

A Work Project, presented as part of the requirements for the Award of a Masters

Degree in Finance from the NOVA – School of Business and Economics

BOND PORTFOLIO DIVERSIFICATION

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Abstract: Portfolio diversification benefits have been extensively documented and acknowledge in the literature since 1952. However, the majority of the studies have focus on an equity context, and only very few on bonds. The study purposed tries to understand and measure the diversification benefits for a pure bond portfolio by investing in securities with different credit risks, maturities and even geographies. Diversification benefits were achieved under the proposed model and some conclusions were withdrawn.

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1. Introduction

Bond markets play a crucial role on the overall economy, providing liquidity to fund economic growth and development. In this way, many stressed the importance of such market as a fundamental “backbone” for an economy. This market is simple as small loans that investors make to companies and governments. It represents an additional vehicle to raise money (borrow) to cover funding needs, that go from investing into new projects, new infrastructure, economic development, etc.

Additionally, bond market have indirect economic effects as well. When considering Government budgets, capital market stand for an extra financing route, which on the other hand helps to keep taxes low, since taxes is the main source of funding that Governments have access to. Therefore, it enables governments to go to debt markets and issue debt on the primary market, instead of only collecting taxes.

Besides the funding scope, there is also the investment perspective. Investors with excess funds seek to invest in order to increase their wealth, by spreading their money across several types of asset classes (or not), seeking an efficient and profitable tradeoff between return and risk.

1.1 Literature Review

The concept of diversification stands for the mix of a wide range of different investments within a portfolio. The goal is to hold a portfolio consisting of different investments in different asset classes, in order to eliminate idiosyncratic risk. The theory that higher risk means higher expected return is not always true, since there is idiosyncratic risk and investors are not compensated for that.

One of the “fathers”, or the most widely studied, of this concept is Markowitz (1952) with his modern portfolio theory. The study aims to compute mathematically this

concept into portfolios of assets, by adding assets not perfectly correlated with the portfolio, decreasing the risk of the overall portfolio.

Several studies regarding asset allocation acknowledge it, given its widely recognized importance for diversification purposes. However, most of them were performed on an equity context, and different conclusions can be withdrawn. One of the subjects extensively explored is the minimum amount of assets required to achieve a well-diversified portfolio. Several early researches (like Evans and Archer, 1968) have concluded the lack of marginal benefits that justify the increment of new assets after 10 securities. But many posterior studies, like Meir Statman (1987), have shown that a randomly chosen stock well-diversified portfolio has to contain at least 30 to 40 stocks. Both studies (Evans and Archer and Statman) have concluded the existence of a marginal costs/benefits trade-off, and such analysis must be performed in order to determine the right size of the portfolio, maximizing their utility function. Already on the XXI century, Statman have reached a different conclusion, testifying the need to incorporate hundreds of stocks (Statman, 2004, Statman and Scheid, 2005). Other studies were also developed, shifting the focus of the portfolio construction from portfolio sizing to risk factors exposure. This new application was firstly introduced with the Capital Asset Pricing Model (CAPM), and later on more complex models were developed.

Only few empirical studies were performed over portfolio bonds. McEnally and Boardman (1979), seem to be the few ones to study how many bonds are required to reach benefits of diversification in terms of risk-reward. The authors concluded the need of 8-16 bonds to significantly reduce the overall portfolio's volatility. Another interesting finding is that diversified portfolios of high-yield (HY) bonds present lower systematic risk comparatively to an investment-grade (IG) portfolio. Unfortunately, this finding may not be applicable to recent periods, given the likelihood of the findings to be outdated and

limited, not tested across different credit risks, maturities, industries and geographies. Additionally, it was only used one metric to measure diversifications, unconditional variance. Comparing to recent equity studies, this already use a much broader set of metrics to measure it, such as higher-order moments, alternatives definition of risk, and risk-adjusted measures.

1.2 Motivation

Most of the diversification studies have greater focus on a pure stock or combined portfolio context, as well as on US underlings rather than the euro-denominated ones. This might be understandable given that the stock market is much more efficient and transparent relative to bond markets (OTC), which translates into easier access and more standardize information. Additionally, Europe went through a severe change in its market structure (mainly in the debt market) with the introduction of a single currency in Europe and after the financial crisis of 2008 that is still felt nowadays.

The study purposed aims to investigate and measure the diversification benefits for a pure bond portfolio by investing in securities with different credit risks, maturities and even geographies. Given the current market and macro context, yields are at record lows, and in this sense there is an observed shift of investors, searching for yield. Therefore, this study does not only limits portfolios for investment grade (IG) bonds but also incorporates high-yield securities (HY) as well as emergent markets bonds. On a first approach, this study analysis if there is any benefit in mixing investment grade securities with high yield and across different maturities among euro-denominated securities. On a second approach, the study examines the previous benefits achieved in the Euro-denominated portfolios and tests it across different DM geographies. Furthermore, it is tested the benefits of incorporating emergent market bonds to the portfolio. The goal is to determine if there is extra diversifications benefits, which may result from different

currencies, market structures, lower correlation with the base portfolio (euro-denominated), and different risk exposures, among others.

2. Bond Market

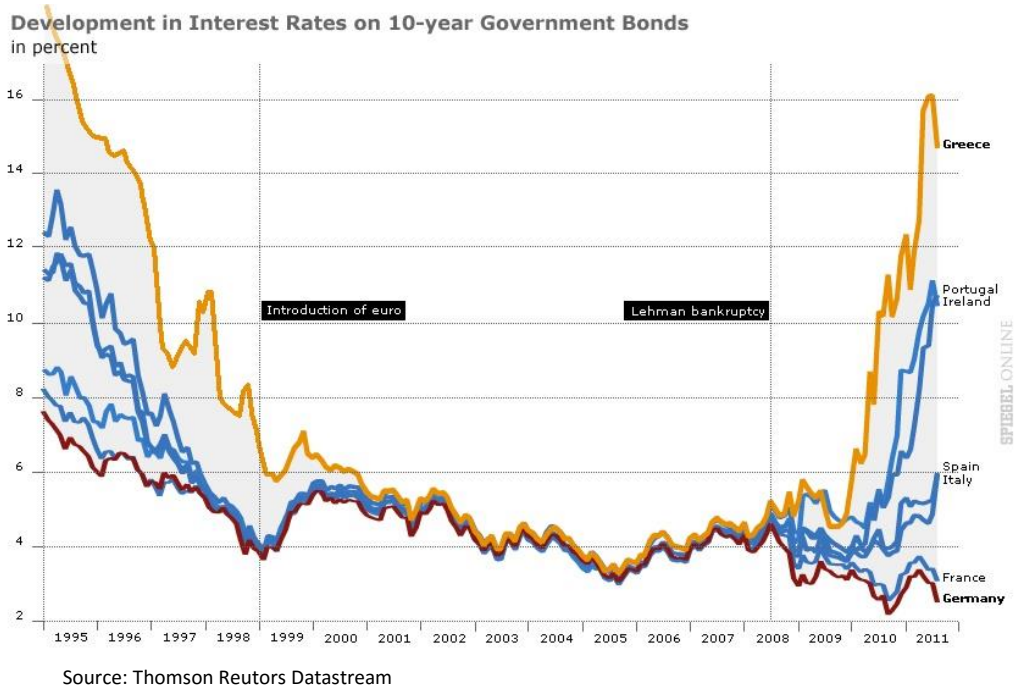
Bond markets have an important role in funding public expenditures and to support economic activity and growth by allowing economic participants to raise funds in the capital markets, through public and private debt placements. The size and significance of this source of finance has grown considerably, predominantly after the financial crisis. In this way, the old traditional habits of companies seeking funds by borrowing from banks (widely seen in Europe vs US), which on the current days is less viable and more costly under the new regulatory environment, are being substitute by bond financing in some developed markets, such US and Europe. According to an IOSCO report, corporate bonds is an important element in economic growth, financial stability and economic recovery, mainly after a severe crises. It provides a vital access of capital, allowing economies to expand, innovate, and improve employment and financial liquidity.

It's getting old, the times when the US has denominated as the world's largest and most liquid bond market, accounting nowadays for approximately 44% of the global bond market volume issuance and about the same size as the US stock market. It must be pointed out that US corporates fund themselves much more through capital markets than bank loans. Therefore, the percentage of corporate bonds issued is much larger versus Europe. The European bond market is about 60% government debt, 29% corporate and 11% asset-backed securities.

Looking at the European market, before 1999, the Euro members bond markets were disconnected, limited in size and scope. The integration of the euro brought a more competitive environment, which drove a dramatic development and growth in the

European bond market, due to the elimination of currency risk (Blanco 2002); the increase of bond standardization, enhancing liquidity and reducing the segmentation of the bond market (Pagano and von Thadden 2004); and a combination of shared fiscal standards with a centralized monetary policy (Côté and Graham 2004). However, the most substantial impact was observed in the government bond sector, fostering high levels of homogeneity in terms of creditworthiness and financial characteristics among the different countries. The European Monetary Union stands for a supranational construction that benefited for several years of bond yields convergence. This strong convergence was interrupted after the beginning of the financial crisis, which resulted in a sharp increase of interest rates on sovereign debt of its members, namely those from the periphery. The strong bond convergence started around 1990's. In 2000's, this convergence course was almost accomplished, and the yields remained at low levels thereafter until late 2009. As stated by the Association for Financial Markets in Europe, "Although individual countries in Europe still have national bond markets where governments, sub sovereign entities and corporations in residence issue bonds, and individual investors participate, the European market, especially across the Euro-zone countries, is increasingly acting like one market." This argument seems to be aligned with the market behavior during the first 10 years of the integration of a single currency. Exhibit 1 shows clearly the declining trend and low interest rates before the financial crisis, which could be translated in the high risk appetite (underpricing of risk), with investors searching for yield. From all the points presented above, it is plausible to conclude that bond markets, particularly since the introduction of a single currency in the Euro Zone and with the last financial crisis, have been suffering constant structural changes, either from market behavior and/or from a heavy regulatory environment.

Exhibit 1 – Historical yields



2.1 Market Structure

The bond market is the world's major source of capital, with rapidly increase, in recent years, in terms of new issues volume. However, the secondary market seems to be somewhat "broken", and its degree is being camouflaged by the current environment of low interest rates, combined with the positive effect of the QE on the bond market. For the last years, investors have been apprehensive about the deterioration of liquidity. Regulatory changes, such as Basel III and the Dodd-Frank, putted in practice after the last financial crisis, have impacted risk appetite by market intermediaries. This is due to the fact that this reforms have increased the capital and liquidity requirements for banks, lowering their ability and willingness to maintain large amount of bonds in their balance sheet, which results in lower return on capital on market making activity.

The current environment of low interest rates, low volatility, together with the QE and all the regulatory changes mask the true impact on the bond market, with the potential for even lower liquidity and discontinuous price deterioration. According to Fed's data, after the financial crisis, the holdings of fixed income inventory on bank's balance sheet

has decreased 80% compared to the levels observed in 2007. With the clear decrease of bank ability for market-making, prices can become more volatile, and then Central Banks like Fed and ECB had to step in (QE). Another change observed was the tremendous increase of bonds supply. Given all the reason discussed, downside risk is really big, since there is high supply, less structural liquidity, and highly dependent (nowadays) on the demand from Central Banks to meet supply.

2.1.1 Microstructure differences between bonds and Stocks

Several differences between the microstructure of bond markets and stock markets can be observed, many of which may be related to bonds characteristics as a financial asset, investment purposes, transparency and risks associated with it.

Bonds are mostly traded through decentralized over-the-counter (OTC) markets, under dealer intermediation, with little pre-trade transparency. On the other hand, stocks are, for the most part, traded on organized exchanges. The lack of transparency on debt markets can be an explanation for the much lower academic attention dedicated to bond market since volume, prices, and trading mechanisms are all jointly endogenous variables.

2.1.2 Bond Portfolio Management

Bonds always have been particularly dominant in institutional investors' portfolio allocation, given its great correlation with liability structures. Though, their complexity have evolved from simple straight cash flows, to a much complex cash flow structures, attracting a broader range of investors. To effectively manage bond portfolios, managers must monitor and control several type of risks exposures in order to be able to better pursue portfolio strategies and enhancing returns.

The issuer is the bond's single most important feature, since that entity stands to be the counterparty of the investor who bought it, and as an investor, you are counting on

the issuer credit risk to have your money back. Therefore, it is crucial to know the issuer the issuer credit quality (rating). There are seven main bond categories, according to issuer: government bonds, agency bonds, investment grade corporate bonds, high yield corporate bonds, foreign bonds, mortgage-backed bonds and municipal bonds.

2.2 Bond Portfolio main Risks

A portfolio manager must employ several mechanisms to monitor and control risk, in order to be aware for the risk factors that the portfolios is exposed and its impact in response to a relevant market changes.

At the same time, to better manage the portfolio's risk exposure. Therefore, changes in market behavior will affect differently two different portfolios, based on different levels of exposure to risk factors. For all said, the portfolio managers have to select a benchmark, taking into account all the risk factors and then has to decide whether to be exposed to all risk factors, replicating the benchmark (passive strategy) or to choose which risk factors a portfolio manager wants to be exposed (active management). In this way, the table below describes the main risk factors, how they can be measured and its market triggers.

Exhibit 2 – Risk factors

Risk Factors	Risk Factor Measurement	Market Changes that Affect Risk Factors
Market Risk	Duration	Change in Yield Levels—Parallel Change in Yield Curve
Yield Curve Risk	Convexity/Distribution of Key Rate Durations (Bullet, Barbell, Ladder, et al.)	Change in Slope and Shape of Yield Curve
Exposure to Market Volatility	Convexity • Negatively convex assets (e.g., callables)/portfolios are adversely affected by volatility • Positively convex assets (e.g., putables)/portfolios are benefited by volatility	Market Volatility • Historical, based on past actual prices or yields • Expected, as indicated by implied volatility of options
Sector Allocation	Percent allocation to each macrosector, microsector, and security and the option-adjust spread (OAS) of each	Change in option-adjusted spreads (OAS) of macrosectors, microsectors, and individual securities

Credit Risk	Average credit rating of portfolio and its sectors	Changes in credit spreads (e.g., spread between Treasuries versus AAA corporates; or spread between AAA corporates versus BBB corporates); also specific company rating changes
Liquidity Risk	Typically measured by the bid/ask price spread—that is, the difference between the price at which a security can be bought and sold at a point in time The liquidity of a security refers to both its marketability (the time it takes to sell a security at its market price, e.g., a registered corporate bond takes less time to sell than a private placement) and the stability of the market price	Different securities have inherently different liquidity (e.g., Treasuries are more liquid than corporates). The liquidity of all securities, particularly riskier securities, decreases during periods of market turmoil.

Source: Advanced Bond Portfolio Management – Best Practices in Modeling and Strategies

2.3 Portfolio Diversification

Portfolio diversification is the concept of distributing one’s money across different investments, in other words, “don’t put all your eggs in the same basket”. The introduction was first established by Markowitz and confirmed by William Sharpe.

There is great contrast between the recommendations of Modern Portfolio theory, proposed by Markowitz back in 1952, and the truth reality of the actual diversification benefits achieved by a vast majority of investors, according with Ashvin B. Chhabra (Managing Director and Head of Wealth Management at Merrill Lynch).

The principles stated by Markowitz, outlined the benefits of portfolio diversification, through the optimization of the combination of different asset classes. The key for this arrangement depends on market risk and return of each asset, as well as on the correlation among assets. Moreover, these assets could be plotted on a risk-return basis and would form the well know curve named as efficient frontier. Afterwards, and based on the utility function of each individual, investors find their appropriate point of allocation between asset classes such as stocks, bonds and cash.

The relationship between portfolio performance and the number of assets held has been under the attention of many investors and financial economists since the famous studies of Markowitz (1952 and 1959) and Sharp (1964) were published. Even though there is an inverse relation between portfolio risk and the number of assets detained in a portfolio, some drawbacks arise such as higher costs associated with transactions costs for rebalancing purposes. Rational investor's aims to find the optimal tradeoff between the optimal theoretical point of diversification and costs associated with it, in order to avoid over-diversification. Therefore, the following factors come into play when determining the optimal point of diversification – cost of maintaining a diversified portfolio (holding costs and transaction costs), correlation among individual stocks and expected return.

However, there is the need to go deeper into each asset class, diversifying within each class. For example, debt securities must be diversified across different maturities and credit ratings (the purpose of this paper), and the same applies for equities (e.g. across different industries), aiming to construct a large portfolio with minimally correlated stocks. However, there is a large gap between theoretical frameworks to achieve the full potential of diversification, and what seems to be the reality.

2.3.1 Stock Portfolio Diversification

Regardless of the benefits of diversification, many investors do not diversify their stocks. Modern portfolio theory is the first to study and present the trade-offs and interactions of systematic risk and returns. Later, academic papers came seeking to answer the questions of how many stocks constitute a diversified portfolio. However, with the great input of William Sharpe (1964) and John Lintner (1965), with the capital asset pricing model (CAPM) marks the birth of asset pricing theory and further more

complex models were developed. These asset pricing models aims to measure risk and relation between return and risk.

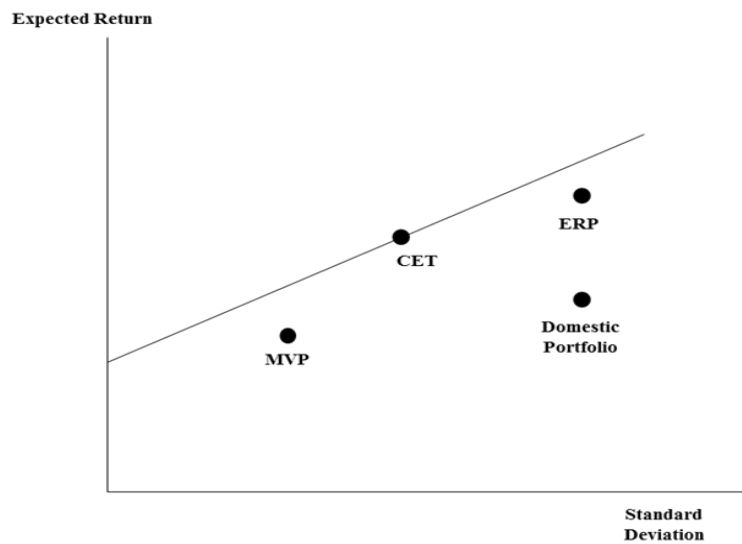
For demonstration and benchmark purposes, but not going in depth in neither of the models, it was found crucial to also study diversifications practices and benefits in equity portfolio. Stock risk has a large idiosyncratic component, which could be mitigated by diversifying the portfolio. Most models suggest investors to hold diversified portfolios in order to eliminate non-rewarded risk. However, according to Barber and Odean (2000), individual investors hold, on average, four stocks in their portfolios.

The scope of modern portfolio analysis were further extended into the advantages of international diversification in 1968 with Grubel's contribution. Several empirical studies followed, such as Levy and Sarnal in 1970, Solnik in 1974 Jorion in 1985, among many others, where most focused on dollar-based investors. The conclusion withdrawn by this authors were that international diversification clearly shows potential benefits compared to a simple domestic portfolio.

According to Bugar and Maurer (1997), that try to diminish the gap between all the studies already performed and what is the reality for a non-US investor, they study the international diversification benefits from a European point-of-view. For the performance of the study, four strategies were used: equally weighted portfolio (EQW), minimum variance portfolio (MVP), the tangency portfolio (CET) and the portfolio in the efficient frontier that has the same risk as the domestic one (ERP).

The figure below demonstrates the strategies deployed by the authors.

Exhibit 3 – Efficient frontier



In terms of the empirical results achieved by the study, potential benefits from international benefits were achieved across the four strategies, mainly in terms of returns enhancement per unit of risk.

Looking at the strategies, the standard deviation (STD) of the MVP is approximately 32% lower than the STD of the German domestic portfolio, and return is 35% higher, which translates into an increase of Sharpe-ratio. Furthermore, CET Sharpe-ratio must be the highest across the four strategies. In terms of the equally risk portfolio (ERP), the study shows an improvement of 285% in returns for the same level of risk as the domestic portfolio.

Exhibit 4 – Strategies summary

	Germany		
	Mean	STD	Sharpe-ratio
EQW	1,3	4,07	0,19
MVP	1,64	2,83	0,39
CET	3,72	4,48	0,71
ERP	3,45	4,14	0,7
Domestic	1,21	4,14	0,16

The four strategies corroborate the economic benefits achieved from diversifying internationally. However, the results only take into consideration “ex post nature” information, the optimal portfolio weights are computed only after the fact.

3. Data

In order to perform the following study, the bond sample data was extracted from BofA Merrill Lynch available corporate indexes with the sample ranging from the beginning of 2001 up to November of 2015. The aim of the study is to measure the diversification benefit across different maturities, as well as credit ratings. Given the complexity of constructing portfolios with such different characteristics, those indexes were used as the underlying portfolios for the study.

Exhibit 5 – BofA Merrill Lynch indexes

Credit Rating / Maturity		Short-Term	Medium-Term	Long-Term
Euro	Investment Grade (IG)	<i>The BofA Merrill Lynch 1-5 Year Euro Corporate Index</i>	<i>The BofA Merrill Lynch 5-10 Year Euro Corporate Index</i>	<i>N.A</i>
	High Yield (HY)	<i>The BofA Merrill Lynch 1-5 Year Euro High Yield Constrained Index</i>	<i>The BofA Merrill Lynch 5-10 Year Euro High Yield Constrained Index</i>	<i>N.A</i>
US	Investment Grade (IG)	<i>The BofA Merrill Lynch 1-5 Year US Corporate Index</i>	<i>The BofA Merrill Lynch 5-10 Year US Corporate Index</i>	<i>The BofA Merrill Lynch 10+ Year US Corporate Index</i>
	High Yield (HY)	<i>The BofA Merrill Lynch 1-5 Year US High Yield Constrained Index</i>	<i>The BofA Merrill Lynch 5-10 Year US High Yield Constrained Index</i>	<i>The BofA Merrill Lynch 10+ Year US High Yield Constrained Index</i>

The indexes in question are capitalization-weighted based, rebalanced on a monthly basis and it does not consider reinvestment income. The constituent securities must have at least one year remaining to maturity date, a fixed coupon schedule and a minimum amount outstanding of 250 million of their local currency. Additionally, callable perpetual and fixed-to-floating securities have to be at least one year from the first call and last call (before turning floating rate), respectively, to be eligible. Other securities were excluded, such as “cocos”, hybrids, securities in legal default and those privately placed issued.

Each index is rebalanced on the last day of each month. Issues qualifying the above criteria are eligible and included into the portfolio for the following periods, but those that no longer meet the requirements, due to a rating or maturity changes during the

running month, are kept in the index until the end of the month, at which the index is adjusted by removing it and/or including new ones.

4. Methodology

To perform the study in question, several portfolios resulted from the combination of the indexes. On a starting point, investment grade and high yield securities were mixed, as well as across different maturities among euro-denominated securities. The first approach was to construct equally-weighted (EW) portfolios and observe the differences in four major metrics: return, volatility, Sharpe ratio and kurtosis. A second approach was to construct an additional portfolio based on a mean-variance optimization, through the sharpe ratio maximization. The optimal portfolio is equivalent to the tangency portfolio, by solving the following maximization:

$$\max S(x) = \frac{\sum_{i=1}^N x_i [E(R_i) - r_f]}{\sqrt{\sum_{i=1}^N \sum_{j=1}^N x_i x_j \text{Cov}(R_i, R_j)}} \quad \sum_{i=1}^N x_i = 1 \quad (x_i \geq 0, i = 1, 2, \dots, N)$$

On a second stage, the analysis is made on a different geographic zone, US, in order to assess the robustness of the relationship determined on the Euro-denominated portfolio.

In order to understand the benefits of diversifying internationally, it is performed the same methodology above combining both geographies (EU and US). Furthermore, the investigation of international diversification benefit is extended, and an emerging market portfolio (index)¹ is added to the pool of portfolios available to invest in.

In theory, EM assets are riskier than DM, however present a lower correlation with DM portfolios. According to Christoffersen, Errunza, Jacobs, and Langlois, 2012, even though tail dependence has increased to EM, its level still relatively low for EM.

¹ Templeton Emerging Markets Bond Fund is a SICAV incorporated in Luxembourg. The Fund's objective is maximum total return. The Fund invests primarily in debt obligations of emerging market issuers.

However, the benefits of international diversification are perceived to decrease over time, mainly to DMs according to the authors. But, EM may still offer some benefit, which is the main rationale to investigate it, given the current low interest rate and returns environment, leading investors to seek for yield. According to BlackRock, only 20% of the bonds currently yield over 4%, meaning that bond investors have to look somewhere else. As the economic fundamentals of EM improve, it strengthens investors' confidence and their debt credit quality has risen. Looking back to those geographies, the historical returns have been quite attractive, with a tightening in spreads. According to some studies, by adding EM securities into a diversified portfolio, there is an enhancement of total return, but it increases the volatility of the portfolio as well as the sensitivity to global macro events. Therefore, there is a greater tradeoff of whether the benefits surpass the risks associated with it. For the purpose study and as proxy of such portfolio, it was used the available EM bond fund by Franklin Templeton Investment Funds - Templeton Emerging Markets Bond Fund is a SICAV incorporated in Luxembourg with the main goal to maximize total return. It invests primarily in debt obligations, from publicly traded companies, of emerging market issuers.

Additionally, after presenting all portfolios and main conclusions, it is drawn the efficient frontier. The aim of this point is for benchmarking the benefit achieved in a bond portfolio versus the equity potential benefit described in point **2.3**. In this sense, the minimum variance portfolio (MVP), the equally-weighted portfolio (EQW) and the equally risk portfolio (ERP) are added to the overall pool of portfolios. For the purpose of such assessment, it is only assumed long-only portfolios.

$$MVP: \min V(x) = \sum_{i=1}^N \sum_{j=1}^N x_i x_j Cov(R_i, R_j) \quad ERP: \max E(x) = \sum_{i=1}^N x_i E(R_i)$$

From the following study it is expected, by combining different portfolios with non-perfect positive correlation, an enhancement of the Sharpe ratio. This improvement may outcome from an overall risk reduction or form an increase of the reward related to the overall risk of the portfolio. It is also expected the relationship among the different portfolios, in terms of credit ratings and maturities, to differ across geographies, given the differences relative to market structure, economic cycles (QE, for example, at different time spans), market liquidity and industries. Furthermore, as a consequence of the two last financial crisis and from the monetary policies deployed (QE and low short-term interest rates), a greater effect may be seen in short term portfolios in Europe and US.

In the purposed study, four simple metrics widely used by investors and practitioners were deployed – Expected return, Volatility, Sharpe ratio and Kurtosis – to determine the benefits of diversification, to understand the relation across the pool of portfolios and how it would be optimized on a risk-adjusted basis.

Returns and volatility are two of the best-known measures of performance of an individual asset or portfolio. In terms of returns, it was used the logarithm of returns given its benefit of normalization versus price return. Given the comparable purpose of this metric, the usage of log returns enables the assessment of the relationship between two or more variables. Therefore, by using log returns it is assumed a convenient normal distribution and also eases someone's life in terms of compounding returns. Additionally, and with great importance, log returns ensure for numerical stability in the model. In terms of volatility, it stands for the deviations of the returns from de mean. The greater dispersion of historical returns, the greater uncertainty inherent with future returns. There is several advantages associated with this metric such as the widely recognition and usage by academics and practitioners, simplicity and very intuitive (Reilly and Brown, 2003).

To assess the relation between return and volatility, the Sharpe ratio was used to measure the excess return per unit of risk. This ratio is one of the best-known and meaningful tools to assess performance. As a measure of absolute risk-adjusted performance, this ratio is determinant when examining diversification benefits.

Additionally, higher moment's metrics were deployed – kurtosis. Kurtosis is a statistical measure that aims to understand the whether the returns are peaked or flat versus the normal distribution, by studying the shape of returns probability curve. Risk-averse investors will probably seek portfolios with low kurtosis, due to the greater likelihood of the tails (extreme events) to fall closer to the expected return.

5. Results

In order to analyze the benefits of diversification achieved by the methodology proposed, it is crucial to look at each portfolio individually, in order to be able to measure and understand where the benefit is coming from.

Exhibit 6 – Performance Metrics for Single

	Eur Corporate Bonds					US Corporate Bonds					Emerging Markets	
	STIG	MTIG	LTIG	STHY	MTHY	STIG	MTIG	LTIG	STHY	MTHY	LTHY	EM Bond Fund
Return	4.2%	5.7%	7.2%	9.9%	7.6%	3.7%	5.2%	6.1%	7.4%	6.7%	10.5%	7.4%
Excess Return	1.9%	3.4%	4.9%	7.6%	5.3%	1.4%	2.9%	3.8%	5.1%	4.4%	8.2%	5.1%
Volatility	2.2%	5.1%	6.8%	11.7%	12.8%	9.6%	10.0%	12.1%	8.0%	9.9%	11.7%	11.1%
Info Sharpe	1.92	1.11	1.07	0.85	0.59	0.39	0.52	0.50	0.92	0.68	0.90	0.67
Sharpe Ratio	0.87	0.66	0.73	0.65	0.41	0.15	0.29	0.31	0.63	0.45	0.70	0.46
Positive Months	73.6%	64.6%	65.2%	72.5%	72.5%	55.1%	53.4%	52.8%	73.6%	69.7%	68.0%	68.2%
Kurtosis	1.81	3.68	1.08	5.16	9.61	0.82	0.25	0.15	14.27	14.83	6.42	15.09
Skewness	-0.17	-0.83	-0.50	-0.14	-1.64	0.40	0.39	0.39	-1.89	-1.99	-1.18	-2.39
Monthly Max	2.3%	4.7%	5.6%	15.2%	12.1%	10.2%	9.6%	12.1%	9.5%	11.6%	12.7%	8.6%
Montly Min	-2.3%	-6.8%	-6.3%	-13.6%	-20.6%	-6.9%	-6.0%	-7.6%	-15.4%	-19.5%	-17.5%	-22.6%

Legend: ST - Short term; MT - Medium term; LT - Long term

Looking at the individual portfolios, exhibit 6, single portfolio Sharpe ratio ranges between 0.15 and 0.87, taking into consideration that each portfolio is already diversified within its own characteristics. Additionally, the 6 month Euribor is used as risk-free proxy. Therefore, besides the Sharpe ratio the info Sharpe ratio was used, which allows to withdrawn some conclusions about the sensitivity of such measure relative to the risk-free benchmark used.

Ignoring the risk-free (info Sharpe), as the time-to-maturity and the credit risk increases in the Euro-denominated portfolios, the info sharped yields lower returns per unit of risk. Surprisingly, for the US based portfolios, it behaves in the opposite direction, it increases with maturity and credit rating. However, when benchmarking it against the risk-free rate, it yields results much more close to each other, and are all considerable smaller (e.g. Euro ST IG 1.92 vs 0.87). The portfolio that offers the higher Sharpe ratio is the US Long term HY portfolio.

From a pure Euro-denominated securities portfolio, it was constructed equally-weighted (EW) portfolios and an additional one which optimize it based on a risk-adjusted performance.

Exhibit 7 – Euro Portfolios

	EW portfolio									MV Opt.	
	STIG & MTIG	STIG & LTIG	MTIG & LTIG	STIG & STHY	STIG & MTHY	MTIG & MTHY	STIG & MTIG & LTIG	STHY & MTHY & LTIG	ST & MT & LT	Long - Only	Long - Short
Return	4.9%	5.7%	6.4%	7.0%	5.9%	6.6%	5.7%	8.7%	6.9%	5.0%	4.3%
Excess Return	2.6%	3.4%	4.1%	4.7%	3.6%	4.3%	3.4%	6.4%	4.6%	2.7%	2.0%
Volatility	3.6%	4.3%	5.8%	6.4%	7.0%	8.0%	4.5%	11.2%	6.1%	2.9%	1.5%
Info Sharpe	1.38	1.33	1.11	1.11	0.85	0.83	1.26	0.78	1.13	1.73	2.86
Sharpe Ratio	0.74	0.79	0.71	0.75	0.52	0.54	0.75	0.58	0.75	0.94	1.35
Positive Months	61.8%	62.8%	60.7%	70.7%	65.4%	62.3%	61.3%	67.5%	66.0%	74.2%	82.6%
Kurtosis	3.13	1.19	1.90	4.97	8.17	7.36	1.92	5.67	5.63	3.70	2.14
Skewness	-0.64	-0.50	-0.67	-0.24	-1.31	-1.26	-0.63	-1.03	-1.11	-0.58	0.93
Monthly Max	3.5%	3.6%	4.8%	8.0%	7.0%	7.7%	4.0%	10.8%	5.5%	2.9%	2.4%
Montly Min	-4.6%	-4.3%	-6.6%	-8.0%	-10.6%	-12.2%	-5.1%	-15.9%	-8.1%	-3.7%	-0.5%

On the EW portfolios, there is a general improvement of the Sharpe ratio, mainly originated through the decrease of overall risk in each new portfolio. There is some positive effect over the Kurtosis, yet it is still quite high. The mean-variance optimal portfolio yields a considerable high Sharpe ratio of more than one (1.35) and there is a considerable improve on Kurtosis and the amount of positive months increased as well. But this strategy is considering that there is no portfolio-short constraints. If there would be short-sell constraints (long-only), the portfolio would yield a return of 5%, but a higher volatility of 2.9%, which means that the Sharpe ratio now is lower, 0.94. A 0.94 Sharpe

ratio is a very good ratio for such simple method, and significantly larger than the standalone portfolios.

The same hypothesis was performed under US based security portfolios, and it's possible to conclude that there is lower potential for diversification, given the lower results achieved under the same approach. It may be explained by the higher transparency and liquidity, as well as by the more well-timed and market based interventions by the US Central Bank.

On a second approach, it was studied the effectiveness of geographical diversification, combining a Euro-denominated portfolio with US bonds. Unexpectedly, most of EW portfolios did not improve as it was expected, however it may be explained by the high correlation between these two markets. In exhibit 8, the EW portfolio that yields the best results in terms of performance adjusted is the combination between the long term IG European portfolios with the long term HY US one.

Exhibit 8 – Equally Weighted EU and USA portfolios

EU/US	Sharpe Ratio						Sharpe Ratio		
	ST IG	MT IG	LT IG	ST HY	MT HY	LT HY	EU & US IG	EU & US HY	EU & US
ST IG	0.33	0.45	0.44	0.75	0.57	0.78	0.49	0.61	0.73
MT IG	0.43	0.50	0.48	0.74	0.59	0.76			
LT IG	0.50	0.55	0.52	0.84	0.68	0.83			
ST HY	0.63	0.68	0.66	0.68	0.60	0.73			
MT HY	0.44	0.50	0.50	0.52	0.45	0.58			

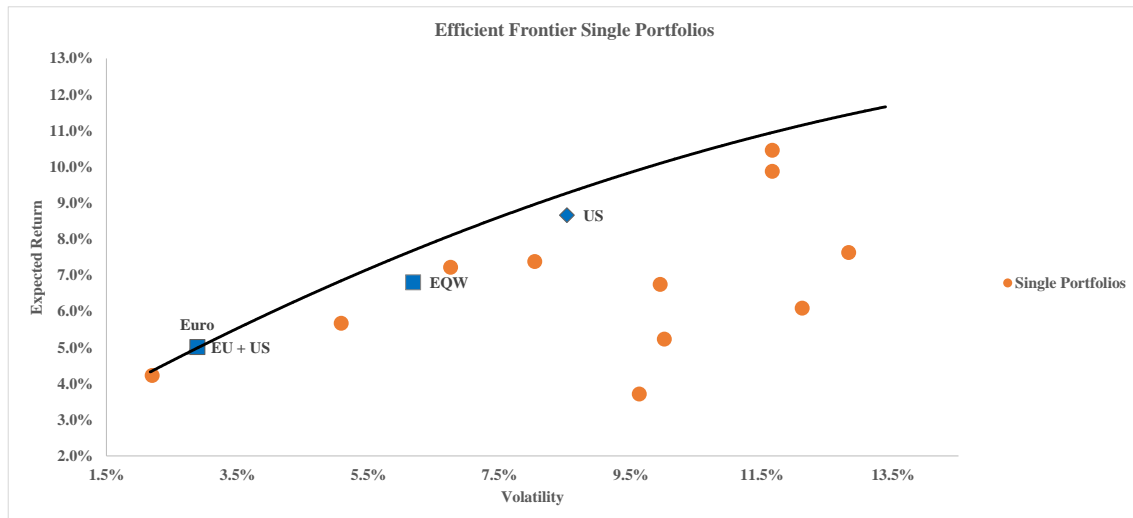
However, if a portfolio would be constructed on the basis of an optimization of risk-reward, the result would be a Sharpe ratio of 1.59, significantly higher than the Euro portfolio (1.35), but a worst kurtosis, on a long-short portfolio. Yet, assuming a long only portfolio, this

Exhibit 9 – Optimal portfolio

	MV Opt.	
	Long Only	Long-Short
Return	5.0%	6%
Excess Return	2.7%	3%
Volatility	2.8%	2%
Info Sharpe	1.76	2.66
Sharpe Ratio	0.95	1.59
Positive Months	74.2%	83%
Kurtosis	3.60	1.48
Skewness	-0.46	0.67
Monthly Max	2.9%	3%
Monthly Min	-3.6%	-1%

optimization would only yield 0.95 in terms of Sharpe ratio and kurtosis, very close to the European one.

Exhibit 10 – Efficient Frontier & Single Portfolios

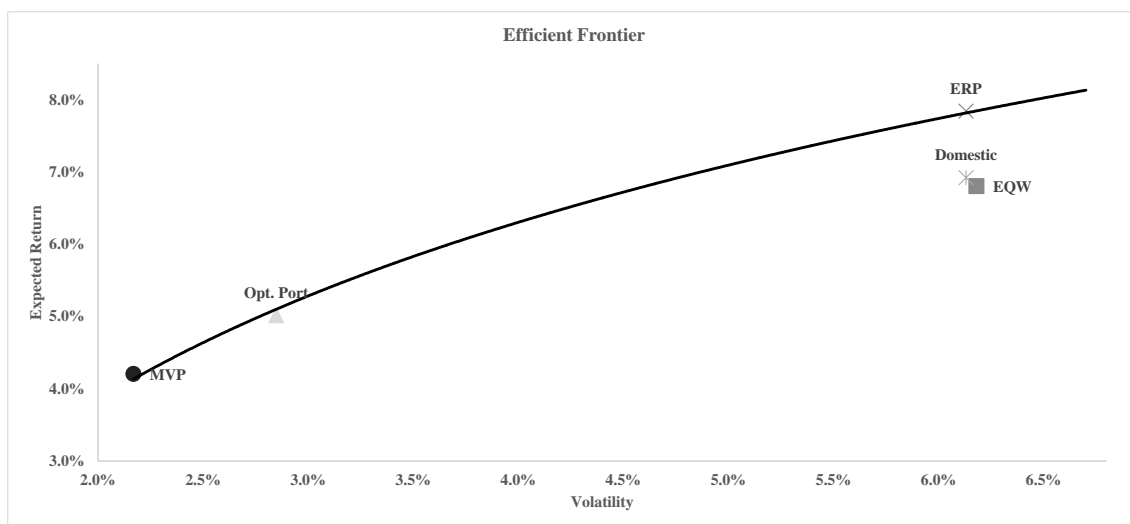


Summarizing the previous portfolios, an efficient frontier was plotted. In Orange there is the single portfolios used to construct the efficient frontiers and in Blue it is the long-only optimal portfolios computed. It seems that most of the potential diversification benefit comes from diversifying portfolios across maturities and credit rating and not from diversifying internationally.

Given the current environment and trend of yield seeking, it was tested the hypothesis of an improvement of portfolio performance metrics by adding a portfolio constructed purely by EM bonds. Analyzing the EM portfolio on a standalone basis, it is possible to see that there is quite high risk associated with it, considering that it is already diversified, since it is a fund that consist mainly on Non-Investment Grade bonds (44.3%) and Investment Grade Government Bonds (36.8%). The fund in question has a Sharpe ratio of 0.46, with relative high volatility. From a risk-reward view, no better results are achieved on neither strategies – long-only and long-short portfolios. Nevertheless, the long-short portfolios are only suitable and reasonable to consider for investors with great

experience, knowledgeable and with a vast access to funding, such as Hedge Funds and Investment Banks. Therefore it is perceived to not be plausible to consider a long-short strategy for an average investor. On the other hand, the long-only portfolio turned-out to be the same as the optimal EU & US long-only portfolio, which means that under the optimization model, it would not be efficient to diversify into emergent markets.

Exhibit 11 – Efficient Frontier



The efficient frontier was plotted in order to see the diversification benefits that could be potential achieved, as well as the benefit relative to the same method in pure stock portfolios. A table summarizing can be also found below.

Exhibit 11 – Portfolio statistics summary

	Mean	STD	Sharpe-ratio
EQW	6.80%	6.18%	0.728
MVP	4.20%	2.17%	0.878
CET	5.02%	2.85%	0.953
ERP	7.84%	6.13%	0.904
Domestic	6.92%	6.13%	0.754

The domestic portfolio used for this study was based on an equally-weighted portfolio of European securities. In this case, the potential benefits reflected in these results accrue for the MVP, CET e ERP in term of sharpe-ratio enhancement. The volatility (standard deviation) in the minimum variance portfolio (MVP) is almost 65% smaller than the one obtained in the domestic portfolio, which confirms the risk reduction

effectiveness of this strategy. Logically, as risk decreases, return is also going to fall. However, risk falls more than return, which results into an increase in sharpe ratio of about 0.12. As the CET portfolio stands for the optimal portfolio, this one presents the highest sharpe-ratio (0.953). In terms of the equal risk portfolio, the expected return is 13% higher than the domestic portfolio for the same level of risk.

These results seem to be in line with the ones achieved in section 2.3, however there is to main differences: the sharpe ratio of the domestic portfolio is significantly larger than the stock portfolio (0.75 vs 0.16) and greater potential benefit from diversifying stock portfolios, since there is an return increase of 285% for the same level of risk for the domestic stock portfolio versus the 13% in the bond domestic portfolio.

Therefore, it is possible to conclude that there is significant diversification benefits to be achieved by diversifying a bond portfolio. Even though there is much lower systematic risk associated with bonds and its closeness to cash (considering to be safer than stocks), it still presents very reasonable results that could be achieved simply by investing across different maturities and credit rating securities. Such results may also be explained by the need to diversify across different asset classes, like stocks, currencies, commodities and cash. The study resumes to a very simple and straight forward exercise to measure diversification benefit. However, it was a challenge to gather all the required information to perform the study, when compared to stocks. Considering that the average investor are uninformed, lack of knowledge about financial markets and on the diversification benefits (seen from the average securities held), the aim of the study was to show the importance of diversification in such simple way.

However, this approach has some pitfalls. Starting, the pool of portfolios (indexes) used are already quite diversified, given the incorporation of hundreds if not thousands of bonds. Nevertheless, it may be seen as the home-bias selection referred to in

diversification literature, limiting the diversification benefit. Another pitfall observed was the lack of information and transparency in the market (OTC traded), which limits the data availability. Additionally, the mean-variance framework used as a tool, is somewhat unstable and too sensitive to inputs, which leads to large changes in weights. Therefore, portfolio optimizers amplify the effect of estimation error by overweighting securities that for instance have unusually high estimated risk premium and/or low estimated risk (extreme values more likely to contain errors). Last, but not least, transaction costs such as commission and bid-ask spread were ignored, however it is important to keep them in mind given their negative impact on a well-diversified portfolio construction – tradeoff between the benefit of adding a new security along with its cost.

6. Conclusion

The significant diversification achieved in this study might be representative to conclude that there is considerable benefit to be achieved inherent to bonds, and as well as by adding bonds to portfolios of different asset classes. The portfolios used are already widely diversified into each category (maturity and credit rating) and does not include transactions and management costs. Therefore, it is only the marginal benefit that is being taken into account, when adding new securities into the portfolio and no cost associated with it are considered (no trade-off). Otherwise, we would reach much lower results.

The lower attention given to the study of bond diversification might be explained by the much lower risk associated with this asset class – lower systematic risk – which is translated into high risk adjusted performance vs stocks in a single-name. In this sense, there is a greater need and potential benefit to better diversify and exploit the returns on equity relative to bonds.

Besides all the pitfalls associated with this study, it is a simple and practical way to diversify and assess the benefits of doing it. The results are highly sensitive by the

proxy of risk-free assumed (Euribor 6 months) and influenced by monetary policies, such QE and short term depository rates in the Central Banks. The lack of transparency was also observed when trying to get good sample, in terms of information and data quality.

The purposed study was performed in order to try to understand why such an important asset class has been off the spotlights of academic and researchers. As the literature suggests, mixing securities with different characteristics will yield higher a Sharpe ratio. There is a clear benefit of going internationally, however emerging markets don't seem to be a significant alternative, given the greater risk associated with it. Furthermore, along with this study it is also possible to conclude the greater importance of bond portfolio diversification across different maturities and credit rating versus internationalization and greater potential benefit of diversification in portfolio of stocks relative to bonds.

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