Portfolio Diversification and International Corporate Bonds

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Abstract

This paper examines the gains to portfolio diversification in the corporate bond market, which has largely gone ignored despite the extensive literature documenting the benefits in equity markets. Analysis of a newly compiled bond level dataset finds that portfolio diversification in corporate bond markets can yield significant gains for US investors by reducing volatility and increasing risk-adjusted expected returns. In contrast to equities, the corporate bond market offers consistent and robust out of sample portfolio gains, particularly during the most recent financial crisis of 2008. Portfolio gains persist even after accounting for short sales, bond characteristics, liquidity, and informational access.

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1 Introduction

At $7.5 trillion, the US corporate bond market is one of the largest asset markets in the US[1]. Given the historically low volatility in investment grade corporate bonds, it is perhaps unsurprising that Burger and Warnock (2007) document low levels of foreign bond holdings in the US and little international diversification within the asset market. However, the unprecedented spike in global credit market volatility during the financial crisis of 2008 has call into question the potential need for international diversification in corporate bond markets. To evaluate the implications of international diversification for US investors, a measure of the potential gains is needed. In contrast to the long literature on the benefits of investing in foreign equity markets, little is known about the potential for international diversification gains in the corporate bond market. This paper will begin to address this gap by asking: Can US investors achieve portfolio diversification gains with international corporate bonds? And if so, are these gains significant?

The primary objective of this paper is to analyze cross country diversification in the corporate bond market. To that end, I carefully construct country portfolios from a newly collected panel of individual corporate bond quotes from six advanced markets for the period Jan 2000 - Dec 2010.[2] The main findings of this paper can be summarized as follows. First, I show that international diversification in the corporate bond market has the potential to significantly reduce portfolio volatility and increase Sharpe ratio for US investors[3]. During the last decade, US investors could have reduced portfolio risk by as much as 82.4% and increased monthly Sharpe ratio by 0.36 by adding foreign corporate bonds. Further, during the most recent financial crisis of 2008, a diversified international portfolio would have realized even larger gains: an 84.8% decrease in monthly volatility and a 0.42 increase in monthly Sharpe ratio. Both in-sample and out of sample estimates suggest that US corporate bond investors can achieve significant benefits from diversifying internationally.

Second, I find large differences in how gains to international diversification are generated in

[1]Source: SIMFA as of Dec 2010

[2]The underlying data include investment grade corporate bonds from the US, Australia, Canada, Europe, Japan, and UK. I refer to Austria, Belgium, France, Germany, Italy, and Netherlands are collectively as Europe given the common currency.

[3]Sharpe ratio is defined as the ratio of excess return over volatility.

equity markets, sovereign bond markets, and corporate bond markets. For example, in-sample Sharpe ratio gains for equities require extreme short portfolio positions, which often lead to poor out of sample diversification gains. By contrast, the corporate bond market does not rely on large short positions to generate the in sample Sharpe ratio gains, and therefore maintains consistent positive gains out of sample. Indeed, during the recent financial crisis, a simple equally weighted portfolio of global corporate bonds would have realized a larger Sharpe ratio and lower return volatility than comparable portfolios of international equities or sovereign bonds. In other words, the relative benefits to international diversification in corporate bond market are stronger and more robust than those found within equity markets.

Lastly, I present evidence that US investors can benefit from investing in foreign corporate bonds, whether they hold a domestic corporate bonds benchmark or a diversified US equity and bond benchmark. Using a multi-asset benchmark of US equities and bonds, I find that diversification gains are comparable to the US corporate bond only case. In particular, the difference between the two benchmark cases were minimal as domestic bonds outperformed domestic equities during this period and estimated portfolio weights in the multi-asset benchmark tend to favor domestic bonds. To construct a potentially more representative US investor portfolio with a larger weight in domestic equities, I derive implied asset weights from the Flow of Funds tables to construct the US multi-asset benchmark. The resulting US portfolio is heavily weighted towards domestic equities and suggests that diversifying through international corporate bonds would have generated even larger gains than the bond only benchmark.

In light of these results, I examine four hypotheses about why these seemingly unexploited diversification gains exist. First, I examine the possibility that diversification gains for US investors diminish when faced with short sale constraints. Strikingly, although this restriction dramatically reduces diversification gains in equity markets, it has little effect on gains in corporate bond markets. Therefore, the result suggests that short sale constraints do not explain unexploited gains. Second, I examine the role of bond and firm specific characteristics for diversification gains. To this end, I rebalance foreign corporate bonds portfolios so that they have the same proportions by ratings, duration, and industry as the US corporate bond benchmark. Once again, I find only a small reduction in diversification gains, suggesting that country effects are potentially stronger for diversification gains than industry or bond specific effects[4]. Third, I evaluate the possibility that diversification gains are being driven by lower liquidity in foreign markets, despite being advanced economies. However, even after eliminating potentially illiquid bonds in the foreign markets, significant gains for US investors persist. Lastly, I consider whether informational barriers and investor recognition might prevent US investors from exploiting gains from international diversification. In order to ensure some regularity in financial reporting and familiarity to US investors, I examine only bonds from foreign firms that have a Yankee bond listed in the US[5]. I find that this restriction does not materially reduce the implied diversification gains.

This paper begins to bridge the gap between the portfolio diversification and efficiency literature and the corporate bond risk literature. The portfolio diversification and efficiency literature has produced a long line of research focusing on international equity markets, for both advance markets and emerging markets. Papers in this spirit include Jorion (1985), DeSantis (1993), Bekeart and Urias (1996), Harvey (1995), Ferson and Harvey (1993), Heston and Rouwenhorst (1994), Ang and Bekeart (2002), and Li, Sarkar, and Wang (2003). On the other hand, much of the corporate bond literature strives to understand the dynamics and the risk factors that affect pricing. In particular, papers such as Duffie and Singleton (1999), Duffee (1999), Elton, Gruber, Agrawal, and Mann (2001), Chen, Lesmond, and Wei (2007), Campbell and Taksler (2003), Jong and Driessen (2009), Bao, Pan, and Wang (2011) examines the effect of recovery, default probabilities, taxes, liquidity, and equity return volatility on bond pricing.

There is a small and limited literature on global bond market diversification that focuses in large part on sovereign bond markets. Paper along these lines include Ilmanen (1995), Levy and Lerman (1988), and more recently Longstaff, Pan, Peddersen, and Singleton (2011), Hansson, Liljeblom, and Lflund (2009), and Burger and Warnock (2007)[6]. Rather than studying sovereign bonds, this is the first paper to focus on international corporate bonds. The motivation for examining corporate

[4]This supports the Heston and Rouwenhorst (1994) finding for international equity markets.

[5]Yankee bonds are cross-listed bonds from foreign firms that are dollar denominated, trade in the US, and subject to SEC disclosure.

[6]Burger and Warnock examine all local currency bonds, which includes large portions of sovereign and government agency bonds.

bonds is two-fold. First, like equities, corporate bonds can be analyzed at the firm level and could have potential for understanding firm, industry, country effects, in a way that sovereign bonds cannot. Second, the price dynamics of corporate bonds and equity return volatility are intimately linked and have been analyzed theoretically with the Merton modelMerton (1974) and estimated empirically by Campbell and Taksler (2003). Therefore, equity market correlations may be exploited in continuing research to understand the comovement between corporate bonds.

The paper is organized as follows. Section 2 outlines the portfolio diversification strategies and defines portfolio gain measures. Section 3 describes the data and summarizes the returns. Section 4 analyzes the diversification gains for the full sample and during the most recent financial crisis. The section also examines the dynamics and time variation in portfolio gains. Section 5 re-examines the diversification gains under various explanations such as no short sale, balanced bond characteristics, liquidity filters, and investor access to financial information. Section 6 analyzes the potential for international corporate bonds to provide portfolio diversification gain to US investors of domestic equities and bonds. Section 7 concludes.

2 Model and Empirical Design

To evaluate the benefits from international diversification, a portfolio allocations strategy to form the optimal international portfolios is required. The optimal portfolio of US and foreign assets will depend on the investor's objective such as minimizing risk versus maximizing risk adjusted return. For each investment objective, a different portfolio allocation strategy is necessary to determine the composition of risky asset in the optimal portfolio. This paper will analyze three portfolio allocation models outlined below. In addition, this section will define three measures of portfolio diversification gains that correspond to each portfolio allocation strategy.

2.1 Investor Portfolio Problem

Within the standard Markowitz mean variance framework, and following DeMiguel, Garlappi, and Uppal (2009), I assume that the representative US investor's preference is fully described by the mean and variance of a chosen portfolio. Given a multivariate normal vector of N asset's excess returns over the risk free, $R = (r_1, ..., r_N)'$, with mean $\mu = (\mu_1, ..., \mu_N)$ and a covariance matrix Σ, the investor selects a vector of portfolio allocations, x, to solve the following expected utility maximization problem:

$$\max_{x} \quad x^{'} * \mu - \frac{\gamma}{2} x^{'} * \Sigma * x \tag{1}$$

where γ is the investor's coefficient of risk aversion. The optimal vector of dollar allocation, $x = (1/\gamma) * \Sigma^{-1} * \mu$, can be reformulated into a vector of relative portfolio weights that sum to one. The resulting vector of portfolio weights w_{tan} is:

$$w_{tan} = \frac{\Sigma^{-1} * \mu}{i' * \Sigma^{-1} * \mu} \tag{2}$$

where i is a vector of N ones. The resulting portfolio with weights, w_{tan}, is known as the tangency portfolio and maximizes the portfolio Sharpe ratio, or excess return divided by the portfolio standard deviation, among all portfolios of risky assets[7]. In addition to being the solution to the above investor's problem, the tangency portfolio also solves the more direct formulation of the mean variance portfolio problem:

$$\min_{w} \quad w^{'} \Sigma w \quad s.t \quad w^{'} * \mu = \mu_p, \quad w^{'} * i = 1 \tag{3}$$

It's clear from the above optimization and the solution in Equation 2 that the tangency portfolio weights require an estimate of the mean and covariance of risky asset returns. However, as argued by **?**, Jorion (1985), Green and Hollifield (1992), and most recently by Jagannathan and Ma (2003), the sample mean is often an imprecise estimate of the population mean, which can lead to instability in the tangency portfolio weight estimates and poor out of sample performance[8]. In light of large estimation errors in mean returns from small finite samples, Green and Hollifield (1992) and Jagannathan and Ma (2003) argue that little is lost by ignoring the means all together and instead study the minimum variance portfolio. The minimum variance portfolio only considers the contribution of an asset return to reducing portfolio variance, and minimize portfolio variance through

[7]See Campbell, Lo, and MacKinlay (1997)

[8]See Britten-Jones (1999).

the covariance structure of the assets. Alternatively, ignoring mean returns can be justified by the assumption that mean returns of the same asset across advanced economies should be comparable. Therefore, the only real diversification stems from variance reduction through the asset correlation structure. The minimum variance portfolio is the solution to the following optimization problem:

$$\min_{w} \quad w^{'}\Sigma w \quad s.t \quad w^{'} * i = 1 \tag{4}$$

The solution for the minimum variance portfolio weight, w_{mv}, is given by:

$$w_{mv} = \frac{\Sigma^{-1} * i}{i' * \Sigma^{-1} * i} \tag{5}$$

In addition to the tangency portfolio and the minimum variance portfolio, I will also analyze the performance of a simple 1/N portfolio allocation strategy advocated by DeMiguel, Garlappi, and Uppal (2009). While this simple portfolio strategy does not optimize with respect to any information from the return data, it reflects a diversified portfolio that is not subject to look ahead bias and can be easily implemented in real time. Further, the equally weighted naive portfolio weights have the added advantage of naturally satisfying short sale constraints. DeMiguel, Garlappi, and Uppal (2009) show that across a large class of sample based mean variance portfolio allocation models, no model consistently out performs the 1/N naive portfolio allocation strategy in out of sample performance. For these reasons, I also include the performance of the naive 1/N strategy to reflect the most basic portfolio gains from diversification.

2.2 Measuring Portfolio Gains

Corresponding to the three portfolio allocation strategies outlined above for the optimally diversified portfolio, I focus on three measures of portfolio gain.[9] In particular, portfolio gains will be evaluated as an increase to portfolio Sharpe ratio, a decrease to portfolio volatility, and an increase in risk adjusted expected return.

Since the tangency portfolio maximizes the portfolio Sharpe ratio of risky asset, I follow DeMiguel,

[9] Gains can also be evaluated in terms of welfare or utility losses. I have computed Certainty Equivalent Return gains, following DeMiguel, Garlappi, and Uppal (2009), and the results are very similar to the Sharpe ratio gains.

Garlappi, and Uppal (2009) and define the first measure of portfolio diversification gains as the difference in monthly Sharpe ratio of holding the US benchmark versus the diversified tangency portfolio of US and foreign assets. Let w_m be a vector of portfolio weights that represent the benchmark portfolio. Since all diversification gains in this paper will be from the perspective of a representative US investor, I will evaluate gains against two types of benchmarks: US corporate bond portfolio[10], and diversified portfolio of US equities, treasury, and corporate bonds. Portfolio returns are then used as an univariate US benchmark. Therefore, the portfolio weight vector w_m will have one for the US benchmark and zeros elsewhere. The portfolio gain to Sharpe ratio can be defined as follows:

$$\varphi(w_m, C, \mu, \Sigma) \equiv \max_w (w\mu/\sqrt{(w'\Sigma w)} - w'_m\mu/\sqrt{(w'_m\Sigma w_m)}|w \subset C) \tag{6}$$

where w is the portfolio weight in the tangency portfolio, μ is the vector of risky returns in excess of the US risk free rate, Σ is the covariance matrix, and C is the set of all possible portfolio weights. For most of the analysis, C could include either positive or negative portfolio weights and of arbitrary magnitude. However, in later analysis, C will also be constrained to be strictly non-negative weights only.

For the minimum variance portfolio, the allocation strategy focuses on maximal risk reduction through the variance covariance matrix. In this case, I define the measure of diversification benefits, ψ, as the percentage reduction in volatility when investors move from the US benchmark portfolio to a minimum variance portfolio of US and foreign assets. Following Li, Sarkar, and Wang (2003), the volatility reduction gain is defined as:

$$\psi(w_m, C, \Sigma) \equiv \max_w (1 - \sqrt{(w'\Sigma w)/(w'_m\Sigma w_m)}|w \subset C) \tag{7}$$

To evaluate the portfolio gains from holding the naive 1/N diversified portfolio, I use a measure that is similar in spirit to the efficiency loss statistic defined by Wang (1998). Following Li, Sarkar, and Wang (2003), the last measure of diversification gains asks what would be the expected return difference between the US benchmark portfolio and a diversified portfolio of the same variance as

[10]For diversification gains within equity and sovereign bond markets, the benchmark will be the US return for the same asset class.

the US benchmark. The measure δ is defined as follows:

$$\delta(w_m, C, \mu, \Sigma) \equiv \max_{w}(w\mu - w_m'\mu | w \subset C, w^{'}\Sigma w \leq w_m^{'}\Sigma w_m) \tag{8}$$

Finally, for statistical inference, I follow Wang (1998) in using a combination of Bayesian inference and Monte Carlo simulation to generate the posterior distribution for φ, ψ and δ and evaluate the diversification gains against the null hypothesis that diversification gains are zero. The choice of this inference method is to accommodate portfolio constraints or no short sale, where sampling distributions for the diversification gain measures of φ, ψ and δ, are unknown. The combination of Bayesian inference and Monte Carlo methods provides the posterior distributions for φ, ψ and δ, on which the null hypothesis can be evaluated.

3 Data

To analyze the benefits of cross country diversification in the corporate bond market, time series of foreign and US corporate bond returns are required. Using the underlying constituents of the Merrill Lynch investment grade corporate bond indices, I collect monthly bond level returns for the following markets: Australia, Canada, Europe, Japan, UK and the US[11]. The monthly data spans the period of Jan 2000 - Dec 2010[12]. Since this international corporate bond data is newly constructed, Table 1 summarizes the composition of country bond portfolios. The row labeled Obs reports the total number of bond quotes for the entire sample period. The US corporate bond index has the most observations for the 2000 - 2010 sample period at 316,250 monthly bond quotes. In addition, the US market also has the largest number of bonds and issuing firms at 8295 bonds issued by 1809 firms. In comparison, Japan has 2640 bonds, but issued by only 203 firms. Japanese firms tend to issue more bonds and at shorter maturity, with subsequent rolling over of the short term debt. In contrast, the UK firms tend to issue longer term bonds and fewer of them. In addition to the total number of bond observations, Table 1 also reports the number of observations

[11]For inclusion in the Merrill Lynch Bond indices, all bonds must be investment grade bonds, have a minimum par requirement, one year or more left to maturity, and a fixed coupon. See Merrill Lynch Rules 2000 for details.
[12]For additional description of data construction, see Appendix.

in sub-categories by rating and industry. By ratings, the majority of bonds are rated A or BBB, and accounts for over 50% of bonds in every market. And across the industry breakdown, industrial firms are the heaviest issuers of corporate bonds across all markets and make up anywhere from 33% to 70% of the investment grade bond markets.

3.1 Sample Statistics

This section summarizes the excess return properties of international corporate bond sample that will be used in the later analysis. To put the newly complied corporate bond data into perspective with other asset markets, I also include both equity and sovereign bond returns for the same set of countries[13]. Since diversification gains are computed from the perspective of an US investor, all foreign returns are translated into US dollar returns and taken to be excess of the US risk free rate. While the main analysis in this paper focuses on hedged returns[14], I also report unhedged or spot converted returns for completeness.

Panel A of Table 2 compares the excess return statistics for hedged returns across the different countries. Looking across the hedged returns for the different bond markets, mean return differences are small, while variation in return volatility is much larger. In particular, the US corporate bond portfolio has the highest annualized return volatility of 5.77% as compared to the other advanced economy corporate bond markets whose return volatility ranges from 1.12% per year for Japan to 5.12% per year for the UK[15]. Along with the first two moments of the return distribution, Table 2 also reports the first order autocorrelation of returns. While large estimates of first order autocorrelation may raise concerns about stale data, I find that the first order autocorrelation for the constructed bond index returns is comparable to that of the MSCI equity index returns. Comparing the hedged and unhedged returns across the different asset markets, I find that hedging

[13]The countries included in foreign sovereign bonds and foreign equities match those for foreign corporate bonds with the exception that Germany substitutes for Europe.

[14]Since the focus of the paper is on diversification in the corporate bond market, hedged returns reduces the effect of currency returns on USD bond returns. Further, global bond mutual funds such as JPMorgan Global Corporate Bond Fund and Wells Management Global Fixed Income fund use derivative contracts to hedge currency risk and benchmark their performance to the hedged USD Merrill Lynch bond index which uses the hedging method as this paper. See Appendix for further discussion of hedging methodology.

[15]Annualized volatility is computed by multiplying monthly volatility by square root of 12, and annualized mean excess return is computed by multiplying monthly mean by 12.

foreign exchange risk dramatically reduces the mean and volatility of corporate bond and sovereign bond returns[16]. By contrast, the difference between hedged and unhedged returns for equity markets are less pronounced.

The potential for variance reduction depends crucially on the correlation structure of international markets. Therefore, Table 3 reports the correlation of hedged returns for the corporate bond, sovereign bond, and equity indices. Comparing the top and bottom panels of Table 3, the correlations are lower for the corporate bond markets than for the equity markets across these advanced economies. The pairwise correlation for equity markets is always above 50%, while correlation for corporate bond returns can be as low as 14%. As an example, the Australian corporate bond portfolio has a 33% correlation with the US corporate bond market, whereas the Australian equity market is correlated with the US equity market at 73%. These low cross country correlations in the corporate bond market will play a critical role in generating significant risk reduction gains in the later analysis.

4 International Credit Risk and Portfolio Diversification Gains

This section analyzes the portfolio gains to US investors of diversifying with foreign corporate bonds. The magnitude of these portfolio gains within the corporate bond market is then evaluated against gains within other asset markets such as sovereign bonds and equities. For each asset class, Table 4 reports the mean and standard deviation of the US benchmark asset and the internationally diversified portfolio, as well as the posterior distribution of measured portfolio gain. For the posterior distribution of the portfolio gain measures, I report the posterior mean, standard deviation, lowest 5%, and lowest 1% of gains.

The first two columns of Table 4 compares the return characteristics of the US benchmark investment grade corporate bond, labeled US IG, against a diversified portfolio of US and foreign corporate bonds, labeled US IG + Foreign IG. The estimated monthly expected excess return for a tangency portfolio of US and foreign corporate bonds is 0.20% with volatility of 0.34%. In comparison, the US benchmark corporate bond return in the first column has monthly expected

[16]This is similar to the finding in Burger and Warnock (2007)

excess return of 0.44% and volatility of 1.66%. Therefore, while the diversified tangency portfolio greatly reduces portfolio risk, it also decreases expected excess return. The tradeoff between lower volatility and lower expected excess return is captured in the return Sharpe ratio, or the expected excess return per unit of risk. The portfolio gain φ measures the difference in portfolio Sharpe ratio of holding the internationally diversified tangency portfolio versus the US benchmark. The posterior distribution of φ in Panel A shows an average increase of 0.36 in monthly Sharpe ratio. Further, the lowest 1% gain from the posterior distribution is 0.15[17]. The posterior distribution of φ shows that US investors holding domestic corporate bonds could have significantly increased their portfolio Sharpe ratio over the last decade by including foreign corporate bonds.

As an alternative to the tangency portfolio, Jagannathan and Ma (2003) and others have argued in favor of focusing on the minimum variance portfolio. The minimum variance portfolio relies only on the estimate of the variance covariance matrix to form the lowest possible risk portfolio. This portfolio is optimal when the investor believes that expected excess returns are not significantly different across advanced economies, and hence variance reduction is their primary objective. Panel B of Table 4 shows that the minimum variance portfolio of international corporate bonds over the last decade had volatility of 0.30% per month, as compared with the US corporate bond benchmark volatility of 1.66%. Panel B also reports the posterior distribution of ψ, which measures the percentage reduction in return volatility. The posterior distribution of ψ validates the large risk diversification potential and shows an average risk reduction of 82.4% when including foreign corporate bonds, and the lowest 1% posterior gain of 78.5%. Therefore, by holding the minimum variance portfolio of US and foreign corporate bonds, investors could have realized large and significant risk reduction over the US benchmark.

To put the international diversification gains in the corporate bond market into perspective against other asset markets, Table 4 also reports the gains for sovereign bond and equity markets. Columns labeled US Eq and US Sov report the benchmark returns for domestic equities and sovereign bonds respectively, while internationally diversified portfolios are detailed under columns

[17] An earlier version of the paper conducted mean variance intersection and spanning tests for each country portfolio individually, as well as jointly. Intersection and spanning were rejected for each individual country portfolio, except the UK, at the 1% confidence level. While individually Japan had the largest alpha, joint intersection and spanning tests without Japan still lead to strong rejections. Results are available upon request.

labeled US Eq + Foreign Eq and US Sov + Foreign Sov. Across the asset markets in Panel A, the posterior mean of φ or Sharpe ratio gain for equities is the same as for corporate bonds at 0.36, while slightly lower for sovereign bonds at 0.25. And while, the standard deviation of the posterior distribution for φ is slightly higher for equities than for corporate bonds, the lowest 1% gain of 0.11 and 0.15 are similar across the two asset markets.

While the posterior distribution of the Sharpe ratio gain appears to be similar between corporate bonds and equities, the source of the diversification gains differ greatly between the two asset markets. In the corporate bond market, the gain in Sharpe ratio is driven largely by a reduction in volatility from 1.66% for the US benchmark to 0.34% for the international tangency portfolio. On the other hand, in the equities market, the gain in Sharpe ratio is dominated by an increase in monthly expected excess return from -0.08% for the US benchmark to 3.06% for the diversified portfolio. The 3.06% monthly expected excess return is coupled with an equally staggering 10.88% monthly volatility. These wild estimates of expected return and volatility for the equity tangency portfolio are due in large part to the extreme long-short portfolio positions implied by sample returns. However, large portfolio positions can lead poor out of sample performance when future excess return and covariance deviate from in-sample estimates. The potential difficulty for equity markets to replicate these gains out of sample will be analyzed in later sections.

Panel B of Table 4 compares volatility reduction gain, ψ, for each of the three asset markets. The corporate bond market exhibits the largest volatility reduction with 82.1%, as compared to equities with 25.9% and sovereign bonds with 55.7%. Similarly, at the lowest 1% posterior gain, corporate bond diversification generates an amazing volatility reduction of 78.5%, while equities and sovereign bonds achieve only 17.5% and 47.0% in risk reduction respectively. The comparison of volatility reduction gains across different asset markets highlights the ability for US corporate bond investors to significantly decreased portfolio risk with international diversification, even more than what can be achieved in the equities and sovereign bond markets. The comparison of risk reduction across asset markets suggests that US corporate bond investors could have an even stronger incentive to diversify internationally than US equity investor.

Finally, Panel C examines the effectiveness of a naive equally weighted diversification strategy within the equity, corporate bond, and sovereign bond market. The advantage of analyzing the 1/N portfolio strategy is that it naturally imposes short sale constraints and represents one measure of out of sample performance. The downside to the portfolio strategy is that it is does not take advantage of any return information. I find that the international corporate bond portfolio had a higher expected excess return and lower volatility than the international equities portfolio. The expected excess return for the naive corporate bond portfolio is 0.28% per month versus 0.10% per month for equities, with volatility of 0.82% and 4.27% respectively for the two asset markets. For the posterior of the δ gain, equities has the highest average gain but also the highest standard deviation. The higher posterior average gain comes from the ability for the naive equity portfolio to simultaneously increase expected excess return, from -0.08% to 0.10%, and decreases return volatility, from 4.78% to 4.27%. By contrast, the naive diversification of corporate bonds reduces risk but at the cost of lower expected excess return. For equities, the higher posterior standard deviation produces negative gains at both the lowest 5% and 1% level. In comparison, the naive 1/N portfolio of corporate bonds realizes a small but positive gain of 0.02% at the 5% posterior probability level. In fact, corporate bonds is the only asset market that has positive δ gains at the lowest 5% posterior probability level; both equities and sovereign bonds have negative gains of -0.07% and -0.08% respectively. Therefore, the gains from simple equally weighted portfolio strategy for corporate bonds appear to be less volatile and more significant, but lower on average, than for equities.

This section showed that US corporate bond investors could have realized substantial gains from international diversification over the last decade. Comparing the diversification gains in corporate bond markets with those in equity markets, I find similar magnitudes for in-sample Sharpe ratio gains, but large differences in how the gains are generated. In particular, I find that in-sample Sharpe ratio gains in corporate bond markets are driven predominately by reductions in volatility, while gains in equity markets are from increases in expected excess return. However, the increase in excess return for diversified equity portfolios requires extreme short positions that may be problematic for out of sample performance. For volatility reduction gains, I find that gains in the corporate bond market is substantially larger than the gains in equity markets or sovereign bond markets. While these results suggest that US investors stand to achieve potentially large diversification gains in the international corporate bond market, some may argue that in sample estimates overstate the true achievable or out of sample gains. Further, these gains may not reflect the available diversification during financial crisis periods, when correlations in equity markets have been known to rise. To address these issues, the next two sections will consider the ability for these gains to hold up during period of the financial crisis and analyze the dynamics of these diversification gains.

4.1 Diversification Gains during the Recent Financial Crisis

There's an open question about the ability for international diversification to withstand a global crisis. As shown in Ang and Bekeart (2002) and others, correlations across international markets tend to increase during a crisis period. Therefore, international diversification gains may be small when investors need it most. To address this concern of diminishing gains to international diversification during crisis periods, I analyze the Sharpe ratio gains and volatility reduction gains for the most recent global financial crisis by repeating the analysis in Table 4 for the subsample period of Jan 2008 - Dec 2010.

Table 5 reports the portfolio diversification for the most recent financial crisis of Jan 2008 - Dec 2010. Clearly, the return volatility for all US benchmark assets, in columns labeled US IG, US Eq, and US Sov, are higher during the crisis period as compared with the full sample in Table 4. In particular, the volatility of the US benchmark for corporate bonds, under the column labeled US IG, was 1.66% monthly, or 5.75% annual, for the full sample versus 2.34% monthly, or 8.11% annualize, during the financial crisis[18]. In addition, the slight increase in expected excess returns for the benchmark US assets during the financial crisis reflects the positive returns realized in 2010. Panel A of Table 5 reports the posterior distribution of the Sharpe ratio gain φ for the three asset markets of corporate bonds, sovereign bonds, and equities. Comparing the posterior mean of φ, the Sharpe ratio gain is largest for corporate bonds at 0.60, second for equities at 0.56, and smallest for sovereign bonds at 0.37. While the equity market and corporate bond market have comparable magnitude gains, the diversified tangency portfolio of equities realizes an implausibly large 21.16%

[18]Annualized volatility is computed by multiplying monthly volatility by square root of 12

monthly expected excess return, with a staggering 53.28% per month portfolio volatility. Like the full sample analysis, the Sharpe ratio gain in equity markets relies on large negative portfolio weights. Compared to the equity tangency portfolio for the full sample from Table 4, there is a dramatic increase in expected excess return from 3.06% to 21.16% and monthly volatility from 10.88% to 53.28%. The large difference between the return in the subsample and the full sample shows the instability of the equity tangency portfolio return over time.

By contrast, the tangency portfolio return for corporate bonds is fairly stable between full sample analysis in Table 4 and sub-period during the financial crisis. The full sample monthly excess return for corporate bonds was 0.20% with volatility 0.34% versus the crisis period excess return of 0.30% with volatility 0.37%. Unlike equities, the Sharpe ratio gain for corporate bonds relies more on risk reduction and estimates of the variance covariance matrix, rather than on increasing expected excess returns. Since covariance structures are generally estimated more precisely than expected excess returns, in-sample Sharpe ratio gains should be a more reliable indicator of future gains for corporate bonds than for equities.

The volatility reduction gain ψ during the financial crisis is reported in Panel B. Similar to the full sample analysis, the corporate bond market has the largest average volatility reduction at 87.4%, while the equity market has the lowest at 27.9%. These gains are very similar to the full sample results reported in Table 4. For the posterior distribution of ψ, the standard deviation of the volatility reduction gain is higher for the crisis period, than for the full sample. The higher standard deviation had the largest effect on equities, where the lowest 1% posterior gain drops from 17.5% for the full sample to only 9.7% during the financial crisis. In comparison, the lowest 1% volatility reduction gain for corporate bonds is 78.5% for the full sample and 81.2% during the crisis. Therefore, from a pure risk reduction perspective, corporate bond markets appear to consistently generate significantly larger gains from international diversification than equity markets, both in crisis periods and in the full sample.

Panel C of Table 5 shows the naive 1/N portfolio diversification gains. For corporate bonds, the data shows that a naive international diversification strategy during the financial crisis would have increased monthly expected excess return gain δ by 0.36% over the US benchmark[19]. In comparison, the international equities portfolio would have realized a negative δ gain of -0.17% per month. However, it may be argued that the negative performance of the naive 1/N equity portfolio is due to the simplicity of the portfolio allocation strategy and the added restriction of positive portfolio weights. Therefore, an alternative measure of out of sample performance is to estimate the portfolio weights using returns from the pre-crisis period of Jan 2000 - Dec 2007, and then compute the realized returns during the financial crisis of Jan 2008 - Dec 2010. Panel D shows that the Sharpe ratio gain over the US benchmark asset of the pre-crisis estimated tangency portfolio was 0.42 for corporate bonds, 0.14 for sovereign bonds, and 0.05 for equities. As compared with the naive 1/N portfolio, the out of sample tangency portfolio shows a positive gain for equities. However, these results still show a dramatic decrease in Sharpe ratio gains when going from in sample gains of 0.56 to out of sample gains of 0.05 for equity markets.

For corporate bonds the difference between in-sample and out of sample gains are much smaller. The differential between in-sample Sharpe ratio gain of 0.60 and the out of sample gain of 0.42 shows that gains in the corporate bond market are more robust to out of sample analysis and potentially more achievable than the gains in equity markets. Further, in the out of sample analysis, the Sharpe ratio gain of 0.42 for corporate bonds is much higher than the 0.05 gain for equities. Therefore, while in-sample Sharpe ratio gains are similar across equities and corporate bonds, out of sample performance suggest that gains in the corporate bond market may be larger and more robust than in equity markets.

For out of sample volatility reduction ψ in Panel D, I find that gains are comparable to the in-sample estimates in Panel A for all asset markets. The out of sample risk reduction gain, ψ, during the financial crisis was 84.8% for corporate bonds, 53.2% for sovereign bonds, and 18.3% for equities. Once again, corporate bonds achieve the highest risk reduction gain as compared with equities and sovereign bonds. This suggests that the superior risk reduction potential in the corporate bond market holds even during the crisis period and are robust to out of sample analysis.

The analysis of diversification gains during the financial crisis provides several interesting find-

[19] Annualized expected excess return is computed from monthly excess return and multiplying by 12.

ings. First, diversification gains in the corporate bond market were consistently positive and significant during the recent financial crisis, for both in-sample and out of sample measures. By comparison, equity markets realized negligible out of sample Sharpe ratio gains, even though in sample estimates were large and significant. The out of sample performance suggests that Sharpe ratio gains are potentially more robust and achievable in the corporate bond market than in the equities market. Second, all asset markets would have benefited in reducing risk from international diversification during the financial crisis. However, the volatility reduction potential in corporate bond markets is four times larger than in equity markets. The exceptional potential for risk reduction through international diversification in the corporate bond market is similar in magnitude for both in-sample and out of sample estimates. Last, the performance of the naive 1/N portfolio strategy shows the importance of short strategies for equity diversification, as a portfolio of equal weighted international equities realizes a negative diversification gain of -0.17% per month. For corporate bonds, the simple equally weighted strategy is still able to generate positive expected returns and a significant risk adjusted return gain.

4.2 Out of Sample Portfolio Dynamics

A large body of empirical evidence has documented the time variation in the co-movement of international equity markets[20]. The dynamic covariance structure of international markets can lead to large variations in diversification gains over time. This section analyzes the return dynamics for the diversified portfolio and the US benchmark. I compare the dynamics of the Sharpe ratio and volatility for the naive 1/N portfolio and US benchmark over time. Since the portfolio weights of the naive 1/N are constant and not estimated from the data, this portfolio allocation strategy is particularly useful for isolating the effects from return dynamics as opposed to changes in portfolio weights[21]. Graphically, the diversification gain at any point in time is the difference between the US benchmark and the international portfolio.

Figures 1 and 2 plot the past 12 month return volatility of the naive 1/N portfolio against the

[20]Most recently, see Bekeart, Hodrick, and Zhang (2010)

[21]Alternatively, rolling estimation window strategies may be used, however, the effect of portfolio weight changes and return dynamics cannot be separately analyzed.

US benchmark for corporate bonds and equities respectively. Figure 1 shows that the international portfolio of corporate bonds has a dramatically lower volatility than the US benchmark, and does so for every month within the sample period. Further, the lower volatility of the international corporate bond portfolio over the US benchmark is particularly pronounced during the financial crisis or the later part of the sample period. By contrast, for equity markets, the lower volatility of the international portfolio over the US benchmark depicted in Figure 2 is mixed over time. In fact, during periods such as 2005-2007, and again from 2008 to 2009, the naive equity portfolio realizes a higher portfolio volatility than the US benchmark. The time variation in the volatility of the equally weighted international portfolio show the relative instability of the risk reduction gains in equity markets versus corporate bond markets. In particular, whereas corporate bonds exhibited large volatility reduction gains during the recent financial crisis, equity markets realized minimal or negative benefits from diversification.

While the diversified corporate bond portfolio delivered consistent risk reduction over time, Sharpe ratio gains do not exhibit this consistency. Figure 3 plots the average realized monthly Sharpe ratio over the past 12 months for the US corporate bond benchmark and the naive 1/N international corporate bond portfolio. For both the equity market and corporate bond market, the naive international portfolio does not generate a higher Sharpe ratio consistently, as compared with the US benchmark. However, it is interesting to examine when the international portfolio out-performed the US benchmark, as gains are distributed differently over time across the two asset markets. Figure 3 shows that after the middle of 2008, the naive corporate bond portfolio realized a noticeably higher Sharpe ratio over the US benchmark[22]. For the same time period, the naive equity portfolio in Figure 4 realized a comparable and sometimes lower Sharpe ratio than the US benchmark. On the other hand, when equity markets realized large Sharpe ratio gains in the middle of 2007, the international corporate bond portfolio produced negative Sharpe ratio gains relative to the US benchmark. The figures show that for corporate bond markets, international diversification seem to generate larger Sharpe ratio gains during crisis periods and less during good time, whereas the reverse pattern appears in equity markets.

[22] The realized Sharpe ratio for Jan 2009 is computed using the past 12 months returns and therefore, really reflect the diversification performance over the period Jan 2008 - Jan 2009 which includes the Lehman default in Oct 2008.

The time variation in the return Sharpe ratio and volatility highlight two findings. First, a simple diversification strategy in corporate bonds would have realized a lower volatility than the US benchmark for every point in time over the entire sample period. In comparison, time-varying return volatility of the international equity portfolio does not always beat the US benchmark. In particular, during the crisis a simple equally weighted portfolio of international equities would have generated minimal, and at times negative, risk reduction over the US benchmark. Two, for corporate bonds, a naive diversification would have generated higher Sharpe ratio gains during crisis periods, but with potentially negative gains during normal times. On the other hand, for equities, Sharpe ratio gains seem larger during normal times as opposed to crisis periods.

5 What Can Explain the Diversification Gains?

The previous sections found large portfolio gains for US investors when diversify into international corporate bonds. In comparison to the equity market, the diversification gains in the corporate bond market appear to be larger and more consistently positive during crisis periods. This section attempts to reconcile these gains with four potential explanations for why positive and significant gains persist in the corporate bond market, and yet US investors shy away from foreign assets as shown in Burger and Warnock (2007). If any of the proposed explanations can sufficiently reduce the portfolio benefits to US investors, then observed low portfolio holdings in foreign assets could be justified. First, I examine the ability for short sale constraints to generate positive portfolio gains, and if by imposing a non-negativity condition on portfolio weights, US investors would realize minimal gains from international diversification. Second, I access the potential for diversification gains to be explained by compositional differences between the US and foreign corporate bond portfolios in rating, duration, and industry. Third, lower market liquidity in foreign corporate bond markets may explain the existence of positive gains that in reality cannot be exploited. Last, the lack of access to reliable financial information and familiarity with foreign firms may discourage US investors from actively seeking out international diversification opportunities. I analyze each potential explanation in turn and examine the ability to sufficiently reduce diversification gains such that a minimal holding of foreign corporate bonds by US investors is justified[23].

5.1 Short Sale Constraints

The significant portfolio gains found earlier for the tangency and minimum variance portfolio allowed portfolio weights to take on arbitrarily large short positions. In practice, foreign assets may be difficult to hold as a short position. Therefore, it is possible that due to short sale constraints, US investors cannot take advantage of the significant diversification gains. To shed light on this issue, this section evaluates the diversification gains when a non-negative portfolio weight restriction is included in the solution of the tangency and minimum variance portfolio.

Table 6 shows the effect of short sale constraints on diversification gains for corporate bond market in column labeled IG and equity market in column labeled Eq. For ease of comparison, the original results from Table 4 with unrestricted portfolio weights are reported under the columns labeled Unconstrained. For investment grade corporate bonds, the non-negative portfolio weights constraint does make a material difference to the Sharpe ratio gain φ. The posterior mean of φ decreases from 0.36 in the unconstrained case to 0.31 for the case with short sale restrictions. By comparison, the non-negative portfolio weight restriction makes a much larger difference in equity markets. The average Sharpe ratio gain drops from 0.36 in the unconstrained case to 0.15 when short sale is forbidden. Furthermore, when short sale constraint is present, the posterior lowest 1% of Sharpe ratio gains is negligible at 0.04 for equities, while for corporate bonds the lowest 1% is a modest gain of 0.13.

For volatility reduction gains ψ, the effect of imposing short sale constraints is less significant. Under non-negative portfolio weight restrictions, it is still the case that corporate bonds realize a much larger volatility gain than equities. For volatility reduction gains with short sale restrictions, Table 6 shows an average gain 81.5% in the corporate bond market, as compared with only 21.3% in the equities market. Therefore, the restriction only positive portfolio holdings does not reverse

[23]While admittedly information and liquidity costs are components of transactions costs, direct acquisition cost is difficult to examined due to the lack of transactional data. While some global bond mutual funds are available during the sample period, these funds invest in both domestic and international sovereigns as well as corporate bonds. The emergence of global corporate bond ETF from State Street and PowerShare beginning in 2011 may not accurately reflect the true acquisition costs for the sample period.

the persistent finding that corporate bonds can generate much larger risk reduction gains for US investors than equities.

To summarize, I find that even with short sale constraints US investors can realize significant benefits from international diversification in the investment grade corporate bond market. By contrast, the same is not true for equity markets. While portfolio constraints decrease Sharpe ratio gains, the effect is particularly pronounced in equity markets, where Sharpe ratio gains are reduced to almost zero. The inability for non-negative portfolio weight restriction to trivialize benefits from diversification in the corporate bond market suggests that short sale constraints are unlikely to explain the low level of foreign holdings by US investors.

5.2 Portfolio Composition and Bond Characteristics

While international equities research commonly uses the aggregate MSCI index, the recent literature beginning with Heston and Rouwenhorst (1994) questions the relative importance of country effect versus industry effects on international diversification. Along the same lines, firm and bond characteristics such as ratings, duration, and industry are well-known to affect the pricing of corporate bonds. Therefore, an over-weighting of one bond characteristic in foreign portfolios relative to the US benchmark could potentially affect the magnitude of diversification gains. In other words, the portfolio gains found earlier could be a reflection of diversification across the duration spectrum or ratings categories, rather than across countries[24].

To isolate the pure cross country diversification effects, I rebalance foreign bond portfolios to match the bond characteristic weights of the US benchmark portfolio. For each country, I generate bins by ratings, duration, and industry. Rating bins are classified as AAA, AA, A, and BBB. Industry bins are Financial, Utilities, and Industrial. And duration bins are 0-2, 2-4, 4-7, 7-10, 10-15, and 15-30. Then, I construct a return for each characteristic bin by value-weighting the individual bond returns within each category. Finally, I aggregate the characteristic bin returns using the US benchmark portfolio weights for each category.

With these rating, industry, and duration balanced foreign corporate bond portfolios, I evaluate

[24] The original restriction to only investment grade corporate bonds does try to control for some rating and credit risk effects, but this section will breakdown the categories even further.

the same measures of diversification gain to the US investors. Table 7 reports the results. For ease of comparison, column ALL IG Unbalanced restates the results from the original unbalance country indices from Table 4. Overall, the portfolio returns and diversification gains are not noticeably different between rebalanced foreign sample and the original unbalanced sample. For example, the posterior mean of the Sharpe ratio gain, φ, with ratings balanced foreign indices is 0.33, as compared with 0.36 for the unbalanced indices. Similarly, industry and duration balanced portfolios have posterior mean Sharpe ratio gains of 0.31 and 0.28 respectively. Furthermore, posterior lowest 1% of gains for all rebalanced portfolios are positive and higher than 0.09. For volatility reduction gains with the minimum variance portfolio, again only small decreases appear when foreign indices are rebalanced by industry, ratings, and duration. Even with the rebalanced foreign portfolios, US investors would have realized substantial volatility reduction gains on average by 70% or more.

While there are many other potential bond characteristics that can be used to reweight the foreign indices, Table 8 shows that rebalancing on industry, duration, and ratings does not significantly reduce the diversification gains found earlier. In other words, differences in bond characteristics across country portfolios do not invalidate the positive portfolio gains to US investors of diversifying with foreign corporate bonds. Furthermore, the similarity between the rebalanced and the original unbalanced portfolio returns suggests that the portfolio gains are driven largely by cross country effects, and to a lesser extent by diversification across characteristics. Similar to the Heston and Rouwenhorst (1994) finding for equity markets, this evidence lends additional support that diversification across countries is potentially more effective in reducing portfolio risk than across industries.

5.3 Market Liquidity

The corporate bond market is notoriously illiquid, and its effect on pricing has been well documented. As argued by Lo, Mamaysky, and Wang (2004) or Chen, Lesmond, and Wei (2007) liquidity costs can inhibit investors from trading frequently and fully hedging their risks. Therefore, if foreign portfolios contain a higher concentration of illiquid bonds, then the aggregate liquidity would be lower for foreign indices relative to the US benchmark. The cost of additional liquidity risk may prevent US investor from capturing the measured gains reported earlier.

As a way to filter out potentially illiquid bonds, this section uses two well-known proxies for bond liquidity, age and issue size. Age is correlated with liquidity because newer issues or younger bonds tend to have more investor interest and are observed to trade more often. Similarly, bonds close to maturity are generally held to maturity and unlikely to trade. Combining these effects, I filter foreign indices by including only bonds issued within the last two years and have more than two years left to maturity[25]. Similar to the age and years to maturity effect, larger issuance size implies more bonds available in the market and higher probability of trading. For the size filter, I use bonds from only the top 20% of issuance size within each country. With the sample of filtered bonds, I compute country level returns by value weighting the individual bond returns. While admittedly there are much more sophisticated measures of bond liquidity, the lack of transactional data and bid/ask quote data on international bonds precludes many advanced measures of liquidity costs proposed by Chen, Lesmond, and Wei (2007) or Bao, Pan, and Wang (2011).

Table 8 compares the return performance for diversification of Age/YTM and Size filtered foreign indices with the US corporate bond benchmark. For ease of comparison, columns US and All IG are repeated from Table 4 and report the earlier gains from the unfiltered foreign indices. The performance of size filtered bonds is remarkably similar to the unfiltered sample. The tangency portfolio of size filtered bonds still increase portfolio Sharpe ratio on average by 0.35 over the US benchmark, as compared with 0.36 for all foreign bonds. Similarly, the size filtered bond portfolios can still significantly reduce return volatility by 81.6% over the US benchmark. The minimal difference in return performance between size filtered foreign indices and all foreign bonds is in part due to the fact that bond returns were value weighted in the original foreign portfolios.

By contrast, the age and years to maturity filtered foreign corporate bonds seem to have a greater ability to reduce portfolio gains from diversification than the size filter. Even so, the column labeled Age/YTM in Table 8 shows that US investors can generate significant positive gains with an average of 0.28 increase in monthly Sharpe ratio and a 74.5% decrease in return volatility over

[25]Merrill Lynch bond constituent list does filters on time to maturity and amount outstanding for liquidity reasons. As specified in the ML data manual, bonds with less than one year left to maturity trade in a very thin and are generally held to maturity.

the US benchmark. These gains indicate that the elimination of potentially less liquid bonds by age, years to maturity, and size does not have the ability to sufficiently reduce gains and explain why diversification in foreign corporate bonds are not attractive to US investors. And while this is not a comprehensive study of market liquidity differences, these results do support the finding in Jong and Driessen (2009) that liquidity risk premiums are comparable between Europe and US investment grade corporate bond markets.

5.4 Investor Access

While the liquidity analysis addresses some issues of accessing foreign corporate bonds, there may be informational barriers that prevent US investors from wanting to hold these instruments. In particular, if the financial reporting of the foreign firm issuing the bond is particularly costly to understand, then US investors may find it optimal to forgo diversification gains. This section identifies firms whose financial information can be easily evaluated by US investors. Foreign cross listed bond in the US, known as Yankee bonds, are subject to SEC disclosure and can be similarly evaluated by US investors as domestic issues. In addition, by cross listing bonds in the US, foreign firms also increase recognition among US investors. For equity cross listings, Forester and Karolyi (1999) find that abnormal returns found with American Depository Receipts are due more to investor recognition than institutional barrier effects. Therefore, if diversification gains are significantly reduced when only bonds from Yankee issuing foreign firms are used, then informational costs and unfamiliarity with foreign issuers could explain why US investors shy away from international corporate bonds.

Table 9 shows the effect on diversification gains of restricting investors to only foreign firms that have Yankee bonds in the US. While most countries have firms that issue Yankee bonds, Australia does not. Therefore, to compare the effect of eliminating issuers without Yankee bonds, the benchmark unrestricted sample of all foreign bonds includes only Canada, Europe, Japan, and the UK. Column labeled Foreign List in US reports the portfolio performance of bonds from only those firms that have a cross-listing in the US. In comparison to the all bonds in Column labeled CAN, EUR, JPN, UK ALL, the cross-listing requirement does not seem to make a large difference in changing the posterior distribution of φ gain and ψ gain. The posterior distribution of φ shows that even with a limited set of bonds from easily recognizable foreign issuers, there is an average of 0.34 increase in their monthly Sharpe ratio over the US benchmark alone. This is only a minimal decrease from the Sharpe ratio gain of 0.35 from the all foreign corporate bonds portfolio in Column labeled CAN, EUR, JPN, UK ALL. Similarly for risk reduction, there is also little difference between the cross-listing issuer sample and the full sample of foreign corporate bonds. The constrained set of bonds from cross listing foreign firms realizes an average volatility reduction of 78.6%, relative to 81.7% for all bonds. These results suggest that informational barriers does not account for the positive gains from diversification, and yet the low holdings of foreign corporate bonds by US investors.

In the above analysis, many of the cross-listing foreign firms are familiar multinationals. And as argued by Errunza, Hogan, and Hung (1999), multinationals provide a way to diversify internationally through their operations, and therefore, are potentially less linked to their country of domicile than local firms. As an extension of the above analysis, I test if large US firms with listings in multiple markets might also provide similar diversification benefits for US investors. Alternatively, the analysis can be interpreted as fixing the location of where the bond is traded and analyzing the difference in diversification potential of US firms versus foreign firms. In doing so, it's possible to identify the effect to diversification gains of where the bond is traded versus where the firm is located.

To this end, I identify corporate bonds that trade in Canada, Europe, Japan, and UK, but are issued by US firms. Since US firms start appearing in the Canadian bond market starting in 2005, I confine my analysis to the subsample of Feb 2005 - Dec 2010. Panel C and D compares the posterior distribution of φ and ψ of all foreign firms, foreign firms with Yankee bonds, and US firms with foreign listed bonds for the subsample period. The posterior distribution for φ in Column US Firms Cross List is clearly shifted downwards relative to Column Foreign Firms Cross List. The lowest 1% posterior Sharpe ratio gain φ is 0.04 for bonds of US firms listed abroad, versus 0.11 for bonds of foreign firms with US listed bonds. Even more dramatic, the average volatility reduction gain ψ drops from 82.3% to 39.0%. These results suggest that while there are some potential gains to risk reduction to holding even foreign bonds issued by US firms, a larger portion of diversification gains is driven by foreign bonds issued by foreign multinationals.

This section shows that restricting bonds to be issued by foreign firms with a Yankee bond listing in the US, has little effect on the diversification results found with the sample of all foreign bonds. By having a US bond issue in addition to a bond outstanding in their home markets, these firms are subject to US disclosure and have readily accessible financial information and more visibility to US investors. These bonds still seem to offer US investors in US corporate bonds potentially significant portfolio diversification gains in both increasing the portfolio Sharpe ratio and decreasing portfolio volatility.

6 Can US equity investors benefit from holding international corporate bonds?

While international diversification gains are generally analyzed within an asset class, this section asks if well-diversified US investors of domestic equities and bonds can also benefit from holding foreign corporate bonds. This question is important for two reasons. First, a domestically diversified portfolio of US equities, corporate bonds, and treasuries is potentially more realistic representation of a portfolio held by an US investor. Second, a multi-asset US benchmark has the potential to make it more difficult for foreign bonds to generate further diversification gains, as benefits may already exist across different asset classes within the US. If foreign corporate bonds provide minimal benefits for a well-diversified US investor, then it is perhaps justifiable to find low US holdings of foreign corporate bonds.

To answer this question, I modify the earlier US benchmark with just domestic corporate bonds and include US equities and treasuries. I assume that investors will use the same portfolio allocation strategy for constructing the multi-asset US benchmark equity and bond portfolio, as for incorporating foreign corporate bonds. Therefore, I estimate the tangency and minimum variance portfolio weights for US equities, corporate bonds, and 30 year treasury, and compute the resulting benchmark portfolio return in the column labeled US under Multi-Asset. Given the seminal work of

Fama and French (1993) in identifying the risk factors underlying the US equity and bond markets, I also estimate optimal US multi-asset benchmark tangency and minimum variance portfolio using the five factors. The five priced factors are the excess market return (mktrf), return on the zero cost portfolios of small minus big (smb), and high minus low (hml), excess return on the 30 year US treasury (TERM), and excess return on the US investment grade corporate bond index (DEF). Therefore, using Fama French factor returns, I again construct the tangency and minimum variance portfolio of US equity and bonds.

In addition to model implied portfolio weights, I also collect observed portfolio shares on US equities and bonds in the data. From the Flow of Funds Table B.100, the implied US portfolio has a 74% share in equities, 17% in corporate bonds, and 9% in treasuries.[26] While the portfolio shares implied by the Flow of Funds data may be more representative of the actual holdings for US investors, this benchmark is likely to be suboptimal with respect to the return data since portfolio weights are not estimated.

Table 10 shows portfolio gains from adding foreign corporate bonds to an already diversified domestic portfolio of US equities and bonds. In Panel A, the multi-asset tangency portfolio return under column labeled US had expected excess return of 0.50% per month and volatility of 1.79%. By contrast, the US plus foreign corporate bonds achieves an expected excess return of 0.20% per month and a return volatility of 0.34%. Similar to the portfolio gains in the original corporate bond only US benchmark case, foreign bonds appear to dramatically reduce portfolio risk, and somewhat also lower expected excess returns. The posterior distribution of the Sharpe ratio gain φ has a mean of 0.34, with the lowest 1% of 0.14. Similarly for the minimum variance portfolio in Panel B, the posterior distribution for ψ shows that international diversification reduces portfolio volatility on average by 81.6%, with the lowest 1% gain of 77.6%. These results suggest that the portfolio gains shown earlier can be extend to US investors holding a well-diversified portfolios of domestic equities and bonds.

Similar results emerge when Fama French factor returns are used. Comparing the US columns

[26]From Table B.100 of Flow of Funds, the 2010 Q4 levels of financial assets for US households are 8516.6 for Corporate Equities, 1918.6 for Corporate Bonds, and 1078.7 for treasuries. While mutual fund holdings and pension fund holdings are clearly important components of a representative US household's financial assets, these positions are excluded since they cannot be proportioned into US equities, US corporate bonds, and US treasuries.

under Multi-Asset and FF Factor, the US benchmark with Fama French factors has higher expected excess return and lower volatility than the US benchmark with raw equity and bond returns. Therefore, the portfolio gains from including foreign corporate bonds are lower for the Fama French US benchmark than the previous benchmark specification using equity and bond returns directly. The two columns under FF Factors show that including foreign corporate bonds on average increase monthly Sharpe ratio by 0.26, and decrease portfolio volatility by 77.4% over the US Fama French benchmark. The Sharpe ratio gain φ and volatility reduction gain ψ are remarkably close to the ones reported in Table 4 when only domestic corporate bonds were used as the US benchmark. This is due to the fact that the multi-asset benchmark puts a heavy weight on US corporate bonds. Therefore, the US multi-asset benchmark of equities and bonds has similar return properties as the US benchmark portfolio with only domestic corporate bonds. And as a consequence, the gains from international diversification do not change drastically with the shift to a multi-asset US benchmark as opposed to a US corporate bond benchmark.

However, in reality US investors may hold a significant portfolio of equities. Therefore, to boost the effect of US equities in the benchmark, I turn to the observed financial asset positions implied by the Flow of Funds data. While these portfolio weights may be more representative of true investor holdings, they are unlikely to perform optimally with respect to the data. In fact, the Flow of Funds observed portfolio weights places 74% portfolio share in US equities. The effect of additional portfolio weight on US equities is evident when comparing the columns labeled US under Multi-Asset and under Flow of Funds. The US Flow of Funds benchmark return has noticeably lower expected excess return and higher volatility than if portfolio weights were estimated from returns. The expected excess return drops from 0.50% per month to 0.16% per month, and return volatility increases from 1.79% per month to 3.71%. Given the poor performance of Flow of Funds US benchmark portfolio, the gains from adding foreign corporate bonds are even larger and more significant than when domestic corporate bonds were used as the US benchmark. For the US benchmark portfolio implied by Flow of Funds, adding foreign bonds would increase the posterior mean monthly Sharpe ratio by an average of 0.57 and can potentially decrease the portfolio volatility by 92.2%. These results suggest that for any US investor with a large domestic equity exposure the gains from diversification with foreign corporate bonds would have been even larger and more significant than for an US investor with only domestic corporate bonds.

Using three different specifications for US multi-asset benchmark of equities and bonds, I show that foreign corporate bonds provide significant portfolio diversification benefits for US equity investors, in addition to US bond investors. Further, given the strong performance of US bonds relative to equities, I find that optimally diversified multi-asset US benchmark portfolios heavily favor domestic corporate bonds over domestic equities. Therefore, the diversification gains were very comparable between using a US corporate bond only benchmark and a well-diversified US multi-asset benchmark. Finally, using the observed portfolio holdings from Flow of Funds to pin down the multi-asset US benchmark portfolio, I find that the increase in domestic equity generates lower expected excess return and higher volatility than the US corporate bond only benchmark. Using the implied portfolio weights implied by the Flow of Funds in an US multi-asset benchmark, I find that the diversification gains from holding foreign corporate bonds are potentially even larger for US investors with high equity exposure.

7 Conclusion

Using a newly compiled dataset of international corporate bond quotes, this paper demonstrates the large potential for US investors to achieve portfolio gains through diversification in the corporate bond market. With only investment grade corporate bonds from advanced markets, I find that portfolio gains as measured by variance reduction and Sharpe ratio increases are large in both in-sample and out of sample analysis. For out of sample analysis, the portfolio gains to diversification in the corporate bond market are robust to different time periods and consistently outperform equities and sovereign bonds. By contrast, the portfolio gains from diversification in equity markets are unstable over time and have poor out of sample properties. This supports the studies that find benefits to diversification in equities are minimal when investors need it the most. For the most recent financial crisis, I find that international equity markets provided limited portfolio benefits for US investors, while corporate bonds would have offered significant risk reduction and Sharpe ratio gains.

Further, I find that the portfolio gains to holding foreign corporate bonds goes beyond investors of US corporate bonds. I show that diversified investors in domestic equities and bonds can also achieve portfolio diversification benefits from international corporate bonds. Using a benchmark portfolio with implied portfolio weights from Flow of Funds, I find that including foreign corporate bonds into a benchmark portfolio with US equities continue to produce higher monthly Sharpe ratios and lower portfolio volatility.

To further explore why these seemingly unexploited portfolio gains exist, I analyze four potential reasons: short sale constraints, bond characteristic, bond liquidity, and investor information access. I find that by imposing a non-negative portfolio weights, portfolio gains to diversification in equity markets dramatically decline, while the same restriction has little effect on gains in corporate bond markets. Similarly, when country portfolios are balanced by bond ratings, industry, and duration to match the US corporate bond benchmark portfolio, I find that significant gains still remain. Portfolio gains are also robust to filters on bond liquidity proxies such as age, size, and years to maturity. Last, I explore the potential effect of investor access to financial information on the firms that issue the foreign bonds. Using only foreign bonds from firms that also issue Yankee bonds in the US, I show that even foreign bonds with high investor recognition and financial reporting standards have the ability to generate large diversification gains for US investors.

These results provide a foundation for further research in this area. In particular, transactional data for international corporate bonds would greatly enhance our ability to examine additional sources for these unexploited gains. Further, analysis on the contribution of firms, industry, and country effects on return comovements and diversification potential may help to identify global versus local risks in this asset market. As well, in the spirit of Errunza, Hogan, and Hung (1999), the diversification gains found here can serve as a foundation to analyze the effectiveness of using cross-listed bonds known as Yankee bonds can capture the same portfolio benefits.

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A Data Construction

From the Merrill Lynch Bond index constituent lists, I impose filters on the types of bonds included in order to focus the analysis on cross country diversification. In particular, I standardize the credit risk across the country portfolios by eliminating any bond that is collateralized, Junior debt, or from quasi-government issuers. Further, I eliminate any bond that is issued by a firm domiciled outside of the country. This filtering method is used to control for effects of cross-listings, which may obscure the true investment opportunities of holding the country's bonds. For example, if there were many Chinese companies with listed bonds in the Japanese market, then the Merrill Japanese Bond index would not properly reflect the credit risk of Japanese companies. Further, the paper also examines the diversification potential for the equity market and sovereign bond market for the same set of countries. Therefore, the analysis would only make sense if the correct country was being used to compare, ie. if all firms in the Japanese Corporate Bond index were Chinese then comparing diversification gains from Japanese corporate bonds against Japanese equities would not be appropriate. Given these reasons, the country indices that I construct contain only bonds from firms domiciled in the market in which it trades. This specification is also similar with the MSCI index for equities[27]. Therefore, rather than using the Merrill Lynch corporate bond indices directly, I use the country corporate bond indices constructed with the above filters. With the filtered set of bond quotes, I re-weight the local currency total monthly bond returns using the Merrill Lynch index weights, and form clean country index returns denominated in the local currency. Total monthly returns are computed using bid-side month end closing prices plus difference in accrued interest. Coupon payments received within the month are assumed to be reinvested at the 1 month LIBID rate. Merrill Lynch index weights are based on market value of the outstanding amounts. The amount-outstanding accounts for partial calls, sinking-fund requirements, and re-opening of issues.

Since all portfolio gains will be from the perspective of a US investor, I translate local currency bond returns into US dollars returns using foreign exchange rates from Datastream. Unhedged

[27] Although, the MSCI will include firms in the location of their primary listing if the firm's domicile is for tax purposes only

returns are converted using the spot US dollar exchange rate, while hedged returns are computed using a 1 month forward rate on the current bond value plus the expected accrued interest. The spot rate is then used on any price change. This currency hedging method does leave some basis risk on the changes in bond value[28]. However, since price changes in bonds are generally small month to month, the bond returns are almost perfectly hedged. Since unhedged returns reflect both the risk of holding the bond as well as currency risk, diversification gains with unhedged returns would confound the effects from currency and corporate credit. Given the primary objective of this paper is to focus on diversification opportunities in the corporate bond markets, and not currency markets, this paper will use hedged returns.

For data on foreign equities, I use MSCI total country equity index returns in local currency available on Datastream, and convert it into dollar returns in the same way as described earlier for the foreign corporate bond returns. [29] Further, the sovereign bond returns are from the Merrill Lynch government bond indices. I also gather the Fama French factor returns from WRDS and the US risk free rate from and the return on the fixed term 30 year Treasury bond from CRSP. All data is sampled for the period of Jan 2000 - Dec 2010, which corresponds to the data period for the corporate bond portfolios.

B Bayesian Inference and Monte Carlo Simulation

Following Wang (1998), I assume that the representative US investor has a diffuse prior, or rather imposes no a priori beliefs, on the means and covariance structure of risky asset returns. Further, I assume the prior probability density to follow:

$$p(\mu, \Sigma) = p(\mu) * p(\Sigma), \quad p(\mu) \propto constant, \quad p(\Sigma) \propto |\Sigma|^{-(N+1)/2} \tag{9}$$

Let $R = (r_1, ..., r_N)'$ denotes a the matrix of excess returns for N risky assets with dimension NxT, and a mean vector μ and covariance matrix Σ. Let $\hat{\mu}$ be the Nx1 vector of sample mean

[28] This method also follows the calculation used by Merrill Lynch for their hedged index returns.

[29] This hedging method leaves larger basis risk in equity returns than bond returns since future prices are unlikely to be close to current prices in equities.

and $\hat{\Sigma}$ be the NxN matrix of sample covariances. Then the posterior density can be expressed as a function of the marginal densities:

$$p(\mu, \Sigma|R) = p(\mu|\Sigma, \hat{\mu}, T) * p(\Sigma|\hat{\Sigma}, T) \tag{10}$$

Under these assumptions, it is well-known that the marginal posterior density $p(\Sigma|\hat{\Sigma}, T)$ is an inverted Wishart distribution with the parameter matrix $T\hat{\Sigma}$ and T-1 degrees of freedom. Then the conditional distribution $p(\mu|\Sigma, \hat{\mu}, T)$ is multivariate normal with mean $\hat{\mu}$ and variance $1/T\Sigma$. Using the marginal distributions, the posterior distribution is particularly easy to implement using Monte Carlo methods. Specifically, I generate a random sample of 100,000 Σ from an inverted Wishart distribution with the parameter matrix $T\Sigma$ and T-1 degrees of freedom. Then for each draw of Σ, I draw a random μ from a multivariate distribution with mean $\hat{\mu}$ and variance $1/T\Sigma$. For each pair (μ, Σ), the diversification gain measures ϕ, δ, ψ can be computed using the optimization outlined above. Repeating this procedure for 100,000 independent draws, the resulting draws of ϕ, δ, ψ are obtained from their respective posterior distributions[30]. For inference against the null hypothesis that there is no diversification gain, I report the lowest 1% and 5% diversification gain, as well as the mean and standard deviation of the posterior distribution.

[30]Recall the diffuse prior was placed on the mean and covariance of returns, which does not necessarily translate to a diffuse prior on ϕ, δ, ψ. However, in simulation Li, Sarkar, and Wang (2003) find the implied priors for the diversification gain measures are also diffuse. See Li et al for further discussion.

Table 1: Summary of Data

This table summarizes the composition of corporate bonds in each country index. Top panel shows the total bond month observation, number of individual bonds, and number of issuing firms. Ratings and Industry composition is expressed as the percent of total monthly bond observations (Obs) within a category. The average, median, and maximum effective duration are statistics over all monthly bond observations. The sample period is Jan 2000 - Dec 2010

	AUS	CAN	EUR	JPN	UK	US
Obs	9,995	52,081	66,586	113,110	26,961	316,250
Bonds	326	1180	2012	2640	569	8295
Firms	124	286	468	203	246	1809
Ratings: as % of Obs						
AAA	10.65	1.89	11.64	1.20	3.00	2.75
AA	28.31	14.50	27.39	46.33	14.35	11.12
A	42.80	52.05	38.77	35.16	43.67	37.95
BBB	18.24	31.56	22.20	17.31	38.98	48.18
Industry: as % of Obs						
Financial	40.86	19.18	44.7	30.68	16.81	21.94
Industrials	52.82	67.90	43.17	33.56	57.92	70.08
Utility	6.32	12.93	12.13	35.75	25.27	7.98
Avg Duration	3	6	4	5	7	6
Median Duration	3	5	4	4	7	5
Max Duration	8	18	21	23	21	30

Table 2: Asset Returns: Jan 2000 - Dec 2010 (in Annualized Percent)

This table shows the annualized mean and standard deviation of excess returns for the corporate bond, sovereign bond, and equity country indices. The table also reports monthly first order autocorrelation for the same asset markets. Panel A presents these statistics for hedged dollar returns, while Panel B does the same for unhedged dollar returns. Germany is used to represent Europe in the equity and sovereign bond returns.

	AUS	CAN	EUR/GER	JPN	UK	US
Panel A: Hedged						
IG Corp Bonds						
Excess Rtn	1.68	4.54	3.56	1.95	3.44	5.23
Stdev	2.40	3.75	2.89	1.12	5.12	5.77
AC1	0.09	0.13	0.20	0.14	0.10	0.24
Sovereign						
Excess Rtn	1.61	4.04	3.87	3.03	2.64	6.14
Stdev	4.92	4.45	4.22	3.00	4.50	13.66
AC1	0.13	0.00	0.16	0.01	0.10	0.00
Equity						
Excess Rtn	4.79	5.83	0.36	-2.52	-0.09	-0.98
Stdev	13.42	16.42	23.06	18.15	15.24	16.55
AC1	0.15	0.23	0.08	0.25	0.08	0.16
Panel B: Un-hedged						
IG Corp Bonds						
Excess Rtn	9.22	8.65	6.60	1.65	4.62	5.23
Stdev	12.98	10.49	11.74	10.33	10.84	5.77
AC1	0.11	0.06	0.09	0.00	0.21	0.24
Sovereign						
Excess Rtn	7.42	7.67	6.22	1.88	3.44	6.14
Stdev	12.91	9.68	11.86	10.84	9.46	13.66
AC1	0.04	-0.02	0.05	0.02	0.03	0.00
Equity						
Excess Rtn	12.33	9.93	3.45	-2.82	1.10	-0.98
Stdev	22.65	22.75	26.00	18.10	17.88	16.55
AC1	0.17	0.18	0.11	0.21	0.26	0.16

Table 3: Monthly Return Correlation

This table reports the pairwise monthly correlation across country indices of corporate bonds, sovereign bonds, and equities. These correlations are computed using the hedged monthly US dollar returns for the three asset markets that span the sample period Jan 2000 - Dec 2010.

	AUS	CAN	EUR/GER	JPN	UK	US
Panel A: Investment Grade Corporate Bonds						
AUS	1.00	0.38	0.55	0.14	0.32	0.33
CAN		1.00	0.74	0.23	0.68	0.75
EUR			1.00	0.30	0.68	0.72
JPN				1.00	0.26	0.30
UK					1.00	0.62
US						1.00
Panel B: Sovereign Bonds						
AUS	1.00	0.73	0.74	0.33	0.70	0.68
CAN		1.00	0.77	0.33	0.79	0.81
GER			1.00	0.36	0.82	0.74
JPN				1.00	0.38	0.34
UK					1.00	0.76
US						1.00
Panel C: Equities						
AUS	1.00	0.68	0.68	0.64	0.75	0.73
CAN		1.00	0.71	0.61	0.74	0.84
GER			1.00	0.58	0.83	0.80
JPN				1.00	0.61	0.62
UK					1.00	0.87
US						1.00

Table 4: Diversified Corporate Bond Portfolios vs other International Asset Portfolios

This table reports the gains to international diversification in three asset markets: investment grade corporate bonds (IG), equities (Eq), and sovereign bonds (Sov). The US benchmark for each asset market is reported under US IG, US Eq, and US Sov for corporate bonds, equities, and sovereign bonds respectively. Columns US IG + Foreign IG, US Eq + Foreign Eq, and US Sov + Foreign Sov, represent internationally diversified portfolios for the same asset markets. Panels A, B, and C report the diversification gains when the international portfolio is the tangency portfolio, minimum variance portfolio, and naive 1/N portfolio respectively. All returns are expressed in monthly percent, in US dollars. Expected return is in excess of the US risk free rate. Portfolio diversification gain φ measures the monthly Sharpe ratio increase, ψ measures the percent volatility decrease, and δ measures monthly risk-adjusted expected return increase. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of gains are also reported. All returns are expressed in monthly percent, in US dollars, and span the sample period Jan 2000 - Dec 2010.

	US IG	US IG + Foreign IG	US Sov	US Sov + Foreign Sov	US Eq	US Eq + Foreign Eq
Panel A: Tangency Portfolio						
Expected Return	0.44	0.20	0.38	0.44	-0.08	3.06
Volatility	1.66	0.34	1.73	1.04	4.78	10.88
Mean φ		0.36		0.25		0.36
Stdev φ		0.10		0.09		0.12
1% lowest φ		0.15		0.07		0.11
5% lowest φ		0.21		0.11		0.17
Panel B: Min Variance Portfolio						
Expected Return	0.44	0.16	0.38	0.25	-0.08	0.32
Volatility	1.66	0.30	1.73	0.78	4.78	3.54
Mean ψ		82.4%		55.7%		27.3%
Stdev ψ		1.5%		3.5%		4.4%
1% lowest ψ		78.5%		47.0%		17.5%
5% lowest ψ		79.7%		49.8%		20.3%
Panel C: 1/N Naive Portfolio						
Expected Return	0.44	0.28	0.38	0.26	-0.08	0.10
Volatility	1.66	0.82	1.73	1.12	4.78	4.27
Mean δ		0.14		0.03		0.20
Stdev δ		0.07		0.07		0.16
1% lowest δ		-0.03		-0.12		-0.18
5% lowest δ		0.02		-0.08		-0.07

Table 5: Portfolio Gains During Financial Crisis of 2008 - 2010

This table reports the diversification gains during the recent financial crisis, or the subsample from Jan 2008 to Dec 2010. All returns are expressed in monthly percent, in US dollars. IG denotes investment grade corporate bonds, Eq represents equities, and Sov indicate sovereign bonds. In-sample portfolios are estimated using the data from the crisis period of Jan 2008 to Dec 2010. Out-of-sample portfolios are estimated using pre-crisis returns from Jan 2000 - Dec 2007, and using those fixed weights to compute realized returns during Jan 2008 - Dec 2010. Expected return is in excess of the US risk free rate. Portfolio diversification gain φ measures the monthly Sharpe ratio increase, ψ measures the percent volatility decrease, and δ measures monthly risk-adjusted expected return increase. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of gains are also reported.

	US IG	US IG + Foreign IG	US Sov	US Sov + Foreign Sov	US Eq	US Eq + Foreign Eq
In Sample						
Panel A: Tangency Portfolio						
Expected Return	0.73	0.30	0.50	0.47	-0.07	21.16
Volatility	2.34	0.37	2.14	1.06	6.43	53.28
Mean φ		0.60		0.37		0.56
Stdev φ		0.21		0.17		0.22
1% lowest φ		0.18		0.06		0.12
5% lowest φ		0.28		0.12		0.22
Panel B: Min Variance Portfolio						
Expected Return	0.73	0.22	0.50	0.32	-0.07	-0.19
Volatility	2.34	0.32	2.14	0.88	6.43	5.01
Mean ψ		87.4%		61.7%		27.9%
Stdev ψ		2.3%		6.2%		8.3%
1% lowest ψ		81.2%		45.5%		9.7%
5% lowest ψ		83.3%		50.9%		14.3%
Panel C: 1/N Naive Portfolio						
Expected Return	0.73	0.49	0.50	0.42	-0.07	-0.21
Volatility	2.34	1.03	2.14	1.42	6.43	5.75
Mean δ		0.39		0.13		-0.17
Stdev δ		0.23		0.16		0.35
1% lowest δ		-0.13		-0.24		-0.99
5% lowest δ		0.02		-0.13		-0.74
Out of Sample						
Panel D: Tangency Portfolio						
Expected Return	0.73	0.28	0.50	0.50	-0.07	0.33
Volatility	2.34	0.39	2.14	1.34	6.43	8.84
Out of Sample φ		0.42		0.14		0.05
Panel E: Min Variance Portfolio						
Expected Return	0.73	0.22	0.50	0.37	-0.07	-0.18
Volatility	2.34	0.36	2.14	1.00	6.43	5.25
Out of Sample ψ		84.8%		53.2%		18.3%

Table 6: Diversification Gains and Portfolio Constraints

This table compares the effect of short sale constraints on portfolio gains to diversification in the equity and corporate bond market. All returns are expressed in monthly percent, in US dollars, and span the sample period Jan 2000 - Dec 2010. The No Short Sale column restricts portfolio weights to to be non-negative, while the Unconstrained column does not. Expected return in excess of the US risk free rate. IG denotes investment grade corporate bonds and Eq represents equities. Portfolio diversification gain φ measures the monthly Sharpe ratio increase and ψ measures the percent volatility decrease. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of gains are also reported.

		No Short Sale	Unconstrained		No Short Sale	Unconstrained
	US IG	US IG + Foreign IG	US IG+ Foreign IG	US Eq	US Eq + Foreign Eq	US Eq + Foreign Eq
Panel A: Tangency Portfolio						
Expected Return	0.44	0.19	0.20	-0.08	0.44	3.04
Volatility	1.66	0.34	0.34	4.78	3.89	10.79
Mean φ		0.31	0.36		0.15	0.36
Stdev φ		0.08	0.10		0.05	0.12
1% lowest φ		0.13	0.15		0.04	0.11
5% lowest φ		0.17	0.21		0.07	0.17
Panel B: Min Var Portfolio						
Expected Return	0.44	0.16	0.16	-0.08	0.29	0.33
Volatility	1.66	0.31	0.30	4.78	3.76	3.54
Mean ψ		81.5%	82.4%		22.1%	27.3%
Stdev ψ		1.5%	1.5%		3.7%	4.4%
1% lowest ψ		77.6%	78.5%		13.4%	17.5%
5% lowest ψ		78.9%	79.7%		16.0%	20.3%

Table 7: Diversification Gains and Characteristic Balanced Portfolios

This table reports diversification gains when the international corporate bond portfolios are industry, ratings, or duration balanced to match the US corporate bond portfolio. All returns are expressed in monthly percent, in US dollars, and span the sample period Jan 2000 - Dec 2010. The bonds in each foreign portfolio is sorted into rating bins, industry bins, and duration bins. Then using the US portfolio weights for each rating bin, each foreign country's rating bin returns are re-weighted to form the ratings balanced country portfolio return. All IG column reports unbalanced foreign portfolio. Expected return in excess of the US risk free rate. Portfolio diversification gain φ measures the monthly Sharpe ratio increase and ψ measures the percent volatility decrease. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of gains are also reported.

	US	All IG UnBalanced	Ratings Balanced	Industry Balanced	Duration Balanced
Panel A: Tangency Portfolio					
Expected Return	0.44	0.20	0.22	0.25	0.41
Volatility	1.66	0.34	0.39	0.46	0.82
Mean φ		0.36	0.33	0.31	0.28
Stdev φ		0.10	0.10	0.09	0.09
1% lowest φ		0.15	0.13	0.12	0.09
5% lowest φ		0.21	0.18	0.16	0.14
Panel B: Min Variance Portfolio					
Expected Return	0.44	0.16	0.17	0.19	0.16
Volatility	1.66	0.30	0.35	0.40	0.51
Mean ψ		82.4%	79.3%	76.2%	69.9%
Stdev ψ		1.5%	1.8%	2.1%	2.5%
1% lowest ψ		78.5%	74.9%	71.0%	63.6%
5% lowest ψ		79.7%	76.3%	72.7%	65.6%

Table 8: Diversification Gains and Liquidity Adjusted Portfolios

This table reports the diversification gains when foreign corporate bond portfolios contain bonds with higher liquidity. The column labeled Size uses only those foreign bonds at the top 20% of each market. The column labeled AgeYTM includes only foreign bonds with less than 2 years from issue date and more than 2 years left to maturity. Column All IG uses all available foreign bonds. All returns are expressed in monthly percent, in US dollars, and span the sample period Jan 2000 - Dec 2010. Expected return in excess of the US risk free rate. Portfolio diversification gain φ measures the monthly Sharpe ratio increase and ψ measures the percent volatility decrease. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of gains are also reported.

	US	All IG	Size	AgeYTM
Panel A: Tangency Portfolio				
Expected Return	0.44	0.20	0.20	0.25
Sharpe Ratio	1.66	0.34	0.35	0.51
Mean φ		0.36	0.35	0.28
Stdev φ		0.10	0.10	0.09
1% lowest φ		0.15	0.15	0.10
5% lowest φ		0.21	0.20	0.14
Panel B: Min Variance Portfolio				
Expected Return	0.44	0.16	0.16	0.18
Volatility	1.66	0.30	0.31	0.43
Mean ψ		82.4%	81.6%	74.5%
Stdev ψ		1.5%	1.6%	2.2%
1% lowest ψ		78.5%	77.5%	69.1%
5% lowest ψ		79.7%	78.8%	70.8%

Table 9: Diversification Gains and Investor Information

This table reports the diversification gains from foreign bond issuers are identified to have accessible financial information and recognition with US investors. US IG column reports diversification gains for all bond and column CAN, EUR, JPN, UK uses all bonds from this subset of countries. Column labeled Foreign Listed in US uses only foreign bonds issued by firms that also have a Yankee bond issue in the US. And column labeled US Listed Abroad reports the diversification gains from foreign traded bonds issued by US firms. All returns are expressed in monthly percent, in US dollars, and span the sample period Jan 2000 - Dec 2010. Expected return in excess of the US risk free rate. Portfolio diversification gain φ measures the monthly Sharpe ratio increase and ψ measures the percent volatility decrease. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of gains are also reported. The top two panel reports returns for the full sample Jan 2000 - Dec 2010, while the bottom two panels looks at the subperiod Feb 2005 - Dec 2010.

	US IG	CAN, EUR, JPN, UK	Foreign Listed in US	US Listed Abroad
Full Sample: Jan 2000 - Dec 2010				
Panel A: Tangency Portfolio				
Expected Return	0.44	0.20	0.22	
Volatility	1.66	0.33	0.39	
Mean φ		0.35	0.34	
Stdev φ		0.10	0.10	
1% lowest φ		0.15	0.14	
5% lowest φ		0.20	0.19	
Panel B: Min Variance Portfolio				
Expected Return	0.44	0.17	0.19	
Volatility	1.66	0.31	0.36	
Mean ψ		81.7%	78.6%	
Stdev ψ		1.6%	1.9%	
1% lowest ψ		77.7%	74.0%	
5% lowest ψ		78.9%	75.5%	
Half Sample: Feb 2005 - Dec 2010				
Panel C: Tangency Portfolio				
Expected Return	0.35	0.18	0.18	0.47
Volatility	1.83	0.34	0.35	1.26
Mean φ		0.39	0.39	0.26
Stdev φ		0.14	0.14	0.12
1% lowest φ		0.11	0.11	0.04
5% lowest φ		0.18	0.18	0.08
Panel D: Min Variance Portfolio				
Expected Return	0.35	0.16	0.16	0.39
Volatility	1.83	0.32	0.33	1.14
Mean ψ		83.1%	82.3%	39.0%
Stdev ψ		2.1%	2.1%	5.8%
1% lowest ψ		77.8%	76.8%	25.1%
5% lowest ψ		79.5%	78.6%	29.2%

Table 10: Portfolio Diversification for US Equity Investors

This table shows the portfolio gains from including foreign corporate bonds for a well-diversified US investor in domestic equities and bonds. All returns are expressed in monthly percent, in US dollars, and span the sample period Jan 2000 - Dec 2010. Expected return in excess of the US risk free rate. The US column under Multi-Asset uses the MSCI US equity, US corporate bond portfolio, and the 30 year Treasury to construct the domestic benchmark. The column labeled US under the FF Factor uses the returns for mktrf, smb, hml, along with US corporate bond and the 30 Treasury for the US benchmark. Last, the column labeled US under Flow of Funds uses portfolio weights implied by the Flow of funds tables to compute US benchmark return. Columns labeled US + Foreign IG represents a portfolio with the US benchmark plus foreign corporate bonds. Portfolio diversification gain φ measures the monthly Sharpe ratio increase and ψ measures the percent volatility decrease. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of gains are also reported.

	Multi-Asset		FF Factors		Flow of Funds	
	US	US + Foreign IG	US	US + Foreign IG	US	US + Foreign IG
Panel A: Tangency Portfolio						
Expected Return	0.50	0.20	0.53	0.22	0.16	0.20
Volatility	1.79	0.34	1.38	0.37	3.71	0.34
Mean φ		0.34		0.26		0.57
Stdev φ		0.10		0.08		0.12
1% lowest φ		0.14		0.09		0.30
5% lowest φ		0.19		0.13		0.38
Panel B: Min Variance Portfolio						
Expected Return	0.41	0.15	0.49	0.16	0.16	0.15
Volatility	1.63	0.29	1.33	0.30	3.71	0.29
Mean ψ		81.6%		77.4%		92.2%
Stdev ψ		1.6%		2.0%		0.7%
1% lowest ψ		77.6%		72.5%		90.4%
5% lowest ψ		78.9%		74.1%		91.0%

Figure 1: Volatility of Naive International Corporate Bond Portfolio vs. US Corporate Bond Benchmark

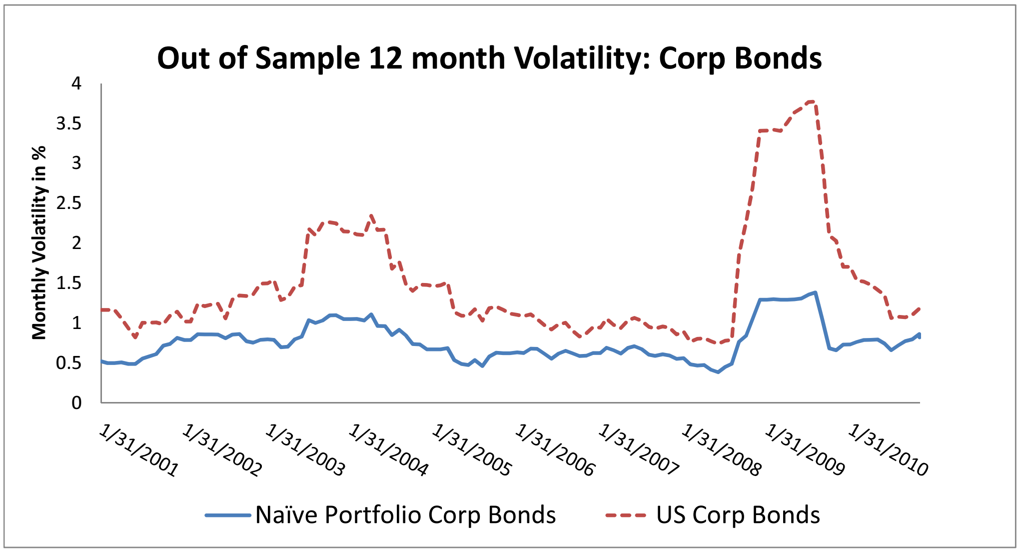

Figure 2: Volatlity of Naive International Equity Portfolio vs. US Equity Benchmark

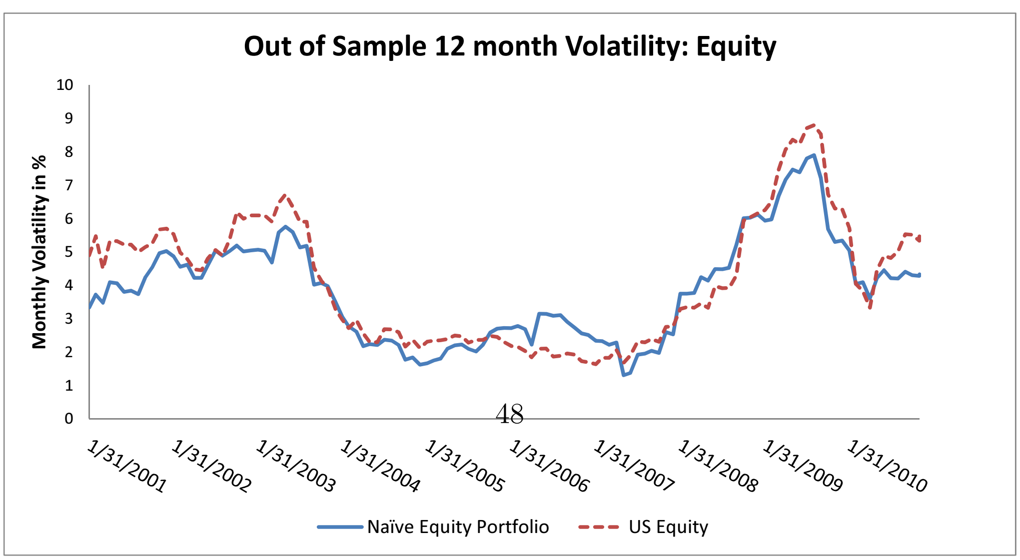

Figure 3: Sharpe Ratio of Naive International Corporate Bond Portfolio vs. US Corporate Bond Benchmark

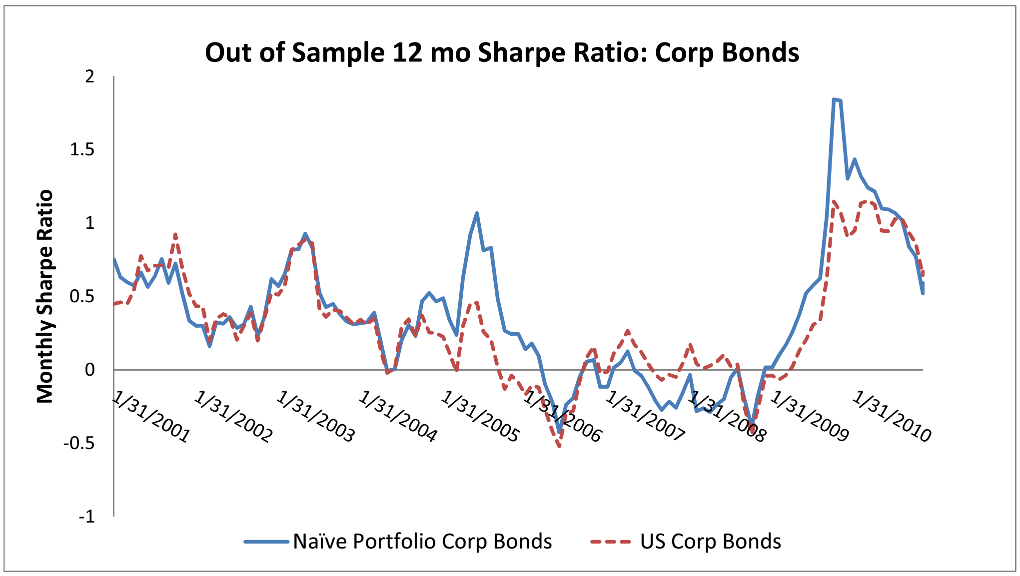

Figure 4: Sharpe Ratio of Naive International Equity Portfolio vs. US Equity Benchmark