International Bond Diversification Strategies; The Impact of Currency, Country, and Credit Risk

by

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JEL: G11, G15, F34
Key words: International Bond Diversification, Emerging market debt, Corporate bonds

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In this paper, we investigate the incremental role of emerging market debt and corporate bonds in internationally diversified government bond portfolios. Contrary to earlier results, we find that when mean-variance spanning tests with restrictions for short sales are conducted, neither unhedged or hedged international government bonds provide significant diversification benefits for investors from different country origins. However, hedged corporate bonds do offer some diversification benefits, and emerging market debt significantly shifts the mean-variance frontier for a developed-market investor. We estimate several ex-ante portfolio strategies and find that passive global benchmarks such as GDP-weighed bond portfolios perform quite well within developed countries.

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1. Introduction

Many institutional investors are restricted by policy to holdings in the bond market. Even when not, equity and bond portfolios are typically managed separately, and then combined into a multi-asset portfolio. While there is ample international evidence on diversification issues concerning international equity portfolios, and also several papers at least mainly dealing with the benefits of international diversification in a mixed stock and bond portfolio framework[1], there are surprisingly few studies focusing on efficient international diversification strategies within the asset class of bonds. Moreover, typically other studies have analyzed diversification benefits from the perspective of a US or UK based investor alone, or focus only on some bond category such as government bonds[2]. While lack of good data to a great extent explains this focus, current better availability of bond indexes now offers a chance to study the full spectrum of international bond diversification possibilities, including both international government bonds, emerging market debt, as well as corporate bonds.

The main purpose of this paper is to investigate the incremental diversification benefits of emerging market debt and corporate bonds for international government bond investors. Our approach separately and jointly considers three different risks in international bond portfolios:

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[1] Among the pioneers in this line are e.g. Grauer and Hakansson (1987), Jorion (1989), and Odier and Solnik (1993). Although some analysis of bond portfolios is also included in such papers, the number of fixed income assets is typically low.

[2] See e.g. Dewachter and Maes (2001) studying US government bonds in U.K. portfolios, Hunter and Simon (2004) for US based bond investors including foreign government bonds, or Varotto (2003) studying various forms of diversification solely within the asset class of corporate bonds.

currency, country, and credit risk. Currency risk is assessed by studying currency hedged versus unhedged portfolios, while country and credit risks are analyzed by including emerging market and corporate bond indexes. We study diversification benefits from the perspective of investors from different country origins. Contrary to earlier results, we find that when mean-variance spanning tests with restrictions for short sales are conducted, neither unhedged or hedged international government bonds provide significant diversification benefits for investors from different country origins. However, hedged corporate bonds do offer some diversification benefits, and emerging market debt significantly shifts the mean-variance frontier for a developed-market investor.

We contribute to the existing literature in several ways. First, by studying simultaneously the international diversification benefits from several types of bonds. The analysis allows us to answer several interesting questions concerning both the relative importance of currency risk, the optimality of hedging, as well as the benefits of including emerging market debt and corporate bonds into an international bond portfolio. Second, given previous evidence of increasing correlations, substantial diversification benefits in bond investments can be questioned, and new evidence is called for. Our data, ranging from January 1997 to May 2006, indeed shows evidence of reduced benefits in pure government bond investments. Third, we study bond portfolio diversification from the perspectives of several different investor categories including the U.S. as well as European and Asian perspectives. Since bond return correlations vary a lot depending on the pair of countries analyzed (higher between geographically or culturally connected countries, see e.g. Levy and Lerman 1988, for more recent data e.g. Hunter and Simon 2004), diversification benefits may look different depending on investor origin.[3] Finally, we use mean-variance spanning tests with non-negativity constraints derived by De Roon, Nijman, and Werker (2001) in addition to more classical tests based on analyses of frontiers and Sharpe ratios for different ex ante portfolio strategies. Such tests have not been used for bond portfolios earlier.

The structure of the paper is the following. In section 2, we review some related literature and formulate our research questions. In section 3 and 4, the method and the data used in the study are presented, together with descriptive statistics. Results will be presented in section 5, while section 6 summarizes our findings.

2. Prior Research on Bond Diversification

Early studies of international market bond correlations tell a mixed story of the relative benefits of international bond diversification for investors from different countries. In Levy and Lerman (1988), the correlations between government bond returns for geographically closely related countries were found to be rather high compared to corresponding stock market correlations. However, also very low correlations, such as for Japan, were detected. From the perspective of a US based investor, the correlations between foreign and domestic bond returns were typically lower than corresponding equity market correlations, leading to the conclusion that an internationally diversified bond portfolio for the US investor dominated an internationally diversified stock portfolio. Despite these apparent benefits, at least for the US investor, the home bias in US bond portfolios was higher than that in stock portfolios as late as

[3] For equities, Chiou (2005) has shown that, as expected, developing countries benefit more from both regional and global diversification.

in 1990 (Tesar and Werner, 1995).

Recent evidence, e.g. Solnik et al (1996), Cappiello et al (2002), documents some increased correlations between bond returns over time, but not systematically for all pairs of countries. In line with previous research, Cappiello et al (2002) found higher within-region correlations, the distinct regions for government bonds being Europe[4], North America, and Japan. The time-series evidence indicate increasingly correlated business conditions between the US and Europe, but not between the US and Japan. However, these increased correlations do not seem to have eliminated diversification benefits of currency hedged foreign bonds to a US bond portfolio (Hunter and Simon, 2004).[5]

These prior studies on government bonds, mainly from the US perspective, give rise to the following research questions:

Question 1. What are the diversification benefits from including foreign government bonds into a domestic bond portfolio, especially for other than US investors ?

Question 2. How have these benefits changed (e.g. in the euro regime) for different countries

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[4] Later evidence for the euro-area by Baele et al (2004) indicates fully integrated money markets, a reasonably high integration in the government and corporate bond markets, whereas the credit market is the least integrated.

[5] Fresh indirect international evidence on the existence of significant diversification benefits from foreign debt is offered by studies on home bias. Sœrensen et al (2006) show that the home bias is actually smaller in the debt portfolios of many countries than in the corresponding equity portfolios. If the markets behave rationally, this empirical evidence would indicate higher actual diversification benefits of foreign debt, and/or lower transaction costs or informational asymmetries for foreign debt securities. Evidence from fund managers' views by Lütje et al (2004) also indicate lower informational advantages and less relative optimism for international bond managers, again supporting less home bias for bond investments.

within and outside Europe? I.e. what is the current level of these benefits?

Our study will include investors from three continents (North America, Europe, as well as Asia). Within Europe, we will look at Germany as an example of a country entering the Eurozone, but also at the U.K. as a country outside the euro zone. Japan and the U.S. represent the other two viewpoints.

The question of currency risk is more crucial for bond portfolios as compared to equities. First, exchange risk typically stands for a larger part of the total asset risk as compared to the case of equities (e.g. Odier and Solnik 1993). On the other hand, currency hedging is easier than for stocks, since the future value of the asset in local currency is less uncertain (i.e. the concept of a "perfect hedge" is not equally unattainable as for stocks). Therefore, hedging is much more common among bond investors as compared to stock investors, and also shown to typically improve performance (see e.g. Jorion 1989, and Eun and Resnick, 1994).

It is possible that increased bond correlations and relatively high currency risk eliminate diversification benefits. Thus, the question of whether unhedged bonds still offer diversification benefits is an interesting one. In an early study (years 1977 to 1990), Levich and Thomas (1993) found that US-based investors would have earned higher returns on unhedged foreign bonds than on US bonds. On the other hand, later Burger and Warnock (2003) conclude that for US investors optimal government bond portfolios rarely include unhedged positions in foreign local-currency bonds. This result is also confirmed by Hunter and Simon (2004).

Most international bond diversification studies have been conducted using traditional ex-post frontiers. Formal mean-variance spanning tests have only been used by Hunter and Simon (2004), and they did not use a non-negativity constraint. Since it may in some cases be harder to short government bonds, and especially emerging market debt and corporate bonds, as it is to short stocks, not allowing for negative weights is even more motivated here as in the case of stock diversification studies. De Roon et al (2001) have developed a mean-variance spanning test with short sales constraints, which we will use in our study.

Question 3: Does the mean-variance frontier significantly shift outward only when hedged (as compared to unhedged) international bonds are included ?

Question 4: Does restricting for short sales produce results different from those without, as reported in prior studies ?

Most international bond diversification studies have focused on government bonds from developed countries. With increasing correlations between developed market bonds, emerging market debt might offer additional diversification benefits. However, the evidence from equity markets is ambiguous concerning the benefits of emerging market assets. While e.g. DeSantis (1994) and Harvey (1995) show that the mean-variance frontier for stocks significantly shifts away only when emerging stock markets are included, De Roon et al (2001) find that when short-sales constraints are enforced, and small transaction costs included, the significant diversification benefits from emerging market stocks disappear. Chances are that the results may be similar for emerging market government bonds, since several recent studies on emerging market spreads have documented significant co-movement in spreads for sovereign debt issues by emerging market countries. E.g. Cifarelli et al (2002) find convincing evidence of co-movement, more so within geographical areas than between them. Yafeh et al (2000) find larger co-movement in the 1990's than in 1870-1913, and argue that today's investors pay less attention to country-specific events than their predecessors did.

Question 5: Does emerging market (hedged) debt provide additional diversification benefits into an internationally diversified developed market bond portfolio?

With the growth of the international corporate bond market, additional vehicles for international diversification are offered in the form of corporate debt instruments. Varotto (2002) studied the role of country, industry, as well as e.g. credit ratings category diversification of corporate debt in a large sample of individual corporate bonds. The results indicate that geographical diversification is more effective in reducing portfolio risk than any of the other investment strategies tested. We will therefore conduct our study focusing on this most important diversification dimension associated with corporate bonds. We will use country / region based corporate bond indexes as proxies for national well diversified corporate bond portfolios, and investigate the additional diversification benefits offered by them.

Question 6: Are there additional diversification benefits from including unhedged or hedged corporate bonds into an internationally diversified bond portfolio?

3. Method

We apply the mean-variance intersection and spanning tests under short sales constraints, derived by De Roon, Nijman and Werker (2001). The test statistic is asymptotically distributed as a mixture of χ^2 distributions, for which case Kodde and Palm (1986) provide statistical tables to assess statistical significance. Before De Roon et al (2001), regression based mean-variance spanning tests have been conducted by Huberman and Kandel (1987) and Bekaert and Urias (1996), whereas DeSantis (1994), Hansen, Heaton, Luttmer (1995), Chen and Knez (1996), and Dahlquist and Soderlind (1999) employed GMM-based tests.[6] Other earlier methods include those by Jobson and Korkie (1989) and Glen and Jorion (1993), who both investigated Sharpe ratios. The relative benefit of the Wald test by De Roon, Nijman and Werker (2001) as compared to these earlier alternatives is that the short sales constraints can now be analyzed separately, and that the power of the test is sufficiently high.

Spanning and intersection tests involve testing statistically whether addition of new "test assets" to a set of "benchmark" assets shifts the mean-variance frontier outward. The test assets in our tests include following subsets: (1) MSCI developed country government bond indexes for 11 countries, (2) 10 emerging country government bond indexes , and (3) five developed country corporate bond indexes. We also consider diversification into multiple subsets jointly. We choose four different scenarios for the benchmark asset: (1) Merrill-Lynch Developed Country Government Bond index, (2) a developed country GDP-weighted government bond index[7], (3) a pure 100% USD home market government bond investor investing in Morgan Stanley Capital International (MSCI) US Government bond index[8] and (4) a mean-variance frontier of 11 developed country government bonds. When there is a single benchmark index, we test for mean-variance intersection using local 1-month TBill return as the zero beta rate. Rejection of null hypothesis indicates that the chosen benchmark index is not mean-variance efficient with respect to the test assets, i.e. non-zero weights in the test assets offer significant diversification benefits compared to investing in the benchmark only (see restrictions corresponding to equation (15) in De Roon, Nijman and Werker (2001)). In case the benchmark assets by themselves form a frontier, we test for mean-variance spanning, i.e. a comparison of the two frontiers is made for all feasible zero beta rates (restrictions corresponding to equation (20) in De Roon, Nijman and Werker (2001)).

We also investigate the impact of currency hedging on mean-variance spanning. We assume a perfect money market hedge through covered interest rate parity. In this case, the monthly currency hedged excess return of an international long-term bond investment is simply the local long bond return minus the local 1-month TBill return, i.e unaffected by the exchange rate movement between home and overseas currency (see Appendix 1 for details on how the currency hedged returns have been calculated).

Throughout the paper, we focus exclusively on unconditional mean-variance intersection and

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[6] Bekaert and Urias (1996) investigate small sample properties of mean-variance spanning test methods and find that regression based methods appear to have better power than GMM- based alternatives.
[7] The weights in the GDP index are annually rebalanced such that a particular year's weight is based on previous year's GDP converted to USD as reported by the IMF for each country in Group 1.

[8] When analyzing diversification benefits from another investor perspective (UK, German, or Japanese investors), we correspondingly use the MSCI index for that country.

spanning tests and leave extensions to conditional investment strategies for future research.

4. The Data

The return data used in this study are monthly total returns for the three categories of bond indices from January 1997 to May 2006. We categorize these as follows: Group 1 includes the government bond indices from 11 developed countries, denoted in local currencies, Group 2 the bond indices from 10 emerging markets, all denominated in USD, and Group 3 the corporate bond indices from five developed markets, in local currencies. We also use monthly money market returns in the reference currencies. When needed, monthly currency exchange rates are used to convert bond index returns into currency unhedged returns or hedged excess returns in the desired currency. The calculation of the four indices used as benchmarks for the intersection and spanning tests were explained in Chapter 3.

The bond index returns are obtained from Datastream and are originally provided to Datastream by Morgan Stanley (Group 1), Lehman Brothers (Group 2), or Merrill Lynch (Group 3). These three dataproviders were selected for respective groups of data based on best possible geographical coverage and earliest possible start date for the return series to maximise sample size.

If available, the corporate bond indices selected are classified as industrial or non-financial and investment grade. If several indices meet the investment grade rating criteria an index with issuers rated in the lower end of investment grade was selected to allow for a larger amount of credit risk premia to clearly separate these indices from the indices in Group 1. If an industrial or non-financial index was not available a broad corporate index was selected.[9]

All indices used are total return indices, i.e. coupons and principal payments are reinvested in the index. The description of the three index categories (Groups 1 to 3) are summarised in Table 1.

INSERT TABLE 1 ABOUT HERE

Descriptive statistics on continuously compounded monthly returns in the currency of denomination for the indices in all three groups are provided in Table 2. The highest average returns as well as the highest standard deviations are found among the emerging market indices (Group 2), with some markets having average monthly returns in excess of one percent. These indices also exhibit some very large positive and negative returns. All returns in excess of +/- 10% were checked for errors in the original total return index data, but only one index value was judged to be erroneous and replaced with the average of the preceding and following index value.[10]

INSERT TABLE 2 ABOUT HERE

[9] Even if Merrill Lynch had the best geographical coverage and longest time-series of corporate indices, it was not possible to find exactly the same type of index for all countries. The indices for USA and EMU are industrial/non-financial, while the indices for UK, Japan, and Canada are broad corporate indices. The ratings (Standard & Poor's) of the issuers included are BBB for USA, A for Japan, and investment grade for the EMU, UK and Canada.

[10] The return for the Lebanese index in November and December 1997 would else have been +151% and –148%, respectively. As we found no financial news to explain this, and as the price index data series in contrast to the total return index data used in our study did not exhibit the same extreme fluctuations, the November index value was smoothed. All other large returns were accompanied with either a simultaneous equity market return in the same direction, and/or a substantial weakening of the local currency.

Beginning-of-month point estimates of currency spot rates quoted against the USD are used to calculate currency unhedged returns for indices denominated in local currency (all the non-USD indices) in Group 1 and 3 (Group 2 is entirely USD-denominated).[11] The source for the spot rates is also Datastream, expressed as foreign currency to USD. Descriptive statistics for currency returns are found in Table 3.

INSERT TABLE 3 ABOUT HERE

As can be seen in Table 3, the standard deviation of all currency returns exceed the standard deviation of the corresponding government or corporate bond return. Leaving returns unhedged will thus notably increase risks unless counterbalanced by good reductions in correlations.

To give an overview of the correlations within each group and between a particular index and indices in other groups, we report intra-group correlations and the average correlation between an index and all indices in the two other groups. These correlations are reported in Table 4, the last two columns representing the average correlation of the index with all indices in the group indicated by the column heading.

INSERT TABLE 4 ABOUT HERE

As can be seen, the largest average intra-group correlation (0.61) can be found in the group for developed markets. It can also clearly be seen that the indices in the emerging markets group (Group 2) on average have low correlations against indices in groups 1 and 3 (0.06, and 0.15, respectively), while the correlation between indices in Group 1 and 3 (0.54) is not much lower than the average intra-group correlation in the set of developed markets. There is, however, substantial within-group variation both within Group 1 (with a minimum correlation of only 0.12) as well as within the group of corporate bonds, where even negative correlations (between Japan and the other markets) are observed. [12]

The correlations of Group 2 with the other two Groups are also the most unstable. For example, constructing equally weighted portfolios of all indices in each group and computing 12-month rolling correlations with the equally weighted portfolios of the other two groups, gives an average rolling correlation of 0.17 between group 1 and 2, with a standard deviation of 0.33, a minimum value of –0.39, and a maximum of 0.87. The corresponding standard deviation between group 2 and 3 is 0.25, but between group 1 and 3 it is only 0.10, with a minimum value of 0.53. This is demonstrated graphically in Figure 1.

INSERT FIGURE 1 ABOUT HERE

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[11] Germany is the only country in our sample entering the Eurozone from the beginning of year 1999. For the German Government bond index in Group 1, we therefore use the DEM to USD currency rate up to the end of 1998, and the EUR to USD rate from 1999 onwards.

[12] If Japan would be excluded, the average intra-group correlation for developed markets (Group 1) would rise to 0.71. For the group containing corporate bonds (Group 3), the exclusion of Japan would also increase the correlation to 0.71.

Also relevant for this study is the correlation with the benchmarks. To preserve space, we report the correlations of each index only with respect to one benchmark, the Merrill Lynch Global Government Index. These are reported in Table 5.

INSERT TABLE 5 ABOUT HERE

As can be seen, the correlations with the benchmark are lower than the average intra-group correlations reported in Table 4. The variability of these correlations is demonstrated in Figure 2, where average 12-month rolling correlations with the ML benchmark for equally-weighted indices for each group are shown. There seems to be an increasing time trend for both the correlations for Group 1 (developed markets) as well as Group 3 (corporate bonds), whereas the picture for Group 2 (emerging market debt) is more variable.[13]

5. Results

We start by reporting on the global diversification benefits for USD denominated investors (see Appendix 2 for corresponding results for investors from the U.K., Germany, as well as from Japan). We test four "home market" benchmark cases against expanded asset ("test assets") sets. Three of the "home market" benchmark cases are single index cases with either (1) the Merrill-Lynch Developed Country Government Bond index, (2) a developed country GDP-weighted government bond index, or (3) a pure 100% USD home market government

[13] Regressing a time trend on the correlation for each group results in positive regression coefficients between 0.0040 and 0.0045. The coefficient estimates are statistically significant on at least a 5% level using heteroskedasticity and autocorrelation consistent standard errors (Andrews 1991).

bond investor investing in Morgan Stanley Capital International (MSCI) US Government bond index. The fourth "home market" benchmark case (4) allows a developed country government bond investor to freely mean-variance-optimize their portfolios among 11 developed MSCI country government bond indices.

Note that we in cases (1) to (3), where the home market benchmark asset is a single index, only test for mean-variance intersection, choosing the risk-free rate as the intercept. Economically, as shown by Gibbons, Shanken and Ross (1986), the mean-variance-intersection chi-square Wald-statistic is closely related to the increase in the maximum obtainable Sharpe ratio given the expanded asset set being tested. In the fourth case, we also test for mean-variance spanning as now the benchmark assets themselves yield a mean-variance frontier. Results are reported in Tables 6 and 7 using unhedged and hedged returns, respectively.[14] In these first tests, we allow for short sales. Base case benchmark (maximum) Sharpe ratios are reported on the left of the tables.

INSERT TABLES 6 AND 7 ABOUT HERE

Table 6, first column, shows that bond diversification to developed country government bonds (Dev) on an unhedged basis does not offer significant diversification benefits for a USD-dominated investor, as none of the intersection tests for the three “home-country” benchmarks rejects the null hypothesis. Table A1 in Appendix 2 reports similar results for German, UK, and Japanese investors.

Sharpe ratios are improved when the developed market government bonds are currency hedged, but the improvement is still insignificant for the USD-dominated investor (Table 7, first column) as well as for the others (Table A2 in Appendix 2). In summary, our results so far differ from those of Hunter and Simon (2004), who still found significant diversification benefits when including hedged foreign bonds to a US bond portfolio.

Diversifying only to corporate bonds (CB) neither leads to significant improvements on an unhedged basis for US or foreign investors (Table 6 and A1), as none of the intersection tests are significant. However, mean-variance spanning is clearly rejected for the US investor in the fourth case if diversification is into global corporate bonds. Given that mean-variance intersection is not rejected in this case, this result simply suggests that diversification benefits arise from outmost sections of the expanded frontier (very low or high risk) and not from expansion of the tangency region.

With currency risk removed, corporate bonds do offer significant diversification benefits at the 5% level for the US benchmark (Table 7) and foreign investors (Table A2), except in the case where free optimization across 11 developed country bond indices is allowed (ALLMSCI): in this case there are no substantial performance improvements from including corporate bonds except perhaps for the most risk tolerant investors (spanning is rejected).

Diversification into emerging countries clearly expands the frontier as indicated by significant Wald statistics for the mean-variance intersection or spanning test for the US investor (Table 6) in all cases where Emerging market government bond asset class ("Em") is included in the

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[14] In line with related literature we assume a perfect hedge. These calculations are detailed in Appendix 1.

test. For UK, German, and Japanese investors (Table A1), the improvement is mostly not significant for Emerging market debt as such, but the combined effect of Emerging market debt and Corporate bonds is significant in all cases. Gauging by the Sharpe ratio improvements, these benefits are also quite substantial as compared to the low Sharpe ratios of benchmark investing only.

Next, diversification benefits are assessed under the more realistic assumption of no short sales. We use Kodde-Palm (1986) statistical table to assess the statistical significance of the DeRoon-Nijman-Werker (2001) chi-square statistics, when taking into account the restriction on short sales. Tables 8 reports the results for the USD-dominated investor, using unhedged returns.

INSERT TABLE 8 ABOUT HERE

As expected, constraining the frontiers by not allowing negative positions dramatically cuts the diversification benefits. However, emerging country bonds still offer significant diversification benefits, especially in the outer areas of the frontiers, as the mean-variance intersection tests generally do not reject but corresponding spanning tests do. This result is driven by a few high-performing but high-risk emerging countries in our sample. The results for the other countries are reported in Table A3 in Appendix 2. The results for the German investor, and to some extent for the Japanese, are in line with those for the US. However, for the UK investor none of the expanded diversification opportunities are statistically significant.

Can currency hedging offset some of the drawbacks with excluding possibilities to short government bonds observed in table 8? Table 9 shows that this is indeed the case: diversification into global corporate bonds significantly improves the performance of global benchmark or US only government bond investors.

INSERT TABLE 9 ABOUT HERE

As Table 9 shows, the best improvements occur with diversification into both corporate bonds and emerging country bonds. As before, however, the benefits mostly result from positions in high-risk emerging country bonds given rejections only in our spanning tests. For investors from the other countries (Table A4), the results are mainly likewise.

INSERT FIGURES 3, 4 AND 5 ABOUT HERE

Figures 3, 4 and 5 summarizes our findings for the US investor, showing the shift of the frontier from the home-country benchmark (positioned near the frontier for developed market government bonds) to a frontier including also corporate bonds (in Figure 3), emerging country bonds (in Figure 4), and both (Figure 5).

6. Summary and Conclusions

Many investors, such as fixed income fund managers, dedicate their attention solely to the asset class of bonds. However, as compared to studies of international diversification benefits for stock portfolios, there are surprisingly few studies of fixed income diversification benefits only. This paper investigates bond diversification benefits and contributes to the earlier studies in several ways: we include several different categories of bonds such as government bonds, emerging market debt, and corporate bonds to assess broadly based international bond market diversification. Second, we assess diversification benefits using methods taking into account short sales constraints and currency hedging. Finally, a contribution of this study is consideration of investor's domicile of either U.S., European (U.K. or Germany) or Japan.

We find increasing correlations within both government bonds as well as corporate bonds over time during our sample period of 1997-2006. The overall level of correlations between these asset classes are relatively high. Only emerging market debt differs by still offering lower correlations both within the asset class as well as with respect to other types of bonds.

First, we analyse international diversification benefits when short sales are allowed. Contrary to earlier studies, and also contrary to more recent ones such as by Hunter and Simon (2004), we do not find significant diversification benefits within the asset class of government bonds. This holds both for US investors as well as investors from U.K., Germany and Japan. Diversification benefits remain insignificant even if we assume perfect hedging of currency risk, and are even smaller when constraining for short sales.

Diversification from government bonds into international corporate bonds also fails to offer significant improvements on a currency unhedged basis for both US and global investors. However, with currency risk removed, corporate bonds do offer significant diversification benefits for both US and non-US government bond investors, even in the case of constraining for short sales.

In contrast, diversification into emerging country debt clearly expands the frontier for investors for all developed country investors. Gauging by the Sharpe ratio improvements, these benefits are also economically quite substantial. Constraining the frontiers by disallowing negative positions dramatically reduces diversification benefits. However, USD denominated emerging country bonds do still offer some statistically significant diversification benefits. The best improvements occur with diversification into both currency hedged corporate bonds and emerging country bonds. However, the benefits have to be obtained by positions in high-risk emerging country bonds, given rejections only in our spanning tests.

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Figure 1. Rolling 12-month correlations between Groups 1 to 3

The figure shows the time series development of the between-group correlations for our three groups (G1: developed market bonds, G2: emerging market debt, and G3: corporate bonds) of bond index returns. For each group, based on the different individual bond index returns included in that group, equally weighted monthly portfolio returns have first been calculated. Then, 12-month rolling correlations have been calculated between each pair of group portfolios. A line showing the average correlation is also included. The time period is from December 1997 to May 2006.

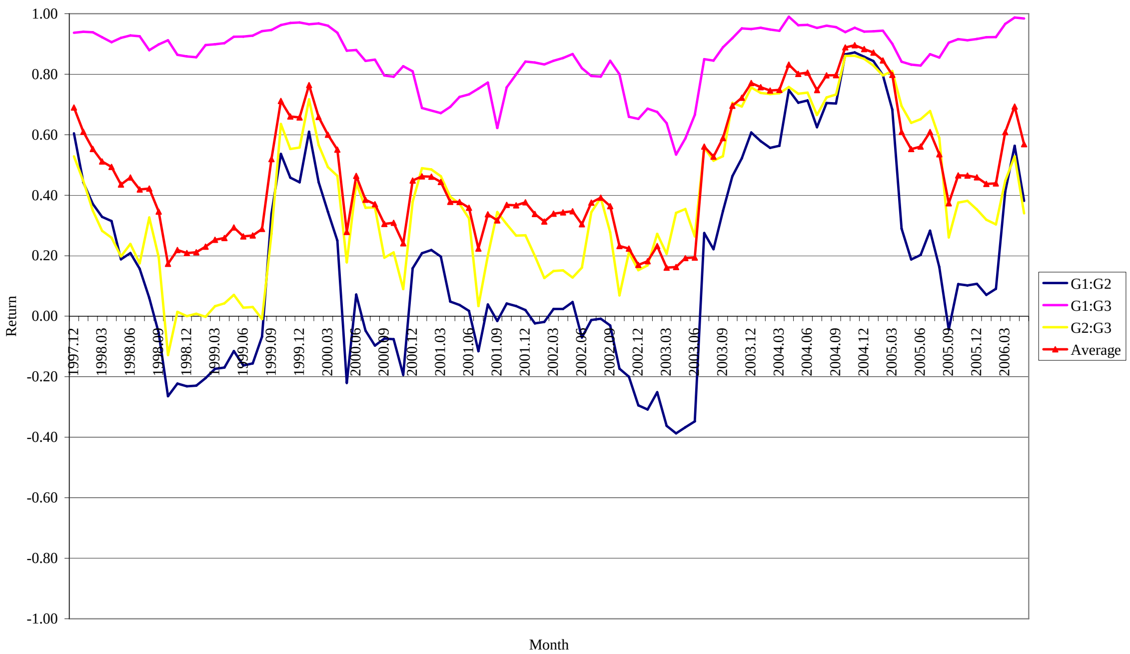

Figure 2. Rolling 12-month correlations between the groups and the ML benchmark

The figure shows the time series development of the correlations between the returns for the bond groups 1 to 3 (G1: developed market bonds, G2: emerging market debt, and G3: corporate bonds) on one hand, and the Merrill Lynch (ML) benchmark index on the other hand. For each group, based on the different individual bond index returns included in that group, equally weighted monthly portfolio returns have first been calculated. Then, for each group portfolio, 12-month rolling correlations have been calculated between the returns for that group, and the ML benchmark. The time period is from December 1997 to May 2006.

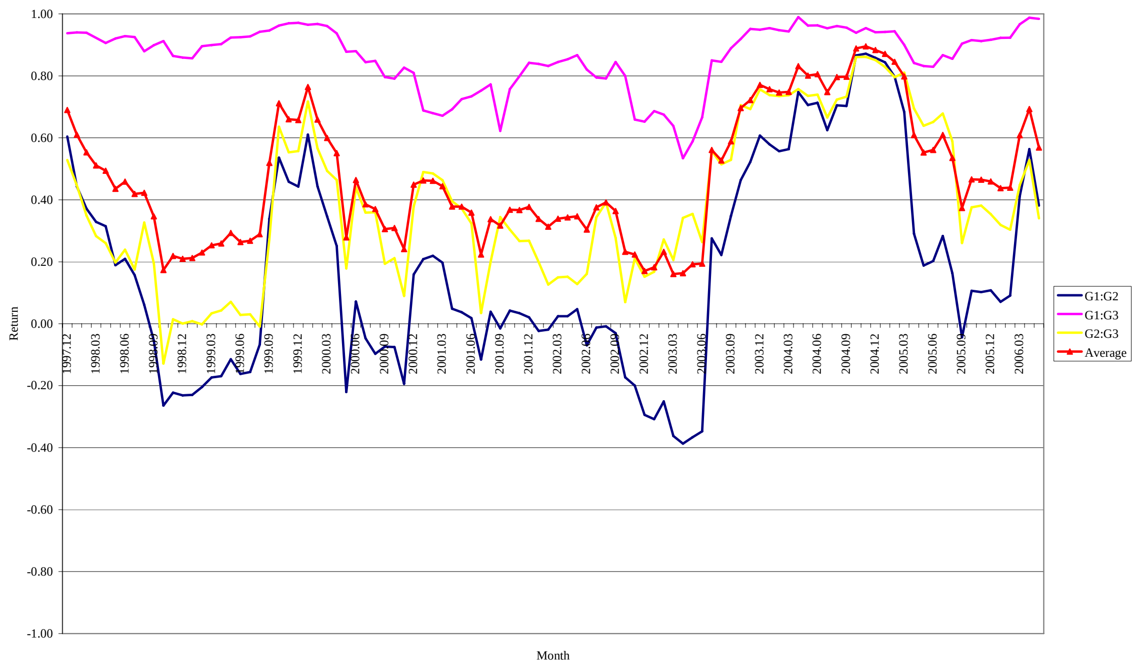

Figure 3. Diversification benefits of unhedged corporate bonds for a US investor

This figure displays the individual assets (developed country government bonds, and corporate bonds), three benchmarks (USAMSCI, GDPBENCH, MLBENCH), as well as three optimized frontiers: 1.) the frontier optimized on the basis of all the developed country government bonds, allowing for short sales (the dotted line), 2.) the same as before, but with a short sales constraint (the continuous thin line), and 3.) the frontier when both developed market government bonds as well as corporate bonds are included as assets (the bold line). All returns are unhedged.

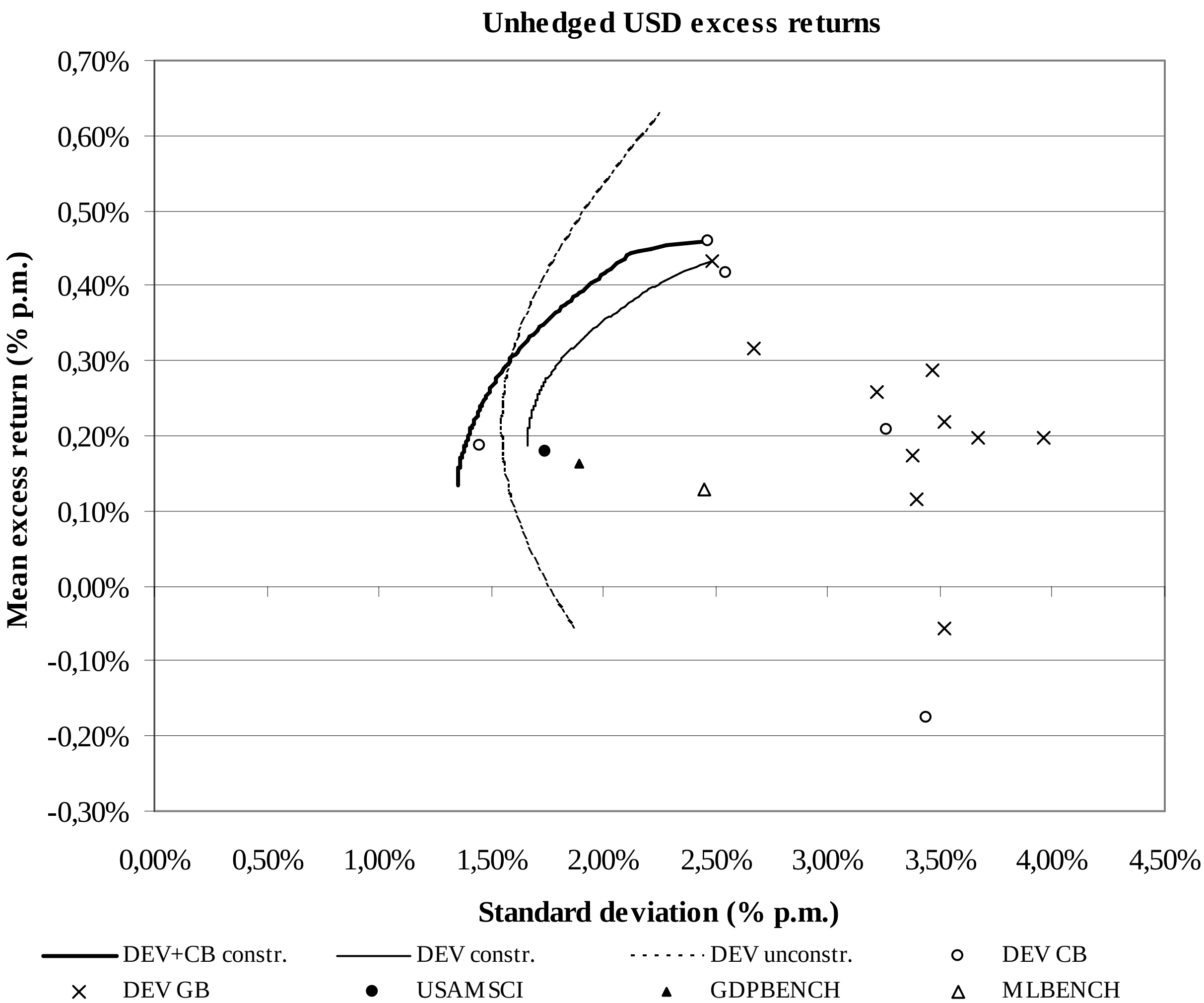

Figure 4. Diversification benefits of emerging market government bonds

This figure displays the individual assets (developed country government bonds, and emerging market debt), three benchmarks (USAMSCI, GDPBENCH, MLBENCH), as well as three optimized frontiers: 1.) the frontier optimized on the basis of all the developed country government bonds, constraining for short sales (the thin continuous line), 2.) the frontier when both developed market government bonds as well as emerging market debt are included as assets (the bold line), and 3.) the unconstrained (i.e. short sales are allowed for) frontier of all these (the dotted line). The government bond returns are unhedged whereas the emerging market debt is USD dominated.

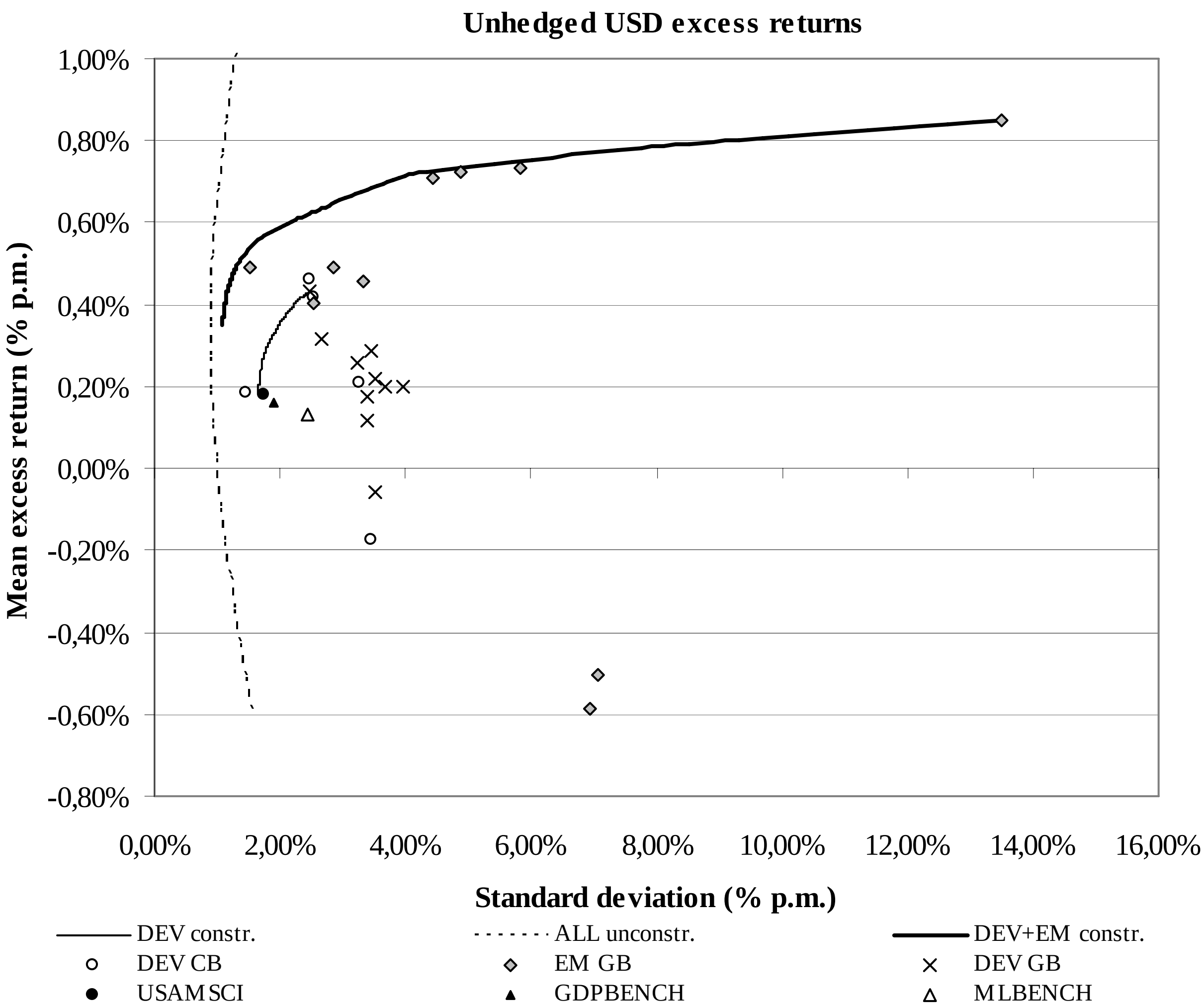

Figure 5. Effect of currency hedging on international bond diversification

This figure displays the individual assets (developed country government bonds, emerging market debt, and corporate bonds), the benchmarks (USAMSCI, GDPBENCH, MLBENCH), as well as four optimized frontiers: 1.) the frontier optimized on the basis of all the unhedged developed country government bonds (the thin continuous line), 2.) the same as before, but hedged (the vague line), 3.) the frontier when both unhedged developed market government bonds, unhedged corporate bonds, and USD dominated emerging market debt are included as assets (the bold line), and 4.) the same as in 3.) but hedged (the dotted line). Short sales are constrained for in each case.

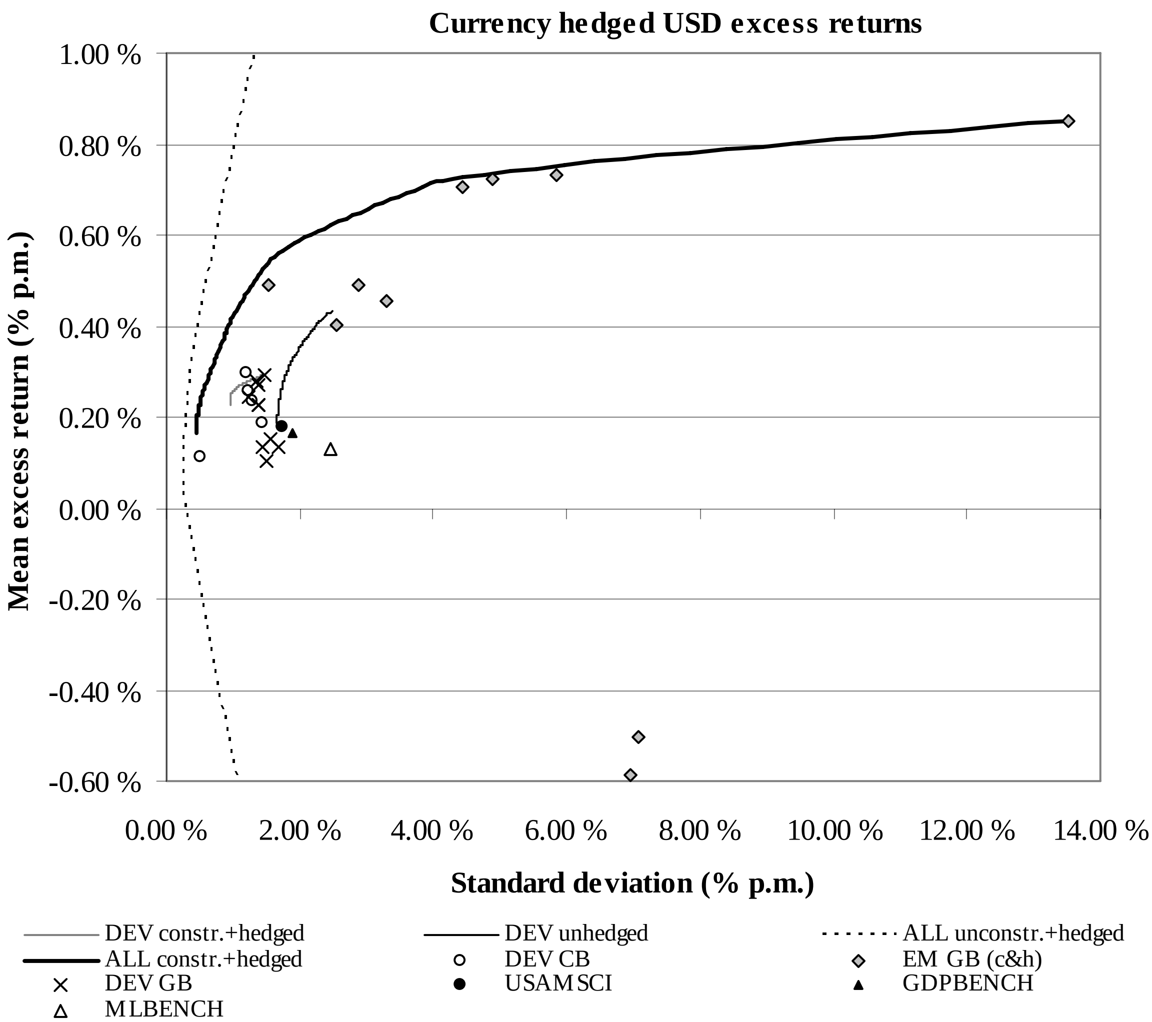

Table 1. Description of the bond indexes used in the study

The table describes the sources and characteristics of the different bond indexes used in the study. For all indexes, monthly total returns have been used. The time period for the data is from January 1997 to May 2006.

	Group 1	Group 2	Group 3
Bond index type included in Group	Developed countries Government	Emerging market	Corporate bond
Index family from which indices in Group are selected from	Morgan Stanley Capital International (MSCI) Sovereign Debt Indices	Lehman Brothers Global Emerging Markets Indices	Merrill Lynch Corporate Indices
Number of indices in Group	11	10	5
Issuers of the bonds	Governments	Governments, agencies, local issues, corporates	Corporate
Rating (S&P)	BBB or higher	BBB+ or lower*	BBB- or higher
Maturity of bonds included	7 – 10 years	At least 1 year	At least 1 year
Currency of denomination	Local currency	USD	Local currency
Coupon	Fixed	Fixed or floating	Fixed
Individual country indexes in Group	USA, UK, Germany, Japan, Switzerland, Canada, Australia, New Zealand, Sweden, Denmark, Norway	Argentina, Brazil, Colombia, Indonesia, Lebanon, Mexico, Philippines, Russia, Turkey, Venezuela	USA, UK, EMU, Japan, Canada

*) Lehman Brothers defines any country that has a long term foreign currency sovereign debt rating of Baa1/BBB+/BBB+ or below using the middle rating of Moody's, S&P, and Fitch as an emerging market. Individual bonds in the indices may have higher ratings, but in the quality breakdown as of 12/31/2006, only 1.6% of the bonds in the Lehman Brothers Global Emerging Markets Index had a rating of A or Aa using Moody's ratings scale.

Table 2. Descriptive statistics for bond returms

The table reports descriptive statistics (means, medians, standard deviations, skewness, minimum and maximum values) for continuously compounded monthly total returns, in the currency of denomination, for three groups of bond indexes. Group 1 includes government bond indexes for 11 developed countries: the U.S., U.K., Germany, Japan, Switzerland, Canada, Australia, New Zeeland, Sweden, Denmark, and Norway. Group 2 includes bond indexes for 10 emerging markets: Argentina, Brazil, Colombia, Indonesia, Lebanon, Mexico, Philippines, Russia, Turkey, and Venezuela. Group 3 includes corporate bond indexes for 5 countries / markets: the U.S., U.K., the EMU area, Japan, and Canada. The data period is from January 1997 to May 2006.

Panel A. Group 1: Developed countries

G1	USA	UK	GER	JPN	SWI	CAN	AUS	NZ	SWE	DEN	NOR	**Average**
Mean	0.0050	0.0056	0.0048	0.0024	0.0035	0.0056	0.0057	0.0062	0.0058	0.0056	0.0056	0.0051
Median	0.0060	0.0070	0.0071	0.0033	0.0045	0.0053	0.0054	0.0073	0.0093	0.0092	0.0057	0.0064
Stdev	0.0174	0.0145	0.0137	0.0137	0.0122	0.0137	0.0169	0.0152	0.0149	0.0134	0.0154	0.0146
Skewness	-0.4273	-0.1765	-0.4443	-1.3370	-0.0883	0.1216	0.2229	0.0279	-0.5919	-0.6115	-0.1742	-0.3162
Min	-0.0560	-0.0349	-0.0260	-0.0645	-0.0217	-0.0262	-0.0323	-0.0321	-0.0354	-0.0274	-0.0340	-0.0355
Max	0.0530	0.0472	0.0358	0.0392	0.0306	0.0470	0.0536	0.0537	0.0350	0.0339	0.0451	0.0431

Panel B. Group 2: Emerging markets

G2	ARG	BRA	COL	IND	LEB	MEX	PHI	RUS	TUR	VEN	**Average**
Mean	-0.0018	0.0105	0.0077	-0.0027	0.0081	0.0072	0.0081	0.0117	0.0103	0.0104	0.0070
Median	0.0109	0.0171	0.0083	0.0067	0.0070	0.0078	0.0089	0.0164	0.0114	0.0145	0.0109
Stdev	0.0708	0.0582	0.0329	0.0692	0.0151	0.0254	0.0284	0.1350	0.0443	0.0486	0.0528
Skewness	-1.2476	-1.2185	-1.2297	-2.5413	0.4203	-2.5605	-0.6144	-5.7658	-1.1172	-2.4952	-1.8370
Min	-0.2583	-0.2619	-0.1425	-0.4211	-0.0525	-0.1563	-0.1358	-1.1472	-0.2088	-0.3149	-0.3099
Max	0.1617	0.1714	0.0943	0.1848	0.0830	0.0703	0.1184	0.3330	0.1429	0.1378	0.1498

Panel C. Group 3: Corporate bonds

G3	USA	UK	EMU	JPN	CAN	**Average**
Mean	0.0051	0.0066	0.0052	0.0012	0.0059	0.0048
Median	0.0061	0.0073	0.0067	0.0012	0.0057	0.0054
Stdev	0.0144	0.0132	0.0122	0.0050	0.0119	0.0113
Skewness	-0.2114	0.0642	-0.2141	-0.5379	-0.0202	-0.1839
Min	-0.0386	-0.0287	-0.0217	-0.0182	-0.0181	-0.0251
Max	0.0390	0.0428	0.0378	0.0132	0.0317	0.0329

Table 3. Descriptive statistics for currency returns

The tabLe reports descriptive statistics (means, medians, standard deviations, skewness, minimum and maximum values) for continuously compounded monthly changes in the foreign exchange rates for 10 currencies (GBP, EUR, YEN, CHF, CAD, AUS, NZL, SEK, DKK, NOK) against the USD. A positive value means an appreciating currency. The data period is from January 1997 to May 2006.

	GBP	EUR	YEN	CHF	CAD	AUS	NZL	SEK	DKK	NOK	**Average**
Mean	-0.0008	-0.0001	-0.0003	-0.0008	-0.0019	0.0006	0.0010	0.0004	-0.0002	-0.0005	**-0.0002**
Median	0.0004	0.0002	0.0016	-0.0022	-0.0017	0.0024	-0.0032	-0.0012	-0.0004	0.0003	**-0.0004**
Stdev	0.0226	0.0286	0.0349	0.0300	0.0195	0.0324	0.0342	0.0307	0.0287	0.0295	**0.0291**
Skewness	-0.1242	-0.0939	-0.9243	-0.1913	0.1757	0.1421	0.3612	-0.0019	-0.0984	-0.0771	**-0.0832**
Min	-0.0606	-0.0728	-0.1663	-0.0681	-0.0494	-0.0777	-0.0785	-0.0856	-0.0694	-0.0657	**-0.0794**
Max	0.0556	0.0653	0.0763	0.0570	0.0486	0.0982	0.0880	0.0758	0.0646	0.0746	**0.0704**

Table 4. Intra-group correlations and average between-group correlations

The table reports, in all but the last two columns, intra-group correlations for the indexes used in our study. In the last two columns, between-group correlations (correlations between a country index, and an equally weighted index for countries in the other two groups) are reported, together with an overall average of these at the very end of each panel. Panel A reports correlations for Group 1, which includes government bond indexes for 11 developed countries: the U.S., U.K., Germany, Japan, Switzerland, Canada, Australia, New Zeeland, Sweden, Denmark, and Norway. Group 2 (in Panel B) includes bond indexes for 10 emerging markets: Argentina, Brazil, Colombia, Indonesia, Lebanon, Mexico, Philippines, Russia, Turkey, and Venezuela. Group 3 (in Panel C) includes corporate bond indexes for 5 countries / markets: the U.S., U.K., the EMU area, Japan, and Canada. The data period is from January 1997 to May 2006

Panel A. Group 1: Developed countries

G1	USA	UK	GER	JPN	SWI	CAN	AUS	NZ	SWE	DEN	NOR	**G2**	**G3**
USA	1.00											-0.01	0.56
UK	0.73	1.00										0.01	0.60
GER	0.78	0.87	1.00									0.01	0.61
JPN	0.22	0.13	0.19	1.00								-0.06	0.29
SWI	0.57	0.62	0.75	0.22	1.00							0.00	0.46
CAN	0.82	0.74	0.72	0.19	0.52	1.00						0.11	0.62
AUS	0.75	0.67	0.62	0.23	0.47	0.79	1.00					0.10	0.52
NZ	0.76	0.70	0.68	0.18	0.48	0.75	0.86	1.00				0.09	0.53
SWE	0.69	0.79	0.89	0.12	0.67	0.69	0.66	0.71	1.00			0.12	0.58
DEN	0.76	0.82	0.94	0.15	0.75	0.73	0.64	0.69	0.92	1.00		0.10	0.62
NOR	0.62	0.70	0.79	0.14	0.58	0.61	0.58	0.61	0.74	0.79	1.00	0.20	0.54
Average	**0.61**											**0.06**	**0.54**

Panel B. Group 2: Emerging markets

G2	ARG	BRA	COL	IND	LEB	MEX	PHI	RUS	TUR	VEN	**G1**	**G3**
ARG	1.00										0.11	0.13
BRA	0.45	1.00									-0.01	0.13
COL	0.31	0.70	1.00								0.11	0.24
IND	0.21	0.49	0.36	1.00							-0.01	0.05
LEB	0.02	0.13	0.18	0.02	1.00						0.15	0.23
MEX	0.42	0.73	0.68	0.57	0.14	1.00					0.25	0.31
PHI	0.29	0.55	0.53	0.49	0.03	0.65	1.00				0.07	0.18
RUS	0.26	0.56	0.49	0.64	-0.04	0.69	0.64	1.00			-0.08	0.01
TUR	0.35	0.63	0.54	0.57	0.06	0.61	0.55	0.62	1.00		-0.07	0.08
VEN	0.46	0.60	0.51	0.48	0.03	0.67	0.39	0.56	0.47	1.00	0.10	0.16
Average	**0.43**										**0.06**	**0.15**

Panel C. Group 3: Corporate bonds

G3	USA	UK	EMU	JPN	CAN	**G1**	**G2**
USA	1.00					0.59	0.27
UK	0.63	1.00				0.62	0.13
EMU	0.71	0.76	1.00			0.66	0.13
JPN	-0.07	-0.03	-0.08	1.00		0.19	-0.02
CAN	0.78	0.69	0.67	0.02	1.00	0.63	0.25
Average	**0.41**					**0.54**	**0.15**

Table 5. Individual correlations with ML Global Benchmark

The table reports the correlation between each individual index on one hand, and the Merrill Lynch (ML) benchmark index on the other hand. The first two rows report this correlation for the countries in Group 1, which includes government bond indexes for 11 developed countries: the U.S., U.K., Germany, Japan, Switzerland, Canada, Australia, New Zeeland, Sweden, Denmark, and Norway. The next two lines reports this correlation for countries in Group 2, which includes bond indexes for 10 emerging markets: Argentina, Brazil, Colombia, Indonesia, Lebanon, Mexico, Philippines, Russia, Turkey, and Venezuela. The last row reports this for the indexes in Group 3, which includes corporate bond indexes for 5 countries / markets: the U.S., U.K., the EMU area, Japan, and Canada. The data period is from January 1997 to May 2006.

Group 1	USA	UK	GER	JPN	SWI	CAN	AUS	NZ	SWE	DEN	NOR	Average
ML Global	0.60	0.45	0.47	0.26	0.36	0.54	0.54	0.56	0.44	0.42	0.36	0.45
Group 2	ARG	BRA	COL	IND	LEB	MEX	PHI	RUS	TUR	VEN		
ML Global	0.10	-0.04	0.13	0.03	0.08	0.11	-0.08	-0.18	-0.06	0.10		0.02
Group 3	USA	UK	EMU	JPN	CAN							
ML Global	0.45	0.33	0.41	0.16	0.48							0.37

Table 6. Diversification benefits from global bond diversification for USD investors. Unhedged returns in USD, portfolio optimization and tests allow for short sales

The table reports in Panel A Sharpe ratios and their improvements (ΔSharpe) as well as χ2 values from intersection tests, together with their p-values, for expanding the investment universe from one of the three alternative initial assets / benchmark portfolios: (1) USAMSCI; the Morgan Stanley Capital International US Government Bond index, (2) MLBENCH; the Merryll-Lynch World Government Bond Index, and (3) GDPBENCH; a constructed annually GDP-weighted global government bond index. In Panel B, we report results of intersection and spanning test for expanding the investment universe from a benchmark case ALL MSCI , i.e. a mean-variance frontier of 11 developed (=Dev) country government bond indices. The test assets are, when applicable: (1) Dev; all non-U.S. developed (Group 1) country government bond indexes, (2) Em; 10 emerging market (Group 2) indexes, and (3) CB; the corporate bond indexes for USA, UK, Japan, Euro area and Canada. Consult e.g. Table 1 for countries included in the three groups. Combinations such as Dev+Em denote that test assets from two groups (here Dev and Em) are included; All in the last column denotes Dev+Em+CB. Short sales are allowed for. Monthly USD denominated logarithmic unhedged raw returns (spanning tests) or returns in excess of 1-month US Tbill rate (intersection tests) in period January 1997-May 2006 are used (113 observations). Statistics significant at the 5% level boldface.

Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Panel A. Intersection tests of expanding a single asset benchmark with test assets								
USAMSCI	ΔSharpe	0.176	0.412	0.160	0.534	0.273	0.560	0.683
(0.103)	χ^2 (Intersection)	8.12	**28.52**	7.07	**44.22**	17.54	**47.93**	**67.93**
	(p-value)	(0.617)	**(0.001)**	(0.216)	**(0.001)**	(0.287)	**(0.000)**	**(0.000)**
MLBENCH	ΔSharpe	0.226	0.462	0.211	0.588	0.323	0.644	0.751
(0.053)	χ^2 (Intersection)	9.08	**29.55**	8.14	**45.96**	18.81	**54.42**	**72.55**
	(p-value)	(0.614)	**(0.001)**	(0.149)	**(0.001)**	(0.279)	**(0.000)**	**(0.000)**
GDPBENC	ΔSharpe	0.209	0.430	0.177	0.555	0.298	0.589	0.700
(0.086)	χ^2 (Intersection)	10.39	**29.09**	7.46	**45.30**	19.22	**50.29**	**68.54**
	(p-value)	(0.496)	**(0.001)**	(0.189)	**(0.002)**	(0.257)	**(0.000)**	**(0.000)**
Panel B. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALL MSCI	ΔSharpe		0.349	0.087			0.498	
(0.289)*	χ^2 (Intersection)		**33.66**	8.79			**55.77**	
	(p-value)		**(0.000)**	(0.118)			**(0.000)**	
	χ^2 (Spanning)		**243.42**	**102.12**			**275.77**	
	(p-value)		**(0.000)**	**(0.000)**			**(0.000)**	

*) maximum Sharpe ratio

Table 7. Diversification benefits from global bond diversification for USD investors. Currency hedged returns, portfolio optimization and tests that allow for short sales

The table reports in Panel A Sharpe ratios and their improvements (ΔSharpe) as well as $\chi 2$ values from intersection tests, together with their p-values, for expanding the investment universe from one of the three alternative initial assets / benchmark portfolios: (1) USB; the Morgan Stanley Capital International US Government Bond index, (2) MLBENCH; the Merryll-Lynch World Government Bond Index, and (3) GDPBENCH; a constructed annually GDP-weighted global government bond index. In Panel B, we report results of intersection and spanning test for expanding the investment universe from a benchmark case ALL MSCI , i.e. a mean-variance frontier of 11 developed (=Dev) country government bond indices. The test assets are, when applicable: (1) Dev; all non-U.S. developed (Group 1) country government bond indexes, (2) Em; 10 emerging market (Group 2) indexes, and (3) CB; the corporate bond indexes for USA, UK, Japan, Euro area and Canada. Consult e.g. Table 1 for countries included in the three groups. Combinations such as Dev+Em denote that test assets from two groups (here Dev and Em) are included; All in the last column denotes Dev+Em+CB. Short sales are allowed for. Monthly USD denominated logarithmic hedged raw returns (spanning tests) or hedged returns in excess of 1-month US Tbill rate (intersection tests) in period January 1997-May 2006 are used (113 observations). Statistics significant at the 5% level boldface.

Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Panel A. Intersection tests of expanding a single asset benchmark with test assets								
USAMSCI	ΔSharpe	0.269	0.412	0.257	0.523	0.360	0.618	0.705
(0.103)	χ^2 (Intersection)	14.63	**28.52**	**13.28**	**42.63**	22.83	**57.01**	**71.77**
	(p-value)	(0.146)	**(0.001)**	**(0.021)**	**(0.002)**	(0.088)	**(0.000)**	**(0.000)**
MLBENCH	ΔSharpe	0.324	0.462	0.309	0.575	0.411	0.638	0.760
(0.053)	χ^2 (Intersection)	15.68	**29.55**	**14.45**	**44.10**	23.94	**53.54**	**74.08**
	(p-value)	(0.153)	**(0.001)**	**(0.013)**	**(0.002)**	(0.091)	**(0.000)**	**(0.000)**
GDPBENC	ΔSharpe	0.290	0.430	0.278	0.542	0.378	0.609	0.724
(0.086)	χ^2 (Intersection)	15.07	**29.09**	**14.08**	**43.37**	23.37	**53.40**	**72.83**
	(p-value)	(0.179)	**(0.001)**	**(0.015)**	**(0.003)**	(0.104)	**(0.000)**	**(0.000)**
Panel B. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALL MSCI	ΔSharpe		0.250	0.087			0.432	
(0.376)*	χ^2 (Intersection)		**24.77**	7.25			**50.54**	
	(p-value)		**(0.006)**	(0.203)			**(0.000)**	
	χ^2 (Spanning)		**62.41**	**784.99**			**971.37**	
	(p-value)		**(0.000)**	**(0.000)**			**(0.000)**	

*) maximum Sharpe ratio

Table 8. Diversification benefits from global bond diversification for USD investors. Unhedged returns in USD, portfolio optimization and tests that do not allow for short sales

The table reports in Panel A Sharpe ratios and their improvements (ΔSharpe) as well as $\chi 2$ values from intersection tests, together with their p-values, for expanding the investment universe from one of the three alternative initial assets / benchmark portfolios: (1) USAMSCI; the Morgan Stanley Capital International US Government Bond index, (2) MLBENCH; the Merryll-Lynch World Government Bond Index, and (3) GDPBENCH; a constructed annually GDP-weighted global government bond index. In Panel B, we report results of intersection and spanning test for expanding the investment universe from a benchmark case ALL MSCI , i.e. a mean-variance frontier of 11 developed (=Dev) country government bond indices. The test assets are, when applicable: (1) Dev; all non-U.S. developed (Group 1) country government bond indexes, (2) Em; 10 emerging market (Group 2) indexes, and (3) CB; the corporate bond indexes for USA, UK, Japan, Euro area and Canada. Consult e.g. Table 1 for countries included in the three groups. Combinations such as Dev+Em denote that test assets from two groups (here Dev and Em) are included; All in the last column denotes Dev+Em+CB. Short sales are allowed for. Monthly USD denominated logarithmic unhedged raw returns (spanning tests) or returns in excess of 1-month US Tbill rate (intersection tests) in period January 1997-May 2006 are used (113 observations). Short sales are not allowed for. All statistics significant at the 5% level boldface. Moreover, significant χ^2 – values according to the Kodde-Palm test (both according to its higher and lower critical value) at the 5% (1%) level are denoted with a* (**). Statistics significant at least at the 5% according to one, but not significant at the 5% level using the other of the two Kodde-Palm critical values, are determined with a ¤.

Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Panel A. Intersection tests of expanding a single asset benchmark with test assets								
USAMSCI	ΔSharpe	0.076	0.269	0.105	0.276	0.105	0.281	0.281
(0.103)	χ^2 (Intersection)	2.40	14.28	3.68	14.84	3.678	15.28	15.28
MLBENCH	ΔSharpe	0.126	0.313	0.156	0.326	0.156	0.331	0.331
(0.053)	χ^2 (Intersection)	5.19	14.77	6.83	18.15	7.44	17.26	18.84
GDPBENC	ΔSharpe	0.093	0.282	0.122	0.293	0.122	0.298	0.298
(0.086)	χ^2 (Intersection)	6.11	14.35	5.46	21.23	10.29	16.08	22.22
Panel B. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALLMSCI	ΔSharpe		0.200	0.029			0.205	
(0.179)*	χ^2 (Intersection)		12.18	3.91			13.33	
	χ^2 (Spanning)		**82.05 ****	23.03			**158.30****	

*) maximum Sharpe ratio

Table 9. Diversification benefits from global bond diversification for USD investors. Currency hedged returns, portfolio optimization and tests that do not allow short sales

The table reports in Panel A Sharpe ratios and their improvements (ΔSharpe) as well as $\chi 2$ values from intersection tests, together with their p-values, for expanding the investment universe from one of the three alternative initial assets / benchmark portfolios: (1) USB; the Morgan Stanley Capital International US Government Bond index, (2) MLBENCH; the Merryll-Lynch World Government Bond Index, and (3) GDPBENCH; a constructed annually GDP-weighted global government bond index. In Panel B, we report results of intersection and spanning test for expanding the investment universe from a benchmark case ALL MSCI , i.e. a mean-variance frontier of 11 developed (=Dev) country government bond indices. The test assets are, when applicable: (1) Dev; all non-U.S. developed (Group 1) country government bond indexes, (2) Em; 10 emerging market (Group 2) indexes, and (3) CB; the corporate bond indexes for USA, UK, Japan, Euro area and Canada. Consult e.g. Table 1 for countries included in the three groups. Combinations such as Dev+Em denote that test assets from two groups (here Dev and Em) are included; All in the last column denotes Dev+Em+CB. Short sales are allowed for. Monthly USD denominated logarithmic hedged raw returns (spanning tests) or hedged returns in excess of 1-month US Tbill rate (intersection tests) in period January 1997-May 2006 are used (113 observations). Short sales are not allowed for. All statistics significant at the 5% level boldface. Moreover, significant χ^2 – values according to the Kodde-Palm test (both according to its higher and lower critical value) at the 5% (1%) level are denoted with a* (**). Statistics significant at least at the 5% according to one, but not significant at the 5% level using the other of the two Kodde-Palm critical values, are determined with a ¤.

Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Panel A. Intersection tests of expanding a single asset benchmark with test assets								
USAMSCI	ΔSharpe	0.157	0.269	0.214	0.329	0.220	0.351	0.358
(0.103)	χ^2 (Intersection)	9.57	14.28	**12.00***	21.05	13.42	22.00	23.82
MLBENCH	ΔSharpe	0.207	0.313	0.264	0.380	0.270	0.401	0.409
(0.053)	χ^2 (Intersection)	8.45	14.77	**12.25***	21.86	12.95	23.46¤	24.67
GDPBENC	ΔSharpe	0.174	0.282	0.231	0.347	0.237	0.368	0.375
(0.086)	χ^2 (Intersection)	8.55	14.35	**12.25***	21.66	13.22	**37.64****	24.45
Panel B. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALLMSCI	ΔSharpe		0.173	0.063			0.201	
(0.260)*	χ^2 (Intersection)		12.63	6.21			16.59	
	χ^2 (Spanning)		**259.30****	**2862.30****			**2793.03****	

*) maximum Sharpe ratio

APPENDIX 1. Currency hedging assumptions.

Currency hedged monthly return of foreign country i investment measured from the point of view of a domestic investor (*dom*) is

$$R_{i,dom} = (1 + E[R_i])(1 + f_i) + (R_i - E[R_i])(1 + e_i) - 1$$

where R_i is the foreign market return in local currency, f_i the forward premium or discount of foreign currency against domestic currency and e_i the exchange rate return.

We assume a "perfect hedge" with $e_i = f_i$ (forward rates are unbiased forecasts of future spot rates) and $\mathrm{cov}(R_i,f_i)=0$ which allows simplification of hedged return to (approximatively)

$$R_{i,dom} \approx R_i + f_i$$

Since covered interest rate parity states the forward premium or discount equals the (monthly) interest rate differential, $f_i = r_{dom} - r_i$, the currency hedged "raw" return in domestic currency is

$R_{i,dom} \approx R_i + r_{dom} - r_i$ and are used in spanning tests with currency hedged returns.

Intersection tests utilize excess returns over domestic short term interest rate whereby the currency hedged excess return is $R_{i,dom} \approx R_i + r_{dom} - r_i - r_{dom} \approx R_i - r_i$, or simply the foreign country excess return.

APPENDIX 2. Results for the other (non-US) countries (U.K., Germany, and Japan) in Table A1 (undhedged returns, no constraints for short sales), A2 (hedged returns, noconstraints for short sales), A3 (unhedged returns, short sales not allowed for) and A4 (hedged returns, short sales not allowed for), respectively.

Table A1. Diversification benefits from global bond diversification for UK, German, and Japanese investors in panels A to C. Unhedged returns in local currency, portfolio optimization and tests allow for short sales

The table reports diversification benefits from global bond diversification for UK, German, and Japanese investors in panels A to C. Each panel has two parts. In Part I, Sharpe ratios and their improvements (ΔSharpe) as well as $\chi 2$ values from intersection tests, together with their p-values, for expanding the investment universe from one of the three alternative initial assets / benchmark portfolios: (1); the Morgan Stanley Capital International Government Bond index for the country in question (UKMSCI, GERMSCI or JAPMSCI), (2) MLBENCH; the Merryll-Lynch World Government Bond Index, and (3) GDPBENCH; a constructed annually GDP-weighted global government bond index. In Part II, we report results of intersection and spanning test for expanding the investment universe from a benchmark case ALL MSCI , i.e. a mean-variance frontier of 11 developed (=Dev) country government bond indices. The test assets are, when applicable: (1) Dev; all non-local developed (Group 1) country government bond indexes, (2) Em; 10 emerging market (Group 2) indexes, and (3) CB; the corporate bond indexes for USA, UK, Japan, Euro area and Canada. Consult e.g. Table 1 for countries included in the three groups. Combinations such as Dev+Em denote that test assets from two groups (here Dev and Em) are included; All in the last column denotes Dev+Em+CB. Short sales are allowed for. Monthly GBP denominated logarithmic unhedged raw returns (spanning tests) or returns in excess of the 1-month local (U.K., German or Japanese) Tbill rate (intersection tests) in period January 1997-May 2006 are used (113 observations). All statistics significant at the 5% level boldface.

Panel A. Results for UK investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
UKMSCI	ΔSharpe	0.128	0.309	0.183	0.453	0.274	0.488	0.642
(0.094)	χ^2 (Intersection)	7.34	17.26	8.61	**32.53**	18.58	**37.020**	**59.70**
	(p-value)	(0.693)	(0.069)	(0.126)	**(0.038)**	(0.234)	**(0.001)**	**(0.000)**
MLBENCH	ΔSharpe	0.248	0.357	0.296	0.579	0.393	0.684	0.784
(-0.025)	χ^2 (Intersection)	8.35	15.11	8.95	**34.60**	19.93	**49.19**	**65.29**
	(p-value)	(0.682)	(0.128)	(0.111)	**(0.031)**	(0.223)	**(0.000)**	**(0.000)**
GDPBENC	ΔSharpe	0.241	0.334	0.279	0.567	0.384	0.633	0.746
(-0.009)	χ^2 (Intersection)	10.53	15.50	8.82	**35.14**	21.04	**44.02**	**61.38**
	(p-value)	(0.484)	(0.115)	(0.117)	**(0.027)**	(0.177)	**(0.000)**	**(0.000)**
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALL MSCI	ΔSharpe		0.274	0.095			0.463	
(0.273)*	χ^2 (Intersection)		**23.64**	10.54			**49.14**	
	(p-value)		**(0.009)**	(0.061)			**(0.000)**	
	χ^2 (Spanning)		**76.34**	**53.25**			**115.49**	
	(p-value)		**(0.000)**	**(0.000)**			**(0.000)**	

*) maximum Sharpe ratio

Table A1 continued

Panel B. Results for German investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
GERMSCI	ΔSharpe	0.177	0.297	0.161	0.456	0.293	0.473	0.609
(0.156)	χ^2 (Intersection)	9.57	**19.94**	8.39	38.64	19.88	**40.93**	**61.95**
	(p-value)	(0.479)	**(0.030)**	(0.136)	(0.007)	(0.177)	**(0.000)**	**(0.000)**
MLBENCH	ΔSharpe	0.231	0.302	0.212	0.515	0.348	0.584	0.685
(0.102)	χ^2 (Intersection)	11.26	17.07	9.87	**41.40**	21.88	**51.48**	**68.13**
	(p-value)	(0.422)	(0.073)	(0.079)	**(0.005)**	(0.147)	**(0.000)**	**(0.000)**
GDPBENC	ΔSharpe	0.260	0.291	0.214	0.521	0.359	0.552	0.667
(0.099)	χ^2 (Intersection)	13.32	15.91	9.83	**41.83**	22.86	**46.36**	**64.52**
	(p-value)	(0.273)	(0.102)	(0.080)	**(0.004)**	(0.117)	**(0.000)**	**(0.000)**
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALL MSCI	ΔSharpe		0.279	0.116			0.432	
(0.333)*	χ^2 (Intersection)		**26.78**	9.49			**48.25**	
	(p-value)		**(0.003)**	(0.091)			**(0.000)**	
	χ^2 (Spanning)		**80.93**	**49.84**			**116.51**	
	(p-value)		**(0.000)**	**(0.000)**			**(0.000)**	

*) maximum Sharpe ratio

Panel C. Results for Japanese investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Panel A. Intersection tests of expanding a single asset benchmark with test assets								
JAPMSCI	ΔSharpe	0.161	0.267	0.166	0.387	0.260	0.460	0.579
(0.166)	χ^2 (Intersection)	8.76	17.65	9.14	30.68	16.99	**40.15**	**58.11**
	(p-value)	(0.556)	(0.061)	(0.104)	(0.060)	(0.320)	**(0.000)**	**(0.000)**
MLBENCH	ΔSharpe	0.167	0.249	0.171	0.401	0.270	0.498	0.615
(0.161)	χ^2 (Intersection)	8.98	15.65	9.26	31.92	17.57	**44.98**	**63.45**
	(p-value)	(0.624)	(0.110)	(0.099)	(0.060)	(0.350)	**(0.000)**	**(0.000)**
GDPBENC	ΔSharpe	0.211	0.245	0.177	0.415	0.294	0.497	0.598
(0.154)	χ^2 (Intersection)	12.09	14.98	9.44	**33.15**	19.54	**44.09**	**59.75**
	(p-value)	(0.357)	(0.133)	(0.093)	**(0.045)**	(0.242)	**(0.000)**	**(0.000)**
Panel B. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALL MSCI	ΔSharpe		0.226	0.099			0.418	
(0.328)*	χ^2 (Intersection)		20.34	7.64			**45.77**	
	(p-value)		**(0.026)**	(0.177)			**(0.000)**	
	χ^2 (Spanning)		**39.43**	**2012.84**			**2264.55**	
	(p-value)		**(0.006)**	**(0.000)**			**(0.000)**	

*) maximum Sharpe ratio

Table A2. Diversification benefits from global bond diversification for UK, German, and Japanese investors in panels A to C. Currency hedged returns, portfolio optimization and tests that allow for short sales

The table reports diversification benefits from global bond diversification for UK, German, and Japanese investors in panels A to C. Each panel has two parts. In Part I, Sharpe ratios and their improvements (ΔSharpe) as well as $\chi 2$ values from intersection tests, together with their p-values, for expanding the investment universe from one of the three alternative initial assets / benchmark portfolios: (1); the Morgan Stanley Capital International Government Bond index for the country in question (UKMSCI, GERMSCI or JAPMSCI), (2) MLBENCH; the Merryll-Lynch World Government Bond Index, and (3) GDPBENCH; a constructed annually GDP-weighted global government bond index. In Part II, we report results of intersection and spanning test for expanding the investment universe from a benchmark case ALL MSCI , i.e. a mean-variance frontier of 11 developed (=Dev) country government bond indices. The test assets are, when applicable: (1) Dev; all non-U.K. developed (Group 1) country government bond indexes, (2) Em; 10 emerging market (Group 2) indexes, and (3) CB; the corporate bond indexes for USA, UK, Japan, Euro area and Canada. Consult e.g. Table 1 for countries included in the three groups. Combinations such as Dev+Em denote that test assets from two groups (here Dev and Em) are included; All in the last column denotes Dev+Em+CB. Short sales are allowed for. Monthly GBP denominated logarithmic hedged raw returns (spanning tests) or hedged returns in excess of the 1-month local (U.K., German or Japanese) Tbill rate (intersection tests) in period January 1997-May 2006 are used (113 observations). All statistics significant at the 5% level boldface.

Panel A. Results for UK investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
UKMSCI	ΔSharpe	0.278	0.418	0.315	0.532	0.369	0.595	0.714
(0.094)	χ^2 (Intersection)	14.85	**28.44**	**17.79**	**42.91**	23.07	**52.32**	**72.10**
	(p-value)	(0.137)	**(0.002)**	**(0.003)**	**(0.002)**	(0.083)	**(0.000)**	**(0.000)**
MLBENCH	ΔSharpe	0.324	0.462	0.309	0.575	0.411	0.638	0.760
(0.053)	χ^2 (Intersection)	15.68	**29.55**	**14.45**	**44.10**	23.94	**53.54**	**74.08**
	(p-value)	(0.153)	**(0.001)**	**(0.013)**	**(0.002)**	(0.091)	**(0.000)**	**(0.000)**
GDPBENC	ΔSharpe	0.290	0.430	0.278	0.542	0.378	0.609	0.724
(0.086)	χ^2 (Intersection)	15.07	**29.09**	**14.08**	**43.37**	23.37	**53.40**	**72.83**
	(p-value)	(0.179)	**(0.001)**	**(0.015)**	**(0.003)**	(0.104)	**(0.000)**	**(0.000)**
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALL MSCI	ΔSharpe		0.250	0.087			0.432	
(0.376)*	χ^2 (Intersection)		**24.77**	7.25			**50.54**	
	(p-value)		**(0.006)**	(0.203)			**(0.000)**	
	χ^2 (Spanning)		**61.14**	**902.27**			**1118.08**	
	(p-value)		**(0.000)**	**(0.000)**			**(0.000)**	

*) maximum Sharpe ratio

Table A2 continued

Panel B. Results for German investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
GERMSCI	ΔSharpe	0.206	0.354	0.195	0.460	0.297	0.551	0.642
(0.166)	χ^2 (Intersection)	12.52	**26.76**	**11.31**	**40.06**	20.59	**53.52**	**68.72**
	(p-value)	(0.251)	**(0.003)**	**(0.046)**	**(0.005)**	(0.151)	**(0.000)**	**(0.000)**
MLBENCH	ΔSharpe	0.324	0.462	0.309	0.575	0.411	0.638	0.760
(0.053)	χ^2 (Intersection)	15.68	**29.55**	**14.45**	**44.10**	23.94	**53.54**	**74.08**
	(p-value)	(0.153)	**(0.001)**	**(0.013)**	**(0.002)**	(0.091)	**(0.000)**	**(0.000)**
GDPBENC	ΔSharpe	0.290	0.430	0.278	0.542	0.378	0.609	0.724
(0.086)	χ^2 (Intersection)	15.07	**29.09**	**14.08**	**43.37**	23.37	**53.40**	**72.83**
	(p-value)	(0.179)	**(0.001)**	**(0.015)**	**(0.003)**	(0.104)	**(0.000)**	**(0.000)**
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALL MSCI	χ^2 (Spanning)		0.250	0.087			0.432	
(0.376)*	(p-value)		**24.77**	7.25			**50.54**	
	ΔSharpe		**(0.006)**	(0.203)			**(0.000)**	
	χ^2 (Intersection)		**56.96**	**967.01**			**1192.92**	
	(p-value)		**(0.000)**	**(0.000)**			**(0.000)**	

*) maximum Sharpe ratio

Panel C. Results for Japanese investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
JAPMSCI	ΔSharpe	0.206	0.391	0.193	0.459	0.297	0.529	0.641
(0.166)	χ^2 (Intersection)	12.52	**31.20**	**11.19**	**40.05**	20.58	**50.22**	**68.70**
	(p-value)	(0.252)	**(0.001)**	**(0.048)**	**(0.005)**	(0.151)	**(0.000)**	**(0.000)**
MLBENCH	ΔSharpe	0.324	0.462	0.309	0.575	0.411	0.638	0.760
(0.053)	χ^2 (Intersection)	15.68	**29.55**	**14.45**	**44.10**	23.94	**53.54**	**74.08**
	(p-value)	(0.153)	**(0.001)**	**(0.013)**	**(0.002)**	(0.091)	**(0.000)**	**(0.000)**
GDPBENC	ΔSharpe	0.290	0.430	0.278	0.542	0.378	0.609	0.724
(0.086)	χ^2 (Intersection)	15.07	**29.09**	**14.08**	**43.37**	23.37	**53.40**	**72.83**
	(p-value)	(0.179)	**(0.001)**	**(0.015)**	**(0.003)**	(0.104)	**(0.000)**	**(0.000)**
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALL MSCI	ΔSharpe		0.250	0.087			0.432	
(0.376)*	χ^2 (Intersection)		**24.77**	**7.25**			**50.54**	
	(p-value)		**(0.006)**	**(0.203)**			**(0.000)**	
	χ^2 (Spanning)		**57.43**	**1014.33**			**1227.11**	
	(p-value)		**(0.000)**	**(0.000)**			**(0.000)**	

*) maximum Sharpe ratio

Table A3. Diversification benefits from global bond diversification for UK, German, and Japanese investors in panels A to C. Unhedged returns in GBP, portfolio optimization and tests that do not allow short sales

The table reports diversification benefits from global bond diversification for UK, German, and Japanese investors in panels A to C. Each panel has two parts. In Part I, Sharpe ratios and their improvements (ΔSharpe) as well as $\chi 2$ values from intersection tests, together with their p-values, for expanding the investment universe from one of the three alternative initial assets / benchmark portfolios: (1); the Morgan Stanley Capital International Government Bond index for the country in question (UKMSCI, GERMSCI or JAPMSCI), (2) MLBENCH; the Merryll-Lynch World Government Bond Index, and (3) GDPBENCH; a constructed annually GDP-weighted global government bond index. In Panel B, we report results of intersection and spanning test for expanding the investment universe from a benchmark case ALL MSCI , i.e. a mean-variance frontier of 11 developed (=Dev) country government bond indices. The test assets are, when applicable: (1) Dev; all non-U.K. developed (Group 1) country government bond indexes, (2) Em; 10 emerging market (Group 2) indexes, and (3) CB; the corporate bond indexes for USA, UK, Japan, Euro area and Canada. Consult e.g. Table 1 for countries included in the three groups. Combinations such as Dev+Em denote that test assets from two groups (here Dev and Em) are included; All in the last column denotes Dev+Em+CB. Short sales are allowed for. Monthly GBP denominated logarithmic unhedged raw returns (spanning tests) or returns in excess of the 1-month local (U.K., German or Japanese) Tbill rate (intersection tests) in period January 1997-May 2006 are used (113 observations). Short sales are not allowed for. All statistics significant at the 5% level boldface. Moreover, significant χ^2 – values according to the Kodde-Palm test (both according to its higher and lower critical value) at the 5% (1%) level are denoted with a* (**). Statistics significant at least at the 5% according to one, but not significant at the 5% level using the other of the two Kodde-Palm critical values, are determined with a ¤.

Panel A. results for UK investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
UKMSCI	ΔSharpe	0.015	0.066	0.089	0.066	0.089	0.116	0.116
(0.094)	χ^2 (Intersection)	0.34	1.88	4.67	1.88	4.67	5.40	5.40
MLBENCH	ΔSharpe	0.134	0.157	0.208	0.185	0.208	0.235	0.235
(-0.025)	χ^2 (Intersection)	4.41	2.67	6.26	7.84	7.14	8.06	9.83
GDPBENC	ΔSharpe	0.118	0.141	0.192	0.169	0.192	0.219	0.219
(-0.009)	χ^2 (Intersection)	5.83	3.22	7.03	10.65	9.51	10.24	12.55
Part Ii. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALLMSCI	ΔSharpe		0.051	0.074			0.101	
(0.109)*	χ^2 (Intersection)		1.91	4.31			5.60	
	χ^2 (Spanning)		11.89	18.57			25.63	

*) maximum Sharpe ratio

Table A3 continued

Panel B. Results for German investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
GERMSCI	ΔSharpe	0.088	0.096	0.098	0.133	0.107	0.122	0.135
(0.156)	χ^2 (Intersection)	5.68	4.33	4.79	7.46	7.68	5.92	8.43
MLBENCH	ΔSharpe	0.142	0.087	0.151	0.186	0.160	0.176	0.189
(0.102)	χ^2 (Intersection)	7.71	2.86	7.20	13.45	9.91	9.12	14.42
GDPBENC	ΔSharpe	0.145	0.091	0.155	0.190	0.164	0.179	0.193
(0.099)	χ^2 (Intersection)	9.33	3.15	8.48	18.22	13.50	11.83	19.43
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALLMSCI	ΔSharpe		0.045	0.019			0.047	
(0.244)*	χ^2 (Intersection)		3.68	4.31			6.36	
	χ^2 (Spanning)		**71.52****	38.82			**334.71****	

*) maximum Sharpe ratio

Panel C. Results for Japanese investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
JAPMSCI	ΔSharpe	0.065	0.099	0.109	0.099	0.109	0.132	0.132
(0.166)	χ^2 (Intersection)	2.85	4.69	6.02	6.67	6.02	7.25	7.25
MLBENCH	ΔSharpe	0.071	0.065	0.115	0.104	0.115	0.137	0.137
(0.161)	χ^2 (Intersection)	5.01	2.76	7.67	7.55	8.37	8.91	10.18
GDPBENC	ΔSharpe	0.078	0.070	0.122	0.112	0.122	0.145	0.145
(0.154)	χ^2 (Intersection)	6.61	2.96	8.35	10.10	10.73	10.73	26.53
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALLMSCI	ΔSharpe	0.000	0.034	0.044	0.034	0.044	0.067	0.067
(0.232)*	χ^2 (Intersection)	0.00	1.80	5.26	1.80	5.26	5.91	0.00
	χ^2 (Spanning)	0.21	4.73	12.45	4.73	12.45	**695.66****	**695.66****

*) maximum Sharpe ratio

Table A4. Diversification benefits from global bond diversification for UK, German, and Japanese investors in panels A to C. Currency hedged returns, portfolio optimization and tests that do not allow short sales

The table reports diversification benefits from global bond diversification for UK, German, and Japanese investors in panels A to C. Each panel has two parts. In Part I, Sharpe ratios and their improvements (ΔSharpe) as well as $\chi 2$ values from intersection tests, together with their p-values, for expanding the investment universe from one of the three alternative initial assets / benchmark portfolios: (1); the Morgan Stanley Capital International Government Bond index for the country in question (UKMSCI, GERMSCI or JAPMSCI), (2) MLBENCH; the Merryll-Lynch World Government Bond Index, and (3) GDPBENCH; a constructed annually GDP-weighted global government bond index. In Panel B, we report results of intersection and spanning test for expanding the investment universe from a benchmark case ALL MSCI , i.e. a mean-variance frontier of 11 developed (=Dev) country government bond indices. The test assets are, when applicable: (1) Dev; all non-U.K. developed (Group 1) country government bond indexes, (2) Em; 10 emerging market (Group 2) indexes, and (3) CB; the corporate bond indexes for USA, UK, Japan, Euro area and Canada. Consult e.g. Table 1 for countries included in the three groups. Combinations such as Dev+Em denote that test assets from two groups (here Dev and Em) are included; All in the last column denotes Dev+Em+CB. Short sales are allowed for. Monthly GBP denominated logarithmic hedged raw returns (spanning tests) or hedged returns in excess of the 1-month local (U.K., German or Japanese) Tbill rate (intersection tests) in period January 1997-May 2006 are used (113 observations). Short sales are not allowed for. All statistics significant at the 5% level boldface. Moreover, significant χ^2 – values according to the Kodde-Palm test (both according to its higher and lower critical value) at the 5% (1%) level are denoted with a* (**). Statistics significant at least at the 5% according to one, but not significant at the 5% level using the other of the two Kodde-Palm critical values, are determined with a ¤.

Panel A. Results for UK investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
UKMSCI	ΔSharpe	0.166	0.274	0.223	0.338	0.229	0.360	0.367
(0.094)	χ^2 (Intersection)	9.63	14.14	**14.62¤**	21.68	16.61	**23.12¤**	25.82
MLBENCH	ΔSharpe	0.207	0.313	0.264	0.380	0.270	0.401	0.409
(0.053)	χ^2 (Intersection)	8.45	14.77	**12.25****	21.86	12.95	**45.85****	24.67
GDPBENC	ΔSharpe	0.174	0.282	0.231	0.347	0.237	0.368	0.375
(0.086)	χ^2 (Intersection)	8.55	14.35	**12.25****	21.66	13.22	22.83	24.45
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALLMSCI	ΔSharpe		0.173	0.063			0.201	
(0.260)*	χ^2 (Intersection)		12.63	6.21			16.59	
	χ^2 (Spanning)		**253.23****	**756.66****			**2247.68****	

*) maximum Sharpe ratio

Table A4 continued

Panel B. Results for German investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
GERMSCI	ΔSharpe	0.094	0.214	0.151	0.267	0.157	0.288	0.295
(0.166)	χ^2 (Intersection)	6.23	12.78	8.62	27.24	11.06	19.53	21.38
MLBENCH	ΔSharpe	0.207	0.313	0.264	0.380	0.270	0.401	0.409
(0.053)	χ^2 (Intersection)	8.45	14.77	**12.25****	21.86	12.95	**23.46¤**	38.13
GDPBENC	ΔSharpe	0.174	0.282	0.231	0.347	0.237	0.368	0.375
(0.086)	χ^2 (Intersection)	8.55	14.35	**12.25****	21.66	13.22	22.83	37.07
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALLMSCI	ΔSharpe		0.173	0.063			0.201	
(0.260)*	χ^2 (Intersection)		12.63	6.21			16.59	
	χ^2 (Spanning)		**221.43****	**319.56****			**1515.18****	

*) maximum Sharpe ratio

Panel C. Results for Japanese investors								
Benchmark (Sharpe ratio)		Test assets						
		Dev	Em	CB	Dev+Em	Dev+CB	Em+CB	All
Part I. Intersection tests of expanding a single asset benchmark with test assets								
JAPMSCI	ΔSharpe	0.094	0.251	0.151	0.266	0.157	0.288	0.295
(0.166)	χ^2 (Intersection)	4.39	16.05	**8.96¤**	17.47	9.67	20.03	21.11
MLBENCH	ΔSharpe	0.207	0.313	0.264	0.380	0.270	0.401	0.409
(0.053)	χ^2 (Intersection)	8.45	14.77	**12.25****	21.86	12.95	**23.46¤**	24.67
GDPBENC	ΔSharpe	0.174	0.282	0.231	0.347	0.237	0.368	0.375
(0.086)	χ^2 (Intersection)	8.55	14.35	**12.25****	21.66	13.22	22.83	24.45
Part II. Intersection and spanning tests of expanding a mean-variance frontier (Dev) with additional test assets								
ALLMSCI	ΔSharpe		0.173	0.063			0.201	
(0.260)*	χ^2 (Intersection)		12.63	6.21			16.59	
	χ^2 (Spanning)		**451.10****	35.06			**3460.99****	

*) maximum Sharpe ratio