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# Credit Risk Diversification

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## Abstract

We study the role of diversification in reducing corporate bond spread volatility. In line with previous research carried out on portfolios of stocks we found that geographical diversification is more effective in reducing portfolio risk than within-country diversification strategies across industry sectors. Implications of our results for credit risk capital regulation in banks are discussed.



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# 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, Grinold, Rudd and Stefek (1992), Heston and Rowenhorst (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 paper we look at diversification in the international corporate bond market.

In our investigation we focus on how to diversify bond return volatility that stems from changes in credit spreads as opposed to other elements that may affect bond returns, such as interest rate risk. A separate treatment of credit and interest rate risk appears to be common practice among risk managers in financial institutions. Different products have been developed in the market place to manage and hedge these two sources of volatility. For instance, interest rate swaps offer ways to neutralize the effects of interest rate uncertainty, whereas recently developed credit derivatives, such as credit default swaps, are increasingly used to deal with credit risk. Also, bank regulators tread credit and interest rate risk separately. Distinct regulatory capital requirements are calculated for market risk, which includes interest rate risk (see Basel Committee, 1996), and credit risk (see Basel Committee, 1988 and 2001). For these reasons, an analysis of credit risk alone is not a mere theoretical exercise. Rather, it is a response to the growing demand among practitioners and regulators for empirical investigation aiming at improving our understanding of this type of risk.

In this study we first determine the effects of international diversification on credit risk and then go on to discuss the causes of international diversification similarly to previous work by Roll (1992), and then by Heston and Rowenhorst (1994) and Griffin and Karolyi (1998). By using a Fama-McBeth (1973) type of regression on global stock index returns, Roll finds that volatility can be reduced more effectively when a portfolio of stocks is geographically distributed because of cross-country differences in industrial structure. 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 Rowenhorst (HR) and Griffin and Karolyi (GK). 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 to which all the studies above refer. 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 extend the country-industry analysis to other effects such as maturity, seniority and credit rating's in order to control for their influence on bond excess returns while studying country and industry diversification. Seniority and credit rating are meant to capture a default premium effect. They appear jointly to allow for the two elements that constitute default premia, i.e. likelihood of default and loss given default, to be estimated and treated separately[1].

Our stated objective is an examination of credit spread volatility and how to reduce it through diversification. The first step in this direction involves the identification of what drives spread levels. Generally, credit spreads are believed to be the result of a default premium only[2]. However, Elton, Gruber, Agrawal and Mann (2001) 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 and a systematic risk premium. They find that the systematic risk premium is a sizeable part of the spread, especially for low-rated bonds. We too assume the existence of a systematic risk premium, and explain it by means of country and industry factors. Portfolios of bonds that are concentrated on a particular industry sector (country) will be subject to a systematic premium that is typical to the particular industry (country) being considered. Our choice of systematic factors differs from that of Elton et al (2001) who refer to the three factor structure proposed by Fama and French (1993). This includes a market portfolio of stocks as well as two micro-economic indicators, a proxy for firm size and the book-to-market equity ratio. We have a different approach because 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 use for our investigation of country and industry credit risk diversification[3].

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[1]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. We regress cross sectional bond returns on sets of dummy variables that simultaneously account for the bonds' degree of seniority and their differing credit ratings. As a consequence, the loss given default element in the credit rating will be captured by seniority dummies thus making rating dummies indicators of the "residual" impact on returns of the probability of default.

[2]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 Turbull (1997) and Das and Tufano (1996).

[3]However, it should be noted that explaining assets' systematic risk through macro-economic factors,

An alternative interpretation of our choice of considering country and industry effects on spread volatility involves the assumption that credit ratings, which we use to proxy the default premium, do not consistently measure such premium across countries and industries. The inclusion in our model of credit spreads of country and industry effects is a way to take into account the systematic differences that are found in the premia associated to a given rating when the rating is assigned to firms in different countries and industries. Such geographical and industrial default premium differentials are estimated and discussed in Nickell, Perraudin, Varotto (2000).

As for tax effects, they 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[4].

As previously mentioned, via an extension of the HR model the bond return volatility induced by credit spreads is decomposed into country, industry, maturity, seniority and credit rating effects. We show that country effects play, relative to the others, a greater role in explaining bond credit risk and that, as a consequence, geographical diversification is more effective in reducing credit risk relative to within-country diversification across industry sectors.

Interestingly, our results highlight a major problem in the current regulatory regime of credit risk capital in banks. Capital requirement rules applied to banks in all developed economies and a large proportion of developing countries as well, set a relation between the capital that banks are required to hold with the credit risk in their books. However, the way regulators measure capital requirements, does not account for the sensitivity of

such as country and industry factors, rather than micro-economic indicators, as traditionally done, 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. Our tests reported in section 6 indicate that the combination of country, industry, maturity, seniority and credit rating factors, correctly approximate the cross-section of average returns. In particular, we show that when bond return series are regressed individually on the bonds' relevant factors the regression constant is generally zero, which is a standard test employed to gauge the accuracy of the specification of asset pricing models.

[4]Tax effects on spread volatility would, perhaps, be more of an issue if investors in different countries were subject to heterogeneous tax regimes. This would imply that, all else equal, spreads would be priced differently thus producing tax related spread volatility. In this case it may be reasonable to assume that such volatility be idionsyncratic in nature.

credit risk to portfolio diversification. We argue that this does not discourage banks from undertaking investment strategies that lead to excessive portfolio concentration. Although profitable in periods of market expansion, these strategies may result in high losses in case of a sudden crisis, with serious consequences for the stability of the financial system as a whole.

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 and industry 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 for our estimations 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 a rating history was available, (iv) that the coupons were constant with a fixed frequency, (v) that repayment was at par, and (vi) that the bonds did not possess a sinking fund. Matrix-priced bonds have not been considered. Therefore, all the bond prices in the sample are dealer quotes.

Another selection criterion was that the price history of the issues did not present large pricing errors. 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, two issues that have defaulted during the sample period have been eliminated. Such a measure was necessary, in that the large negative return that occurred at default would have biased estimates in our regression analyses[5].

The final sample is made of a total of 3071 bonds, issued by 662 different firms, covering the period from January 1993 until February 1998.

The sample includes firms from 9 countries, namely Australia, Austria, Canada,

[5] An alternative would be to retain all the bonds and exclude only the outlier events in their price series, as suggested by Elton et al (2001). In our case the market-value of the issues involved was so small that even if included in the sample, results would not have been affected.

France, Germany, Japan, Netherlands, UK and US, and 8 broad industry sectors as defined in the Financial Times Actuaries/Goldman Sachs[6]. 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 1 describes the distribution of issuers across countries and industry sectors. Table 2 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 securities that are backed by some forms of collateral or simply have priority repayment privilege in case of default. Junior bonds, on the other hand, are unsecured issues and rank below senior bonds in the event of default.

Investment grade firms account for more than 95% of the total, with A, AA, and AAA grades representing 87% of the total[7].

It is interesting to note that the number of currency obligors (1196), reported in table 3, is almost twice as big as the number of obligors (662). This indicates that multiple issues from the same obligor tend to be denominated in different currencies, which can probably be interpreted as firms' attempt to hedge their liabilities' foreign exchange risk. The leading currency in our sample is the US dollar, adopted by 30.5% of the obligors, of which 42.7% are not US-domiciled, followed by the British pound 13.7% (40.2% non-UK firms) , Swiss Franc 10.5% (100% non-Swiss firms) and Deutsche mark 9.9% (90.7% non-German firms).

# 3 Excess Returns

In order to investigate credit risk diversification, it is necessary to single out the portion of bond total returns that can be attributed to credit spread changes[8]. This can be thought of as a simple excess return calculation involving the difference between total return and

[6] The original classification includes 7 industry sectors only. We introduce an additional sector by separating banks from the category "Finance, Insurance, and Real Estate".

[7] 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, amongst others, Reuters and Bloomberg through their data services.

[8] Here, like in other studies, we abstract from the effect of liquidity on excess bond returns.

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, the first step is to convert asset returns into the same currency unit, say US dollars, to make them comparable[9]. 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 will be interpreted as the compensation for risk requested by investors in the chosen benchmark country.

Spread risk related returns cannot be calculated alike. The spread 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). In other words, one should calculate spreads with respect to the risk-free term structure of the country whose currency the bond is denominated into, because it is that country's term structure that investors take as a benchmark to price the spread.

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,

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

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 a very marginal element of spread induced bond excess returns. As Beckers et al note, the term $r_x(r_l - r_{fl})$ is very small and can usually be ignored if returns are calculated over a relatively short period of time and, the currencies in which the securities are denominated are not subject to shocks of large magnitude. 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 $r_x(r_l - r_{fl})$ is negligible then,

[9] 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 fx risk, asset returns could be dealt with without prior convertion of asset prices into the same numeraire currency.

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

that is, converted spreads are approximately equal to local currency spreads. 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. This means that foreign exchange effects on spreads are in general not important when spreads are derived as deviations from converted local risk free returns instead of numeraire currency risk free returns. Exchange rate returns for all the currencies in our sample, which include the major European ones together with US, Canadian and Australian dollar and Japanese Yen, did not exhibit monthly variations that significantly affect the factors we extract from bond returns to study credit risk diversification.

There is another reason why our approach departs from the standard manner in which asset price excess returns are calculated. The risk free rate is not the same irrespective of the bond under consideration but it depends on the structure of the bond's cash flows. Since the term structure of interest rates is generally not flat, even if risk-free returns are computed over the same period, their value should vary to reflect a maturity effect. This point is usually irrelevant when one deals with portfolios of stocks because stocks are "irredeemable" in nature. Their life is spread over a theoretically infinite horizon, which implies an homogenous maturity effect for all stocks. This means that the risk-free return associated with stocks can be reasonable assumed not to vary across securities. However, maturity effects cannot be overlooked when dealing with redeemable securities, such as bonds.

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 $t$. $B_\tau$ is the price of a pure discount risk free bond issued by the country whose currency bond $i$ is denominated into, and maturing at time $\tau$ with a redemption value of 1. Risk free bond price quotes for all the countries represented in the sample are extracted from Datastream's benchmark government interest rate curves. To match the exact maturity of bond payments, risk free interest rates, which are only available for discrete maturities, have been linearly interpolated.

# 4 The methodology

In the previous section we have extracted the portion of bond total returns that is generated by credit spread changes. Our objectives is to determine which investment strategy, between portfolio diversification by countries and industries, 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 this purpose, we first derive bond excess return indices by country and industry sector. Indices are estimated by employing the methodology proposed by Heston and Rouwenhorst (1994) and adopted in later studies of the two authors, as well as in Griffin and Karolyi (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.

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

$$\begin{aligned} Ret_{z,t} &= a + c_{t,1}C_{z,1} + ... + c_{t,9}C_{z,9} + i_{t,1}I_{z,1} + ... + i_{t,8}I_{z,8} + \\ & \quad m_{t,1}M_{z,t,1} + ... + m_{t,3}M_{z,t,3} + r_{t,1}R_{z,t,1} + ... + r_{t,4}R_{z,t,4} + s_{t,1}S_{z,1} + s_{t,2}S_{z,2} + e_z \end{aligned} \tag{1}$$

where $Ret_{z,t}$ 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 3, 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 (1), indicated in lower case, are estimated.

The estimation is performed every month from January 1993 to February 1998 by using weighted least squares, the weights being the total nominal value of each issue, in US dollars. As it stands, the model cannot be estimated as it is not identified due to perfect multicollinearity caused by linear dependence between the regression constant and each group of dummies (dummies are grouped by country, industry and so on). This is solved by introducing, for any period $t$, linear constraints on the regression coefficients as suggested in Kennedy (1986),

$$\sum_{f=1}^{9} \alpha_f c_f = 0 \tag{2}$$

$$\sum_{g=1}^{8} \beta_g i_g = 0 \tag{3}$$

$$\sum_{h=1}^{3} \gamma_h m_h = 0 \tag{4}$$

$$\sum_{l=1}^{2} \delta_l s_l = 0 \tag{5}$$

$$\sum_{n=1}^{4} \theta_n r_n = 0 \tag{6}$$

where, $\alpha_f$, $\beta_g$, $\gamma_h$, $\delta_l$ and $\theta_n$ 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. 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

[10] The restrictions impose that the (weighted) average of the dummies in each group is zero. Therefore,

appealing economic interpretation. 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.

The second interesting implication that follows from the restrictions in equations (2) to (**??**) is that they provide a simple way to model, and hence understand, the effect of portfolio diversification on returns. Assume that a portfolio be constructed by investing into bonds distributed across all the countries in the sample, in the proportions indicated by their relative market capitalization, ie the $\alpha_f$ weights employed in restriction (2). Then, the country composition of the market would be replicated. Restriction (2) implies that country effects, estimated as deviations from the market, would disappear from the returns of the portfolio because "re-absorbed" into the market return, which is the mean from which they individually deviate. If the portfolio as a whole were not diversified across industries and bond characteristics then, the return of the portfolio would still 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 "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. In our cross-section, unlike in HR's, the last assumption is more difficult to justify, since, at any given point in time, our sample may include several bonds issued by the same firm. To avoid correlated errors, the simplest solution would be to consider, at any $t$, only one of the multiple issues from the same obligor. However, this would severely limit the number of

the (weighted) average of the dependent variable is expressed by the (weighted) least square estimate of the regression constant.

[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.

securities involved in the estimation of the regression coefficients. By comparing columns 2 and 3 of table 1 it can be easily seen that the sample size would drop on average by two thirds (from 1573 to 444 observations). Ultimately, this greatly reduces the efficiency of the estimates[12]. Moreover, the judgement involved in the choice of what securities should be retained, would probably induce an estimation bias. Even if the securities were chosen at random, it would not be possible to exclude that the estimates were sample dependent. We avoid these problems by estimating equation (1) repeatedly, for every $t$, on samples without multiple issues. But, the unique security issued by a given obligor is allowed to vary across samples. The security is selected randomly (with replacement) from an obligor's set of multiple issues available at that time. The time $t$ regression coefficient will then be the average of all the coefficient estimates obtained from the different random samples[13].

## 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 indices 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 US, for example, can be defined as,

$$R_{us} = a + \sum_g w_{us,g}\widehat{i}_g I_{us,g} + \sum_h w_{us,h}\widehat{m}_h M_{us,h} + \sum_l w_{us,l}\widehat{s}_l S_{us,l} + \sum_n w_{us,n}\widehat{r}_n R_{us,n} + \widehat{c}_{us} \tag{7}$$

where $a$ is the market index return, $\widehat{c}_{us}$ is the "pure" country effect or US bond excess return deviation from the market return, $\sum_g x_{us,g}\widehat{i}_g I_{us,g}$ 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 US. $w_{us,g}$ is the total value of US bonds included in

[12]The average volatility of the time series of the coefficients is 80.17% grater when mutliple issue are eliminated from the sample. This efficiency drop has been measured by comparing the volatility of the coefficients' time series calculated on the full sample (ie including multiple issues) and the average volatility of 1000 samples without multiple issues, in which individual issues have been randomly chosen form the ones available from the set of multiple issues of each obligor.

[13]Coefficients estimated on the whole sample with multiple issues, and the average coefficients estimated with 1000 random samples without mutliple issues, do not differ substantially. With either set of coefficients the results in the paper do not qualitatively change.

industry $g$ relative to the total value of all US bonds in the sample. A similar interpretation applies to the other summations. By the same token, the actual industry index for the banking sector, for instance, can be written as,

$$R_{bk} = a + \sum_{f} w_{bk,f}\widehat{c}_f C_{bk,f} + \sum_{h} w_{bk,h}\widehat{m}_h M_{bk,h} + \sum_{l} w_{bk,l}\widehat{s}_l S_{bk,l} + \sum_{n} w_{bk,n}\widehat{r}_n R_{bk,n} + \widehat{i}_{bk} \tag{8}$$

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 two issues that motivate this study. First, we want to demonstrate empirically whether geographical diversification is more effective in reducing portfolio credit risk than within-country industrial diversification. Second, we are interested in the causes that determine the different outcome in the two investment strategies.

A direct answer to the comparative efficacy of country versus industry diversification is found by simply observing the volatility of country and industry excess return 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 an indicator of the effects on portfolio credit risk of industry and country diversification respectively. Since, as reported in table 4, the value weighted average volatility of industry indices is 0.129, and that of country indices is 0.152, 18.26% higher, we conclude that country diversification is more effective in reducing credit risk than industry diversification.

But, what causes this result? In the previous section we have decomposed country and industry indices into basic effects. So, for example, a country index is the sum of a market effect, plus a "pure" country effect plus the combined influence of all the industries as well as maturities, seniority classes and ratings of the bonds that constitute the index. Since the volatility of a country index is conditioned by all these effects it may be interesting to find out the measure of their contribution to the volatility of the index and, consequently, to its degree of diversification. For example, Roll (1992), HR (1994) and GK(1998) are concerned with industry effects on country diversification.

In the previous section we discussed the economic interpretation of restrictions (2) to (**??**). For example, restriction (2) on the country coefficients can be seen as describing the consequences of complete country diversification on the return of an international portfolio. Complete country diversification occurs when the decomposed return of the portfolio no longer includes country effects because they have been re-absorbed into - or have become orthogonal to - the market return. In other words, the particular country composition of the portfolio matches that of the market. Thus, country effects that have been estimated as deviations from the market return find now expression, as a whole, in the particular "country average" effect that is the market return itself. In general, diversification of any of the dimensions we have considered in this study, ie country, industry, maturity, seniority and rating implies that the decomposed portfolio return does not include the effect of the dimension being diversified, as it will be fully represented by another element of the return decomposition, the market return. Intuitively, as more dimensions are diversified the return of the portfolio will grow closer to the market return, which will be the only element left in the portfolio return decomposition.

The upper section of table 4 shows how country index volatility vary when industry, maturity, seniority and rating effects are subtracted from the index total return. It turns out that 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 index total value weighted average volatility of 0.152. This means that all these dimensions were already (almost) completely diversified in the index-portfolio. So, country index volatility is affected, on average, only by the market and a "pure" country effect. This answers the same question that Roll, HR and GK investigated in connection with the stock market and we now look at with reference to the bond market and, specifically, to credit risk. Industry effects do not appear to have an important role in explaining country diversification.

This can alternatively be seen, as suggested by HR and GK, by comparing 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 5. Combined industry effects represent only 8.8% of the total variance of the country index[14]. 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.

Going back to our initial discussion of the greater efficacy of international diversification relative to industrial diversification in reducing portfolio credit risk, there is yet another way in which this can be demonstrated. We have previously said that the decomposition of country and industry return indices indicates that the indices' volatility is mainly the result of the market plus a pure country effect for country indices and a pure industry effect for industry indices. 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 25.41% (from 0.153 to 0.114) whereas industrial diversification would cause a credit risk reduction by slightly more than half that amount, 13.27% (from 0.131 to 0.114), which confirms our previous conclusion.

Table 4 allows us to highlight another important phenomenon. US investors do not appear to gain from investing abroad in terms of reduction of portfolio credit risk. The volatility of the US bond index is 0.111, which is already slightly lower than the volatility of the market (0.114). This allows us to emphasize the fact that although, in general, through international diversification, portfolio volatility is normally 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

[14] 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.

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 US in our sample, whose volatility of 0.111 is 37.17% lower than the average volatility observed internationally[15].

## 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 risk that would be eliminated when the average bond is included in a geographically or industrially diversified (generic) portfolio. Simply, this is accomplished by regressing individual bond time series on all the relevant effects or factors estimated with equation (1). 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 risk reduction will then be 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,

$$\mathbf{Ret}_z = k_z\mathbf{1} + b_{z,a}\mathbf{a} + b_{z,c}\mathbf{c} + b_{z,i}\mathbf{i} + b_{z,s}\mathbf{s} + b_{z,m1}\mathbf{m}_1 + ... + b_{z,m3}\mathbf{m}_3 + b_{z,r1}\mathbf{r}_1 + ... + b_{z,r4}\mathbf{r}_4 + \mathbf{e}_z \tag{9}$$

where, $k_z$ is the regression constant, $\mathbf{a}$, $\mathbf{c}$, $\mathbf{i}$, $\mathbf{s}$, $\mathbf{m}_1$, $\mathbf{m}_2$, $\mathbf{m}_3$, $\mathbf{r}_1$, $\mathbf{r}_2$, $\mathbf{r}_3$ and $\mathbf{r}_4$ include time series of pure index effects derived from cross-section regressions, every month over

[15] Elton and Gruber (1995) p. 266-72 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 intriguing 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 diverisfication is negligible. On the contrary, international diversification of portfolios of US stocks produces a 7.5% fall in portfolio risk.

the sample period, of bond excess returns as in equation 1. $b_{.,.}$ 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 $\tau$. Also, assume that the rating stays in category 4 (AAA) all along. Then, bond $z$'s regression will look like,

$$\mathbf{Ret}_z = k_z\mathbf{1} + b_{z,a}\mathbf{a} + b_{z,c}\mathbf{c} + b_{z,i}\mathbf{i} + b_{z,s}\mathbf{s} + b_{z,m2}\mathbf{m}_2 + b_{z,m3}\mathbf{m}_3 + b_{z,r4}\mathbf{r}_4 + \mathbf{e}_z$$

where, $\mathbf{m}_2 = [0_1 \; ... \; 0_\tau \quad m_{\tau+1,2} \; ... \; m_{T,2}]'$ and $\mathbf{r}_4 = [r_{t,4} \; ... \; r_{T,4}]'$.[16]

Autocorrelation and ARCH test reported in table 6 indicate that the regression is correctly specified for more than 74% of the obligors in the sample. A further test on the correct specification of the model is the exact factor structure test generally performed on multifactor models of asset returns[17]. Exact factor structure implies that the return factors or indices estimated with equation (1) are sufficient to explain the expected value of bond returns. If true, this implies that $k_z$ should not be statistically significant, in general[18]. Results in table 7 show that this is actually the case. In fact, $k_z$ is significant only in 3.51% of the bonds (average by obligor) in the sample, which compares with a

[16] 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 would make our panel severly unbalanced. To avoid the mathematical and computational complications of handling unbalanced panels empirical researchers commonly "reduce" the full panel to a balanced subsample 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.

[17] See for example Campbell, Lo and MacKinlay (1997), p. 223-24.

[18] 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 riparametrization, the indices in equation (9) can be expressed as excess return indices. This, which can be obtained by re-estimating regression (9) after having added the market excess return to all the other regressors, would not change the statistical properties of the regression and hence the result of our inference on the constant, $k_z$.

significance rate of 46.14% when returns are regressed on $k_z$ only[19]. Similarly, a likelihood ratio test on the restriction that model 9 has zero constant is passed on 98.95% of the cases at a 5% confidence level.

Table 7 reports the significance of index effects across all bonds in the sample. The occasional autocorrelation of residuals is dealt with by calculating $t$-statistics based on autocorrelation (and heteroscedasticity) consistent Newey-West standard deviations. The more significant factor is the market (43.16% of the cases), followed by the country factor (40.53%) and, surprisingly, by the maturity factor (31.05%) (see diagonal elements in the table). Industry factors are significant only in 16.49% of the cases, below rating factors with a combined significance of 21.05%.

After eliminating factors that were not statistically significant we proceed to estimate the unrestricted and restricted models' R-squared[20]. Table 10 reports the results when restrictions involve country and industry factors. The most interesting findings 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 of country effects causes a reduction in explained volatility of 27.32%, from an average R-squared of 36.16% to 26.28%, against a fall of only 11.75%, to an average R-squared of 31.91%, when industry effects are eliminated.

# 6 Implications for bank capital regulation

In section 4 we have 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 portfolios 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 we identify 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.

[19] 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.

[20] 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.

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. Interestingly, these rules do not take into account the risk reduction benefits of credit risk diversification. The credit risk of each security in a bank portfolio is assessed independently of the other securities in the portfolio. The reason behind this over-simplistic approach has to do with the objectives of the G8 countries that agreed the Accord back in 1988. At that time, there was not a uniform regulatory treatment of bank capital across countries and the purpose of the Accord was to lay down a level playing field in which minimum standard were guaranteed internationally. Since no international rules were in place before, and national regulatory systems differed substantially in aims and sophistication, the obvious and practical solution was to come up with a simple set-up that could allow everybody involved to align their system to the agreed standard. It was also understood that the Accord would have to be refined over time. Indeed, modifications and additions have been numerous since its inception (see, for example, Basel Committee on Banking Supervision (BCBS) 1996). In fact, the Basel Committee on Banking Supervision, the forum that originated the Accord and is now responsible for its revisions, is now considering updating capital regulation for credit risk. A proposal for a new capital adequacy regime, which was released this year for comments from the industry (see BCBS 2001), does make an improvement on the previous rules in that it acknowledges the role of diversification in reducing idiosyncratic credit risk. Yet, it does not take into account how diversification across countries and industry sectors may affect portfolio risk. It recognises that a higher number of securities in the portfolio may reduce risk, but treats all securities alike regardless of the country of origin and industry sector of the issuer. So, for example a portfolio of 1000 different corporate loans all issued by high-tech US companies would attract the same capital charges as a portfolio of 1000 corporate loans distributed geographically and across industries[21].

Our results show that beyond the elimination of idiosyncratic risk, country and industry diversification can bring about substantial benefits. Moreover, these benefits are highly dependent on the investment strategy undertaken. Table 10 shows that by elimination of the country effect, the drop in portfolio risk is on average 27.32%, whereas the diversification of the industry effect reduces risk by 11.75%, with great oscillations across individual countries and industries. Geographical diversification of Australian assets re-

[21] Although extreme this example is not mere speculation. It is well known that banks in the US, and abroad, adopted permissive lending policies towards e-businesses before the speculative high-tech stock price bubble started to burst in 2000.

duces risk the most with a fall in R-squared of 59.07% (from 40.48% to 16.57%). At the opposite side of the spectrum lies Japan with a reduction of only 17.02% (from 35.21% to 29.21%). For industry sectors the highest variation is with capital goods, -19.77%, and the lowest with utilities, -8.32%.

This shows that the distortions of a capital regime that is insensitive to country and industry diversification would not probably be small. Flat capital charges that do not vary with the composition of the portfolio, may lead to gross under or over-estimation of risk in bank portfolios. An undesirable side-effect could be that the proposed regulation may encourage banks to jump on the bandwagon and concentrate investment on the sector or country (for example high-tech in the late nineties) that are performing well at a particular point in time. While this could boost returns, it would also leave banks dangerously exposed to market turbulence of non-systematic nature that may affect a particular country or industry - which could be avoided through diversification. In other words, the present proposal leaves room for what is called, in regulatory parlance, as regulatory capital arbitrage[22], that is, actions that can be taken by banks to circumvent regulation by increasing the risk in their books without being affected by a corresponding increase in capital. It is therefore important that the new methodology regulators are planning to implement for the calculation of credit risk capital requirements, incorporate provisions addressing the issue of diversification and its effect on total portfolio risk.

# 7 Conclusion

This study, for the first time, provides an analysis of the risk reduction effects of diversification on corporate bond spreads. We show that diversification can indeed reduce credit risk and that the best way to achieve this end is through cross-border investments.

Similarly to what other researchers have found in the equity market, we also conclude that industry effects cannot explain the higher risk reduction achieved with international diversification.

Our results have direct bearing on the ongoing debate among bank regulators about proposed reforms of credit risk capital requirements in banks. We argue that since current regulation and the newly proposed capital adequacy rules ignore diversification effects on portfolio risk, they can produce distortions leading banks to undertake more risky

[22] See Jones (1998).

investment strategies. This may leave banks with too tiny a capital buffer in case of a sudden market downturn, which may translate into multiple cases of insolvency or default and a consequent generalised weakening of the financial system, exactly when its smooth functioning is most needed for monetary policy transmission and credit generation.

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**Table 1**

**Summary Statistics by Country and Industry Sector**

Sample period 1/93 - 2/98.

| | Monthly Average Market Value (%) | Monthly Average* No. of Obligors | Monthly Average* No. of Issues | Total No. Obligors | Total No. Issues |
|---|---|---|---|---|---|
| **Australia** | 3.52 | 37.86 | 121.41 | 49 | 217 |
| **Austria** | 3.24 | 7.62 | 58.02 | 10 | 101 |
| **Canada** | 2.79 | 27.22 | 82.24 | 42 | 149 |
| **France** | 16.80 | 35.27 | 233.22 | 46 | 409 |
| **Germany** | 5.63 | 15.62 | 130.27 | 22 | 313 |
| **Japan** | 13.07 | 33.33 | 110.32 | 53 | 227 |
| **Netherlands** | 13.32 | 50.30 | 228.65 | 79 | 484 |
| **UK** | 13.22 | 81.10 | 184.14 | 119 | 344 |
| **US** | 28.42 | 155.92 | 425.03 | 242 | 827 |
| **Total** | **100.00** | **444.24** | **1573.30** | **662** | **3071** |
| | | | | | |
| **Financial** | 35.40 | 140.83 | 557.03 | 212 | 1143 |
| **Energy** | 2.51 | 17.95 | 44.03 | 24 | 65 |
| **Utilities** | 11.67 | 41.37 | 148.17 | 58 | 242 |
| **Transportation** | 2.59 | 11.83 | 41.97 | 17 | 73 |
| **Consumer Goods** | 11.52 | 83.73 | 166.73 | 126 | 313 |
| **Capital Goods** | 2.32 | 20.48 | 32.86 | 35 | 64 |
| **Basic Industries** | 2.05 | 19.49 | 35.97 | 34 | 65 |
| **Banking** | 31.95 | 108.57 | 546.54 | 156 | 1106 |
| **Total** | **100.00** | **444.24** | **1573.30** | **662** | **3071** |

* Average population available each month during the sample period.

## Table 2

## Summary Statistics by Maturity, Seniority and Credit Rating

Sample period 1/93 - 2/98

| | Monthly Average Market Value (%) | Monthly Average* No. of Maturity Obligors | Monthly Average* No. of Maturity Issues | Total No. Maturity Obligors | Total No. Maturity Issues |
|---|---|---|---|---|---|
| **<2 yrs** | 25.65 | 204.22 | 450.05 | 532 | 1899 |
| **2-5 yrs** | 45.21 | 281.84 | 719.21 | 569 | 2308 |
| **>5 yrs** | 29.14 | 174.38 | 404.05 | 343 | 1032 |
| **Total** | **100.00** | **660.44** | **1573.30** | **1444** | **5239** |

| | Monthly Average Market Value (%) | Monthly Average* No. of Seniority Obligors | Monthly Average* No. of Seniority Issues | Total No. Seniority Obligors | Total No. Seniority Issues |
|---|---|---|---|---|---|
| **Secured** | 25.76 | 158.10 | 437.98 | 237 | 811 |
| **Unsecured** | 74.24 | 324.00 | 1135.32 | 511 | 2260 |
| **Total** | **100.00** | **482.10** | **1573.30** | **748.00** | **3071.00** |

| | Monthly Average Market Value (%) | Monthly Average* No. of Rating Obligors | Monthly Average* No. of Rating Issues | Total No. Rating Obligors | Total No. Rating Issues |
|---|---|---|---|---|---|
| **>= BBB** | 3.46 | 37.11 | 65.03 | 109 | 194 |
| **A** | 24.63 | 175.87 | 386.32 | 343 | 884 |
| **AA** | 33.92 | 152.30 | 523.14 | 306 | 1260 |
| **AAA** | 37.98 | 78.95 | 598.81 | 133 | 1273 |
| **Total** | **100.00** | **444.24** | **1573.30** | **891** | **3611** |

* Average population available each month during the sample period.

**Table 3**

## Total Number of Issues by Currency

| *Country* | *Currency** A$ | C$ | FFr | DM | Y | Fl | SFr | £ | L | US$ | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Australia** | 169 | 8 | 1 | 2 | 2 | 0 | 3 | 6 | 3 | 23 | **217** |
| **Austria** | 1 | 12 | 1 | 19 | 4 | 4 | 24 | 7 | 9 | 20 | **101** |
| **Canada** | 0 | 112 | 2 | 6 | 1 | 0 | 9 | 5 | 0 | 14 | **149** |
| **France** | 7 | 49 | 143 | 31 | 13 | 12 | 49 | 14 | 25 | 66 | **409** |
| **Germany** | 13 | 35 | 11 | 21 | 1 | 24 | 60 | 29 | 43 | 76 | **313** |
| **Japan** | 0 | 15 | 5 | 12 | 88 | 0 | 12 | 9 | 0 | 86 | **227** |
| **Netherlands** | 4 | 33 | 29 | 79 | 2 | 132 | 59 | 20 | 39 | 87 | **484** |
| **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** | **212** | **331** | **234** | **245** | **124** | **187** | **311** | **303** | **166** | **958** | **3071** |

## Total Number of Currency Obligors

| *Country* | *Currency** A$ | C$ | FFr | DM | Y | Fl | SFr | £ | L | US$ | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Australia** | 38 | 6 | 1 | 2 | 2 | 0 | 3 | 6 | 3 | 13 | **74** |
| **Austria** | 1 | 5 | 1 | 9 | 4 | 2 | 5 | 5 | 5 | 5 | **42** |
| **Canada** | 0 | 26 | 1 | 6 | 1 | 0 | 8 | 5 | 0 | 12 | **59** |
| **France** | 2 | 15 | 38 | 14 | 7 | 7 | 15 | 7 | 13 | 17 | **135** |
| **Germany** | 4 | 8 | 8 | 11 | 1 | 9 | 19 | 8 | 13 | 17 | **98** |
| **Japan** | 0 | 7 | 4 | 8 | 30 | 0 | 7 | 7 | 0 | 34 | **97** |
| **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** | **105** | **88** | **118** | **58** | **47** | **126** | **164** | **67** | **365** | **1196** |

* 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.

**Table 4**

## Volatility Estimates of Excess Return Bond Indices and Combinations of Their Constituent Elements

Through regression (1) 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 percent 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** | 0.197 | 0.114 | 0.186 | 0.192 | 0.192 | 0.193 | 0.196 |
| **Austria** | 0.187 | 0.114 | 0.151 | 0.181 | 0.164 | 0.180 | 0.178 |
| **Canada** | 0.199 | 0.114 | 0.200 | 0.198 | 0.202 | 0.199 | 0.200 |
| **France** | 0.156 | 0.114 | 0.148 | 0.160 | 0.147 | 0.155 | 0.152 |
| **Germany** | 0.183 | 0.114 | 0.165 | 0.173 | 0.175 | 0.183 | 0.181 |
| **Japan** | 0.164 | 0.114 | 0.181 | 0.180 | 0.163 | 0.163 | 0.168 |
| **Netherlands** | 0.150 | 0.114 | 0.137 | 0.147 | 0.143 | 0.147 | 0.150 |
| **UK** | 0.184 | 0.114 | 0.174 | 0.183 | 0.174 | 0.184 | 0.185 |
| **US** | 0.111 | 0.114 | 0.130 | 0.119 | 0.122 | 0.113 | 0.108 |
| **Average** | **0.170** | **0.114** | **0.163** | **0.170** | **0.165** | **0.168** | **0.169** |
| **Value Weighted Average** | **0.152** | **0.114** | **0.153** | **0.156** | **0.150** | **0.152** | **0.151** |

| *Industry Bond Indices* | **Total St.Dev.** | **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** | 0.114 | 0.114 | 0.125 | 0.120 | 0.121 | 0.113 | 0.114 |
| **Energy** | 0.139 | 0.114 | 0.142 | 0.147 | 0.137 | 0.140 | 0.139 |
| **Utilities** | 0.150 | 0.114 | 0.140 | 0.152 | 0.138 | 0.148 | 0.151 |
| **Transportation** | 0.184 | 0.114 | 0.176 | 0.192 | 0.167 | 0.184 | 0.184 |
| **Consumer Goods** | 0.128 | 0.114 | 0.120 | 0.125 | 0.129 | 0.130 | 0.119 |
| **Capital Goods** | 0.141 | 0.114 | 0.129 | 0.134 | 0.135 | 0.142 | 0.138 |
| **Basic Industries** | 0.204 | 0.114 | 0.184 | 0.203 | 0.192 | 0.206 | 0.196 |
| **Banking** | 0.127 | 0.114 | 0.132 | 0.134 | 0.125 | 0.128 | 0.125 |
| **Average** | **0.148** | **0.114** | **0.143** | **0.151** | **0.143** | **0.149** | **0.146** |
| **Value Weighted Average** | **0.129** | **0.114** | **0.131** | **0.133** | **0.128** | **0.129** | **0.127** |

## Table 5

### Decomposition of Excess Bond Index Returns

We decompose country and industry excess return indices and calculate the variance of their constituent elements. The table also gives the ratio of individual elements' variance with the variance of the index in excess of the average market return. Returns are measured in US dollars and expressed in percent per month. This table can be directly compared with table 3 in Heston and Rowenhorst (1994) and table 2 in Griffin and Karolyi (1998).

| | Pure* Country Effect | | Sum^ Industry Effects | | Sum Maturity Effects | | Sum Seniority Effects | | Sum Rating Effects | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Variance (%) | Ratio rel. to market | Variance (%) | Ratio rel. to market | Variance (%) | Ratio rel. to market | Variance (%) | Ratio rel. to market | Variance (%) | Ratio rel. to market |
| **Australia** | 3.187 | 0.998 | 0.060 | 0.019 | 0.023 | 0.007 | 0.067 | 0.021 | 0.010 | 0.003 |
| **Austria** | 1.349 | 0.808 | 0.226 | 0.135 | 0.170 | 0.102 | 0.083 | 0.050 | 0.167 | 0.100 |
| **Canada** | 2.193 | 1.020 | 0.037 | 0.017 | 0.011 | 0.005 | 0.006 | 0.003 | 0.029 | 0.014 |
| **France** | 1.145 | 0.928 | 0.062 | 0.050 | 0.020 | 0.016 | 0.010 | 0.008 | 0.043 | 0.035 |
| **Germany** | 1.787 | 0.833 | 0.140 | 0.065 | 0.026 | 0.012 | 0.014 | 0.006 | 0.068 | 0.032 |
| **Japan** | 1.468 | 1.528 | 0.203 | 0.211 | 0.038 | 0.040 | 0.002 | 0.002 | 0.036 | 0.038 |
| **Netherlands** | 0.590 | 0.911 | 0.051 | 0.078 | 0.030 | 0.046 | 0.016 | 0.024 | 0.016 | 0.024 |
| **UK** | 1.539 | 1.003 | 0.007 | 0.005 | 0.058 | 0.038 | 0.001 | 0.001 | 0.028 | 0.019 |
| **US** | 0.418 | 1.019 | 0.088 | 0.214 | 0.066 | 0.162 | 0.002 | 0.005 | 0.030 | 0.072 |
| **Average** | **1.519** | **1.005** | **0.097** | **0.088** | **0.049** | **0.048** | **0.022** | **0.013** | **0.047** | **0.037** |

| | Pure Industry Effect | | Sum Country Effects | | Sum Maturity Effects | | Sum Seniority Effects | | Sum Rating Effects | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Variance (%) | Ratio rel. to market | Variance (%) | Ratio rel. to market | Variance (%) | Ratio rel. to market | Variance (%) | Ratio rel. to market | Variance (%) | Ratio rel. to market |
| **Financial** | 0.247 | 1.601 | 0.087 | 0.565 | 0.014 | 0.091 | 0.005 | 0.034 | 0.002 | 0.011 |
| **Energy** | 0.732 | 1.190 | 0.096 | 0.155 | 0.012 | 0.019 | 0.001 | 0.001 | 0.035 | 0.056 |
| **Utilities** | 0.662 | 1.464 | 0.325 | 0.719 | 0.025 | 0.055 | 0.002 | 0.004 | 0.040 | 0.089 |
| **Transportation** | 1.625 | 1.091 | 0.350 | 0.235 | 0.086 | 0.058 | 0.004 | 0.002 | 0.023 | 0.016 |
| **Consumer Goods** | 0.424 | 0.650 | 0.086 | 0.132 | 0.011 | 0.017 | 0.009 | 0.014 | 0.069 | 0.106 |
| **Capital Goods** | 1.238 | 0.864 | 0.037 | 0.026 | 0.018 | 0.012 | 0.018 | 0.012 | 0.027 | 0.019 |
| **Basic Industries** | 1.930 | 0.916 | 0.160 | 0.076 | 0.094 | 0.045 | 0.012 | 0.006 | 0.066 | 0.031 |
| **Banking** | 0.290 | 1.002 | 0.087 | 0.300 | 0.004 | 0.014 | 0.003 | 0.010 | 0.011 | 0.037 |
| **Average** | **0.894** | **1.097** | **0.154** | **0.276** | **0.033** | **0.039** | **0.007** | **0.010** | **0.034** | **0.046** |

* 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. ^ 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.

## Table 6

## Autocorrelation and ARCH Tests

The table gives the results of autocorrelation tests (Ljung-Box Q-test) on the errors and squared errors from regression (9). Time series of the excess returns of individual bonds are regressed on adjusted country, industry, maturity, seniority and credit rating indices. Index 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 across all the bonds - individually tested - when grouped by the country or industry sector of their issuers. 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^** | | | | | | **Ljung-Box Q-test on Squared Residuals^** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***Lag (months)*** | | | | | | ***Lag (months)*** | | | | | |
| ***Countries*** | **1** | **2** | **3** | **4** | **5** | **6** | **1** | **2** | **3** | **4** | **5** | **6** |
| **Australia** | 75.18 | 78.93 | 80.15 | 79.37 | 77.30 | 81.22 | 75.34 | 72.98 | 77.88 | 81.03 | 80.75 | 82.17 |
| **Austria** | 68.37 | 82.80 | 86.14 | 83.48 | 70.58 | 82.04 | 90.33 | 87.10 | 95.22 | 88.58 | 90.77 | 91.20 |
| **Canada** | 66.19 | 78.70 | 75.72 | 77.99 | 76.28 | 72.52 | 86.92 | 86.80 | 87.16 | 90.83 | 89.28 | 90.27 |
| **France** | 74.83 | 78.58 | 78.00 | 78.81 | 84.20 | 83.23 | 85.08 | 79.82 | 88.17 | 92.92 | 89.98 | 93.35 |
| **Germany** | 77.16 | 80.83 | 79.39 | 80.82 | 80.37 | 80.32 | 90.94 | 89.80 | 91.78 | 95.30 | 96.23 | 95.72 |
| **Japan** | 87.75 | 84.15 | 88.84 | 90.27 | 89.43 | 88.78 | 87.70 | 84.83 | 91.04 | 90.62 | 93.06 | 93.70 |
| **Netherlands** | 71.65 | 79.48 | 79.95 | 79.03 | 77.21 | 79.60 | 85.00 | 87.01 | 85.62 | 86.37 | 88.91 | 91.60 |
| **UK** | 89.64 | 87.91 | 87.57 | 86.34 | 86.69 | 87.87 | 88.76 | 90.06 | 89.97 | 88.40 | 88.57 | 91.97 |
| **US** | 66.85 | 76.33 | 78.49 | 81.36 | 80.52 | 78.41 | 75.53 | 78.45 | 81.49 | 82.98 | 85.22 | 86.83 |
| **Average** | **75.29** | **80.86** | **81.58** | **81.94** | **80.29** | **81.55** | **85.07** | **84.10** | **87.60** | **88.56** | **89.20** | **90.76** |
| | | | | | | | | | | | | |
| ***Industries*** | | | | | | | | | | | | |
| **Financial** | 72.09 | 80.89 | 81.23 | 82.05 | 81.52 | 84.22 | 79.14 | 81.02 | 84.64 | 87.40 | 87.25 | 90.24 |
| **Energy** | 61.64 | 72.86 | 77.36 | 88.38 | 88.19 | 83.01 | 72.43 | 78.50 | 74.54 | 75.24 | 82.87 | 90.56 |
| **Utilities** | 66.93 | 71.50 | 70.92 | 72.24 | 74.53 | 71.90 | 77.47 | 79.72 | 81.35 | 81.40 | 84.81 | 85.65 |
| **Transportation** | 75.69 | 79.51 | 87.30 | 86.15 | 93.67 | 93.79 | 93.01 | 91.21 | 84.79 | 91.45 | 91.45 | 94.62 |
| **Consumer Goods** | 81.42 | 82.81 | 84.69 | 83.29 | 81.08 | 81.90 | 85.33 | 84.28 | 88.09 | 86.45 | 87.50 | 87.72 |
| **Capital Goods** | 77.86 | 80.39 | 80.53 | 84.24 | 80.53 | 80.53 | 92.98 | 87.01 | 95.09 | 93.61 | 94.12 | 95.41 |
| **Basic Industries** | 84.67 | 93.05 | 90.79 | 93.05 | 94.82 | 93.05 | 96.15 | 92.58 | 91.39 | 91.37 | 89.69 | 89.69 |
| **Banking** | 74.96 | 79.03 | 80.14 | 80.91 | 79.61 | 77.10 | 80.80 | 81.97 | 84.43 | 86.49 | 87.79 | 89.81 |
| **Average** | **74.41** | **80.00** | **81.62** | **83.79** | **84.24** | **83.19** | **84.66** | **84.53** | **85.54** | **86.68** | **88.19** | **90.46** |

^Confidence level at 5%.

## Table 7

### Individual and Pairwise Significance of Market, Country, Industry, Maturity, Seniority, Rating Effects (or Factors)

The table gives percentages which indicate the number of instances in which factors are statistically significant, individually or in pairs, in explaining bond excess returns. Significance is based on t-statitics at 5% confidence level. Standard deviations in the t-statistics are Newey-West autocorrelation (and heteroschedasticity) consistent. This is to account for the occasional autocorrelation (see table 8) detected in the residuals of the regressions of individual bond excess returns on the relevant factors (see equation 9). 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)** | 3.51 | | | | | | | 0.53 | 20 |
| **Market Factor (Mu)** | 1.75 | 43.16 | | | | | | 8.25 | 246 |
| **Country Factor (Cn)** | 1.75 | 21.58 | 40.53 | | | | | 8.77 | 231 |
| **Industry Factor (In)** | 1.05 | 10.00 | 10.18 | 16.49 | | | | 1.58 | 94 |
| **Maturity Factor (M)** | 1.40 | 17.89 | 15.61 | 7.02 | 31.05 | | | 4.74 | 177 |
| **Seniority Factor (S)** | 0.70 | 9.30 | 7.54 | 2.98 | 6.84 | 16.32 | | 2.63 | 93 |
| **Rating Factor (R)** | 1.58 | 11.93 | 11.23 | 6.49 | 10.18 | 3.51 | 21.05 | 2.63 | 120 |

| ***By Issue*** | **k** | **Mu** | **Cn** | **In** | **M** | **S** | **R** | **Only diagonal factor significant** | **Number of Issues** |
|---|---|---|---|---|---|---|---|---|---|
| **Constant (k)** | 4.71 | | | | | | | 0.78 | 115 |
| **Market Factor (Mu)** | 2.21 | 39.38 | | | | | | 7.65 | 962 |
| **Country Factor (Cn)** | 2.13 | 18.54 | 36.92 | | | | | 7.49 | 902 |
| **Industry Factor (In)** | 0.94 | 9.46 | 11.17 | 18.54 | | | | 2.21 | 453 |
| **Maturity Factor (M)** | 1.51 | 16.37 | 13.02 | 7.00 | 28.49 | | | 4.42 | 696 |
| **Seniority Factor (S)** | 1.06 | 8.19 | 7.33 | 4.01 | 5.81 | 16.13 | | 3.07 | 394 |
| **Rating Factor (R)** | 1.39 | 9.54 | 8.84 | 6.06 | 7.61 | 3.60 | 18.67 | 3.23 | 456 |

## Table 8

### Individual Significance of Sub-factors

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

| | By Obligor | By Issue |
|---|---|---|
| **<2 yrs** | 24.47 | 22.88 |
| **2-5 yrs** | 11.40 | 11.91 |
| **>5 yrs** | 18.87 | 19.89 |
| **Secured** | 19.20 | 17.31 |
| **Unsecured** | 16.74 | 15.68 |
| **>= BBB** | 24.57 | 23.78 |
| **A** | 23.08 | 24.31 |
| **AA** | 12.29 | 12.16 |
| **AAA** | 16.53 | 13.90 |

### 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-statitics at 5% confidence level. T-statistics are calculated with Newey-West standards deviations.

| | Number of Factors | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **Mean** |
| **By Obligor** | 21.40 | 29.30 | 24.39 | 14.21 | 6.32 | 3.68 | 0.70 | 1.69 |
| **By Issue** | 24.36 | 29.19 | 23.95 | 12.98 | 6.14 | 2.82 | 0.57 | 1.58 |

## Table 9

### Systematic Risk in Bond Excess Returns as Explained by Statitistically Significant Factors

The first column reports the average R-squared of the regression of excess return time series of individual bonds on all the relevant factors, including country, industry, maturity, seniority and credit rating factors, whenever they are statistically significant. 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 percent per month

| | **Average R-squared** | **Average R-squared Excluding Country Effects** | **Average R-squared with Market and Country Effects Only** |
|---|---|---|---|
| **Australia** | 40.48 | 16.57 | 28.82 |
| **Austria** | 36.07 | 26.42 | 17.09 |
| **Canada** | 34.20 | 23.14 | 18.81 |
| **France** | 26.22 | 19.60 | 10.21 |
| **Germany** | 26.91 | 19.96 | 13.31 |
| **Japan** | 35.21 | 29.21 | 14.80 |
| **Netherlands** | 29.69 | 23.32 | 14.79 |
| **UK** | 35.67 | 22.01 | 21.61 |
| **US** | 41.21 | 33.73 | 16.49 |
| **Cross-Country Average** | **33.96** | **23.77** | **17.33** |
| **Cross-Obligor Average** | **36.16** | **26.28** | **17.66** |

| | **Average R-squared** | **Average R-squared Excluding Industry Effects** | **Average R-squared with Market and Industry Effects Only** |
|---|---|---|---|
| **Financial** | 35.67 | 32.09 | 10.87 |
| **Energy** | 36.70 | 30.51 | 13.71 |
| **Utilities** | 37.01 | 33.93 | 13.52 |
| **Transportation** | 36.55 | 31.35 | 13.99 |
| **Consumer Goods** | 37.74 | 32.39 | 13.66 |
| **Capital Goods** | 32.08 | 25.74 | 10.89 |
| **Basic Industries** | 40.28 | 33.38 | 14.82 |
| **Banking** | 35.02 | 31.70 | 10.42 |
| **Cross-Industry Average** | **36.38** | **31.39** | **12.74** |
| **Cross-Obligor Average** | **36.16** | **31.91** | **11.93** |

## Table 10

## Systematic Risk in Bond Excess Returns as Explained by Statitistically Significant Factors

The first column reports the average R-squared of the regression of excess return time series of individual bonds on all the relevant factors, including country, industry, maturity, seniority and credit rating factors, whenever they are statistically significant. 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 (seniority/rating) factor is not included among the regressors. In the last column, R-squared is 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 percent per month

| | Average R-squared | Average R-squared Excluding Maturity Effects | Average R-squared with Market and Maturity Effects Only |
|---|---|---|---|
| **<2 yrs** | 31.60 | 24.43 | 12.57 |
| **2-5 yrs** | 40.95 | 38.31 | 14.69 |
| **>5 yrs** | 34.59 | 29.69 | 11.40 |
| **Cross-Seniority Average** | **35.71** | **30.81** | **12.89** |
| **Cross-Obligor Average** | **36.23** | **31.49** | **13.19** |

| | Average R-squared | Average R-squared Excluding Seniority Effects | Average R-squared with Market and Seniority Effects Only |
|---|---|---|---|
| **Secured** | 34.04 | 29.62 | 13.14 |
| **Unsecured** | 36.73 | 32.46 | 12.22 |
| **Cross-Seniority Average** | **35.38** | **31.04** | **12.68** |
| **Cross-Obligor Average** | **35.86** | **31.54** | **12.52** |

| | Average R-squared | Average R-squared Excluding Rating Effects | Average R-squared with Market and Rating Effects Only |
|---|---|---|---|
| **>= BBB** | 32.87 | 29.18 | 9.53 |
| **A** | 38.31 | 32.20 | 17.62 |
| **AA** | 36.74 | 33.90 | 12.01 |
| **AAA** | 35.24 | 31.73 | 11.25 |
| **Cross-Rating Average** | **35.79** | **31.76** | **12.60** |
| **Cross-Obligor Average** | **36.79** | **32.43** | **13.96** |