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Portfolio Diversification and International Corporate Bonds

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Abstract

This article examines the benefits of corporate bond diversification for U.S. investors. Analysis of a newly compiled bond-level data set for 2000–2010 finds that diversification with corporate bonds can significantly reduce volatility and increase risk-adjusted returns for U.S. investors. Unlike diversification with equities, corporate bonds offer significant out-of-sample risk reduction, particularly during the recent financial crisis. Risk-reduction gains are large even when the benchmark includes international equities or when longer samples of equities and sovereign bonds are used to inform corporate bond returns. Finally, significant risk-reduction gains remain after accounting for bond characteristics, liquidity, and informational costs.

I. Introduction

At $7.5 trillion, the corporate bond market is one of the largest asset markets in the United States.[1] Although investment-grade bonds have long been considered low-risk assets that require little need for diversification, the unprecedented high volatility observed during the recent financial crisis has challenged this conventional view. In contrast to the extensive literature on the benefits of equity diversification, little is known about the potential for diversification across corporate bond markets. Corporate bonds are particularly useful for studying diversification in the bond markets because they can be analyzed at both the firm and country levels. Moreover, corporate bond returns and equity returns are closely related, as demonstrated in the Merton (1974) model. Finally, as documented by Burger and Warnock (2007), U.S. investors hold a minimal amount of international bonds. This makes measures of diversification gains important for understanding the consequences of any potential home bias in the bond market. This article addresses the gap by asking: Can U.S. investors achieve portfolio diversification gains with international corporate bonds? And if so, how significant are these gains?

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[1]Source: Securities Industry and Financial Markets Association (SIMFA) as of Dec. 2010.

To that end, I construct country portfolios from a newly collected panel data set of individual corporate bond quotes from six advanced markets for Jan. 2000–Dec. 2010.[2] The main findings of this article 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 the Sharpe ratio for U.S. investors. During the last decade, investors holding a U.S. corporate bond-only benchmark could have reduced portfolio risk by as much as 80.0% and increased the monthly Sharpe ratio by 0.341 by adding foreign corporate bonds. Even when the U.S. benchmark includes international equities, foreign corporate bonds continue to generate large and significant risk-reduction gains for U.S. investors. Furthermore, I find that these large risk reductions did not diminish during the recent financial crisis of 2008. The out-of-sample gains suggest that risk-reduction gains may have been as large as 83.2% during the crisis period.

Second, international equities and corporate bonds offer different diversification benefits for U.S. investors. I find that corporate bonds offer significantly larger risk-reduction gains than international equities. By contrast, although Sharpe ratio gains from corporate bonds are also larger than from equities, the difference is not statistically significant. However, Sharpe ratio gains from international equities are greatly reduced under short-sale constraints. Therefore, corporate bonds appear to offer both superior risk-reduction potential and Sharpe ratio gains that are less sensitive to non-negative portfolio constraints, as compared to equities.

Third, I find that risk-reduction gains remain large, even when the moments of corporate bond returns are jointly estimated with longer histories of equity and sovereign bond returns. Although equity returns were noticeably higher in the longer sample of 1985–2010 as compared to the shorter sample of 2000–2010, the low correlation between equities and corporate bonds dampens the effect of this variation on corporate bond returns. In comparison, sovereign bond returns are highly correlated with corporate bond returns but do not change substantially between the long and short sample periods. Therefore, the combined estimation not only preserves the return characteristics of corporate bond returns but also continues to imply large and significant risk-reduction gains for U.S. investors.

In light of these results, I explore several potential explanations for the large diversification gains to U.S. investors. I begin by examining whether a mismatch in bond characteristics between the U.S. and international corporate bond portfolios can explain the diversification gains. To this end, I rebalance foreign corporate bond portfolios to have the same proportion of bonds by rating, duration, and industry composition as the U.S. corporate bond benchmark. I find only a small reduction in diversification gains. Furthermore, I explore the possibility that liquidity differences across domestic and foreign corporate bond portfolios can reconcile the diversification gains. After eliminating potentially illiquid bonds, as proxied by older bonds and bonds from smaller issuances, I find that large and significant risk reduction gains remain. Finally, I investigate whether differences

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

in information quality and investor recognition across domestic and foreign corporate bond portfolios explain these gains. To ensure regularity in financial reporting and familiarity to U.S. investors, I use only foreign bonds from issuers that also have a Yankee bond listed in the United States.[3] Again, I find that this exclusion does not substantially reduce the implied diversification gains.

This article seeks to bridge the gap between the portfolio efficiency and diversification literature and the corporate bond risk literature. The portfolio diversification literature has produced a long line of research focusing on international equities, for both advanced markets and emerging markets. Papers with this focus include Jorion (1985), DeSantis (1993), Bekaert and Urias (1996), Harvey (1995), Ferson and Harvey (1993), Heston and Rouwenhorst (1994), Ang and Bekaert (2002), and Li, Sarkar, and Wang (2003). Conversely, the corporate bond literature explores the pricing of risk factors, with little consideration for diversification. For example, Duffie and Singleton (1999), Duffee (1999), Elton, Gruber, Agrawal, and Mann (2001), Chen, Lesmond, and Wei (2007), Campbell and Taksler (2003), De Jong and Driessen (2012), and Bao, Pan, and Wang (2011) examine the effect of recovery, default probabilities, taxes, liquidity, and equity return volatility on bond pricing. Finally, there is a small and limited diversification literature on bonds that focuses almost exclusively on sovereign bonds. Papers along these lines include Ilmanen (1995), Levy and Lerman (1988), Jorion (1989), and more recently Longstaff, Pan, Pedersen, and Singleton (2011), Hansson, Liljeblom, and Loflund (2009), and Burger and Warnock (2007). Rather than studying sovereign bonds, this is the first paper to focus on international corporate bonds. As mentioned above, like equities, corporate bonds can be analyzed at the firm level in a way that sovereign bonds cannot. Moreover, the firm-level relation between equities and corporate bonds can be further exploited to understand common risks across equity and bond markets.

The article is organized as follows: Section II outlines the portfolio allocation strategies and defines diversification gain measures. Section III describes the data and summarizes the returns. Section IV analyzes the diversification gains for the full sample, with and without short-sale constraints. Section V evaluates out-of-sample risk-reduction gains, both before and during the recent financial crisis. Section VI combines long-sample data of equities and sovereign bonds to augment the short-sample estimates of international corporate bonds. Section VII analyzes various explanations for diversification gains, such as bond characteristics, liquidity differences, and informational costs. Section VIII explores the role of exchange-rate hedging. Section IX concludes.

II. Model and Empirical Design

To form the benchmark and diversified portfolios, I evaluate two efficient portfolios on the mean-variance efficient frontier and an augmented equal-weighted portfolio. Following the standard Markowitz (1952) mean-variance framework, I assume that the representative U.S. investor's preference is fully

[3]Yankee bonds are dollar-denominated cross-listed bonds from foreign issuers that trade in the United States and are subject to U.S. Securities and Exchange Commission (SEC) disclosure rules.

described by the mean and variance of a chosen portfolio. Given a multivariate normal vector of N asset returns, $R=(r_1,\ldots,r_N)'$, with mean $\mu=(\mu_1,\ldots,\mu_N)'$, a covariance matrix Σ, and the risk-free rate r_f, the tangency portfolio maximizes the portfolio Sharpe ratio among all portfolios of risky assets. The vector of portfolio weights for the tangency portfolio, w_{tan}, is:

$$w_{\text{tan}} = \frac{\Sigma^{-1}\times(\mu-r_f)}{i'\times\Sigma^{-1}\times(\mu-r_f)}, \tag{1}$$

where i is a vector of N ones. Although the tangency portfolio represents one way to optimally trade off expected return and volatility, a large literature on estimation errors has shown that estimates of mean returns are often unstable in finite small samples. The large estimation error in computing mean returns can lead the tangency portfolio to have volatile weights across sample periods and poor out-of-sample performance. Green and Hollifield (1992) and Jagannathan and Ma (2003) argue that little is lost by ignoring the mean return and instead studying the minimum-variance portfolio.[4] The minimum-variance portfolio is the lowest risk portfolio on the efficient frontier that depends only on the covariance structure of returns. The minimum-variance portfolio weight, w_{mv}, is given by:

$$w_{\text{mv}} = \frac{\Sigma^{-1}\times i}{i'\times\Sigma^{-1}\times i}. \tag{2}$$

In addition to the portfolios on the mean-variance frontier, I evaluate the performance of a simple augmented equal-weight strategy. The naive $1/N$ portfolio allocation strategy advocated by DeMiguel, Garlappi, and Uppal (2009) does not rely on any parameter estimates or optimization and was shown to have out-of-sample performance similar to that of a large class of more sophisticated portfolio allocation strategies. One drawback to the naive $1/N$ portfolio is that the monthly rebalancing can introduce liquidity concerns and impose large transaction costs; therefore, I use an initial equal-weight (IEW) strategy, advocated by Asparouhova, Bessembinder, and Kalcheva (2013) and Blume and Stambaugh (1983), that rebalances portfolio positions to equal weights at the beginning of each year.

A. Measures of Diversification Gains

Corresponding to the portfolio allocation strategies outlined above, I measure portfolio gains in two ways: a reduction in portfolio volatility and an increase in risk-adjusted return (Sharpe ratio).[5] From the perspective of a representative U.S. investor, diversification gains are evaluated against three benchmark specifications: a U.S. corporate bond portfolio; a U.S. multi-asset portfolio that includes U.S. corporate bonds, equities, and Treasuries; and a U.S. multi-asset with international equities portfolio. For all benchmark specifications, the same asset

[4]Other proposed methods to address estimation error include shrinkage methods and asset pricing models.

[5]Gains can also be evaluated in terms of welfare losses. Results for certainty equivalent return gains, following DeMiguel et al. (2009), are similar to the reported Sharpe ratio gains.

allocation strategy is used for both the benchmark and the diversified portfolio weights. The Sharpe ratio gain, φ, is defined as:

$$\text{(3)} \qquad \varphi(w^* \mid w^B, \mu, \Sigma, r_f) \quad \equiv \quad \max \left\{ \frac{(w^{*'} \mu - r_f)}{\sqrt{(w^{*'} \Sigma w^*)}} - \frac{(w^{B'} \mu - r_f)}{\sqrt{(w^{B'} \Sigma w^B)}} \right\},$$

where w^* is the vector of weights for the diversified portfolio and w^B is the vector of weights for the benchmark assets. Because the tangency portfolio achieves the maximal Sharpe ratio portfolio on the mean-variance frontier, φ can be interpreted as the Sharpe ratio increase of moving from the benchmark tangency portfolio to the optimally diversified tangency portfolio.

In addition to Sharpe ratio gains, diversification gains can be measured by pure risk reduction. Following the discussion above on the estimation error for expected returns and the instability of the tangency portfolio, a more robust measure of diversification benefits may be risk-reduction gains. Furthermore, it can be argued that expected returns are likely to be comparable across the developed markets examined in this article, and that the only true diversification is through risk reduction. Given these considerations, I focus primarily on risk-reduction gains. I define the risk-reduction gain, ψ, as:

$$\text{(4)} \qquad \psi \left(w^* \mid w^B, \mu, \Sigma \right) \quad \equiv \quad \max \left\{ 1 - \frac{\sqrt{(w^{*'} \Sigma w^*)}}{\sqrt{(w^{B'} \Sigma w^B)}} \right\}.$$

Because, by design, the minimum-variance portfolio achieves the lowest possible variance, ψ will be the percentage volatility reduction for the optimally diversified minimum-variance portfolio over the benchmark minimum-variance portfolio.

For statistical inference, I follow Wang (1998) and use Monte Carlo methods to generate a Bayesian posterior distribution for the two diversification gains defined above. Starting with a diffuse prior, I evaluate the posterior distribution of φ and ψ against the null hypothesis that diversification gains are 0. As described in Wang, this inference method can easily accommodate test statistics with unknown sampling distributions, which is the case for the defined diversification measures under short-sale constraints. In addition, I use bootstrap methods to compare the gains from equities with the gains from corporate bonds. I bootstrap asset returns with replacement to construct a sequence of 120 monthly returns that is used to compute the mean and volatility of returns for the U.S. multi-asset benchmark and the diversified portfolio with either international equities or international corporate bonds. I then compute the probability (p-value) that gains from corporate bonds are lower than those from equities, from a sample of 250,000 bootstrapped simulations.

III. Data

To analyze the diversification benefits from corporate bonds, time series of 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, the

United Kingdom, and the United States.[6] The monthly data span Jan. 2000–Dec. 2010.

Table 1 describes the composition of country bond portfolios. The U.S. corporate bond index has the largest number of observations at 316,250 monthly bond quotes. The U.S. market also has the largest number of bonds and issuing firms at 8,295 bonds issued by 1,809 firms. In comparison, Japan has 2,640 bonds but issued by only 203 firms. Japanese firms tend to issue shorter maturity bonds, with more frequent rollover. Table 1 also reports the number of observations by rating and industry. The majority of bonds are rated A or BBB, and industrial firms are the heaviest issuers across all corporate bond markets.

TABLE 1

Summary of Data

Table 1 summarizes the composition of corporate bonds in each country index. The top panel shows the number of monthly bond observations, number of individual bonds, and number of issuing firms. The next two panels report the breakdown of monthly bond observations by ratings and industry, as a percentage of total monthly bond observations. The last panel reports average, median, and maximum effective duration are computed across monthly bond observations. The sample period is Jan. 2000–Dec. 2010.

	AUS	CAN	EUR	JPN	UK	US
No. of obs.	9,995	52,081	66,586	113,110	26,961	316,250
Bonds	326	1,180	2,012	2,640	569	8,295
Firms	124	286	468	203	246	1,809
By 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
By industry (as % of obs.)						
Financial	40.86	19.18	44.7	30.68	16.81	21.94
Industrial	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

In addition, Table 2 summarizes the return properties of international corporate bonds. To put the newly compiled corporate bond data into perspective with other asset markets, I report returns for equities and sovereign bonds.[7] Because diversification gains are computed from the perspective of a U.S. investor, all foreign returns are translated into U.S. dollar returns and taken in excess of the U.S. risk-free rate.[8] To target diversification gains only from bond dynamics, the majority of this article focuses on the hedged returns reported in Panel A, as the absence of currency risk allows them to exhibit return characteristics that are most comparable to U.S. bonds.[9] Unhedged returns (spot returns) in Panel B are

[6]All bonds must be investment grade, with a minimum par requirement, 1 year or more left to maturity, and a fixed coupon. Additional details on bond index construction are available from Merrill Lynch (https://www.ml.com).

[7]Germany substitutes for Europe. Equity returns are from Morgan Stanley Capital International (MSCI) and sovereign bonds are from Merrill Lynch Government Bond Indices.

[8]The U.S. risk-free rate is from the Fama–French monthly returns in Wharton Research Data Services (WRDS). U.S. Treasury or sovereign return is from the Merrill Lynch 7- to 15-year U.S. government bond index.

[9]Global bond mutual funds such as JPMorgan Global Corporate Bond Fund benchmark their performance to the hedged USD Merrill Lynch bond index.

TABLE 2

Asset Returns: Summary Statistics

Table 2 shows the annualized mean, annualized standard deviation, and monthly correlation of corporate bond, sovereign bond, and equity returns over Jan. 2000–Dec. 2010. Panels A and B present hedged and unhedged dollar returns in percentages. Panel C reports the correlation for monthly hedged dollar returns for the three asset markets. Germany represents Europe in the equity and sovereign bond returns. IG stands for investment grade.

	AUS	CAN	EUR/GER	JPN	UK	US
Panel A. Hedged						
1. IG Corporate Bonds						
Mean return	4.16	7.03	6.04	4.43	5.92	7.71
Std. dev.	2.42	3.66	2.79	1.26	5.06	5.70
2. Sovereign						
Mean return	3.76	6.45	6.06	5.42	5.11	7.20
Std. dev.	4.98	4.45	4.31	3.08	4.50	7.22
3. Equity						
Mean return	7.28	8.31	2.84	−0.04	2.40	1.50
Std. dev.	13.44	16.38	23.05	18.14	15.20	16.50
Panel B. Unhedged						
1. IG Corporate Bonds						
Mean return	11.71	11.13	9.13	4.13	7.11	7.71
Std. dev.	12.86	10.42	11.75	10.21	10.79	5.70
2. Sovereign						
Mean return	11.31	10.55	9.15	5.13	6.30	7.20
Std. dev.	12.94	9.59	11.98	10.79	9.44	7.22
3. Equity						
Mean return	14.82	12.41	5.93	−0.33	3.58	1.50
Std. dev.	22.60	22.71	25.97	18.01	17.84	16.50
Panel C. Correlation						
1. IG Corporate Bonds						
AUS	1.00	0.36	0.55	0.21	0.32	0.32
CAN		1.00	0.73	0.19	0.68	0.75
EUR			1.00	0.26	0.69	0.71
JPN				1.00	0.23	0.25
UK					1.00	0.63
US						1.00
2. Sovereign Bonds						
AUS	1.00	0.74	0.76	0.36	0.71	0.70
CAN		1.00	0.76	0.35	0.79	0.84
GER			1.00	0.35	0.82	0.79
JPN				1.00	0.38	0.34
UK					1.00	0.80
US						1.00
3. Equities						
AUS	1.00	0.66	0.68	0.64	0.73	0.74
CAN		1.00	0.65	0.61	0.71	0.80
GER			1.00	0.54	0.81	0.81
JPN				1.00	0.59	0.61
UK					1.00	0.86
US						1.00

included for comparison and are used below to examine the effects of currency hedging on diversification gains.

Panel A of Table 2 compares the annualized returns for hedged assets across different countries.[10] For bond markets, differences in the mean returns are small, and differences in the volatility estimates are larger. In particular, the U.S. corporate bond portfolio has the highest annualized return volatility, at 5.70%, as compared to the other advanced economy corporate bond markets, whose return volatilities range from 1.26% per year for Japan to 5.06% per year for the

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

United Kingdom.[11] When I compare hedged versus unhedged returns, I find that hedging currency risk dramatically reduces the volatility of bond returns. By contrast, the volatility difference between hedged and unhedged returns for equities is less pronounced. Moreover, currency variation dominates the unhedged return volatility of sovereign bonds and corporate bonds, thus making the return characteristics across these two bond types very similar. In comparison, hedged returns exhibit more noticeable volatility differences across the two bond types.

The potential for variance reduction depends crucially on the correlation structure of international markets. Therefore, I include in Table 2 the correlation of monthly hedged returns for corporate bonds, sovereign bonds, and equities. As Panel C illustrates, the pairwise correlations are lower for the corporate bond markets than for the equity markets for the same countries. The correlations across equity markets are consistently above 0.50, whereas the correlations for corporate bond returns can be as low as 0.19. For example, Australian corporate bonds have a 0.32 correlation with U.S. corporate bonds, whereas Australian equities have a 0.74 correlation with U.S. equities. Moreover, hedged corporate bond returns present lower correlation than sovereign returns for each country pair. These low correlations across the international corporate bond markets play a critical role in generating significant risk-reduction gains.

IV. Corporate Bond Diversification and Portfolio Gains

Table 3 illustrates the portfolio gains to U.S. investors from corporate bond diversification. Columns 1 and 2 report the return characteristics of the U.S. investment-grade corporate bond benchmark (US IG) and of the diversified portfolio of U.S. and international corporate bonds (Bench + Intl IG). The US IG return in Panel A has monthly expected return of 0.643% and volatility of 1.645%, or annualized expected return of 7.72% and volatility of 5.70%. For the diversified portfolio of U.S. and foreign corporate bonds, the tangency portfolio has monthly expected return of 0.423% and volatility of 0.380%. Similarly, the minimum-variance portfolio has monthly expected return of 0.374% and volatility of 0.334%. Therefore, it is clear that although the diversified portfolio offers substantially lower volatility, the lower volatility is accompanied by lower expected return.

One way to evaluate the combined effect of lower volatility and lower expected return is through the Sharpe ratio. The posterior distribution of the Sharpe ratio gain, φ, in Panel B of Table 3 shows an average increase of 0.341 in the monthly Sharpe ratio, with the lowest 1% gain at 0.140.[12] Although these results indicate significant Sharpe ratio gains, the tangency portfolio is susceptible to large estimation errors. Alternatively, I measure the volatility reduction to the minimum-variance portfolio. The posterior distribution of the pure risk-reduction gain, ψ, in

[11] To test for stale data, I compute first-order autocorrelation for the newly constructed corporate bond indices. Serial correlations are comparable to those of the commonly used MSCI equity indices.

[12] An earlier version of this paper conducted mean-variance intersection and spanning tests. Intersection and spanning were rejected for each country portfolio at the 1% confidence level, except for the United Kingdom.

TABLE 3

Diversified Gains in U.S. Benchmark Portfolios

Table 3 reports the diversification gains for three U.S. benchmark portfolios: investment-grade corporate bonds only (US IG); U.S. corporate bonds, equities, and Treasuries (US(IG + Eq + Gov)); and the diversified portfolio of U.S. corporate bond, U.S. equity, U.S. Treasury, and international equities (US(IG + Eq + Gov) + Intl Eq). Diversified portfolios with international corporate bonds are reported in columns 2, 5, and 7 and those with international equities are reported in column 4. Min-var stands for minimum variance, and Diff pVal stands for difference in p-values. Panels A and C report portfolio returns for the tangency portfolio and the minimum-variance portfolio, with and without short-sale constraint, respectively. Panels B and D report the mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of Sharpe ratio gains, φ, and risk-reduction gains, ψ. All returns are expressed in U.S. dollars and as a monthly percentage. The sample spans Jan. 2000–Dec. 2010.

	US IG	Bench + Intl IG	US(IG + Eq + Gov)	Bench + Intl Eq	Bench + Intl IG	US(IG + Eq + Gov) + Intl Eq	Bench + Intl IG
	Without Short-Sale Constraint						
	1	2	3	4	5	6	7
Panel A. Portfolio Return							
Tangency mean return	0.643	0.423	0.690	1.031	0.417	1.031	0.453
Tangency volatility	1.645	0.380	1.779	2.062	0.361	2.062	0.388
Min-var mean return	0.643	0.374	0.571	0.615	0.363	0.615	0.347
Min-var volatility	1.645	0.334	1.544	1.451	0.312	1.451	0.293
Panel B. Diversification Gains							
Posterior φ mean		0.341		0.167	0.330		0.245
Posterior φ std. dev.		0.097		0.071	0.092		0.077
Posterior φ 1%		0.140		0.037	0.139		0.090
Posterior φ 5%		0.191		0.063	0.187		0.127
φ Diff pVal					0.215		
Posterior ψ mean		0.800		0.078	0.801		0.801
Posterior ψ std. dev.		0.017		0.029	0.017		0.017
Posterior ψ 1%		0.757		0.022	0.758		0.758
Posterior ψ 5%		0.771		0.034	0.772		0.772
ψ Diff pVal					0.000		
	With Short-Sale Constraint						
	1	2	3	4	5	6	7
Panel C. Portfolio Return							
Tangency mean return	0.643	0.414	0.639	0.629	0.412	0.629	0.414
Tangency volatility	1.645	0.387	1.627	1.498	0.383	1.498	0.372
Min-var mean return	0.643	0.370	0.571	0.592	0.361	0.592	0.358
Min-var volatility	1.645	0.346	1.544	1.460	0.333	1.460	0.320
Panel D. Diversification Gains							
Posterior φ mean		0.284		0.038	0.275		0.264
Posterior φ std. dev.		0.081		0.036	0.078		0.076
Posterior φ 1%		0.112		0.000	0.108		0.102
Posterior φ 5%		0.156		0.000	0.151		0.144
Posterior ψ mean		0.791		0.061	0.785		0.781
Posterior ψ std. dev.		0.017		0.022	0.017		0.018
Posterior ψ 1%		0.748		0.017	0.741		0.736
Posterior ψ 5%		0.762		0.027	0.755		0.751

Panel B shows large and significant benefits to diversifying with international corporate bonds. If investors holding the U.S. corporate bond benchmark had diversified internationally with corporate bonds, they would have achieved an average risk reduction of 80.0%. Moreover, even at the lowest 1% of the posterior distribution, U.S. investors would have realized a large risk-reduction gain of 75.7%.

Beyond diversification within the corporate bond market, Table 3 details the diversification gains for a U.S. multi-asset portfolio of U.S. corporate bonds, U.S. equities, and U.S. Treasuries (US(IG + Eq + Gov)). The return characteristics of the U.S. multi-asset tangency portfolio in column 3 are similar to those of the U.S. corporate bond-only benchmark. The minimal change between the two benchmark specifications stems from the large weight on U.S. corporate bonds in the U.S. multi-asset benchmark. The strong performance of U.S. corporate bonds within the sample period, relative to U.S. equities and Treasuries, causes the mean-variance optimized portfolios to favor U.S. corporate bonds.[13] Therefore, diversification gains remain relatively unchanged when the U.S. corporate bond-only benchmark is replaced by the U.S. multi-asset benchmark.

Finally, I evaluate the diversification gains for a U.S. investor who holds international equities in addition to U.S. corporate bonds, equities, and Treasuries (US(IG + Eq + Gov) + Intl Eq). This benchmark is important because it evaluates the marginal contribution of international corporate bonds in a U.S. investor portfolio that is already diversified with foreign equities. The last two columns of Table 3 show that even with international equities in the benchmark, foreign corporate bonds can still extend significant diversification benefits to U.S. investors. Foreign corporate bonds reduce the volatility of the international benchmark by an average of 80.1%, with a lowest 1% of the posterior risk-reduction gain of 75.8%. Although risk reduction remains large, Sharpe ratio gains exhibit a noticeable decrease when international equities are present in the benchmark. The average Sharpe ratio gains, φ, are 0.330 for the U.S. multi-asset benchmark and 0.245 for the U.S. multi-asset benchmark with international equities. The lower gain stems from an increase in the expected return and the Sharpe ratio of the benchmark with foreign equities. Meanwhile, the diversified tangency portfolio continues to favor international corporate bonds and maintains a similar Sharpe ratio. These results suggest that when international equities are added to the U.S. multi-asset benchmark, corporate bond diversification continues to generate large and significant risk-reduction gains, but smaller Sharpe ratio gains.

Although the analysis above measures the marginal contribution of international corporate bonds, it does not compare the diversification potential of international equities with that of international corporate bonds. Using the U.S. multi-asset benchmark, column 4 of Table 3 shows that the diversification gains from international equities are markedly smaller than the diversification gains from international corporate bonds shown in column 5. To evaluate the statistical significance of the difference, I use bootstrapped returns and compute the difference between the gain from international equities and the gain from international corporate bonds. The p-value (Diff pVal) measures the probability that the gains from international corporate bonds are less than the gains from international equities in 250,000 simulations. The ψ Diff pVal in Panel B of Table 3 finds that international corporate bonds provide a statistically significantly higher risk-reduction gain than international equities. On the other hand, the φ Diff pVal reveals that foreign corporate bonds do not generate significantly larger Sharpe ratio gains than foreign equities. These results suggest that international corporate bonds may offer some of the same risk-adjusted expected return gains as international equities. However, the risk reduction gains from corporate bonds are significantly larger than those from international equities.

[13]Alternative benchmark portfolio weights based on actual U.S. investor holdings from the Flow of Funds imply even larger gains.

A. Short-Sale Constraints

It can be argued that negative portfolio positions in foreign assets may be hard to achieve in practice, and diversification gains may be greatly reduced if U.S. investors are faced with short-sale constraints. To evaluate this scenario, Panels C and D of Table 3 report the diversification gains for the constrained benchmark and diversified portfolios. Column 2 of Panel C shows that the constrained optimal minimum-variance portfolio still realizes a low volatility of 0.346% per month, as compared to the 0.334% monthly volatility for the unconstrained portfolio in Panel A. Because short-sale constraints appear to have little effect on the volatility of the diversified minimum-variance portfolio, risk-reduction gains are minimally changed by the portfolio weight constraint. The minor effect of short-sale constraints on risk reduction suggests that the gains rely on the low correlation across corporate bond markets, rather than on extreme long and short positions. Even for the U.S. multi-asset with international equities benchmark (US(IG + Eq + Gov) + Intl Eq), the constrained minimum-variance portfolio maintains a posterior mean risk-reduction gain of 78.1%.

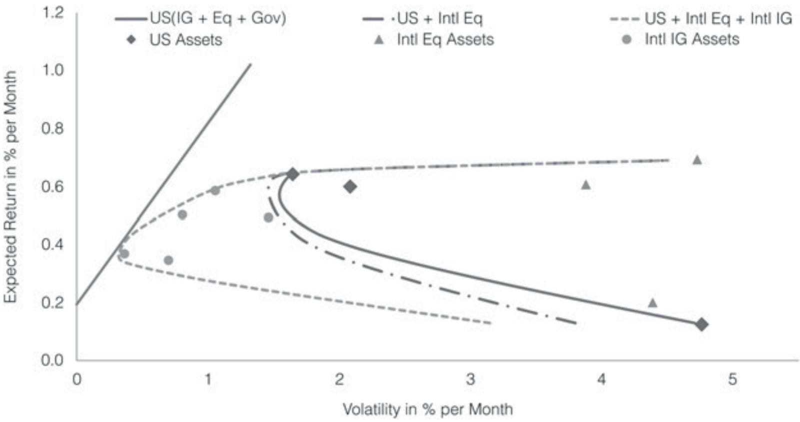
Although the short-sale constraint has little effect on the minimum-variance portfolio, Panel C of Table 3 shows that the constraint does affect the tangency portfolio. The constrained tangency portfolio for the U.S. multi-asset with international equities benchmark has monthly expected return of 0.629% and volatility of 1.498%, as compared to the unconstrained case with 1.031% monthly expected return and 2.062% volatility. The dramatic change in the benchmark portfolio return highlights the effect of short-sale constraints on the tangency portfolio with equities. In particular, the high correlation among international equity returns causes the unconstrained tangency portfolio to take large long and short positions to generate higher Sharpe ratios. Under short-sale constraints, the Sharpe ratio is dramatically lower for the U.S. multi-asset benchmark with foreign equities. By contrast, the diversified tangency portfolio that places a larger weight on corporate bonds does not rely on extreme long–short positions to generate higher Sharpe ratios and therefore is less affected by portfolio constraints.

Finally, to visualize the diversification gains under short-sale constraints, I graph the constrained mean-variance frontier. In Figure 1, the solid line represents the constrained mean-variance frontier with U.S. multi-asset benchmark, with solid diamonds marking individual asset returns. The long dashed-dotted line shows the constrained efficient frontier when international equities are added to the U.S. multi-asset benchmark, with triangular markers representing international equity returns. Because the short-sale constraint prevents the portfolio from using leveraged positions to achieve higher expected returns, international equities help extend the efficient frontier to a higher risk and return region of the mean-variance space. The short dashed line plots the fully diversified constrained frontier with the U.S. multi-asset with both foreign equities and corporate bonds, with solid dots marking individual country corporate bond returns. Finally, the solid straight line represents the capital allocation line that connects the risk-free rate with the tangency portfolio of the fully diversified portfolio with corporate bonds. Figure 1 reveals that corporate bond diversification extends the frontier to a much lower volatility region of the mean-variance space. Moreover, both the tangency and the minimum-variance portfolios are located at the low-volatility end of the frontier. Finally, Figure 1 shows that the U.S. corporate bond portfolio offers higher expected returns, and higher volatility, than any of the other advanced economy corporate bond portfolios. Therefore, for the constrained efficient frontier, the U.S. corporate bond benchmark portfolio plays an important role in generating the optimal mean-variance portfolios.

FIGURE 1

Diversification with Hedged Corporate Bonds (2000–2010)

Figure 1 displays the benefits of diversification to a U.S. investor from international equities and corporate bonds. The graph shows the constrained (no short sale) mean-variance efficient frontier for the U.S. multi-asset benchmark (solid line), benchmark plus international equities (dash–dot line), and benchmark plus international equities and corporate bonds (dash line). The capital allocation line is marked by the straight line. All returns are currency hedged and in U.S. dollars.



This section demonstrates that significant diversification potential exists for U.S. investors through international corporate bonds. Even for a U.S. multi-asset with international equities benchmark, corporate bond diversification generates statistically significant risk-reduction and Sharpe ratio gains. When gains from foreign equities are compared with gains from foreign corporate bonds, I find statistically significant differences in risk-reduction gains, but not in Sharpe ratio gains. Given the limited time series of the corporate bond returns and the potential issues of estimation error that surround the tangency portfolio and Sharpe ratio estimates, the remainder of this article focuses primarily on diversification benefits as measured by risk reduction ψ. Although the above results demonstrate large risk-reduction gains, the in-sample analysis does not capture any time variation in the gains. In particular, gains may diminish for U.S. investors during crisis periods. To address this issue, the next section examines the out-of-sample diversification benefits before and during the recent financial crisis.

V. Out-of-Sample Performance and the Financial Crisis

As shown in Ang and Bekaert (2002) and others, correlations across international equity markets tend to increase during crisis periods. Therefore, international diversification gains may be small when investors need them most.

To evaluate whether gains diminish during crisis periods, I assess the out-of-sample risk-reduction performance of the minimum-variance portfolio during the global financial crisis of 2008–2010. Furthermore, I measure the out-of-sample risk-reduction gain using the IEW portfolio described above. For statistical significance, I bootstrap returns and compute the probability (p-value) that the out-of-sample diversified portfolio will have a higher volatility than the out-of-sample benchmark portfolio.

In Panel A.1 of Table 4, I estimate the minimum-variance portfolio using the precrisis period of 2000–2007 and report the out-of-sample risk-reduction gains during the financial crisis of 2008–2010.[14] Columns 1 and 2 show that during the financial crisis, a diversified minimum-variance portfolio with international bonds would have realized an 83.2% risk reduction against the U.S. corporate bond-only benchmark. The out-of-sample volatility of the diversified minimum-variance portfolio during the financial crisis was only 0.389% per month, as compared to 2.316% per month for the U.S. corporate bond-only benchmark. The bootstrapped p-value for ψ shows that the out-of-sample risk-reduction gains during the financial crisis are highly significant.

TABLE 4

Out-of-Sample Gains and Performance during the Financial Crisis of 2008–2010

Table 4 reports out-of-sample risk-reduction gains for two subperiods: the precrisis period of 2000–2007 and the recent financial crisis period of 2008–2010. Diversification gains are computed for three U.S. benchmarks: investment-grade corporate bond only (US IG), U.S. corporate bond and U.S. equity (US(IG + Eq)), and diversified portfolio of U.S. corporate bond, U.S. equity, U.S. Treasury, and international equities (US(IG + Eq + Gov) + Intl Eq). Diversified portfolios with international corporate bonds are reported in columns 2, 5, and 7 and those with international equities are reported in column 4. φ measures the Sharpe ratio increase for the tangency portfolio, and ψ measures the percentage risk reduction of the minimum-variance portfolio. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of gains are reported. All returns are expressed in U.S. dollars and as a monthly percentage.

	US IG	Bench + Intl IG	US(IG + Eq + Gov)	Bench + Intl Eq	Bench + Intl IG	US(IG + Eq + Gov) + Intl Eq	Bench + Intl IG
	1	2	3	4	5	6	7
Panel A. Minimum Variance							
1. Crisis 2008–2010							
Expected return	0.776	0.289	0.697	0.522	0.300	0.522	0.274
Volatility	2.316	0.389	2.499	2.373	0.342	2.373	0.320
Out sample ψ		0.832		0.051	0.863		0.865
Bootstrap p-value		0.000		0.299	0.000		0.000
2. 2003–2007							
Expected return	0.433	0.377	0.487	0.565	0.381	0.565	0.338
Volatility	1.359	0.351	1.352	1.287	0.342	1.287	0.375
Out sample ψ		0.742		0.048	0.747		0.708
Bootstrap p-value		0.000		0.540	0.000		0.000
Panel B. Initial Equal Weight							
1. Crisis 2008–2010							
Expected return	0.755	0.538	0.467	0.068	0.483	0.068	0.246
Volatility	2.287	0.987	2.580	4.213	1.281	4.213	2.614
Out sample ψ		0.569		−0.633	0.503		0.379
Bootstrap p-value		0.000		1.000	0.000		0.002
2. 2000–2007							
Expected return	0.592	0.473	0.470	0.525	0.457	0.525	0.502
Volatility	1.321	0.724	1.405	2.512	0.788	2.512	1.532
Out sample ψ		0.452		−0.787	0.439		0.390
Bootstrap p-value		0.000		0.644	0.000		0.000

[14]Given the large difference between crisis and noncrisis period data, I separate bootstrap returns from the precrisis data for estimation and from the crisis data for evaluation.

Large and significant risk-reduction gains also hold for both the U.S. multi-asset benchmark and the U.S. multi-asset plus international equities benchmark. In fact, the risk-reduction gains are slightly larger for the multi-asset benchmarks than for the U.S. corporate bond-only benchmark. The posterior average risk-reduction gain is 86.3% for the U.S. multi-asset benchmark and 86.5% for the U.S. multi-asset benchmark with international equities. The larger out-of-sample risk-reduction gains for the multi-asset benchmarks stem from the terrible performance of equities during the financial crisis, when the large weights on equities dramatically increased out-of-sample benchmark volatility. In addition, column 4 of Table 4 shows that the out-of-sample risk-reduction gains from international equities alone are small and statistically insignificant for the crisis period. By contrast, column 5 reports large and robust out-of-sample gains from foreign corporate bonds against the same U.S. multi-asset benchmark portfolio.

An alternative to the out-of-sample minimum-variance portfolio is the IEW portfolio. Unlike the minimum-variance portfolio, the IEW portfolio represents a simple diversification strategy that is estimation free. To reduce liquidity concerns and transaction costs, the IEW portfolio rebalances to equal weights at the beginning of each year, instead of monthly. Panel B.1 of Table 4 reports the realized volatility of the IEW portfolio and the corresponding risk-reduction gain ψ for the crisis period. For the U.S. corporate bond-only benchmark, the IEW portfolio with international corporate bonds would have reduced volatility by a statistically significant 56.9% during the financial crisis.

For the U.S. multi-asset with international equities benchmark, the benchmark IEW portfolio would have realized an expected return of 0.068% per month with volatility of 4.213% per month. In comparison, the diversified IEW portfolio with international corporate bonds would have produced an expected return of 0.246% per month with volatility of 2.614% per month. Therefore, adding international corporate bonds to an IEW benchmark portfolio of U.S. multi-assets and international equities would have simultaneously increased expected return and reduced portfolio volatility.

Finally, I examine the out-of-sample performance of the minimum-variance portfolio during normal or precrisis times. Using the first 36 months of the sample period as the estimation window, I evaluate the resulting minimum-variance portfolio during 2003–2007. Panel A.2 of Table 4 reports the out-of-sample performance of the minimum-variance portfolio during a noncrisis period.[15] The out-of-sample diversification gain suggests a significant 74.2% risk reduction, against the U.S. corporate bond-only benchmark. Although the out-of-sample risk-reduction gains are smaller for the noncrisis period than for the crisis period, diversified portfolios with international corporate bonds continue to generate statistically significant gains of over 70% for all benchmarks. Finally, in Panel B.2, I report the performance of the IEW portfolio for the noncrisis period. Without a need to estimate portfolio weights, the IEW portfolio can be evaluated over the entire noncrisis period of 2000–2007. I find that including foreign corporate bonds in an IEW portfolio would have significantly reduced portfolio

[15]The 36-month estimation window was selected to ensure a stable estimation of mean-variance weights.

volatility by anywhere from 39.0% to 45.2%, depending on the benchmark specification.[16]

This section demonstrates that beyond in-sample diversification gains, international corporate bonds can deliver large and significant out-of-sample risk-reduction gains during both the crisis and the noncrisis times. The out-of-sample measures capture risk-reduction gains that are arguably more realistic and achievable. By comparison, equity diversification generated only small out-of-sample risk-reduction gains that were not statistically significant. Finally, including international corporate bonds in a simple IEW portfolio can produce significant out-of-sample risk reduction without sacrificing expected returns.

VI. Longer Sample Assets and Diversification Gains

Although the previous sections show large and significant risk-reduction gains both in and out of sample, the sample period may not be representative of gains measured over a longer horizon. In particular, the specific period used in this article records abnormally low expected returns for domestic and international equities compared to their longer historical returns.[17] Although international corporate bond data are unavailable for earlier periods, I use longer histories (from 1985 to 2010) of equity and sovereign bond returns to derive predictive estimates of corporate bond returns. As shown in Stambaugh (1997), a combined estimation of assets with different sample lengths can both inform the short-sample asset returns and increase the estimation precision of the longer history assets. Predictive moments are based on the regression of the long-sample asset (equities or sovereign bonds) on the short-sample asset (corporate bonds) and the long-run performance of the long-sample assets. The maximum likelihood estimators of the short-sample asset (corporate bonds) mean, $\hat{\mu}_2$, and covariance, $\hat{\Sigma}_{22}$, follow the equations below:

$$\begin{aligned}\hat{\mu}_2 &= \hat{\mu}_{2,s} + \hat{B}(\hat{\mu}_1 - \hat{\mu}_{1,s}),\\ \hat{\Sigma}_{22} &= \hat{B}\hat{\Sigma}_{11}\hat{B}' + \hat{V},\end{aligned}$$

where $\hat{\mu}_{1,s}$ and $\hat{\mu}_{2,s}$ are the truncated sample mean vectors for the long-sample assets and the short-sample assets, respectively; $\hat{\Sigma}_{11}$ is the long-sample covariance; and $\hat{B}$, $\hat{V}$ are the regression coefficient and residual covariance matrix, respectively.[18] The univariate case provides intuition for the equations above. Suppose the long-sample asset (equities) has a higher mean return in the long sample versus the short sample, such that $(\hat{\mu}_1 - \hat{\mu}_{1,s}) > 0$. If the regression coefficient, $\hat{B}$, is also positive, the combined estimation implies a higher expected return for the truncated sample asset (corporate bonds). The size of the revision to the expected return of the short-sample asset, $\hat{\mu}_{2,s}$, depends on the magnitude of the regression beta coefficient and the magnitude of the differential,

[16]By design, the IEW portfolio assigns positive and equal weights to all assets; thus, adding international equity assets necessarily increases portfolio volatility.

[17]I thank the referee for pointing this out.

[18]For additional details, see the Internet Appendix (available at www.jfqa.org).

$(\hat{\mu}_1 - \hat{\mu}_{1,s})$. A similar logic holds for the revision on variance and covariance estimates.[19]

Before turning to diversification gains, I first explore how return estimates of international corporate bonds change when longer time series of equities and sovereign bond returns are used in the combined estimation procedure described above. The top panel of Table 5 reports the combined and truncated sample estimates of all asset returns: equities (Eq), sovereign bonds (Gov), and corporate bonds (IG). First, equity returns for all countries were higher in the long sample than in the short sample, with particularly striking increases for the equity markets

TABLE 5

Combined Sample Length Corporate Bond Return Estimates

Table 5 reports the return estimates of equities (Eq), sovereign bonds (Gov), and corporate bonds (IG), when longer histories of equities or sovereign bonds are estimated jointly with the sample for international corporate bonds. The columns under "Combined" use the longer samples of equity and sovereign returns from 1985–2010, and the columns under "Truncated" report asset returns from 2000–2010 only. The returns are expressed in U.S. dollars and as a monthly percentage. Panel A.1 reports the risk-reduction gains to the minimum-variance (MV) portfolio when long samples of equities and sovereign bonds are combined with the short-period corporate bond returns. Panel A.2 reports the risk-reduction gains from the short period of 2000–2010. Diversified portfolios with international corporate bonds are reported in columns 2, 5, and 7 and those with sovereign bonds are reported in column 4.

	Truncated			1985–2010		Combined		
	Eq	Gov	IG	Long Eq	Long Gov	IG by Long Eq	IG by Long Gov	IG by Long Eq + Gov
	1	2	3	4	5	6	7	8
Australia								
Expected return	0.606	0.314	0.347	0.816	0.562	0.338	0.449	0.451
Volatility	3.880	1.436	0.699	4.811	1.781	0.710	0.822	0.835
Correlated with IG	−0.240	0.847						
Canada								
Expected return	0.693	0.537	0.586	0.844	0.644	0.591	0.650	0.666
Volatility	4.728	1.284	1.056	4.561	1.933	1.055	1.374	1.467
Correlated with IG	0.144	0.740						
Japan								
Expected return	−0.003	0.452	0.369	0.446	0.646	0.362	0.437	0.444
Volatility	5.236	0.888	0.363	5.900	1.462	0.366	0.545	0.571
Correlated with IG	−0.235	0.854						
United Kingdom								
Expected return	0.200	0.426	0.493	0.670	0.545	0.515	0.579	0.637
Volatility	4.388	1.300	1.461	4.739	1.739	1.463	1.683	1.872
Correlated with IG	0.135	0.644						
United States								
Expected return	0.125	0.600	0.643	0.902	0.662	0.684	0.675	0.772
Volatility	4.762	2.083	1.645	4.583	1.981	1.644	1.611	1.710
Correlated with IG	0.156	0.650						

	US IG	Bench + Intl IG	US(IG + Eq + Gov)	Bench + Intl Gov	Bench + Intl IG	US(IG + Eq + Gov) + Intl Eq	Bench + Intl IG
	1	2	3	4	5	6	7
Panel A.1. MV Combined Maximum Likelihood (1985–2010)							
Expected return	0.762	0.424	0.732	0.633	0.427	0.721	0.423
Volatility	1.807	0.487	1.696	1.158	0.482	1.599	0.480
Volatility gain ψ		0.730		0.317	0.716		0.700
Panel A.2. MV Truncated (2000–2010)							
Expected return	0.643	0.370	0.571	0.412	0.358	0.601	0.341
Volatility	1.645	0.336	1.544	0.696	0.317	1.482	0.298
Volatility gain ψ		0.796		0.549	0.795		0.799

[19]Bayesian posterior mean and covariance estimators that take into account estimation error are also available from the author.

in Japan, the United Kingdom, and the United States.[20] By contrast, for sovereign bond returns, the mean estimates remain stable across the two periods. For asset volatility, both equities and sovereign bonds appear to have similar estimates across the two sample periods, with a slightly higher volatility estimate for the longer sample. The notable exception is Japan, whose sovereign bond returns have a much lower volatility of 0.888% per month, or 3.08% annualized, in the short sample, as compared to 1.462% per month, or 5.06% annualized, in the longer sample.

Second, Table 5 shows that the correlation between sovereign and corporate bonds is large and positive, whereas the correlation between equities and corporate bonds is small and sometimes negative. These correlation coefficients indicate that the long time series of sovereign bond returns have a larger effect on corporate bond estimates than the longer sample of equities. As an example, the volatility estimate of Australian corporate bonds is minimally revised, going from 0.699% to 0.710%, when equities are used as the long sample asset. In comparison, when sovereign bonds are used as the long-sample asset, the predictive estimate of the volatility goes from 0.699% to 0.822%.

Although sovereign bond returns are highly correlated with corporate bond returns, sovereign bond returns estimates from the longer sample are not very different from those from the truncated sample. Therefore, regardless of the long-sample asset used, revised corporate bond return estimates report only a slightly higher expected return and volatility than those from the truncated sample. Moreover, when longer histories of both equities and sovereign bonds are included, the combined estimates are similar to those with only sovereign bonds as the long-sample asset. The only exception is the U.S. corporate bond return, whose combined estimate suggests a potentially implausible high expected return of 0.772% per month, or 9.26% per year. The large increase stems from the positive correlation between corporate bonds and equities and from the much higher expected return for U.S. equities in the longer sample.

To demonstrate the effect of jointly estimated predictive asset moments on diversification gains, I compare risk-reduction gains from the truncated sample and from the joint estimation in Panels A.1 and A.2 of Table 5.[21] For the U.S. corporate bond-only benchmark and the U.S. multi-asset with international equities benchmark, the risk-reduction gains of the minimum-variance portfolio are nearly the same for the combined sample as for the truncated sample. For the U.S. corporate bond-only benchmark, the risk-reduction gain implied by the combined sample estimate is 73.0%, as compared to 79.6% for the truncated sample estimate. Furthermore, for the U.S. multi-asset with international equities benchmark, the combined history estimation continues to suggest a large risk-reduction gain of 70.0%. In summary, I find that risk-reduction gains remain large and are similar to those estimated from the truncated sample.

Given the high correlation between hedged sovereign and corporate bond returns discussed above, Panels A.1 and A.2 of Table 5 evaluate the risk-reduction

[20] Long history of pan-European data is not available, so I exclude Europe from all analyses in this section.

[21] For diversification gains, all long histories of international equities and sovereign bonds are used together. Given the low cross-country, cross-asset correlation, corporate bond return estimates are similar to the country-by-country results reported previously.

gains from sovereign bonds. For the truncated sample of 2000–2010, column 4 of Panel A.2 shows that the addition of sovereign bonds to a U.S. multi-asset portfolio can generate a risk reduction of 54.9%, as compared to the 79.5% volatility decrease from corporate bonds. Moreover, for the longer sample period of 1985–2010 shown in Panel A.1, the long series of sovereign bond returns had the potential to reduce portfolio volatility by 31.7%. Although Panel A.1 also suggests a volatility reduction of 71.6% from corporate bonds, the risk-reduction gain across the two bond types is not directly comparable, as the predictive moments of corporate bonds were revised using the longer time series of sovereign returns. These results suggest that although both sovereign and corporate bonds present opportunities for large risk reduction, absent any common currency variation,[22] corporate bonds may offer additional diversification benefits through their lower cross-country correlation.

This section uses longer time series of international equity and sovereign bond returns to augment estimates of international corporate bonds and to measure the implied diversification gains. I find that although international and U.S. equities realized much higher returns in the longer period of 1985–2010, the effect of including long-sample equities is limited by their low correlation with corporate bonds. By contrast, longer histories of sovereign bond returns are highly informative for corporate bond returns but appear to have stable return properties across periods. Therefore, the combined sample estimates of corporate bond returns suggest only slightly higher volatility and expected returns. Given the minimal change to corporate bond estimates, large risk-reduction potential remains when longer return histories are used, with implied gains of 70% or above for all benchmark specifications.

VII. What Explains the Diversification Gains?

Despite the findings above that corporate bonds have the potential to generate large risk-reduction gains, U.S. investors have been documented to hold very few foreign bonds (see Burger and Warnock (2007)). However, there may be additional risks and costs of holding foreign corporate bonds for U.S. investors not considered above that can justify the low observed holdings and significantly reduce diversification gains once appropriately taken into account. This section explores three potential explanations for the gains found above and evaluates the ability for each to significantly reduce gains. First, I analyze the possibility that diversification gains arise from the compositional differences between U.S. and foreign corporate bond portfolios in rating, duration, and industry. Second, I test whether liquidity differences between U.S. and foreign corporate bond portfolios are driving diversification gains. Third, I examine the possibility that higher informational costs of evaluating foreign firms for U.S. investors can justify the diversification gains. For each potential scenario, I make adjustments to the foreign portfolios and evaluate whether the modifications can sufficiently reduce the diversification gains to U.S. investors.

[22] All bond returns are currency hedged.

A. Liquidity and Bond Characteristics

Beginning with Heston and Rouwenhorst (1994), the question of country versus industry effects on diversification has been actively debated. For example, it may be that the gains found above stem from diversification across industries or other bond characteristics, rather than across countries. Similarly, bond-level liquidity differences may be driving diversification gains across country portfolios. As argued by Lo, Mamaysky, and Wang (2004) or Chen et al. (2007), liquidity costs can deter investors from trading frequently enough to fully hedge their risks. Therefore, if foreign bond portfolios have a heavy concentration of bonds with high liquidity costs, the gains found earlier would not be capturing international diversification. To explore these issues, I reweight foreign corporate bond portfolios by bond characteristics and liquidity proxies. In particular, I rebalance foreign bond portfolios to match the bond characteristic of the U.S. benchmark portfolio, and filter for only the most liquid foreign bonds.

I evaluate three bond characteristics: rating, duration, and industry. For each country portfolio, I group individual bonds into rating, duration, and industry bins.[23] Then by each country, I value-weight the individual bonds in a bin (e.g., Australian BBB) and construct a single return. Finally, I use the proportion of each bin category (e.g., BBB) in the U.S. portfolio to reweight the characteristic returns for each country portfolio. With the foreign portfolios balanced to characteristic weights of the U.S. corporate bond portfolio, I measure the risk-reduction diversification gain to U.S. investors.

Table 6 reports the diversification gains for the U.S. corporate bond-only benchmark (US IG) and the U.S. multi-asset benchmark with international equities (US Div Bench). Results from the unbalanced country indices in Table 3 (Intl IG All) are included for ease of comparison. The minimum-variance portfolio in Panel A shows little change to diversification gains from bond characteristic rebalancing. After controlling for bond characteristics, foreign corporate bond portfolios continue to deliver large and significant risk-reduction gains. Comparing across the different bond characteristics reveals that duration has the largest effect on diversification gains. Nonetheless, duration-matched portfolios have the potential to deliver a significant 68.6% risk reduction for the U.S. corporate bond-only benchmark. Moreover, for the U.S. multi-asset with international equities benchmark in Panel C, duration-matched foreign portfolios bring an average posterior risk reduction of 70.1%, and a lowest 1% posterior risk reduction of 63.8%.

To address the potential differences in liquidity, I use age and years left to maturity (Age/YTM), or size of issuance (Size), as proxies for individual bond liquidity. It is well known that bonds from small issuances have lower liquidity. Similarly, older bonds tend to have lower liquidity and trade infrequently as they are generally held to maturity. To eliminate bonds with lower liquidity from the foreign portfolios, I include in the foreign portfolios only bonds that have been issued within the last 2 years of the quote and that have at least 2 years left to

[23]Rating bins are classified as AAA, AA, A, and BBB. Industry bins are Financial, Utilities, and Industrial. Duration bins are 0–2, 2–4, 4–7, 7–10, 10–15, and 15–30.

TABLE 6

Diversification Gains and Characteristic Balanced Portfolios

Table 6 reports diversification gains when the international corporate bond portfolios are balanced by industry, ratings, or duration to match the U.S. corporate bond portfolio. The bonds in each foreign portfolio are sorted into rating bins, industry bins, and duration bins. U.S. portfolio weights for bins are used to adjust the foreign country's bin returns and are reweighted to form a balanced country portfolio return. Column 6 uses only foreign bonds at the top 20% of each market. Column 7 includes only foreign bonds with less than 2 years from issue date and more than 2 years left to maturity. Column 2 reports gains from unbalanced foreign portfolios. The two benchmark portfolios are the U.S. corporate bond (US IG, Panels A and B) and the U.S. multi-asset with international equities (US Div Bench, Panels C and D). The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of risk-reduction gain, ψ, is reported for the out-of-sample minimum-variance portfolio. The bootstrap p-values are reported for initial equal-weight portfolios. All returns are expressed in monthly percentage and in U.S. dollars, and span Jan. 2000–Dec. 2010.

	US IG	All Intl IG	Rating Matched	Industry Matched	Duration Matched	Size Matched	Age/YTM Matched
	1	2	3	4	5	6	7
Panel A. Minimum-Variance Portfolio							
Expected return	0.643	0.374	0.391	0.404	0.376	0.377	0.399
Volatility	1.645	0.334	0.372	0.425	0.525	0.350	0.451
Posterior ψ mean		0.800	0.777	0.746	0.686	0.791	0.730
Posterior ψ std. dev.		0.017	0.019	0.022	0.026	0.018	0.023
Posterior ψ 1%		0.757	0.729	0.692	0.621	0.745	0.673
Posterior ψ 5%		0.771	0.744	0.709	0.641	0.760	0.691
Panel B. Initial Equal Weight							
Expected return	0.436	0.284	0.294	0.291	0.273	0.281	0.286
Volatility	1.665	0.823	0.840	0.835	0.854	0.823	0.853
Sample ψ		0.512	0.503	0.505	0.493	0.510	0.493
Bootstrap p-value		0.000	0.000	0.000	0.000	0.000	0.000
	US Div Bench	All Intl IG	Rating Matched	Industry Matched	Duration Matched	Size Matched	Age/YTM Matched
	1	2	3	4	5	6	7
Panel C. Minimum-Variance Portfolio							
Expected return	0.615	0.347	0.360	0.367	0.328	0.349	0.358
Volatility	1.451	0.293	0.331	0.363	0.441	0.303	0.380
Posterior ψ mean		0.801	0.775	0.754	0.701	0.795	0.742
Posterior ψ std. dev.		0.017	0.019	0.021	0.025	0.018	0.022
Posterior ψ 1%		0.758	0.727	0.701	0.638	0.750	0.687
Posterior ψ 5%		0.772	0.742	0.718	0.658	0.764	0.704
Panel D. Initial Equal Weight							
Expected return	0.407	0.436	0.441	0.439	0.431	0.436	0.439
Volatility	3.083	1.895	1.909	1.900	1.897	1.893	1.893
Sample ψ		0.385	0.381	0.384	0.385	0.386	0.386
Bootstrap p-value		0.000	0.000	0.000	0.000	0.000	0.000

maturity.[24] For the size-of-issuance criterion, I select bonds from the largest 20% of issuance size within each country. With foreign portfolios that contain only the more liquid bonds, individual bonds are value-weighted to create country portfolio returns.

Columns 6 and 7 of Table 6 report the diversification gains from only the most liquid bonds in the foreign country portfolios. The performance of size-filtered bond portfolios is again similar to the original analysis with all bonds, for all benchmarks. In Panel C, for example, the size-filtered bond portfolios can still significantly reduce portfolio volatility by 79.5%, against the U.S. multi-asset with foreign equities benchmark. The age and years-to-maturity adjustment appears to have a greater effect on reducing portfolio gains than does the

[24]The lack of transactional data or bid/ask quotes data for international corporate bonds precludes the more sophisticated measures of liquidity proposed by Chen et al. (2007) or Bao et al. (2011).

size filter. Even so, the column labeled "Age/YTM" shows that U.S. investors can still achieve a 74.2% decrease in return volatility against the U.S. multi-asset with international equities benchmark.

Beyond the in-sample risk-reduction gains, I evaluate out-of-sample risk reduction for the IEW portfolio using the same set of liquidity-filtered and characteristic-balanced portfolios. Again, I find little evidence that risk-reduction gains are substantially affected by the adjusted foreign portfolios, as compared to the original country portfolios. For the U.S. corporate bond-only benchmark in Panel B of Table 6, the out-of-sample risk-reduction gains are 51.2% with the original country portfolios, as compared to 49.3% or more with the adjusted foreign portfolios.[25] In summary, Table 6 shows that risk-reduction gains are remarkably robust to foreign portfolios that are rebalanced on industry, duration, or ratings or are filtered for liquidity. The similarity between the matched and unmatched portfolios suggests that the diversification gains are driven largely by country effects rather than by differences in bond characteristics. Moreover, I find that liquidity adjustments do not greatly reduce diversification gains reported above.[26]

B. Investor Information Access

This section evaluates the potential for higher information costs associated with foreign corporate bonds to explain diversification gains. If the foreign corporate bond portfolios contain obscure foreign issuers with difficult-to-analyze financial statements for U.S. investors, the gains found above may represent higher information costs and not international diversification. This section exploits the sample of foreign bonds listed in the United States, known as Yankee bonds, that are subject to SEC disclosure rules and that can be analyzed by U.S. investors as easily as domestic bond issuers. In addition, by listing bonds in the United States, foreign issuers increase recognition among U.S. investors, which makes them potentially more comparable to domestic issuers.[27]

Table 7 reports diversification gains when foreign bond portfolios are restricted to issuers that also have Yankee bond listings. Although most countries have firms that issue Yankee bonds, Australia does not. Therefore, the comparable unrestricted sample of all foreign corporate bonds excludes Australia. For each benchmark specification, the column labeled "Intl IG w/US Listing" reports gains using only foreign bonds that also have a Yankee listing. Table 7 shows that even with only foreign corporate bonds from issuers with Yankee listings, U.S. investors stand to gain a large and significant 76.2% risk reduction over the U.S. multi-asset with international equities benchmark. Moreover, the out-of-sample analysis reveals that adding this restricted set of foreign bonds to an IEW portfolio can generate a significant 33.2% risk reduction.

[25] These numbers differ from Table 4 because the sample is split between crisis and noncrisis periods.

[26] De Jong and Driessen (2012) find that liquidity risk premiums are comparable between European and U.S. investment-grade corporate bond markets.

[27] Foerster and Karolyi (1999) find that equity cross-listings, or American depositary receipts, exhibit positive abnormal returns because of higher investor recognition.

TABLE 7

Diversification Gains and Investor Information

Table 7 reports the diversification gains from foreign bond issuers identified as having financial information accessible to, and as being recognized by, U.S. investors. The two benchmark portfolios are the U.S. corporate bond (US IG) and the U.S. multi-asset with international equities (US Div Bench). Column 2 reports diversification gains from all bonds in the country portfolios. Column 3 reports gains only from foreign bonds issued by firms that also have a Yankee bond issued in the United States. All returns are expressed in monthly percentage and in U.S. dollars, and span the full sample period of Jan. 2000–Dec. 2010. The mean, standard deviation, 5% lowest level, and 1% lowest level from the posterior distribution of risk-reduction gain, ψ, are reported for the out-of-sample minimum-variance portfolio. The bootstrap p-values are reported for initial equal-weight portfolios and measure the probability that the diversified portfolio has higher volatility than the benchmark.

	Full Sample: 2000–2010				
	US IG	CAN, EUR JPN, UK	Intl IG w/ US Listing	US Div Bench	Intl IG w/ US Listing
	1	2	3	4	5
Panel A. Minimum-Variance Portfolio					
Expected return	0.643	0.384	0.407	0.615	0.388
Volatility	1.645	0.340	0.382	1.451	0.350
Mean ψ		0.796	0.771		0.762
Std. dev. ψ		0.018	0.020		0.020
1% lowest ψ		0.751	0.721		0.710
5% lowest ψ		0.765	0.737		0.727
Panel B. Initial Equal Weight					
Expected return	0.643	0.519	0.523	0.407	0.444
Volatility	1.645	0.896	0.866	3.083	2.059
Sample ψ		0.456	0.474		0.332
Bootstrap p-value		0.000	0.000		0.000

This section shows that restricting foreign bond portfolios to include only firms with Yankee bonds has a minimal effect on the large and significant risk-reduction gains. Given that these foreign issuers have disclosure requirements similar to those for domestic firms, asymmetric information costs to U.S. investors of evaluating these foreign bonds should be limited. The persistent risk-reduction gains with this set of restricted foreign bonds suggest that potential informational barriers cannot account for the large diversification gains.

VIII. Exchange Rate Hedging and Risk-Reduction Gains

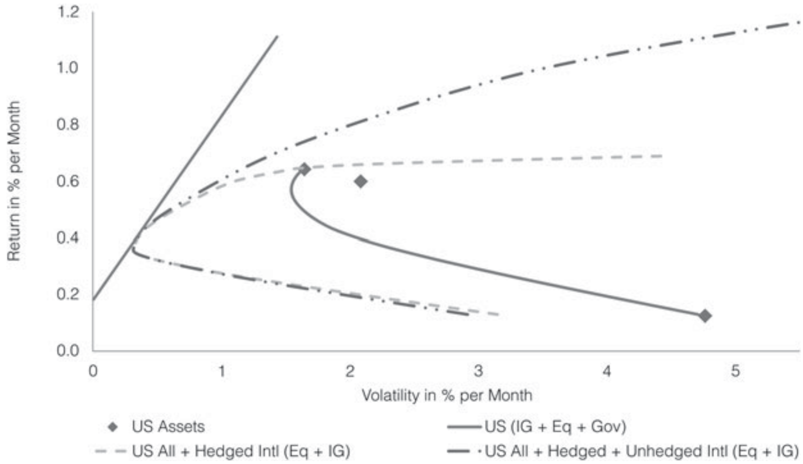
One question that naturally arises is the degree to which currency hedging plays a role in the diversification gains from international corporate bonds. To address this question, I analyze the constrained (no short sale) efficient frontier with both hedged and unhedged corporate bonds and equities. In Figure 2, the solid line depicts the U.S. multi-asset portfolio of domestic equities, Treasuries, and corporate bonds. The long dashed line represents the U.S. multi-asset portfolio with hedged international equities and corporate bonds. Finally, the short dashed line plots the frontier with the U.S. multi-asset portfolio and both hedged and unhedged assets. Figure 2 shows that unhedged asset returns expand the constrained efficient frontier. The currency exposure from unhedged assets provides an increase in expected return and volatility that extends the frontier to a higher risk and higher return region of the mean-variance space.

However, Figure 2 also reveals that both the diversified tangency and the minimum-variance portfolio lie in a region of the efficient frontier that can be

FIGURE 2

Diversification with Hedged and Unhedged Corporate Bonds (2000–2010)

Figure 2 illustrates the effect of currency hedging on diversification benefits. The figure shows the constrained (no short sale) efficient frontier for the U.S. multi-asset benchmark (solid line), benchmark plus hedged international equities and corporate bonds (dash line), and benchmark plus both hedged and unhedged international equities and corporate bonds (double dot-dash line). The capital allocation line is marked by the straight line.



achieved with a combination of U.S. assets and only hedged foreign asset returns. This implies that the optimal portfolios on the capital allocation line, formed by holding proportions of the risk-free asset and the tangency portfolio, require no unhedged assets. This result differs from the finding in Jorion (1989) for sovereign bonds and equities, where the tangency portfolio is a combination of hedged foreign bonds and unhedged foreign equities. Therefore, unhedged assets are useful only to investors who require higher expected returns and are restricted to portfolios on the constrained efficient frontier.[28]

IX. Conclusion

Using a newly compiled data set of international corporate bond quotes, this article shows the large potential for U.S. investors to achieve portfolio gains through corporate bond diversification. With only investment-grade corporate bonds from advanced markets, I find that international diversification with corporate bonds can provide significant risk reduction of 80.0% and Sharpe ratio gains of 0.341 against a U.S. corporate bond benchmark. The large risk-reduction gains are robust out of sample, particularly during the financial crisis of 2008, and are minimally altered by short-sale constraints. By contrast, diversification gains offered by international equities have poor out-of-sample performance and become limited when short-sale constraints are imposed. Moreover, I find that even for U.S. investors who hold portfolios of domestic assets and international

[28]The restriction to only the constrained efficient frontier represents an extreme case when investors are subject to short-sale constraints and cannot borrow cash to achieve the capital allocation line.

equities, corporate bond diversification has the potential to generate significant monthly Sharpe ratio gains of 0.245 and reduce monthly volatility by 80.1%.

In the time series, I augment the sample of international corporate bonds with a longer sample of equity and sovereign bond returns to jointly estimate predictive moments for asset returns. I find that longer series of equities and sovereign bonds do not substantially revise corporate bond return estimates, and diversification with corporate bonds continues to generate large risk-reduction gains. The low correlation between equities and corporate bonds and the stable return characteristics of sovereign bonds attenuate the effect of longer asset histories on diversification gains.

To further explore why such large diversification gains may exist, I evaluate three potential reasons: bond characteristics, bond liquidity, and investor information access. I find that when country portfolios are balanced by bond rating, industry, and duration to match the U.S. corporate bond benchmark portfolio, significant risk-reduction gains remain. Gains also appear to be robust to adjustments on bond liquidity proxies such as age, size, and years to maturity. Furthermore, I explore the potential for poor informational quality from foreign issuers to explain diversification gains. Using only foreign bonds from issuers with Yankee bond listings, I show that even foreign bonds with high investor recognition and strong financial reporting standards have the ability to generate large diversification gains for U.S. investors.

Finally, graphical representations of the efficient frontier with short-sale constraints reveal an interesting relationship between domestic U.S. assets, foreign assets, and exchange rate hedging. I find that exchange rate exposed foreign assets expand the mean-variance frontier but are not needed for the optimal tangency and minimum-variance portfolio. Moreover, I show that the U.S. corporate bond benchmark portfolio plays a nontrivial role in generating the efficient frontier.

These results provide a foundation for further research on the common risk and diversification potential across equity and bond markets. In particular, transactional data for international corporate bonds would greatly enhance our ability to explore additional sources of these gains. In addition, analysis of corporate bond diversification at the firm level may help identify global versus local risk factors in this asset market. Finally, in the spirit of Errunza, Hogan, and Hung (1999), the results in this article can be the basis of further analysis on the benefits of diversification across bond returns through multinational corporations.

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