Historical Returns of the Market Portfolio[ϕ]

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COMMENTS INVITED

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Abstract

Using a newly constructed unique dataset, this study is the first to document returns of the market portfolio for a long period and with a high level of detail. Our market portfolio basically contains all assets in which financial investors have invested. We analyze nominal, real, and excess return and risk characteristics of this global multi-asset market portfolio and the asset categories over the period 1960 to 2015. The global market portfolio realizes a compounded real return of 4.38% with a standard deviation of 11.6% from 1960 until 2015. In the inflationary period from 1960 to 1979, the compounded real return of the GMP is 2.27%, while this is 5.57% in the disinflationary period from 1980 to 2015. The reward for the average investor is a compounded return of 3.24%-points above the saver's. We also compare the performance of an investor who holds the market portfolio with an investor who uses simple heuristics for the portfolio allocation. Our results suggest that the market portfolio is close to the mean-variance frontier, but our heuristic allocations achieve a significantly higher reward for risk.

Keywords: Asset Allocation, Benchmarking, Investing, Market Portfolio

JEL Classification: G11, G12

Introduction

This study aims to fill both a gap in the academic literature as well as a gap in return data availability for finance practitioners by providing returns of the global market portfolio (GMP) over the period 1960 to 2015 from the perspective of an USD investor. A study on returns of the GMP has not been done before for such a long period and with such a level of detail. We document in detail how we collected historical returns data on global asset classes, which is challenging for the period before 1985. Moreover, we make the resulting data publicly available so other researchers can use them in their own applications. Our GMP basically contains all assets in which financial investors have invested.

This paper contains unique features compared to the scarce academic literature on international asset returns. First, our sample period significantly extends the 1960-1980 period of Ibbotson and Siegel (1983), who are the first with a rigorous study on a global multi-asset market portfolio. They find a nominal compounded return of 8.36% for their so-called world market wealth portfolio over the period 1960-1980.[1] Compared to that study, we focus on assets in which financial investors have actually invested. For example, we do not take farmland into account, as it usually belongs to owners that do not hold it as a financial investment and hereby it is not publicly available.

Second, in comparison with Dimson, Marsh, and Staunton (2002), a groundbreaking study that documents annual returns for equities, government bonds, and treasury bills in sixteen countries for the 101-year period 1900-2000, we include returns for more assets like for example corporate bonds and real estate. Also, we use an all-maturity market capitalization weighted government bonds index instead of a GDP-weighted long term government bonds index. The latter is less useful for representing the performance of the asset class global government bonds. Obviously, the length of their sample period remains unmatched.

This study on the returns of the GMP contains important information for both theoretical and practical applications. First, the mean-variance efficient frontier of Markowitz (1952) is the core in the CAPM. Tobin (1958) improves the efficient frontier by adding a risk-free asset. By combining the risk-free asset with the optimal portfolio on the efficient frontier we are able to construct the Capital Allocation Line (CAL). Every possible portfolio on the CAL has an ex-ante superior risk-adjusted expected return compared to other portfolios on the efficient frontier. Sharpe (1964) shows that the ex-ante optimal portfolio is the GMP, in which all assets are weighed according to their market capitalization. Roll (1977) argues that the CAPM cannot be tested as returns on the true market portfolio are unobservable, as they include all assets that economic agents hold, such as human capital, housing, and art. However, using a portfolio that closely resembles the market portfolio may have important implications for studies on asset prices. For example, Baltussen, Post, and Van Vliet (2012) indicate that the excess returns of equity value strategies are markedly smaller when evaluated against a CAPM-market portfolio consisting of both stocks and bonds, instead of the traditional use of only stocks. Although our study cannot resolve Roll's critique entirely, we aim to estimate

[1] Ibbotson, Siegel and Love (1985) extend the results of the previous study from 1980 to 1984, while Ibbotson, Carr, and Robinson (1982) are seminal to document international equity and bond returns for a long historical sample.

the historical returns of the *invested* market portfolio as closely as possible. We cannot guarantee that the *invested* market portfolio has been also fully *investable*, as there may have been episodes during our sample period in which capital constraints were imposed on certain types of investors such that certain assets were not accessible. For the more recent period we think this is not an issue, as index providers typically require asset investability before they are included in their indexes. For earlier data, we built on the seminal insights by Ibbotson, Carr, and Robinson (1982) and Ibbotson and Siegel (1983).

Second, the GMP is also important for investors in practice. Sharpe (2010) advocates that the GMP can be used as a starting point or benchmark for portfolio construction. As the GMP reflects the average investor in publicly available assets at any point in time, it is a natural benchmark for investors. Moreover, passive investors in the GMP save costs of trading since only marginal rebalancing is required due to differences in net issuance of asset classes. Sharpe (1991) argues that investors without a reason to deviate from the average should keep their costs as low as possible by being passive investors in the GMP. Even though the returns on the GMP are a natural benchmark, because it reflects the returns of the average dollar invested, it remains to be seen whether it is also a mean-variance efficient portfolio as theory suggests. Practitioners may want to challenge its mean-variance efficiency and use their findings to support asset allocation decisions or advice they give to their clients. As far as we know, there is no commercial index provider that has offered its clients access to a global market index, let alone with a history back to 1960. Our effort can be seen as an attempt to satisfy the need of some practitioners that otherwise would be deprived of this return series.

Third, this new data enables an extensive analysis of return and risk characteristics of the GMP and the asset categories over the period 1960 to 2015. We include conditional analyses on recessionary and inflationary periods. We also compare the performance of an investor who holds the GMP with an investor who uses simple heuristics for the portfolio allocation. By comparing the performance of the GMP with alternative portfolio allocation schemes, we can find out whether the GMP has been a good, if not optimal, portfolio during our 56-year sample period. This analysis will also touch upon mean-reversion across asset classes. Moreover, this new data set provides an opportunity to gauge the difference in return and risk for the average investor and saver.

Our main findings can be summarized as follows. The GMP realizes an average compounded real return of 4.39% with a standard deviation of 11.7% from 1960 until 2015. The arithmetic mean is 5.07%. In the inflationary period from 1960 to 1979, the compounded real return of the GMP is 2.27%, while this is 5.59% in the disinflationary period from 1980 to 2015. The reward for the average investor is a compounded return of 3.25%-points above the saver's. Finally, our results suggest that the GMP is close to the mean-variance frontier, but with other allocations there is room for a better reward for risk.

In the next section, we discuss the returns of the GMP and the four asset categories Equities Broad, Real Estate, Nongovernment Bonds and Government Bonds Broad over the period 1960 until 2015. In the subsequent section, we analyze the performance of several heuristic allocation strategies relative to the GMP. Afterwards, we examine the ex-post mean-variance efficient frontier. The final section summarizes and contains our conclusions.

Returns of the Global Market Portfolio 1960-2015

We define the GMP as all assets held by financial investors. We distinguish four asset categories. The asset category Equities Broad contains the asset classes equities and private equity, the asset category Real Estate resembles the asset class real estate, the asset category Nongovernment Bonds contains the asset classes investment grade credits and high yield bonds, and the asset category Government Bonds contains the asset classes government bonds, inflation-linked bonds, and emerging market debt. We do not include hedge funds or commodities. Hedge funds are vehicles that primarily employ active strategies in (derivatives on) asset classes that we already cover. Including them would result in double counting. Investments in commodities are typically in derivatives contracts, which are in zero-net-supply.

For each asset category, we compose a total return series in US dollars. With these series, we basically cover the whole global invested market. We refer to Appendix A for details on the construction of our return series. We also perform robustness checks on our return series, for which we report the results in Appendix B. The robustness checks suggest that our data set of returns is reliable. Despite that we find indications that our data represent good estimates for historical returns, we are aware that our estimates are surrounded by uncertainty. Finally, appendix C describes the market capitalizations we use to arrive at the market capitalization weighted returns of the GMP.

Nominal returns

Table 1 shows the statistical properties based upon the annual nominal returns of the GMP and its four asset categories from 1960 until 2015. We also include the risk-free return and inflation in the table. As we report all returns in US dollars, we use US Treasury bills for the risk-free rate and US inflation to convert nominal returns to real returns in our analyses. This mirrors the methodology of Dimson, Marsh and Staunton (2002).[2] During our 56-year sample period, the GMP delivers a compounded annual return of 8.35%. Equities Broad realizes the highest compounded annual return with 9.46%, followed by Real Estate (9.19%), Nongovernment Bonds (7.44%) and Government Bonds (6.98%). An investment in three-month Treasury bills would have returned 4.95%, while inflation has averaged 3.80% during our sample period. This implies that the equity return has been 4.51 pps above cash, the multiplicative premium is 4.30 bps. Standard deviations for the asset categories vary from 7.1% for Government Bonds Broad to 25.8% for Real Estate. The GMP has a standard deviation of 11.5%. None of the asset categories' returns distinguish significantly from returns of the GMP as illustrated by the p-values, except if we split the sample into up and down markets as measured by the return of the GMP. Besides the more usual statistics, in Table 1 we also report data for which we split the sample into years in a recession and outside a recession based on NBER data. Here, we assign a recession label to years with at least one quarter in an official NBER recession. During expansions, asset categories' returns significantly differ from returns of the GMP. Also, we distinguish an

[2] We use three-month secondary market Treasury bills. For inflation, we use the seasonally adjusted consumer price index for all urban consumers from the Bureau of Labor Statistics.

inflationary environment, being 1960-1979 as inflation was in an uptrend, and a disinflationary environment from 1980 onwards.

Table 1

Statistical properties for nominal returns (1960-2015; [p-values] based on performance versus GMP)

	GMP	EB	RE	NGB	GBB	TB	CPI*
Compounded average return (%)	8.35	9.46	9.19	7.44	6.98	4.95	3.80
Arithmetic average return (%)	8.98	11.03	12.12	7.71	7.21	5.00	3.84
	-	[0.191]	[0.342]	[0.683]	[0.600]	[0.105]	[0.026]
Standard deviation (%)	11.52	17.76	25.84	7.89	7.12	3.31	2.93
Minimum annual return (%)	-24.40	-43.52	-41.84	-3.33	-5.28	0.03	-0.02
Maximum annual return (%)	35.73	42.80	80.52	33.50	27.19	15.27	13.25
Maximum cumulative drawdown (%)	-24.45	-43.52	-57.26	-3.33	-8.24	0.00	-0.02
# years with return < 0%	14	15	14	8	6	0	1
# years with return < -10%	2	7	8	0	0	0	0
Longest period cumulative R < 0%	3	5	6	1	3	0	1
Avg. return when R(GMP) < 0% (%)	-6.45	-13.50	-9.30	3.03	4.75	5.00	4.35
	-	[0.001]	[0.385]	[0.000]	[0.001]	[0.000]	[0.001]
Avg. return when R(GMP) > 0% (%)	14.12	19.20	19.26	9.27	8.03	5.00	3.68
	-	[0.000]	[0.139]	[0.000]	[0.000]	[0.000]	[0.000]
Avg. return in recessions (%)	3.32	2.67	-1.17	6.79	7.06	6.43	5.28
	-	[0.470]	[0.292]	[0.121]	[0.164]	[0.222]	[0.343]
Avg. return in expansions (%)	11.24	14.37	17.44	8.08	7.27	4.43	3.27
	-	[0.008]	[0.038]	[0.020]	[0.010]	[0.000]	[0.000]
Avg. return inflationary period (%)	7.80	9.48	12.28	6.56	6.11	5.37	4.98
	-	[0.471]	[0.436]	[0.767]	[0.750]	[0.617]	[0.565]
Avg. return disinflationary period (%)	9.63	11.88	12.03	8.35	7.82	4.80	3.21
	-	[0.283]	[0.574]	[0.773]	[0.682]	[0.108]	[0.019]
Sharpe ratio	0.69	0.56	0.43	0.83	0.85	-	-
Sortino ratio	1.96	1.28	1.12	8.45	6.09	-	-
Skewness	-0.36	-0.67	0.47	1.18	0.74	0.64	1.63
Excess kurtosis	0.69	0.52	0.48	2.02	0.42	0.75	2.62
P-value JB	[0.312]	[0.092]	[0.274]	[0.000]	[0.064]	[0.078]	[0.000]

* Global Market Portfolio (GMP), Equities Broad (EB), Real Estate (RE), Nongovernment Bonds (NGB), Government Bonds Broad (GBB), 3-month Treasury-bills (TB) and inflation (CPI).

If we adjust the returns for risk by the Sharpe (1994) and Sortino ratios, it appears that the GMP has the highest Sharpe ratio (0.69) as it benefits from diversification.[3] Still, the Sortino ratio for the GMP, which

[3] For more on the Sortino ratio, see Sortino and Price (1994). The minimum required rate of return is 0% in our calculation of the Sortino ratio.

shows the reward for downward risk, lags the ones for Nongovernment Bonds and Government Bonds Broad. The skewness of the GMP is -0.36, which indicates that returns have an asymmetric probability distribution with extreme observations or more observations on the left side of the return distribution. The excess kurtosis has a value of 0.69, which means that the distribution of nominal returns has fatter tails than the normal distribution. However, we do not reject the null hypothesis that the returns of the GMP are normally distributed at a significance level of 5%, using the Jarque and Bera (1987) test.[4]

Real returns

Real returns are useful as these provide insight in the development of purchasing power through time, so we adjust the returns for inflation. Figure 1 shows the cumulative real return of the GMP and the four asset categories. The real value of the GMP grows from 100 at the end of 1959 to 1,105 at year end 2015, which implies a compounded annual return of 4.39%. Equities Broad reach a value of 1,954 (5.45%), followed by Real Estate with 1,699 (5.19%), Nongovernment Bonds with 687 (3.50%) and Government Bonds Broad with 541 (3.06%). The risk-free asset grows to 185 and delivers a compounded annual return of (1.10%).

Figure 1

Cumulative Real Return of the GMP and the Four Asset Categories, 1959-2015

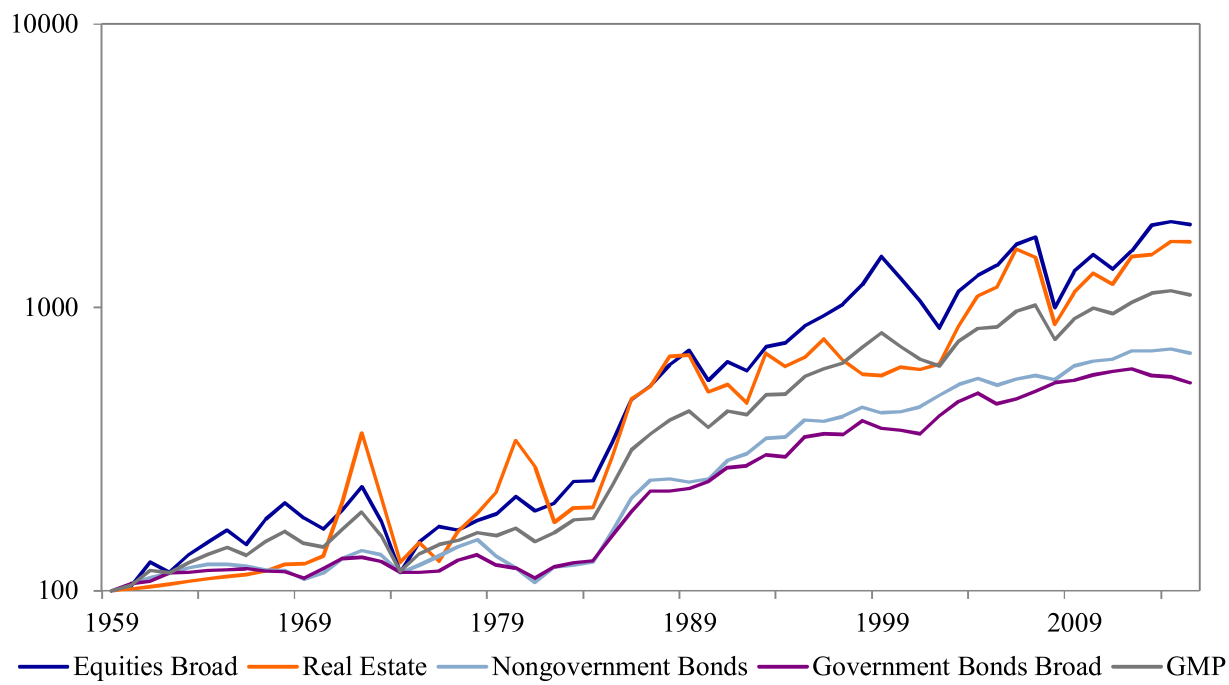


Table 2 shows additional statistical properties for real returns. The GMP has the highest Sharpe ratio. However, taking downward risk into account as measured by the Sortino ratio, Nongovernment Bonds and Government Bonds performed better than the GMP. During recession years, none of the asset categories'

[4] Throughout this article, we maintain a significance level of 5% for all significance tests.

returns relative to the GMP significantly differ from zero. In expansionary years, the picture is comparable with rising markets, i.e. a higher return than the GMP for Equities Broad and Real Estate and a lower one for Nongovernment Bonds and Government Bonds Broad.

Table 2

Statistical properties for real returns (1960-2015; [p-values] based on performance versus GMP)

	GMP	EB	RE	NGB	GBB	TB*
Compounded average return (%)	4.38	5.45	5.19	3.50	3.06	1.10
Arithmetic average return (%)	5.04	7.02	8.01	3.82	3.30	1.13
	-	[0.191]	[0.342]	[0.683]	[0.600]	[0.105]
Standard deviation (%)	11.60	17.51	24.67	8.34	7.24	2.30
Minimum annual return (%)	-25.25	-43.51	-41.82	-13.43	-8.34	-3.42
Maximum annual return (%)	33.64	41.12	74.57	30.73	22.55	7.24
Maximum cumulative drawdown (%)	-38.14	-50.05	-65.00	-29.10	-17.19	-10.69
# years with return < 0%	16	16	16	16	18	18
# years with return < -10%	6	11	11	3	0	0
Longest period cumulative R < 0%	12	10	13	6	6	9
Avg. return when R(GMP) < 0% (%)	-9.27	-15.06	-9.54	-1.44	0.44	0.49
	-	[0.002]	[0.781]	[0.001]	[0.001]	[0.000]
Avg. return when R(GMP) > 0% (%)	10.77	15.86	15.03	5.93	4.45	1.38
	-	[0.000]	[0.220]	[0.000]	[0.000]	[0.000]
Avg. return in recessions (%)	-1.72	-2.36	-6.17	1.63	1.82	1.12
	-	[0.470]	[0.292]	[0.121]	[0.164]	[0.222]
Avg. return in expansions (%)	7.747	10.775	13.680	4.699	3.896	1.134
	-	[0.008]	[0.038]	[0.020]	[0.010]	[0.000]
Avg. return inflationary period (%)	2.88	4.53	7.15	1.63	1.17	0.42
	-	[0.471]	[0.436]	[0.767]	[0.750]	[0.617]
Avg. return disinflationary period (%)	6.24	8.41	8.49	5.04	4.49	1.52
	-	[0.283]	[0.574]	[0.773]	[0.682]	[0.108]
Sharpe ratio	0.34	0.34	0.28	0.32	0.30	-
Sortino ratio	0.80	0.69	0.65	1.09	1.21	1.19
Skewness	-0.36	-0.64	0.38	0.77	0.72	0.37
Excess kurtosis	0.79	0.43	0.59	2.11	0.46	0.11
P-value JB	[0.263]	[0.119]	[0.341]	[0.000]	[0.068]	[0.526]

* Global Market Portfolio (GMP), Equities Broad (EB), Real Estate (RE), Nongovernment Bonds (NGB), Government Bonds Broad (GBB) and 3-month Treasury-bills (TB).

In the inflationary period from 1960 to 1979, the average annual real return of the GMP is 2.88% (compounded this is 2.27%, not reported in table), while in the disinflationary period from 1980 to 2015 the GMP has an average return of 6.24% (compounded 5.57%). So, the gap between both periods is 3.41 pps.

Table 3

Average compounded real returns by decade (%)

From →: To ↓:	1960	1970	1980	1990	2000	2010
Global Market Portfolio						
1969	3.92					
1979	2.27	0.65				
1989	4.98	5.52	10.62			
1999	5.38	5.87	8.57	6.56		
2009	4.51	4.66	6.03	3.81	1.12	
2015	4.38	4.48	5.57	3.69	1.94	3.32
Equities Broad						
1969	6.07					
1979	3.16	0.33				
1989	6.72	7.05	14.22			
1999	7.02	7.34	11.03	7.93		
2009	5.33	5.14	6.80	3.27	-1.19	
2015	5.45	5.32	6.75	4.00	1.62	6.48
Real Estate						
1969	2.19					
1979	4.11	6.07				
1989	6.59	8.85	11.71			
1999	4.47	5.24	4.83	-1.62		
2009	4.96	5.67	5.53	2.58	6.95	
2015	5.19	5.85	5.79	3.60	7.00	7.08
Nongovernment Bonds						
1969	0.92					
1979	1.40	1.89				
1989	2.98	4.03	6.20			
1999	3.68	4.62	6.00	5.81		
2009	3.72	4.43	5.30	4.85	3.89	
2015	3.50	4.07	4.69	4.11	3.06	1.70
Government Bonds Broad						
1969	1.02					
1979	1.05	1.07				
1989	2.80	3.70	6.40			
1999	3.35	4.13	5.70	5.00		
2009	3.48	4.10	5.14	4.51	4.02	
2015	3.06	3.51	4.20	3.36	2.35	-0.38

As can be seen already from Figure 1, the real return for the GMP is relatively flattish in the first part of the graph, while at the latter part it is also not steep. Table 3 shows the compounded real returns over several periods. On the diagonal, the returns by decade show up. There, it is also obvious that the eighties and nineties yield higher returns than other decades, for both the GMP and the asset categories, with Real Estate being the only exception in the nineties. To illustrate, the GMP yields a real return in the eighties and nineties of 10.62% and 6.56% respectively, while the other four decades delivered, in chronological order, 3.92%, 0.65% and 1.12%. The last six years of our sample comes at 3.32%.

As also can be seen in Table 3, there has not been a single decade in our sample period with a negative compounded real return for the GMP, Nongovernment Bonds or Government Bonds Broad. Equities Broad ended in negative territory in the 2000-2009 period, while the same applies to Real Estate in the 1990-1999 period, as mentioned before.

Table 4 panel A shows the correlation matrix for real returns. The returns of Government Bonds Broad have the lowest correlation with those of the GMP, as well as with Equities Broad and Real Estate. Equities Broad's returns have the highest correlation with returns of the GMP since Equities Broad has the highest average weight of all asset categories in the GMP during the period of 56 years.

Table 4

Correlations of annual real returns (1960-2015)

	GMP	EB	RE	NB	GBB
Panel A.					
GMP	1.00				
Equities Broad (EB)	0.96	1.00			
Real Estate (RE)	0.71	0.67	1.00		
Nongovernment Bonds (NB)	0.70	0.50	0.45	1.00	
Government Bonds Broad (GBB)	0.52	0.28	0.33	0.87	1.00
Panel B. Correlations in up markets in the upper right part, down markets in the lower left part.					
GMP	1.00	0.89	0.58	0.76	0.67
Equities Broad (EB)	0.90	1.00	0.49	0.45	0.29
Real Estate (RE)	0.84	0.80	1.00	0.34	0.29
Nongovernment Bonds (NB)	0.42	0.04	0.26	1.00	0.88
Government Bonds Broad (GBB)	0.20	-0.22	0.10	0.82	1.00

Table 4 panel B shows separate correlations for up markets (upper right part of the matrix), and down markets (lower left matrix) of the GMP. For return correlations between the GMP and for Equities Broad or Real Estate it appears that correlations are higher in down markets. This is in line with results reported by Chow, Jacquier, Kritzman, and Lowry (1999). This also applies to the correlations of returns for Equities and Real Estate themselves. The reverse applies to Nongovernment Bonds and Government Bonds Broad. The negative correlation between Equities Broad and Government Bonds Broad in down markets illustrates the benefits of diversification.

Excess returns

We finalize this section with excess returns. The data offer the opportunity to compare the return of the average investment portfolio to a risk-free investment. We show what the average saver gives up compared to the average investor, but also the price that the investor pays to achieve a higher return.

Table 5

Statistical properties for excess returns (1960-2015; [p-values] based on performance versus GMP)

	GMP	EB	RE	NGB	GBB*
Compounded average return (%)	3.24	4.30	4.04	2.37	1.94
Arithmetic average return (%)	3.87	5.83	6.90	2.67	2.16
	-	[0.191]	[0.342]	[0.683]	[0.600]
Standard deviation (%)	11.23	17.24	24.66	7.90	6.88
Minimum annual return (%)	-25.44	-44.31	-42.64	-15.98	-13.13
Maximum annual return (%)	27.28	37.78	73.26	24.51	17.91
Maximum cumulative drawdown (%)	-35.03	-47.54	-63.24	-32.33	-22.97
# years with return < 0%	18	18	21	21	25
# years with return < -10%	8	10	11	3	1
Longest period cumulative R < 0%	12	7	15	7	14
Avg. return when R(GMP) < 0% (%)	-8.93	-13.96	-9.81	-1.90	-0.42
	-	[0.003]	[0.648]	[0.001]	[0.002]
Avg. return when R(GMP) > 0% (%)	9.93	15.20	14.81	4.83	3.38
	-	[0.000]	[0.182]	[0.000]	[0.000]
Avg. return in recessions (%)	-2.78	-3.37	-7.00	0.53	0.71
	-	[0.470]	[0.292]	[0.121]	[0.164]
Avg. return in expansions (%)	6.53	9.51	12.46	3.52	2.74
	-	[0.008]	[0.038]	[0.020]	[0.010]
Avg. return inflationary period (%)	2.40	4.02	6.63	1.18	0.74
	-	[0.471]	[0.436]	[0.767]	[0.750]
Avg. return disinflationary period (%)	4.69	6.84	7.04	3.49	2.95
	-	[0.283]	[0.574]	[0.773]	[0.682]
Sharpe ratio	0.24	0.27	0.23	0.19	0.15
Sortino ratio	0.59	0.57	0.54	0.70	0.69
Skewness	-0.42	-0.58	0.33	0.42	0.48
Excess kurtosis	0.32	0.32	0.37	0.72	-0.12
P-value JB	[0.388]	[0.181]	[0.511]	[0.241]	[0.340]

* Global Market Portfolio (GMP), Equities Broad (EB), Real Estate (RE), Nongovernment Bonds (NGB) and Government Bonds Broad (GBB).

The reward for the average investor, in our sample period, is a compounded return of 3.24 pps above the saver, as shown in Table 5. This reward comes with a standard deviation of 11.2%. In 18 of the 56 years the investor ends with a lower return than the saver, the remaining 38 years the investor's return ends above the saver's return. The pain for the average investor is a maximum annual loss of wealth of 25.44% and a maximum cumulative loss of 35.03%, compared to the results for a saver. The longest period that the cumulative return of the investor lagged the saver is 12 years. In a down market the average investor loses 8.93 pps relative to the saver, in a recession 2.78 pps. In both inflationary and disinflationary environments, the investor is on average better off than a saver.

Figure 2 shows that the excess return for investors has arisen gradually during time. After this 56-year sample period, the investor achieved a 501% return compared to a saver (log scale on the left axis). The figure also shows that the investor experienced three downfalls exceeding a cumulative loss of 20% compared to the saver: 35% in 1974, 26% in 2002 and 25% in 2008 (right axis).

We finalize our discussion of real returns with Table 6 which is an overview of the composition of the GMP and the nominal, real and excess returns on the GMP for each year in our sample period 1959-2015. While we have investigated the historical returns of the GMP and its underlying four asset categories, it is interesting to examine whether the GMP can compete with alternative heuristic portfolio compositions. This follows in the next section.

Figure 2

Excess returns and drawdowns for excess returns of the GMP

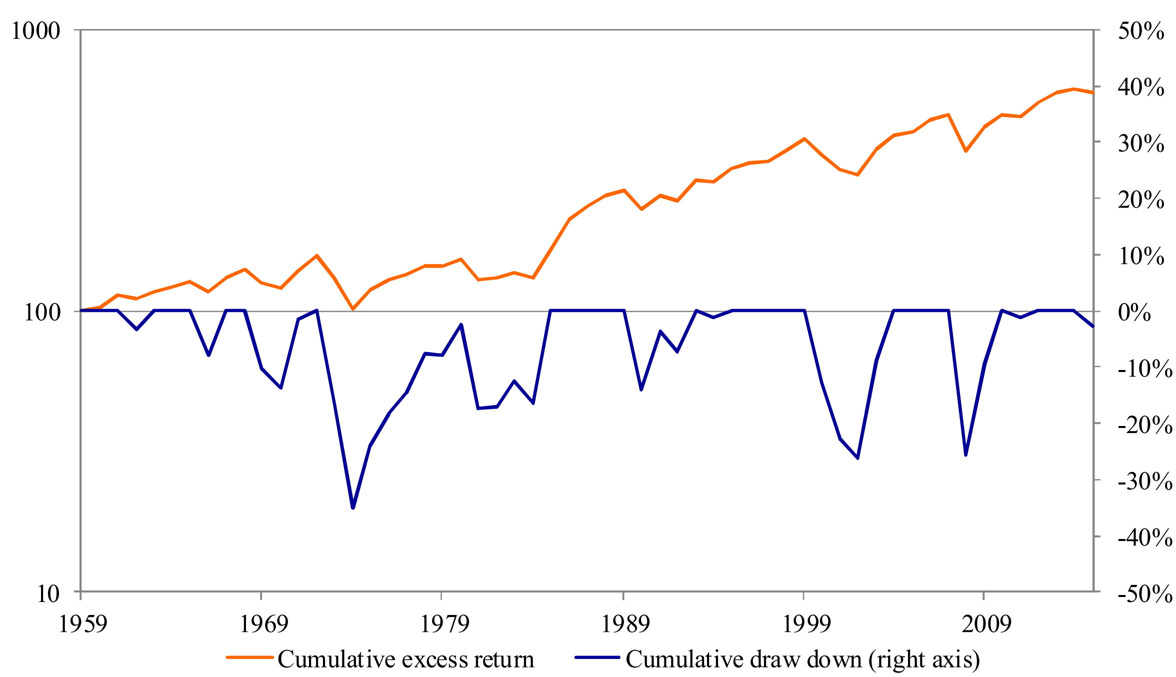


Table 6

Composition and returns of the global market portfolio (%)

Year	Composition				Returns		
	Equities Broad	Real Estate	Nongovern-ment Bonds	Government Bonds Broad	Nominal Return	Real Returns	Excess Return
1959	51.6	1.4	17.6	29.4	-	-	-
1960	49.9	1.3	17.7	31.1	5.8	4.4	2.8
1961	54.1	1.2	15.5	29.1	13.4	12.7	10.8
1962	50.9	1.4	16.8	30.9	-0.7	-1.9	-3.4
1963	54.2	1.4	16.2	28.2	10.6	8.8	7.1
1964	56.7	1.4	15.3	26.6	8.1	6.9	4.3
1965	58.9	1.5	14.4	25.3	7.9	5.9	3.7
1966	57.3	1.7	14.8	26.3	-3.2	-6.3	-7.8
1967	62.0	1.6	13.0	23.3	15.9	12.2	11.0
1968	64.4	1.6	12.5	21.5	13.7	8.5	7.6
1969	63.9	2.0	12.6	21.6	-4.0	-9.4	-10.3
1970	61.4	2.1	13.4	23.1	2.7	-2.7	-3.8
1971	60.4	2.0	14.4	23.2	19.1	15.3	14.0
1972	63.3	1.8	13.8	21.1	18.6	14.7	13.9
1973	59.8	2.1	14.9	23.1	-9.8	-17.2	-16.1
1974	49.2	3.0	18.0	29.7	-16.2	-25.3	-22.6
1975	50.8	2.6	18.0	28.7	23.8	15.6	16.8
1976	50.0	2.2	17.8	30.0	13.3	7.8	7.7
1977	44.7	2.3	18.8	34.2	10.2	3.3	4.5
1978	42.7	2.2	18.6	36.4	16.4	6.8	8.2
1979	45.8	2.3	16.3	35.5	10.5	-2.5	-0.3
1980	48.8	2.2	14.8	34.3	19.0	5.9	6.0
1981	47.0	2.5	14.8	35.8	-2.2	-10.2	-15.2
1982	45.7	2.4	14.9	37.0	11.8	7.7	0.4
1983	48.7	2.1	13.3	35.9	14.8	10.6	5.3
1984	48.4	2.2	13.1	36.3	5.2	1.1	-4.5
1985	49.6	2.8	12.7	35.0	35.7	30.8	25.8
1986	52.9	3.4	11.6	32.1	35.2	33.6	27.3
1987	55.3	4.1	10.8	29.8	19.2	14.2	12.4
1988	58.4	5.1	9.7	26.7	16.5	11.6	8.9
1989	60.4	4.9	9.3	25.4	12.6	7.6	3.7
1990	52.5	4.1	11.6	31.8	-7.0	-12.5	-13.9
1991	52.6	3.7	11.8	31.8	18.0	14.6	11.7
1992	50.3	3.6	12.5	33.6	-0.2	-3.1	-3.6
1993	53.0	4.4	8.8	33.9	20.8	17.5	17.2
1994	55.6	4.5	7.5	32.4	3.1	0.5	-1.2
1995	56.5	4.0	7.6	31.9	18.3	15.4	12.0
1996	57.1	5.3	7.3	30.3	9.9	6.3	4.4
1997	59.7	4.8	8.1	27.4	6.8	5.0	1.5
1998	57.1	3.8	14.3	24.8	15.3	13.5	9.9
1999	63.6	3.3	11.8	21.3	15.6	12.6	10.3
2000	60.5	3.3	15.1	21.1	-7.5	-10.6	-12.8
2001	54.9	3.8	18.3	23.0	-8.4	-9.9	-11.6
2002	45.1	3.9	22.3	28.7	-2.9	-5.3	-4.5
2003	48.6	4.4	20.2	26.9	25.1	22.6	23.9
2004	49.3	4.7	18.6	27.4	14.2	10.6	12.7
2005	52.6	5.0	17.0	25.4	4.8	1.4	1.6
2006	53.9	6.0	16.1	24.0	16.3	13.4	10.9
2007	53.4	5.6	16.7	24.3	9.4	5.0	4.6
2008	40.5	3.5	21.6	34.4	-24.4	-24.4	-25.4
2009	42.3	4.0	21.1	32.5	21.5	18.2	21.3
2010	42.9	4.3	19.6	33.2	10.7	9.1	10.5
2011	39.4	4.5	20.4	35.7	-1.0	-3.9	-1.0
2012	40.0	5.1	20.2	34.8	11.5	9.6	11.4
2013	44.5	5.3	19.0	31.1	9.1	7.5	9.1
2014	44.1	5.9	18.9	31.2	2.6	1.9	2.6
2015	43.7	6.1	19.1	31.1	-2.7	-3.3	-2.7

The performance of heuristic portfolios versus the GMP

There is only one true benchmark for passive investors. This is the portfolio in which all investable assets are weighed according to their market capitalization weights. As such, the GMP is the portfolio for the true passive investor. At any point in time the GMP mirrors the benchmark with marginal rebalancing to keep track with the benchmark due to differences in issuance and redemptions of asset categories.

There are various reasons to believe that the GMP is not an ex-ante optimal portfolio. From the asset demand side, investors might not be able to incorporate news efficiently into asset prices, leading from time to time to over- and undervaluation at the asset class level. A practical investment strategy that does not require sophisticated fair value models use valuation signals based on long-term mean-reversion. For example, Asness, Moskowitz, and Pedersen (2013) use the current asset price relative to its five-year historical price to determine deviations from fair value within asset classes. From the asset supply side, corporate managers may time the market by issuing shares that are overvalued and repurchasing those that are undervalued. Graham and Harvey (2001) survey CFOs for important factors when issuing new shares, and stock price turns out to be most important. Empirical evidence that confirm the underperformance of new equity issuance can be found in Loughran and Ritter (1995), Baker and Wurgler (2000), and Gompers and Lerner (2003). When calculating the time-series return at the asset class level, these timing effects are hidden. Dichev's (2007) empirical results suggest that by dollar-weighting equity returns the average return for investors can be more than one percentage point lower over long sample periods. The returns on the GMP that we document, account for the time-varying relative market capitalization of each asset class. For example, when equities represent a higher share of the GMP, its returns have more impact relative to periods in which its share is lower. Hence, in this sense, it is a dollar-weighted return series.

The asset demand and asset supply side arguments motivate us to examine three heuristic portfolios with fixed-weights that are annually rebalanced. In other words, these portfolios correspond to time-weighted returns, as their allocation does not change over time. Therefore, these are implicitly mean-reversion strategies as in Bernstein (2010). As these portfolios differ from market capitalization weights, they cannot be followed by all investors at the same time.

The first alternative portfolio is an equally weighted portfolio. For the second portfolio, we take the size of each asset category's market capitalization into account and form portfolio weights based on its market capitalization rank. This is a long-only version of the portfolio ranking methodology of Koijen, Moskowitz, Pedersen, and Vrugt (2016). Specifically, the weight of each asset category i at the start of year t is given by

$$W_{i,t} = \frac{rank_i}{\sum_i^N rank_i}$$

where $W_{i,t}$ is the weight of asset category i in the ranking based portfolio at (the start of) year t, $rank_i$ is the rank in a sort from smallest to largest asset category as measured by market capitalization at the end of year t-1, and N represents the number of asset categories. So, to illustrate, the smallest asset category has a ranking of 1 while the sum of the ranks equals 10 (i.e. 1+2+3+4=10) which results in a portfolio weight of

10% (i.e. 1/10) for the smallest asset category. Similarly, the largest asset category has a weight of 40% (i.e. 4/10). As the ranking of the asset categories' market capitalization is the same in each year of our sample, this results in a portfolio that starts each year with a 40% weight of Equities Broad, 30% of Government Bonds Broad, 20% of Nongovernment Bonds and 10% of Real Estate. Third, we consider a 50/50 portfolio which contains 50% Equities Broad and 50% Government Bonds Broad. The average weight of Equities Broad in the GMP is 52.5% the period 1959-2014, while Real Estate, Nongovernment Bonds and Government Bonds have average weights of 3.2%, 15.0% and 29.3%.[5]

Table 7 provides an overview of the real return and risk characteristics of the GMP and the three heuristic-based portfolios. All three alternative portfolios result in a higher average compounded return than the return of 4.38% for the GMP. The equally weighted portfolio (EW) has an average compounded real return of 4.89%, followed with 4.80% for the rank weighted portfolio (RW) and 4.65% for the 50/50 portfolio. The annual compounded return difference with the GMP of at best about 0.50 pps might not be astonishing, but it is economically meaningful. During our sample period, the return relative to the return of the GMP cumulates to 31% for the equal weighted portfolio, 25% for the rank weighted portfolio and 15% for the 50/50 portfolio, as shown in Figure 3Figure 2. However, the p-value shows that none of the annual arithmetic real returns relative to the GMP's return is statistically significant. Two of the heuristic based portfolios combine their higher return with a lower standard deviation. In the end, they all have a higher Sharpe ratio than the GMP. In addition, we tested if the Sharpe ratios of the heuristic portfolios are significantly higher than the GMP by the test of Jobson and Korkie (1981) with Memmel (2003) correction. The Sharpe ratios of the RW & 50/50 portfolio are significantly different from the Sharpe ratio of the GMP, whereas the Sharpe ratio of the EW portfolio is not significantly different.[6]

Table 7 also shows other measures of risk. It appears that the GMP has the largest yearly and maximum cumulative drawdown in real terms with -25.25% and -38.14% respectively. The GMP resulted in 16 years in a negative real return, while in 6 of those years the real return fell below 10%. The longest period that the GMP has a negative cumulative return is 12 years. In other words, the longest period to set a new high after a previous high in the real value of the GMP was 12 years. All three alternative portfolios perform equal or better on each of these measures. The 50/50 portfolio seems to be the most defensive portfolio with a maximum cumulative draw down of 32.14% and three years in which the real return falls below -10%.

We also split our sample in up- and down markets as measured by the real return of the GMP, and in years for which the NBER has determined one or more quarters as being in a recession, and years in expansion. Our sample contains 16 years of down markets and 40 years of up markets, these same numbers apply to recession and expansionary years. We also split into inflationary years versus disinflationary years. For this last split, we take the first sub-sample period from 1960 through 1979 as inflationary years as inflation peaked in 1979, and the period 1980-2015 as deflationary years. Again, results are reported in Table 7.

[5] We do not use the market capitalization of 2015 in our return calculations.

[6] The portfolio which uses the average asset category weights over the period 1959-2014 has a compounded real return of 4.86% and a standard deviation of 11.50%. The Sharpe ratio is 0.39. These portfolio weights are only known ex-post, contrary to the weights of the heuristic allocation schemes.

Table 7

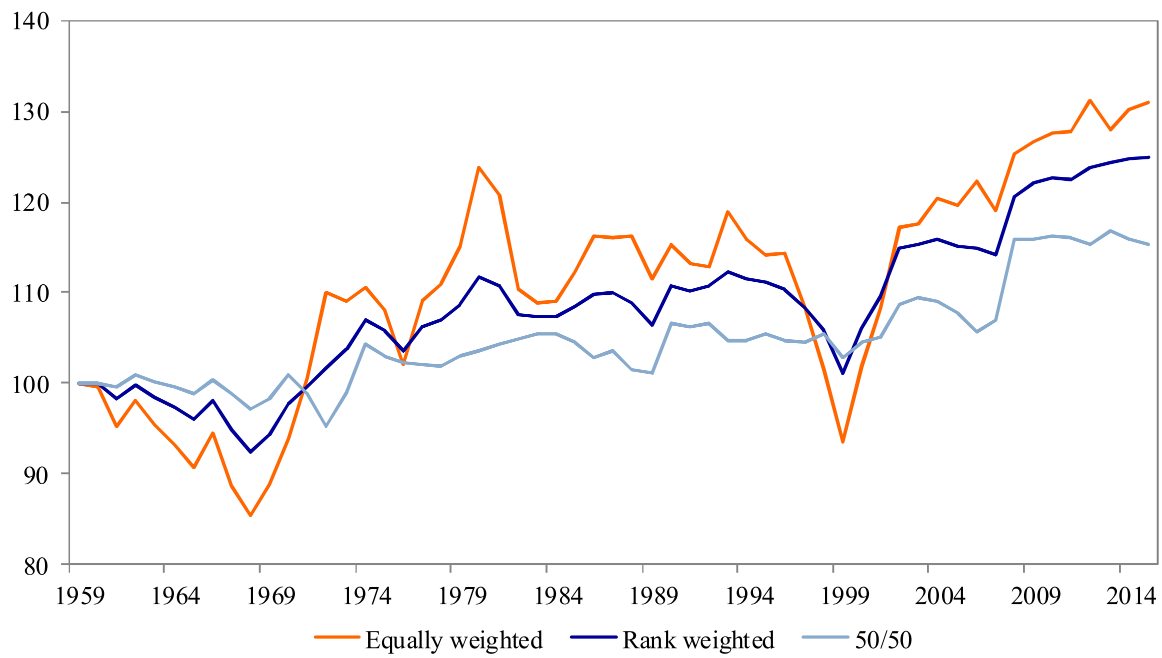
Statistical properties for three heuristic alternative allocation schemes (real returns 1960-2015; [p-values] based on performance versus GMP)

	GMP	EW	RW	50/50*
Compounded average return (%)	4.38	4.89	4.80	4.65
Arithmetic average return (%)	5.04	5.54	5.37	5.16
	-	[0.321]	[0.145]	[0.314]
Standard deviation (%)	11.60	11.82	10.92	10.37
Minimum annual return (%)	-25.25	-24.25	-22.96	-21.24
Maximum annual return (%)	33.64	38.51	35.22	31.56
Maximum cumulative drawdown (%)	-38.14	-37.85	-34.89	-32.14
# years with return < 0%	16	15	16	16
# years with return < -10%	6	4	4	3
Longest period cumulative R < 0%	12	12	11	10
Avg. return when R(GMP) < 0% (%)	-9.27	-6.40	-7.13	-7.31
	-	[0.002]	[0.000]	[0.002]
Avg. return when R(GMP) > 0% (%)	10.77	10.31	10.37	10.15
	-	[0.485]	[0.142]	[0.003]
Avg. return in recessions (%)	-2.26	-0.77	-0.81	-0.78
	-	[0.155]	[0.022]	[0.041]
Avg. return in expansions (%)	5.86	6.41	5.91	5.48
	-	[0.477]	[0.772]	[0.275]
Avg. return inflationary period (%)	2.88	3.62	3.20	2.85
	-	[0.439]	[0.360]	[0.722]
Avg. return disinflationary period (%)	6.24	6.61	6.57	6.45
	-	[0.528]	[0.267]	[0.325]
Sharpe ratio	0.34	0.37	0.39	0.40
P-Value Jobson and Korkie	-	[0.520]	[0.019]	[0.000]
Sortino ratio	0.80	1.01	1.02	1.02
Skewness	-0.36	0.23	0.00	-0.12
Excess kurtosis	0.79	1.20	1.14	0.68
P-value JB	-	[0.144]	[0.217]	[0.545]
Turnover from annual rebalancing (%; double counted)	3.23	7.93	7.26	6.86

* Global Market Portfolio (GMP), Equally weighted (EW), Rank weighted (RW), half Equities Broad and half Government Bonds Broad (50/50).

Figure 3

Cumulative performance of three heuristic portfolios relative to the performance of the GMP (1959-2015)



All three alternative portfolios appear to have a common appealing characteristic compared with the GMP. Their average real return in down markets is higher, i.e. less negative, than for the GMP. In down markets the GMP drops on average 9.37%, while the alternative portfolios on average return at least 1.96 pps more. This difference is also statistically significant with p-values measuring the performance relative to the GMP near 0, indicating that is highly unlikely to be a coincidence. The higher returns in down markets boost the Sortino ratio which calculates the reward for downward risk. The Sortino ratio for the GMP is 0.80, while it is between 1.01 and 1.02 for the heuristic portfolios. The average return for the GMP in up markets is an insignificant 0.45 pps higher than the EW portfolio. However, compared to the 50/50 portfolio the GMP has a significant 0.21 pps higher return in up markets. But, this difference is small compared to the difference in down markets when the 50/50 portfolio realizes a significant 1.96 pps higher return.

A split between recessionary and expansionary years results in a comparable pattern, albeit less outspoken. The average return of the GMP in a recession year is -2.26% while the heuristic based portfolios have an average return of 1.44-1.49 pps above that. For two of the alternative portfolios these results are also significant with p-values below 5%. In expansionary years, differences are not statistically significant.

Our results suggest that the heuristic based portfolios achieve a higher return in falling markets and in recessions. From a utility perspective, this is an attractive characteristic, since Kahneman and Tversky (1979) demonstrate that investors feel the pain of financial loss much more intensely than the pleasure felt from financial gain of the same amount. That pain often results in risk-averse behavior, or risk avoidance that is disproportionate to the expected outcome.

Our results show that both the equally weighted and the rank weighted portfolio achieve a higher return than the GMP in an inflationary environment as well as in a disinflationary environment. However, p-values indicate that the returns relative to the GMP are not significantly distinguishable from zero. This split in sub samples illustrates that investors have benefitted the most in a disinflationary environment. The arithmetic average real return for the GMP in the inflationary period up to 1979 is 2.88%. In the disinflationary period from 1980 to 2015 it yields an average return of 6.24%, which is 3.36 pps above the first period.[7]

Finally, we examined the turnover of the GMP and the three heuristic portfolios. The GMP also requires rebalancing as issuance and redemptions differ between asset categories.[8] So, even the ultimate passive investor cannot be completely passive. The turnover analysis is interesting to get an idea about the transaction costs involved of the GMP as well as the additional costs that alternative weighting schemes bring along. As appears from Table 7, the GMP has an average annual turnover of 3.2%. We show double counting data which reflects both rebalancing induced buying and selling. The heuristic portfolios result in annual rebalancing an additional 3.6% to 4.7% of the portfolio. In case historical trading costs would have amounted to 50 basis points for a single trip, they would have resulted in an additional 2 basis points transaction costs above the rebalancing costs of the GMP.[9] We consider the transaction costs as marginal given the (size of the) outperformance of the heuristic portfolios in negative markets and during recessions.

We also examined the impact of less frequent rebalancing up to a period of once in five years. Then, turnover drops to at best 1.9% for the GMP and 3.07% for the heuristic portfolios (results not reported in a table). The impact of less frequent rebalancing on returns for the GMP is marginally positive and negative for the heuristic portfolios, as they appear no longer to benefit from mean reversion. So, the return gap between the heuristic portfolios and the GMP decreases. The average return of all three heuristic portfolios is 39 bps above the GMP with annual rebalancing. This drops to 20 bps if we average the relative return to the GMP for all three heuristic portfolios for rebalancing frequencies of every two, three, four and five years. Still, conclusions remain broadly unchanged. For example, the average Sharpe ratio for rebalancing once in two, three, four and five years is 0.35 (0.34 for yearly rebalancing) for the GMP, and 0.38 (0.39) for the heuristic portfolios. For the average Sortino ratio these figures are 0.81 (0.80 for yearly rebalancing) for the GMP, and 0.95 (1.02) for the heuristic portfolios.

To conclude this section, the return difference between heuristic based portfolios and the GMP might not be astonishing, but it is economically meaningful. Especially as our results suggest that the heuristic based

[7] Using compounded returns, the difference is 3.30 pps.

[8] The composition of the GMP is marginally affected by every dividend or coupon payment of an asset as this basically is a withdrawal from the asset category it belongs to. However, we suppose that dividends and coupon payments during the year are reinvested in the asset category as we use and focus on total returns. In theory, one should spread every dividend and coupon over each asset category according to its presence in the GMP. Even if we would like to correct for this small bias, we would not be able due to a lack of data. This effect also attributes to the annual rebalancing of the GMP.

[9] Obviously, compared to recent transaction costs, this estimate is too conservative. But, for the past it is harder to determine true transaction costs as direct and indirect transaction costs (bid-ask spreads) were higher than nowadays. Our transaction costs match the transaction costs which Anderson, Bianchi and Goldberg (2012) use for the period 1956-1970. For 1971-2010 they use 10 basis points.

portfolios tend to achieve a higher return in falling markets and in recessions. In other market conditions, the return differences with the GMP do not significantly differ from zero.

One could argue that the heuristic based portfolios benefit from hindsight bias. But, on the other hand, the heuristics we use are rather simple and are likely to pop up ex-ante in an investor's mind. Therefore, this ex-post analysis suggests that the GMP has not been the optimal portfolio. Nevertheless, the limited size of the GMP's underperformance compared to the heuristic based portfolios points towards a good composition of the GMP. Therefore, we conclude that all investors together did a reasonable job in determining the GMP, but there is room for improvement. Even with simple heuristics it is possible to achieve a better reward for risk, in particular for downward risk. In the next section, we perform an ex-post mean-variance analysis.

The Mean-Variance Frontier of the Four Asset Categories

Figure 4 depicts the mean-variance efficient frontier of the four asset categories based upon the annual real returns from 1960 until 2015.[10] The average real risk-free rate is 1.13% for this period. Thus, on the efficient frontier we find portfolios with higher Sharpe ratios than the GMP. The point at the efficient frontier which has the same standard deviation lies 0.54 pps above the arithmetic average real return of 5.04% from the GMP.

The Capital Allocation Line (CAL) combines the risk-free asset with the tangency portfolio on the efficient frontier. The tangency portfolio contains the highest Sharpe ratio of all portfolios on the efficient frontier. Its composition is 31% Equities Broad, 4% Real Estate, 0% Nongovernment Bonds and 65% Government Bonds Broad. The CAL contains portfolios with the highest Sharpe ratios in Figure 4.

Figure 5 draws the composition of each of the portfolios on the efficient frontier.[11] On the vertical axis, we have the average real return from 1960 until 2015. On the horizontal axis, we have the standard deviations of the portfolios. All individual asset categories lie below the efficient frontier since a portfolio of different asset categories provides diversification advantages. Based upon the mean-variance optimization nongovernment bonds do not appear in any portfolio.

The portfolio weight of government bonds broad decrease monotonically, whereas the portfolio weight of real estate monotonically increases if we require portfolios with higher average returns. Until an average arithmetic return of 7.24% the weight of equities broad increases, since beyond that return solely real estate can keep track with the required return of the portfolio.

The ex-post mean-variance analysis shows that the GMP has not been the optimal portfolio. This result is in line with the outcome from the analysis with the alternative heuristic portfolio allocation schemes. Both results suggest that the GMP is not far from the mean-variance frontier, but there seem to be portfolios that could have been chosen ex-ante, which have more attractive combinations of return and risk.

[10] The mean-variance frontier is constructed with arithmetic annual returns.
[11] All portfolios on the efficient frontier are fully invested and short selling is not allowed.

Figure 4

Mean-variance efficient frontier for the four asset categories, 1960-2015

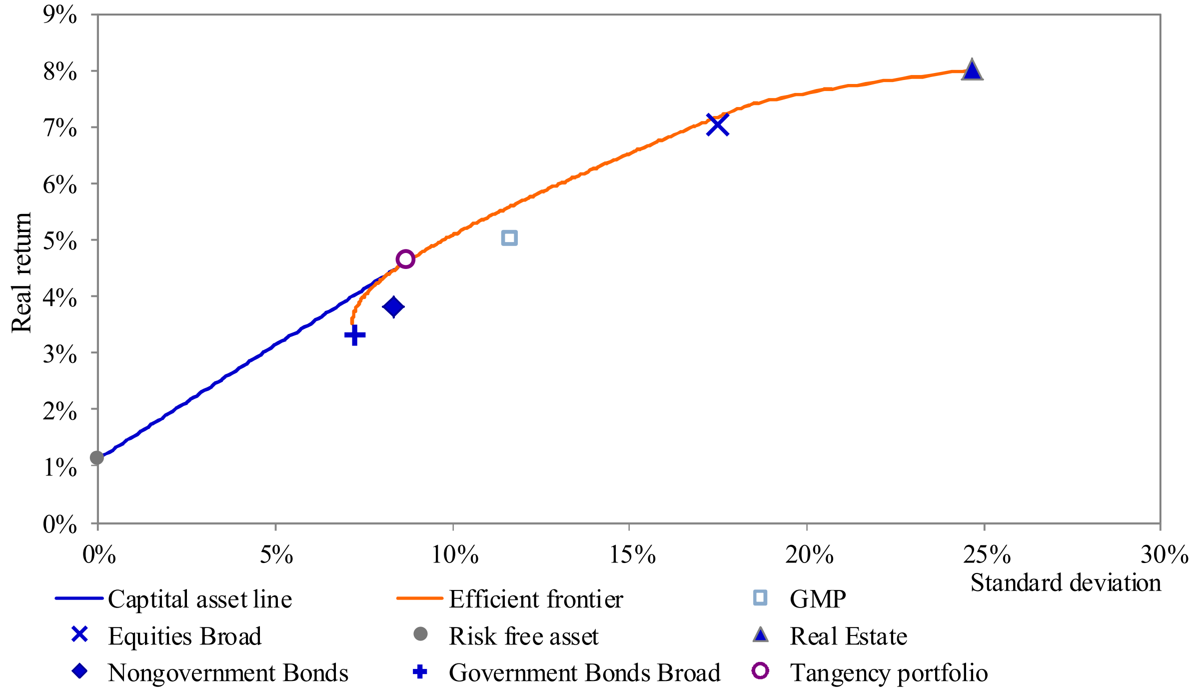
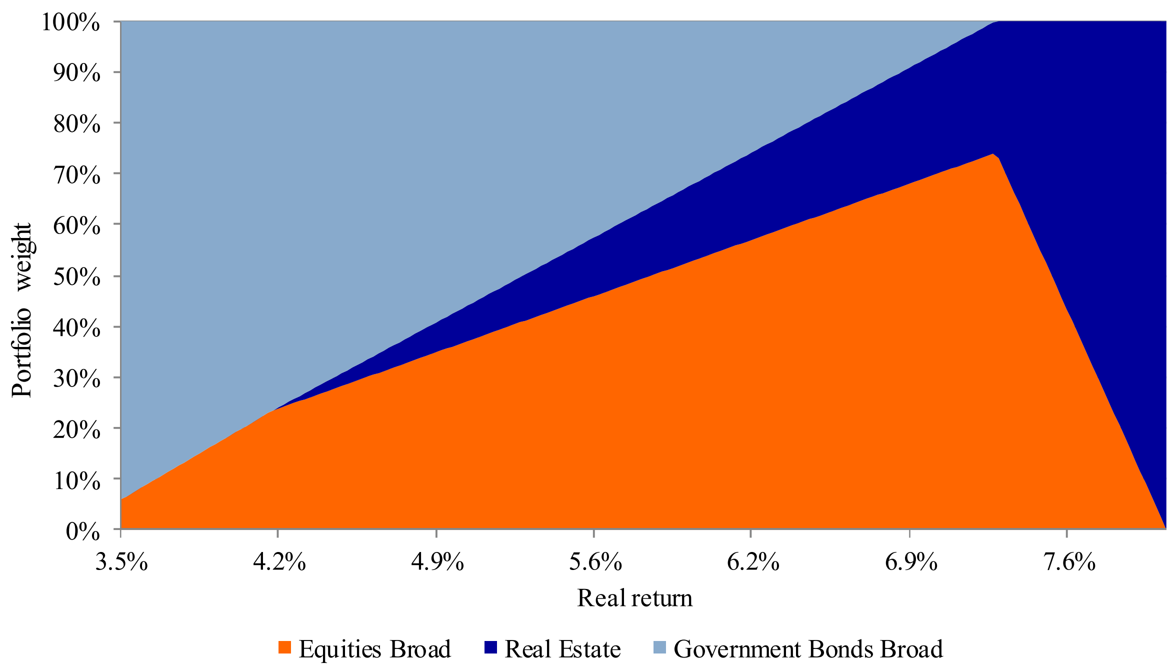


Figure 5

Weights and average arithmetic real returns of the portfolios on the mean-variance efficient frontier



Conclusion

We construct a new data set that offers the opportunity to analyze nominal, real, and excess return and risk characteristics of the global multi-asset market portfolio and the asset categories over the period 1960 to 2015. We document how we collected historical returns data on global asset classes. A study on returns of the GMP has not been done before for such a long period and with this level of detail. Moreover, we make the resulting data publicly available so other researchers can use them in their specific applications. Despite that we find indications that our data represent good estimates for historical returns, we are aware that our estimates are surrounded by uncertainty.

Over the period 1960 to 2015, we estimate the market portfolio to realize an average compounded real return of 4.38% with a standard deviation of 11.6%. In the inflationary period from 1960 to 1979, the compounded real return of the GMP is 2.27%, while this is 5.57% in the disinflationary period from 1980 to 2015. The reward for the average investor is a compounded return of 3.24%-points above the saver's.

We also investigate three heuristic portfolios and compare their risk and return to the GMP. All three alternative portfolios result in a higher average compounded return than the return of 4.38% for the GMP. The equally weighted portfolio has an average compounded real return of 4.89%, followed with 4.80% for the rank weighted portfolio and 4.65% for the 50/50 portfolio. In addition, we find that all three alternative portfolios appear to have a common appealing characteristic compared with the GMP. Their average real return in down markets is higher, i.e. less negative, than for the GMP. In down markets the GMP drops on average 9.27%, while the alternative portfolios on average return at least 1.96 pps more. Our results suggest that the market portfolio is close to the mean-variance frontier, but our heuristic allocations achieve a significantly higher reward for risk.

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Appendix A. Data details of returns

For each of the four main asset categories in this study, Equities Broad, Real Estate, Nongovernment Bonds and Government Bonds Broad, we composed market capitalization weighted total return series in US dollars which we expect to be representative for the performance for an asset category. The return series for a main asset category are based on the asset classes that belong to it. In selecting the return data sources, we stay close to the selected data sources for market capitalization data as referred in Appendix C. Below, we discuss these four main asset categories and the eight asset classes involved.

Equities Broad

Equities

Period 1995-2015

For the period 1995 to 2015, we use a market capitalization weighted total return of the MSCI All Countries World Index and the MSCI All Countries World Small Cap Index.

Period 1988-1994

From its inception at the end of 1987 through 1994, we use the total return MSCI All Countries World Index. Before 1995 we do not take small caps into account in our return calculations as there is no global small cap index available. The median weight of small caps is 13% from year end 1994 through 2015. Excluding the return of small caps hardly matters for that period as the monthly returns of the all cap portfolio show a correlation of (a rounded) 1.00 with those of the standard MSCI All Countries Index, while the average compounded annual performance of 7.0% and 7.1% respectively are very close to each other. We do not expect the lack of global small cap returns before 1995 to have a significant impact on our return estimate for equities.

Period 1985-1987

For the period 1985 to 1987, we use the return on the MSCI World Index. Hereby, we exclude emerging markets for this period. This introduces just a minor bias as emerging markets represent 0.8% of the MSCI All Countries World Index at the start of 1988.

Period 1960-1984

From 1960 until 1984, we use the global equity returns from Ibottson, Siegel and Love (1985). Their universe is larger than for the MSCI World Index with a market capitalization at the end of 1984 of USD 3,214 billion versus USD 1,765 billion, respectively. Nevertheless, the returns of the MSCI World Index are representative for the global stock market, especially after 1984. We further discuss this in Appendix B.

Private equity

Period 2002-2015

We use the LPX Composite from 2002 until 2015 as a measure for the performance of private equity. The LPX Composite is a diversified global equity index that covers listed private equity companies. We refer to the website of the index provider for more detailed information.[12]

Period 1994-2001

For the period 1994 until 2001 we use the LPX50. The LPX50 is a global equity index that covers the 50 largest listed private equity companies, which fulfill certain liquidity constraints. With 50 constituents, its breadth is less than the LPX Composite, but it has a longer history. To our knowledge, LPX is the only provider that has global private equity indices with such a long history available.

Period 1990-1993

We estimate the performance of private equity for the period 1990 through 1993 using the three-factor model of Fama and French (1993). First, we estimate the factor loadings on size, value and the excess market return using the global developed market factors from the data library of Kenneth French over the period 1994-2015.[13] This regression results in a R^2 of 0.79. Subsequently, using the 1990-1993 global factor return series, we derived estimates for private equity returns. For the first six months in 1990, we only use the global equity market factor, which we proxy with the MSCI World Index. The risk-free rate comes from the Kenneth French database and we use the estimation period 1994-2015 again. R^2 is now 0.70, which is only slightly below the 0.79 for the three-factor model. This suggests that the global equity market factor is the dominant factor in explaining private equity returns.

Before 1990 we do not take the performance of the asset class private equity into account due to a lack of historical return data. So, implicitly it means that before 1990 we suppose the performance of private equity to equal the performance of equities. This introduces just a minor bias as the weight of private equity in the asset category Equities Broad amounts to 1.7% at the end of 1990 while back then it represents 0.9% in the market portfolio.

Real estate

Period 1984-2015

From 1984, we use returns from the GPR General World Index from Global Property Research, which has an inception date of 31 December 1983. This index has the broadest market coverage that we were able to find. To illustrate, at the end of 1983 the market capitalization of the GPR General World Index amounted

[12] http://www.lpx-group.com/lpx/home.html
[13] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html#Developed

USD 26.1 billion, while the MSCI Real Estate Index reached USD 17.2 billion.[14] The market capitalization of the GPR General World Index was USD 1,751 billion at the end of 2015. This means that the market coverage of the GPR index is also larger than of the FTSE EPRA/NAREIT Global Index with a market capitalization of USD 1,428 billion and the S&P Global Real Estate Investment Trusts Index with a market capitalization of USD 1,117 billion at the end of 2015.

Period 1970-1983

For the period 1970-1983, we derive total returns for the MSCI Real Estate Price Index, following Doeswijk and van Vliet (2011). This is a discontinued industry index of the MSCI World Index. To the best of our knowledge this is the only global real estate related index that dates back from 1970.

Period 1960-1969

For the first ten years in our sample, we use returns on business real estate for the United States from Ibbotson, Siegel and Love (1985). As far as we are aware, there are no commercial real estate returns available for other countries which date back to this period.

The average weight for the United States in three other asset classes for the first ten years in our sample is 60%, i.e. 73% for equities, 60% for government bonds and 47% for investment grade credits. This implies that only the use of the data for the United States for the period 1960-1969 is likely to cover somewhere around 60% of the global real estate market as well, which would be roughly in line with the three other asset classes mentioned before. As the weight of real estate in the global multi-asset market portfolio is around 1-2% during this period, this will hardly effect the return of the market portfolio as we seem to miss less than 1 pp. weight.

Nongovernment bonds

Investment grade credits

2010-2015

We use a market capitalization weighted average total return of the Bloomberg Barclays Global Aggregate Corporate Float Adjusted Index and the Bloomberg Barclays Global Aggregate Securitized Float Adjusted Index for the most recent period. Prior to 2010, there are no annual free float adjusted returns available.

2001-2009

We use a market capitalization weighted average total return of the Bloomberg Barclays Global Aggregate Corporate Index and the Bloomberg Barclays Global Aggregate Securitized Index for the period 2001-2009. We derive annual total returns from its inception in 2001.

[14] Market capitalization data for the MSCI Real Estate industry index start in 1986. This number is an estimate derived from discounting the January 1986 market capitalization by the price return of the MSCI Real Estate industry back to year end 1983.

1997-2000

For the period 1997 to 2000, we use a market capitalization weighted average total return of the Bank of America Merrill Lynch Global Broad Market Corporate Index and the Bank of America Merrill Lynch Global Collateralized Index.

1960-1996

We are not aware of the existence of a corporate or collateralized global index that starts before 1997. However, we are able to compose our own global corporate bond index for the period 1960 to 1996, which we use to represent the returns of investment grade credits before 1997. We expect the returns of corporate bonds to be a good estimate for the returns on investment grade credits for two reasons.

First, there is a strong correlation between returns on investment grade corporate bonds and collateralized bonds. The correlation of monthly returns in the index that we composed for the period 1997-2015, as we describe above, is 0.86. The correlation of annual returns is 0.72. Without the exceptional financial crises years 2008 and 2009, these figures are 0.88 and 0.84. The compounded average return for corporate bonds is 5.80%, while collateralized bonds return 5.13% from 1997 through 2015.

Second, although at the start of 1997 the market capitalization of the Bank of America Merrill Lynch Global Collateralized Index accounts for 60% of the combined market value of the Bank of America Merrill Lynch Global Broad Market Corporate Index and the Bank of America Merrill Lynch Global Collateralized Index, it is unlikely that collateralized debt securities have been a been a heavy weight for the entire 1960-1996 period. Although Frehen, Goetzmann and Rouwenhorst (2014) trace back early examples of mortgage backed securities date to the eighteenth century, Midanek and Midanek (1995) note that the secondary market remained small and fragmented until the seventies. The asset backed security market started in 1986 when securities backed by computer leases are created, see Cowan (2003).

In constructing a global corporate global bond index before 1997, we use total return estimates for eleven countries over this period. These countries are Austria, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, the United Kingdom and the United States. Below, we explain in detail how we estimate the market capitalization weights of these countries from year end 1959 to year end 1995, as well as our method to calculate the annual total returns per country from 1960 through 1996.

Country weights

Unfortunately, to our knowledge, there are no time series of annual market capitalization weights of nongovernment bonds before 1997. However, the OECD has annual data on net corporate bond issuance over this period, as well as a couple of years with market capitalization data.[15]

In general, the higher the market capitalization of a country's nongovernment bonds market is, the higher its net issuance is likely to be. In other words, whether we determine the weight of a country in the nongovernment bond index on its market capitalization compared to other countries' market capitalizations

[15] We used the yearly volumes of the OECD Financial Statistics books from 1974 until 1996.

or on its relative net issuance should lead to comparable results. We use the net issuance data throughout the period 1960 to 1995 to determine the year-end country weights. As an accuracy check, we compare these weights with the few observation points that we have on market capitalization weights.

For 10 out of 11 countries, the net issuance data start in 1960, with Austria starting in 1967, columns two to four, summarize the availability of net issuance data for each country. Belgium and Canada have missing data for the year 1969. We deal with these few missing data points for these three countries by using the median growth rate of net issuance of the other countries to derive an estimate. Here, we backfill Austria by discounting growth rates from the 1967 data point, while we fill 1969 for Belgium and Canada by using the median growth rate for 1969 and their issuance data for 1968.

Unfortunately, some net issuance data series end before 1995. We proceed by freezing market weights from 1993 for 1994 and 1995 for all countries. As market weights tend to change gradually, the freeze of market weights is likely to have a limited effect on the global nongovernment bonds return that we calculate with these weights. For three countries, net issuance data end before 1993: Austria (1991), Belgium (1987) and Canada (1990). For these countries, we freeze country weights also before 1993. As these three countries represent a combined 3-4% of our corporate bond index, this will neither significantly impact the return of the global nongovernment bond portfolio.

We estimate market capitalizations by taking a ten-year equally weighted moving average of net issuance data for eleven countries, and relate the net issuance for each country to its ten-year moving average relative to the total net issuance of all countries. By using a ten-year moving average, we arrive at a gradually changing estimate, contrary to using yearly issuance data that can be volatile and sometimes negative. From 1965 to 1969, we use an expanding window estimate, as we have no ten-year history available. For the five years before that, we freeze the weights at the 1965 levels. As market weights tend to change gradually, the freeze of market weights for 1960 to 1964 is likely to have a limited impact on the return of the global nongovernment bonds portfolio that we calculate with these weights, let alone the impact on the return of the global multi-asset market portfolio.

To examine the strength of the link between estimated market capitalization series based on net issuance data and reported market capitalization, we compare both for 1967 and 1978. For both years, most countries have market capitalization data for exactly these years, or a few years earlier or later. To arrive at data for 1967 for all countries, we used one of the two following methodologies. If there is an additional year available with market capitalization data within four years before and after 1967, we estimate 1967 by adding respectively subtracting net issuance data.[16] Subsequently, we average these two 1967 outcomes for the most robust estimate.[17] This first method applies to Canada, Italy, Japan and the United States. If there is only one year

[16] We choose a range of up to four years as this enables us to check the accuracy of our market capitalization estimates in 1967 for all eleven countries in our sample.
[17] We use this two-way calculation as simply adding or subtracting net issuance data to/from available market capitalization data does not end up with earlier, respectively later, market capitalization observations. We do not know exactly where these differences arise from. It might have to do with changes in the market value of nominal net issuance during a year through year-end or imperfect reporting of historical data.

with market capitalization data within four years available, we estimate the closest market capitalization data point by adding respectively subtracting a country's net issuance. This applies to Germany, the Netherlands and the United Kingdom. The fifth column in Table A1 shows which year(s) we use as a base year. We use exchange rates of the Dimson, Marsh, and Staunton (2016b) database to convert all local currencies into US dollars.

For the 1978 data comparison, we have market capitalization data for 1978 for six countries (Canada, France, Germany, Japan, Spain and the United States). For two countries, we have observations for 1977 (Austria and the United Kingdom). Here, we add the issuance in 1978 to market capitalization of 1977 to arrive at the market capitalization figure for 1978. We do not take Belgium, Italy and the Netherlands into account for the 1978 comparison, as these countries have no market observations within five years of 1978, and we want to exclude the possibility that imperfect reporting of historical net issuance data affects the comparison between issuance and market capitalization too much. The last column in Table A1 summarizes the base years for the comparison in 1978.

Table A1

Overview of data availability for net issuance and market capitalization

Country	Issuance data			Market capitalization data	
	Start	Missing	End	1967	1978
Austria	1967	-	1991	1967	1977
Belgium	1960	1969	1987	1967	-
Canada	1960	1969	1990	1964 & 1968	1978
France	1960	-	1996	1967	1978
Germany	1960	-	1996	1971	1978
Italy	1960	-	1996	1964 & 1968	-
Japan	1960	-	1996	1964 & 1969	1978
Netherlands	1960	-	1995	1966	-
Spain	1960	-	1996	1967	1978
UK	1960	-	1996	1964	1977
US	1960	-	1993	1964 & 1968	1978

Figure A1 shows the country weights for 1967 based on market capitalization and based on net issuance, relative to the total of all countries involved in this comparison. The largest difference arises for the United States, where issuance data underestimate the market capitalization by 12 pps. The total of all absolute differences sums up to 27 pps in 1967. Stated differently, our weights overlap for 73%. Although not perfect, the net issuance data seems to fit relatively well for 1967.

Figure A1

Comparison of Nongovernment Bonds' country weights for 1967 based on market capitalization and net issuance (eleven countries)

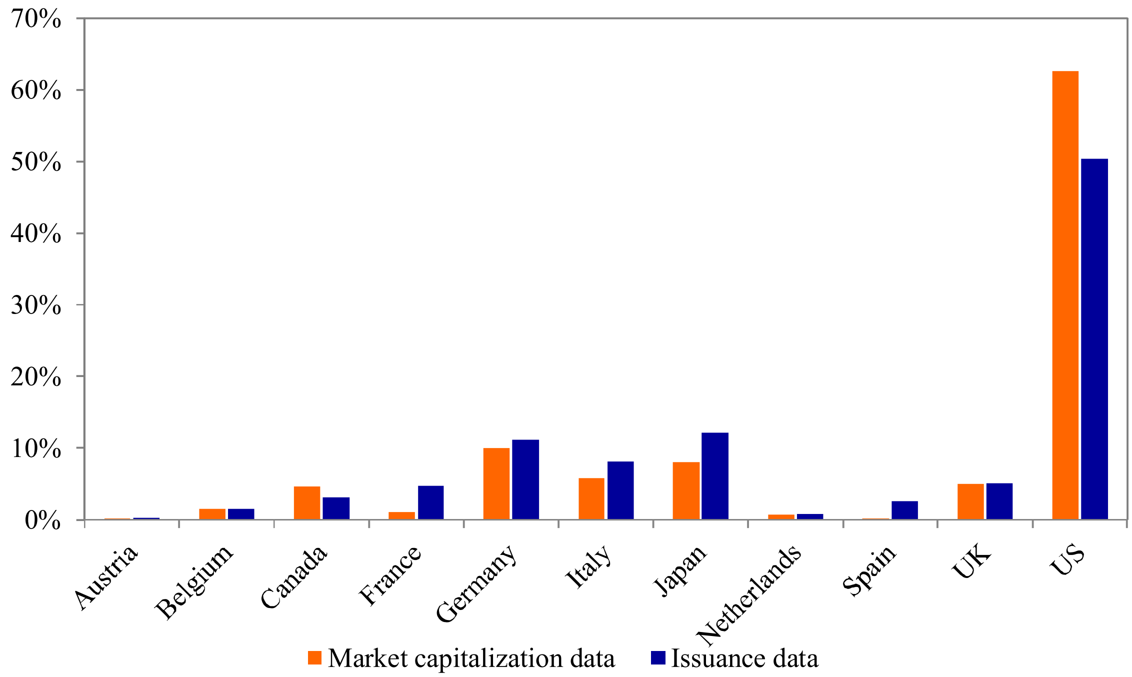


Figure A2 shows the country weights for 1978. Now, France shows the largest difference with a 4 pps overestimate of the market capitalization. The total of all absolute differences is 13 pps for 1978, or an index overlap of 87%. Therefore, this validity check suggests that our methodology to arrive at a time series of estimated relative market capitalizations seems to mirror reported market capitalizations weights well. Given the (lack of) availability of historical market capitalization data this seems us to be the best way to estimate market capitalizations weights. Figure A3 provides an overview of the country weights we use in our Nongovernment Bonds index for the period 1959-1995.

Yields

For the US, we use total return data for the period 1985 to 1996 from the Bloomberg Barclays US Aggregate Corporate Index. For 1960 to 1984 we use total return data from Ibbotson, Siegel and Love (1985, p. 37, 2nd and 3rd column). Like Ibbotson, Carr, and Robinson (1982), we use yields from 1959 to 1969 of the OECD for other countries. As there are no data available for 31 December 1959, we used the yields of 31 January 1960 as an estimate, assuming that the yields did not change during the first month of our sample.[18]

For some countries, there are missing observations in the OECD data: Austria (1960-1964), Belgium (1980-1996), Italy (1990-1994), the Netherlands (1985-1986), Spain (1980, 1984-1987) and the United Kingdom (1995-1996). For the United Kingdom, we used corporate bonds total return data from Bloomberg Barclays

[18] This seems a reasonable assumption. The 10-year interest rate on US Treasuries only was 4.69% in December 1959 and 4.72% in January 1960. Moody's BAA corporate bond yield in the US increased from 5.28% to 5.34% over the first month in 1960. Source: FRED Database (St Louis FED).

Figure A2

Comparison of Nongovernment Bonds' country weights for 1978 based on market capitalization and net issuance (eight countries)

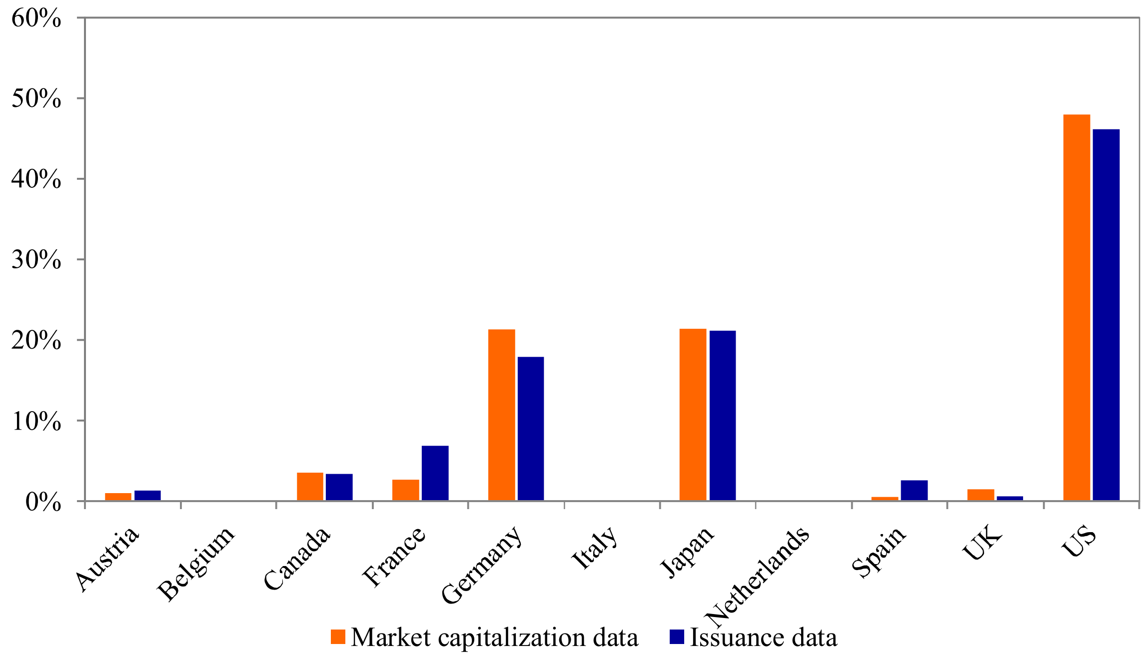
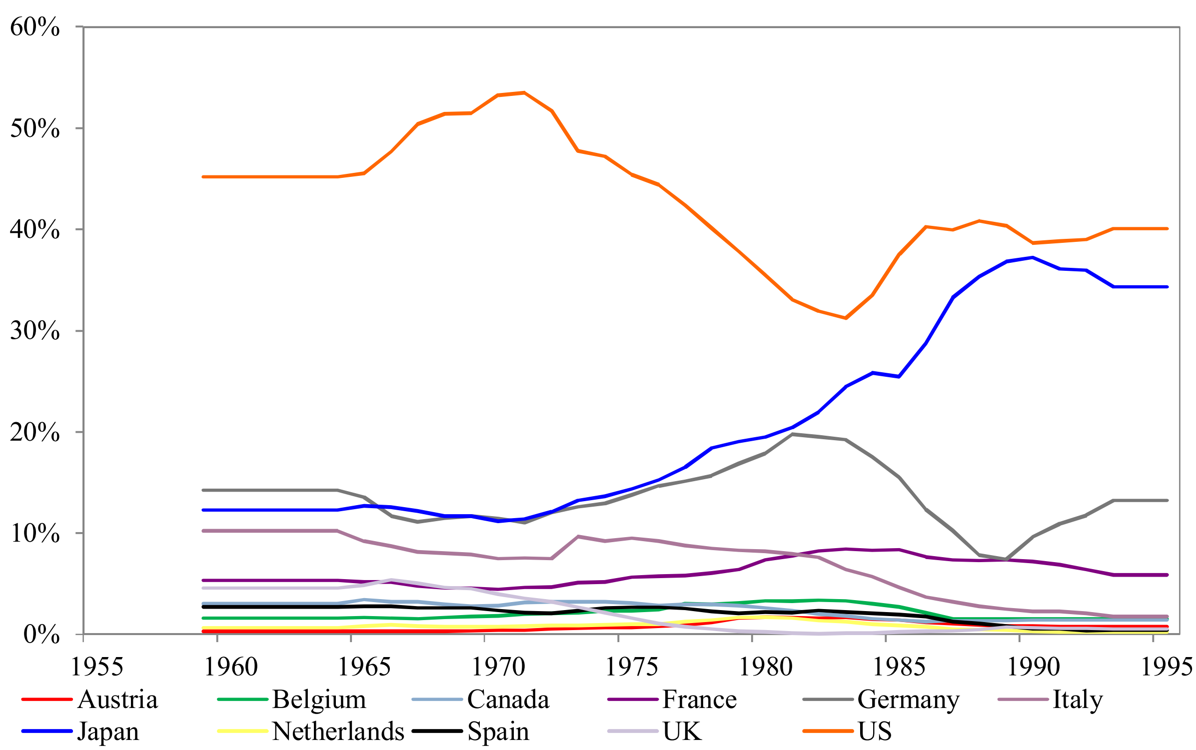


Figure A3

Country weights in our global Nongovernment Bonds index (1959-1995)



(2010, p. 63, fig. 77) for these two years to circumvent the problem of missing yield data that we used to calculate returns.

When there is no yield data available for a year, we excluded a country for that year and the year that follows the missing observation (as the change in yield is needed to calculate a return). Due to missing observations, in 23 years we do not include one or more countries, while in 14 years we cover all eleven countries. Despite missing yield data for one or more countries in 23 years, it appears that the market capitalization that we take into account varies from 93.9 to 99.7% in those 23 years. Therefore, despite some missing yield observations, the data cover almost the whole market capitalization of the eleven countries that we use to compose a global nongovernment total return bond index.

Returns

We calculated returns using Equation A1:

$$r_t = -D_t(y_t - y_{t-1}) + \frac{(y_t - y_{t-1})^2}{2} C_t + y_{t-1} \quad \text{(A1)}$$

Where:

r_t = *total return*

D_t = *modified duration* = $\left[1 - \frac{1}{(1+0.5y)^{2M}}\right] / y$

y_t = *yield*

M = *assumed maturity of the bonds*

C_t = *convexity* ≈ D^2.

We used the maturity estimates of Ibbotson, Carr and Robinson (1982) and extend them to 1996. For the equations of the modified duration and convexity we follow Serrat and Tuckman (2011).[19] With Equation A2, we calculate the convexity:

$$C = \frac{1}{B} \frac{d^2(B(r))}{dr^2} \quad \text{(A2)}$$

where:

C = *convexity*

r = *floating interest rate of the bond*

B = *price of the bond.*

Another way of expressing C in terms of the modified duration D is:

$$\frac{d}{dr} B(r) = -D * B \quad \text{(A3)}$$

Therefore:

$$C * B = \frac{d(-D*B)}{dr} = (-D)(-D * B) + (-\frac{dD}{dr})(B) \quad \text{(A4)}$$

[19] See Equation 4.14 on page 132 and Equation 4.45 on page 146.

which is equal to:

$$C = D^2 - \frac{dD}{dr} \tag{A5}$$

As the last component is negligible we approximate the convexity by:

$$C \approx D^2$$

Final return series with correction for defaults

Obviously, for each year we sum the multiplications of all percent market capitalization weights and corresponding returns to arrive at our total return series for 1960 to 1996. Finally, we still make a correction for defaults for the non-US weight in our index, as we use total return series of external suppliers for the US, as described above. Moody's (2012, exhibit 23, p. 27) contains annual credit loss rates on global investment grade from 1982 on. As Moody's (2012, exhibit 16, p. 20) global corporate issuer default counts for the period 1920-2011 shows, we only have credit losses in 1970, 1973 and 1977 for the period 1960-1981. During the 30-year period 1982-2011 there were 15 years with a credit loss. We proceed by assuming that the credit loss in those three years equals the median credit loss on investment grade for the fifteen years with a credit loss. This median is 0.11 pps (average equals 0.12 pps). We correct the return on the non-US weight in our index with a proportioned 0.11 pps. Hereby, we implicitly assume that global credit losses are evenly distributed across the countries in our sample, relative to a country's weight in the index. We remark that this credit loss correction only has a minor effect on the return series.

High yield bonds

Period 2002-2015

For the period 2002 until 2015, we use the Bloomberg Barclays Global Corporate High Yield Index. This index represents the industrial, utility and financial institutions issuers from the union of the US High Yield, the Pan-European High Yield, and Emerging Markets Hard Currency High Yield Indices.

Period 1998-2001

For the period 1998 to 2001, we use the Bank of America Merrill Lynch Global High Yield Index. This index contains below investment grade corporate debt.

Period 1985-1997

From 1985 through 1997, we use the total returns on the Bank of America US High Yield Index. Before 1998, there is no global high yield index available. However, the US has dominated the global corporate high yield market. To illustrate this, the correlation between monthly returns of the Bank of America Merrill Lynch Global High Yield Index and the Bank of America US High Yield Index is 0.98 in the three-year period 1998-2000, while the average compounded annual returns have been 3.1% and 4.0% respectively. The 90 basis-point return gap between the two indices might seem large, but the annualized standard deviation of the monthly returns is 6.4% and 7.2% respectively in this three year period. So, the difference in returns is limited given this standard deviation.[20]

Government Bonds Broad

Government bonds

Period 2010-2015

For the period 2010-2015 we based the returns on the Bloomberg Barclays Multiverse Government Index in which we replaced the Bloomberg Barclays Global Treasuries Index by the Bloomberg Barclays Global Treasuries Float Adjusted Index. Hereby, we created a global multiverse government index with a free float adjustment. Prior to 2010, there are no annual free float adjusted returns for global treasuries available.

Period 2001-2009

From 2001 until 2009, we use the Bloomberg Barclays Multiverse Government Index. This index has the broadest coverage of the global government bonds irrespective from its credit rating. This is the union of the Bloomberg Barclays Global Treasuries Index, the Bloomberg Barclays Emerging Markets Local Currency Government Bond Index, the Bloomberg Barclays Euro Treasury High Yield Index, and the native-currency segments of “Agencies” and “Local Authorities” from the Bloomberg Barclays Global Government-Related Index, and the Bloomberg Barclays Global High Yield Index.[21]

Period 1987-2000

From 1987 until 2000, we use the Bloomberg Barclays Global Treasuries Index, like Doeswijk, Lam and Swinkels (2014). Unfortunately, there is no information on the other Bloomberg Barclays indexes that make up the Multiverse Government Index before 2001. Note that on 31 January 2001, the Bloomberg Barclays Global Treasuries Index is about 80% of the market value of the Bloomberg Barclays Multiverse Government Index.[22] The correlation between the total monthly returns of both series is over 99.8% over the period January 2001 to December 2015.

Period 1960-1986

We construct a market capitalization based total return index for government bonds. Although we solely need this index for the period 1960-1986, we construct our own global government bond index for the period

[20] The correlation between monthly returns of the US dollar hedged Bank of America Merrill Lynch Global High Yield Index and the Bank of America US High Yield Index is 0.97 in the three year period 1998-2000, while the average compounded annual return for the US dollar hedged Bank of America Merrill Lynch Global High Yield Index has been 2.9% with a standard deviation of 6.3%. The marginal difference itself between the unhedged and the US dollars hedged global index also suggests the dominance of the US in the global high yield market in these early years of the global index.

[21] Note that countries with capital constraints or limited currency convertibility are not included in this index. Examples of countries that are not included are Brazil, China, and India.

[22] On 31 January 2001, the Barclays Global Treasury Index has a market value of US dollar 6.24 trillion, while the Barclays Multiverse Government Index has a market value of US dollar 7.91 trillion. About US dollar 0.73 trillion is due to differences in the Treasury segment of both indexes, and US dollar 0.94 trillion due to the Agencies and Local Authorities.

1960-2010 as it enables us to perform a robustness check of our index versus an external global bond index.[23] We use 20 countries to construct our index. . The Dimson, Marsh, and Staunton (2016b) database contains annual returns for each of them.[24] Next, we need market capitalization data.

We calculate debt amounts in US dollars to derive market capitalization-based portfolio weights. However, these historical debt data are not available. Hence, we use debt-to-GDP ratios and GDP data to calculate the debt amount data. This is an important difference with the Dimson, Marsh, and Staunton (2016b) global government bond portfolio, as they only use GDP-weights and do not adjust for differences in debt-to-GDP ratios. We multiply the debt-to-GDP ratios data with the GDP, as shown in Equation A6.

$$Debt_t = GDP_t * \frac{Debt_t}{GDP_t} \tag{A6}$$

where:

$GDP_t =$ GDP in USD at the end of the year *t*

$\frac{Debt_t}{GDP_t} =$ Debt-to-GDP ratio at the end of year *t*.

Our main source for the GDP data is the World Bank. However, their US dollar GDP data start at the end of 1960. Since the first year we calculate returns for is 1960, we need to obtain portfolio weights from the end of 1959. In order to calculate the missing GDP data for each country at the end of 1959, we use the GDP growth rates in 1960. For this purpose, we take the GDP data in local currencies from Dincecco and Prado (2013). Since the growth rates are in local currencies, we also adjust the growth rates for changes in the exchange rate of the US dollar versus the local currency of each country by using the exchange rates *(ER)* from the Dimson, Marsh and Staunton (DMS) database, as shown in Equation A7.[25]

$$GR_t^{\$USD} = \frac{GDP_t^{DP}}{GDP_{t-1}^{DP}} * \frac{ER_{t-1}}{ER_t} - 1 \tag{A7}$$

where

$GR_t^{\$USD}$ = Growth rate of GDP in USD for the year t

GDP_t^{DP} = GDP at the end of year t in local currencies from Dincecco and Prado (2013)

ER_t = Exchange rate of foreign currency per one USD at the end of year t.

The final step to calculate the missing GDP data in US dollars at the end of 1959 for the World Bank is shown in Equation A8.

$$GDP_{1959} = \frac{GDP_{1960}}{1+GR_{1960}^{\$USD}} \tag{A8}$$

For GDP data of the countries Germany, New Zealand and Switzerland we have additional missing data for certain years. Germany has missing data for the period 1960-1969, New Zealand has missing data for 1970 and Switzerland has missing data for the period 1970-1979. Likewise, for the missing data at the end of the

[23] Our data source for debt-to-GDP ratios ends in December 2009 as we will discuss further on.
[24] Note that the Barclays Global Treasury index covers 19 countries when the index is launched in 1992, while this was 13 in January 1987, the date that the index series was backfilled.
[25] The exchange rates are expressed as the number of local currencies equivalent to one unit of the US dollar.

year 1959 for all countries, we again use the Equations 3 and 4 from above to calculate the missing data with the growth rates of GDP data from Dincecco and Prado (2013).

Now we turn to the data for the debt-to-GDP ratios. The World Bank starts reporting central government debt from 1990. The OECD starts publishing public debt since 1970 and the IMF's database does not have a consistent definition of public debt across countries, especially before 1980, see Abbas, Belhocine, El-Ganainy, and Horton (2010). Therefore, we use the central government debt-to-GDP ratios from Reinhart and Rogoff (2010). They focus on gross central government debt as time series for other broader measures of government debt are not available for many countries.[26] They provide central government debt data for the following seventeen countries: Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Japan, Norway, South Africa, Spain, Sweden, Switzerland, United Kingdom and the United States.

For the other three remaining countries Italy, the Netherlands and New Zealand we use the International Monetary Fund's (IMFs) debt-to-GDP ratios as described by Abbas, Belhocine, El-Ganainy, and Horton (2010).[27] Hereby we might overestimate the amount of debt for these three countries. However, as the central government represents by far the largest part of the general government debt, the bias is probably negligible.

For the return on the market portfolio, we need the returns of the entire government bond market, also named 'all maturities'. In most cases, government bond returns from the DMS database do not reflect all maturity returns. Based on the description of the DMS data sources, we categorized the government bond returns for all countries and each year into one out of the three following categories: a return that reflects an all maturity return, a return that reflects the return on a ten-year bond or a return of a bond that has a maturity above ten year (which in practice appears to imply a maturity around twenty).

Figure A4 illustrates the weight of these three maturity categories in our debt-weighted index with returns from DMS. We need a maturity adjustment for most countries to come closer to the return of an all maturities global government bond index.[28]

The maturity distribution of DMS data does not come close to the maturities reported for Bloomberg Barclays indices, shown in Figure A5.[29] For the period 1987-2015, the median maturity for the Bloomberg Barclays Global Treasury Index is 7.9 and for the Bloomberg Barclays US Government Index this is 8.1. For the Bloomberg Barclays US Government Long Index the median maturity is 22.7 for that period. Before

[26] In footnote 3 (page 574) they state: *"Our focus on gross central government debt owes to the fact that time series of broader measures of government are not available for many countries…"*

[27] Because of a change in data sources for debt-to-GDP in 2002 from the New Zealand government to the IMF World Economic Outlook, this year has no observation in the dataset by Abbas et al. (2010). We linearly interpolate between 2001 and 2003 to obtain the estimate for 2002. For South-Africa, we used the growth rate in debt-to-GDP from 2009 to 2010 from the IMF to estimate the 2010 debt-to-GDP ratio with the 2009 observation from Reinhart and Rogoff (2010) as they lacked this data point for 2010.

[28] For corporate bonds we do not make a maturity adjustment. The market capitalization weighted maturity of our non-US corporate bond index averages 8.1. US returns are based on ISL'85 and are market capitalization weighted returns for intermediate and long term bonds. On their turn, they partly rely on the Lehman Brothers Kuhn Loeb corporate bond indexes which define intermediate bonds as one to ten years and long term as a maturity of ten years or more.

[29] For the construction of this graph, we suppose all maturities returns in the DMS database to have an average maturity of 6 before 1984 and 8 afterwards. This assumption has little relevance, as all maturities returns constitute a small portion of our debt weighted index, as shown in Figure A4.

Figure A4

The weight of maturity categories in the debt weighted global government bond market, based on DMS government bond returns

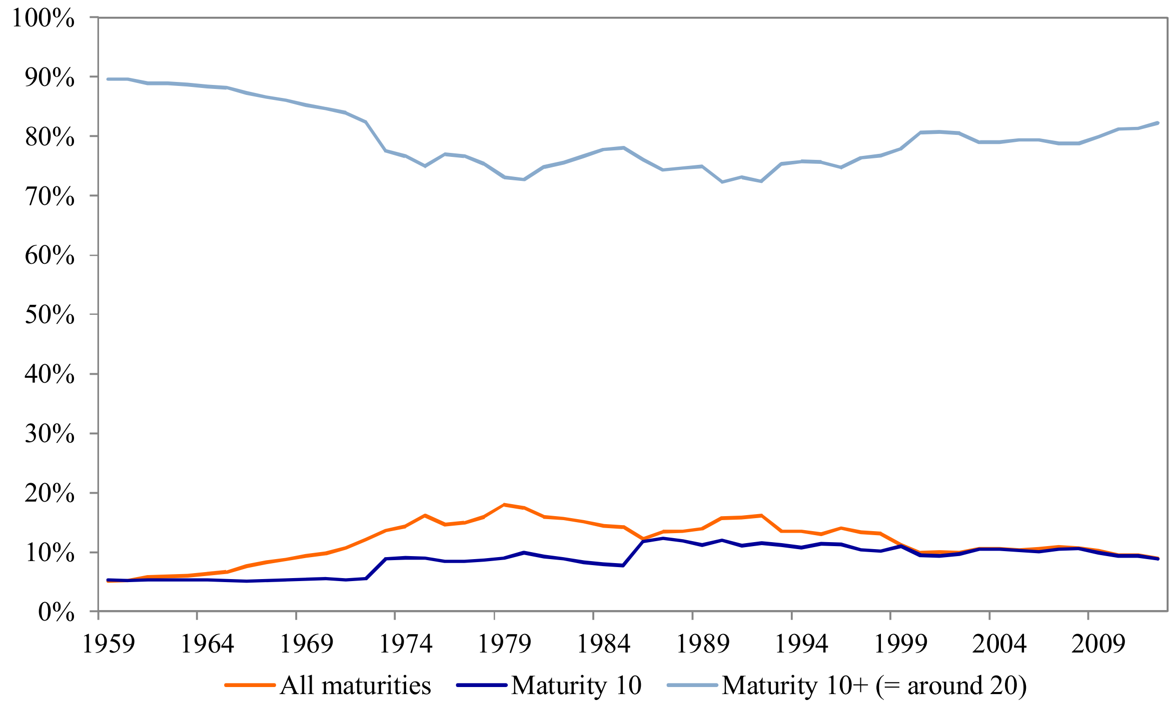
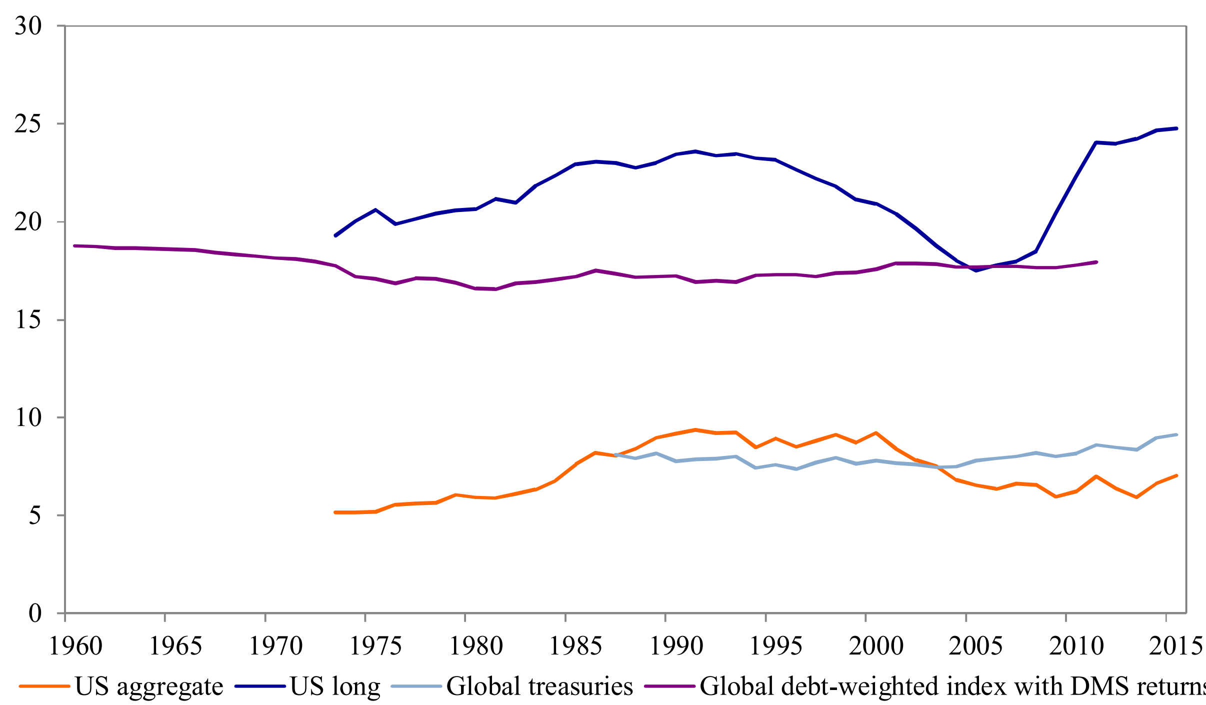


Figure A5

Maturities for Bloomberg Barclays Capital indices and our global debt weighted index with DMS returns



1987 we do not have global maturities data from Bloomberg Barclays available, but for the Bloomberg Barclays US Government Index the median maturity is 5.9 for the period from 1973 through 1986. It is likely, that the maturity for the global index also would have been lower in the period 1973-1986, at least for the simple reasons that the US is a heavy weight in the index.

To come closer to the true global bond market return with the DMS returns, we target a maturity of 6 for the period 1960-1984 and 8 for the period 1985-2011. For 1985-2011 we base the target maturity on the Bloomberg Barclays Capital Global Treasury Index, for the period 1960-1984 we target the maturity two years less, as the largest component of the index, the US, has a lower maturity in the seventies and early eighties than after 1984. In order to arrive at a certain target maturity, we firstly determine the yearly (multiplicative) relative performance of a 20-year bond over a 5-year bond, using data from Ibbotson (2015). Furthermore, we assume that the relative performance has a linear pattern. So, by dividing the relative performance by 15 years, which is the difference in maturity, we know the performance for each additional year of maturity a bond has over a 5-year maturity bond. Equation A9 describes this calculation:

$$RM_{i,t}^{1} = \frac{\frac{(1+R_t^{20})}{(1+R_t^{5})}-1}{M_{Ibbotson}^{20}-M_{Ibbotson}^{5}} \tag{A9}$$

where

$RM_{i,t}^{1}$ = return for one and each year of additional maturity a bond has over a 5-year maturity bond for country i, in year t,

$R_{i,t}^{20}$ = return of 20-year maturity bond for country i in year t,

$R_{i,t}^{5}$ = return of 5-year maturity bond for country i in year t,

$M_{Ibbotson}^{20}$ = 20

$M_{Ibbotson}^{5}$ = 5.

Now we determine the maturity adjustment so we can end up in maturity adjusted returns. For both maturity categories, 10 and 20 years, we multiply the relative return of a bonds' one year of additional maturity with the difference of its maturity and the targeted maturity. For example, if we want to adjust the category with 10 year maturity bonds to a target maturity of 6 years the multiplication factor is 4, i.e. 10-6. For each country and for each year we determine this multiplication factor. We describe this in Equation A10.

$$MA_{i,t} = RM_{i,t}^{1} * (M_{i,t} - TM_t) \tag{A10}$$

where

$MA_{i,t}$ = maturity adjustment for country i in year t,

$M_{i,t}$ = maturity category for country i in year t,

TM_t = targeted maturity in year t, which equals 6 from 1960 to 1984 and 8 for 1985 to 2011.

Now, for all years and for all countries we have arrived at a maturity adjustment and we can derive the maturity adjusted returns, as shown in Equation A11. Obviously, we do not correct the all maturities category, as we perform this adjustment to arrive at an all maturities estimate. In other words, the maturity adjustment is zero for the all maturities category.

$$RA_{i,t} = (1 + RU_{i,t}) * (1 - MA_{it}) - 1 \tag{A11}$$

where

$RA_{i,t}$ = adjusted return for country i in year t, reflecting an estimated all maturity return,

$RU_{i,t}$ = unadjusted return for country i in year t,

$MA_{i,t}$ = maturity adjustment for country i in year t.

In the maturity adjustment process, we assume that the relative performance of the 20 year versus the 5 year bond in the US is representative for all 19 other countries in our sample, as we only have US data available for both five and twenty year government bond returns.[30] This might seem far stretching at first sight. However, in the period 1960-2011 for which we construct our global bond index, local government bond returns for all countries show a positive correlation to US government bond returns. The correlations vary from 0.15 to 0.87, with an average of 0.50 and a median of 0.49. A further analysis in Appendix B suggests that the assumption is not as far stretching as one might think. Our index comes very close to global all maturity indices that are available for sub-periods.

Inflation linked bonds

Period 1998-2015

For inflation linked bonds we use the Bloomberg Barclays Capital Global Aggregate Inflation-Linked Index for the period 1998-2015. This index includes securities which offer the potential for protection against inflation as their cash flows are linked to an underlying inflation index. All securities included in the index need to be issued by an investment-grade rated sovereign in its local currency.

Period 1997

For 1997 we use the Bank of America Merrill Lynch World Government Inflation-Linked All Maturities Index.

Period 1985-1996

We use the Bank of America Merrill Lynch UK Government Inflation-Linked All Maturities Index for the period 1985-2006. Although inflation-linked bonds have existed for a long time, the UK was the first major country to offer them as alternatives to nominal government bonds to the public. The US created treasury inflation protected securities (TIPS) in 1997.

Emerging market debt

The asset class emerging market debt (EMD) requires a different approach than the other asset classes in this study as it contains four sub-asset classes with different characteristics, following Doeswijk, Lam and

[30] Here, we use the data from the Ibbotson SBBI 2015 Classic Yearbook – Market Results for Stocks, Bonds, Bills and Inflation 1926-2014, published by Morningstar Inc., Chicago.

Swinkels (2014a). We distinguish external hard currency debt, hard currency corporate debt, local currency nominal government debt and inflation linked debt. There is no global index available, which contains all these four categories. Therefore, we compose a comprehensive market capitalization weighted global emerging market debt total return index for the period 1994-2015.

We use the JP Morgan Emerging Markets Bond Index Global Composite (EMBI) for external hard currency debt, the JP Morgan Corporate Emerging Markets Bond Index Broad (CEMBI) for US dollar-denominated emerging-market corporate bonds, the JP Morgan Government Bond Index - Emerging Markets Global Composite (GBI) for local currency debt and the Bloomberg Barclays Capital Emerging Markets Government Inflation-Linked Index (EMGILI) for inflation-linked bonds.

Figure A6 illustrates the relative market capitalization weights for all four categories in our EMD index, using the methodology of Doeswijk, Lam and Swinkels (2014a) to estimate the market capitalization of each category.

Figure A6 also shows the availability of return data. Dotted data indicate that there are no return data available, whereas we do have an estimation of the relative market capitalization weights for each year. Thus, in 1994 we start with the EMBI only, which covers 83% of the EMB index at that time as there are no return data for the other three indices.[31] Afterwards, the coverage gradually falls to 65% until return data for CEMBI and GBI become available in 2002. Then, the market coverage of our EMD index jumps to almost 100%. When return data for EMGILI become available in 2004, the coverage reaches 100%.

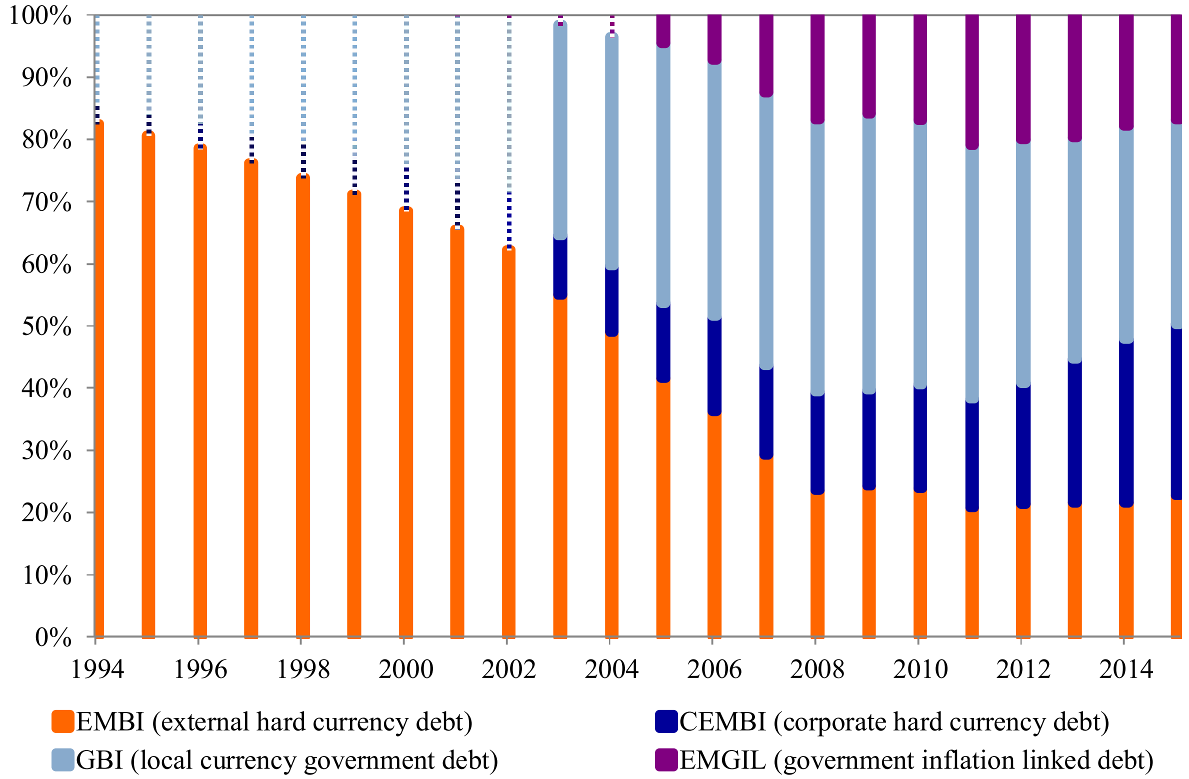
The limited return data availability for the period 1994 to 2001 introduces a bias in our EMD index, but as the total returns of EMBI are positively correlated to CEMBI (0.86) as well as to GBI (0.71) in the 2002-2015 period, it seems our EMD is a reasonable proxy for the 1994-2001 period. In any case, the impact of any bias in our EMD index on the global multi-asset market portfolio will be marginal as EMD represents less than 1% of the market portfolio at the end of 1993. This also applies to its impact on our government broad index with a weight of less than 3%.

For each year t from 1994 to 2015 we determine the return of our EMD index by summing the multiplications of the relative market capitalization weights at the end of year t-1 and the accompanying returns in year t. Subsequently, we divide this sum by the total relative market capitalization that we consider. This last step is necessary as the availability of return data, or market coverage in other words, is less than 100% in several years.

[31] We use the year-end market capitalization in year [t-1] to calculate market capitalization weighted return in year [t]. The 83% figure represents the relative market capitalization of EMBI at the end of 1993, which we use in combination with the return of 1994.

Figure A6

Previous year-end relative market capitalizations and the availability of return data in a year for each category of emerging markets debt. Dotted data indicate that there is no return data available for that year.



Appendix B. Robustness checks

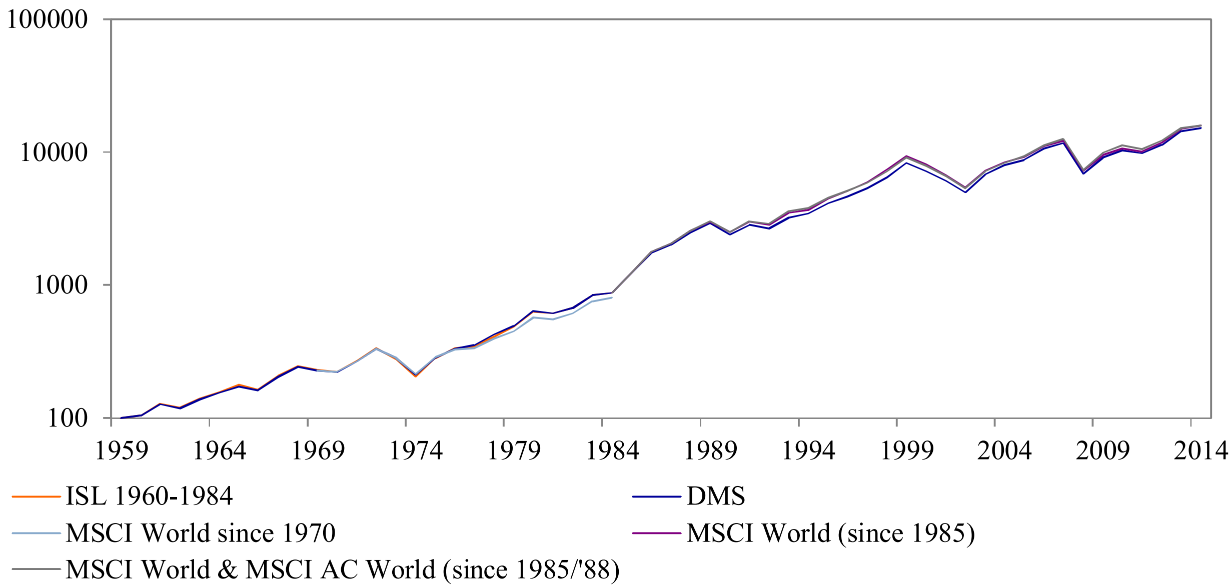
In this appendix, we compare our data to alternative data sources to get insight into the sensitivity of the results for the use of other sources, i.e. we check the robustness of our approach. We perform this check only for the asset classes equities, real estate, government bonds and investment grade credits. For these asset classes, we do have decades long data available from alternative data sources, which enables us to do robustness checks.

Equities

Figure A7 shows the cumulative total performance of five global equity series. It contains data from ISL (1985) who provide total return data from 1960 through 1984. Next, it shows the total return performance from 1960-2014 from the DMS-database. We also show the total return performance for the MSCI World Index from its inception in 1970 to 1984 (with the starting value of the DMS-index at the end of 1969), a separate series shows the total return performance of the MSCI World index from 1985 (with the starting value of the Dimson, Marsh, and Staunton (2016b) index at the end of 1984) and finally it contains a series from 1985 (with the starting value of the DMS-index at the end of 1984) that replaces the MSCI World Index with MSCI AC World Index.

Figure A7

Cumulative total performance of five global equity series



For the period till 1984 the data from ISL and DMS resemble each other very closely with an average annualized compounded return of 9.07% and 9.05% respectively, while the correlation of annual returns is a rounded 1.00. For the period 1970-1984 these data are 9.30%, 9.36% and 1.00 respectively. The return for MSCI World Index comes in at 8.73% for this period, which is 60 pps behind the other two indices, while the correlation of the total return with both indices is 0.99.

After 1984 there are hardly any differences between data from DMS and MSCI. For the period 1985-2014 the return is 9.97% according to DMS, while the MSCI World Index returns 10.15%. The index that we have composed for this study returns 10.21% during that period (before 1985 we use the ISL (1985) data). For the period 1987-2014, these figures are 7.74%, 7.85% and 7.91% respectively, while the MSCI AC World Index generates an average return of 7.84% during this period. Correlations are close to 1.00. In short, this analysis suggests that the results for equities are robust.

Real estate

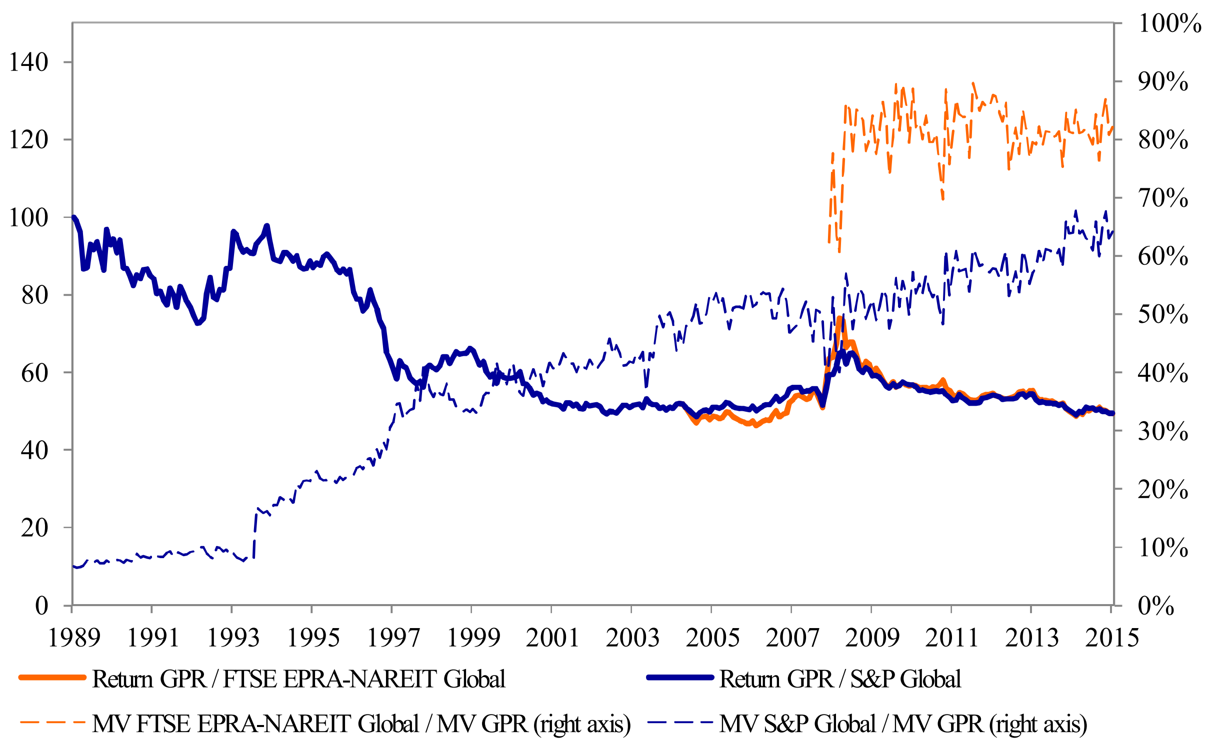
For real estate, we show two alternative data sources with a limited return history, the FTSE EPRA / NAREIT Global Index and the S&P Global Real Estate Investment Trusts (REITs) Index. As can be seen in Figure A8, both have a market value that is clearly below the market value of the GPR Index which implies their universe differs from GPR's. On balance, both perform roughly in line with the GPR Index in the period 2005-2015. The GPR index returns an average compounded annual return of 6.4% during the start of the S&P Global REITs Index in 1995, while the FTSE EPRA / NAREIT Global Index and the S&P Global Real Estate Investment Trusts (REITs) Index deliver 6.4% and 6.8% respectively. Since 1995, the correlation of monthly total returns with the GPR Index is 0.99 and 0.96 respectively. In 2008, 2009 and 2010, the relative performance of GPR differs from the FTSE EPRA / NAREIT and S&P indices, as a result of different universes. At the end of 2008 the market capitalization of GPR is 1.3 respectively 1.9 times as large as the other two index providers.

Before 2005, the relative total return performance of the GPR differs from the S&P Global REITs Index. The further we go back in time, the less we can compare them. Back in 1990, the market capitalization of the S&P Global REITs Index equals 7% of GPR's market capitalization, as also can be seen in

The GPR Index seems to be the best suited index for this study since its inception in 1984. It has the largest market capitalization and an extensive history.

Figure A8

Total performance of the GPR Index relative to the FTSE EPRA / NAREIT Global Index and the S&P Global REITs Index, and the market capitalization of the FTSE EPRA / NAREIT Global Index and the S&P Global Real Estate Investment Trusts Index relative to the GPR Index



Investment grade credits

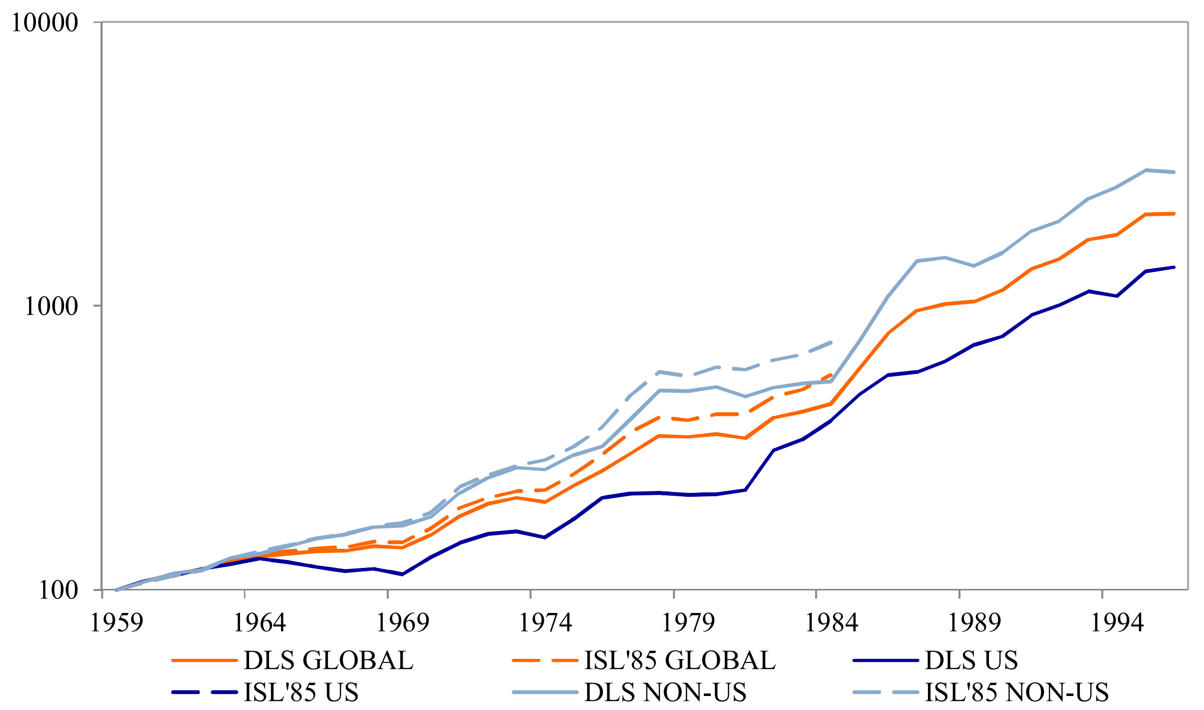
As an indicator of the performance of investment grade credits we constructed an investment grade corporate bond index. Figure A9 illustrates the performance of our index at global level, US-level and non-US level.

Also, it contains the indices for the ISL (1985) study. We are not aware of any other study documenting global corporate bond returns from the sixties through the eighties.

At global level, for the period 1960-1984, the returns of our index have a correlation of 0.94 to those of ISL, while average annual compounded returns are 6.22% and 7.21% respectively. For the US we use ISL’85 data for the period 1960-1984, and another data source afterwards. The yearly compounded return in the first 25 years is 5.65%. For non-US corporate bonds, we compose our own index from 1960. The correlation with ISL’85 at non-US level is 0.89. At non-US level, returns are 7.00% for our index and 8.35% for the ISL’85 index.

Figure A9

Performance indices for IG corporate bonds with Doeswijk, Lam and Swinkels (DLS) and Ibottson, Siegel and Love (ILS) data

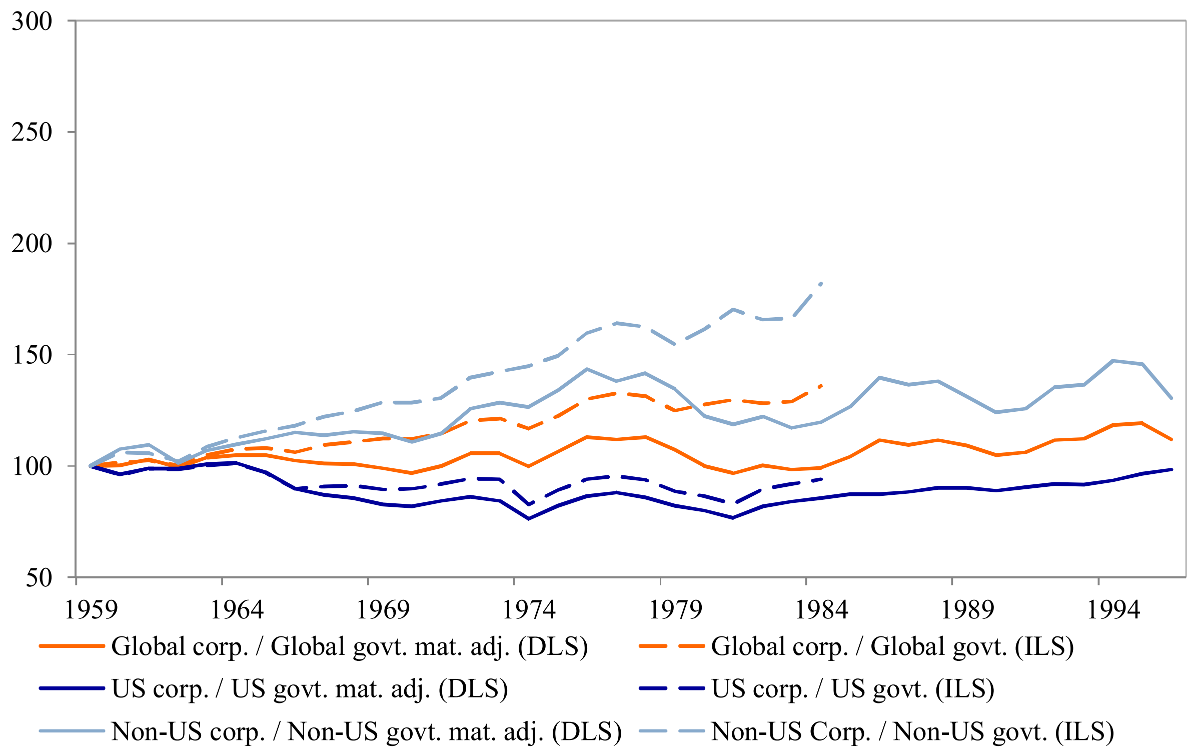


We also examined the total return performance of corporate bonds relative to government bonds for our data set and for ISL’85. Figure A10 provides a graphical illustration of the differences. For the period 1960-1984, we report an average compounded underperformance of global corporate bonds compared to government bonds of 3 bps a year, while ISL’85 report an outperformance of 123 bps. Both series have a correlation of 0.64. For US corporate bonds, the correlation is 0.96. Our data results show that the corporate index for the US lags our government bond index by a yearly average of 62 bps, while its lags a yearly average of 25 bps with ISL’85 data. However, there is a larger difference for the non-US region where we report an average outperformance of corporate bonds over government bonds of 72 bps a year. ISL’85 document an annual outperformance of 242 bps. This is a rather large difference over a 25-year period. In our data set, there is a correlation of 0.34 between the annual premium of corporate bonds in the US and in the non-US region. The ISL’85 data result in a correlation of 0.09.

We do not know where the differences in non-US corporate bond returns and corporate bonds’ premiums over government bonds arise from. Unfortunately, we have no source data of the ISL’85 study available for a more detailed comparison. Possibly, there is a significant difference between currency and maturity mismatches between the two corporate bond datasets. However, on balance, we do feel comfortable with our data. Our data show a higher correlation between the US and non-US return differences relative to government bonds. Next, the non-US premium of corporate bonds over government bonds in our data set is more in line with what we ex-ante would have expected for a period with two oil crises and a huge recession in the early eighties.

Figure A10

Performance indices for IG corporate bonds versus government bonds with Doeswijk, Lam and Swinkels (DLS) and Ibottson, Siegel and Love (ILS) data



Government bonds

We compare several global government bond indices in Table A2. The indices in columns two to five are our indices that we described in the previous appendix with data details of returns. Column six contains the global bond index from the Dimson, Marsh, and Staunton (2016b) database, column seven shows the returns for an index based on Ibbotson, Siegel and Love (1985), we refer to this study as ISL’85, and column eight contains data for the Bloomberg Barclays Capital Global Treasury Index. All data are total returns in unhedged US dollars.

For the robustness check, we composed a market capitalization weighted global government bond index from ISL'85 returns by using the reported market capitalizations and returns for United States government bonds and foreign domestic government bonds to create a market capitalization weighted government bond index. The ISL'85 data contain returns for bonds with a maturity that differs by country, but we distracted from the description of the data sources that the index is closer to an all maturity index than the global bond index from DMS which is primarily based on 20-year bond returns.[32]

The average compounded annual return for the 1960-1984 period has been 5.91% according to ISL'85. Surprisingly, this is close to the 6.09% from DMS. However, this is coincidence, as a further analysis shows that US and non-US returns do not come close to each other, but both deviations cancel each other out during the time frame 1960-1984. This can be found in tables y and z to which we return later. Our GDP weighted global index also comes close with a return of 6.02%, but this index actually is comparable to the global index of DMS. The DMS global government bond index is a GDP weighted index, with weights unreported. We use their returns and our GDP-weights to arrive at an index that is basically the same with comparable returns, standard deviations and correlation. So, again, US and non-US returns do not match ISL'85 data. Our debt weighted maturity adjusted index is 35 bps above the return reported by ISL'85. This obviously comes closer than the debt weighted index or the GDP-weighted maturity adjusted index, with differences of -99 bps and 136 bps respectively.

The return of our global maturity adjusted index also comes closest to the Bloomberg Barclays Capital Global Treasury Index during the period 1987-2011 with a difference of average compounded annual returns of 31 bps above Bloomberg Barclays'. For this period, DMS reports an average return 216 bps above the Bloomberg Barclays Capital Global Treasury Index as they primarily use bonds with a 20-year maturity. Again, the debt weighted maturity adjusted index mirrors the return of the Bloomberg Barclays index better than the GDP weighted maturity adjusted index as its return is 53 bps higher than Bloomberg Barclays.

For the period 1987-2011, the standard deviation of our government debt weighted maturity adjusted index is almost identical to the one for the Bloomberg Barclays index. For the period 1960-1984, standard deviations were all in a range of 1% around the standard deviation of ISL'85. For both sub periods, correlations are (very) close to ISL'85 or the index from Bloomberg Barclays.

For the period 1960-2011, the compounded return of our global debt weighted maturity index is 102 bps below the DMS global bond index, which is GDP weighted and contains maturities mostly around 20. Both the weighting method and the maturity adjustment attribute to this difference.

[32] Unfortunately, the appendix at request with the data details of the ISL'85 study, as well as the data themselves, have gone lost during the past 30 years, as we noticed from the authors. However, they informed us that their study was basically an update from the Ibbotson and Siegel (1983) paper. On its turn, this paper refers for some details to the Ibbotson, Carr and Robinson (1982) study. There, we found information on the maturity of government bonds.

This robustness check shows that the return of our debt weighted maturity adjusted global government bond index comes very close to other benchmark indices in both sub-periods, referring to the ISL'85 index and the Bloomberg Barclays Capital Global Treasury Index. As a further examination, we also will check the US and non-US returns.

Table A2

Return characteristics for several global government bond indices (total returns, unhedged USD)

(1)	GDP weighted (2)	Debt weighted (3)	GDP w. mat. adj. (4)	Debt w. mat. adj. (5)	DMS (6)	ISL'85 (7)	BBC global tr. (8)
1960-1984							
Average compounded return (%)	6.02	4.92	7.27	6.26	6.09	5.91	NA
Standard deviation (%)	6.21	6.46	4.52	4.64	6.25	5.56	NA
Correlations							
GDP weighted index	1.00	0.97	0.87	0.83	1.00	0.93	NA
Debt weighted index		1.00	0.82	0.86	0.97	0.94	NA
GDP weighted maturity adj. index			1.00	0.94	0.86	0.89	NA
Debt weighted maturity adj. index				1.00	0.83	0.90	NA
DMS global bond index					1.00	0.93	NA
ISL'85 global bond index						1.00	NA
Bloomberg BC global treasury							1.000
1987-2011							
Average compounded return (%)	9.43	9.31	7.91	7.68	9.53	NA	7.37
Standard deviation (%)	8.69	8.93	7.07	7.24	8.28	NA	7.18
Correlations							
GDP weighted index	1.00	0.99	0.86	0.84	1.00	NA	0.89
Debt weighted index		1.00	0.84	0.85	0.99	NA	0.88
GDP weighted maturity adj. index			1.00	0.98	0.86	NA	0.94
Debt weighted maturity adj. index				1.00	0.84	NA	0.93
DMS global bond index					1.00	NA	0.87
ISL'85 global bond index						1.000	NA
Bloomberg BC global treasury							1.000
1960-2011							
Average compounded return (%)	8.55	7.97	8.21	7.63	8.65	NA	NA
Standard deviation (%)	8.88	9.29	6.68	6.94	8.72	NA	NA

Table A3 shows return characteristics for several US government bond market indices. Column two contains the returns from DMS, column three shows our maturity adjusted return data, column four contains the ISL'85 data for the US, columns five and six contain data based on the Ibbotson SBBI 2015 Classic Yearbook and reflect the return on intermediate (five year) and long term (twenty year) bonds and finally column seven and eight are from Bloomberg Barclays Capital and show the US Aggregate Index for all maturities and long term government bonds respectively.

DMS and Ibbotson's long term bonds data are the same for the period 1960-1984. Their returns are 1.21% below the return for ISL'85. Our maturity adjusted US index comes closest to the ISL'85 data with a return of 5.91% versus 6.63% for ISL'85, almost matching standard deviations and a correlation of 0.98.

For the 12-year period 1973-1984, the Ibbotson intermediate bonds data come closest to the Bloomberg Barclays US Aggregate Index, while our maturity adjusted index and the ISL'85 show approximately the same return characteristics. It should be noted that returns for twenty year bonds are way off returns for indices that intend to reflect all maturity returns, i.e. our maturity adjusted index, the ISL'85 index and the Bloomberg Barclays US Aggregate Index, with returns around 2% higher for the all maturity indices. For the period 1973-2014 both our maturity adjusted index and the Ibbotson intermediate bond index come close to the Bloomberg Barclays US Aggregate Index.

Also for the US, the robustness check suggests our maturity adjusted index to be a good estimate of the return on the US government bond market. It comes close to both the ISL'85 and the Bloomberg Barclays US Aggregate Index. We now turn to the non-US market as a final check.

We provide return characteristics of the non-US government bond market in Table A4Table A4. The non-US GDP weighted unadjusted returns from DMS are 1.2% higher than from ISL'85, while for the US it was the other way around with a gap of -1.2%. Hereby, at a global level it seemed that a GDP weighted index with unadjusted DMS returns were a proper reflection of the performance of the global bond market. Our non-US maturity adjusted index comes close to ISL'85 again. This suggests that GDP weighted unadjusted returns are not as suitable for the purpose of reflecting the performance of the global bond market as the debt weighted maturity adjusted returns. Table A2, Table A3 and Table A4 suggest that debt weighting instead of GDP weighting as well as using maturity adjusted returns instead of unadjusted returns contribute to creating a global all maturity benchmark.

Our debt weighted maturity adjusted global government bond index seems a good estimate of the return on the global government bond market. It has shown to be close to two other all maturity indices at different sub-periods. Also, the analysis for the US and non-US underpin the global results. As mentioned in the previous appendix, we use our debt weighted maturity adjusted global government bond index in this study for the period 1960 through 1986. From 1987 onwards, we use the returns from the Bloomberg Barclays Capital Global Treasury Index.

Table A3

Return characteristics for several US government bond indices (total returns)

(1)	DMS (2)	Maturity Adjusted (3)	ISL '85 (4)	Ibbotson intermediate (5)	Ibbotson long (6)	BBC aggregate (7)	BBC aggr. long (8)
1960-1984							
Average compounded return (%)	4.70	6.31	5.91	6.63	4.70	NA	NA
Standard deviation (%)	9.90	6.50	6.57	6.40	9.90	NA	NA
Correlations							
DMS	1.00	0.95	0.95	0.92	1.00	NA	NA
Maturity adj. index		1.00	0.98	1.00	0.95	NA	NA
ISL '85			1.00	0.97	0.95	NA	NA
Ibbotson intermediate index				1.00	0.92	NA	NA
Ibbotson long index					1.00	NA	NA
Bloomberg BC US aggregate						1.00	NA
Bloomberg BC US aggregate long							1.00
1973-1984							
Average compounded return (%)	6.10	8.02	7.99	8.44	6.10	8.52	6.61
Standard deviation (%)	12.57	7.64	7.21	7.48	12.57	7.09	12.72
Correlations							
DMS	1.00	0.98	0.97	0.97	1.00	0.96	1.00
Maturity adj. index		1.00	0.99	1.00	0.98	0.99	0.97
ISL '85			1.00	0.98	0.97	0.99	0.96
Ibbotson intermediate index				1.00	0.97	0.99	0.96
Ibbotson long index					1.00	0.96	1.00
Bloomberg BC US aggregate						1.00	0.95
Bloomberg BC US aggregate long							1.00
1973-2014							
Average compounded return (%)	8.65	7.34	NA	7.42	8.65	7.49	8.76
Standard deviation (%)	12.59	7.28	NA	6.61	12.59	6.44	12.36
Correlations							
DMS	1.00	0.91	NA	0.86	1.00	0.88	1.00
Maturity adj. index		1.00	NA	0.99	0.91	0.99	0.91
ISL '85			1.00	NA	NA	NA	NA
Ibbotson intermediate index				1.00	0.86	0.99	0.87
Ibbotson long index					1.00	0.88	1.00
Bloomberg BC US aggregate						1.00	0.89
Bloomberg BC US aggregate long							1.00

Table A4

Return characteristics for several non-US government bond indices (total returns, unhedged USD)

(1)	GDP weighted (2)	Debt weighted (3)	GDP w. mat. adj. (4)	Debt. w. mat. adj. (5)	ISL'85 (6)
1960-1984					
Average compounded return (%)	6.95	5.13	7.93	6.23	5.79
Standard deviation (%)	7.14	7.88	7.02	7.67	7.56
Correlations					
GDP weighted index	1.00	0.93	0.94	0.87	0.92
Debt weighted index		1.00	0.86	0.94	0.95
GDP weighted maturity adj. index			1.00	0.92	0.84
Debt weighted maturity adj. index				1.00	0.87
ISL'85 non-US bond index					1.00

Appendix C. Market capitalizations

We use the market capitalizations from Doeswijk, Lam and Swinkels (2014a) which we update for the period 2013-2015 as described in their study. Following the discussion in Westerling (2014) and Doeswijk, Lam and Swinkels (2014b) we correct market capitalizations for financial assets held by some major central banks. We subtract the market value of the Bloomberg Barclays Capital Global Aggregate Float Adjusted Index from the market value of the Bloomberg Barclays Global Aggregate Index for both government bonds and investment-grade securities to determine the free float correction that we make to our market capitalization data.[33,34] For all other data details and a description of our methodology for the composition of the GMP we refer to Doeswijk, Lam and Swinkels (2014a).[35]

[33] Here follows a description from a Barclays Capital research report of Myers and Upbin (2009): "With an inception date of July 1, 2009, the Barclays Capital Global Aggregate Float Adjusted Index provides a broad-based measure of the global investment-grade fixed-rate debt markets that excludes government holdings and quantitative easing purchases. The underlying constituents of the Global Aggregate Float Adjusted Index are the same as the flagship Global Aggregate Index and conform to the same general conventions, but currently deduct net holdings of US treasuries, US agencies, and fixed-rate MBS pass-throughs held in Federal Reserve SOMA accounts, as well as Sterling Gilts and Japanese Yen held by the Bank of England and the Bank of Japan, respectively".

[34] We do not take ECB holdings into account. Adjustments for ECB holdings bring a lot of uncertainty as one has to work with estimates due to a lack of details. It would also introduce a hindsight bias as data are not timely available.

[35] There is one difference as in this study we combine the asset classes equities and private equity into the asset category Equities Broad for the entire 1960-2015 period. Doeswijk, Lam, Swinkels (2014a) estimate the market capitalization for the asset class private equity from 1990 onwards. Before 1990, we assume the market capitalization of private equity to have grown in line with the market capitalization of the asset class equities. This assumption has a limited quantitative impact, as private equity represents just 1.7% of the asset category Equities Broad in 1990 and 0.9% of the global market portfolio.