in each period in section 3, I construct time-varying indicators of the relative importance of the various determinants of credit spreads, including rating, country-of-risk and sectoral attributions, the coupon rate, maturity, and liquidity. I also inspect the proportion of cross-sectional variance that is explained by these determinants. The estimate of the time-to-maturity coefficient suggests an upward sloping corporate spread curve, which also steepens in time. High importance of the coupon effect underlines either the impact of duration and convexity on corporate bond pricing or the impact of the tax effect. The analysis helps to quantify the time-varying market segmentation: the magnitude and the dispersion of the country effects increased significantly from 2010 and the sector effect became significant starting from 2007.

In section 3.4, I construct exact maturity-matched and volume-weighted credit spread indices for different rating, country or industry attribution of underlying bonds and decompose their variances into the impact of the maturity, coupon, liquidity effects, the pure rating (country or industry) effect and the residual effects induced by the differences in rating, country and sector decompositions between a given index and the weighted average market portfolio (Section 3.4). Both cross-sectional and time-series analyses confirm that the rating effect was the major driver of corporate bond spreads during the pre-crisis period, while the recent episode of the financial crisis was characterised by increased cross-country and cross-sector heterogeneity compared to previous historical developments. The proportion of the variance attributed to the rating effect declined, whereas the proportion of the variance explained by the country effect increased towards the end of the sample.

Section 4 considers the determinants of credit spreads components. It finds that the sector and rating effects for high-rated and low-rated bonds can be explained rather well by the information contained in default rates and equity prices. By contrast, the rating effects for bonds in the middle segment of the rating scale has lower proportion of variance explained and requires the information about cyclical component of economic environment. The country effects in general are more closely linked to country-specific default rates and returns on aggregate stock indices, whereas most of determinants of credit spreads suggested by theoretical and empirical studies are important for the common factor in credit spreads, affecting all bonds identically, and the coefficient describing the steepness of the term structure of corporate spreads.

## 2. THE EURO-DENOMINATED INVESTMENT GRADE CORPORATE BOND MARKET: SOME STYLISED FACTS

This section describes the dataset (see Annex 1 for more details) and briefly discusses the structural changes that have shaped the euro-denominated corporate bond market over the last two decades. The data comprise all available

bonds included in the Merrill Lynch EMU corporate bond index over the period January 1997 – February 2013. Although this index does not cover the entire euro-denominated investment grade corporate bond market, it constitutes a very good approximation for it. The major steps of construction of dataset include: gathering the information on monthly decomposition of the selected bond index for each month; eliminating bonds with embedded special features; proper attribution of bond's country-of-risk; constructing a time series of changes in rating for each bond; gathering the information on daily bid-, ask- and mid-yields to maturity for each bond; compilation of liquidity indicators; calculation of the exactly maturity matched corporate spreads for each bond for each day against the euro area risk-free benchmark interest rate; construction of the volume-weighted country, rating and sector corporate spread indices and the country-specific corporate spread indices for financial and non-financial bonds.

The country attribution of bonds reveals that country-specification, provided by agencies, could be misleading, as it sometimes exposes a country-of-issuance or a country-of-domicile, and not a country-of-risk[3]. Another important feature of a decomposition of this index is the presence of bonds with countries of risk attributions outside the euro area and even Europe. I consider that euro-denominated bonds were issued anticipating the demand from European investors and they are important to the domestic euro area market. High yield euro-denominated corporate issuances[4] are left out of the scope of our analysis.

### 2.1 Developments in the euro-denominated corporate bond market

The total outstanding value of all corporate investment grade euro-denominated bonds without special features in our sample increased from about 90 billion euro in the beginning of 1997 to about 1400 billion euro in 2010 (see Annex 2 for descriptive statistics). This outstanding volume, however, kept almost unchanged over the next 3 years. Looking at the separate rating categories, the substantial increase in the outstanding value of lower-rated bonds and the significant drop in the outstanding volume of high-rates issues are noteworthy. The increase in volume of lower-rated bonds is to some extent explained by enlarged participation of non-financial corporations (NFCs) and by substantial downgrading process. To address the issue of cross-country heterogeneity in downgrading process I compute the index of rating drift[5] (see Annex 2). Besides, Annex 3 documents a counterintuitive break-up of the existence of country ceilings in corporate bond rating practice exercised by rating agencies during the euro-area sovereign debt crisis for all euro area countries in our sample, except Germany and the Netherlands, and even sharp

[3] Table A1 in Annex 1 provides the country of risk attribution of bonds in our sample, indicating the shares of bonds, which were issued in domestic and foreign countries. Several reasons, including differences in legislative and tax systems are causing the issuances of corporate bonds in foreign countries, thus, 34% of Belgian bonds, 28% of German bonds, 24% of Spanish bonds, 49% of Portuguese bonds in our sample were issued in the Netherlands. Moreover, 83% of Greek bonds were issued in Great Britain.

[4] This market segment was almost non-existent in 1997 and as a rough approximation reached about 15% of the total outstanding volume of investment grade issuances in 2013 (this figure is based on the decomposition of the Merrill Lynch EMU high yield bond index HEOO). This share is comparable to the relative weight of the BBB2 (BBB-) segment in the total volume of investment grade issuances in our sample. However, the high-yield segment of the market includes several rating notches, covering BB, B, CCC, CC and C rated bonds. Inclusion of these securities in our sample under the single composite non-investment grade rating category might mask the heterogeneous pricing of bonds, belonging to high, medium and low qualities sub-investment grade corporate issuances. Moreover, low liquidity of high yield issuances would require the usage of out-of-counter market quotes as the indicative quotes might be either not available or misleading. Furthermore, additional or completely alternative explanatory variables for credit spreads might be needed in our analysis of credit spread determinants in case it would include sub-investment grade corporate debt issuances. As pointed out by Fridson and Garman (1998), non-investment grade debt offerings had a reputation as "story bonds" for which value was not a direct function of quantifiable financial ratios.

[5] Rating drift is specified as the number of upgraded issues, excluding the number of downgraded issues, as the percentage of the average number of rated issues during a certain time interval. Rating drifts were used as supplementary illustrative indicators of fragmentation in the corporate bond market in Financial Integration Report (ECB(2014)).

declines of sovereign ratings of some countries under stress to the levels of the minimal investment grade corporate ratings in these countries. Computation of liquidity proxies is reported in Annex 4. As illustrated above, substantial downgrading process has changed the rating decomposition of the overall market and its country or industry components. At the same time, available euro-denominated corporate bond mask the heterogeneous developments in corporate bond spreads across individual countries as well as different industrial segments of the market and even include non-European euro-denominated bonds. Therefore, our analysis of corporate bond spreads determinants is based on the comprehensive dataset of the most representative individual euro-denominated investment grade bonds.

## 2.2 Compilation of corporate spreads

Euro-denominated corporate bond indices mix bonds with different maturities or just differentiate between very broad maturity buckets. To distinguish properly between term- and risk-premia in corporate bond pricing, one needs to create maturity-matched spreads subtracting the benchmark risk-free interest rate with the exact maturity match from a corporate bond yield. Previous studies used the US Treasury yield curve to proxy risk-free rate in case of bonds issued by US corporations (e.g., Gilchrist and Zakrajsek, 2011) and the German sovereign yield curve in case of euro-denominated bonds issued by European and non-European companies (e.g., Baele et al, 2004, Gilchrist and Mojon, 2012). The euro area sovereign debt crisis triggered "flight-to-quality" portfolio shifts from sovereigns of distressed countries towards highly liquid and perceived to become "safe haven" government bonds of non-distressed countries, most notably Germany. As a result, the price on more liquid[6] and perceived to be "safe haven" assets increased significantly during the crisis periods. Therefore, to separate the changes in credit spreads due to the rating, country or sector effects from the mechanical changes in spreads due to movements in German government yields, I need to use another benchmark for the euro area risk-free rate. In the same vein, the alternative measurement of corporate bond spreads with respect to government bond yields of a corresponding country-of-risk would suffer from the same potential introduction of the "extra" country effect if the pricing of sovereign bonds was contaminated by the sovereign debt crisis or, in the opposite, by "flight-to-quality" and liquidity effects. As illustrated in Annex 3, the euro area sovereign debt crisis had significant impact not only on the divergence between bond yields of non-distressed and distressed euro area sovereigns and corporates, but on the changes in sovereign versus corporate ratings as well, especially in countries under stress, leading to the break-up of the existence of country ceiling for corporate bonds ratings in all countries in our sample except Germany and the Netherlands. Furthermore, an overpricing of sovereign risk during the euro area sovereign debt crisis was reflected in the sharp decline of sovereign ratings of some countries under stress to the levels below the weighted average corporate ratings and even to the levels of the minimal investment grade corporate ratings in these countries. Thus, even the exactly maturity-matched corporate spreads measured with respect to the government bond yields, derived from the national sovereign curves, often take negative values during the crisis period in case of Spain and Italy. Therefore,

[6] The liquidity effect can be quantified from the spread between sovereign and agency bonds, which bear the same credit risk and only differ in terms of liquidity (see ECB (2014)). As shown in ECB (2014), the OMT announcement in 2012 led to a sustained decline in the liquidity premium, although, in particular, for German assets, it remained elevated.

credit spreads in this paper are constructed with the exact maturity match against the euro-area risk-free rate proxied by the Overnight Indexed Swap (OIS)[7] curve.

## 3. RELATIVE IMPORTANCE OF FACTORS AFFECTING CORPORATE BOND SPREADS

### 3.1 Theoretical and empirical determinants of credit spreads: literature overview

There is an extensive body of literature devoted to theoretical modelling of credit spreads, which can be mainly divided into two parts: structural-form and reduced-form modelling approaches[8]. An empirical analysis of theoretical models shows that they have difficulties in explaining observed credit spreads for different issues with the same rating and the observed term structure of credit spreads. However, they could highlight some potential determinants of credit spreads. Now, let's consider the major factors driving credit spreads from both theoretical and empirical point of views, distinguishing between bond-specific and common factors, affecting all corporate bonds or the subgroup of bonds in the same way.

Special features, embedded in a bond (callable, putable, floating rate, etc.), naturally result in different pricing. As only insignificant part of bonds in our sample has embedded special features, I choose to simply exclude them from further consideration. Alternatively, Gilchrist and Zakrajsek (2011) adjusted credit spreads for the callability of underlying issues as about two thirds of securities in their sample of bonds issued by the US corporations were callable. Some of remaining bonds in our sample have the explicit government guaranties, but I assume that this feature is already reflected in the ratings of these bonds.

According to structural-form models, the company's asset value and its volatility as well as the leverage ratio of a firm should determine credit risk of a corporate bond. The company's asset value could be deducted from the balance sheet, which is not frequently updated. Therefore, some empirical studies replace the asset value by equity return on individual equities or stock indices[9]. Additionally, Campbell and Taksler (2003) show that idiosyncratic firm-level equity volatility explains as much cross-sectional variation in corporate yields as do credit ratings. Another proxy of the financial health of a firm is its Distance to Default (DD) – model-driven quantitative estimate, originated by the ideas formulated in Merton (1974), that use the firm's stock returns data and balance sheet information. Moody's/ KMV Expected Default Frequencies (EDFs) are also based on the DD framework. However, firms DD or EDF are less volatile than corporate spreads. Additionally to abovementioned proxies of financial

[7] The OIS rates are available for the certain grid of maturities. I use a linear spline interpolation to obtain the OIS rates to the exact time-to-maturity of corporate bonds in our sample.

[8] Structural-form or contingent-claim theoretical credit risk models (originally developed by Merton (1974) using insights of option pricing theory) relate the default process of a firm to the value of the firm's assets. Thus, the firm's default risk is linked to the variability of the firm's assets value, the value of debt issued by the firm and its maturity. The Merton model has been extended relaxing some of its restrictive assumptions (e.g., Longstaff and Schwartz (1995) and many others). However, these models still suffer from many flaws. First, they require the company's asset value to be observable and continuous in time. Second, they cannot incorporate changes in credit ratings of corporate bonds. Third, they assume that default is predictable shortly in advance against the empirical background of sudden defaults of even highly rated firms. Alternatively, reduced-form credit risk models do not condition default of a company on the developments of its asset value, but assume that default is generated by an intensity-based or hazard-rate process (e.g., Jarrow et al (1997) and many others). These models, however, assume that default and recovery processes are postulated exogenously and cannot be easily linked to fundamentals of corporate bonds.

[9] Collin-Dufresne et al. (2001) indicate that the sensitivity of credit spreads to the S&P 500 return is several times large than the sensitivity to company's own equity return. The return on the stock index cannot be solely attributed to financial health of issuers, it also reflects the cyclical component of economic environment, and the risk premium of corporate bonds may vary in time and increase during recessions.

health of a firm, private rating agencies (e.g. Moody's, Standard & Poor's, etc.) provide guidance to investors assigning rating classes to corporate bond issues. Several studies confirm that ratings are not perfectly correlated with actual defaults; additionally, ratings are correlated with the past rating changes. Loeffler (2007) illustrates that ratings embody the judgemental assessments of long-term credit quality of an issue and capture different aspects of credit quality as market-based measures of default risk[10]. Ratings are the only available proxies for firms' financial health for our sample of corporate bonds. Besides, as I analyse the cross-sections of corporate spreads, the limitations of ratings, consisting in slow reaction to changes in credit quality of issuers and in a low predictive power for defaults, become less relevant.

Time to maturity is another important characteristic, affecting corporate spreads: normally the term structure of credit spreads is upward sloping, but it could be also downward sloping or humped-shaped depending on rating category. The upward sloping term structure of credit spreads is more common for highly-rated corporate issues: their long-term bonds can more likely get downgraded, rather than upgraded to even higher ratings. Contrarily, the long-term very low-rated corporate bonds can more likely get upgraded, what implies the downward sloping term structure of their corporate spreads. Moreover, time to maturity and credit risk are not independent, less risky firms tend to issue longer rated bonds as more risky firms, belonging to the same rating category. The level of a coupon paid by a bond influences its yield-to-maturity as bonds with the same yield-to-maturity and different coupon rates have different duration and convexity. Moreover, a coupon rate of a bond might impact its credit spread through the tax effect: in some countries tax rates on capital gains and interest income are different. Additionally, as in most countries capital gains are paid at the time of sale, while coupon payments are subject to the current year taxation, bonds with lower coupons will have a more favourable tax treatment. Country of risk together with industry (sector) specification of an issuer affects corporate bond pricing. Country-specific risk factors reflects investor's assessment of current and future macroeconomic conditions in a given country and industry-specific risk factors capture investor's expectations concerning the prospect of a given industry that are not yet incorporated into ratings. Since high liquidity is an attractive feature of a security, investors demand additional compensation for holding less liquid securities creating the liquidity premium[11] in corporate bond spreads. According to structural-form theoretical models, risk-free rate is another determinant of corporates spreads. Besides, lower interest rates are associated with the weakening of economy and the risk premium on corporate bonds normally increases during recessions. The slope of the default-free term structure influences corporate spreads as well as first, it indicates the future short-term risk-free rate and second, it constitutes another proxy of current and future economic environment and business cycle conditions.

Numerous empirical studies confirm that only some fraction of variance in corporate bond spreads can be explained by systematic movements in default risk of individual firms. This fact led to the emergence of the "*credit spread*

[10] He shows that ratings become more informative than other measures of default risk as the horizon increases or issuers become less risky. Moreover, according to Loeffler (2007), the combination of ratings and market-based measures of default risk improves the prediction of defaults over the use of a single measure. Elton et al (2002) find that several refined rating characteristics can be better linked to corporate bonds prices as simple rating categories; in line with their results, I use the composite measure of Moody's and Standard & Poor's ratings for further analysis.

[11] Houweling et al (2005) compare several proxies of liquidity for corporate bonds (issued amount, listed, on-the-run, age, missing prices, yield volatility, number of contributors and yield dispersion) and find significant liquidity premia in corporate spreads, ranging from 13 to 23 basis points. Moreover, they show that liquidity risk premium is time varying.

*puzzle"* concept in corporate finance (see literature overview in Christensen (2008)). Even models, accounting for default loss, tax effects, liquidity premia, business cycle conditions and bond specific characteristic can not explain all variation in corporate bond spreads[12]. Driessen (2005) refers to the missing piece as a large risk premia possibly caused by a tendency for firms to default in waves. Gilchrist and Zakrajsek (2011) refers to it as the excess bond premium[13] and argue that it should represent variations in pricing the default risk and not the risk of default itself, and that innovations to the excess bond premium are orthogonal to the current state of economy.

### 3.2 Modelling the relative importance of credit spread determinants

To analyse the relative importance of credit spread determinants this paper employs the model similar to the one that Heston and Rouwenhorst (1994) proposed for equity returns. Mahieu and Pieterse-Bloemm (2011) employed a similar model investigating the impact of country versus rating factors on the pricing of their cross-section of individual European corporate bonds. This paper accounts not only for country and sectoral attributions of individual bonds, but also for several other factors, affecting corporate bond spreads, such as ratings classes and changes in ratings and other bond-specific characteristics, which were discussed in the previous section. The similar analysis was already presented in Baele et al. (2004) for the sample of euro-denominated corporate bonds, covering the period 1998-2003. The current study not only extends this analysis in time dimension, but additionally analyses the country versus the rating and sector effects within the volume-weighted country (rating/ sector) corporate bond spread indices and the country-sector-specific indices (Section 3.4) and considers the determinants of corporate spreads components (Section 4). Additionally, as shown in Annex 4, the liquidity proxy used in Baele et al. (2004) is related to the quality of data supplied by data providers and not to actual liquidity conditions on the market. Therefore, this paper introduces the bid-ask spreads, scaled by the mid-yields as more refined proxy of liquidity. Moreover, corporate spreads in Baele et al. (2004) are measured with respect to German sovereign bond yields, which cannot be considered as a proxy of risk-free rate at least during the euro area sovereign debt crisis. To separate the changes in credit spreads due to the rating, country and sector effects and the term, coupon and liquidity premia from the mechanical changes in spreads due to movements in German government yields, I use another benchmark for the euro area risk-free rate, namely the OIS curve.

[12] Collin-Dufresne et al. (2001) find that only 25% of the variation in credit spreads is explained after controlling for changes in short- and long-term Treasury yields, the return on stock index additionally to firms-specific characteristics, describing their financial health. Driessen (2005) leaves about one third of variation unexplained after carefully considering default risk factor, two credit risk factors common for all firms in his sample, liquidity risk and tax effect. Gilchrist and Zakrajsek (2011) find that their measure of default risk together with other bond-specific characteristics after controlling for the level, the slope and the curvature factor of the Treasury term structure and for volatility of the long-term Treasury yield, can explain only up to 65% of variance in credit spreads.

[13] Additionally, they show that the predictive content of credits spreads is mainly owing to the excess bond premium. I will continue with the analysis of the predictive content of the excess bond premia for our sample of euro-denominated corporate bonds in my subsequent paper.

To disentangle the changes in corporate bond spreads due to differences in systematic risk factors let's estimate the following cross-sectional regression[14], taking into account potential drivers of corporate spreads:

$$Spread^{i}_{c,r,s,\tau}(t) = \alpha_t + \sum_{r=1}^{10} \beta_{r,t} R^{r}_{i,t} + \sum_{c=1}^{14} \gamma_{c,t} C^{c}_{i} + \sum_{s=1}^{2} \sigma_{s,t} S^{s}_{i} + {}_t\tau_{i,t} + \rho_t coupon_i + \lambda_t liq_{i,t} + \varepsilon_{i,t} \qquad (1)$$

Where $Spread^{i}_{c,r,s,\tau}(t)$ is a spread of a corporate bond *i* at time *t* with respect to the OIS rate with exactly the same time-to-maturity; $\tau_{i,t}$ is remaining time to maturity for a corporate bond *i* at time *t*; $R^{r}_{i,t}$, $C^{c}_{i}$ and $S^{s}_{i}$ are rating, country and sector dummies for a corporate bond *i* at time *t;* $liq_{i,t}$ is a proxy of liquidity for a corporate bond *i* at time *t* and $coup_i$ is a coupon rate, paid by a corporate bond *i*.

To avoid multicollinearity, a constraint[15] for coefficients on rating, country and sector dummies is imposed. It requires the weighted sum of coefficients to be equal to zero:

$$\sum_{r=1}^{10} \omega_{r,t} \beta_{r,t} = 0, \sum_{c=1}^{14} \upsilon_{c,t} \gamma_{c,t} = 0, \sum_{s=1}^{2} \eta_{s,t} \sigma_{s,t} = 0 \qquad (2)$$

Here $\omega_{r,t}$, $\upsilon_{c,t}$, $\eta_{s,t}$ are the weights of rating *r*, country *c* and sector *s* in the total outstanding volume of bonds in our sample at time *t*. More specific, the economic interpretation of this constraint implies that the weighted average rating, country or sector component is equal to zero at each time *t* and, therefore, $\alpha_t$ is the common factor, affecting all corporate spreads identically. In other words, if we sum equation *(1)* across all bonds using market weights, then due to *(2)* the weighted rating, country and sector components sum up to zero and the spread of the **weighted average corporate bond market portfolio** (volume-weighted corporate bond spread index for all bonds in our sample) can be written as:

$$Spread^{vw}(t) = \alpha_t + {}_t\tau^{wv}_{t} + \rho_t coupon^{wv}_{t} + \lambda_t liq^{wv}_{t} \qquad (3)$$

Here $\tau^{vw_t}$ is the volume-weighted average of remaining time to maturities for all corporate bonds in the market at time *t*; $liq^{vw_t}$ is the volume-weighted average liquidity measure for corporate bond market at time *t* and $coup^{vw}$ is the volume-weighted average coupon rate. Thus, our constraint has advantages in economic interpretation of results

[14] Equation *(1)* uses estimated left- and right-hand side variables, namely, corporate bond spreads are calculated with respect to the OIS rates with the exact maturity match and underlying values of the OIS rates are obtained from the grip values using linear interpolation. Additionally, the liquidity proxy is also compiled on the basis of the bid-, ask- and mid- yields of corporate bonds. Therefore, our estimates of regression *(1)* might suffer from parameter bias and standard error miss-calculation. Brief literature overview of errors-in-variables regressions can be found in Gillard (2006); the method of instrumental variables and the method of moments are often given prominence by econometrician while dealing with errors-in-variables regressions. However, I prefer to simplify the estimations and to use the ordinary least squares (OLS) method keeping in mind potential parameter bias and standard error miss-calculation. I also have estimated equation *(1)* by the weighted least squares (WLS) method using the outstanding values of bond issues as weights. The WLS parameter estimates were similar to those obtained by using OLS, albeit noisier. Therefore, only the OLS estimates are reported.

[15] Alternative constraints could either imply the absence of the constant term in equation *(1)* or setting the coefficients on one of rating, sector and country dummies to zero. These constraints induce different interpretations of obtained estimation results. Estimations, obtained using alternative parameter constraints provided similar results to the estimations using constraint (2); they are not presented to economise space.

due to the direct comparison with the weighted market portfolio[16]. Moreover, it stabilises the coefficients on country, rating and sector dummies through assigning bigger weights to bonds with the bigger volumes of issuances, which have higher probability to be traded at the market, thus, to have real and not indicative quotes.

Let's define an increment (or a decrement) to a corporate spread in equation (*1*) linked to specific corporate bond characteristics such as maturity, coupon and liquidity as the **maturity/ coupon/ liquidity effect;** thus, the terms $\varphi_t \tau_{i,t}$ , $\rho_t coupon_i$ and $\lambda_t liq_{i,t}$ represent the maturity, the coupon and the liquidity effects for a corporate bond *i* at time *t*, respectively. In the similar vein, the terms $\varphi_t \tau_t^{wv}$ , $\rho_t coupon_t^{wv}$ and $\lambda_t liq_t^{wv}$ represent the maturity/ coupon/ liquidity effects for the weighted market portfolio in equation (*3*). Along similar lines, the magnitude of coefficients on rating, country and sector dummies are representing the **rating/ country/ sector effect** for a bond. The rating (country/ sector) effect measures an extra increment (or a decrement) of a corporate spread for a bond with a given rating (country/ sector) on the top of the volume-weighted corporate spread index. Our constraint directly implies the absence of the country, sector or rating effects within the volume-weighted market index (equation *3*). Annex 4 elaborates on construction of the pure country (rating / sector) spreads and decomposition of the volume-weighted country (rating / sector) spread indices into the pure country (rating / sector) spreads and the weighted average rating and sector (country and sector / rating and country) components. Annex 4 also decomposes the country- sector-specific spread index (e.g. volume-weighted spread index for German non-financial corporations) into the pure country-sector spread and the residual components.

### 3.3 Empirical analysis of relative importance of corporate spread determinants

Our empirical analysis is based on the comprehensive dataset of the most representative individual corporate bonds; see Annexes 1, 2, 3 and 4 for more details on dataset and Section 2 for the stylised facts regarding the developments on the corporate euro-denominated bond market and the construction of corporate spreads and liquidity proxy. Cross-sectional regression *(1)* is estimated with the presence of constraint *(2)*, relating corporate bond spreads to a constant, a bond's coupon rate, remaining time to maturity and liquidity and a set of dummies, distinguishing between 14 countries, 10 rating categories and 2 sectors (financial and non-financial) for 164 monthly time intervals from July 1999 to February 2013. Table 1 reports the average (across time intervals) size and significance[17] levels of parameters for the whole sample and two subsamples: starting from 2007 and from 2010. Additionally, Charts A6.1 in the Annex 6 illustrate the evolution of the rating, country and sector effects (coefficients on rating, country and sector dummies) and their cross-sectional dispersions.

[16] This comparison, however, could become confusing in case of rebalancing of decomposition of the weighted market portfolio. Specifically, in the beginning of our sample, more than 80% of the market was covered by high-rated issues, therefore the rating effect for even the AA3-rated bonds was positive, meaning that AA3-rated bonds had higher spreads than the weighted market portfolio. In the course of time, more lower-rated securities entered the market or were downgraded, pulling down the weighted average rating of the market portfolio. Thus, the rating effect of the AA3-rated bonds became negative.

[17] Due to parameter constraints I eliminate 3 dummies (1 country, 1 rating and 1 sector dummy) from the set of explanatory variables in order to calculate standard errors and corresponding t-statistic for parameter estimates. Afterwards, I recalculate standard errors eliminating 3 other dummies from regressors and report the average of two estimates (when applicable). Another way would be to perform the Wald test for coefficients at 3 eliminated dummies.

**Table 1. Average parameter estimates and significance of coefficients in cross-sectional regression**

***a) Average through July 1999 – February 2013***

| Country effect | | | | | | Rating effect | | | | | | Sector effect | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* |
| AT | 0 | 0.41 | FR | -7 | 0.37 | AAA | -64 | 0.00 | BBB1 | 47 | 0.00 | Financials | 23 | 0.32 |
| AU | -1 | 0.51 | GB | 2 | 0.29 | AA1 | -48 | 0.00 | BBB2 | 76 | 0.00 | Non-financials | -22 | 0.34 |
| BE | 0 | 0.46 | IT | 11 | 0.18 | AA2 | -34 | 0.00 | BBB3 | 135 | 0.00 | | *coeff* | *p-value* |
| CH | -4 | 0.38 | JP | 17 | 0.45 | AA3 | -31 | 0.00 | | | | **Common effect** | 67 | 0.09 |
| DE | -14 | 0.40 | NL | -9 | 0.44 | A1 | -14 | 0.12 | | | | **Maturity** | 3 | 0.04 |
| DK | -9 | 0.33 | SE | -8 | 0.37 | A2 | 6 | 0.25 | | | | **Coupon** | 5 | 0.04 |
| ES | 26 | 0.39 | US | 23 | 0.14 | A3 | 18 | 0.19 | | | | **Liquidity** | -300 | 0.18 |

***b) Average through January 2007 – February 2013***

| Country effect | | | | | | Rating effect | | | | | | Sector effect | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* |
| AT | 1 | 0.31 | FR | -5 | 0.41 | AAA | -99 | 0.00 | BBB1 | 59 | 0.00 | Financials | 50 | 0.01 |
| AU | -9 | 0.40 | GB | 7 | 0.28 | AA1 | -71 | 0.00 | BBB2 | 99 | 0.00 | Non-financials | -47 | 0.01 |
| BE | 1 | 0.43 | IT | 23 | 0.11 | AA2 | -46 | 0.00 | BBB3 | 151 | 0.00 | | *coeff* | *p-value* |
| CH | -19 | 0.31 | JP | 37 | 0.32 | AA3 | -44 | 0.00 | | | | **Common effect** | 118 | 0.02 |
| DE | -29 | 0.10 | NL | -16 | 0.25 | A1 | -18 | 0.18 | | | | **Maturity** | 4 | 0.04 |
| DK | -31 | 0.25 | SE | -16 | 0.31 | A2 | 11 | 0.24 | | | | **Coupon** | 7 | 0.06 |
| ES | 54 | 0.30 | US | 31 | 0.13 | A3 | 23 | 0.15 | | | | **Liquidity** | -498 | 0.09 |

***c) Average through January 2010 – February 2013***

| Country effect | | | | | | Rating effect | | | | | | Sector effect | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* | | *coeff* | *p-value* |
| AT | -10 | 0.41 | FR | -2 | 0.34 | AAA | -98 | 0.01 | BBB1 | 50 | 0.00 | Financials | 58 | 0.00 |
| AU | -26 | 0.22 | GB | 1 | 0.21 | AA1 | -59 | 0.00 | BBB2 | 87 | 0.00 | Non-financials | -57 | 0.00 |
| BE | 11 | 0.40 | IT | 72 | 0.06 | AA2 | -43 | 0.00 | BBB3 | 127 | 0.00 | | *coeff* | *p-value* |
| CH | -33 | 0.08 | JP | 14 | 0.45 | AA3 | -49 | 0.00 | | | | **Common effect** | 105 | 0.00 |
| DE | -38 | 0.02 | NL | -20 | 0.21 | A1 | -27 | 0.01 | | | | **Maturity** | 5 | 0.00 |
| DK | -43 | 0.03 | SE | -40 | 0.07 | A2 | 3 | 0.24 | | | | **Coupon** | 10 | 0.00 |
| ES | 103 | 0.01 | US | 5 | 0.25 | A3 | 9 | 0.19 | | | | **Liquidity** | -253 | 0.06 |

Parameter estimates reveal the importance of the common, maturity, coupon and rating effect for corporate spreads in our sample. On contrary, an increased cross-country and cross-sector heterogeneity in corporate bond pricing is justified for the recent episode of the financial crisis compared to the previous developments. Specifically, the values of the rating effects are nearly all statistically significant on average for all subsamples for bonds with all ratings, except the middle part of the rating scale (the A1-A3-rated bonds). Relatively to the intercept, which, together with the volume-weighted maturity, coupon and liquidity effects represents the spread on the weighted market portfolio (as outlined by equation *(3)*), highly rated bonds have lower credit spreads. Therefore, the rating effects (coefficients on rating dummies) for the AAA-A1-rated bonds are negative. At the same time, the positive rating effects for lower ratings reflect higher spreads for the A2-BBB3-rated bonds compared to the volume-weighted market corporate spread index. However, within the context of our constraint, the changes in the sign and magnitude of coefficients on rating dummies also depend on the rebalancing of the rating decomposition of the weighted market portfolio[18]. The intercept, which represents the common component, and the coupon and maturity effects are significant for all

[18] As demonstrated by Chart A2.1 in Annex 2, more than 80% of the outstanding volume of corporate debt in the beginning of 1999 was covered by the AAA and AA issues, while at the end of the sample this segment was adjusted to about 20% of the market volume. Consequently, coefficients on rating dummies for the A3, A2, A1 and partly even the AA3 rating categories have small positive values in the middle of 1999. At this time the market consisted to 80% from very high-rated bonds, and, therefore, even the AA3 category was considered low compared to the weighted market portfolio, what in turn required the higher spreads for the A3, A2, A1 and partly the AA3-rated bonds relative to the spread of the weighted market portfolio. In the course of time, more lower-rated securities entered the market or were downgraded, pulling down the weighted average rating of the market portfolio. The AA3, A1, A2 and even the A3 rating categories became higher than the weighted average market rating and the spread for the AA3, A1, A2 and A3-rated bonds became lower than the spread of the market portfolio, leading to the negative rating effects for these rating categories.

subsamples, whereas the coefficient for liquidity term is close to be significant on average starting from 2007. High importance of the coupon effect for pricing of euro-denominated corporate bonds indicates either the impact of duration and convexity or the tax effect (see Section 3.1). The average value of the coefficient for the maturity term suggests the upward sloping corporate spread curve with the 3-5 basis points increase per year of remaining maturity. The coefficient at maturity term has also an increasing trend starting from low values in the beginning of the sample and reaching 5 at the end of the sample, indicating continuous steepening of the corporate spread curve. The liquidity effect is close to be statistically significant towards the end of our sample and has expected negative sign, reflecting lower spreads for more liquid bonds. The sector effects (coefficients on sector dummies) are insignificant on average for the whole sample, but become significant on average for the sample starting from 2007. Charts A6.1 in Annex 6 confirm that sectoral attribution was not important for corporate bonds pricing before 2007 and the sector effects were close to zero[19]. Also, the parameters related to country dummies are not statistically significant on average for the whole sample and for the sample, starting from 2007. However, the coefficients on dummies for Switzerland, Germany, Denmark, Spain, Italy and Sweden become significant, starting from 2010[20]. Coefficients on all dummies exhibit two waves of divergence from each other – in 2009 and 2012. However, the importance of different factors for corporate bonds pricing was dissimilar during these episodes[21]. The cross-sectional dispersion of the sector effects was the lowest before mid-2007, when it outranged the dispersion of the country effects. Thus, during the period without market stress, the rating effect in corporate bond pricing had the highest dispersion, while the sectoral differences were negligible. During the first episode of the financial crisis, the rating component still had the highest dispersion, but the dispersion of the sector component increased. In contrary, the second episode of the financial crisis in 2012 was characterised by the highest dispersion of the country effects in corporate bonds pricing, the sector effects had the second highest dispersion and the rating effects – the lowest. This indicates an increased cross-country and cross-sector heterogeneity in corporate bonds pricing in the recent period of the financial crisis compared to previous historical developments.

To get another indication of the relative importance of various factors, Charts A6.2 in Annex 6 depicts the proportion of cross-sectional variance, explained[22] by regression *(1)* and its components over time. Analysis of variance also confirms that the corporate spreads in our sample were heavily driven by the rating effects until the recent episode of the financial crisis, while the impact of the sector and country effect on corporate spreads became pronounced from 2007 and amplified further during 2012-2013. On average, our cross-sectional regression explains

[19] In 2007 bonds of financial corporations have started to yield more than bonds of non-financial corporations with similar characteristics. Starting from 2007, financial corporations on average pay a premium of 50 basis points over the spread of the weighted market portfolio, while non-financial corporations in our sample get a premium of a similar magnitude.

[20] Thus, starting from 2010, Spanish and Italian corporations pay a country premium of 103 and 72 basis points, respectively, over the weighted market portfolio, while Swiss, German, Danish and Swedish corporations receive a premium of 33, 38, 43 and 40 basis points, respectively. The premium is close to zero on average and insignificant for France, Great Britain and the United States.

[21] During the first episode of the financial crisis, the spread of a BBB3-rated corporate bond was about 550 basis points higher than the spread of an AAA-rated bond with the similar characteristics, whereas this difference was only about 330 basis points in 2012. Contrarily, during the first episode of the financial crisis, the spread of a bond of a financial corporation was about 100 basis points higher than the spread of the weighted average market portfolio, while this difference amounts to about 120 basis points in 2012. Similarly, the magnitude of the country effects increased significantly in the first half of 2012 with remarkable escalations of the country effects for Spain and Italy, in particular. Corporate bonds of Greece, Ireland and Portugal were excluded from the regression sample as they are not present in the index during the whole period of analysis.

[22] Due to covariance structure between regression components, the proportion of variance explained by a single component might even turn negative.

38% of variance in corporate spreads, which is of similar magnitude as in other studies, where ratings were used. In 2000 as well as in 2013, the proportion of cross-sectional variance, explained by regression, increased to the levels higher than 50%. The rating effect on average explains about 20% of cross-sectional variance in corporate spreads and the country effect – only about 5% on average. In the beginning of our sample, the big bulk of total variance explained (up to 45%) could be attributed to the rating effect. However, towards the end of the sample, the proportion of variance, attributed to the rating effect declined, while the proportion of variance explained by the country effect increased. At the end of the sample, both of them have similar magnitude of about 23% of total cross-sectional variance in spreads.

### 3.4 Relative importance of corporate spread determinants for the weighted country/ rating/ sector spread indices and the country-specific sector spread indices

As shown in Annex 5, reach economic interpretation of our parameter constraint allows us to continue the analysis of the relative importance of different corporate spreads determinants by considering the maturity-matched volume-weighted country, rating or sector corporate spread indices[23] and the country-specific spread indices separately for financial and non-financial bonds. These indices and their cross-sectional dispersions are depicted in Charts A7 in Annex 7. The cross-sectional dispersion in spreads of the weighted rating portfolios was the highest until mid-2011, when it was outraged by the dispersion in spreads of the weighted country portfolios[24] (see Chart A7d). This again signals an increased cross-country heterogeneity in corporate bond pricing compared to previous developments.

Instead of looking at the cross-sectional variance of corporate spreads at a given point in time and decompose it into the variance, explained by the rating, country and sector effects, let's focus here on a time-series dimension of spreads volatility. This analysis again justifies, that the rating effect plays more prominent role than the sector and country effects for the weighted rating, country and sector market portfolios; however, the dominance of this effect was more pronounced before the crisis and becomes less pronounced afterwards. Table 2 presents the variance decomposition[25] of the weighted rating (country, sector) spread indices into the maturity, coupon, liquidity, pure rating (country, sector) effects and the residual country and sector (rating and sector, rating and country) effects for the whole sample (Panels A-C) and for the pre-crisis period (Panels D-F). Table 2 reveals the following regularities: first, the coupon effect is important for all three types of indices on average for both the pre-crisis period and the

[23] Equation (*A5.2)* in Annex 5 illustrates that the weighted country spread index can be decomposed into the pure country spread and the weighted average rating and sector premia. The weighted average rating and sector premia deviate from zero only when the rating and industry distributions in a particular country deviate for the market rating and industry distributions. In a similar way, equation (*A5.4*) demonstrates that the spread within a rating category represents the spread of the geographically and industrially diversified portfolio of corporate bonds with a particular rating category plus the weighted average country and industry premia. And equation (*A5.6*) decomposes the weighted sector index in a similar fashion.

[24] The dispersion in spreads of the weighted sector portfolios was quite low all time, except the end of 2011, when it sharply increased and became higher than the dispersion of the rating corporate spread indices, at this time the volume-weighted spread of financial corporations paid a premium of 140 basis points over the volume-weighted spread of non-financial corporations. The first episode of the financial crisis was also characterised by the highest dispersion between the spreads of the weighted rating portfolios; the volume-weighted spread of the BBB3-rated bonds was more than 420 basis points higher than the weighted spread of the AAA-rated bonds (see Chart A7a). At the end of our sample in February 2013, the volume-weighted rating and country corporate spread indices had the cross-sectional dispersions of similar magnitudes, while the dispersion in spreads of the weighted sector portfolios was very low.

[25] The variance ratios of these effects may not sum up to 1, but be lower (higher) than 1 due to positive (negative) covariance terms in the variance decomposition, which are not presented.

whole sample. However, it is not important for high and low-rated bonds and is mainly important for bonds with medium ratings. Also, it is not important for some country indices, including Spain, Italy and the USA. Second, the maturity and the liquidity effects were not important in explaining the variances of corporate spread indices. Third, considering the whole sample, the most dominant effect for each index is its own pure rating (country/ sector) effect. Forth, measured for the whole sample, the residual rating effect is important for both the weighted country and the weighted sector spread indices, whereas the second residual effect (other than the residual rating effect) was not important for both types of indices. And fifth, in case of the weighted rating indices, the residual sector effect is important, while the residual country effect is not important. However, the similar exercise repeated only for the pre-crisis period (Panels D-F) indicates that the rating effect becomes dominant for all three types of indices. Thus, the variances of the volume-weighted corporate spread indices for almost all countries are to the high extent owing to the residual rating effect, it explains 44% of variance on average among different countries, while the pure country effect explains on average 35% of variance (see Panel E). In a similar way, the variances of the volume-weighted sector spread indices can be attributed mainly to the residual rating effect, it explains 76% of variance on average among financials and non-financials, while the pure sector effect explains on average 36% of variance (see Panel F).

In a similar fashion, I decompose the variances of the volume-weighted corporate spread indices for financial and industrial bonds for selected euro area countries[26] into the maturity, coupon, liquidity, pure country and pure sector effects and the residual rating effects again for the whole sample and for the pre-crisis period (see Table A7 in Annex 7). Once again, the prominent role of the rating effect for the country-specific spread indices for financial and industrial corporate bonds is confirmed for the pre-crisis period. However, the latest episode of the financial crisis highlighted the higher importance of the country effect for the volume-weighted financial and industrial bond indices for Spain and Italy and the dominance of the sector effect for other countries. More specifically, first, similarly to the results derived for the country indices, the coupon effect is not important for a subset of countries, including Spain, Italy and Belgium and is important for Austria. In case of Germany, France and the Netherlands it is important only for bonds of non-financial corporations. Second, considering the whole sample, the pure sector effect dominates the pure country effect and the residual rating effect on average across countries and, in particular, for Austria, Belgium, France, Germany and the Netherlands. Conversely, the pure country effect dominates the pure sector effect for Spain and Italy. However, considering only the pre-crisis period, the residual rating effect was the main determinant for the variation in corporate spread indices; it explained about 82% of variance on average among countries, while the pure country and the pure sector effects explained only 26% and 21% of total variance, respectively.

[26] Due to data limitations, I cannot investigate the volume-weighted country-specific rating spread indices. For most of countries there are not enough bonds of a given rating for each point in time to construct the time series of the volume-weighted spreads.

## Table 2. Variance decomposition of rating (country and sector) corporate spread indices

### *a) Rating indices*

| Variances ratios of | AAA | AA1 | AA2 | AA3 | A1 | A2 | A3 | BBB1 | BBB2 | BBB3 | average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| maturity effect | 0.05 | 0.04 | 0.11 | 0.15 | 0.16 | 0.08 | 0.14 | 0.09 | 0.07 | 0.02 | 0.09 |
| coupon effect | 0.18 | 0.21 | **0.49** | **0.75** | **0.90** | **0.50** | **0.87** | **0.49** | **0.42** | 0.24 | **0.51** |
| liquidity effect | 0.10 | 0.13 | 0.25 | 0.23 | 0.28 | 0.13 | 0.23 | 0.10 | 0.08 | 0.04 | 0.16 |
| pure rating effect | **1.48** | **0.94** | **0.58** | **0.90** | **0.46** | **0.33** | **0.69** | **0.66** | **1.66** | **1.83** | **0.95** |
| w v average of country components | 0.08 | 0.16 | 0.15 | 0.22 | 0.08 | 0.04 | 0.10 | 0.18 | 0.11 | 0.04 | 0.12 |
| w v average of sector components | **0.48** | 0.34 | 0.25 | **0.51** | 0.16 | 0.07 | **0.74** | **0.45** | **0.43** | 0.25 | **0.37** |

### *b) Country indices*

| Variance ratios of | AT | AU | BE | CH | DE | DK | ES | FR | GB | IT | JP | NL | SE | US | average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| maturity effect | 0.15 | 0.18 | 0.05 | 0.12 | 0.07 | 0.06 | 0.01 | 0.19 | 0.09 | 0.03 | 0.03 | 0.08 | 0.11 | 0.05 | 0.09 |
| coupon effect | **1.06** | **0.92** | **0.39** | **1.12** | **0.56** | **0.47** | 0.09 | **0.85** | **0.60** | 0.10 | **0.34** | **0.37** | **0.53** | 0.29 | **0.55** |
| liquidity effect | **0.48** | **0.59** | 0.11 | 0.31 | 0.18 | 0.19 | 0.03 | 0.25 | 0.14 | 0.02 | 0.15 | 0.14 | 0.17 | 0.07 | 0.20 |
| pure country effect | **0.61** | **0.71** | 0.27 | **1.05** | **0.50** | **1.23** | **0.58** | 0.10 | 0.22 | **0.52** | **1.14** | 0.15 | **0.70** | **0.60** | **0.60** |
| w v average of rating components | **0.49** | **0.79** | 0.17 | **0.53** | 0.08 | **0.45** | 0.06 | 0.22 | 0.09 | 0.09 | **0.55** | **0.66** | **0.51** | 0.05 | **0.34** |
| w v average of sector components | **0.25** | **0.59** | 0.02 | **0.34** | 0.06 | 0.07 | 0.03 | **0.31** | 0.04 | 0.00 | **0.25** | 0.21 | 0.17 | 0.16 | 0.18 |

### *c) Sector indices*

| Variance ratios of | Fin | Ind | average |
|---|---|---|---|
| maturity effect | 0.04 | 0.16 | 0.10 |
| coupon effect | **0.28** | **0.84** | **0.56** |
| liquidity effect | 0.09 | 0.22 | 0.15 |
| pure sector effect | **0.62** | **1.42** | **1.02** |
| w v average of rating components | **0.22** | **0.35** | **0.28** |
| w v average of country components | 0.01 | 0.02 | 0.01 |

### *d) Rating indices (July 1999-June 2008)*

| Variance Ratios of | AAA | AA1 | AA2 | AA3 | A1 | A2 | A3 | BBB1 | BBB2 | BBB3 | average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| maturity effect | 0.03 | 0.07 | 0.07 | 0.11 | 0.10 | 0.08 | 0.07 | 0.06 | 0.02 | 0.01 | 0.06 |
| coupon effect | 0.29 | **0.33** | **0.57** | **0.88** | **0.87** | **0.63** | **0.56** | **0.35** | 0.24 | 0.11 | **0.48** |
| liquidity effect | 0.03 | 0.03 | 0.07 | 0.09 | 0.10 | 0.07 | 0.06 | 0.03 | 0.02 | 0.01 | 0.05 |
| pure rating effect | **1.02** | **0.70** | **0.81** | **1.07** | **0.81** | **0.58** | **0.56** | **0.58** | **1.14** | **1.61** | **0.89** |
| w v average of country components | 0.02 | 0.03 | 0.03 | 0.12 | 0.01 | 0.02 | 0.04 | 0.02 | 0.04 | 0.02 | 0.03 |
| w v average of sector components | 0.13 | 0.11 | 0.09 | 0.19 | 0.00 | 0.06 | 0.18 | 0.11 | 0.08 | 0.02 | 0.10 |

### *e) Country indices (July 1999-June 2008)*

| Variance Ratios of | AT | AU | BE | CH | DE | DK | ES | FR | GB | IT | JP | NL | SE | US | average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| maturity effect | 0.17 | 0.04 | 0.08 | 0.07 | 0.05 | 0.03 | 0.05 | 0.09 | 0.10 | 0.06 | 0.02 | 0.06 | 0.04 | 0.09 | 0.07 |
| coupon effect | **1.15** | **0.60** | **0.48** | **0.53** | **0.55** | 0.26 | **0.38** | **0.69** | **0.86** | 0.27 | 0.22 | **0.48** | 0.29 | **0.56** | **0.52** |
| liquidity effect | 0.13 | 0.08 | 0.06 | 0.09 | 0.05 | 0.03 | 0.05 | 0.07 | 0.11 | 0.01 | 0.04 | 0.05 | 0.05 | 0.07 | 0.06 |
| pure country effect | 0.35 | 0.12 | 0.25 | **0.53** | 0.09 | **0.74** | **0.52** | 0.15 | **0.46** | 0.31 | 0.18 | 0.12 | 0.16 | **0.86** | **0.35** |
| w v average of rating components | **1.69** | **0.60** | 0.27 | **0.65** | 0.14 | **0.43** | 0.21 | **0.39** | 0.15 | **0.56** | **0.36** | **0.30** | **0.30** | 0.18 | **0.44** |
| w v average of sector components | 0.14 | 0.07 | 0.00 | 0.05 | 0.01 | 0.03 | 0.05 | 0.08 | 0.03 | 0.01 | 0.13 | 0.08 | 0.06 | 0.08 | 0.06 |

### *f) Sector indices (July 1999-June 2008)*

| Variance Ratios of | Fin | Ind | average |
|---|---|---|---|
| maturity effect | 0.12 | 0.07 | 0.09 |
| coupon effect | **1.02** | **0.49** | **0.76** |
| liquidity effect | 0.11 | 0.05 | 0.08 |
| pure sector effect | **0.53** | 0.20 | **0.36** |
| w v average of rating components | **1.24** | 0.29 | **0.76** |
| w v average of country components | 0.02 | 0.01 | 0.01 |

## 4. DETERMINANTS OF CREDIT SPREADS COMPONENTS

Theoretical and empirical bond-specific determinants of credit spreads as well as factors, affecting all corporate bonds or the subgroup of bonds in the same fashion, were discussed in Section 3.1. To disentangle the changes in corporate bond spreads due to differences in systematic risk factors cross-sectional regression *(1)* took into account potential drivers of corporate spreads, such as rating, sector, maturity, coupon, liquidity and country of risk. The estimated parameter $\alpha_t$ in regression *(1)* can be interpreted as the common factor, affecting all corporate spreads identically and equation *(3)* specifies that the spread of the weighted average corporate bond market portfolio is composed from the common factor added together with the volume-weighted maturity, coupon and liquidity effects. Parameters $\beta_r$, $\gamma_c$ and $\sigma_s$ represent the magnitudes of the rating, country and sector effects[27]. Now, let's assess which explanatory variables are driving the common factor and the rating, country and sector effects as well as parameters $\varphi$, $\rho$ and $\lambda$ (which specify the magnitudes of the maturity, coupon and liquidity effects when they are multiplied by remaining maturity, a coupon rate and liquidity of corresponding bond(s)).

As discussed in Section 3.1, major determinants of credit spreads also include: a company's asset value and it's volatility (which can be proxied by equity returns on stock indices and equity volatilities), expected default frequencies, risk free rates and the slope of the default-free term structure together with indicators of current and future economic environment and business cycle conditions. Let's employ the following general equation, linking the parameters of regression *(1)* to potential explanatory variables:

$$\Delta c_t = \alpha_0 + \alpha_1 \Delta c_{t-1} + \beta_1 \Delta gdp_t + \beta_2 \Delta gdp_{t-1} + \gamma_1 \Delta edf_t^{nfc} + \gamma_2 \Delta edf_{t-1}^{nfc} + \gamma_3 \Delta divedf_t^{nfc} + \gamma_4 \Delta divedf_{t-1}^{nfc}$$
$$+ \varphi_1 \Delta edf_t^{bank} + \varphi_2 \Delta edf_{t-1}^{bank} + \varphi_3 \Delta divedf_t^{bank} + \varphi_4 \Delta divdedf_{t-1}^{bank} + \varphi_1 \Delta strr_t + \varphi_2 \Delta ltrr_t + \varphi_3 \Delta slope_{tt}$$
$$+ \eta \Delta vol + \mu_1 \Delta ind_t + \mu_2 \Delta ind_{t-1} + \mu_3 \Delta fin_t + \mu_4 \Delta fin_{t-1} \qquad (4)$$

I use the general-to-specific estimation technique. The general equation *(4)* is estimated recursively, the most insignificant parameter with the highest p-value is eliminated from regression at each step; the procedure is repeated until only significant regressors are left in the obtained specific equation. Equation (*4*) is estimated in differences because all variables of interest (the common factor, the rating, country and sector effects $\beta_r$, $\gamma_c$ and $\sigma_s$, etc.) exhibit very high persistence. In equation *(4)*:

$c_t$ refers to the variable of interest (parameters, describing country, rating, sector effects, etc.);

$gdp_t$ is expected 12-months ahead GDP growth from Consensus Forecast[28];

[27] They serve as additional increments (or decrements) to the common factor, while composing the spreads of the weighted average portfolios of a rating category *r*, a country *c* or sector *s*, respectively, added together with the volume-weighted maturity, coupon and liquidity effects (as specified by equations (*A5.2*) and (*A5.4*) and (*A5.6*) in Annex 5).

[28] The macroeconomic expectations data from Consensus Economics consist of year-on-year growth expectations for the current and the next year. In order to obtain a comparable and consistent time-series of inflation and GDP growth expectations, the expectations for the current year and the next year are weighted together to measure 12-month ahead expectations: $E_{12,t}=m\ E_{C,t}/12 + (12-m)\ E_{N,t}/12$ ; where $E_{12,t}$ denotes the 12-month ahead expectations of a certain macroeconomic variable at time *t*, $E_{C,t}$ and $E_{N,t}$ denote the time *t* expectations of the macroeconomic variable for the current and the next year, respectively, and *m* is the number of remaining months during the current year.

$edf_t^{nfc}$ and $edf_t^{bank}$ are the median values of the Moody's KMV EDFs for non-financial corporations and banks;

$divedf_t^{nfc}$ and $divedf_t^{bank}$ are divergences in default rates for non-financial corporations and banks, computed as normalised uncertainties in the estimates of EDFs[29];

$strr_t$ and $ltrr_t$ refer to the short-term and long-term euro area real interest rates, measured as the 3-months Euribor deflated with HICP and the difference between the 10-year euro swap rate and expected inflation over the next 10-years from Consensus Forecast;

$slope_t$ is the slope of the nominal default-free interest rate curve, proxied by the difference between the 10-year euro swap rate and the 3-months Euribor;

$vol_t$ is the implied volatility of options on Eurostoxx 50 Vstoxx;

$ind_t$ and $fin_t$ are the returns on Eurostoxx Industrial and Financial Indices[30] .

Expected GDP growth and expected default frequencies are available at both the euro area and the country-specific levels[31]; I always employ the country-specific values if they are available and substitute them with the euro area aggregates in case the country specific data are not available.

**Table 3. Determinants of components of corporate bond spreads**

*a) Common factor (intercept) and rating effects for higher-rated bonds*

| | Intercept | | Matur | | Coupon | | AAA | | AA1 | | AA2 | | AA3 | | A1 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Coef.** | **Std. Err.** | **Coef.** | **Std. Err.** | **Coef.** | **Std. Err.** | **Coef.** | **Std. Err.** | **Coef.** | **Std. Err.** | **Coef.** | **Std. Err.** | **Coef.** | **Std. Err.** | **Coef.** | **Std. Err.** |
| **Own lag** | | | -0.17 | *(0.1)*** | | | | | | | | | -0.21 | *(0.1)**** | -0.23 | *(0.1)**** |
| **Cyclical position** | -25.68 | *(11.5)*** | | | | | | | | | | | | | 7.73 | *(2.6)**** |
| **Cyclical position (t-1)** | 23.72 | *(10.8)*** | -0.61 | *(0.3)** | | | | | | | | | | | | |
| **Default rate for NFC** | 40.32 | *(18.0)*** | -2.32 | *(1.0)*** | | | | | | | -23.65 | *(6.0)**** | | | | |
| **Default rate for NFC (-1)** | -47.90 | *(20.7)*** | 2.16 | *(1.0)*** | | | 25.25 | *(13.6)** | | | | | | | | |
| **Divergence in default rates for NFCs (-1)** | | | -0.58 | *(0.3)*** | | | 6.69 | *(3.4)** | | | | | | | | |
| **Default rate for banks** | 97.95 | *(35.1)**** | -3.61 | *(1.7)*** | | | -66.44 | *(21.9)**** | | | | | | | | |
| **Divergence in default rates for banks** | | | | | | | | | | | 4.71 | *(1.4)**** | | | -2.38 | *(1.3)** |
| **Divergence in default rates for banks (-1)** | 12.90 | *(3.8)**** | -0.65 | *(0.2)**** | | | -5.18 | *(2.5)*** | | | | | | | -2.60 | *(1.4)** |
| **Real 3-month rate** | | | -50.69 | *(24.7)*** | | | | | | | | | | | | |
| **Real 10-year rate** | | | | | 2.16 | *(1.0)*** | -14.56 | *(6.8)*** | -16.29 | *(5.7)**** | -7.56 | *(3.8)** | 5.68 | *(2.8)*** | 6.80 | *(3.9)** |
| **Slope of nominal yield curve** | -25.40 | *(6.7)**** | | | -2.05 | *(0.8)*** | 17.93 | *(5.5)**** | 22.15 | *(4.6)**** | 8.52 | *(3.1)**** | | | -7.12 | *(3.2)*** |
| **Changes in stock volatility** | 32.69 | *(7.6)**** | -0.79 | *(0.4)** | | | -16.04 | *(5.3)**** | -22.00 | *(4.4)**** | -9.51 | *(2.7)**** | | | | |
| **Return for DJ Eurostock Industrial** | | | -3.03 | *(1.5)** | | | 64.04 | *(17.5)**** | 53.36 | *(13.8)**** | | | | | | |
| **Return for DJ Eurostock Industrial (-1)** | | | 4.21 | *(1.4)**** | | | | | | | | | | | -14.69 | *(8.1)** |
| **Return for DJ Eurostock Financial** | | | | | -7.00 | *(1.6)**** | | | | | | | 35.24 | *(5.7)**** | | |
| **Return for DJ Eurostock Financial (-1)** | -76.72 | *(24.9)**** | | | -3.56 | *(1.6)*** | 72.25 | *(16.5)**** | 46.29 | *(9.0)**** | 35.63 | *(6.2)**** | 34.29 | *(6.4)**** | | |
| **Adjusted R-squared** | **48.7%** | | **28.1%** | | **14.9%** | | **48.0%** | | **50.4%** | | **37.3%** | | **33.8%** | | **13.2%** | |

[29] Divergences in default rates for non-financial corporations and banks are computed as normalised uncertainties in the estimates of EDFs $divedf^{nfc,C}_t=(edf^{nfc,C,75\%}_t - edf^{nfc,C,25\%}_t)/edf^{nfc,C}_t$ and $divedf^{bank,C}_t=(edf^{bank,C,75\%}_t - edf^{bank,C,25\%}_t)/edf^{bank,C}_t$, where $edf^{nfc,C,75\%}_t$, $edf^{nfc,C,25\%}_t$, $edf^{bank,C,75\%}_t$ and $edf^{bank,C,25\%}_t$ are the 75% and 25% percentiles of estimates of EDFs for non-financial corporations and banks $edf^{nfc,C}_t$ and $edf^{bank,C}_t$ for country *C* at time *t*.

[30] Returns on Eurostoxx Industrial and Financial Indices ($ind\_index_t$ and $fin\_index_t$) at time *t* are computed as $ind_t=(ind\_index_t - ind\_index_{t-1})/ ind\_index_{t-1}$ and $fin_t=(fin\_index_t - fin\_index_{t-1})/ fin\_index_{t-1}$ .

[31] Expected GDP growth is available for Germany, France, Spain, Italy and the Netherlands, whereas expected default frequencies are available for Austria, Belgium, Germany, Spain, France, Italy and the Netherlands.

## b) *Rating effects for lower-rated bonds and sector effects*

| Variable | A2 | | A3 | | BBB1 | | BBB2 | | BBB3 | | Financials | | Non-financials | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| Own lag | | | -0.22 | (0.1)*** | -0.22 | (0.1)*** | | | -0.16 | (0.1)** | | | | |
| Cyclical position | 8.82 | (4.6)* | -9.86 | (5.5)* | -14.13 | (6.5)** | | | | | | | | |
| Cyclical position (t-1) | -7.50 | (4.2)* | 11.13 | (5.0)** | 12.33 | (6.2)* | | | | | | | | |
| Default rate for NFC | | | -30.47 | (9.6)*** | | | 73.23 | (16.0)*** | | | -13.67 | (7.8)* | 13.73 | (7.1)* |
| Default rate for NFC (-1) | -16.86 | (8.2)** | | | 23.74 | (11.7)** | -62.16 | (19.7)*** | | | | | | |
| Divergence in default rates for NFCs (-1) | | | | | | | | | -18.25 | (10.8)* | -4.02 | (2.0)** | 4.05 | (1.8)** |
| Default rate for banks | | | | | | | | | | | 36.96 | (13.8)*** | -35.54 | (12.6)*** |
| Divergence in default rates for banks | -26.63 | (14.9)* | 4.37 | (1.8)** | | | | | -19.55 | (7.7)** | | | | |
| Divergence in default rates for banks (-1) | 27.48 | (15.0)* | | | 4.12 | (2.1)* | | | | | | | | |
| Real 3-month rate | | | | | | | 1407.51 | (473.5)*** | | | | | | |
| Slope of nominal yield curve | | | | | -9.81 | (3.8)** | | | -25.90 | (14.5)* | | | 3.86 | (2.3)* |
| Changes in stock volatility | | | | | 16.56 | (3.6)*** | 16.06 | (7.3)** | 30.46 | (18.1)* | 7.12 | (3.2)** | -5.02 | (2.9)* |
| Return for DJ Eurostock Industrial | | | -37.92 | (13.3)*** | | | | | | | | | | |
| Return for DJ Eurostock Industrial (-1) | | | | | | | | | -190.07 | (48.3)*** | 44.03 | (13.1)*** | -42.01 | (12.3)*** |
| Return for DJ Eurostock Financial | -39.24 | (7.8)*** | | | | | | | -111.55 | (46.4)** | -21.72 | (10.8)** | 25.64 | (9.8)*** |
| Return for DJ Eurostock Financial (-1) | -25.98 | (10.4)** | -26.74 | (8.9)*** | -25.81 | (14.3)* | -88.58 | (23.6)*** | | | -66.23 | (10.9)*** | 58.05 | (10.2)*** |
| Adjusted R-squared | 16.5% | | 19.3% | | 34.6% | | 31.2% | | 23.1% | | 34.4% | | 34.5% | |

## c) *Country effects*

| Variable | AT | | AU | | BE | | CH | | DE | | DK | | ES | | FR | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| Own lag | -0.25 | (0.1)*** | -0.19 | (0.1)** | -0.38 | (0.1)*** | -0.17 | (0.1)** | | | | | | | | |
| Cyclical position | | | | | | | | | 5.34 | (2.6)** | | | 20.87 | (6.7)*** | | |
| Cyclical position (t-1) | 12.88 | (3.1)*** | | | | | | | -4.67 | (2.5)* | | | | | | |
| Default rate for NFC | | | | | | | | | 9.38 | (4.2)** | | | -84.17 | (32.7)** | -8.48 | (2.6)*** |
| Default rate for NFC (-1) | | | | | | | | | | | | | 65.99 | (28.5)** | | |
| Divergence in default rates for NFCs | | | | | 3.09 | (1.1)*** | | | | | | | | | | |
| Divergence in default rates for NFCs (-1) | | | | | | | | | | | | | 5.30 | (2.5)** | | |
| Default rate for banks | | | -78.64 | (20.3)*** | | | | | | | -61.93 | (30.5)** | 17.24 | (6.3)*** | | |
| Default rate for banks (-1) | | | 45.43 | (23.7)* | | | | | | | | | 27.01 | (6.4)*** | 16.05 | (7.0)** |
| Divergence in default rates for banks | | | | | | | | | | | | | | | -1.67 | (0.9)* |
| Divergence in default rates for banks (-1) | | | | | | | -4.90 | (2.4)** | | | | | | | | |
| Real 3-month rate | 749.63 | (236.8)*** | | | -851.26 | (309.1)*** | | | | | -1198 | (490.6)** | 1113.63 | (437.8)** | | |
| Real 10-year rate | | | | | | | -11.86 | (7.0)* | | | 15.75 | (7.9)** | | | | |
| Slope of nominal yield curve | | | -8.08 | (4.3)* | | | 16.44 | (5.6)*** | 6.38 | (2.4)*** | | | | | | |
| Changes in stock volatility | 13.98 | (4.0)*** | | | 10.88 | (5.2)** | | | | | | | | | | |
| Return for DJ Eurostock Industrial (-1) | | | -80.55 | (23.0)*** | | | | | -36.76 | (12.9)*** | -102.98 | (35.2)*** | | | | |
| Return for DJ Eurostock Financial | -23.07 | (10.5)** | | | 55.75 | (13.7)*** | 23.12 | (10.8)** | 34.40 | (6.8)*** | | | -69.47 | (16.8)*** | | |
| Return for DJ Eurostock Financial (-1) | -34.18 | (8.9)*** | 71.04 | (20.2)*** | 52.54 | (10.7)*** | | | 40.47 | (10.6)*** | 116.02 | (29.2)*** | | | | |
| Adjusted R-squared | 33.6% | | 18.5% | | 33.8% | | 10.0% | | 25.6% | | 12.7% | | 33.1% | | 8.8% | |

## d) *Country effects (continued) and liquidity term*

| Variable | GB | | IT | | JP | | NL | | SE | | US | | Liquidity | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| Own lag | | | -0.27 | (0.1)*** | 0.21 | (0.1)*** | -0.14 | (0.1)* | | | -0.18 | (0.1)** | -0.21 | (0.1)*** |
| Cyclical position (t-1) | | | 11.10 | (6.1)* | | | | | | | | | | |
| Default rate for NFC | -20.64 | (7.2)*** | | | | | 14.02 | (7.0)** | 27.16 | (9.2)*** | | | | |
| Divergence in default rates for NFCs | | | | | | | | | -6.94 | (3.0)** | | | | |
| Divergence in default rates for NFCs (-1) | -4.57 | (1.8)** | 9.27 | (3.8)** | | | | | | | -9.17 | (3.3)*** | | |
| Default rate for banks | | | 63.62 | (9.3)*** | 65.89 | (33.9)* | | | | | | | | |
| Default rate for banks (-1) | | | 21.12 | (10.4)** | | | 7.48 | (3.0)** | | | | | | |
| Divergence in default rates for banks | -3.37 | (1.3)** | 13.09 | (3.5)*** | | | | | | | | | | |
| Divergence in default rates for banks (-1) | -2.74 | (1.3)** | | | -7.18 | (3.7)* | | | | | | | | |
| Real 3-month rate | | | | | | | | | 555.00 | (327.4)* | | | | |
| Real 10-year rate | | | | | | | | | -15.63 | (6.6)** | | | | |
| Slope of nominal yield curve | | | | | | | 5.54 | (2.6)** | 17.64 | (5.7)*** | | | 201.93 | (88.7)** |
| Changes in stock volatility | | | | | | | | | -11.43 | (4.3)*** | 14.06 | (5.3)*** | -466.31 | (114.9)*** |
| Return for DJ Eurostock Industrial | | | | | | | | | | | -30.47 | (16.7)* | 886.87 | (479.1)* |
| Return for DJ Eurostock Industrial (-1) | | | | | | | -47.01 | (13.9)*** | | | | | | |
| Return for DJ Eurostock Financial | -20.70 | (8.4)** | | | | | 28.03 | (7.7)*** | | | | | -805.91 | (404.5)** |
| Return for DJ Eurostock Financial (-1) | -25.13 | (5.9)*** | 54.28 | (18.3)*** | -44.21 | (17.4)** | 53.24 | (11.8)*** | | | -61.99 | (11.8)*** | 679.53 | (229.6)*** |
| Adjusted R-squared | 17.7% | | 29.2% | | 10.0% | | 18.6% | | 12.5% | | 26.6% | | 22.2% | |

Table 3 reports the estimation results for the specific regressions (estimated using the general-to-specific approach) for the common factor $\alpha_t$, the coefficients at maturity, coupon and liquidity terms ($\varphi$, $\rho$ and $\lambda$) and the magnitudes of the rating, country and sector effects (the coefficients on rating, country and sector dummies $\beta_r$, $\gamma_c$ and $\sigma_s$). First, the proportion of variance explained by the regression is relatively high for the common factor, for the rating effects for high-rated bonds (the AAA and AA segments of the market) and low-rated bonds (the BBB segment) and for the sector effects (coefficients on dummies for bonds belonging to financial and non-financial sectors). The rating effects for the middle segment of a rating scale (the A-rated bonds) have only less than 19% variance explained, whereas the rating effect for the AA1-rated bonds has more than 50% of variance explained. The country effects also have low proportion of variance explained, ranging from only 9% for Switzerland to 34% for Belgium. Second, as expected, all selected explanatory variables are important for the development of different components of corporate bond spreads. However, neither the coefficients on the coupon and liquidity terms nor the rating effects for high-rated and very low-rated bonds as well as the sector effects depend on the cyclical component of economic environment, proxied by GDP growth. GDP growth was important only for the common factor, for the coefficient describing the term structure of corporate spreads, for the rating effects only for middle-rated bonds and for the country effects only for a subset of countries, including Germany, Spain and Italy. Third, variables describing default rates are found to be important for most of the credit spreads components, including the common factor, the rating effects and the country effects for the majority of countries. And forth, information from stock markets (returns and volatilities) and information on real interest rates and the slope of the risk-free yield curve was also important for most of the credit spread components.

## 5. CONCLUSIONS

This paper investigates the properties of the euro-denominated investment grade corporate bond market on the basis of the comprehensive dataset of the most representative for the market individual bonds without embedded special features. First, this paper describes the substantial changes in rating, country and industry decomposition of the euro-denominated investment grade corporate bond market. Cross-country heterogeneity in the downgrading and upgrading processes, quantified as rating drifts, is considered together with the pronounced impact of the sovereign debt crisis on the changes in sovereign and corporate ratings, leading to the break-up of the country ceilings of corporate ratings for all countries in our sample, except Germany and the Netherlands. Sovereign ratings in some countries under stress even declined to the levels of the minimal investment grade corporate ratings in these countries.

Second, I empirically investigate the relative importance of the credit spreads determinants, paying attention to rating, country and sectoral attributions of underlying bonds as well as to bond-specific characteristics, such as a coupon rate, remaining time to maturity and liquidity. Time to maturity term suggests that the corporate spread curve is on average upward sloping with a 3-5 basis points increase per year of remaining maturity with the continuous steepening of the corporate spread curve in time. High importance of the coupon effect for pricing of euro-denominated corporate bonds indicates either the impact of duration and convexity on corporate bond pricing or the

impact of the tax effect. All available proxies of liquidity suffer from the fact that I have to use indicative quotes instead of information about real trades. However, the average bid-ask spread, scaled by the mid-yields is more in line with the stylised facts regarding the developments in corporate bond market liquidity, than alternative liquidity measures. This paper constructs the time series of the rating, country and sector effects in corporate bond pricing and the proportion of cross-sectional variance of corporate bond spreads, explained by these effects. These time series can be used to monitor the time-varying pattern of the relative importance of different credit spread determinants for corporate bond pricing and to quantify the time-varying market segmentation. Industry attribution was not important for corporate bond pricing before 2007, afterwards bonds of financial corporations started to yield more than bonds of non-financials with similar characteristics. The magnitude and the dispersion of the country effects increased significantly starting from 2010 with the remarkable escalation in the first half of 2012 of the country effect for Spain and Italy, in particular[32]. Our analysis shows that before 2007, the rating effect was the major driver of the corporate bond spreads, while the recent episode of the financial crisis was characterised by an increased cross-country and cross-industry heterogeneity compared to previous historical developments.

Third, this paper continues with the investigation of the relative importance of the credit spreads determinants for the weighted country (rating and sector) corporate spread indices as well as the weighted country-specific spread indices for financial and non-financial bonds, distinguishing between the maturity, coupon and liquidity effects as well as the pure country (rating/ or sector) spreads and the residual premia, induced by the differences in the rating, country and industry distributions between a given subsample of bonds and the overall sample, representing the market portfolio. During the pre-crisis period, the rating effect plays more prominent role than the sector and the country effects for all types of indices. However, the dominance of this effect becomes less pronounced, when the period of the financial crisis is included in the sample. Moreover, the cross-sectional dispersion in spreads of the weighted rating portfolios was the highest until mid-2011, when it was outraged by the dispersion in spreads of the weighted country portfolios, signalling an increased cross-country heterogeneity in corporate bonds pricing.

And fourth, I consider the determinants of the components of credit spreads, such as the common factor, affecting all bonds identically, the country, rating and sector effects together with the maturity, liquidity and coupon effects. All credit spreads determinants suggested by theoretical and empirical analyses (the cyclical component of economic environment, information contained in default rates, returns and volatilities of stock indices, real interest rates and the slope of the risk-free yield curve) are important for the common factor in credit spreads, affecting all bonds identically, and for the coefficient, describing the steepness of the term structure of corporate spreads. The sector effects as well as the rating effects for high-rated bonds (the AAA and AA segments of the market) and low-rated bonds (the BBB segment) can be explained rather well by the information contained in default rates and stock prices. In contrary, the rating effects for the middle segment of a rating scale (the A-rated bonds) have lower proportion of variance explained and require the information about the cyclical position, proxied by the expected GDP growth. Additionally, only a subset of the country effects can be explained relatively well by our explanatory variables and can be more linked to the country-specific default rates and returns on aggregate stock indices, rather than to the expected economic growth.

[32] Greek and Portuguese bonds were excluded from the index due to downgrading to sub-investment grade.

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## Annex 1: Description of the dataset and applied filters

I use the information on all available bonds contained in the Merrill Lynch EMU corporate bond index ER00[33], which incorporates euro-denominated[34] investment grade bonds with the minimum size of issue of 250 million euros. The constitution of the index suffers due to several structural breaks, which have to be taken into account[35]. Bonds without investment grade and with embedded special features (asset-backed, callable, putable, floating rate, perpetual and sinking fund) were excluded[36] from our sample as their pricing is contaminated by different categories of risk. Some of remaining bonds have the explicit government guaranties, but I assume that this special feature is already reflected in the rating of these bonds. I assume that the performance of a particular bond is representative for the market as long as it is included in the index, and, therefore, I keep this bond in our data sample only for the abovementioned period. Our data sample covers the period January 1997 - February 2013 and consists in total of 5267 individual bonds (see Table 1.A). Country attribution of the euro-denominated bonds reveals that country-specification, provided by agencies, could be misleading, as it often exposes the country of issuance, and not the country of risk[37] for some bonds. I use 10 rating categories including subdivisions to distinguish between plus and minus-rated bonds[38] and monitor the changes in rating over time. In line with the results of Elton et al (2002) regarding the superiority of composite ratings over a single rating measure, I use the composite measure of Moody's and Standard & Poor's ratings.

For the subsequent cross-sectional and time series analysis I have to shrink our dataset in order to obtain reliable parameter estimates. First, as the analysis is concentrated on monthly frequency[39], for each monthly interval I take out bonds which were quoted less that once during every week in a given month. I assume that the bond's liquidity pattern could vary during its lifetime and let a bond out of the sample (or let it back in the sample) depending on current liquidity. Second, I make sure that all bonds with less than one year of remaining time to maturity are excluded from the sample as their pricing becomes illiquid and not representative. Third, I concentrate only on bonds of countries of risk, which have not less than 5 bonds on average among all monthly time intervals. This leads to in the restriction of our dataset to begin from the middle of 1999 and in the following country decomposition of our dataset: Austria (AT), Australia (AU), Belgium (BE), Switzerland (CH), Germany (DE), Denmark (DK), Spain

[33] Although this index does not cover the entire corporate euro-denominated bonds market, it constitutes a very good approximation for it.

[34] Bonds were denominated in domestic currencies of corresponding euro-zone members during pre-EMU period.

[35] Before 2005 the minimum size for constituent inclusion into the index was 100 million euros, therefore I let the bonds, included into the index before 2005, to remain in the index until maturity. I would assume that bonds with the issuance size of 100 million euros were representative for the euro-denominated corporate bond market only during the first stage of the development. As of 31/12/2003 callable, fixed to floating and perpetual callable securities were permitted to enter the index, but these bonds are eliminated from our sample through filtration as they belong to different risk categories.

[36] Contrarily to the dataset covering bonds, issued by the US financial and non-financial corporations (as used e.g. in Gilchrist and Zakrajsek, 2011), where about two thirds of securities were callable, only about 20% of euro-denominated corporate bonds in our sample have embedded special features. Alternatively to elimination of bonds with embedded special features, Gilchrist and Zakrajsek (2011) adjusted credit spreads for the callability of underlying issues.

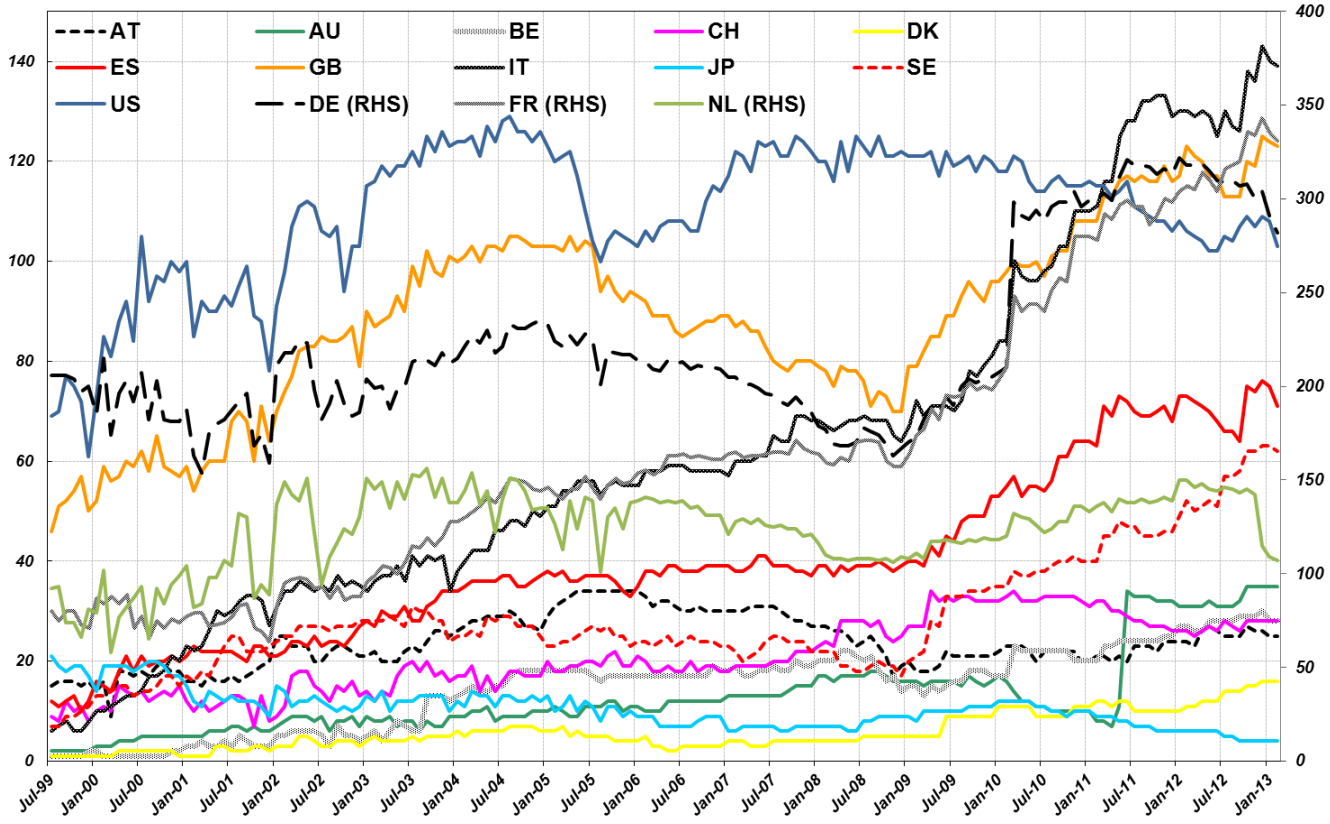
[37] Several reasons, including differences in legislative and tax systems are causing the issuances of corporate bonds in foreign countries, thus, 34% of Belgian bonds, 28% of German bonds, 24% of Spanish bonds, 49% of Portuguese bonds in our sample were issued in the Netherlands. Moreover, 83% of Greek bonds were issued in Great Britain.

[38] I discriminate between 10 subcategories: AAA, AA1 (AA+), AA2 (AA), AA3 (AA-), A1 (A+), A2 (A), A3 (A-), BBB1 (BBB+), BBB2 (BBB) and BBB3 (BBB-) rated bonds.

[39] To eliminate the potential day-of-week effect in corporate bonds pricing, I use not the end-of-month as the date for the end of our monthly time intervals, but Friday, which was closest to the end-of-month.

(ES), France (FR), Great Britain (GB), Italy (IT), Japan (JP), the Netherlands (NL), Sweden (SE) and the United States (US). The evolution of number of bonds per given country in our sample is presented in Chart A1. Germany is the unconditional leader of the number of bonds in our sample, which never drops less than 154 bonds and is equal to 232 bonds in average among time intervals. It is followed by France, the Netherlands, the United States, Great Britain, Italy and Spain, which have 166, 123, 110, 89, 63 and 40 bonds in average among time intervals, other countries remind behind and have less than 30 bonds on average across time. Finally, I eliminate outliers from our data sample. It turns out that only a few bonds have yields, which are noticeably different from yields of bonds within the same rating class, maturity and country.

**Charts A1.1 – Number of bonds per country of risk in the reduced sample used in the cross-sectional regression and time series-analysis (as in Sections 3.3 and 3.4).**




*Source: ECB calculations, Merrill Lynch and Bloomberg.*

**Table A1. Overall number of bonds without special features in ER00 Merrill Lynch index (during January 1997 – February 2013) with country of risk and country of issuance attributions.**

| Country-of-risk | Number of bonds | |
|---|---|---|
| **Austria (AT)** | 103 | |
| ***Issued in AT*** | | *94%* |
| **Belgium (BE)** | 70 | |
| ***Issued in BE*** | | *40%* |
| ***Issued in NL*** | | *31%* |
| ***Issued in LU*** | | *16%* |
| ***Issued in FR*** | | *3%* |
| ***Issued in offshores*** | | *1%* |
| **Germany (DE)** | 1361 | |
| ***Issued in DE*** | | *60%* |
| ***Issued in NL*** | | *28%* |
| ***Issued in offshores*** | | *2%* |
| ***Issued in GB*** | | *3%* |
| ***Issued in IE*** | | *1%* |
| **Finland (FI)** | 49 | |
| **France (FR)** | 923 | |
| ***Issued in FR*** | | *92%* |
| ***Issued in NL*** | | *2%* |
| **Spain (ES)** | 228 | |
| ***Issued in ES*** | | *61%* |
| ***Issued in NL*** | | *22%* |
| ***Issued in CW, KY*** | | *7%* |
| **Greece (GR)** | 18 | |
| ***Issued in GR*** | | *17%* |
| ***Issued in GB*** | | *83%* |
| **Ireland (IE)** | 61 | |
| ***Issued in IE*** | | *92%* |
| **Italy (IT)** | 371 | |
| ***Issued in IT*** | | *75%* |
| ***Issued in NL*** | | *7%* |
| ***Issued in CW, KY*** | | *2%* |
| ***Issued in IE*** | | *1%* |
| **Luxembourg (LU)** | 27 | |
| ***Issued in LU*** | | *96%* |
| **Netherlands (NL)** | 643 | |
| ***Issued in NL*** | | *96%* |
| **Norway (NO)** | 49 | |
| **Sweden (SE)** | 142 | |
| **Portugal (PT)** | 43 | |
| ***Issued in PT*** | | *37%* |
| ***Issued in NL*** | | *49%* |
| ***Issued in CW, KY*** | | *12%* |

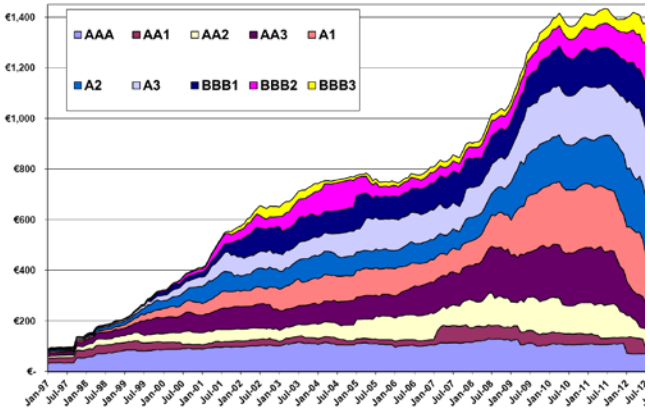
| Country-of-risk | Number of bonds | |
|---|---|---|
| **Australia** | 80 | |
| **Japan** | 64 | |
| **Canada** | 31 | |
| **Cayman Islands** | 22 | |
| **Czech Republic** | 16 | |
| **Russia** | 16 | |
| **Jersey** | 15 | |
| **Poland** | 11 | |
| **Hong Kong** | 7 | |
| **Hungary** | 7 | |
| **Korea** | 7 | |
| **New Zealand** | 7 | |
| **Arab Emirates, Saudi Arabia** | 5 | |
| **Iceland** | 5 | |
| **Brazil** | 4 | |
| **Mexico** | 4 | |
| **Bermuda** | 3 | |
| **Estonia** | 3 | |
| **Kazakhstan** | 3 | |
| **South Africa** | 3 | |
| **China** | 2 | |
| **Croatia** | 2 | |
| **Chile** | 1 | |
| **Cyprus** | 1 | |
| **India** | 1 | |
| **Isle of Man** | 1 | |
| **Israel** | 1 | |
| **Malaysia** | 1 | |
| **Romania** | 1 | |
| **Singapore** | 1 | |
| **Slovenia** | 1 | |
| **Tunisia** | 1 | |
| **Great Britain (GB)** | 380 | |
| ***Issued in GB*** | | *89%* |
| ***Issued in NL*** | | *6%* |
| **Untied States (US)** | 566 | |
| ***Issued in US*** | | *86%* |
| **Denmark (DK)** | 37 | |
| **Switzerland (CH)** | 98 | |
| ***Issued in CH*** | | *38%* |
| ***Issued in NL*** | | *4%* |
| ***Issued in Jersey, Guernsey*** | | *11%* |
| ***Issued in Bermuda*** | | *4%* |
| ***Issued in CW, KY*** | | *4%* |

## Annex 2. Developments in the euro-denominated corporate bond market

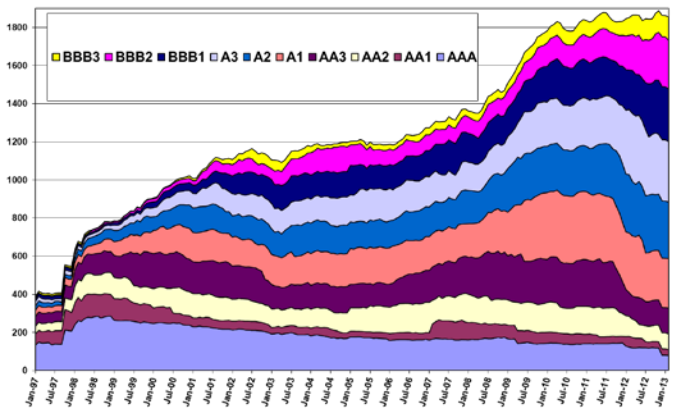
The total outstanding value of all corporate investment grade euro-denominated bonds without special features in our sample increased from about 90 billion euro in the beginning of 1997 to about 1400 billion euro in 2010. This outstanding volume, however, kept almost unchanged over the next 3 years. Looking at the separate rating categories, the substantial increase in the outstanding value of lower-rated bonds and the significant drop in the outstanding volume of high-rates issues are noteworthy. As a percentage of the total outstanding value, the BBB- and the A-segments increased from 5%/ 16% in 1997 to about 35%/ 48% in 2013, respectively. The outstanding value of the AAA-segment experienced the significant drop from 36% in 1997 to only 2% in 2013 and the AA-segment declined from 43% in 1997 to 15% in 2013 with the most pronounced decrease for the AA1 category (from 21% to only 1%). The increase in volume of lower-rated bonds is to some extent explained by enlarged participation of non-financial corporations and by substantial downgrading process. In 1997 the market was dominated by debt issued by highly-rated financial corporations; the relative weight of financial sector constituted about 81% of the total outstanding value of corporate bonds, compared to 16% and 3% for industrial sector and utilities, respectively. By 2013, however, the share of the outstanding debt issued by utilities slightly increased to 13%, whereas the share of industrials experienced more substantial growth to about 38%. This increase came at the expense of the share of financials, which declined to 48% herewith the more or less constant and small shares of the outstanding debt issued by companies providing financial services and insurance and with the significant drop of the outstanding debt issued by banks.

**Chart A2.1. Corporate euro-denominated bond outstanding amount and number of bonds per rating category**

*a) outstanding amount (in bln euros)*



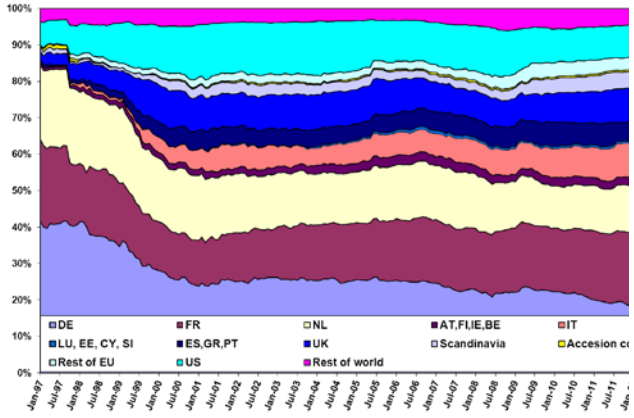

*b) number of bonds*



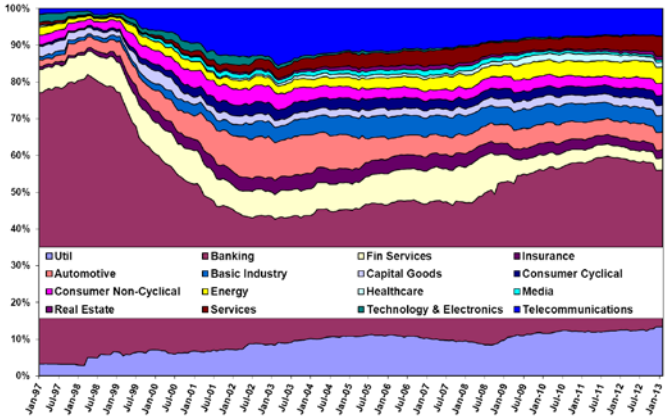

*Source: ECB calculations and Bloomberg.*

**Chart A2.2. Corporate investment grade euro-denominated bond outstanding amount per country of risk and per industry**

*a) per countries of risk(percentages)*




*b) per industry (percentages)*

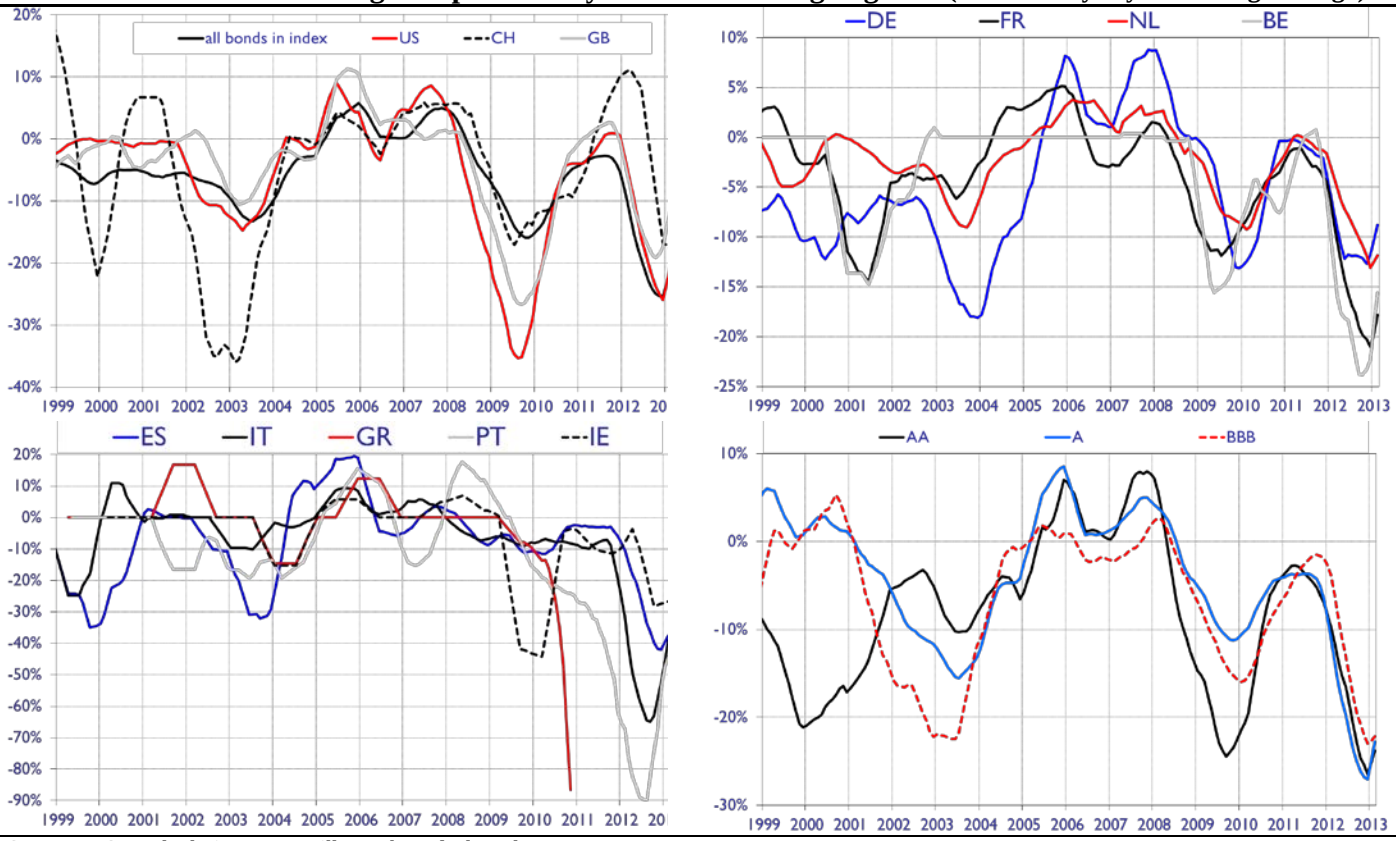



*Source: ECB calculations and Bloomberg.*

To address the issue of cross-country heterogeneity in downgrading process I compute the index of **rating drift**. Rating drift is specified as the number of upgraded issues, excluding the number of downgraded issues, as the percentage of the average number of rated issues during a certain time interval. Rating drifts were used as supplementary illustrative indicators of fragmentation in the corporate bond market in Financial Integration Report (ECB (2014)).

Charts A2.3 present rating drifts, calculated for the interval of 6 months and smoothed by 1-year moving averages. .In the recent past, rating drifts exhibited two major waves of downgrades across all countries – in 2009 and in 2012. The first wave of downgrades (in 2009) was more pronounced for the US, British and Swiss corporate bonds in our sample, whereas the recent second wave is more pronounced for corporate issuances of the euro area countries. Moreover, while the values of rating drift for countries less affected by financial tensions reached only -8%-15% in the second half of 2012, the rating drift has reached -27%, -37%, -39% and -44% in Ireland, Spain, Italy and Portugal at the same time, respectively. More prominent downgrades amounting to 65%-90% of all rated issues were observed for Italian, Portuguese and Greek corporate issuances in the middle of 2012. Greek corporate bonds were completely excluded from the Merrill Lynch corporate bond index at the end of 2010. In terms of downgrades per rating segment, the first wave of downgrades was more pronounced for the high-rated segment (AA1 and AA2), pointing towards high-rated financial corporations, whereas the recent second wave of downgrades was more associated with the medium-rated and the low-rated segment

**Charts A2.3. 6-months rating drift per country of risk and rating segment (smoothed by 1-year moving average)**




*Source: ECB calculations, Merrill Lynch and Bloomberg.*
*Note: Rating drift=(number of issuer upgrades for 6 months –number of issuer downgrades for 6 months)/ average rated issues during 6 months.*

## Annex 3. Breakup of the existence of country ceilings for corporate bond ratings

In the second half of 2011 and the first half of 2012, the euro area sovereign bond market experienced severe tensions and a significant degree of fragmentation, leading to big yield gaps between sovereign and corporate issues of distressed and non-distressed countries, high volatility levels and liquidity drawn. Perceived unsustainability of balances of payments and sovereign fiscal positions of countries under stress together with some political uncertainties and a perceived risk of redenomination (i.e. perceived risk of a euro area break up) led in some cases to an overpricing of sovereign risk. While the ECB (2014) discusses the intensification of financial fragmentation caused by the tensions at the sovereign debt markets, providing indicators of fragmentation separately for sovereign and corporate bonds[40], this Annex assesses how the sovereign debt crisis affected changes of ratings of both corporate and government bonds at the same time. Charts A3 present the weighted average ratings for corporate

[40] Government bonds yield dispersion, which is used as an indicator of financial fragmentation in sovereign debt market, is influenced by risk aversion among investors. During 2003-2007, all euro area government bonds were broadly equally priced, irrespective of ratings and differences in fiscal positions between countries, which were already pronounced at that time. This reflected a high risk tolerance, low risk premia and a possible under-appreciation of sovereign risk before 2007. Weak economic fundamentals cannot serve as the sole explanation of the sovereign bond market tensions in 2011-2012 as even in the euro area countries with solid economic fundamentals and relatively low level of sovereign debt, the sovereign CDS spreads have reached historical high levels. The latter indicate possible contagion from development in the perceptions of credit risk from the distressed euro area countries to non-distressed countries and potential impact of the concerns regarding the EU rules to enforce fiscal discipline. Several institutional changes were introduced by the European authorities in response to the intensification of sovereign stress and debt market malfunctioning, including the European Financial Stability Facility (EFSF), the Single Supervisory Mechanism (SSM) and the non-standard ECB monetary policy measures.

bonds[41] for selected countries together with the weighted average ratings for financial and industrial bonds separately, the minimal and the maximal corporate ratings as well as ratings for long-term sovereign debt for selected countries. Interesting question is related to the intuitive assumption regarding the existence of the country ceiling in rating practice exercised by rating agencies (if ratings of corporate issues could get higher than ratings of sovereign bonds of a corresponding country of risk[42)]. Charts A3 confirm that on the basis of our dataset, the sovereign rating was always higher or equal to the maximal corporate rating only in case of Germany and the Netherlands. Contrariwise, the composite Moody's and Standard & Poors sovereign rating for Austria declined by 0.5 notches from the AAA level in January 2012, while the maximal corporate rating stayed at the AAA level; the maximal corporate rating for Belgium increased to the AA (Aa2) level in December 2012, whereas the sovereign rating stayed unchanged 0.5 notches lower. In the same vein, the maximal corporate rating was higher than the sovereign rating for the period between January 2012 and November 2012 in case of France. The intensification of the sovereign debt crisis had more pronounced impact on changes in sovereign versus corporate ratings for two countries under stress in our sample. Specifically, the Spanish sovereign rating was exceeded by the maximal rating of Spanish corporate bonds and by the weighted average rating of Spanish financial corporations in November 2011, by the weighted average Spanish corporate rating and by the weighted average rating of Spanish non-financial corporations in June 2012 and even became equal to the minimal Spanish investment grade corporate rating (BBB-) in October 2012. The Italian sovereign rating did not reach the level of the minimal Italian investment grade corporate rating, but got lower than the weighted average corporate rating and the weighted average ratings of both Italian financial and non-financial corporations in July 2012. Thus, an overpricing of sovereign risk during the euro area sovereign debt crisis was reflected not only in sharply increased divergence between bond yields of non-distressed and distressed euro area sovereigns and corporates in 2011-2012 as was previously reported in several publications, but also in a counterintuitive break-up of the existence of country ceilings for corporate bond ratings and even in the sharp declines of sovereign ratings in some countries under stress to the levels of the minimal investment grade corporate ratings in these countries. One of the factors, contributing to this result might be the maturity mismatch between sovereign and corporate bonds in our sample; as underlined in Section 3.1, time to maturity and credit risks are not independent. I compare ratings for the long-term sovereign debt with the weighted average ratings of corporate bonds. The weighted average maturity of bonds attributed to euro area countries declined with time from about 5.9 years in 1999 to 5.1 years in 2014[43]. However, this maturity gap between sovereign and corporate issues in our sample can not explain the existence of country ceilings in the pre-crisis period and the subsequent break-up of it. Moreover, even the exactly maturity-matched corporate spreads measured with respect to the government bond yields, derived from the national sovereign curves, often take negative values during the crisis period in case of Spain and Italy.

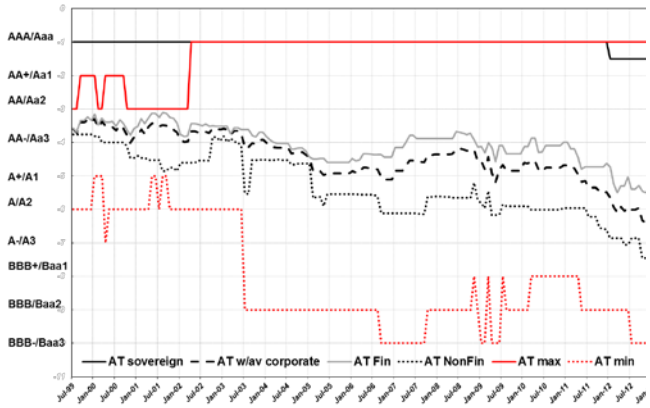
[41] These charts present weighted average ratings for the smaller set of bonds, used for the subsequent analysis of factors affecting corporate spreads (in Section 3). Ratings for sovereign issues are compiled as a composite (average) measure of Moody's and Standard & Poors ratings (similarly to ratings for corporate issues).

[42] Country-of-risk attribution of a corporate bond might not coincide with country-of-residence and/ or country-of-issuance attributions. See Table A1 in Annex 1 for the shares of corporate bonds in our sample issued in domestic and sovereign countries.

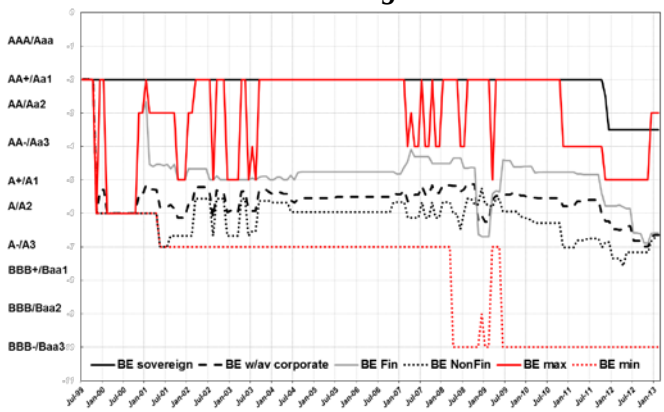
[43] These figures are presented in my subsequent paper on leading indicator properties of corporate spreads.

**Charts A3. Sovereign and corporate ratings per country (average of Moody's and Standard & Poor's ratings)**

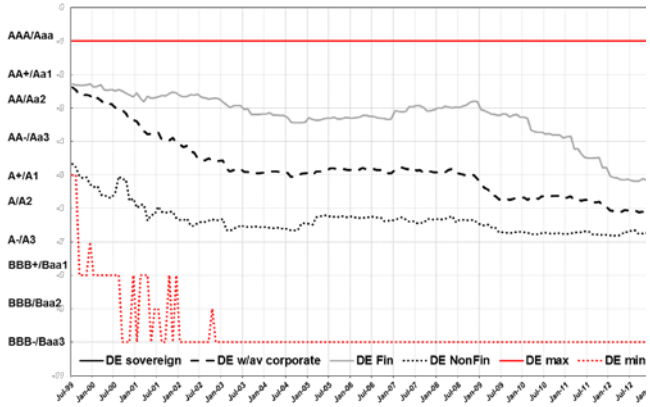
*Austria*



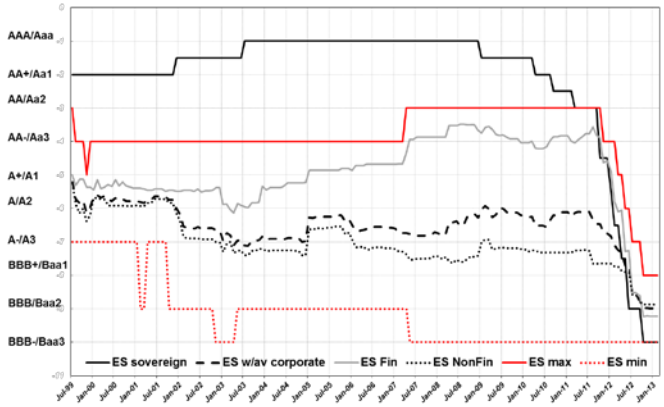

*Belgium*



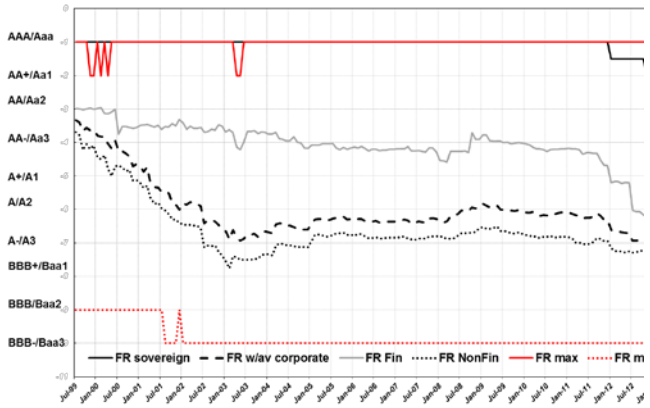

*Germany*



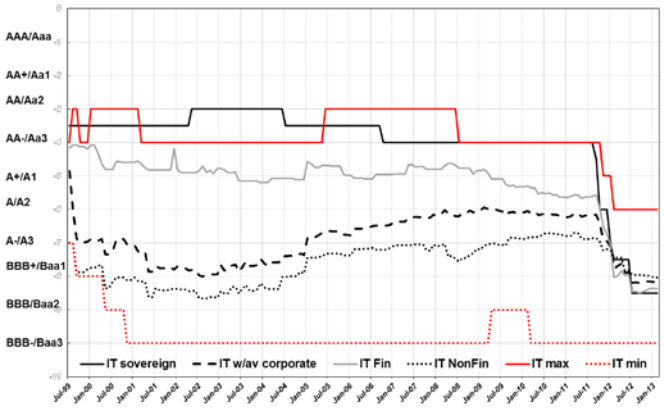

*Spain*



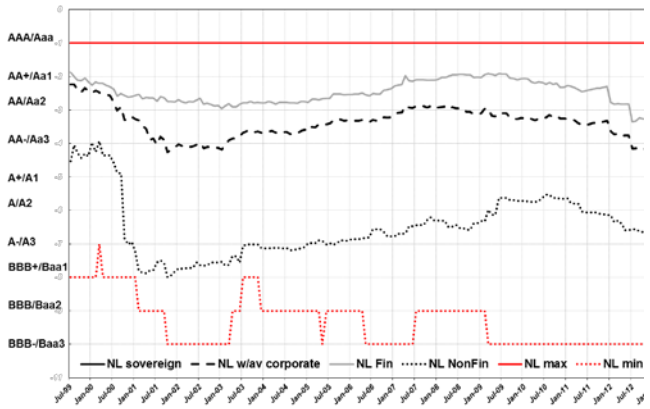

*France*



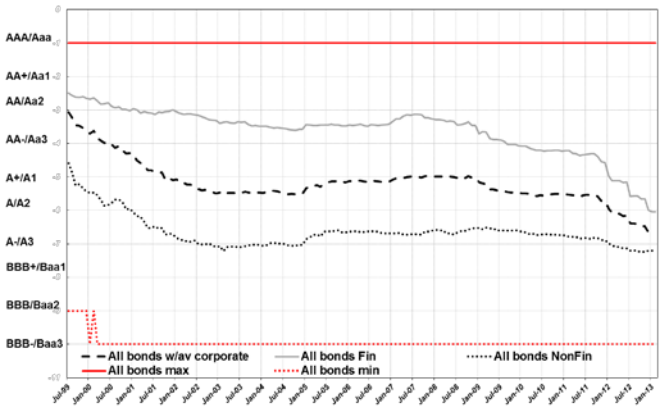

*Italy*




*Netherlands*




*All bonds in sample*



*Source: ECB calculations, Merrill Lynch and Bloomberg.*
*Note: Charts present weighted average for all bonds, weighted average for financial bonds and weighted average for non-financial bonds ratings in selected countries-of-risk. Maximal and minimal corporate ratings as well as ratings for long-term sovereign debt are depicted as well. Composite measure of Moody's and Standard & Poor's ratings is used. Chart for all bonds in sample corresponds to a reduced subset of bonds, used for the cross-sectional and time-series (in Section 3).*

## Annex 4. Proxies of liquidity.

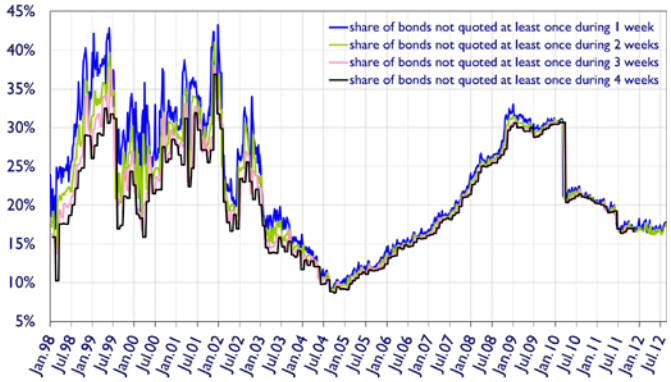
Unfortunately, the information about real trades on the corporate bond market is not available. Therefore, I have to base our proxies of liquidity on available market quotes, supplied by data providers. However, some part of these quotes might be only "indicative" quotes of market makers, which do not reflect real trades. Based on available market quotes, Baele et al. (2004) measured liquidity by the ratio of days that a given bond was quoted relative to the total number of trading days within every time interval. They reported that until the end of 1999, less than 30% of BBB-rated bonds were quoted at least once a week, compared to about 90% for higher rated bonds, and that liquidity of BBB-rated bonds improved significantly in 2000, and since then has been comparable to other rating categories. Following charts depict similar measures of liquidity for our dataset. In particular, Chart A4.2 demonstrates the share of bonds not quoted at least once during the intervals of 1-4 weeks and the average number of quotes per bond per day during the same time intervals. Chart A4.4 presents the average number of quotes per bond per day during one week, distinguishing between different rating categories and different countries. As can be seen, these liquidity measures are more related to quality of data, supplied by data providers, rather than to the actual liquidity patterns on the market: the strange increasing pattern in number of bonds not quoted at least once during the intervals of 1-4 weeks between 2005 and 2008 cannot be attributed to the real drawn of liquidity on the corporate bond market. Moreover, Chart A4.2 presents a counterintuitive picture: it shows, for example, that Greek bonds had the highest liquidity (on average about 5 quotes per week) before liquidity suddenly dropped to zero in the beginning of 2010[44]. Moreover, according to charts, in the middle of 2012 (at the end of our sample for this exercise), the least liquid bonds had the AAA and the AA2 ratings and were attributed to Austria, followed by Belgium, Switzerland and Germany. At the same time, the most liquid bonds had the BBB3 rating and were attributed to Italy, Ireland and France. This contradicts to stylized facts regarding the developments in corporate bond market liquidity and is caused by the fact that I have to use indicative quotes instead of the information, based on real trades.

In order to create better proxy of liquidity, I consider the bid-ask spread, scaled by the mid-yield of a given bond for a given day. Chart A4.2 depicts these average bid-ask spreads scaled by the mid-yields for different rating categories and countries in our sample. The significant increase of the average bid-ask spreads in 2011 coincides with the styled facts: liquidity in corporate bond market dropped sharply during this time. However, our indicator of liquidity also suffers from the fact that I use indicative quotes, instead of information about real trades. Therefore, I treat this proxy of liquidity with caution, while introducing it into the econometric exercise.

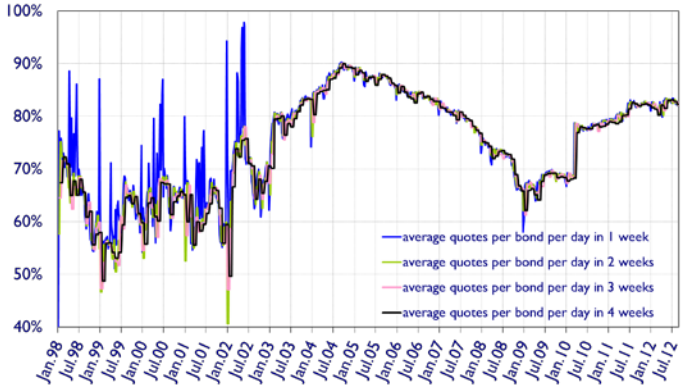
[44] Greek corporate bonds were completely excluded from the Merrill Lynch corporate bond index at the end of 2010.

**Chart A4.1. Share of bonds not quoted at least once during 1-4 weeks and average quotes per bond per day in 1-4 weeks**

*c) share of bonds not quoted (in %)*



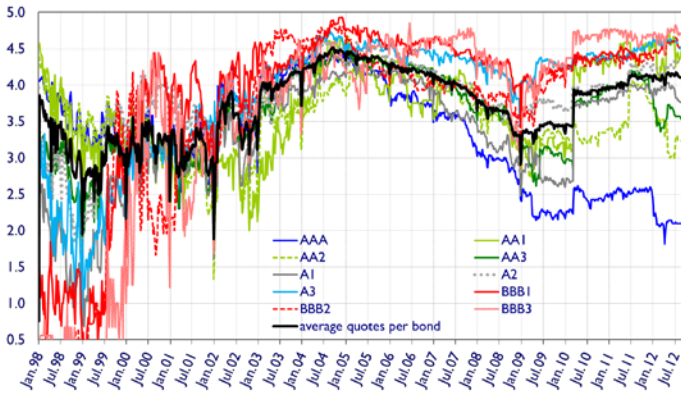

*d) average quotes per day per bond (in %)*



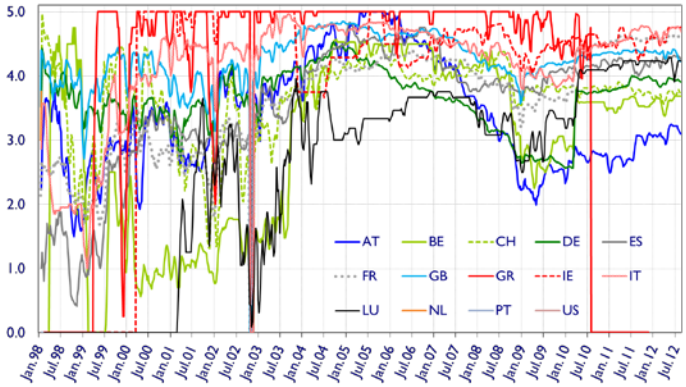

*Source: ECB calculations and Bloomberg.*

**Chart A4.2. Average number of quotes per bond in 1 week interval (per rating category and per country)**

*a) per rating category*



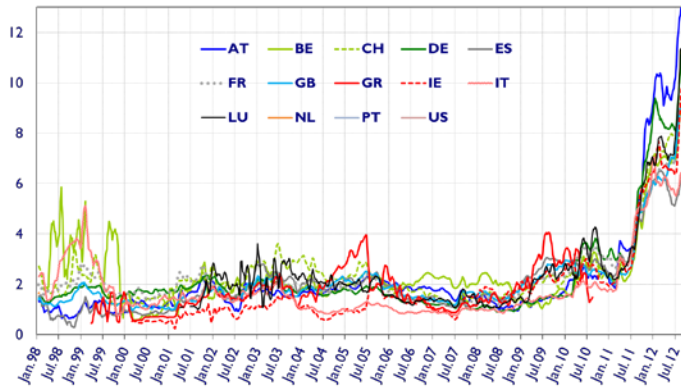

*b) per country*



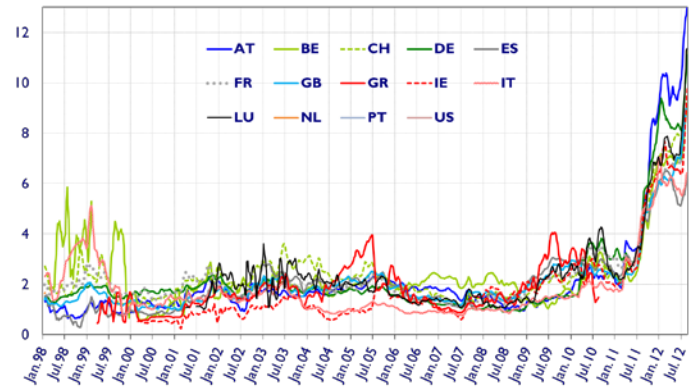

*Source: ECB calculations and Bloomberg.*

**Chart A4.3. Average bid-ask spread, scaled by the mid-yield, (in 1 week interval, per rating and per country)**

*a) per rating category*




*b) per country*




*Source: ECB calculations and Bloomberg.*

## Annex 5. Construction of pure country (rating or sector) spreads and decomposition of volume-weighted country (rating or sector) spread indices and weighted country-sector-specific indices.

The cross-sectional regression *(1)* is also useful for constructing the pure country (rating, sector) spreads for the volume-weighted country (rating or sector) corporate spread indices. Summing up equation *(1)* in the presence of parameter constraint (*2*) using market weights across bonds, issued by a particular country *c* gives us the **pure country *c* spread** $Spread^{vw}_{c,pure}(t)$ if the rating and sector distributions in country *c* matches the rating and sector distribution in the whole market.

$$Spread^{vw}_{c,pure}(t) = \alpha_t + {}_t\tau^{wv}_{c,t} + \rho_t coupon^{wv}_{c,t} + \lambda_t liq^{wv}_{c,t} + \gamma_{c,t} \qquad (A5.1)$$

Where $\tau^{vw_{c,t}}$ is the volume-weighted average of remaining time to maturity for bonds, attributed to country *c* at time *t*; $liq^{vw_{c,t}}$ is the volume-weighted average liquidity in country *c* at time *t;* $coup^{vw_c}$ is the volume-weighted average coupon rate in country *c* and $\gamma_{c,t}$ is the country *c* effect (coefficient on country *c* dummy).

If the rating and sector distributions in country *c* differ from the distributions for the whole market, then the **volume-weighted country *c* spread** $Spread^{vw}_{c}(t)$ (weighted corporate spread index for bonds attributed to country *c*) could be decomposed into the pure country *c* spread $Spread^{vw}_{c,pure}(t)$ and the residual rating and sector effects (the weighted average of remaining rating and sector components):

$$Spread^{vw}_{c}(t) = \alpha_t + {}_t\tau^{wv}_{c,t} + \rho_t coupon^{wv}_{c,t} + \lambda_t liq^{wv}_{c,t} + \gamma_{c,t} + \frac{1}{\omega_{c,t}}\sum_{i=1}\sum_{r=1}^{10}\beta_{r,t}R^{r}_{i,t} + \frac{1}{\eta_{c,t}}\sum_{i=1}\sum_{s=1}^{2}\sigma_{s,t}S^{s}_{i,t} \qquad (A5.2)$$

Where index *i* sums up only bonds issued by country c and weights $\omega_{c,t}$ / $\sigma_{c,t}$ correspond to the rating / the sector distributions in country *c*.

Similarly, summing up equation *(1)* in the presence of constraint (*2*) using market weights across bonds in a particular rating category *r* gives us the **pure rating *r* spread** $Spread^{vw}_{r,pure}(t)$, which represents the spread of geographically and industrially diversified portfolio of corporate bonds with rating *r*, the portfolio has the same countries and sectors decomposition as the volume-weighted market portfolio.

$$Spread^{vw}_{r,pure}(t) = \alpha_t + {}_t\tau^{wv}_{r,t} + \rho_t coupon^{wv}_{r,t} + \lambda_t liq^{wv}_{r,t} + \beta_{r,t} \qquad (A5.3)$$

Taking into account, that the country and industry decompositions of bonds in a rating category *r* might diverge from the market decompositions, the **volume-weighted rating *r* spread index** $Spread^{vw}_{r}(t)$ could be decomposed into the pure rating *r* spread $Spread^{vw}_{r,pure}(t)$ and the residual country and sector effects (the weighted averages of country and sector components):

$$Spread_r^{vw}(t) = \alpha_t + {}_t\tau_{r,t}^{wv} + \rho_t coupon_{r,t}^{wv} + \lambda_t liq_{r,t}^{wv} + \beta_{r,t} + \frac{1}{v_{r,t}} \sum_{i=1} \sum_{c=1}^{14} \gamma_{c,t} C_{i,t}^{c} + \frac{1}{\eta_{r,t}} \sum_{i=1} \sum_{s=1}^{2} \sigma_{s,t} S_{i,t}^{s} \qquad (A5.4)$$

Where index *i* sums up only bonds, belonging to a rating category *r*, weights $v_{r,t}$ / $\sigma_{r,t}$ correspond to the country / sector distributions of bonds in a rating category *r*; $\tau^{vw_{r,t}}$ is the volume-weighted average of remaining time to maturity of bonds, attributed to rating *r* at time *t*; $liq^{vw_{r,t}}$ is the volume-weighted average liquidity for a rating category *r* at time *t;* $coup^{vw_r}$ is the volume-weighted average coupon rate for a rating category *r* and $\beta_{r,t}$ is the rating effect for a rating category *r* (coefficient on rating *r* dummy).

Analogically, summing up equation *(1)* in the presence of constraint (*2*) using market weights across bonds belonging to a particular sector category *s* gives us the **pure sector *s* spread** $Spread_{s,pure}^{vw}(t)$, which represents the spread of geographically and ratings diversified portfolio of corporate bonds issued by firms attributed to industry *s*, the portfolio has the same countries and ratings decomposition as the volume-weighted market portfolio.

$$Spread_{s,pure}^{vw}(t) = \alpha_t + {}_t\tau_{s,t}^{wv} + \rho_t coupon_{s,t}^{wv} + \lambda_t liq_{s,t}^{wv} + \sigma_{s,t} \qquad (A5.5)$$

Taking into account, that the country and ratings decompositions of bonds of sector *s* might diverge from the market decompositions, the **volume-weighted sector *s* spread index** $Spread_s^{vw}(t)$could be decomposed into the pure sector *s* spread $Spread_{s,pure}^{vw}(t)$ and the residual country and rating effects (the weighted averages of country and ratings components):

$$Spread_s^{vw}(t) = \alpha_t + {}_t\tau_{s,t}^{wv} + \rho_t coupon_{s,t}^{wv} + \lambda_t liq_{s,t}^{wv} + \sigma_{s,t} + \frac{1}{v_{s,t}} \sum_{i=1} \sum_{c=1}^{14} \gamma_{c,t} C_{i,t}^{c} + \frac{1}{\omega_{s,t}} \sum_{i=1} \sum_{r=1}^{10} \beta_{r,t} R_{i,t}^{r} \qquad (A5.6)$$

Where index *i* sums up only bonds, belonging to industry *s*, weights $v_{s,t}$ / $\sigma_{s,t}$ correspond to the country / ratings distributions of bonds, belonging to sector *s*; $\tau^{vw_{s,t}}$ is the volume-weighted average of remaining time to maturity of bonds, attributed to industry *s* at time *t*; $liq^{vw_{s,t}}$ is the volume-weighted average liquidity of corporate bonds, belonging to sector *s* at time *t;* $coup^{vw_s}$ is the volume-weighted average coupon rate for a sector category *s* and $\sigma_{s,t}$ is the sector *s* effect (coefficient on sector *s* dummy).

In the same fashion, one can create spreads for the country-specific spread indices for financial and non-financial corporate bonds. Summing up equation *(1)* using market weights across bonds, attributed to a particular country *c* and sector *s*, gives us the **pure country *c*- sector *s* spread** $Spread_{c,s,pure}^{vw}(t)$ if the rating distribution in the subsample of bonds, attributed to country *c* and sector *s*, matches the rating distribution in the whole sample of bonds.

$$Spread_{c,s,pure}^{vw}(t) = \alpha_t + {}_t\tau_{c,s,t}^{wv} + \rho_t coupon_{c,s,t}^{wv} + \lambda_t liq_{c,s,t}^{wv} + \gamma_{c,t} + \sigma_{s,t} \qquad (A5.7)$$

Where $\tau^{vw_{c,s,t}}$ is the volume-weighted average of remaining time to maturity for bonds, attributed to country *c* and sector *s* at time *t*; $liq^{vw_{c,s,t}}$ is the volume-weighted average liquidity in country *c* and sector *s* at time *t;* $coup^{vw_{c,s}}$ is the volume-weighted average coupon rate in country *c* and sector *s;* $\gamma_{c,t}$ is the country *c* effect (coefficient on country *c* dummy) and $\sigma_{s,t}$ is the sector *s* effect (coefficient on sector *s* dummy).

If the rating distribution in country *c* and sector *s* differs from the distribution for the whole sample, then the **volume-weighted country *c* – sector *s* spread index** $Spread^{vw}_{c,s}(t)$ could be decomposed into the pure country *c* – sector *s* spread $Spread^{vw}_{c,s,pure}(t)$ and the residual rating effect (the weighted average of rating components).

$$Spread^{vw}_{c,s}(t) = \alpha_t + {}_t\tau^{wv}_{c,s,t} + \rho_t coupon^{wv}_{c,s,t} + \lambda_t liq^{wv}_{c,s,t} + \gamma_{c,t} + \sigma_{s,t} + \frac{1}{\omega_{c,s,t}} \sum_{i=1}^{10} \sum_{r=1} \beta_{r,t} R^r_{i,t} \qquad (A5.8)$$

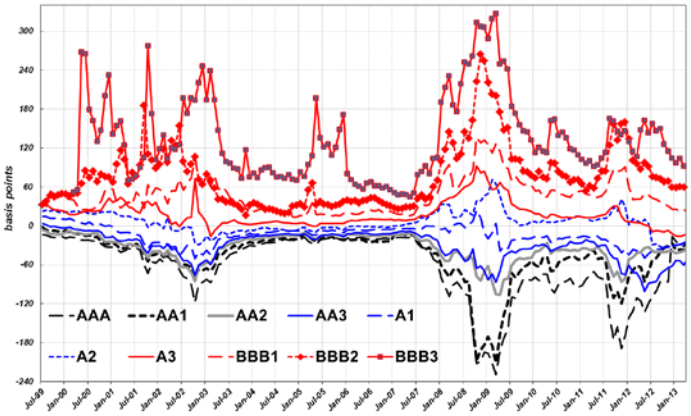
Where index i sums up only bonds, attributed to country *c* and sector *s* and weights $\omega_{c,s,t}$ correspond to the ratings distributions for bonds, belonging to country *c* and sector *s*.

The country-specific rating as well as the rating-specific sector volume-weighted portfolios can be created in a similar way. Due to data limitations, I can not construct the time series of the volume-weighted spreads of these portfolios.

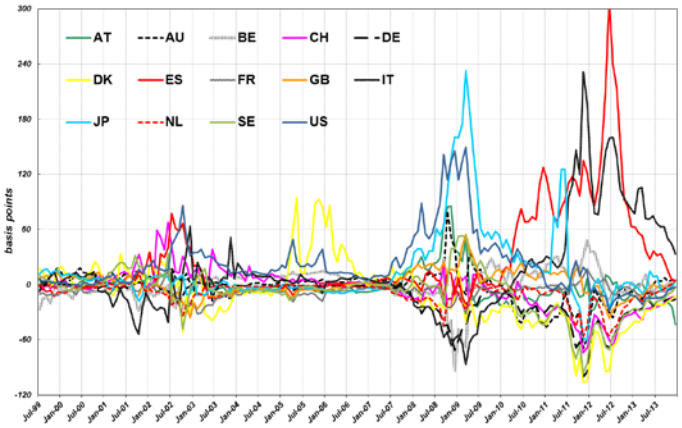
## Annex 6. Additional estimation output of cross-sectional analysis

### Charts A6.1. Rating, country and sector effects and their cross-sectional dispersions

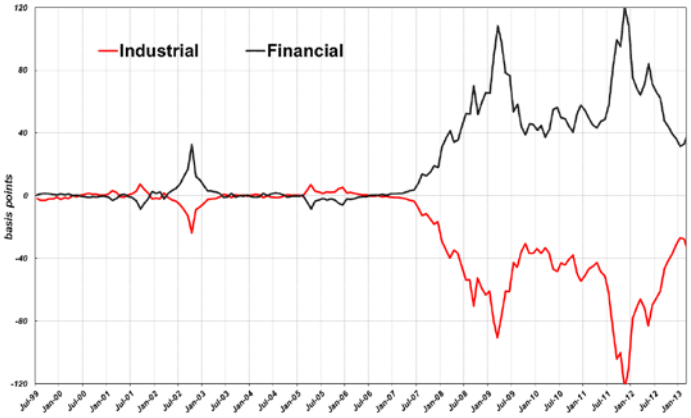
*a) rating effects*



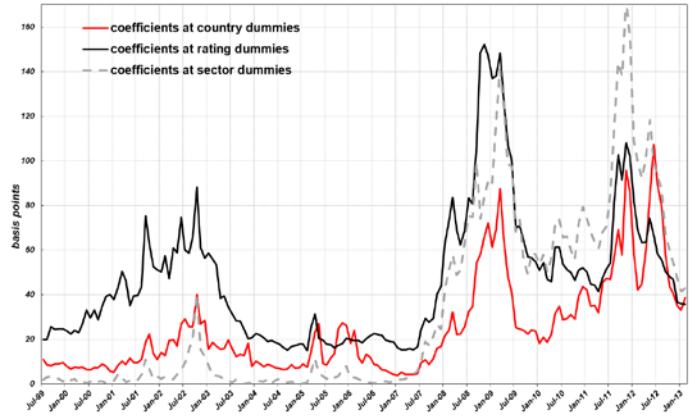

*b) country effects*




*c) sector effects*



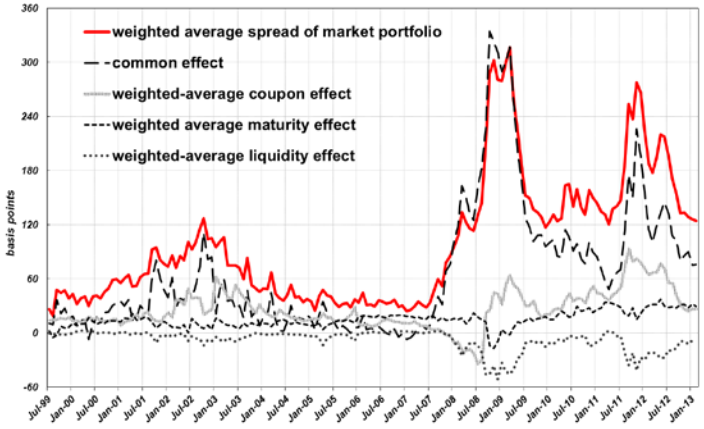

*d) cross-sectional dispersions*



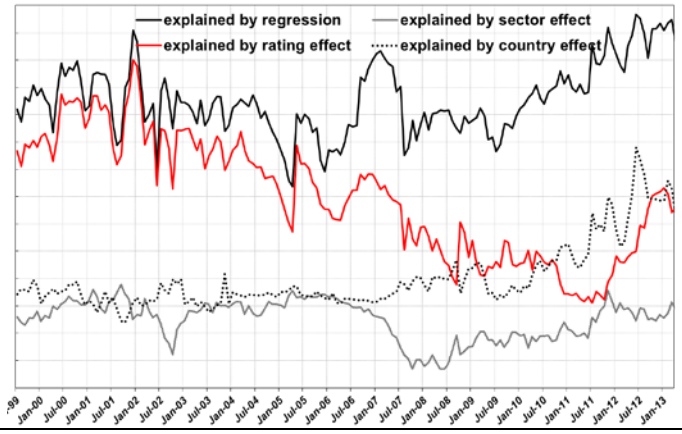

*Source: ECB calculations, Merrill Lynch and Bloomberg.*
*Note: Estimations of cross-sectional regression (1) are done using the first parameter constraint (2).*

**Charts A6.2. Spread of weighted market portfolio and it's decomposition into common, maturity, coupon and liquidity effects *(in basis points)* and proportion of cross-sectional variance, explained by regression and it's components *(in %)***

*a) spread of weighted market portfolio and it's decomposition*




*b) proportion of cross-sectional variance explained*

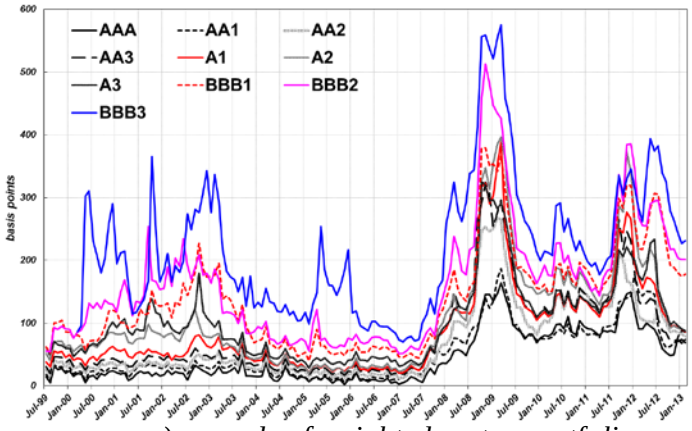



*Source: ECB calculations and Bloomberg.*

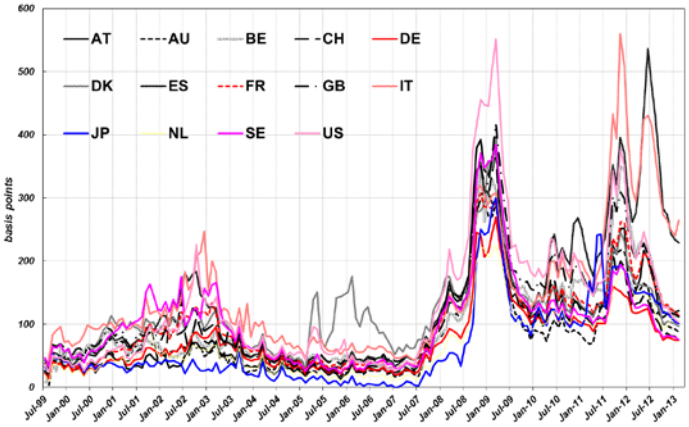
## Annex 7: Additional estimation output of time-series analysis of relative importance of corporate spread determinants for the weighted country/rating/sector portfolios

**Charts A7. Spreads of weighted rating, country and sector portfolios and their cross-sectional dispersion *(in bps)***

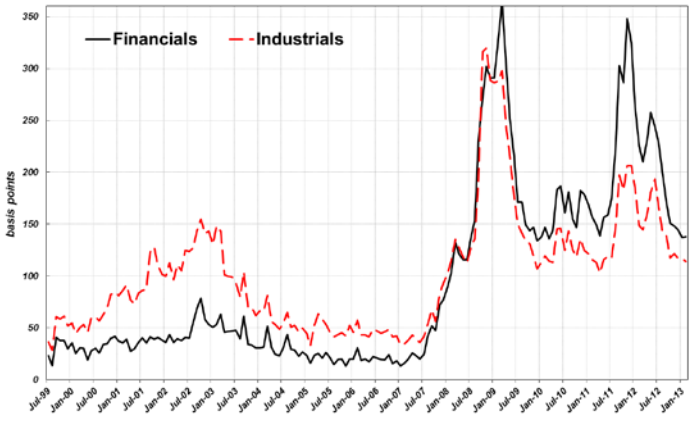
*a) spreads of weighted rating portfolios*



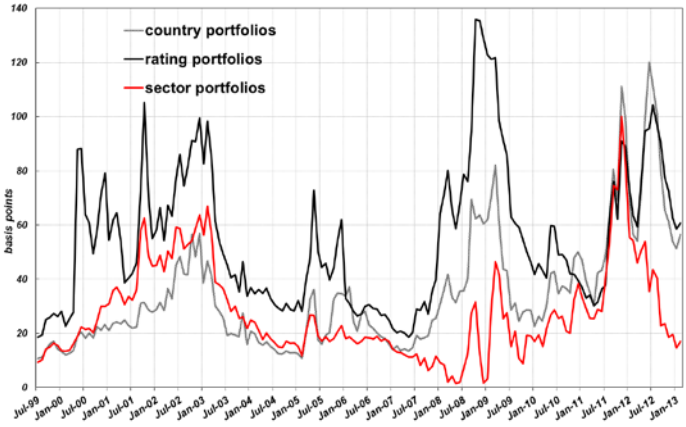

*b) spreads of weighted country portfolios*




*c) spreads of weighted sector portfolios*




*d) cross-sectional dispersions in spreads of portfolios*




*Source: ECB calculations, Merrill Lynch and Bloomberg.*

**Table A7. Variance decompositions of volume-weighted spread indices for financial and industrial bonds for selected euro area countries**

a) ***Whole sample (July 1999-February 2013)***

| Value-weighted portfolios | DE | | | ES | | | IT | | | FR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variance ratios of | Fin | Ind | Aver | Fin | Ind | Aver | Fin | Ind | Aver | Fin | Ind | Aver |
| maturity effect | 0.03 | 0.07 | 0.05 | 0.00 | 0.02 | 0.01 | 0.01 | 0.07 | 0.04 | 0.04 | 0.19 | 0.12 |
| coupon effect | 0.27 | **0.53** | **0.40** | 0.05 | 0.12 | 0.08 | 0.04 | 0.21 | 0.13 | 0.21 | **0.83** | **0.52** |
| liquidity effect | 0.12 | 0.14 | 0.13 | 0.03 | 0.03 | 0.03 | 0.01 | 0.03 | 0.02 | 0.08 | 0.23 | 0.15 |
| pure country effect | **0.30** | **0.42** | **0.36** | **0.34** | **0.67** | **0.50** | 0.25 | **0.94** | **0.60** | 0.03 | 0.10 | 0.06 |
| pure sector effect | **0.67** | **0.88** | **0.77** | 0.11 | 0.20 | 0.16 | 0.10 | **0.33** | 0.22 | **0.44** | **1.44** | **0.94** |
| w v average of rating components | **0.47** | 0.21 | **0.34** | 0.09 | 0.14 | 0.12 | 0.09 | **0.30** | 0.20 | 0.27 | 0.29 | 0.28 |

| Value-weighted portfolios | AT | | | BE | | | NL | | | AVERAGE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variance ratios of | Fin | Ind | Aver | Fin | Ind | Aver | Fin | Ind | Aver | Fin | Ind | Aver |
| maturity effect | 0.04 | 0.12 | 0.08 | 0.02 | 0.04 | 0.03 | 0.06 | 0.05 | 0.05 | 0.03 | 0.08 | 0.06 |
| coupon effect | **0.32** | **0.70** | **0.51** | 0.16 | 0.25 | 0.21 | 0.24 | **0.30** | **0.27** | 0.19 | **0.42** | **0.30** |
| liquidity effect | 0.19 | 0.21 | 0.20 | 0.05 | 0.07 | 0.06 | 0.10 | 0.08 | 0.09 | 0.08 | 0.11 | 0.10 |
| pure country effect | 0.20 | **0.36** | 0.28 | 0.11 | 0.16 | 0.14 | 0.11 | 0.09 | 0.10 | 0.19 | **0.39** | **0.29** |
| pure sector effect | **0.74** | **1.20** | **0.97** | **0.31** | **0.44** | **0.38** | **0.67** | **0.53** | **0.60** | **0.44** | **0.72** | **0.58** |
| w v average of rating components | 0.18 | **0.52** | **0.35** | 0.15 | 0.09 | 0.12 | **0.98** | 0.15 | **0.57** | **0.32** | **0.24** | **0.28** |

b) ***Pre-crisis period (July 1999-June 2008)***

| Value-weighted portfolios | DE | | | ES | | | IT | | | FR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variance ratios of | Fin | Ind | Aver | Fin | Ind | Aver | Fin | Ind | Aver | Fin | Ind | Aver |
| maturity effect | 0.04 | 0.05 | 0.04 | 0.09 | 0.03 | 0.06 | 0.21 | 0.05 | 0.13 | 0.12 | 0.06 | 0.09 |
| coupon effect | **0.44** | **0.44** | **0.44** | **0.66** | 0.17 | **0.42** | **0.95** | 0.18 | **0.57** | **0.91** | **0.41** | **0.66** |
| liquidity effect | 0.04 | **0.27** | 0.15 | 0.10 | 0.02 | 0.06 | 0.04 | 0.01 | 0.03 | 0.08 | 0.04 | 0.06 |
| pure country effect | 0.08 | 0.07 | 0.07 | **0.76** | **0.25** | **0.51** | **1.22** | 0.20 | **0.71** | 0.20 | 0.09 | 0.14 |
| pure sector effect | 0.23 | 0.17 | 0.20 | 0.27 | 0.08 | 0.18 | **0.43** | 0.06 | **0.25** | **0.42** | 0.17 | 0.29 |
| w v average of rating components | **0.63** | 0.10 | **0.37** | **0.47** | 0.21 | **0.34** | **3.56** | **0.50** | **2.03** | **3.30** | 0.16 | **1.73** |

| Value-weighted portfolios | AT | | | BE | | | NL | | | AVERAGE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variance ratios of | Fin | Ind | Aver | Fin | Ind | Aver | Fin | Ind | Aver | Fin | Ind | Aver |
| maturity effect | 0.08 | 0.06 | 0.07 | 0.07 | 0.04 | 0.05 | 0.04 | 0.02 | 0.03 | 0.09 | 0.04 | 0.07 |
| coupon effect | **0.59** | **0.31** | **0.45** | **0.61** | 0.24 | **0.42** | **0.34** | 0.16 | **0.25** | **0.64** | **0.27** | **0.46** |
| liquidity effect | 0.06 | 0.04 | 0.05 | 0.09 | 0.02 | 0.06 | 0.04 | 0.02 | 0.03 | 0.06 | 0.06 | 0.06 |
| pure country effect | 0.18 | 0.10 | 0.14 | **0.30** | 0.12 | 0.21 | 0.09 | 0.04 | 0.06 | **0.40** | 0.12 | 0.26 |
| pure sector effect | **0.30** | 0.16 | 0.23 | 0.27 | 0.09 | 0.18 | 0.18 | 0.06 | 0.12 | **0.30** | 0.11 | 0.21 |
| w v average of rating components | **0.77** | **0.68** | **0.73** | **0.33** | 0.17 | **0.25** | **0.45** | 0.15 | **0.30** | **1.36** | **0.28** | **0.82** |

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