Credit risk diversification:
evidence from the eurobond market

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Abstract

This paper studies the role of diversification in reducing the volatility of corporate bond returns induced by changes in credit spreads. Specifically, it looks at how credit risk can be diminished when a portfolio is diversified across countries, industry sectors, maturities, seniority types and credit ratings. The role of national industrial structures for international diversification is also investigated. The results suggest that geographical diversification is more effective in reducing portfolio risk than alternative investment strategies considered, and that industry effects are not material to this result. Finally, the paper explores the implications of these findings for credit risk capital regulation in banks.

Summary

It is well known that portfolio risk can be reduced through diversification. Spreading portfolio holdings across countries and industrial sectors, for example, may help reduce portfolio volatility. It is less clear, however, whether these asset allocation strategies are effective in reducing return volatility from changes in credit spreads in a bond portfolio. While equity portfolio diversification has been widely investigated, diversification in portfolios of corporate bonds has only been analysed partially and sporadically.

This study looks at the effects of cross-country and industry diversification on credit risk. It also analyses other dimensions, namely maturity, seniority and credit rating diversification, because return uncertainty in bonds with different maturity, seniority and rating might be explained by different risk factors which are not perfectly correlated. For example, a firm's credit rating may determine the ease with which the firm can access financial markets for funding or decide the balance of power with customers and suppliers, when setting contractual obligations, such as terms of payments or speed of delivery. It follows that differences in credit standing may affect the firm's economic environment and the risk factors that influence the firm's profitability. This, in turn, allows the portfolio manager who invests in companies with varying credit quality to achieve diversification benefits.

The paper's analysis departs from the existing literature by introducing 'locally systematic' risk factors whose nature is systematic and idiosyncratic at the same time. Usually, diversification is defined as the reduction of idiosyncratic risk in the portfolio. The paper maintains the assumption that portfolio volatility is reduced through diversification of idiosyncratic risk as well as locally systematic risk. The latter is represented by country, industry, maturity, seniority and rating factors, estimated as *deviations* from the average market return. The average market return is truly systematic because it cannot be diversified away. Locally systematic risks, on the other hand, can be diversified away only if the portfolio is distributed across assets that are subject to different local factors. For example, to diversify the (locally systematic) German country effect in a portfolio of German bonds one needs to invest in other countries. Increasing the number of German securities would only reduce the idiosyncratic risk of the portfolio, narrowly defined as residual or unexplained bond volatility. Therefore, locally systematic risks are more persistent than idiosyncratic risk in that only a specific portfolio allocation strategy would cause their diversification. At the same time, they are not as persistent as the average market return since they too can be diversified away. This approach gives more structure to what was previously

indistinctly described as idiosyncratic risk. It also provides a formal framework to describe phenomena that are already known and widely applied by portfolio managers.

The findings in the paper suggest that international diversification is most effective in reducing portfolio credit risk. Previous studies have shown that a similar conclusion also applies to equity risk. Surprisingly, diversification across maturity bands is found to be the second best strategy, superior to industry diversification.

Finally, the results may have a bearing on the ongoing debate on how to reform the current framework for setting banks' credit risk capital requirements. The capital adequacy rules in Pillar 1 of the New Basel Accord, as in the current Accord, do not take into account diversification effects on portfolio risk. Therefore, the results emphasise the potential importance of Pillar 2 of the new Accord within which supervisors are encouraged to take into account the extent of sectoral and geographical portfolio concentration when assessing the riskiness of banks relative to the capital they hold.

1. Introduction

Several studies in the finance literature look at the effect of portfolio diversification. Grubel (1968), Levy and Sarnat (1970) and Solnik (1974) and more recently Roll (1992), Beckers, Richard, Rudd and Stefek (1992), Heston and Rouwenhorst (1994), Griffin and Karolyi (1998) and Hargis and Mei (2000) document the benefits of international diversification in the stock market. Similar studies conducted on the bond market are scarce. Examples are Kaplanis and Schaefer (1991) and Cholerton, Pieraerts, and Solnik (1986) both concerned with government bonds.

In this work we look at diversification in the international corporate eurobond market. In our investigation we focus on how to diversify bond return volatility that stems from changes in credit spreads. We start by exploring the effectiveness of geographical versus industrial diversification, an issue that has attracted the attention of previous researchers. We then proceed to examine maturity, seniority and credit rating effects on portfolio diversification. We find that factors for specific maturities and credit ratings are priced, and may reduce portfolio risk when diversified. For example, it is well known that, all else equal, long-maturity bonds are more volatile than short-maturity ones. But, the combination of two well-diversified portfolios, including short-maturity and long-maturity bonds respectively — when all else is kept constant — produces a new portfolio whose volatility is lower than the average volatility of the constituents portfolios. If long and short-maturity bonds depended on the same factor, except for different sensitivity to the factor, then this result could not be explained. We show that the difference between the combined portfolio volatility and the average volatility of the original portfolios may be the effect of diversification of maturity-specific factors.

In this study, we also examine to what extent industrial effects can explain the benefits of geographical diversification, an issue that was previously analysed only in the stock market. By using a Fama-McBeth (1973) type of regression on global stock index returns, Roll (1992) finds that volatility can be reduced more effectively when a portfolio of stocks is geographically distributed, because of cross-country differences in industrial structure. In fact, there may be limited scope for diversification in local portfolios as most countries tend to have a partially specialised economy. Industrial effects are also detected by Heston and Rouwenhorst (HR) (1994) and Griffin and Karolyi (GK) (1998). However, they argue that international returns exhibit low correlation mainly because of reasons other than countries' industrial composition. These may be national idiosyncrasies born of country-specific shocks and differences in national legal and institutional regimes.

We undertake an analysis similar to that in the above contributions but concentrate on the bond market, rather than on the stock market. As in HR, we first estimate and then decompose national bond indices into country and industry effects. In agreement with HR and GK, we find that industrial effects explain little of total country index variation. We also show that country effects play, relative to the others, a greater role in explaining bond credit risk and that, geographical diversification is more effective in reducing credit risk when compared to within-country diversification across industry sectors.

Generally, credit spreads are believed to be the result of a default premium only.[1] A significant departure from this view is proposed by Elton, Gruber, Agrawal and Mann (2001), who have recently suggested that the spread between corporate and government bond yields may be explained by three components, namely a default premium, a tax premium[2] and a systematic risk premium. We too assume the existence of a systematic risk premium and explain the return volatility it generates with a combination of several factors. The HR model, which we adopt, can be seen as an extension of the idea in Elton *et al* (2001), in that it allows one to differentiate the systematic risk factor into global and local components. The average market return which is the truly non-diversifiable element of individual returns, is identified as the globally systematic risk component. Locally systematic components due to country, industry, maturity, seniority and credit rating effects, are estimated as deviations from the average market return. These effects are not entirely systematic because they are not as pervasive as the average market return and, at the same time, are not idiosyncratic because they are more persistent than actual idiosyncratic risk.

Our choice of systematic factors is consistent with the factor structure in Fama and French (1993). Fama and French explain bond excess returns with a systematic factor plus two term structure factors representing a maturity and default premium. However, unlike Fama and

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[1] Some examples are Bodie, Kane and Marcus (1993), Fons (1994) and Cumby and Evans (1995). In recently developed credit rating based pricing models spreads result from the combined effect of default and credit rating transition premia. See for example Jarrow, Lando and Turnbull (1997) and Das and Tufano (1996).
[2] Tax effects are not contemplated in our framework because we are not interested in the level of credit spreads, to which tax premia contribute, but on spread variations. Since taxes are relatively constant over time, their impact on spread volatility (and spread induced price volatility) should be unimportant. Tax effects on spread volatility may become an issue when bonds are traded among investors from different countries that adopt heterogeneous tax regimes. This would imply that, all else equal, spreads are priced differently by investors of different nationality, thus producing tax related spread volatility. We assume such volatility to be idiosyncratic. In addition, tax effects should be negligible in the eurobond market as eurobonds are bearer securities and are not subject to withholding tax on interest payments. These are among the most attractive features of eurobonds in that they allow investors to avoid detection by their national tax authorities. Indeed the absence of withholding tax and registration requirements were the main reasons that caused the eurobond market to grow in the first place, by driving huge sums of money out of the United States in the 1960s following the introduction there of a withholding tax on income derived from local fixed income securities.

French's, our prime interest is not pricing. Instead of using factors to price bonds we use bond prices to estimate country and industry factors, which we then employ for our investigation of credit risk diversification.[3]

Interestingly, our results highlight a well-known problem in the current regulatory regime of credit risk capital in banks. The Basel Accord (1988) that has been widely adopted in both developed and developing economies, sets a relation between the capital that banks are required to hold with the credit risk in their books. However, the Accord does not take account of credit risk diversification although most regulators take account of this in setting capital requirements for individual institutions. This supervisory oversight of asset concentration will be formalised in the new Basel Accord.

The paper is organised as follows. In Section 2 we describe the data; Section 3 provides a definition of excess returns; in Section 4 we give details of the HR model and our extensions; Section 5 explores the effects of country, industry, maturity, seniority and credit rating diversification; Section 6 describes the implications of our findings for bank capital regulation. Finally, we conclude with Section 7.

2.   The data

The data that we use in this work are eurobonds listed on the Reuters 3000 Fixed Income service. The bonds in the sample were selected on the basis that: (i) they were straight bonds (not floaters); (ii) they were neither callable nor convertible; (iii) that the coupons were constant with a fixed frequency; and (iv) that repayment was at par. All the bond prices in the sample are dealer quotes.

Bonds with a price history with large pricing errors were excluded. All issues whose prices included a daily variation of more than plus or minus 10%, followed, the next day, by a price change of similar magnitude in the opposite direction, were eliminated. This denotes an isolated spike in the series that is probably due to a mistake in recording the data. Also, the prices of two issues that defaulted during the sample period were excluded from the sample immediately before

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[3] Explaining assets' systematic risk through country and industry factors would probably not be a bad idea, even within a pricing model. The pricing model of Fama and French (1993), also found in Elton *et al* (2001), is used, in both studies, on US portfolios. When the set of securities under analysis includes assets from different countries, like in this paper, it is probably sensible to try and represent the various sources of variation in the international market with country and industry-specific variables.

default. This appears to be a sensible step as, at the time of default, the issues were rated BBB, which indicates that they were probably grossly mispriced.[4]

The final sample is made of a total of 2,984 bonds, issued by 663 different firms, spanning the period from January 1993 until February 1998.

The sample includes firms from nine countries, namely Australia, Austria, Canada, France, Germany, Japan, Netherlands, United Kingdom and United States, and eight broad industry sectors as defined in the Financial Times Actuaries/Goldman Sachs.[5] The industry groups are (i) finance; insurance and real estate; (ii) banking; (iii) energy; (iv) utilities; (v) transportation and storage; (vi) consumer goods and services; (vii) capital goods; and (viii) basic industries.

Table A describes the distribution of issuers across countries and industry sectors. Table B provides details of the size of the sub-samples identified by different maturity, seniority and rating. We consider three maturity intervals, up to two years, from two to five years and above five years. We distinguish between two seniority categories, 'senior' and 'junior'. Under the first heading we include all securities that are backed by some forms of collateral or simply have priority repayment privilege in case of default. Specifically, 'senior groups together bonds that are classified as guaranteed, collateralised, mortgage or senior proper. The second heading comprises unsecured and subordinated issues. A definition for the various seniority types can be found in the appendix.

On average, over the sample period, investment grade issues account for 99.24% of the total, with A, AA, and AAA grades representing 95.40% of the total.[6]

It is interesting to note that when each obligor in the sample is counted as many times as the different currencies in which the obligor issues his bonds, the total number of 'currency obligors' (1,168), reported in Table C, is almost twice as big as the number of obligors (663). This indicates that multiple issues from the same obligor tend to be denominated in different currencies, probably a way in which companies try to hedge their liabilities' foreign exchange risk.

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[4] Our approach to eliminating 'problematic' bond prices is consistent with the methodology adopted by Elton *et al* (2001) and Skinner (1998).
[5] The original classification includes seven industry sectors only. We introduce an additional sector by separating banks from the category 'Finance, insurance and real estate'.
[6] The rating scale adopted throughout the paper is that of the rating agency Standard and Poor's. However, our bonds may be rated by other agencies. We convert non-S&P ratings to the S&P rating scale by adopting standard conversion tables supplied by, among others, Reuters and Bloomberg through their data services.

Table A: Summary statistics by country and industry sector

Sample period 1/93 - 2/98

	Monthly Average Market Value (%)	Monthly Average[a] Number of Obligors	Monthly Average[a] Number of Issues	Total Number Obligors	Total Number Issues
Australia	3.23	37.62	112.17	49	198
Austria	1.19	6.84	24.56	10	48
Canada	2.91	27.71	82.78	43	151
France	16.82	34.13	227.90	46	399
Germany	5.62	14.97	128.62	22	310
Japan	13.44	33.30	109.25	53	224
Netherlands	13.75	50.30	228.41	79	483
UK	13.66	81.10	184.14	119	344
US	29.37	155.92	425.03	242	827
Total	**100.00**	**441.89**	**1,522.87**	**663**	**2,984**
Financial	36.49	140.98	556.57	213	1,143
Energy	2.59	17.95	44.03	24	65
Utilities	11.94	41.37	147.17	58	241
Transportation	2.36	11.30	37.56	17	64
Consumer Goods	11.90	83.73	166.73	126	313
Capital Goods	2.40	20.48	32.86	35	64
Basic Industries	1.49	19.43	25.84	34	51
Banking	30.82	106.65	512.11	156	1,043
Total	**100.00**	**441.89**	**1,522.87**	**663**	**2,984**

[a] Average population available each month in the sample period.

Table B: Summary statistics by maturity, seniority and credit rating

Sample period 1/93 - 2/98

	Monthly Average Market Value (%)	Monthly Average[a] Number of Maturity Obligors	Monthly Average[a] Number of Maturity Issues	Total Number Maturity Obligors	Total Number Maturity Issues
<2 yrs	25.95	200.05	440.43	529	1,851
2-5 yrs	45.52	278.76	698.89	569	2,243
>5 yrs	28.53	172.57	383.56	341	991
Total	**100.00**	**651.38**	**1,522.87**	**1,439**	**5,085**

	Monthly Average Market Value (%)	Monthly Average[a] Number of Seniority Obligors	Monthly Average[a] Number of Seniority Issues	Total Number Seniority Obligors	Total Number Seniority Issues
Senior	30.35	201.16	493.60	332	1,010
Junior	69.65	300.08	1,029.27	457	1,974
Total	**100.00**	**501.24**	**1,522.87**	**789**	**2,984**

	Monthly Average Market Value (%)	Monthly Average[a] Number of Rating Obligors	Monthly Average[a] Number of Rating Issues	Total Number Rating Obligors	Total Number Rating Issues
<= BBB	3.58	37.32	65.03	109	194
A	25.47	176.52	386.75	345	886
AA	34.82	152.29	520.08	306	1,251
AAA	36.13	75.76	551.02	132	1,192
Total	**100.00**	**441.89**	**1,522.87**	**892**	**3,523**

[a] Average population available each month in the sample period.

Table C: Summary statistics by currency

Total number of issues by currency

Country	Currency [a]										Total
	A$	C$	FFr	DM	Y	Fl	SFr	£	L	US$	
Australia	158	8	1	1	2	0	3	5	3	17	**198**
Austria	1	2	0	9	2	0	24	2	2	6	**48**
Canada	0	113	2	6	1	0	9	6	0	14	**151**
France	7	49	141	29	13	12	49	14	25	60	**399**
Germany	13	35	11	20	1	24	60	29	42	75	**310**
Japan	0	15	4	12	88	0	12	9	0	84	**224**
Netherlands	4	33	29	79	2	131	59	20	39	87	**483**
UK	4	11	16	25	6	3	17	181	18	63	**344**
US	14	56	26	50	7	12	78	32	29	523	**827**
Total	**201**	**322**	**230**	**231**	**122**	**182**	**311**	**298**	**158**	**929**	**2,984**

Total number of currency obligors

Country	Currency [a]										Total
	A$	C$	FFr	DM	Y	Fl	SFr	£	L	US$	
Australia	38	6	1	1	2	0	3	5	3	12	**71**
Austria	1	2	0	6	2	0	5	1	2	3	**22**
Canada	0	27	1	6	1	0	8	5	0	12	**60**
France	2	15	37	13	7	7	15	7	13	16	**132**
Germany	4	8	8	10	1	9	19	8	12	17	**96**
Japan	0	7	3	8	30	0	7	7	0	34	**96**
Netherlands	4	14	13	32	2	23	23	14	16	32	**173**
UK	4	5	8	10	5	2	7	98	5	26	**170**
US	5	19	14	26	6	4	39	14	12	209	**348**
Total	**58**	**103**	**85**	**112**	**56**	**45**	**126**	**159**	**63**	**361**	**1,168**

[a] A$ = Australian dollar, C$ = Canadian dollar, FFr = French franc, DM = Deutsche Mark, Y = Yen, Fl = Netherlands guilder, SFr = Swiss franc, £ = British pound, L = Italian lira, US$ = US dollars.

The leading currency in our sample is the US dollar, adopted by 30.9% of the obligors, of which 42.1% are not US-domiciled, followed by the British pound 13.6% (38.4% non-UK firms), Swiss franc 10.8% (100% non-Swiss firms) and Deutsche Mark 9.6% (91.1% non-German firms).

3.   Excess returns

As a first step, we single out the portion of bond return that can be attributed to credit spread changes.[7] This can be thought of as a simple excess return calculation involving the difference between total return and the risk-free return. Although the credit risk induced returns we use in this paper will be called excess returns, their definition does not coincide with that usually found in the literature. In several studies concerned with portfolios of international assets, asset returns

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[7] Here, like in other studies, we abstract from the effect of liquidity on excess bond return. However, we indirectly account for liquidity in our analysis of portfolio diversification by estimating country, industry, maturity, seniority and credit rating effects on bond index returns with weighted least squares, in which large issues are weighted more than small ones.

are first converted into the same currency unit, say US dollars.[8] Then, the researcher adopts the point of view of an investor in a particular country and measures deviations of the local and foreign assets' total returns from that country's risk-free return. The resulting excess return is then interpreted as the compensation for risk requested by investors in the chosen country.

Spread risk related returns cannot be calculated alike. The spread, or risk premium, of a corporate bond is defined as the difference between the bond's total return and the 'local' risk-free return (as opposed to the benchmark country's risk-free return). Therefore, we define credit-spread induced excess returns as the difference between total returns and 'local' risk-free returns, where both have been previously converted into a given numeraire currency. Following the notation in Beckers *et al* (1992), numeraire currency (spread related) excess returns are defined as,

$$r_n - r_c = \left(r_l - r_{fl}\right) + r_x\left(r_l - r_{fl}\right)$$

where, r_n is the converted total return, r_c is the converted local risk-free return, r_l and r_{fl} denote the total return in local currency and the local risk-free return in local currency respectively, and r_x is the rate of return due to changes in exchange rates.

An important implication of this definition is that foreign exchange risk, which is normally a non-negligible component of excess returns as traditionally defined, becomes immaterial. As Beckers *et al* note, the term $r_x\left(r_l - r_{fl}\right)$ is very small and can usually be ignored. If this is the case, then it should not make much difference whether spreads are converted into a numeraire currency or left in their original currency. In fact, if the size of $r_x\left(r_l - r_{fl}\right)$ is negligible then,

$$r_n - r_c \cong r_l - r_{fl}$$

In this paper we report results obtained from spreads converted into a same currency unit, US dollars. However, calculations performed with local currency spreads yield almost identical results.

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[8] It is assumed here that foreign exchange risk is left unhedged. If we made the assumption that the investor employed, for example, forward contracts to fully hedge foreign exchange risk, asset returns could be dealt with in local currency.

We define the local risk-free return associated with bond i at time t as follows,

$$r_{fl,i,t} = \frac{Q_{i,t}}{Q_{i,t-1}} - 1$$

where,

$$Q_{i,t} = \sum_{\tau > t} c_{i,\tau} B_{\tau}$$

where c_i are the contractual cash flows of bond i (coupon and principal) paid after time t. B_{τ} is a discount factor given by the price of a pure discount risk-free bond issued by the country whose currency, bond i is denominated into, and maturing at time τ with a redemption value of one. Risk-free bond price quotes for all the countries represented in the sample are extracted from zero government interest rate curves.[9]

4.   The method

This paper's objective is to determine what investment strategy, among portfolio diversification by country, industry, maturity, seniority and credit rating, is more effective in diminishing spread-induced volatility of bond returns. We are also interested to ascertain to what extent differences in countries' industrial structure may explain the effects of country diversification.

For these purposes, we first decompose bond excess return indices into 'pure' effects. Effects are estimated by employing the method in Heston and Rouwenhorst (HR) (1994) and Griffin and Karolyi (GK) (1998). The advantage of this approach is that it is based on an intuitive structure of returns. Price variations are assumed to be explained by the behaviour of the market as a whole, plus industry and country effects. We extend the original modelling assumptions by allowing for maturity, seniority and credit rating effects as well.

However, we should point out that the data generating process (DGP) hypothesised here is different from the DGP of HR. They assume that the return of bond z that belongs to industry g and country f follows the model,

$$\phi_{z,t} = a_t + c_{f,t} + i_{g,t} + e_{z,t} \tag{1}$$

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[9] The zero curves are bootstrapped from benchmark government bonds provided by Datastream.

where a_t is the base level of return in period t, $c_{f,t}$ is the country effect, $i_{g,t}$ is the industry effect and $e_{z,t}$ is a firm-specific disturbance. The model implies that the return of all securities from, say, country f will have the same sensitivity — equal to unity — to the country f effect. Similarly, all securities from industry g will have a sensitivity equal to the industry g effect. We relax this assumption and postulate the following,

$$\phi_{z,t} = b_{z,a}a_t + b_{z,c}c_{f,t} + b_{z,i}i_{g,t} + b_{z,m}m_{h,t} + b_{z,s}s_{l,t} + b_{z,r}r_{n,t} + e_{z,t} \qquad \textbf{(2)}$$

Apart from the inclusion of additional effects, namely maturity, seniority and rating (denoted as $m_{h,t}$, $s_{l,t}$ and $r_{n,t}$ respectively), the new model includes sensitivity coefficients $b_{\cdot,\cdot}$ for the various effects, which may vary across securities. This model is clearly more flexible than HR's. Standard specification tests reported in Section 5.1 appear to indicate it does a good job in approximating the behaviour of bond excess returns.

Given this return structure, country, industry, maturity, seniority and credit rating effects can be estimated through a simple cross-section dummy regression. The regression will look like,

$$
\begin{aligned}
\phi_{z,t} = a &+ c_{1,t}C_{z,1} + ... + c_{9,t}C_{z,9} + i_{1,t}I_{z,1} + ... + i_{8,t}I_{z,8} + \\
&m_{1,t}M_{z,1,t} + ... + m_{3,t}M_{z,3,t} + r_{1,t}R_{z,1,t} + ... + r_{4,t}R_{z,4,t} + s_{1,t}S_{z,1} + s_{2,t}S_{z,2} + e_{z,t}
\end{aligned} \qquad \textbf{(3)}
$$

where $\phi_{z,t}$ is the excess return of bond z at time t. Capital letters denote dummies (C, I, M, R, S stand for country, industry, maturity, rating and seniority respectively) and a a constant term. So, for example, $C_{z,3}$ is equal to one if bond z belongs to country three, and zero otherwise. Among the dummy variables, only those denoting maturity and credit rating are time dependent, because these are the only characteristics, among those considered, that are subject to change over time, for any particular bond issue z. The regression is run on the cross section of bonds available at any point in time t in the sample period (t, T). For any t, the parameters of equation (3), indicated in lower case, are estimated.

It should be noted that we estimate pure return effects with (3), which, in substance, is the same regression as in HR, even though our DGP is different from HR's. It turns out that regression (3) is consistent with both DGPs. Griffin and Karolyi (1998) point out that the same estimates of the coefficients in (3) are obtained even without constraining *individual* returns to a specific DGP. Instead, it is sufficient to assume the return structure in (1) for national industry index returns

rather than individual returns. The DGP of Griffin and Karolyi consistent with regression **(3)**, without the additional effects introduced here, would then be,

$$\overline{\phi}_{f,g,t} = a_t + c_{f,t} + .i_{g,t} + e_{f,g,t}$$

where $\overline{\phi}_{f,g,t}$ is the average return in industry g of country f at time t. As a result, individual returns are no longer tied to HR's data generating process which can be reformulated as in **(2)**.

We estimate equation **(3)** for each month from January 1993 to February 1998 using weighted least squares, where the weights are the total nominal values of each issue, in US dollars. We employ weighted least squares for two reasons. First, by combining this estimation procedure with a set of constraints on the parameters, which are introduced below, the regression constant can be nicely interpreted as the average market return. This will have important implications when we discuss portfolio diversification. Second, weighting larger issues more is a way to take into account liquidity effects on returns and minimise their impact on our estimates.

As it stands, the model cannot be estimated as it is not identified. In fact, the linear dependence between the regression constant and each group of dummies (dummies are grouped by country, industry, maturity) causes perfect multicollinearity. This is solved by introducing, for any period t, linear constraints on the regression coefficients as suggested in Kennedy (1986),

$$\sum_{f=1}^{9} \alpha_f c_f = 0 \qquad\qquad\qquad\qquad\text{(4)}$$

$$\sum_{g=1}^{8} \beta_g i_g = 0 \qquad\qquad\qquad\qquad\text{(5)}$$

$$\sum_{h=1}^{3} \gamma_h m_h = 0 \qquad\qquad\qquad\qquad\text{(6)}$$

$$\sum_{l=1}^{2} \delta_l s_l = 0 \qquad\qquad\qquad\qquad\text{(7)}$$

$$\sum_{n=1}^{4} \theta_n r_n = 0 \qquad\qquad\qquad\qquad\text{(8)}$$

where, $\alpha_f, \beta_g, \gamma_h, \delta_l$ and θ_n are the value weights of country f, industry g, maturity h, seniority l and rating n respectively, and $\sum_f \alpha_f = \sum_g \beta_g = \sum_h \gamma_h = \sum_l \delta_l = \sum_n \theta_n = 1$. Such restrictions are appealing for two reasons:

(i)   Ease of interpretation of regression coefficients. The identification problem can alternatively be solved by dropping one dummy variable from each group of dummies. But,

in this case, the dummy that is excluded from a dummy group becomes a benchmark. The effect on the dependent variable of the remaining dummies in the group, is expressed by the dummies' coefficients in terms of deviations from the benchmark. In his work, Kennedy suggests that the adoption of the restrictions above allows for a more immediate interpretation of the meaning of dummies' coefficients. They are no longer expressed in terms of a reference variable that varies for each group. Instead, in every group, each dummy captures deviations of the dependent variable from the dependent variable's cross-sectional unconditional mean, which corresponds to the regression constant.[10] This is useful because the common benchmark now is the regression constant, which has an appealing economic meaning. It represents the whole market average excess return. Therefore, country, industry and other dummies' coefficients describe the cross-sectional behaviour of excess returns in a particular country, industry or of particular bond characteristics as deviations from the average market return.

(ii) The second interesting implication that follows from the restrictions in equations **(4)** to **(8)** is that they provide a simple way to model, and hence understand, the effect of portfolio diversification on returns. Assume that a portfolio is constructed by investing into bonds distributed across all the countries in the sample, in the proportions indicated by their relative market capitalisation, ie the α_f weights employed in restriction **(4)**. Then, the country composition of the market would be replicated, and fully expressed by the regression constant which represents, by virtue of the restrictions above, the average market return. As a result, the returns of the portfolio would no longer have any country effects. Still, if the portfolio as a whole were not diversified across industries and bond characteristics, the return of the portfolio would preserve industry and bond characteristic effects over and above the effect of the market. In other words, through diversification, portfolio returns lose the source of variation stemming from the dimension being diversified (eg the country dimension). Therefore, portfolio risk can be seen as composed by a core element that cannot be diversified away, ie the volatility of the market as a whole, plus additional sources of volatility that arise because of the differing composition of the portfolio relative to the market in terms of the countries, industries, maturities, seniority classes and ratings represented and their relative weight. The former type of risk is

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[10] The restrictions impose that the (weighted) average of the dummies in each group is zero. Therefore, the (weighted) average of the dependent variable is expressed by the (weighted) least square estimate of the regression constant.

'globally' systematic whereas the latter types are only 'locally' systematic because they can be eliminated by increasing asset diversity in the portfolio.[11]

The error term in the regression, e_z, represents firm-specific risk. As in HR, we assume that it has zero mean and finite variance and is uncorrelated across firms. This allows us to treat e_z as idiosyncratic risk, which disappears in large, well-diversified portfolios. However, in our cross section, unlike in HR's, at any given point in time, our sample may include several securities issued by the same firm. This implies that the regression errors associated with those securities will be correlated. Yet, diversification of firm-specific risk is not prevented because of this. If, as we assume, errors are uncorrelated across bonds from different obligors, when the number of obligors is sufficiently high, the errors will no longer contribute to the volatility of the portfolio. The only difference, relative to the case in which all errors are uncorrelated, is that when some errors are correlated the same asymptotic level of total portfolio risk is achieved, through diversification, more slowly, that is with a higher number of securities.

4.1 Country and industry index decomposition

An interesting aspect of the HR regression is that an exact and economically meaningful relationship can be established between the pure return effects obtained from the regression and, actual bond indices, estimated by simply averaging out the excess returns of bonds of a given country, industry sector, maturity, seniority or credit rating. As a result, the value-weighted index excess return of the United States, for example, can be defined as,

$$\phi_{us} = a + \sum_{g} w_{us,g}\hat{i}_g I_{us,g} + \sum_{h} w_{us,h}\hat{m}_h M_{us,h} + \sum_{l} w_{us,l}\hat{s}_l S_{us,l} + \sum_{n} w_{us,n}\hat{r}_n R_{us,n} + \hat{c}_{us} \quad \textbf{(9)}$$

where a is the market index return, $\hat{c}_{us}$ is the 'pure' country effect that is the average excess return deviation from the market return of US bonds, $I_{us,g}$ is a dummy and takes value 1 if the industry sector g is represented in the United States, 0 otherwise. $\sum_{g} w_{us,g}\hat{i}_g I_{us,g}$ measures the discrepancy between US bond returns and market returns due to differences between the average industrial structure in the market and that of the United States. $w_{us,g}$ is the total value of US bonds included in industry g relative to the total value of all US bonds in the sample. A similar

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[11] The difference between idiosyncratic risk and 'locally' systematic risk is that the former can be decreased by simply increasing the number of assets in the portfolio regardless of their characteristics (ie country of issue, industry, maturity), while the latter can only be diminished through diversification by asset characteristic.

interpretation applies to the other summations. By the same token, the actual industry index for the banking sector, for instance, can be written as,

$$\phi_{bk} = a + \sum_{f} w_{bk,f} \hat{c}_f C_{bk,f} + \sum_{h} w_{bk,h} \hat{m}_h M_{bk,h} + \sum_{l} w_{bk,l} \hat{s}_l S_{bk,l} + \sum_{n} w_{bk,n} \hat{r}_n R_{bk,n} + \hat{i}_{bk} \qquad (10)$$

where $w_{bk,f}$ is the total value of bonds in the banking sector of country f relative to the total value of the bonds in the whole banking industry. Actual bond indices by maturity, seniority and credit rating can be constructed in a similar way by aggregation of pure constituent effects.

5.   Diversification effects

With the methodology developed in the previous section we now go on to address the issues that motivate this study, namely the relative importance of alternative diversification strategies.

A direct answer to the comparative efficacy of country versus industry diversification is found by simply observing the volatility of the excess returns of country and industry bond indices. By adopting the point of view of an index-tracking type of investor, country and industry indices can be seen as actual investment portfolios. Their volatility is a measure of the amount of credit risk that could not be diversified within the index portfolios. By construction, a country index includes bonds from all industry sectors in the country. Hence it is industrially diversified. Similarly, an industry index comprises bonds from all countries in which the particular industry sector is represented. Therefore, industry indices are geographically diversified. It follows that country and industry index volatility can be taken as a preliminary indicator of the effects on portfolio credit risk of industry and country diversification respectively. Since, as reported in Table D, the value-weighted average volatility of industry indices is 13.8 basis points (bp), and that of country indices is 16.7 bp, 20.88% higher, this approach suggests that country diversification is more effective in reducing credit risk than industry diversification.

A problem that arises when we simply look at average country or industry index volatility to infer the effect of industry and country diversification respectively, is that index volatility is affected by the number of securities in the index. If the number in the index is small then the observed volatility may differ from the asymptotic volatility that we obtain when all the idiosyncratic risk of individual securities in the index has been diversified away. Unreported results indicate that

the idiosyncratic risk adjustment[12] for the actual index volatilities is generally immaterial and does not alter the relative importance of the diversification effects explored in this study.

Table D: Volatility estimates of excess return bond indices and combinations of their constituent elements

Through regression **(3)** country (industry) bond excess return indices are decomposed into a market effect, pure country (industry) effect and the sum effect of all the industries (countries), maturities, seniority classes and credit ratings of the bonds that constitute the various indices. Below, the impact of geographical and industrial diversification is measured by comparing the total volatility of country and industry indices with that of the indices when some of the effects disappear because of diversification. Excess returns are denominated in US dollars and expressed in per cent per month.

Standard Deviation

Country Bond Indices	Total	Market Effect Only	Country and Market Effects Only	Excluding Sum of Industry Effects	Excluding Sum of Maturity Effects	Excluding Sum of Seniority Effects	Excluding Sum of Rating Effects
Australia	0.192	0.121	0.189	0.191	0.189	0.191	0.191
Austria	0.358	0.121	0.318	0.348	0.348	0.352	0.341
Canada	0.197	0.121	0.196	0.194	0.201	0.196	0.197
France	0.190	0.121	0.181	0.200	0.171	0.187	0.190
Germany	0.208	0.121	0.200	0.204	0.205	0.206	0.208
Japan	0.167	0.121	0.184	0.183	0.165	0.166	0.169
Netherlands	0.154	0.121	0.146	0.154	0.146	0.153	0.155
UK	0.205	0.121	0.192	0.205	0.191	0.205	0.207
US	0.120	0.121	0.139	0.129	0.135	0.121	0.115
Average	**0.199**	**0.121**	**0.194**	**0.201**	**0.195**	**0.198**	**0.197**
Value-Weighted Average	**0.167**	**0.121**	**0.169**	**0.173**	**0.165**	**0.166**	**0.166**

Industry Bond Indices	Total	Market Effect Only	Industry and Market Effects Only	Excluding Sum of Country Effects	Excluding Sum of Maturity Effects	Excluding Sum of Seniority Effects	Excluding Sum of Rating Effects
Financial	0.125	0.121	0.139	0.130	0.132	0.125	0.126
Energy	0.134	0.121	0.141	0.139	0.135	0.135	0.137
Utilities	0.166	0.121	0.169	0.184	0.151	0.166	0.167
Transportation	0.239	0.121	0.219	0.246	0.210	0.238	0.238
Consumer Goods	0.139	0.121	0.132	0.138	0.142	0.139	0.130
Capital Goods	0.138	0.121	0.132	0.132	0.134	0.138	0.138
Basic Industries	0.233	0.121	0.216	0.227	0.230	0.233	0.226
Banking	0.130	0.121	0.134	0.135	0.126	0.131	0.131
Average	**0.163**	**0.121**	**0.160**	**0.166**	**0.158**	**0.163**	**0.161**
Value-Weighted Average	**0.138**	**0.121**	**0.143**	**0.143**	**0.137**	**0.138**	**0.138**

Looking directly at the volatility of index returns may also be problematic when the majority of the countries considered are mostly concentrated on a small number of industry sectors (because of an actual industrial bias in those countries or more simply because of a sample bias). If this is the case, the volatility of a country index may not truly represent the effects of industrial diversification. Therefore, our initial results need to be refined to take into account industry (and

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[12] Let the volatility of the index be $\sigma_p^2 = \sum_{i,j}^{n} w_i w_j \sigma_i \sigma_j \rho_{ij}$ where w_i is the relative market value of bond i, σ_i is the excess return volatility of bond i and ρ_{ij} is the correlation between bond i and j. We define 'idiosyncratic risk adjustment' as $\sigma_p - \hat{\sigma}\sqrt{\hat{\rho}}$ where $\hat{\rho}$ is the average correlation $\left(\sigma_p^2 - \sum_i^n \sigma_i^2 w_i^2 \right) \Big/ \sum_{i \neq j}^n w_i w_j \sigma_i \sigma_j$ and $\hat{\sigma}$ is the average volatility $\sigma_p^2 \Big/ \left(\sum_i^n w_i^2 + \hat{\rho} \sum_{i \neq j}^n w_i w_j \right)$. The asymptotic volatility $\hat{\sigma}\sqrt{\hat{\rho}}$ is derived by taking the limit for $n \to \infty$ of the index volatility σ_p when (a) individual volatilities and correlations are substituted with $\hat{\sigma}$ and $\hat{\rho}$ and (b) each bond in the index is given equal weight.

other) effects when looking at country index volatility, and similarly, country (and other) effects when we analyse industry index volatility. To this end we employ the HR methodology. The methodology is particularly useful because it allows us to isolate from excess returns the particular (country, industry, …) effect we wish to investigate without any interference from other effects.

Equations **(9)** and **(10)** indicate that the return of an index can be decomposed into the sum of country, industry, maturity, seniority and rating effects. The full diversification of one of those dimensions will cause the corresponding effect to disappear from the index return and its decomposition as it will be 'absorbed' in the average market return.

The upper section of Table D shows how country index volatility varies when industry, maturity, seniority and rating effects are fully diversified. The volatility of the index remains virtually unchanged. The elimination of one effect at a time (columns 4 to 7) or all the effects together (column 3) produces only marginal deviations from the total value-weighted average volatility of 16.7 bp. This means that all these dimensions were already (almost) completely diversified in the index portfolio. Again, country diversification is stronger than industry diversification since the weighted average volatility of the country index, without all but the country effect, is 16.9 bp, 18.28% higher than the weighted average volatility of the industry index without non-industry effects. A similar conclusion can be reached in another way. We may ask what would happen if the 'pure' effects were diversified as well, that is if an investor decided to invest in all the country or industry indices proportionally to their market value. Both, country and industry index portfolios would obviously become the market index-portfolio. But, what is worth noticing is the reduction in volatility that this last diversification would cause. Country diversification would bring about a drop in portfolio volatility of 27.69% (from 16.7 to 12.1 bp) whereas industrial diversification would cause a credit risk reduction by less than half that amount, 12.60% (from 13.8 bp to 12.1 bp), which confirms, more directly, our previous inference.

An interesting implication of the results in Table D is that, since country index volatility is affected, on average, only by the market and a 'pure' country effect, one can deduce that industry effects do not appear to have an important role in explaining country diversification. A similar result was found to hold true by HR and GK in the equity market. This can alternatively be seen, as suggested by HR and GK, through a comparison of the proportion of variance of a country index that is explained by the sole country effects relative to the variance explained by the combined industry effects. Results are reported in Table F. Combined industry effects represent

only 10.4% of the total variance of the country index.[13] This is fairly close to the 7.1% found in the equity market by HR who look, as we do, at developed country economies. The percentage is even lower (2%) for equities, when emerging markets are included in the sample, as shown in GK's paper. It is probably reasonable to expect a similar trend if our analysis on bond securities were extended to those markets too.

Table D allows us to highlight another important phenomenon. Investors who track the US bond index do not seem to benefit, in terms of risk reduction, from diversifying their holdings into bond indices of other countries. The volatility of the US bond index is 12.0 bp, which is slightly lower than the volatility of the market (12.1 bp). Therefore, although, in general, through international diversification, portfolio volatility is reduced, there may be cases in which this conclusion does not hold. Let us illustrate this point with a little comparative statics. If the volatility of local, country-specific portfolios were identical across countries then, invariably, cross-border diversification would cause portfolio volatility to fall (or remain the same in the limit case where countries were all perfectly correlated). However, in practice, country volatilities are not uniform. If we assumed, for a moment, that countries were perfectly correlated, the volatility of the market average portfolio would be the average of all countries' volatilities. The market volatility would then be higher than that of the less risky countries. The fact that cross-country correlation is normally well below unity tends to pull the volatility of the market down, at a lower level than that observed among the various countries. Exceptions would be countries with a very low local risk, such as the United States in our sample, whose volatility of 12.0 bp is 39.45% lower than the average volatility observed internationally.[14]

The peculiar volatility value of the US index can perhaps be explained more naturally by using the model adopted in this work. Although, by construction, a US investor can, through geographical diversification, eliminate the locally systematic risk associated with the US country effect, volatility may not fall because diversification can inject into the portfolio more risk of a

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[13] More precisely, we express the country index in excess of the market return as in HR and GK, so that our figures are comparable with theirs.

[14] Elton and Gruber (1995) illustrate this point well. They calculate the optimum mixture of local assets and international assets for a US investor for three types of asset types, stocks, long-term bonds and T-bills. Our results on the bond market cannot be directly compared to theirs because they use total return indices while we use indices based on spread-induced excess returns. Moreover, their long-term bond indices are a mixture of government and corporate bonds while we look at corporate bonds only. Nonetheless, it is interesting to observe that their results are similar to ours. Indeed, their findings show that the risk reduction that a US investor in the bond market can achieve from international diversification is negligible.

globally systematic nature. This is to say that the negative covariance between average market return and country effect outweighs the risk reduction obtained through the elimination of locally systematic country (or other) effects.

A similar interpretation can be extended to the results in Table E in which the volatility of maturity, seniority and credit rating indices is decomposed. Again, the low maturity bond index exhibits a much lower volatility than the market return. It is well known that uncertainty increases with the time horizon of one's investment and it is not surprising that excess returns of longer-maturity bonds are more volatile. The market index will reflect the characteristics of average-maturity bonds, since the index is the average of all the bonds in the market, which cover the whole maturity spectrum. When an investor who holds a portfolio of short-maturity bonds diversifies the maturity dimension, the 'locally' systematic risk related to maturity will be removed, but this will also eliminate the strong negative covariance between the market and the pure short-maturity effect. The combination of these two effects, as shown in Table E, results in higher volatility. Indeed, the volatility of the average-maturity portfolio, represented by the market, at 12.1 bp is 73.04% higher than the volatility of the short-maturity portfolio. It should be noted that there is almost no difference between the volatility of senior and junior bond indices. This is not surprising since more than 95% of the bonds in the sample are rated A or above, and it is plausible to assume absolute priority to be priced only 'mildly' by investors when default is so remote. Deviations from absolute priority, as documented by, for example, Eberhart, Moore and Roenfeldt (1990), Eberhart and Sweeney (1992) and Betker (1995) may also help explain why average senior and junior bond volatility are so similar. Another reason that seniority effects are found not to be significant could be that rating effects fully capture seniority effects, that is the uncertainty associated to the loss investors suffer in case of default. In fact, although differences may be found across credit rating agencies, in general, credit ratings are assigned on the basis of the combined assessment of both likelihood of default and loss, given default.

The attentive reader has surely not missed the slight inversion between the volatility values of senior and junior bonds. Senior bonds are counter-intuitively reported to be more volatile than junior bonds. This is probably due to a modest sample bias. We explain in a similar way the small inversions that characterise AA (12.2 bp) and AAA (12.7 bp) rated bonds, when non-rating effects are filtered out from the corresponding indices.

Table E: Volatility estimates of excess return bond indices and combinations of their constituent elements

Through regression **(3)** maturity, seniority and rating bond excess return indices can be decomposed into constituent effects. We report below the standard deviation of the indices and of their various decompositions.

	Total	Maturity Effect Only	Maturity and Market Effects Only	Excluding Sum of Country Effects	Excluding Sum of Industry Effects	Excluding Sum of Seniority Effects	Excluding Sum of Rating Effects
<2 yrs	0.070	0.121	0.064	0.070	0.067	0.068	0.068
2-5 yrs	0.118	0.121	0.115	0.116	0.119	0.118	0.117
>5 yrs	0.222	0.121	0.217	0.219	0.220	0.222	0.222
Average	**0.137**	**0.121**	**0.132**	**0.135**	**0.135**	**0.136**	**0.136**
Value-Weighted Average	**0.135**	**0.121**	**0.131**	**0.134**	**0.134**	**0.135**	**0.134**

	Total	Market Effect Only	Seniority and Market Effects Only	Excluding Sum of Country Effects	Excluding Sum of Industry Effects	Excluding Sum of Maturity Effects	Excluding Sum of Rating Effects
Senior	0.123	0.121	0.126	0.123	0.124	0.128	0.123
Junior	0.124	0.121	0.121	0.123	0.125	0.121	0.123
Average	**0.123**	**0.121**	**0.124**	**0.123**	**0.124**	**0.124**	**0.123**
Value-Weighted Average	**0.123**	**0.121**	**0.122**	**0.123**	**0.124**	**0.123**	**0.123**

	Total	Market Effect Only	Rating and Market Effects Only	Excluding Sum of Country Effects	Excluding Sum of Industry Effects	Excluding Sum of Maturity Effects	Excluding Sum of Seniority Effects
<= BBB	0.277	0.121	0.277	0.275	0.283	0.278	0.276
A	0.128	0.121	0.129	0.122	0.131	0.134	0.128
AA	0.132	0.121	0.122	0.131	0.133	0.122	0.132
AAA	0.129	0.121	0.127	0.130	0.127	0.129	0.128
Average	**0.167**	**0.121**	**0.164**	**0.165**	**0.169**	**0.166**	**0.166**
Value-Weighted Average	**0.135**	**0.121**	**0.131**	**0.134**	**0.136**	**0.133**	**0.135**

Table F: Decomposition of excess bond index returns

	Pure[a] Country Effect		Sum[b] Industry Effects		Sum Maturity Effects		Sum Seniority Effects		Sum Rating Effects	
	Variance (%) x100	Ratio rel. to market	Variance (%) x100	Ratio rel. to market	Variance (%) x100	Ratio rel. to market	Variance (%) x100	Ratio rel. to market	Variance (%) x100	Ratio rel. to market
Australia	3.112	1.008	0.074	0.024	0.031	0.010	0.054	0.017	0.017	0.006
Austria	8.942	0.818	0.291	0.027	0.304	0.028	0.015	0.001	0.205	0.019
Canada	2.247	0.963	0.060	0.026	0.016	0.007	0.004	0.002	0.033	0.014
France	2.034	0.988	0.090	0.044	0.070	0.034	0.009	0.004	0.046	0.022
Germany	2.171	0.867	0.149	0.060	0.019	0.008	0.015	0.006	0.078	0.031
Japan	1.821	1.626	0.395	0.353	0.037	0.033	0.002	0.002	0.041	0.037
Netherlands	0.614	0.942	0.089	0.136	0.030	0.046	0.017	0.026	0.022	0.034
UK	1.888	0.997	0.008	0.004	0.087	0.046	0.001	0.000	0.040	0.021
US	0.467	1.084	0.112	0.259	0.087	0.201	0.000	0.000	0.025	0.058
Average	**2.589**	**1.033**	**0.141**	**0.104**	**0.076**	**0.046**	**0.013**	**0.007**	**0.056**	**0.027**

	Pure Industry Effect		Sum Country Effects		Sum Maturity Effects		Sum Seniority Effects		Sum Rating Effects	
	Variance (%) x100	Ratio rel. to market	Variance (%) x100	Ratio rel. to market	Variance (%) x100	Ratio rel. to market	Variance (%) x100	Ratio rel. to market	Variance (%) x100	Ratio rel. to market
Financial	0.406	1.937	0.099	0.472	0.015	0.072	0.009	0.041	0.004	0.020
Energy	0.828	1.374	0.105	0.175	0.019	0.032	0.001	0.001	0.072	0.120
Utilities	1.117	1.568	0.429	0.603	0.039	0.054	0.000	0.001	0.050	0.070
Transportation	2.999	0.963	0.593	0.190	0.219	0.070	0.014	0.005	0.027	0.009
Consumer Goods	0.428	0.665	0.110	0.172	0.015	0.023	0.009	0.014	0.065	0.101
Capital Goods	1.258	0.999	0.058	0.046	0.013	0.010	0.014	0.011	0.051	0.041
Basic Industries	3.440	0.965	0.157	0.044	0.033	0.009	0.001	0.000	0.322	0.090
Banking	0.347	1.173	0.126	0.426	0.008	0.028	0.004	0.013	0.011	0.037
Average	**1.353**	**1.206**	**0.210**	**0.266**	**0.045**	**0.037**	**0.006**	**0.011**	**0.075**	**0.061**

[a] Pure country (industry) effects can be defined as the average deviation of bond excess returns in a particular country (industry) from the market average return.
[b] Sum of industry, country, maturity, seniority or rating effects are the return deviation from the market average return of bond portfolios diversified across industries, country, maturity, seniority or rating respectively.

5.1 Further evidence

So far, we have compared industrial and geographical diversification by looking at the volatility of a restricted set of portfolios, namely, geographically diversified industry index-portfolios and industrially diversified country index-portfolios. Now we would like to extend our analysis of diversification to generic portfolios. We do so by studying the impact on volatility of country and industry effects on all the bonds in our sample, individually. By singling out the marginal risk that can be ascribed to country and industry effects on the average bond, one obtains a measure of the locally systematic risk that would be eliminated when the average bond was included in a geographically or industrially diversified (generic) portfolio. This is accomplished by regressing individual bond time series on all the relevant effects or factors estimated with **(3)**. The regression will be the data generating process specified in **(2)**. Then, if interested in the risk reduction caused by geographical (industrial) diversification, the country (industry) factor is dropped and the regression re-estimated. A measure of diversification-induced reduction of locally systematic risk will then be the coefficient of semi-partial determination of the dropped variable, that is the difference in R-squared between the regression with full factor structure (unrestricted) and the restricted one.

Formally, the unrestricted model is defined as follows,

$$\boldsymbol{\varphi}_z = k_z \mathbf{1} + b_{z,a}\hat{\mathbf{a}} + b_{z,c}\hat{\mathbf{c}} + b_{z,i}\hat{\mathbf{i}} + b_{z,s}\hat{\mathbf{s}} + b_{z,m1}\hat{\mathbf{m}}_1 + ... + b_{z,m3}\hat{\mathbf{m}}_3 + b_{z,r1}\hat{\mathbf{r}}_1 + ... + b_{z,r4}\hat{\mathbf{r}}_4 + \mathbf{e}_z \qquad \textbf{(11)}$$

where, k_z is the regression constant, $\hat{\mathbf{a}}, \hat{\mathbf{c}}, \hat{\mathbf{i}}, \hat{\mathbf{s}}, \hat{\mathbf{m}}_1, \hat{\mathbf{m}}_2, \hat{\mathbf{m}}_3, \hat{\mathbf{r}}_1, \hat{\mathbf{r}}_2, \hat{\mathbf{r}}_3$ and $\hat{\mathbf{r}}_4$ include the time series of pure index effects derived from the cross-section regressions of bond excess returns defined in equation **(3)**, estimated every month over the sample period. $b_{.,.}$ are effect sensitivities, which need to be estimated. Maturity and rating effects will be present in the number required to capture all the maturity and rating changes happened during the life of bond z. For example, if for a particular bond issue no credit rating changes occur then, only one rating effect will be included in the regression. If there is one rating change, there will be two variables for rating effects in the regression. One will include observations of the initial rating effect up to the time of the rating change. After that time the variable will have zero values. The other variable, will include zeros up to the time of the rating change and, observations of the last rating effect from then onwards. Suppose that bond z's time series is available from t to T and that during that period its maturity switches from band 3 (over 5 years) to band 2 (from 2 to 5 years) at time τ.

Also, assume that the rating stays in category 4 (AAA) all along. Then, bond z's regression will look like,

$$\boldsymbol{\varphi}_z = k_z \mathbf{1} + b_{z,a}\hat{\mathbf{a}} + b_{z,c}\hat{\mathbf{c}} + b_{z,i}\hat{\mathbf{i}} + b_{z,s}\hat{\mathbf{s}} + b_{z,m2}\hat{\mathbf{m}}_2 + b_{z,m3}\hat{\mathbf{m}}_3 + b_{z,r4}\hat{\mathbf{r}}_4 + \mathbf{e}_z \qquad (12)$$

where, $\hat{\mathbf{m}}_2 = [0_1 \, ... \, 0_\tau \, \hat{m}_{\tau+1,2} \, ... \, \hat{m}_{T,2}]'$, $\hat{\mathbf{m}}_3 = [\hat{m}_{t,3} \, ... \, \hat{m}_{\tau,3} \, 0_{\tau+1} \, ... \, 0_T]'$ and $\hat{\mathbf{r}}_4 = [r_{t,4} \, ... \, r_{T,4}]'$.[15]

The correct specification of the regression above, that is our DGP, is tested by looking at (i) autocorrelation, (ii) ARCH effects in the errors of regression **(11)**, and (iii) by checking whether the regression constant is statistically significant (exact factor pricing test).[16] For autocorrelation and conditional volatility tests we compute the Ljung-Box Q statistic on regression errors and their square values respectively, lagged from one to six months. The p-value of the Q statistic is derived for each bond in the sample. If the p-value is greater than 5% then correlation and ARCH effects are considered not to be statistically significant. Table G reports the percentage of obligors for which the Q statistic indicates that autocorrelation or ARCH effects are not significant. To produce the figures in the table, first we group bond issues by their issuing company. Then we determine the value-weighted percentage of bonds from the same company that do not show significant autocorrelation or ARCH effects. Finally, we calculate an equally weighted average of these percentages across all obligors. The results show that autocorrelation and ARCH effects are not very common. The former are not present in at least 74% of the issuers in the sample, while the latter are even less frequent, as more than 81% of the issuers do not exhibit significant autoregressive conditional volatility. This appears to suggest that our DGP is correctly specified for a large portion of the securities in the sample.

A further test on the correct specification of the model is the exact factor pricing test generally performed on multifactor models of asset returns. Exact factor pricing implies that the return factors or indices estimated with equation **(3)** are sufficient to explain the expected value of bond

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[15] An alternative to an analysis conducted on one bond at a time would be a panel regression involving all the bonds in the sample. However, the time series of the bonds in our sample overlap only partially and frequently do not overlap at all, which makes our panel severely unbalanced. To avoid the mathematical and computational complications of handling unbalanced panels empirical researchers commonly 'reduce' the full panel to a balanced sub-sample by eliminating non-overlapping observations from the various time series. This solution is not viable in our case since non-overlapping series would leave us with an empty sample.

[16] See, for example, Campbell, Lo and MacKinlay (1997).

returns. If true, this implies that k_z should not be statistically significant.[17] Results in Table H appear to support this hypothesis, k_z is significant only in 4.56% of the bonds (average by obligor) in the sample, which compares with a significance rate of 42.63% when returns are regressed on k_z alone.[18] We also perform a likelihood ratio test in which the unrestricted model includes all factors and the constant, as indicated in **(11)**, while the restricted model includes all factors but the constant. The null hypothesis of zero constant is only rejected in 4.91% of the cases at a 5% confidence level.

Table G: Autocorrelation and ARCH tests

The table gives the results of autocorrelation tests (Ljung-Box Q-test) on the errors and squared errors from regression **(11)**. Time series of the excess returns of individual bonds are regressed on country, industry, maturity, seniority and credit rating effects obtained from the decomposition of bond indices. Effect sensitivities are estimated by OLS. The figures in the table are percentages that indicate the rate of acceptance of the hypothesis of absence of autocorrelation of the regression errors across all the bonds — individually tested — when grouped by country or industry sector. First, we calculate the rate with which individual obligors pass the test by computing weighted average pass rates among multiple issues from the same obligor, for each obligor. Weights are the market value of the bonds. The percentages we report are, then, the simple average of obligor-specific pass rates calculated in the previous step. Excess returns are monthly and denominated in US dollars.

| | Ljung-Box Q-test on Residuals[a] | | | | | | Ljung-Box Q-test on Squared Residuals[a] | | | | | |
| | *Lag (months)* | | | | | | *Lag (months)* | | | | | |
Countries	1	2	3	4	5	6	1	2	3	4	5	6
Australia	69.22	74.07	73.47	78.70	74.69	78.65	73.20	70.70	71.70	75.14	74.75	76.99
Austria	73.62	68.05	75.70	75.70	72.93	63.78	91.31	77.94	90.50	82.89	90.06	92.83
Canada	71.36	76.61	71.17	71.87	76.11	70.50	85.47	85.30	85.07	85.25	89.22	87.97
France	72.82	80.15	81.24	81.91	86.36	88.47	86.64	85.23	85.55	86.00	88.19	89.17
Germany	74.75	79.80	74.98	74.98	74.89	74.14	85.38	82.82	88.53	93.76	94.55	94.83
Japan	80.30	87.96	90.28	91.33	91.46	92.47	84.97	85.26	85.90	87.03	87.04	90.23
Netherlands	73.94	80.72	83.45	80.44	78.56	79.82	84.68	84.84	87.27	89.27	92.51	93.03
UK	86.78	88.28	86.25	85.23	86.76	84.62	84.38	86.29	88.72	88.06	88.58	89.16
US	68.19	76.06	79.51	79.79	80.16	78.01	74.98	76.78	77.97	81.07	85.10	86.07
Average	**74.55**	**79.08**	**79.56**	**79.99**	**80.21**	**78.94**	**83.44**	**81.68**	**84.58**	**85.39**	**87.78**	**88.92**
Industries												
Financial	72.48	79.31	81.33	80.39	81.02	81.75	78.03	79.46	82.20	85.46	87.50	89.04
Energy	68.47	77.44	82.86	88.07	93.38	89.38	80.33	85.28	81.50	85.13	90.13	90.13
Utilities	64.57	73.38	70.33	75.96	77.85	74.23	76.76	75.82	73.68	77.88	77.53	79.56
Transportation	76.65	78.80	83.34	81.12	83.08	86.58	82.89	83.30	88.81	82.39	89.86	89.86
Consumer Goods	76.27	81.67	84.26	83.80	82.54	83.59	79.57	78.97	81.82	84.14	85.26	86.59
Capital Goods	79.30	84.69	82.08	78.23	79.79	75.41	88.10	90.12	88.51	86.97	94.67	90.82
Basic Industries	86.67	88.53	86.81	91.96	90.11	91.85	94.54	91.09	89.37	89.37	89.37	90.23
Banking	75.03	79.44	79.47	78.68	79.06	75.27	81.60	81.78	84.44	84.23	87.86	88.57
Average	**74.93**	**80.41**	**81.31**	**82.28**	**83.35**	**82.26**	**82.73**	**83.23**	**83.79**	**84.45**	**87.77**	**88.10**

[a] Confidence level at 5%.

Table H reports the significance of locally systematic index effects across all bonds in the sample. The numbers in the table show the proportion of issues and obligors for which individual and pairs of regressors in **(11)** are statistically significant at a 5% level. The last column reports the

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[17] Notice that our indices are not excess return indices as those normally employed in multifactor structure models but deviations from the market excess return index. However, through a simple reparametrisation, the indices in equation **(11)** can be expressed as excess return indices. This, which can be obtained by re-estimating regression **(11)** after having added the market excess return to all the other regressors, would not change the statistical properties of the regression and hence our inference on the constant, k_z.

[18] When we regress bond returns on k_{z} alone the significance of the constant is still not very high because we are dealing with monthly spread-induced bond excess returns whose mean is already very close to zero.

number of issues or issuers for which the various regressors in the first column are found to be significant. A regressor is defined to be significant for a particular obligor if the regressor is significant for at least 50% of the obligor's issues. In Table H, the cross-obligor (cross-issue) average significance of maturity, seniority and rating factors is calculated by taking the sub-factor (eg maturity below two years) with highest significance among all the sub-factors of similar type (eg maturity) for each obligor (issue) in the sample. Table I exhibits the frequency with which given numbers of factors, regardless of their type, are found to be significant across the obligors (issues) in the sample.

Table H: Individual and pairwise significance of market, country, industry, maturity, seniority and rating factors

The table gives percentages which indicate the number of instances in which factors (or effects) are statistically significant, individually or in pairs, in explaining bond excess returns. Significance is based on t-statistics at 5% confidence level. Standard deviations in the t-statistics are Newey-West autocorrelation (and heteroscedasticity) consistent. This is to account for the occasional autocorrelation (see Table G) detected in the residuals of the regressions of individual bond excess returns on the relevant factors (see equation **(11)**). Factor sensitivities are estimated by OLS. A factor is defined to be significant for a particular obligor if the factor is significant for at least 50% of all the obligor's issues. Maturity, seniority and rating factors are represented by the sub-factor (eg maturity below 2 years) with highest significance among all the sub-factors of similar type (eg maturity).

By Obligor	k	Mu	Cn	In	M	S	R	Only diagonal factor significant	Number of Obligors
Constant (k)	4.74							1.05	27
Market Factor (Mu)	2.46	44.56						7.02	254
Country Factor (Cn)	2.11	20.70	38.42					5.96	219
Industry Factor (In)	1.75	8.95	9.65	14.91				0.70	85
Maturity Factor (M)	1.58	20.18	16.67	6.14	35.96			5.79	205
Seniority Factor (S)	0.88	8.77	6.67	4.39	5.26	15.26		2.81	87
Rating Factor (R)	1.58	12.28	11.58	5.61	8.77	4.56	21.05	3.33	120

By Issue	k	Mu	Cn	In	M	S	R	Only diagonal factor significant	Number of Issues
Constant (k)	4.69							0.68	111
Market Factor (Mu)	1.99	40.83						8.20	966
Country Factor (Cn)	2.32	18.51	36.01					7.10	852
Industry Factor (In)	1.35	9.55	10.86	17.75				2.07	420
Maturity Factor (M)	1.82	17.33	13.95	6.72	30.85			5.62	730
Seniority Factor (S)	1.18	7.44	6.68	4.23	4.56	13.91		1.86	329
Rating Factor (R)	1.65	9.97	9.04	5.79	7.35	3.63	18.85	2.96	446

In Tables H and I significance is measured with t-statistics. The occasional autocorrelation of residuals of regression **(11)** is dealt with by calculating t-values based on autocorrelation (and heteroscedasticity) consistent Newey-West standard deviations.

The significance of a return effect (or factor) is the first indicator of its importance for diversification. When an effect is not significant it means that the effect becomes indistinguishable from the idiosyncratic noise e_z. This implies that its diversification will not lower portfolio volatility (beyond the reduction caused by lower idiosyncratic risk). By contrast, when a locally systematic effect is priced, then its diversification may reduce portfolio volatility.

The most significant effect, after the undiversifiable average market return, is the country effect (38.42% of the cases) followed by the maturity effect (35.96%) (see diagonal elements in the table). Industry factors are significant only in 14.91% of the cases, below rating factors with a combined significance of 21.05%.

Table I: Number of significant factors

The percentages below indicate the frequency with which a given number of factors are statistically significant in relation to the number of bonds for which the sub-factors are relevant. Significance is based on t-statistics at 5% confidence level. t-statistics are calculated with Newey-West standard deviations.

	Number of Factors							
	0	1	2	3	4	5	6	Mean
By Obligor	21.23	26.14	29.12	12.46	7.37	3.16	0.53	1.70
By Issue	24.51	28.78	23.80	13.14	6.89	2.41	0.46	1.58

After eliminating factors that are not statistically significant we proceed to estimate the unrestricted and restricted models' R-squared.[19]

Table J reports the results when restrictions involve country and industry factors. The first column shows the mean R-squared of regression **(11)**. Regression R-squared are computed for each bond in the sample and then averaged out by country of issue (first section of the table) and industry sector (second section). Each regression includes only the factors that are found to be statistically significant for the specific bond return series. As before, significance tests are based on t-statistics calculated with Newey-West standard deviations. Factor sensitivities are estimated by OLS. The second column shows the average R-squared when the country factor (or industry factor in the second part of the table) is not included among the regressors. In the last column, R-squared are derived from regressions in which all but the market and country (industry) factors have been eliminated. The cross-obligor average reported at the bottom of each section of the table is the average of all R-squared associated with individual obligors. An obligor's R-squared is a weighted average of the R-squared relative to all the bonds issued by that obligor, where weights are the bonds' amounts outstanding expressed in US dollars.

The most interesting findings in Table J are the cross-obligor R-squared averages because they refer to the whole sample population without conditioning on specific countries or industry sectors. Once again the superiority of international diversification is confirmed. The exclusion

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[19] Of course, if the factor that is dropped in the restricted model is not statistically significant for the bond issue under analysis, the unrestricted and restricted models will be identical. Also, for theoretical reasons, the market factor is always included in the regression (even when its significance is low).

of country effects (column 2) causes a reduction in explained volatility of 26.20%, from an average R-squared of 35.68% to 26.34%, against a fall of only 11.73%, to an average R-squared of 31.50%, when industry effects are eliminated.

Maturity, seniority and credit rating diversification is more difficult to explain on intuitive grounds. It appears sensible to expect that these risk dimensions depend on one factor only. For example, it is plausible to assume portfolios of short-maturity bonds to be less volatile than portfolios with longer-maturity bonds because short-maturity debt is less sensitive to the common market factor. Following this line of thought, the market factor, which represents an average maturity, will show a volatility that averages the volatility of well-diversified bond portfolios in different maturity bands. This is consistent with the single-factor hypothesis because the combination of portfolios that depend on the same factor will produce a portfolio whose sensitivity to the factor is the average of the sensitivities of the original portfolios. As a consequence, the volatility of the composite portfolio will be the average volatility of the constituent portfolios.

Columns 2 and 3 in Table E, show that indeed short-maturity bond portfolios are less volatile than long-maturity ones, but the weighted average volatility across the portfolios representing different maturities is higher than the volatility of the market. The difference in volatility between the market portfolio and maturity-specific portfolios may be explained with the existence of locally systematic maturity factors, which are present in portfolios of bonds with a particular maturity (thus inducing 'additional' volatility of a locally systematic nature), and are diversified away in the market portfolio. The hypothesis of the existence and relevance of locally systematic maturity factors is supported by our results in Tables H, I and K. Indeed, even when the sensitivity to the globally systematic factor is accounted for, Table H shows that the significance of maturity effects is second only to the country effects. Table K documents the importance of maturity effects in terms of their contribution to excess return volatility as indicated by the relatively large drop in R-squared that occurs when they are diversified.[20]

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[20] Alternatively, one could explain the fact that the weighted average volatility across the portfolios representing different maturities is higher than the volatility of the market portfolio through the greater influence of idiosyncratic risk in maturity-specific portfolios as they are made up of a smaller number of securities than the market portfolio. While this is true, it should be noted that even the smallest maturity-specific portfolio, which is that of five year or longer-maturity bonds, includes 172 different obligors (see Table B). This number is already quite high and should ensure a portfolio volatility close to its asymptotic value.

Table J: Systematic risk in bond excess returns as explained by statistically significant factors

The first column reports the mean R-squared of regression **(11)**. Regression R-squared are computed for each bond in the sample and then averaged out. A bond excess return is regressed on all the factors that are significant in explaining its return series. Significance tests are based on t-statistics calculated with Newey-West standard deviations. Factor sensitivities are estimated by OLS. The second column shows average R-squared when the country factor (or industry factor in the second part of the table) is not included among the regressors. In the last column, R-squared are derived from regressions in which all but the market and country (industry) factors have been eliminated. Excess returns are denominated in US dollars and expressed in per cent per month. The cross-obligor average is the average of the R-squared associated with individual obligors which, in turn, is a weighted average of the R-squared relative to all the bonds each obligor has issued. Weights are bonds' amounts outstanding expressed in US dollars.

	Average R-squared	Average R-squared Excluding Country Effects	Average R-squared with Market and Country Effects Only
Australia	41.25	19.80	27.31
Austria	45.28	25.06	34.26
Canada	34.13	22.34	19.40
France	23.22	17.41	8.44
Germany	28.95	22.14	14.27
Japan	32.30	26.89	15.49
Netherlands	27.85	22.25	13.76
UK	38.39	25.52	22.34
US	39.49	32.61	16.79
Cross-Country Average	**34.54**	**23.78**	**19.12**
Cross-Obligor Average	**35.68**	**26.34**	**17.93**

	Average R-squared	Average R-squared Excluding Industry Effects	Average R-squared with Market and Industry Effects Only
Financial	35.70	32.39	11.22
Energy	34.89	29.30	12.64
Utilities	37.38	34.01	13.66
Transportation	32.58	28.08	14.43
Consumer Goods	35.91	30.47	13.55
Capital Goods	32.60	26.73	10.00
Basic Industries	40.01	32.84	14.40
Banking	35.00	31.56	10.11
Cross-Industry Average	**35.51**	**30.67**	**12.50**
Cross-Obligor Average	**35.68**	**31.50**	**11.87**

The same argument can be used to justify the importance of locally systematic credit rating effects. By contrast, locally systematic seniority effects do not appear to be important (the weighted average volatility across seniorities reported in column 3 of Table E is 12.2 bp which is almost identical to 12.1, the volatility of the market return).

The existence of locally systematic maturity and rating effects suggests that the uncertainty associated with maturity and rating indices does not vary only in terms of intensity (ie, as if the indices were dependent only on the sensitivity to a common risk factor) but also in character.

Bonds with longer maturity, for instance, are known to be more volatile, but there is no reason to think that the economic factors that make cash flows more uncertain in a distant future are the same factors that make cash flows more certain when they are closer to the present time. In other words, the causes that generate short and long-term uncertainty are likely to be different. For example, it is reasonable to expect long-term uncertainty to be affected by a greater number and more heterogeneous types of risk-generating events. This may ultimately produce the (locally systematic) idiosyncrasies that allow for maturity and credit rating diversification effects.

Table K: Systematic risk in bond excess returns as explained by statistically significant factors

The first column reports the mean R-squared of regression **(11)**. Regression R-squared are computed for each bond in the sample and then averaged out. A bond excess return is regressed on all the factors that are significant in explaining its return series. Significance tests are based on t-statistics calculated with Newey-West standard deviations. Factor sensitivities are estimated by OLS. The second column shows average R-squared when the maturity factor (seniority/rating) is not included among the regressors. In the last column, R-squared are derived from regressions in which all but the market and maturity (seniority/rating) factors have been eliminated. Excess returns are denominated in US dollars and expressed in per cent per month. The cross-obligor average is the average of the R-squared associated with individual obligors which, in turn, is a weighted average of the R-squared relative to all the bonds each obligor has issued. Weights are bonds' amounts outstanding expressed in US dollars.

	Average R-squared	Average R-squared Excluding Maturity Effects	Average R-squared with Market and Maturity Effects Only
<2 yrs	31.52	25.09	13.14
2-5 yrs	38.04	34.76	13.62
>5 yrs	35.71	29.30	12.96
Cross-Maturity Average	**35.09**	**29.71**	**13.24**
Cross-Obligor Average	**35.24**	**30.14**	**13.30**

	Average R-squared	Average R-squared Excluding Seniority Effects	Average R-squared with Market and Seniority Effects Only
Senior	34.36	30.66	11.76
Junior	35.85	32.67	11.70
Cross-Seniority Average	**35.11**	**31.66**	**11.73**
Cross-Obligor Average	**35.27**	**31.87**	**11.72**

	Average R-squared	Average R-squared Excluding Rating Effects	Average R-squared with Market and Rating Effects Only
<= BBB	32.95	29.04	8.99
A	37.42	31.46	17.85
AA	34.67	32.02	11.42
AAA	35.38	32.43	11.64
Cross-Rating Average	**35.11**	**31.24**	**12.47**
Cross-Obligor Average	**35.76**	**31.58**	**13.89**

Similarly, it is not difficult to explain why the type of uncertainty, as opposed to its intensity, may vary across credit ratings. Obligors with a lower rating may, for example, find it difficult to seek financing through the same channels used by firms with a better credit standing. Finding

business partners, the balance of power with customers and suppliers and the very business strategy of the firm may be deeply influenced by the perceived solvability of the firm. Therefore, a rating may be an important determinant of the economic environment the firm has to live in, and of the type of uncertainties the firm faces in its everyday business activity.

6.   Implications for bank capital regulation

In Section 4 we introduced the distinction between globally and locally systematic risk and idiosyncratic risk. Idiosyncratic risk is diversified by merely increasing the number of securities (issued by different obligors) in the portfolio regardless of the securities' characteristics. Locally systematic risk, on the other hand, can only be diversified by increasing the diversity of securities' characteristics, such as the country and industry sector of the issuer. This is because of the existence of risk sources that are country and industry specific. Globally systematic risk is more pervasive and affects, in various degrees, all securities in the market place.

The current regulation of credit risk capital in banks, based on the 1988 Basel Accord and presently endorsed by more than 100 countries, establishes rules that set capital requirements for banks in relation to the amount of credit risk in their portfolios. As is well known, the current rules do not take into account the risk reduction benefits of credit risk diversification. Proposals for a New Capital Accord, (see Basel Committee on Banking Supervision (2003)), improve on the previous rules. While minimum capital requirements as specified in Pillar 1 of the New Accord are based on individual credit exposures, under Pillar 2 a process of supervisory review explicitly takes account of concentration risk both with respect to geographic and sectoral exposures. In addition, it is envisaged that bank will carry out stress tests on a portfolio basis.To further refine capital regulation with respect to concentration risk regulators could draw on the new generation of credit risk models currently used by banks.[22] Credit risk models such as JP Morgan's CreditMetrics and Credit Risk+ already include features designed to capture country and industry effects on portfolio returns. Regulators have been considering these models[23] but,

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[21] See Jones (1998).
[22] For a description and an empirical analysis of this new breed of credit risk models see, for example, Crouhy, Galai and Mark (2000), Gordy (2000) and Nickell, Perraudin and Varotto (2001).
[23] For example, in 1998 the Bank of England and the Financial Services Authority (FSA) hosted a conference to examine developments in credit risk modelling and their regulatory implications. The conference was co-organised by the Federal Reserve Board of Governors, the Federal Reserve Bank of New York and the Bank of Japan, and was attended by central bankers, regulators, academics and senior practitioners working in the field. For a summary of the contributions presented at the conference see Jackson, Nickell and Perraudin (1999).

for the time being, seem to share the opinion that more work needs to be done to increase their accuracy before they can be used for regulatory capital purposes.[24]

7.   Conclusion

This study provides an in-depth analysis of the effects of diversification on spread-induced return volatility in portfolios of corporate bonds. We investigate several types of diversification including geographical, industrial, and across maturity bands, seniority types and credit ratings. Our results suggest that diversification can indeed reduce credit risk and that the best way to achieve this is through cross-border investments. Smaller benefits are also obtainable through diversification across other dimensions, namely, industry sector, maturity and credit rating.

In this work, systematic risk is decomposed into global and local components. The model proposed by Heston and Rouwenhorst (1994) can be seen as a method for decomposing bond indices into a factor that is globally systematic and, as such, cannot be diversified away, and other effects that are only locally systematic. For example, we derive country effects that are persistent within a portfolio that is country specific, and in this sense are systematic, but can be diversified away when combined together through geographical portfolio diversification. For this reason, we regard country as well as industry, maturity, seniority and credit rating effects, as 'locally' systematic. Locally systematic effects, as residual return variations from the globally systematic factor, allow us to disentangle changes in portfolio volatility due to swings of portfolio sensitivity to the global factor versus changes caused by the diversification of locally systematic effects. This made it possible to recognise and understand the reduction in portfolio credit risk that maturity and credit rating diversification generates.

Similarly to other research, which unlike this was carried out on the equity market, we look at the question of whether differences in national industrial structures may explain the benefits of international diversification. In line with Heston and Rouwenhorst (1994) and Griffin and Karolyi (1998), we find that industry effects are responsible but for a small portion of country index volatility suggesting they do not play an important role in geographical diversification.

Our results may have a bearing on the ongoing debate on how to reform the current framework for setting credit risk capital requirements in banks. The capital adequacy rules in Pillar 1 of the New Basel Accord, as in the current Accord, do not take full account of diversification effects on portfolio risk, and to that extent may not accurately capture the risk involved in some investment

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[24] See Nickell, Perraudin and Varotto (2001).

strategies. Therefore, the results emphasise the importance of Pillar 2 of the new Accord, within which supervisors are encouraged to take into account the extent of sectoral and geographical portfolio concentration when assessing the riskiness of banks relative to the capital they hold.

Appendix

The following seniority types are listed roughly in decreasing order or repayment priority.

Senior liquidation status types:

1. Collateralised: Collateralised debt is secured by specifically allocated assets including financial instruments, property, equipment, held in trust.

2. Guaranteed: Guaranteed debt is accompanied by a pledged guarantee of (re)payment of interest and/or principal by a non-sovereign government issuer and/or other entity or entities.

3. Mortgage: The issuer has provided an unspecified lien to the bondholders on his properties to satisfy any unpaid obligation.

4. Secured: Secured means that additional security is provided for payment of interest and principal.

5. Senior proper: Denotes an unsecured issue ranked higher than 'unsecured' issues.

Junior liquidation status types:

1. Unsecured: Unsecured means that no provision is made for additional security enhancement. An 'unsecured' security type is ranked higher than any subordinated security types.

2. Subordinated: Denotes issues ranked below 'unsecured' issues.

Source: Reuters 3000 Fixed Income Services.

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