Historical Returns of the Market Portfolio

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Abstract

We create an annual return index of the invested global multiasset market portfolio. We use a newly constructed unique data set covering the entire market of financial investors. We analyze returns and risk from 1960 to 2017, a period during which the market portfolio realized a compounded real return in U.S. dollars of 4.45%, with a standard deviation of annual returns of 11.2%. The compounded excess return was 3.39%. We publish these data on returns of the market portfolio, so they can be used for future asset pricing and corporate finance studies. (*JEL* E44, G11, G12, M21, N20)

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Introduction

Returns of the invested global multiasset market portfolio have not been documented before. In this study, we create an annual return index for the invested global multiasset market portfolio for the period 1960–2017. We weight returns of ten asset classes by their market capitalizations. This market portfolio basically contains all assets in which financial investors have invested. The weight in the market portfolio of asset classes other than equities and government bonds has increased from 20% at the end of 1959 to 35% in 2017. Hence, including asset classes beyond equities and government bonds is increasingly important for assessing the market portfolio. Market capitalization weighting and a total market coverage result in a unique historical insight into the actual returns on invested capital of financial investors. This paper complements that of Doeswijk, Lam, and Swinkels (2014a), who solely document the historical *composition* of the market portfolio, but not its historical *returns*.

Our return index of the market portfolio is a major contribution to the literature. The only global multiasset return index that has been previously documented is the global return index of *wealth* for the period 1960–1984 by Ibbotson, Siegel, and Love (1985). Other research into long-term historical returns reports separate return series for a limited number of asset classes without providing insight into the aggregate market-capitalization-weighted return time series. Therefore, this study adds to the understanding of asset pricing. We make the resultant data for the market portfolio publicly available, so researchers can use them for other applications, such as calculating market betas in asset pricing studies or for determining a firm's cost of capital.

Ilmanen (2011) indicates that large parts of global wealth are not investable for financial investors. A case in point is real estate. The value of all real estate in the developed world amounts to US$217 trillion in 2015, according to Savills (2016), about twice our estimate for the entire invested global multiasset market portfolio for 2015 of US$104 trillion. In the scarce academic literature on international returns, real estate dominates the *wealth* portfolios in the seminal studies of Ibbotson and Siegel (1983), Ibbotson, Siegel, and Love (1985),[1] and Jordà et al. (2019). The latter report returns on *wealth* by country and provide equally weighted and gross domestic product (GDP)-weighted period averages, but they do not include a global value-weighted return time series as provided by Ibbotson, Siegel, and Love (1985) for the period 1960–1984. The groundbreaking study by Dimson, Marsh, and Staunton (2002)[2] documents annual returns for equities, long-term government bonds, and Treasury bills in sixteen countries for the 101-year period from 1900 to 2000. They also report

[1] Ibbotson, Siegel, and Love (1985) extend the results of the previous study from 1980 to 1984, and Ibbotson, Carr, and Robinson (1982) document international equity and bond returns for a long historical sample. Ibbotson and Siegel (1983) were the first to rigorously study weighted multiasset returns on a global level in their so-called "world market wealth portfolio."

[2] Updates are available at the Web site of the Credit Suisse Research Institute.

these return series at the global level, but their data set does not contain returns of a multiasset portfolio.

The number of asset classes that are part of our market portfolio is unrivaled. First, none of the studies mentioned above use market-capitalization-weighted returns for global real estate. The real estate returns in Ibbotson, Siegel, and Love (1985) only concern the United States. Jordà et al. (2019), the first to document a long set of total returns on housing for a large number of countries, and Dimson, Marsh, and Staunton (2018a) include national private housing returns, but they do not include commercial real estate. However, private housing has limited investability for financial investors. We include both commercial real estate and housing, but the weight of housing is small compared to commercial real estate. Next, this is the first study to use an invested market-value-weighted return index for commodities. Ibbotson and Siegel (1983) use a supply-weighted return index for gold and silver, whereas commodities are not included in Jordà et al. (2019) and Dimson, Marsh, and Staunton (2002). Also, investment-grade credits are part of the Ibbotson, Siegel, and Love (1985) study, but they are not part of Dimson, Marsh, and Staunton (2002) and Jordà et al. (2019).[3] For both government bonds and investment-grade credits, the length of our market-capitalization-weighted return series is unique. Moreover, our government bond index represents an all-maturities index. This differs from Dimson, Marsh, and Staunton (2002), who document a GDP-weighted long-term government bonds index. Although their focus on long-term bonds enables a clear comparison of bond returns by country, it is less useful for representing the performance of the global government bonds asset class in this study.[4] Finally, return series on more recent asset classes add to the breadth of this study as they are not present in the other studies. These are private equity, high-yield bonds, leveraged loans, inflation-linked bonds, and emerging market debt.

In addition to the unique features described above, our returns have a distinct advantage over those reported on *wealth* portfolios. The returns of our market portfolio are based on actual returns observed in financial markets.[5] They are not affected by return measurement problems that characterize return estimates for real estate, like determining rental yields net of maintenance, depreciation, and defaults, as described in, for example, Chambers, Spaenjers, and Steiner (2019). Ibbotson, Siegel, and Love (1985) and Jordà et al. (2019) do not use financial market returns for real estate. As their wealth

[3] Kuvshinov (2018) uses equity and housing data from Jordà et al. (2019) and adds corporate bond returns for sixteen countries with start dates ranging from as early as 1870 to 1975, and end dates vary from 1988 to 2016. The study reports the average real and excess returns across countries for corporate bonds in local currencies. But an aggregated market-capitalization-weighted international return time series is not available.

[4] Using market cap weights causes lower-quality credits to be more heavily represented because of the "bums problem" described in Siegel (2003).

[5] We base our real estate returns from the period 1960–1971 on a combination of returns in financial markets and on intrinsic values, as we describe in Appendix A. Afterward, we only use returns in financial markets. Because of the limited weight of real estate in the invested market portfolio, this has no significant effect on the reported returns of the market portfolio.

portfolios are heavily tilted toward real estate, the aggregate returns they report are surrounded by more uncertainty than the returns we report.[6] Our use of financial market returns across all asset categories also likely allows for a better comparison of standard deviations and correlation coefficients. Moreover, in asset pricing we are often interested in the covariance of the return of an asset with the return of the market portfolio to determine its systematic risk and associated expected return. A market portfolio dominated by appraisal-based or, even, transactions-based housing values might lead to underestimation of an asset's systematic risk by up to one-half (see Geltner 1993).

This study on the returns of the market portfolio is important for at least three reasons. First, the market portfolio is relevant for studying financial markets, in the sense that the market portfolio reflects the entire opportunity set of investors. It is an arithmetic fact that the average investor must hold the market portfolio. As Cochrane (2011, p. 1081) says, "but *the average investor must hold the market portfolio*. We cannot all time the market, we cannot all buy value, and we cannot all be smarter than average. We cannot even all rebalance." One could add that the average investor cannot even reinvest dividends or interest payments.[7] Sharpe (2010) advocates that the market portfolio can be used as a starting point or benchmark for portfolio construction. The market portfolio is the only macro-consistent benchmark and reflects the return of the average dollar invested in publicly available assets at any point in time. For example, it takes into account that on average investors allocated 10% of their portfolio to commodities at the end of 1979 and more than 60% to equities at the end of 1999. This study provides a new historical insight into the actual returns of the average investor, as no index provider offers a global multiasset market index, let alone one with a history back to 1960. Our effort is an attempt to satisfy the need of researchers and investors whom otherwise would be deprived of a comprehensive return series.

Second, the market portfolio matters for asset pricing. Sharpe's (1964) capital asset pricing model (CAPM) specifies that, under certain conditions, the set of ex ante optimal portfolios consists of the market portfolio, in which all risky assets are weighted according to their market capitalization, plus long or short positions in the riskless asset. Although the true market portfolio is unobservable

[6] To illustrate, Chambers, Spaenjers, and Steiner (2019), studying realized income, expenses, and transactions in the U.K. residential market, find an average net income yield of 2.8% for the period 1901–1970, whereas Jordà et al. (2019) estimate an average yield of 4.2% for that same period. Eichholtz, Lindenthal, and Korevaar (2019), documenting actual rents and housing quality in seven cities over a 500-year period, remark that Jordà et al. (2019) often do not control for housing quality. The results of Eichholtz, Lindenthal, and Korevaar (2019) underscore the importance of quality controls when constructing indices of housing rents. Without controlling for quality improvements, their indices would have overstated rental growth manifold.

[7] In this study, we use total returns that include reinvestments of dividends and coupons. Returns without reinvestment are not available for most asset classes for a large part of the sample period. The use of total returns slightly overestimates the true returns of the market portfolio that should not include these reinvestments. However, the quantitative effect is marginal. If we assume that the payout yield of the global market portfolio is 4%, on average paid out in the middle of the year, and using our estimated excess return of 3.39% per year, the return contribution of the reinvestments would be approximately 4% x 0.5 x 3.39% = 0.07%.

because it contains all assets that economic agents hold, including assets such as human capital and art, the return of our market portfolio reflects the return on basically all assets held by *financial investors* around the world. Hence, we report returns of their investable universe. Roll (1977) argues that the inability to observe the market portfolio hinders tests of the CAPM. Stambaugh (1982) navigates this obstacle with a test that includes bonds, residential real estate, and durables, and finds that the inclusion of the assets has limited impact. However, extending the market portfolio seems to affect conclusions in certain asset pricing applications. For example, Baltussen, Post, and Van Vliet (2012) indicate that the value premium is substantially lower once the market portfolio contains bonds, in addition to the conventional stock market portfolio. Moreover, Kamara and Young (2018) use the returns on our invested global multiasset market portfolio in estimating the cost of equity and show that it lowers the outcome compared with a less comprehensive proxy for the return of the market. Jagannathan and Wang (1996) reveal the added value of including a proxy for nontradable human capital in the U.S. market portfolio. Jordà et al. (2019) and Jordà, Schularick, and Taylor (2019) include housing in addition to equities and government bonds, but they do not provide a global multiasset return time series that can be used by others, for example, to calculate market betas.

Third, our study contributes to the inequality debate in economics that has gained traction following Piketty (2014). An important and highly debated number is the return on capital. The average return of our market-capitalization-weighted invested global multiasset market portfolio is an estimate for the return that financial investors have achieved since 1960.

This study on the returns of the market portfolio offers opportunities for several additional applications or analyses. We include an overview of correlations between asset categories and show conditional analyses on the returns during recessionary and expansionary periods and inflationary and disinflationary periods. Understanding asset returns during these economic situations has attracted a wealth of research interest (see, e.g., Lustig and Verdelhan 2012 on stock returns during recessions and expansions and Gultekin 1983 for a multicountry study on the effect of inflation on stock returns). Our results can also lead to macro-consistent forecasts, as advocated by Singer and Terhaar (1997). They apply a theoretical framework to develop consistent long-term forecasts for the aggregated capital market.

Our main findings can be summarized as follows. The global market portfolio realizes an average compounded real return of 4.45%, with a standard deviation of annual returns of 11.2% from 1960 until 2017, gross of trading costs, taxes, and/or management fees. The arithmetic average real return of the market portfolio is 5.05%. Our compounded return broadly matches the values from Piketty (2014), but the numbers are not that easy to compare, because, apart from other methodological differences, the author defines capital as household wealth and uses national account data for calculating returns. Regarding conditional returns, it appears that the average annual real return of the market portfolio in expansions is a statistically significant 9.68 percentage points higher than the return in recessions. In the inflationary period from 1960 to 1979, the average real return is 2.77 percentage points below the return in the disinflationary period from 1980 to 2017, but this gap is statistically insignificant. The reward for the market portfolio is a compounded return of 3.39 percentage points above the riskless rate.

1. Measuring Returns of the Invested Market Portfolio

1.1. Measuring returns

We define the market portfolio as all assets held by financial investors around the globe. We distinguish ten asset classes that we aggregate to five asset categories. The asset category *equities broad* contains the asset classes equities and private equity; the asset category *real estate* only includes the asset class real estate; the asset category *nongovernment bonds* contains the asset classes investment-grade credits, high-yield bonds, and leveraged loans; the asset category *government bonds broad* contains the asset classes government bonds, inflation-linked bonds, and emerging market debt; and, finally, the asset category *commodities* reflects the asset class commodities, which is tilted toward physical gold.

Private equity and real estate can be listed (i.e., listed companies whose primary business it is to invest in private equity or real estate) or nonlisted. We assume the quality of the return data of listed assets to be higher, as they are based on transaction prices. Therefore, in this study we also use listed returns as a proxy for unlisted assets. This approach is in line with that of Idzorek, Barad, and Meier (2007, p. 38), who state "although all investors may not yet agree that direct commercial real estate investments and indirect commercial real estate investments (REITs) provide the same risk-reward exposure to commercial real estate, a growing body of research indicates that investment returns from the two markets are either the same or nearly the same."[8] Also, Hoesli and Oikarinen (2011) show that the long-run REIT market performance is much more closely related to the direct real estate market than to the general stock market.

Appendix A outlines that listed returns have been available for private equity since 1994. Before 1994, we do not take private equity *returns* into account in our equities broad index, which implicitly means that we use listed equity returns for private equity. This only has a marginal effect as the weight of private equity in the asset category equities broad amounted to 1.5% at the end of 1993, whereas, back then, it represented 0.8% in the market portfolio. For real estate, we use a combination of listed returns and intrinsic values for the period 1960–1971 and listed returns afterward.

[8] Pagliari, Scherer, and Monopoli (2005) found that, controlling for the difference in leverage, the returns on private real estate and listed real estate do not notably differ. Oikarinen, Hoesli, and Serrano (2011) confirm this finding.

Although Jordà et al. (2019) report housing to be around half of their documented wealth, we do not consider housing to be a separate asset class. For financial investors, housing offers limited availability. For instance, homeownership in the United States averaged 65% in the period 1964–2017, according to data from the U.S. Census Bureau.[9] Next, Piketty and Zucman (2014) state that the household house ownership share in the United Kingdom is 95%, whereas in Germany and France almost all houses are owned by households or nonfinancial corporations. Furthermore, at the end of our sample period, the market value of commercial real estate in both the GPR General World Index and the FTSE NAREIT Equity REITs Index is 7 times the value of residential real estate in these indices (see General Property Research 2018; National Association of Real Estate Investment Trusts 2018, p. 21). Also, for a large part of our sample period, investability is further constrained by the required amount of money to compose a diversified residential real estate portfolio. Residential REITs, or residential investment funds, were not always readily available, particularly in the earlier decades in our sample period. Even today, we are not aware of a single listed fund that offers exposure to the international residential real estate market, let alone a global fund. So, in this study, real estate returns primarily reflect returns for (leveraged) global commercial real estate based on transactions in financial markets, while returns consist of a small part of housing. This reflects the investable real estate universe.

For each asset category, we construct a total return series in U.S. dollars. Figure 1 shows a schematic overview of the return data by asset class for the entire sample period. For the asset classes not part of the market portfolio in 1960, as they appeared afterward, the average weight in the market portfolio at their inception is 0.4%. So this study basically covers the entire invested global market. Appendix A documents in detail how we collected and spliced historical returns data on global asset classes. We also perform robustness checks on our return series, and the Online Appendix reports the results. The robustness checks suggest that our data set of returns is reliable. Even though we find evidence that our data represent good estimates for historical returns, we are aware that some uncertainty surrounds our estimates. Later on, we explicitly discuss the effect of uncertainty in our return series for the returns on the market portfolio. We show that diversification reduces estimation errors at the aggregated level. Appendix B describes the market capitalizations we use to calculate the market-capitalization-weighted returns of the market portfolio.

We exclude hedge funds, investment funds, and other investment products. These vehicles employ active or passive strategies in asset classes that we already cover, so including them would result in double counting. Like Ibbotson and Siegel (1983), we also exclude family or state-owned businesses,

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[9] See table 14 in Historical Tables at https://www.census.gov/housing/hvs/data/histtabs.html. The table contains quarterly data since 1964.

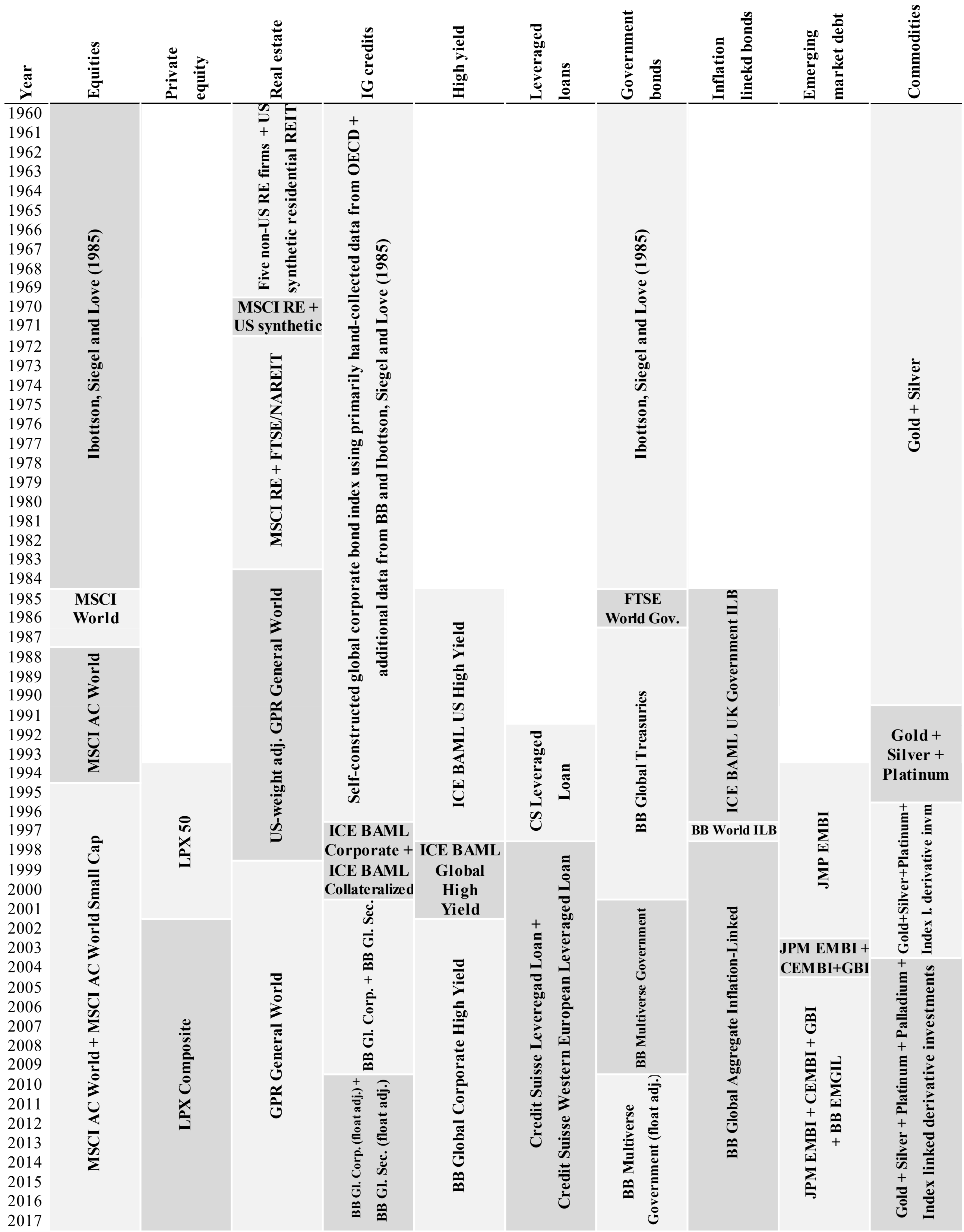

Figure 1
Schematic overview of the return data by asset class

antiques, stamps, art, and human capital, all of which usually belong to owners who do not hold them as a financial investment, and therefore, such investments are not publicly available.

The extent to which an asset class becomes more (or less) investable is endogenous. When risk-sharing benefits are large and agency problems are acceptable, asset classes may appear, increase in size, and become investable to certain types of financial investors. In general, all assets in our invested market portfolio have been investable at every point in our sample period. However, minor exceptions can apply. To illustrate, gold investments were not allowed in the United States until 1974. Also, investability might have been constrained to primarily institutional investors and high net worth individuals in some parts of our sample, with no or limited access for retail investors to some smaller asset classes in the past, for example, private equity in the nineties or real estate in the sixties. We do not report a separate market portfolio for retail investors or different domiciles. However, constraints apply to small weights in the market portfolio and are limited to a part of the investor base. Therefore, they are unlikely to significantly affect our results. Nowadays, all asset classes are available for both institutional and retail investors through active and passive mutual or exchange-traded funds (ETFs).

1.2. Transaction costs

The market portfolio has an average turnover from the annual rebalancing of 3.2%.[10] The turnover is double counted, so it includes buying and selling. If historical trading costs would have amounted to 50 basis points (bps) for a single trip,[11] then the transaction costs for the market portfolio would have been 1.6 bps, that is, 3.2% multiplied by 0.5%. So transaction costs arising from differences in net issuance are marginal. The returns we report are all gross of trading costs, taxes, and/or any management fees.

1.3. Estimation errors and the representativeness of the sample period

Every study that documents or uses historical returns is characterized by some uncertainty surrounding the data series. In the Online Appendix we perform robustness checks on our data. We compare the indices we use to alternative indices, if available. For individual return series, we find that annual compounded returns only show tiny differences, whereas returns for individual years logically differ. However, as we demonstrate, these differences and particularly outliers are mitigated at the aggregated level. Because of diversification, only small differences surface in the multiasset portfolios we compose with our return series and alternative return series. Our analysis suggests that at the aggregate level the estimation error that arises through imperfect returns series might be smaller

[10] Marginal rebalancing for the market portfolio is required because of differences in net issuance of asset categories. Therefore, each year the market portfolio has to be reset at actual portfolio weightings for all asset categories. Turnover concerns switching transactions between all asset categories. Turnover within the indices, also due to differences in issues and redemptions, is excluded because we lack data to calculate it. However, Pederson (2018) estimates turnover within the total U.S. equity market at a single counted 5.3% to 11.8% (depending on the definition of turnover) and 20% on average for all U.S. fixed-income securities as they have a finite maturity compared to equities, which tend to be perpetual.

[11] Obviously, compared to recent transaction costs, this estimate is too conservative. But for the past it is more difficult to determine true transaction costs, because direct and indirect transaction costs (bid-ask spreads) were higher than nowadays. Our transaction costs match the transaction costs that Anderson, Bianchi, and Goldberg (2012) use for the period 1956–1970. For 1971–2010, they use 10 bps. Note that actual trading costs might differ across asset classes.

than 10 bps for the average annual compounded return. Outliers in estimation errors for annual returns might be limited to well within 2 percentage points. Apart from estimation errors during the sample period, every study is also surrounded by uncertainty about the representativeness of the sample period.

The closure of markets and expropriation of assets like in Russia and China did not occur in our sample period for any developed market. Also, our sample does not contain countries with hyperinflation, like what happened in Germany over the period 1921–1923. There has been no global war or depression. Even at the country level, not a single OECD country, with the exception of Finland, experienced a stock market crash with a depression (see Barro and Ursúa 2017, table 2). However, before 1960, disasters *did* affect economies and financial markets. The advantage for our data set is that our returns are measured relatively precisely, as accurate financial asset prices are difficult to obtain during global wars with (temporarily) closed exchanges or during hyperinflation periods that hamper international investments. However, the disadvantage may be that our returns paint a too rosy picture of long-term asset returns. Therefore, we also compare our returns with those reported by others over the period 1900–1959.

As can be derived from Dimson, Marsh, and Staunton (2017), the real return of their market-capitalization-weighted global equity index has been 5.05% in the period 1900–1959 and 5.31% for the period 1960–2016. This is a small difference, but for their GDP-weighted global long government bonds index these values are -0.34% and 4.14%. For a 50/50 equity bond portfolio that is rebalanced every 5 years, the real returns are 2.76% and 5.01%, a 2.24 percentage points gap. Particularly for (long-term) government bonds, returns in our 58-year sample period have been good relative to the 60 years before. So, despite our 58-year-long sample period, some care is still required in generalizing the results of this study. Also, our subsample analyses may not easily be generalized, as our sample only includes seven U.S. recessions (16 years in total) and one inflationary period.

Finally, our data set is unlikely to suffer from a significant survivorship bias as described in Brown, Goetzmann, and Ross (1995). The indices we use or create to compose the asset class return indices intend to include all major index constituents whether or not they survived. Most of the indexes we use are published in real time, with limited or no backfilling. The advantage of using real-time published indexes is that constituent countries and individual assets are known ex ante, eliminating potential survivorship bias in back-tested series for which ex post constituents have to be determined. The chance that a data source excludes a major index constituent is further mitigated by the fact that our sample period does not contain disasters, as we have described above. An index constituent can move to another category, like in the case of Greece, which was moved from developed markets to emerging markets by MSCI in 2013. But Greece remains in our equities broad index, because we include emerging markets.

2. Unconditional Returns in U.S. Dollars

2.1. Nominal returns

Table 1 shows the statistical properties based on the annual returns of the global market portfolio and its five asset categories, from 1960 until 2017. We also include the risk-free return in the table. As we report returns in U.S. dollars, we use 3-month secondary market U.S. Treasury bills from Refinitiv Datastream for the risk-free rate. To convert nominal returns to real returns we use changes in the seasonally adjusted U.S. consumer price index for all urban consumers from the Bureau of Labor Statistics as inflation. This methodology mirrors that of Dimson, Marsh, and Staunton (2002). During our 58-year sample period, the market portfolio delivers a compounded annual return of 8.36%, gross of trading costs, taxes, and/or any management fees. Real estate realizes the highest compounded annual return (10.45%), followed by equities broad (9.76%), nongovernment bonds (7.51%), government bonds broad (6.66%), and commodities (6.03%). An investment in 3-month Treasury bills would have returned 4.80%. Inflation has averaged 3.74% during our sample period. The arithmetic average nominal return for the market portfolio is 8.93%.

The compounded annualized total return of equities broad of 9.76% consists of a compounded capital gain of 6.64% and a compounded dividend return of 2.92%. Obviously, the standard deviation of the annual capital gains of 17.1% is above the standard deviation of dividend returns of 0.9% as dividends tend to change gradually, which dampens changes in dividend yields. During our sample period, the popularity of share buy backs increases as a way to return cash to shareholders. Bagwell and Shoven (1989) show that share buybacks in the United States represent around 10% of the combined cash return through dividends and share buybacks in the period 1977–1983. However, the importance of share buybacks quickly increased to 40% in 1987. Data for the period 1988–2018 from Damodaran (2019) show that since the mid-nineties another jump took place from 50% to 70%. So share buybacks represent a larger amount than dividends in the United States since the mid-nineties. Von Eije and Megginson (2007) show that share buybacks also have surged in the European Union, to over half the value of cash dividends. For real estate, the total return of 10.45% comes from a capital gain of 5.94% and a dividend return of 4.26%. The standard deviations for capital gains and dividend returns are 19.2% and 1.1%. For real estate, at the aggregated level, share buybacks play a smaller role in returning cash to shareholders because of the legislative considerations associated with REITs (see data from Boudry 2011).

The global return premium of real estate versus equities broad is 0.69 percentage points, or a geometric 0.63 percentage points, but is statistically insignificant. If we focus on the United States, the return on real estate also has been higher than for equities. The geometric return difference

Table 1
Statistical properties for unconditional annual returns (US$, 1960–2017)

	GMP	EB	RE	NGB	GBB	COM	TB[a]
A. Unconditional returns							
Compounded average nominal return (%)	8.36	9.76	10.45	7.51	6.66	6.03	4.80
Compounded average excess return (%)	3.39	4.73	5.39	2.59	1.77	1.18	–
Compounded average real return (%)	4.45	5.80	6.46	3.63	2.81	2.21	1.02
Arithmetic average nominal return (%)	8.93	11.28	12.31	7.79	6.89	8.75	4.85
Arithmetic average excess return (%)	3.98	6.24	7.22	2.89	2.01	3.74	–
Arithmetic average real return (%)	5.05	7.34	8.26	3.96	3.06	4.53	1.04
B. Distribution of unconditional real returns							
Standard deviation (%)[b]	11.2	17.3	19.3	8.4	7.3	24.9	2.3
Minimum annual return (%)	-24.2	-43.4	-41.8	-14.0	-9.9	-39.2	-3.4
Maximum annual return (%)	33.1	41.1	56.3	32.8	22.6	134.3	7.2
# years with return < 0%	15	16	18	15	18	30	20
Longest-period cumulative R < 0%	12	10	7	6	6	38	9
Sharpe ratio	0.36	0.37	0.37	0.36	0.28	0.13	–
Skewness	-0.36	-0.67	-0.09	0.84	0.53	2.66	0.42
Kurtosis	0.74	0.51	0.54	2.55	0.26	12.43	0.07
p-value normal distribution (JB)	.278	.085	.674	.000	.243	.000	.427

[a]Global market portfolio (GMP), equities broad (EB), real estate (RE), nongovernment bonds (NGB), government bonds broad (GBB), commodities (COM), and 3-month Treasury bills (TB).
[b]We likely slightly underestimate the standard deviation of real estate, because, in our return calculation, we partly use intrinsic values instead of returns only based on market prices from 1960 to 1971.

between the FTSE/NAREIT Equity REIT Index and the S&P 500 is 1.14 percentage points from its inception at year-end 1971 to 2017 and is again statistically insignificant. For this period, the global difference is 0.19 percentage points at the asset class level. The excess return of real estate over equities might be partially attributable to the premium for small cap value stocks (see Anderson et al. 2005). Compared to Jordà et al. (2019), our average compounded nominal return for real estate of 10.54% seems not far off their post-1950 period average geometric return in U.S. dollars of 11.70% when equally weighting the sixteen countries in their sample (see their table A.14). However, a fair comparison is impossible as we report *levered* returns on primarily commercial real estate, whereas they present *unlevered* returns on housing. In addition, we use market capitalization weighting instead of equal weighting. For the post-1950 period, they provide a GDP-weighted average of 6.40% for housing, but this is an arithmetic average of real returns in local currencies, not in nominal U.S. dollars (see their table VII).

2.2. Excess returns

The data offer the opportunity to compare the return of the average investment portfolio to the risk-free asset. The compounded return for the market portfolio is 3.39 percentage points above the riskless rate, as shown in panel A from Table 1.[12] The equity (real estate) return is 4.96 (5.65) percentage points above cash, and the multiplicative premium is 4.73 (5.39) percentage points.

The market portfolio experienced three drawdowns in excess of 20% relative to savers: 32% in 1974, 26% in 2002, and 25% in 2008 (not in the table). The longest period that the cumulative return of the market portfolio lagged the risk-free investment is 6 years, from 1973 to 1978. In 17 of the 58 years (29.3% of all annual observations), the market portfolio ends with a lower return than the riskless rate, and, for the remaining 41 years, the return of the market portfolio ends above the riskless rate. The drawdowns are small and short lived compared to U.S. equities in Fama and French (2018). For example, they report negative excess returns after a 1-year period in 36.0% of their simulations, whereas this is 23.4%, 15.6%, and 4.1% for 5-, 10-, and 30-year periods, respectively. Beyond a 6-year period, the market portfolio has not experienced negative excess returns. Obviously, this is due to diversification across asset classes and countries.

2.3. Real returns

Real returns are useful as they provide insight into the development of purchasing power through time. Therefore, we adjust our nominal returns in U.S. dollars for consumer price inflation in the United States, as we indicated before. Figure 2 shows the cumulative real return of the market portfolio and the five asset categories. The real value of the market portfolio grows from 100 at the end of 1959 to 1,246 at year-end 2017. This growth implies a compounded annual real return of 4.45%. Real estate reaches a value of 3,775 (6.46%), followed by equities broad with 2,630 (5.80%), nongovernment bonds with 792 (3.63%), government bonds broad with 499 (2.81%), and commodities with 355 (2.21%). The risk-free asset grows to 180 and delivers a compounded annual return of 1.02%.

The arithmetic average real return of the market portfolio of 5.19% for the period 1960–2010 is somewhat above the global value from Piketty (2014) of 4.4%. He estimates a return on capital of 5.0% for France and 3.9% for the United Kingdom for the period 1960–2010 and labels the combination of these series global.[13] Our compounded return of 4.53% for that period might be a better measure for a comparison to Piketty's 4.4%, because his returns are rather stable. Piketty's

[12] We use geometric return calculations for real and excess returns in the table.

[13] We derive these values from the technical appendix to Piketty (2014); it is available on his Web site (http://piketty.pse.ens.fr/en/capital21c2). We used the data files belonging to chapter six (sheet TS6.1 and TS6.2). We calculate the global number ourselves as their graph (i.e., figure 10.9) is labeled globally, but, by accident, it actually is based on a French data series, a fact that Piketty confirmed to us by e-mail.

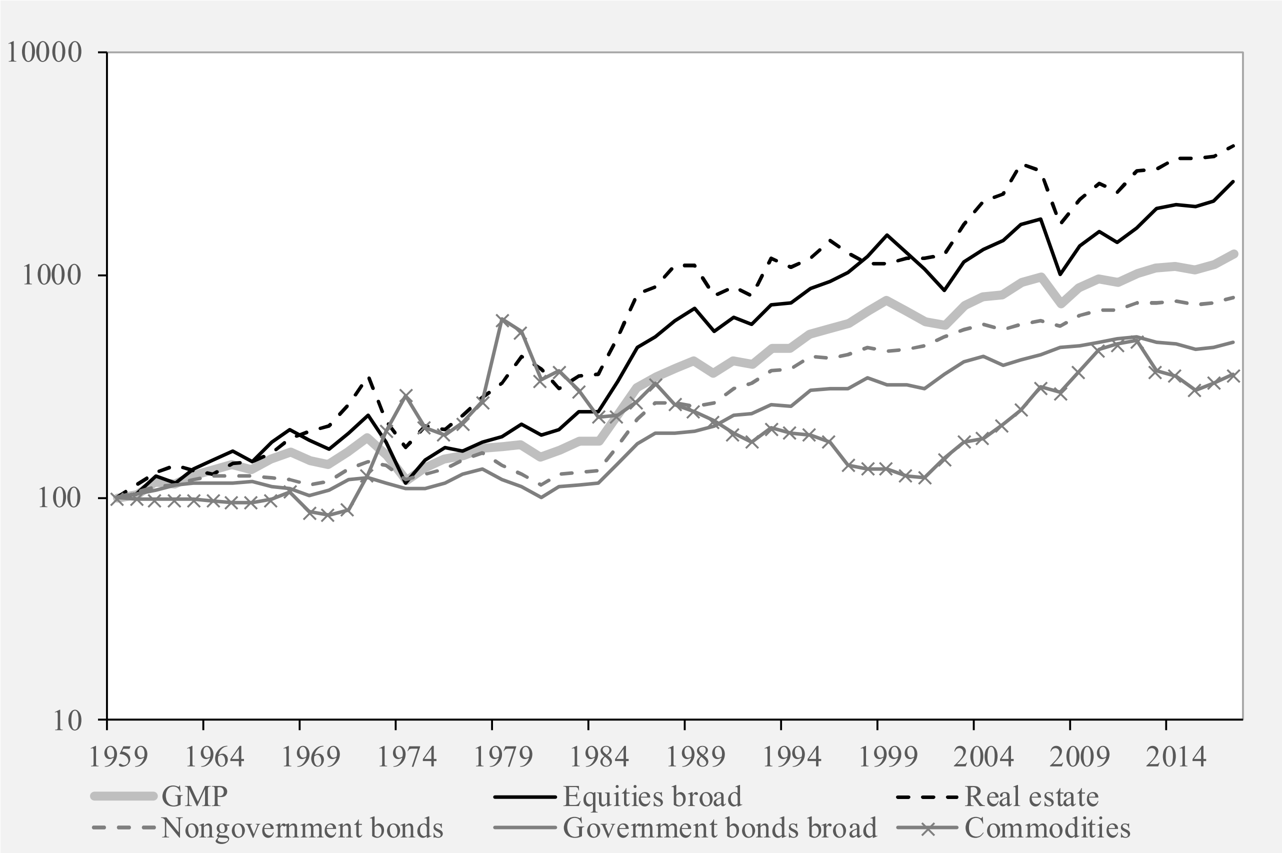

Figure 2
Cumulative real return index of the global market portfolio and the five asset categories (1959–2017)

returns are not truly global, are in local currency, and likely have lower standard deviations (unreported). Next, the returns are not easy to compare for three additional reasons. First, Piketty (2014) defines capital as household wealth and derives his return values from macroeconomic data by dividing the total of various kinds of capital income by the aggregate stock of capital. Second, Bonnet et al. (2014) argue that Piketty's return is mainly driven by rising housing prices, whereas housing has just a marginal weight in our invested market portfolio. Third, researchers have been debating whether the equities part of the market portfolio fully benefits from economic growth. Bernstein and Arnott (2003, 2017) claim that a significant part of economic growth results from "entrepreneurial capitalism." New enterprises create a dilution effect that causes earnings and dividends from existing companies to grow slower than the economy. However, Straehl and Ibbotson (2017a, 2017b) find that aggregate total payouts (dividends and buybacks) grow in line with GDP.

Jordà et al. (2019) report a GDP-weighted, cross-sample arithmetic average real return on capital for their sixteen countries of 6.01% in local currencies for the 1950–2015 subperiod. The separate value for equities is 8.19%, for housing 6.40%, for bonds 2.70%, and for bills 1.23%. An estimate for the arithmetic average real return on our invested market portfolio for 1950–2015 would be roughly 5.5%

in U.S. dollars.[14] Although they do not compose a global wealth portfolio, they do provide equally weighted (across countries) U.S. dollar geometric real returns for the period 1950–2015 in their table A.14, with 3.23% for bonds, 6.50% for equities, and 8.04% for housing. An estimate for the compounded average return for our invested market portfolio over that period would be roughly 5.2%. Given the fact that housing constitutes approximately half of their wealth portfolio and the high returns they report for housing, the (unreported) market-value-weighted return on capital of global wealth likely would have been above the return of our invested market portfolio. The results of Jordà et al. (2019) may not be confused with the return and risk characteristics of the invested market portfolio. They provide valuable insights into the return on aggregate wealth, an important matter from the macroeconomic point of view. Our market portfolio is relevant for studying financial markets in the sense that the invested market portfolio reflects the return of investments available for financial investors.

Figure 2 shows that the real return for the market portfolio is relatively low, although positive, in the first part of the period studied. Table 2 shows the compounded real returns over several periods. The returns shown on the diagonal are decade-by-decade returns. The eighties and nineties obviously produced higher returns than did other decades for the market portfolio, equities broad, nongovernment bonds, and government bonds broad. For instance, the market portfolio yields a real return in the eighties and nineties of 9.17% and 6.48%, respectively, whereas the other four decades delivered, in chronological order, 3.78%, 1.65%, and 1.29%. For the last 8 years of our sample period, the market portfolio returned on average 4.55% per year. However, for commodities, the eighties and nineties are the worst decades, whereas for real estate the eighties are the best decade and the nineties the worst decade. Table 2 also shows that most calendar decades in our sample period have not experienced a negative compounded real return for the market portfolio or the asset categories, with the exceptions being equities broad for the 2000–2009 period and commodities, which has three decades of negative real returns.

2.4. Distribution and correlations of annual real returns

Panel B of Table 1 reports that the market portfolio has a standard deviation of real returns of 11.2%. Standard deviations for the asset categories vary from 7.3% for government bonds broad to 24.9% for commodities.[15] In 43 years the market portfolio has a positive real return, leaving 15 years with a negative return. The longest period that the cumulative return from a prior high was negative is 12 years, from 1973 to 1984.

[14] Here, we use a 50/50 equities and government bonds portfolio for the period 1950–1959, with returns from Dimson, Marsh, and Staunton (2017), that we rebalance after 5 years.

[15] Pagliari (2017) notes that the measured volatility of private (unleveraged) real estate as measured by NCREIF Property is only two-thirds of that of public real estate equity as measured by NAREIT Equity over the period 1978–2013. However, Sharpe ratios for annual investment horizons are similar with 0.51 and 0.47.

Table 2
Average compounded real returns by decade (US$, %)

From →: To ↓:	1960	1970	1980	1990	2000	2010
Global market portfolio						
1969	3.78					
1979	2.71	1.65				
1989	4.82	5.34	9.17			
1999	5.23	5.72	7.81	6.48		
2009	4.43	4.59	5.59	3.85	1.29	
2017	4.45	4.59	5.37	4.05	2.73	4.55
Equities broad						
1969	6.07					
1979	3.16	0.33				
1989	6.72	7.05	14.22			
1999	7.03	7.35	11.04	7.94		
2009	5.36	5.18	6.85	3.34	-1.06	
2017	5.80	5.74	7.21	4.82	3.12	8.60
Real estate						
1969	7.08					
1979	6.09	5.10				
1989	8.35	8.98	13.00			
1999	6.22	5.94	6.36	0.11		
2009	6.37	6.19	6.56	3.47	6.95	
2017	6.46	6.33	6.66	4.48	6.99	7.03
Nongovernment bonds						
1969	1.25					
1979	1.64	2.04				
1989	3.21	4.20	6.41			
1999	3.86	4.75	6.13	5.85		
2009	3.85	4.52	5.36	4.83	3.83	
2017	3.63	4.14	4.69	4.09	3.12	2.25
Government bonds broad						
1969	0.23					
1979	0.97	1.72				
1989	2.30	3.35	5.01			
1999	2.97	3.90	5.01	5.00		
2009	3.18	3.94	4.69	4.52	4.04	
2017	2.81	3.35	3.79	3.36	2.45	0.49
Commodities						
1969	-1.46					
1979	9.65	22.02				
1989	3.01	5.32	-9.11			
1999	0.76	1.51	-7.41	-5.69		
2009	2.64	3.69	-1.79	2.09	10.51	
2017	2.21	2.99	-1.51	1.36	5.50	-0.44

If we adjust the returns for risk using the Sharpe (1994) ratio, the Sharpe ratios appear to be remarkably similar for all but commodities. The skewness of the market portfolio 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 0.74, which means that the distribution of real returns has fatter tails than the normal distribution. However, we do not reject the null hypothesis that the annual returns of the market portfolio are normally distributed at a significance level of 5%, using the Jarque and Bera (1987) test.

Table 3, panel A, shows the correlation matrix for real returns. Equities broad's returns have the highest correlation with the returns of the market portfolio, because equities broad has the highest average weight of all asset categories in the market portfolio during the 58-year period and a high volatility compared to other large asset classes. The returns of government bonds broad have a low correlation with those of the market portfolio, equities broad, and real estate. Returns of commodities are uncorrelated to the market portfolio or any of the asset categories.

Table 3, panel B, shows separate correlations for upmarkets (upper-right part of the matrix) and downmarkets (lower-left matrix) of the market portfolio. For return correlations between the market portfolio and equities broad or real estate, correlations appear to be higher in downmarkets. This also applies to the correlations of returns for equities and real estate themselves. This is in line with results reported by Chow et al. (1999) and supports the use of correlation estimates that take downside risk into account for portfolio allocation and risk management as Campbell, Koedijk, and Kofman (2002) argue. Return correlations between the market portfolio and nongovernment bonds or government bonds broad are lower in downmarkets, whereas commodities show primarily negative correlations in downmarkets. The negative correlation between returns on equities broad and government bonds broad in downmarkets illustrates the benefits of diversification.

Figure 3 shows correlations over time for rolling periods of 20 years. Panels A and B show correlations between returns on asset categories and on equities broad or government bonds broad, respectively, the two largest asset categories. For equities broad, the correlation with real estate is relatively high and stable, varying between 0.57 and 0.88. The correlation between government bonds broad and nongovernment bonds fluctuates even less until 2008, when correlation falls during the financial crisis from 0.83 in 2007 to 0.69 in 2009. To illustrate, returns in the United States for the Bloomberg Barclays U.S. Aggregate Corporate Index and for the Bloomberg Barclays U.S. Treasuries Index not only oppose each other in 2008 and 2009 but also differ by -19% and 22%, respectively. At the global level and taking all segments within both asset categories into account, returns still differ by -12% and 11% in these 2 years, undermining the correlation between the asset

Table 3
Correlations of annual real returns (US$, 1960–2017)

	GMP	EB	RE	NB	GBB	COM[a]
A. Unconditional correlations						
Global market portfolio (GMP)	1.00					
Equities broad (EB)	0.95	1.00				
Real estate (RE)	0.76	0.73	1.00			
Nongovernment bonds (NB)	0.71	0.52	0.51	1.00		
Government bonds broad (GBB)	0.52	0.27	0.30	0.87	1.00	
Commodities (COM)	0.03	-0.04	0.09	-0.06	-0.01	1.00
B. Correlations in upmarkets in the upper-right part, downmarkets in the lower-left part						
Global market portfolio (GMP)	1.00	0.87	0.62	0.79	0.70	0.05
Equities broad (EB)	0.90	1.00	0.58	0.48	0.31	-0.07
Real estate (RE)	0.78	0.76	1.00	0.42	0.29	0.20
Nongovernment bonds (NB)	0.67	0.36	0.41	1.00	0.90	-0.11
Government bonds broad (GBB)	0.26	-0.15	0.06	0.75	1.00	-0.07
Commodities (COM)	-0.31	-0.46	-0.39	-0.03	0.13	1.00

[a]Global market portfolio (GMP), equities broad (EB), real estate (RE), nongovernment bonds (NGB), government bonds broad (GBB), commodities (COM), and 3-month Treasury bills (TB).

categories. Using twenty observations from 2017, but excluding 2008 and 2009, leads to a correlation of 0.86, which would be basically the same as the first observation in 1979 of 0.89.

Panel A also shows that the correlation between equities broad and government bonds broad drops to 0.13 in 2006, with a further decline afterward. This suggests a shift from a mildly positive correlation to an uncorrelated return series (see Campbell, Sundaram, and Viceira 2017 for similar evidence on the U.S.-only case). Possibly, interest rates have declined below levels at which they spur equities. Panel B shows a similar pattern also applies to the correlation between real estate and government bonds broad.

Commodities have shown negative correlation to equities broad and government bonds broad up to the mid-nineties, mostly because of extraordinary returns in the seventies, in particular 1979. That is the reason correlation jumps in 1999, when the 1979 observation is lost in our 20-year rolling window. Afterward, commodities and equities broad or government bond broad are mildly positively correlated.

Figure 3, panels C and D, show the correlation between the market portfolio and the asset categories on the one side and inflation or real economic growth on the other side. As we measure returns in

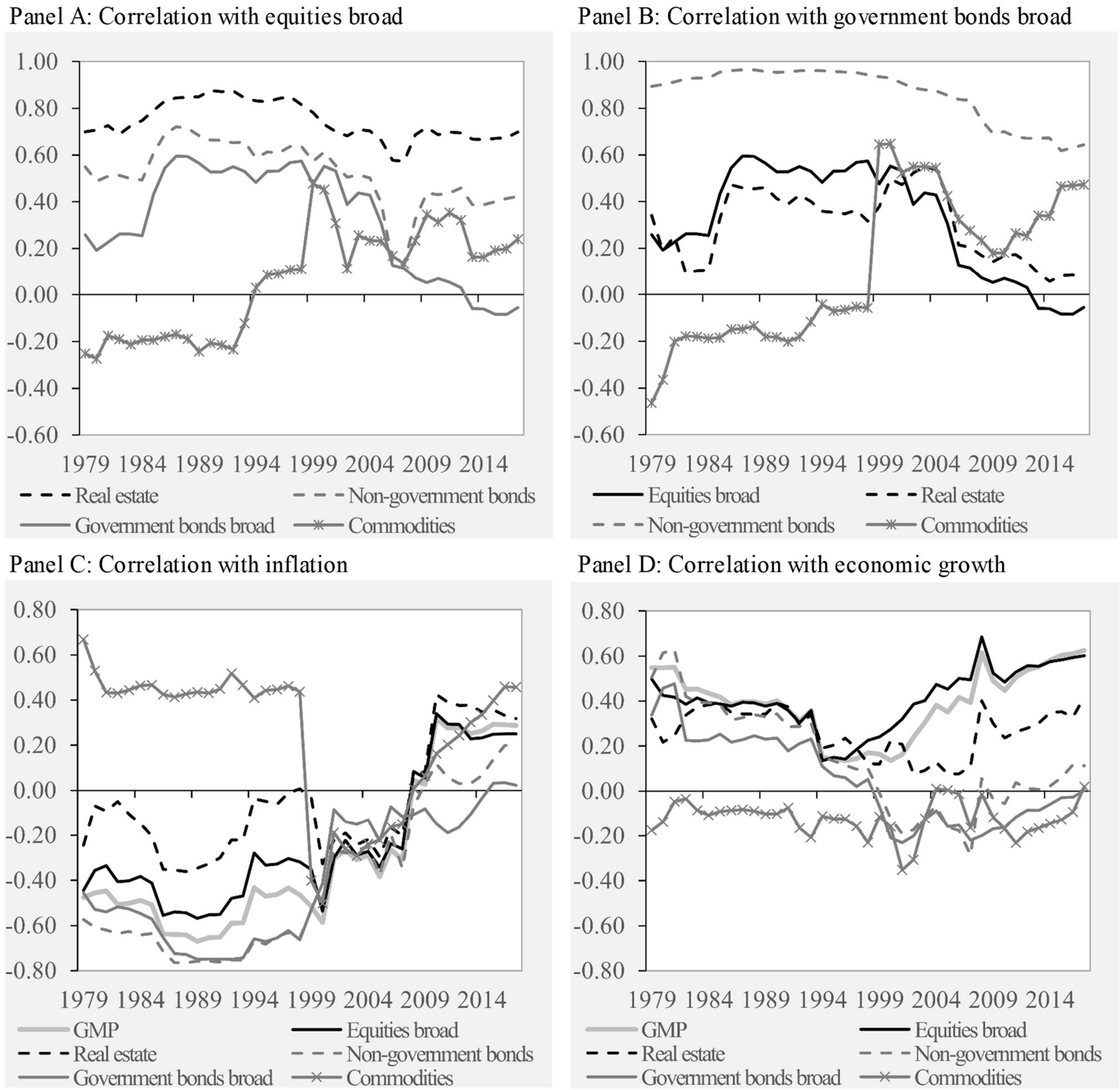

Figure 3
Correlations for rolling periods of 20 years

U.S. dollars, we use U.S. inflation and U.S. economic growth.[16] Until 1999, there is a negative correlation with inflation, except for commodities, which show a positive correlation, whereas real estate is hardly (negatively) correlated with inflation. After 1999, correlations are closer to zero. At the end of our sample period, government bonds broad are uncorrelated with inflation, whereas all other asset categories show a low positive correlation with inflation.

During the whole sample period, the market portfolio itself, equities broad, and real estate have a positive correlation with economic growth, although this correlation is marginal in some years (see panel D). Initially, nongovernment bonds and government bonds broad also have a positive

[16] We use data from FRED for real economic growth in the United States (data code GDPC1).

correlation with economic growth, which gradually decreases to become basically uncorrelated since the mid-nineties. The correlation between commodities and economic growth is a bit negative or close to zero throughout the entire sample period.

2.5. Base currency effects

We have examined the performance of the market portfolio and the five asset categories in nine other major currencies.[17] Doing so illuminates which descriptive statistics seem to be general or currency specific. During our sample period, the U.S. dollar weakens more (or does not gain enough) versus other currencies than inflation differences warrant, except for the Canadian dollar. This currency movement generates a positive effect on the real return measured in U.S. dollars. Hence, real returns for 8 of the 9 other currencies we consider are below the return in U.S. dollars. The compounded average annual real return on the market portfolio is lowest when measured in yen (2.87%) and highest in Canadian dollars (4.93%), compared with 4.45% in U.S. dollars.

Regarding volatility, the base currency hardly appears to affect the standard deviation of the more volatile asset categories: equities broad, real estate, and commodities are on average 1.2, 0.1, and 0.4 percentage points, respectively, above the standard deviation of U.S. dollar returns, which varies from 17.3 for equities to 24.9 for commodities. Adding currency volatility to asset categories with already high volatility has virtually no effect. However, for nongovernment bonds and government bonds broad, the standard deviations are on average 2.4 and 3.1 percentage points, respectively, higher than the standard deviation of 8.4% and 7.3% for U.S. dollar returns. The United States has a large weight in the data series. Adding currency volatility to the relatively stable returns from U.S. fixed income matters. So measuring returns in currencies other than the U.S. dollar hardly affects the volatility of already highly volatile asset classes, but noticeably increases the volatility for fixed income assets.

3. Conditional Real Returns

Table 4 shows that the average return in downmarkets is -9.65%. This is 10.18% in upmarkets. Table 4 also reports data for which we split the sample into recessions and expansions, based on NBER data. Here, we assign a recession label to years with at least one quarter in an official NBER recession. The annual real return difference for the market portfolio between expansionary and recessionary periods is 9.68%, which is statistically significant (p-value of .002, not in the table). The KS test

[17] These additional currencies are the Australian dollar, Canadian dollar, European euro, Japanese yen, New Zealand dollar, Norwegian krone, Swedish krona, Swiss franc, and the Great British pound sterling.

Table 4
Statistical properties for conditional annual real returns (US$, 1960–2017)

	GMP	EB	RE	NGB	GBB	COM	TB[a]
Avg. return when R(GMP) < 0% (%)	-9.65	-16.36	-8.69	-0.88	0.60	1.43	0.67
Avg. return when R(GMP) > 0% (%)	10.18	15.60	14.17	5.64	3.92	5.61	1.17
Avg. return in recessions (%)	-1.96	-2.31	-2.00	1.55	1.39	1.82	1.12
Avg. return in expansions (%)	7.72	11.01	12.17	4.87	3.70	5.56	1.01
p-value same distribution recession regime (KS)	.026	.032	.057	.379	.503	.264	.951
Avg. return inflationary period (%)	3.24	4.53	7.51	1.88	1.12	13.58	0.42
Avg. return disinflationary period (%)	6.01	8.81	8.65	5.05	4.08	-0.24	1.37
p-value same distribution inflationary period (KS)	.637	.917	.785	.522	.169	.102	.038

The Kolmogorov (1941)-Smirnov (1939) (KS) test compares two empirical return distributions with the null hypothesis that both return distributions are the same. The test statistic is based on the maximum distance between the two cumulative return distributions.

[a]Global market portfolio (GMP), equities broad (EB), real estate (RE), nongovernment bonds (NGB), government bonds broad (GBB), commodities (COM), and 3-month Treasury bills (TB).

suggests that the return distributions for the market portfolio are statistically significantly different for expansions and recessions, as the *p*-value is .026.[18] In periods of recession, equities broad and real estate return less than the market portfolio, but the opposite is true in expansions, when the return is more.[19] These findings are consistent with the correlations analysis in Section 2.4.

We also determine an inflationary environment, namely, the period 1960–1979 when inflation was in an uptrend. The period from 1980 onward has been a disinflationary environment. In the inflationary period from 1960 to 1979, the average annual real return of the market portfolio was 3.24% (when compounded, this value is 2.71%; not reported in the table), whereas in the disinflationary period from 1980 to 2017, the market portfolio had an average return of 6.01% (compounded 5.37%). But the gap of 2.77 percentage points is insignificant (*p*-value of .374; not in the table). Also, contrary to the difference of return distributions during recessionary and expansionary periods, the KS test (*p*-value .637) indicates that the real return distribution of the market portfolio during inflationary periods is not statistically different from the distribution in disinflationary periods.

[18] The Kolmogorov (1941)-Smirnov (1939) (KS) test compares two empirical return distributions and rejects the null hypothesis that both return distributions are the same. The test statistic is based on the maximum distance between the two cumulative return distributions.

[19] Here, this finding appears to be opposite of that of Lustig and Verdelhan (2012) at first sight. However, they report high (low) excess equity returns at monthly and quarterly frequencies after an economic trough (peak). Compared to their study, one could regard our results as returns around a recession, as we use annual returns and assign every year with one or more quarters in a recession to the subsample with recessions. Next, we use global returns contrary to domestic returns. So these results are sensitive to data, definitions, and methodology.

4. Composition and the Annual Returns of the Market Portfolio

Table 5 provides an overview of the market capitalization and the composition of the invested global market portfolio, as well as the nominal, real, and excess returns of the market portfolio for each year in our sample period 1959–2017. The market capitalization of the market portfolio amounted to US$126 trillion at year-end 2017. The average weight in the market portfolio is 50.8% for equities broad, 3.3% for real estate, 15.1% for nongovernment bonds, 28.6% for government bonds broad, and 2.2% for commodities. We remark that the weight of commodities in the market portfolio varies a lot with a low of 0.5% in 2000 and a high of 9.7% in 1979.

5. Conclusion

This study documents an annual return index of the invested global multiasset market portfolio since 1960. Returns on the invested market portfolio are relevant for studying financial markets in the sense that the invested market portfolio reflects the opportunity set for all financial investors. Our returns can be used as a proxy for the returns of the market portfolio in asset pricing or corporate finance studies. We contribute to the current inequality debate in financial economics by estimating the return on capital of investors. As previous research does not provide a global multiasset return time series with such a long history, this study is a major contribution to the literature.

We construct a new and unique data set that contains market-capitalization-weighted return series for ten different asset classes that we aggregate into the five asset categories: equities, real estate, nongovernment bonds, government bonds broad, and commodities. This data set basically covers the whole invested market since 1960 and is unmatched in its breadth of asset classes. We use market-capitalization-weighted return indices that are unrivaled for several asset classes. For the first time, we combine the return indices into a market-capitalization-weighted return index of the invested market portfolio. The returns of our market portfolio are based on actual returns observed in financial markets and, therefore, are not affected by return measurement problems typical to nonlisted assets. All robustness checks that we perform suggest that our data set of returns is reliable.

We report an average compounded real return for the invested market portfolio of 4.45%, with a standard deviation of 11.2% from 1960 until 2017. We document the time variation in correlations between returns on asset categories and correlations between returns and economic growth or inflation. Finally, the annual real return for the market portfolio is a statistically significant 9.68%, a value that is higher during expansionary than during recessionary periods. There is no significant difference between returns in the inflationary period from 1960 to 1979 and the disinflationary period from 1980 to 2017. We make the resultant return time series of our invested market portfolio publicly available. Hereby, researchers can use the annual return series for purposes of their own interest.

Table 5
End-of-year market capitalization, composition, and returns of the global market portfolio (% US$, 1959–2017)

Year	Market value (US$ tn)	Composition: Equities Broad	Real Estate	Nongovernment Bonds	Government Bonds Broad	Commodities	Returns: Nominal return	Real return	Excess return
1959	0.7	50.9	1.3	17.3	29.0	1.5			
1960	0.7	49.2	1.3	17.4	30.7	1.3	5.3	3.8	2.2
1961	0.8	53.5	1.2	15.3	28.8	1.2	14.0	13.2	11.3
1962	0.8	50.2	1.4	16.6	30.5	1.3	-0.9	-2.1	-3.6
1963	0.8	53.5	1.4	16.0	27.9	1.2	10.7	8.9	7.2
1964	0.9	56.0	1.4	15.1	26.3	1.2	7.9	6.6	4.1
1965	0.9	58.2	1.4	14.2	25.0	1.2	7.9	5.9	3.7
1966	0.9	56.5	1.7	14.6	25.9	1.4	-3.0	-6.2	-7.7
1967	1.0	61.1	1.6	12.9	23.0	1.4	15.1	11.4	10.2
1968	1.1	63.4	1.6	12.3	21.1	1.6	13.6	8.5	7.6
1969	1.1	62.9	1.9	12.4	21.2	1.5	-4.4	-9.7	-10.6
1970	1.1	60.5	2.1	13.2	22.8	1.5	2.1	-3.3	-4.3
1971	1.3	59.6	1.9	14.2	22.9	1.4	19.2	15.5	14.1
1972	1.6	62.2	1.8	13.5	20.8	1.7	18.1	14.2	13.4
1973	1.6	58.1	2.1	14.5	22.4	3.0	-8.6	-16.1	-14.9
1974	1.4	46.4	2.9	17.0	28.0	5.8	-13.1	-22.4	-19.7
1975	1.6	48.8	2.5	17.2	27.5	3.9	21.7	13.6	14.7
1976	1.9	48.4	2.1	17.2	29.0	3.3	14.0	8.5	8.3
1977	2.2	43.1	2.2	18.2	32.9	3.6	10.8	3.9	5.1
1978	2.6	40.9	2.2	17.8	34.9	4.3	17.6	7.9	9.4
1979	3.1	41.4	2.1	14.8	32.1	9.7	16.3	2.7	5.0
1980	3.7	44.7	2.0	13.5	31.4	8.4	14.5	1.9	2.0
1981	3.6	44.2	2.3	13.9	33.7	5.8	-5.3	-13.1	-17.9
1982	4.0	42.9	2.2	14.0	34.8	6.1	13.1	9.0	1.6
1983	4.6	46.4	2.0	12.7	34.2	4.7	12.4	8.3	3.0
1984	4.6	46.6	2.1	12.6	34.9	3.8	4.4	0.3	-5.3
1985	6.2	48.0	2.7	12.3	33.9	3.1	34.5	29.6	24.7
1986	8.2	51.4	3.3	11.3	31.2	2.8	34.6	33.1	26.7
1987	9.0	53.4	3.9	10.5	28.9	3.3	17.2	12.3	10.5
1988	10.6	57.0	5.0	9.5	26.1	2.4	15.3	10.5	7.8
1989	11.9	59.1	4.8	9.1	24.9	2.2	12.1	7.1	3.3
1990	11.2	51.3	4.0	11.4	31.1	2.3	-6.9	-12.4	-13.7
1991	13.4	51.6	3.6	11.8	31.2	1.7	17.5	14.1	11.2
1992	13.7	49.5	3.5	12.4	33.0	1.6	-0.1	-3.0	-3.5
1993	16.7	52.0	4.3	8.7	33.3	1.6	20.5	17.2	16.9
1994	17.7	54.7	4.4	7.5	31.9	1.5	3.2	0.6	-1.1
1995	20.8	55.7	4.0	7.6	31.4	1.3	18.1	15.2	11.7
1996	23.4	56.4	5.2	7.3	30.0	1.1	9.8	6.2	4.4
1997	25.8	59.1	4.8	8.2	27.1	0.8	6.8	5.0	1.4
1998	32.9	56.6	3.8	14.3	24.6	0.7	15.2	13.3	9.7
1999	39.5	62.9	3.2	11.9	21.3	0.6	15.5	12.5	10.2
2000	38.8	59.9	3.3	15.4	20.9	0.5	-7.4	-10.5	-12.7
2001	36.2	54.3	3.7	18.6	22.8	0.6	-8.4	-9.8	-11.5
2002	35.9	44.5	3.9	22.5	28.3	0.8	-2.6	-5.0	-4.2
2003	46.3	47.9	4.3	20.5	26.5	0.8	25.1	22.6	23.9
2004	53.9	48.7	4.7	18.9	27.0	0.7	14.2	10.5	12.6
2005	57.2	51.7	4.9	17.5	25.0	0.9	5.0	1.6	1.7
2006	67.1	52.8	5.9	16.8	23.5	1.0	16.4	13.5	11.0
2007	73.6	52.1	5.4	17.6	23.7	1.2	9.6	5.3	4.8
2008	57.8	39.4	3.4	22.2	33.5	1.5	-24.3	-24.2	-25.3
2009	74.3	41.1	3.9	21.8	31.5	1.7	22.2	18.9	22.0
2010	83.9	41.5	4.2	20.1	32.2	2.0	11.0	9.5	10.9
2011	84.0	38.2	4.4	20.7	34.5	2.3	-0.7	-3.7	-0.8
2012	93.6	38.7	4.9	20.5	33.6	2.3	11.5	9.6	11.4
2013	101.7	43.4	5.2	19.5	30.3	1.6	8.4	6.8	8.4
2014	105.6	42.9	5.8	19.4	30.4	1.5	2.6	1.9	2.5
2015	103.6	42.7	5.9	19.7	30.3	1.4	-2.8	-3.4	-2.8
2016	109.3	42.8	5.7	19.7	30.3	1.5	6.0	3.9	5.6
2017	126.5	44.7	5.7	19.1	29.1	1.5	15.6	13.2	14.5
Average		50.8	3.3	15.1	28.6	2.2	8.9	5.1	4.0

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Appendix A. Data Details of Returns

For each of the five main asset categories in this study, equities broad, real estate, nongovernment bonds, government bonds broad, and commodities, we compose market-capitalization-weighted total return series in U.S. dollars. We expect the series to be representative of the performance of an asset category. The return series for a main asset category is 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 referenced in Appendix B. Below, we discuss these five main asset categories and the ten asset classes involved. As indicated in our main text, we report robustness checks of the return series we use in the Online Appendix.

A.1. Equities Broad

A.1.1. Equities

Period 1995–2017

For the period 1995 to 2017, we use a free float 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 of the MSCI All Countries World Index. Before 1995, we cannot take small caps into account in our return calculations, because a global small cap index is not available. The median weight of small caps is 14% from year-end 1994 through 2017. 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, whereas the average compounded annual performance of 7.9% and 7.7% is very close to each other. Hence, we do not expect the unavailability of global small cap returns before 1995 to significantly affect our return estimate for equities.

Period 1985–1987

For the period 1985 to 1987, we use the return of the MSCI World Index. Hereby, we cannot include emerging markets for this period. This introduces just a minor bias as emerging markets represented 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 Ibbotson, Siegel, and Love (1985). Their universe is larger than for the MSCI World Index with a market capitalization at the end of 1984 of US$3,214 billion versus US$1,765 billion.

Dividend index

We construct a dividend index by dividing the total return index by the price index from the same sources described above. However, Ibbotson, Siegel, and Love (1985) only include total return data. From the robustness check in the Online Appendix, it follows that the total returns of Ibbotson, Siegel, and Love (1985) and Dimson, Marsh, and Staunton (2017) are close to each other. But the dividend data of Dimson, Marsh, and Staunton (2017) are not publicly available. Nevertheless, we are able to construct a global dividend index for the period 1960–1984 by using market capitalizations from Dimson, Marsh, and Staunton (2018b) and dividend yields from Jordà et al. (2019). This methodology implies we consider nine countries, because three other countries displayed in Dimson, Marsh, and Staunton (2018b) have no material weight in the period 1960–1984. Together, these nine countries represent on average 89% of the market capitalization of the global equity index from Dimson, Marsh, and Staunton (2018b) during the 1960–1984 period. Jordà et al. (2019) conclude that equity returns are similar to those of Dimson, Marsh, and Staunton (2017), so using the dividend data of Jordà et al. (2019) should result in a reliable estimate of the global dividend index for the period 1960–1984. However, Jordà et al. (2019) do not cover Canada in their analyses on equity markets, so we use the dividend yield from Global Financial Data for Canada.

We combine the dividend index of equities with the dividend index of private equity to derive a market-capitalization-weighted dividend index of the asset category equities broad.

A.1.2. Private equity

Period 2002–2017

We use the LPX Composite from 2002 until 2017 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 Web site of the index provider for more detailed information.[20]

Period 1994–2001

For the period 1994 until 2001, we use the LPX50. The LPX50 is a global equity index that covers the fifty largest listed private equity companies, which fulfill certain liquidity constraints. 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. Before 1994, we do not take the performance of the asset class private equity into account in the asset category equities broad, because historical data on returns are unavailable. This means we suppose returns of private equity to follow those of equities for the period 1960–1993. In case our return estimates would deviate from the true but unknown private equity returns over this period, this would have a minor influence

[20] http://www.lpx-group.com/lpx/home.html

on the returns of the asset category, as the weight in equities broad amounted to 1.5% at the end of 1993, whereas back then private equity represented 0.8% of the invested market portfolio.

Dividend index

We construct a dividend index by dividing the total return index by the price index from the same sources described above. We combine the dividend index of private equity with the dividend index of equities to derive a market-capitalization-weighted dividend index of the asset category equities broad.

A.2. Real Estate

Period 1999–2017

From 1999, we use listed returns from the GPR General World Index from Global Property Research. This index has the broadest market coverage that we have been able to find. As an illustration, at the end of 1983, the market capitalization of the GPR General World Index amounted US$26.1 billion, whereas the MSCI Real Estate Index reached US$17.2 billion.[21] The market capitalization of the GPR General World Index was US$2,032 billion at the end of 2017. 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 US$1,676 billion and the S&P Global Real Estate Investment Trusts Index with a market capitalization of US$1,310 billion at the end of 2017.

Period 1984–1998

The GPR General World Index has an inception date of December 31, 1983. However, we use an adjusted GPR General World Index for the period 1984–1998 to raise the U.S. weight in the index for that period. Figure A1 shows that the U.S. weight in the index jumps in 1997 from 15.5% to 40.3% in just 14 months. Regulatory changes in 1993 boosted the presence of REITs (see Feng, McKay Price, and Sirmans 2011), which subsequently boosted United States's presence in the GPR General World Index a few years later. Although the GPR index may fairly reflect the investment opportunities in *listed* U.S. real estate companies for that period, we use the returns as an estimate for both *listed and unlisted* real estate, for both REITs and other real estate investments. Therefore, we correct the data to ensure the large invested U.S. real estate market is fairly represented in the index.

We bring the 24.8 percentage points jump in index weight backward to year-end 1983, and, subsequently, we let this index addition develop like the original index weight. We phase out our index addition in 1997 and 1998 by correcting for each index addition in the 14-month period that the jump in U.S. index weight takes place. Figure A1 also shows the adjusted weight for the United

[21] 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.

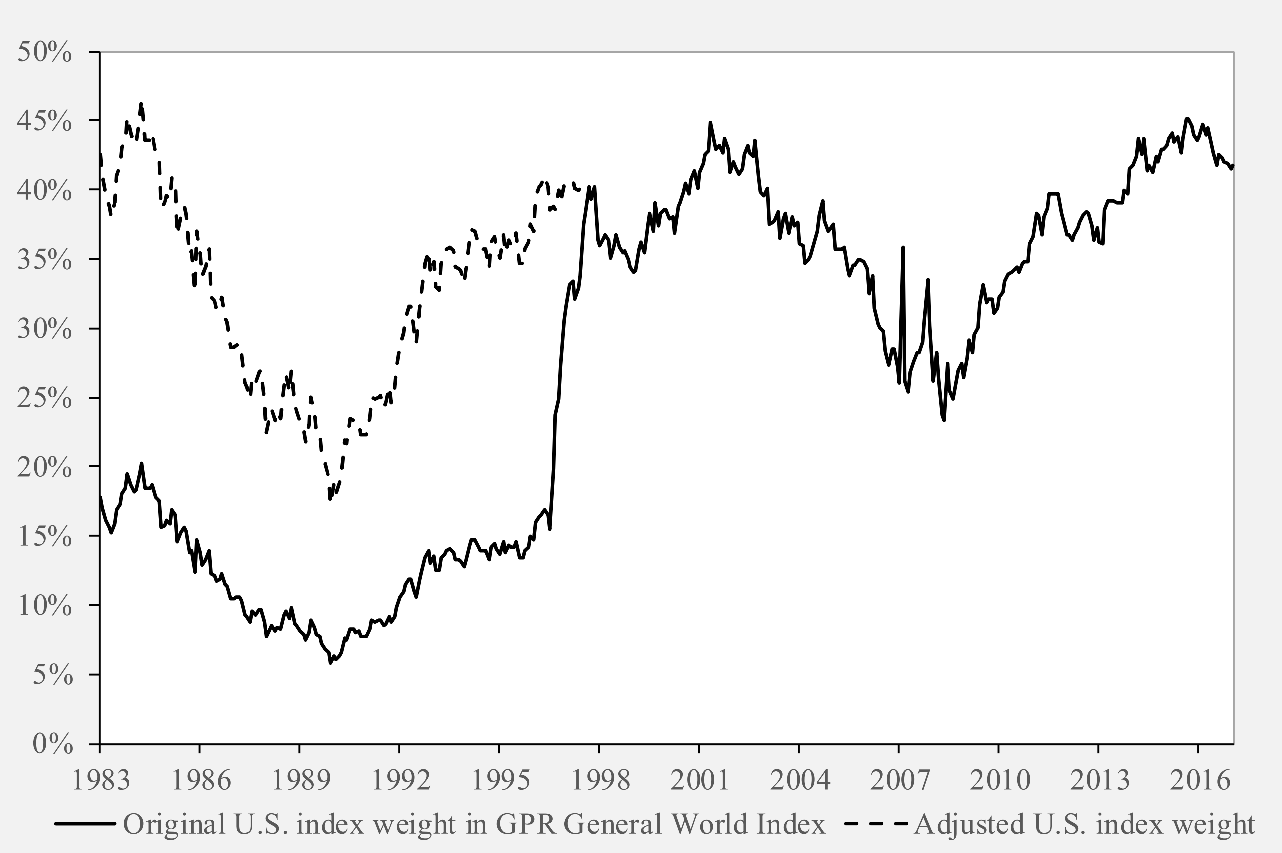

Figure A1
Original U.S. weight in the GPR General World Index and our adjusted U.S. weight

States. The additional index weight for the United States in the period 1983–1998 comes at the expense of both Europe and Asia, proportional to their index weight. We use the adjusted regional weights and the regional total returns in U.S. dollars to calculate the total adjusted returns. The compounded average total return for the adjusted index is 11.64% for the period 1983–1998, whereas it is 11.01% for the actual GPR General World Index. The annualized standard deviations of monthly returns are 15.6% and 17.6%.

Period 1972–1983

For the period 1972–1983, we combine two data series. First, 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 that originates from Capital International Indices. Originally, they focused on composing indices for non-North-American markets. From December 1974 onward, they also include North American companies in their industry indices, but the U.S. weight in their real estate index remained marginal with just one small cap since 1980.[22] The Capital International Real Estate Index is a stock-market-based index, like the FTSE/NAREIT Equity REIT Index.

[22] For more details on the history of Capital International Indices, see Sikorsky (1982).

We compose a global total return real estate index by combining the MSCI Real Estate Index with the FTSE/NAREIT Equity REIT Index for the United States that starts in 1972. We derive the index weights for both series by adjusting the market capitalizations at year-end 1983 by the change in their price indices. Hereby, we arrive at starting weights at year-end 1971 of 56.7% for the MSCI Real Estate Index and 43.3% for the FTSE/NAREIT Equity REIT index.

Period 1970–1971

Before 1972, a data series with real estate returns is not available for the U.S. market. Therefore, we construct a synthetic U.S. residential REIT index as house prices are available for the period before 1972. To the best of our knowledge, data on market prices for commercial real estate were not available back then. Therefore, we use residential data as an estimator for the commercial real estate market.[23] The correlation of monthly returns of the FTSE/NAREIT Equity Residential Index and the FTSE NAREIT Equity REIT Index is 0.90 for the period from 1994, the inception date of the FTSE NAREIT subindices, to 2017. The compounded annual nominal returns in that period are 11.8% and 10.4%, with a corresponding standard deviation of 19.0% and 19.1%. Hence, the residential market seems to provide a reasonable estimate for the whole real estate market.

We use the following figures to construct the synthetic U.S. residential REIT index. For house prices data, we use Shiller (2015). For each year we take the rental income returns net of depreciation from Sprinkel and Genetski (1977, p. 246). Combining these gives us the total return on real estate for an unleveraged position. However, we adjust for leverage using a fixed leverage of 46%, which corresponds to the average in the 1990–2012 U.S. sample of Giacomini, Ling, and Naranjo (2017). For the costs of leveraging, we use the annual return on midterm corporate bonds from Ibbotson, Siegel, and Love (1985). We reinvest the rental income, and we value the midterm loan at market prices.

Obviously, our synthetic residential REIT index does not reflect deviations of stock market prices from the intrinsic value. Therefore, we underestimate the standard deviation of the returns. As an illustration, the S&P 500 returned 8.7% in the period 1960–1972, with a standard deviation of 12.9%, whereas the synthetic REIT returned 8.2% but with a standard deviation of 4.2%. But any remaining estimation error in our return data for real estate is mitigated as we combine our U.S. synthetic REIT with listed non-U.S. real estate. Moreover, U.S. real estate had a small weight in the market portfolio in 1970 and 1971.

[23] Ibbotson and Siegel (1983) use a building costs index, an estimated depreciation rate, and residential rental income to arrive at their estimate for the return on business real estate. The Federal Reserve maintains a "commercial real estate price index" series that goes back to 1946, but this is an appraisal-based assessment of commercial real estate prices, instead of the transactions or market prices that we are looking for.

For the years 1970 and 1971, we combine the return of the synthetic U.S. REIT index with the return of the MSCI Real Estate Index. Before 1971, we cannot calculate reliable market capitalizations because of a lack of data on market capitalization and price indices. Therefore, we continue by using the year-end weights from 1971, that is, 43.3% for the United States and 56.7% for the rest of the world, as mentioned above. From 1971 backward to 1960, we use buy-and-hold total returns.

Period 1960–1969

For the United States we use the synthetic residential REIT index that we previously described. For the rest of the world, we resort to five real estate companies in the MSCI Real Estate Index that are also are listed in 1960, as the MSCI Real Estate Index itself starts in 1970. These five companies are Land Securities from the United Kingdom, Foncière Lyonnaise from France, Generale Immobiliare from Italy, Mitsubishi Estate from Japan, and Mitsui Real Estate from Japan. With five stocks, we overestimate the standard deviation relative to a broadly diversified global non-U.S. index. Hereby, we counterbalance the underestimation of the standard deviation for the synthetic U.S. residential REIT index. Note, however, that Evans and Archer (1968) find that for the period 1957–1967 a portfolio of 10 randomly selected stocks would be enough for a well-diversified portfolio. So even though our sample is small with only five stocks, it ensures international diversification and therefore eliminates a part of the idiosyncratic risks involved.

We create a non-U.S. real estate total return index for four countries with these five companies, supposing that the companies' returns are indicative of the corresponding countries. Although this is not completely true, deviations are likely to be uncorrelated. We put the year-end 1969 country weights for the non-U.S. index as the average country weight in the three asset classes equities, government bonds, and investment-grade credits. This results in 39% for the United Kingdom, 14% for France, 20% for Italy, and 26% for Japan. The 26% for Japan we split into 18% for Mitsubishi Estate and 8% for Mitsui Real Estate, to reflect their difference in market capitalization. We derive price returns from Capital International S.A. (1975)[24] and dividend yields from the Capital Group (1971),[25] and we use the exchange rates from Dimson, Marsh, and Staunton (2017) to convert local

[24] For all five stocks we carefully derive annual returns from an enlarged semilogarithmic bar chart that contains the low, high, and closing prices of each year. We ensure that the annual returns add to the cumulative 10-year return. Another option would be to retrieve financial newspapers from the sixties and look for the five stock's prices from all year-end editions. However, this would introduce the risk that we miss a corporate event like a stock split, stock dividends, distributions, or right offerings, and missing this information could lead to huge errors in the returns we calculate. For Land Securities from the United Kingdom, we use data from Refinitiv Datastream for the period 1965–1969.

[25] This edition provides dividends from 1967. For price returns we used the 1975 edition, because the 1971 edition contains line graphs instead of the more useful bar graphs with year-end prices from the 1975 edition. Because we have different years for the books, we are required to adjust the dividends for corporate actions. This adjustment enables us to use the dividends from the 1971 edition in comparison with the prices from the 1975 edition. Consequently, we scale them with the ratio of the dividend in 1970 (1971 for the companies from Japan) that we take from both editions. To calculate the dividend yield in year t, we divide the dividend over year t-1 by the average of the year-end stock prices at year t and t-1. We assume dividend yields in 1960–1967 equal the average of the dividend yields in 1968 and 1969,

currencies to U.S. dollars. We do not rebalance the index. We backfill the MSCI Real Estate Index, as described for the period 1970–1971, with the returns of the non-U.S. real estate index that we composed. In the Online Appendix we perform extensive robustness checks on our real estate returns, particularly for the period until 1983.

One need not be concerned about the investability of real estate in the early years of our sample period. President Eisenhower, 4 years before eventually signing the Real Estate Investment Trust Act ("REIT Act") into law in 1960, vetoed the REIT Act and explained "[i]t is by no means clear how far a new provision of this sort might be applied. Though intended to be applicable only to a small number of trusts, it could, and might well become, available to many real-estate companies which were originally organized and have always carried on their activities as fully taxable corporations" (see Riano 2015). The first European real estate security was already listed on a stock exchange in 1850 (see Brounen and Koedijk 2012). So, obviously, companies and investors have been investing in real estate before the arrival of REITs. Also, we actually base our non-U.S. returns in the first decade on five real estate stocks.

Dividend index

We construct a dividend index by dividing the total return index by the price index from the same sources as described above. Before 1984, we calculated a dividend index using annual dividend yields. As we do not have a dividend yield of the synthetic U.S. residential REIT index that we use in the period 1960–1971 as described above, we suppose for that period that the dividend yield equals the net rental yield for the U.S. part in the index.

A.3. Nongovernment Bonds

A.3.1. Investment-grade credits

2010–2017

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, annual free-float-adjusted returns were not available.

because we have no dividend data before 1967. For Land Securities from the United Kingdom, we have the dividend yield since 1965 from Refinitiv Datastream. We backfill this dividend yield from 1964 to 1960 using the dividend yields from Barclays' (2010) U.K. equity index, supposing they move proportionally to each other. Although the dividend yields for earlier years are surrounded by some uncertainty, any estimation errors will only have a limited impact as price returns dominate misestimates of a part of the dividend yield for the period 1960–1965/1967.

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.

1997–2000

For the period 1997 to 2000, we use a market-capitalization-weighted average total return of the ICE BofAML Global Broad Market Corporate Index and the ICE BofAML Global Broad Market Collateralized Index.

1960–1996

We are not aware of the existence of a corporate or a collateralized *global* index that starts before 1997. However, we are able to hand-collect data from nondigitalized OECD books to create our own global corporate bond index for the period 1960 to 1996. We use this global corporate bond index to represent the returns of investment-grade credits before 1997. This means we are not able to include assets such as mortgage-backed securities (MBS),[26] asset-backed securities (ABS), eurobonds, Yankee bonds, sovereign bonds, or supranational bonds in our return calculations for investment-grade credits.[27] Bonds of local authorities and agencies are within our asset class government bonds.

Although we cannot include other segments within investment-grade credits because of the limited availability of historical data, the returns of corporate bonds seem to be a (very) good estimate for the returns on the whole asset class investment-grade credits for three reasons. First, from a theoretical point of view, ex ante one should expect a strong correlation between returns as all bonds within this asset class have nominal cash flows and a low risk of default. Second, some segments are small and hardly matter, especially in the period up to 1996. Third, data for the United States during the 21-year period from 1975 to 1996 hardly show a difference between an index with only corporate bonds and a market-capitalization-weighted index, which includes corporate bonds, MBS, ABS, Yankee bonds, sovereign bonds, and supranational bonds.[28, 29]

[26] Corporate bonds and MBS are two large segments within investment-grade credits. Although Frehen, Goetzmann, and Rouwenhorst (2014) trace early examples of MBS 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 were created (see Cowan 2003).

[27] So-called "144a bonds" have existed since 1990 (see, e.g., Chaplinsky and Ramchand 2004).

[28] For this analysis we have the following Bloomberg Barclays indices available: the U.S. Aggregate Corporate Index, the U.S. Aggregate MBS Index, the U.S. Aggregate Asset-Backed Securities Index, the U.S. Aggregate Yankee (Agg Eligible) Index (subindex with index ID 162), the U.S. Aggregate Sovereign Index, and the U.S. Aggregate Supranational Index. All these indices were available in 1975, except for the U.S. Aggregate Asset-Backed Securities Index, which is available from 1992.

[29] We lack data for one segment, eurobonds, that would have had a material index weight. As Claes, De Ceuster, and Polfliet (2002) remark, consistent data for this market are not available. However, when we combine their estimates for the size of the global eurobond market in 1980, 1985, 1990, 1995, and 2000 with the size of our global market capitalization for investment-grade credits, the presence of eurobonds in this asset class appears to grow from close to nil

Table A1 illustrates that U.S. corporate bonds have a compounded average annual return of 10.16% during the period 1976–1996, slightly above the 10.07% of the broader index that takes all six segments into account. The standard deviation of the annual returns is 10.5% and 10.1%, whereas the correlation between annual returns on both indices is 0.99. The average absolute difference in annual return is 1.04%, with a maximum difference of 3.27%. These differences are limited given the standard deviation of 10%.[30] In short, the values show just small differences between the U.S. corporate index and the broader U.S. investment-grade bonds index. Therefore, this analysis supports the view that one does not need to know returns on segments other than corporate bonds for a fair estimate of the returns on the whole asset class investment-grade credits for the period 1960–1996.

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.[31]

In general, the higher the market capitalization of a country's nongovernment bonds market is, the more likely it is that net issuance is higher. In other words, either method of determining the weight of a country in the nongovernment bond index should lead to comparable results: on its market capitalization compared to other countries' market capitalizations or on its relative net issuance. 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.

to approximately 7%, 17%, 23%, and 16%, respectively. Knauss (1969) shows that the issuance of eurobonds represents 4% to 8% of the total bond issuance by corporations in the European Economic Community in the period 1964 to 1968. For eurobonds one also should expect a very high correlation to corporate bonds. Moreover, the index weight itself is not so large that it would significantly alter our comparison given strong positive correlations among assets within the asset class investment-grade credits.

[30] A Cusum test fails to reject the null hypothesis of a constant relationship between the U.S. corporate index and the broader U.S. investment-grade bonds index.

[31] We used the yearly volumes of the OECD Financial Statistics books from 1974 until 1996, from which we collect (a) net annual bond issuance by public nonfinancial enterprises, private nonfinancial enterprises, and financial institutions, which also include mortgage bonds, and (b) incidental observations about market capitalizations.

Table A1
Statistics for the U.S. corporate bond index and the U.S. broad investment-grade index (US$, 1976–1996)

	Compounded return (%)	Standard deviation (%)	Correlation	Average annual difference (%)	Average absolute difference (%)	Maximum annual difference (%)
U.S. corporate bonds	10.16	10.5	0.99	0.13	1.04	3.27
U.S. broad IG credits	10.07	10.1				

For 10 of 11 countries, the net issuance data start in 1960, with Austria starting in 1967. The three columns under "Issuance data" in Table A2 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, whereas 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 the following 2 years 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 two countries, net issuance data end before 1993: in 1991 for Austria, and in 1990 for Belgium. For both countries, we also freeze country weights before 1993. As these two countries represent a combined 2% of our corporate bond index, doing so will not significantly affect the return of the global nongovernment bond portfolio.

We estimate country market capitalization weights by taking a 10-year moving average of net issuance data and relate it to the total net issuance of all countries. By using a 10-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 do not have 10-year history available. For the 5 years before that, we freeze the weights at the 1965 levels. As market weights tend to change gradually, freezing the 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 multiasset 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 these 2 years, most countries have market capitalization data for exactly these years or a few years earlier or

Table A2
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	1990	1967	–
Canada	1960	1969	1995	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

This table shows the data availability for bond issuance data and market capitalization data by country. We compare country weights based on bond issuance and market capitalizations for the 2 base years 1967 and 1978. For these 2 years, most countries have market capitalization data for exactly these years or a few years earlier or later. If market capitalization data are not available, we estimate them using one or more observations of market capitalizations in the surrounding years, with a correction for net issuance in the year(s) between.

later. To arrive at data for 1967 for all countries, we used 1 of the 2 following methodologies if 1967 itself is not available. If there is an additional year available with market capitalization data within 4 years before *and* after 1967, we estimate 1967 by adding or subtracting net issuance data.[32] Subsequently, we average these two 1967 outcomes for the most robust estimate.[33] This first method applies to Canada, Italy, Japan, and the United States. If there is only 1 year with market capitalization data within the 4 years available, we estimate the 1967 market capitalization by adding (subtracting) a country's net issuance to (from) the closest observation. This applies to Germany, the Netherlands, and the United Kingdom. Table A2, the first column under "Market capitalization data", shows which year(s) we use as a base year. We use exchange rates from the Dimson, Marsh, and Staunton (2017) database to convert all local currencies into U.S. dollars.

[32] We choose a range of up to 4 years, because this length of time enables us to check the accuracy of our market capitalization estimates in 1967 for all eleven countries in our sample.

[33] We use this two-way calculation, because simply adding or subtracting net issuance data to or from available market capitalization data does not lead to earlier or 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.

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 the market capitalization of 1977 to arrive at the market capitalization value for 1978. We do not account for Belgium, Italy, and the Netherlands in the 1978 comparison, as these countries have no market observations within 5 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 A2 summarizes the base years for the comparison in 1978.

Figure A2 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 7 percentage points. The total of all absolute differences sums to 17 percentage points for 1967. Stated differently, our weights overlap for 83%. Although not perfect, the net issuance data seems to fit relatively well for 1967.

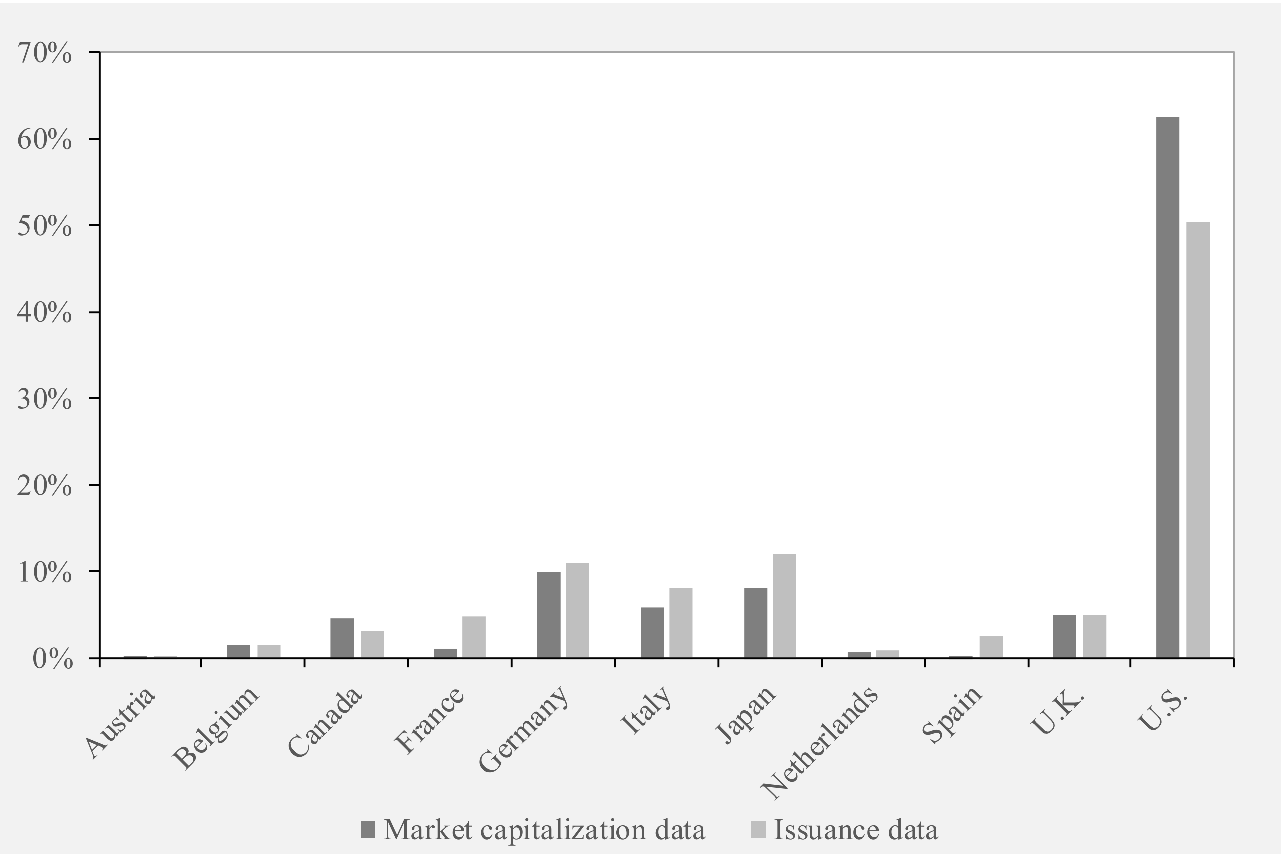

Figure A2
Comparison of nongovernment bonds' country weights for 1967
The graph compares country weights for eleven countries based on bond issuance data with market capitalizations for 1967. If market capitalization data are not available for 1967, we estimate them using one or more observations of market capitalizations in the surrounding years, with a correction for net issuance in the year(s) between.

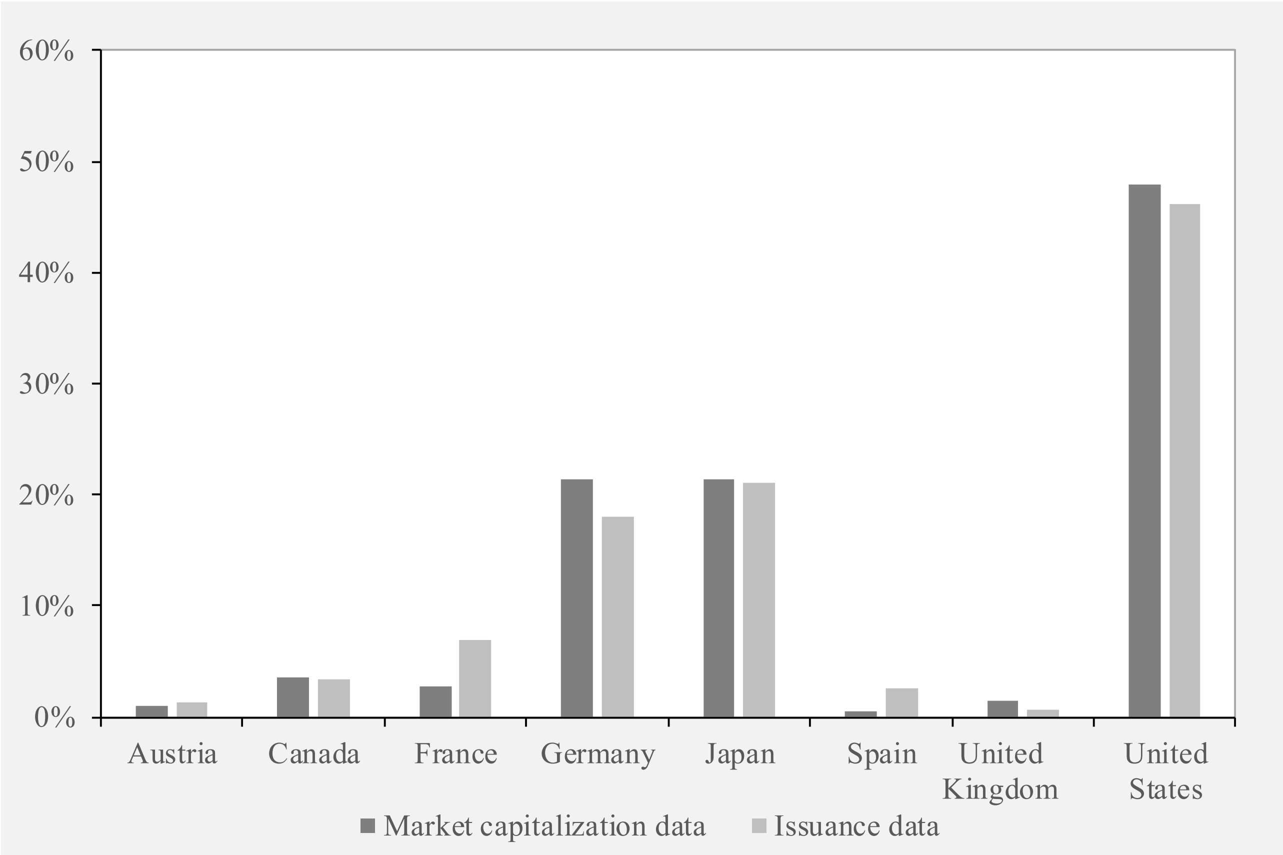

Figure A3
Comparison of nongovernment bonds' country weights for 1978
The graph compares country weights for eight countries based on bond issuance data with market capitalizations for 1978. If market capitalization data are not available for 1978, we estimate them using one or more observations of market capitalizations in the surrounding years, with a correction for net issuance in the year(s) between.

Figure A3 shows the country weights for 1978. Again, the United States shows the largest difference, now with a 5-percentage-point overestimation of the market capitalization. For 1978, the total of all absolute differences was 12 percentage points, which implicates an index overlap of 88%. 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 to us to be the best way to estimate market capitalizations weights. Figure A4 provides an overview of the country weights we use in our nongovernment bonds index for the period 1959–1995.

As an additional check we compare the U.S. index weights in our index with the index of Ibbotson, Siegel, and Love (1985) that runs until 1984, a check that is not possible for other individual countries as they only provide a U.S. and a non-U.S. weight.[34] The U.S. index weights appear to average 35.8%

[34] Unfortunately, the appendix with the data details of the Ibbotson, Siegel, and Love (1985) study, as well as the data themselves, have been lost during the past 30 years, as the authors confirmed. However, they informed us that their study was basically an update of the Ibbotson and Siegel (1983) paper. On its turn, the 1983 paper refers to some details from the Ibbotson, Carr, and Robinson (1982) study. Specifically, the authors refer to a paper from Salomon Brothers published in 1981 for their market capitalization weights. We were not able to find that paper.

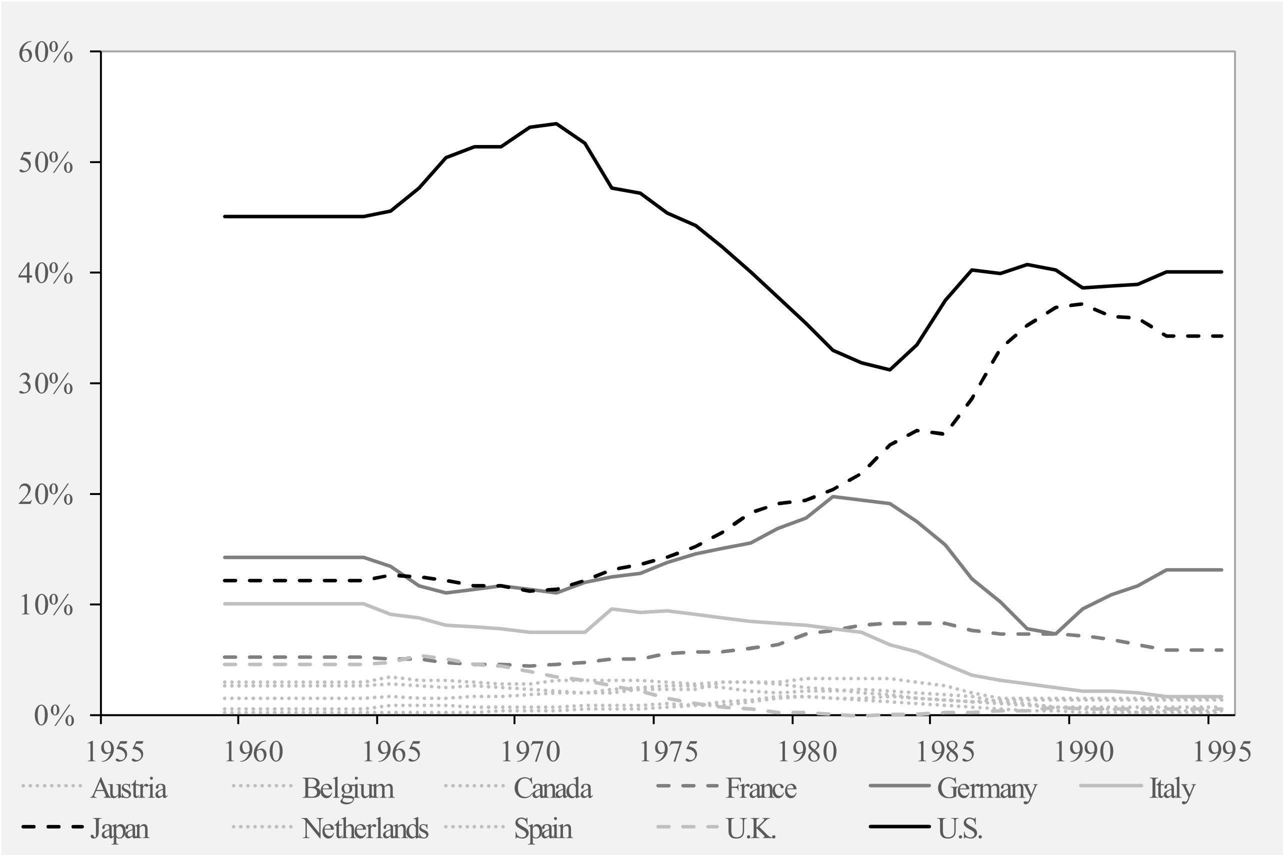

Figure A4
Country weights in our global nongovernment bonds index (1959–1995)

and 38.9%. The average absolute difference in the annual weights is 4.0%, whereas the maximum absolute difference in weights is 7.6%. Like the comparison with market capitalizations in 1967 and 1978, this check also confirms that relative net issuance is a fair estimate of market-capitalization-based index weights.

Yields

For the United States, we use the total return data for the period 1985 to 1996 from the Bloomberg Barclays U.S. Aggregate Corporate Index.[35] For 1960 to 1984, we use the total return data from Ibbotson, Siegel, and Love (1985, p. 37, 2nd and 3rd columns). Like Ibbotson, Carr, and Robinson (1982), we use corporate yields from 1959 to 1996 of OECD (1976) and OECD (1975–1996) for other countries. As no data are available for December 31, 1959, we use the yields of January 31, 1960, as an estimate, assuming that the yields did not change during the first month of our sample.[36]

Some countries have missing observations in the OECD yields data, namely, Austria (1960–1963), Belgium (1980–1996), Italy (1990–1994), the Netherlands (1985–1986), Spain (1980, 1984–1987),

[35] This index equals the Bloomberg Barclays U.S. Credit Index until 1999.
[36] This seems a reasonable assumption. The 10-year interest rate on U.S. Treasuries only was 4.69% in December 1959 and 4.72% in January 1960. The Moody's BAA corporate bond yield in the United States increased from 5.28% to 5.34% over the first month in 1960. *Source*: FRED Database (St. Louis FED).

and the United Kingdom (1995–1996). For the United Kingdom, we used corporate bonds total return data from Barclays (2010, p. 63, figure 77) for these 2 years to circumvent the problem of missing yield data that we used to calculate returns.

When yield data are not 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). For the 22 years in which we miss yield data for one or more countries, our coverage varies between 93.4% and 99.6% of the global market capitalization. Hence, despite some missing yield observations, this has almost no impact on our estimates of global corporate bonds.

Returns

We calculate returns using Equation (A1):

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

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 use the maturity estimates of Ibbotson, Carr, and Robinson (1982) and extend them to 1996.[37] For the equations of the modified duration and convexity, we follow Serrat and Tuckman (2011).[38] With Equation (A2), we calculate the convexity:

$$\mathrm{C} = \frac{1}{B} \frac{d^2(B(r))}{dr^2}, \tag{A2}$$

where

C = *convexity*,

r = *interest rate of the bond*,

B = *price of the bond.*

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

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

[37] However, the United Kingdom is an exception, because the OECD data also contain the maturity for the United Kingdom for the whole period 1960–1996.

[38] See equation (4.14) on page 132 and equation (4.45) on page 146.

Therefore,

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

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 percentage 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-U.S. weight in our index, as we use total return series of external suppliers for the United States, as described above. Moody's (2012, exhibit 23, p. 27) contains annual credit loss rates on global investment-grade credits from 1982 onward. 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 from 1982 to 2011, 15 years experienced a credit loss. We proceed by assuming that the credit loss in those 3 years equals the median credit loss on investment grade for the 15 years with a credit loss. This median is 0.11 percentage points (average equals 0.12 percentage points). We correct the return of the non-U.S. weight in our index 0.11 percentage points. 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.

A.3.2. High-yield bonds

Period 2002–2017

For the period 2002 until 2017, 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 U.S. 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 ICE BofAML Global High-Yield Index. This index contains below investment-grade corporate debt.

Period 1985–1997

From 1985 through 1997, we use the total returns of the ICE BofAML U.S. High-Yield Index. Before 1998, a global high-yield index is not available. However, the United States has dominated the global corporate high-yield market. To illustrate this, the correlation between monthly returns of the ICE BofAML Global High-Yield Index and the ICE BofAML U.S. High-Yield Index is 0.98 in the 3-year period from 1998 to 2000, whereas the average compounded annual returns have been 3.1% and 4.0%, respectively. The 90-bp return gap between the two indices might seem large, but the annualized standard deviation of the monthly returns is 6.4% and 7.2% in this 3-year period. So the difference in returns is limited given this standard deviation.[39]

A.3.3. Leveraged loans

Period 1998–2017

For the period from 1998 to 2017, we use the market-capitalization-weighted combination of the Credit Suisse Leveraged Loan Index, which represents the United States, and the Credit Suisse Western European Leveraged Loan Index to reflect global investments in loans to (highly) leveraged companies. These indices have a higher market coverage and a longer history than do indices from other providers. We are not aware of investable leveraged loan markets in other regions. At least, no providers are offering leveraged loan indices for other regions.

Period 1992–1997

For 1992 until 1997 we use the Credit Suisse Leveraged Loan Index. A European index did not exist before 1998. However, this hardly affects our global index. At the end of 1997, the United States represented 93% of our global index, and the initial index weight of Europe was just 7%, whereas annual returns had a positive correlation of 0.90 for the period 1998–2017. At the end of 2017, Europe had an index weight of 21%. Before 1992, we do not take leveraged loans into account because they represent a relatively new asset class with a weight of only 0.1% in the invested market portfolio at the end of 1991. Over the last 10 years, the index weight is around 1% of the market portfolio.

A.4. Government Bonds Broad

A.4.1. Government bonds

Period 2010–2017

For the period from 2010 to 2017, we base the returns on the Bloomberg Barclays Multiverse Government Index in which we replace the Bloomberg Barclays Global Treasuries Index with the Bloomberg Barclays Global Treasuries Float-Adjusted Index. Hereby, we create a global multiverse

[39] The correlation between monthly returns of the U.S.-dollar-hedged ICE BofAML Global High-Yield Index and the ICE BofAML U.S. High-Yield Index is 0.97 over the 3-year period from 1998 to 2000, whereas the average compounded annual return for the U.S.-dollar-hedged ICE BofAML Global High-Yield Index has been 2.9% with a standard deviation of 6.3%. The marginal difference itself between the unhedged and the U.S.-dollar-hedged global indices also suggests the dominance of the United States in the global high-yield market in the early years of the global index.

government index with a free float adjustment. Prior to 2010, annual free-float-adjusted returns for global treasuries are unavailable.

Period 2001–2009

From 2001 until 2009, we use the Bloomberg Barclays Multiverse Government Index. This index has the broadest coverage of global government bonds regardless of 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, 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.[40]

Period 1987–2000

From 1987 until 2000, we use the Bloomberg Barclays Global Treasuries Index, like Doeswijk, Lam, and Swinkels (2014a). Unfortunately, there is no information on the other Bloomberg Barclays indexes that make up the Multiverse Government Index before 2001. Note that on January 31, 2001, the Bloomberg Barclays Global Treasuries Index was about 80% of the market value of the Bloomberg Barclays Multiverse Government Index.[41] The correlation between the total monthly returns of both series was 1.00 over the period January 2001 to December 2015. The Bloomberg Barclays Global Treasury index covered nineteen countries at its base date in 1987.

Period 1985–1986

For 1985 and 1986, we use the FTSE World Government Bond Index (WGBI). This index is a market-capitalization-weighted, all-maturity global government bond index. The index contained nine countries in 1985 and 1986.[42]

Period 1960–1984

We use the annual market capitalizations and returns for U.S. government bonds and foreign domestic government bonds from Ibbotson, Siegel, and Love (1985) to compose a market-capitalization-weighted global government bond index for the period 1960–1984. From Ibbotson, Carr, and Robinson (1982), we can derive that this index contained twelve countries and had an average maturity between 7 and 8 years for the period 1959–1980.[43]

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

[41] On January 31, 2001, the Barclays Global Treasury Index has a market value of US\$6.24 trillion, whereas the Barclays Multiverse Government Index has a market value of US\$7.91 trillion. About US\$0.73 trillion is due to differences in the Treasury segment of both indexes, and US\$0.94 trillion is due to the agencies and local authorities.

[42] These countries are Australia, Canada, France, Germany, Japan, the Netherlands, Switzerland, the United Kingdom, and the United States.

[43] The countries in the index are Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States.

A.4.2. Inflation-linked bonds

Period 1998–2017

For inflation-linked bonds, we use the Bloomberg Barclays Global Aggregate Inflation-Linked Index for the period 1998–2017. This index includes securities that offer the potential for protection against inflation, because 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 Bloomberg Barclays World Government Inflation-Linked All-Maturities Index.

Period 1985–1996

We use the ICE BofAML U.K. Government Inflation-Linked All-Maturities Index for the period 1985–1996. Although inflation-linked bonds have existed for a long time, the United Kingdom was the first major country to offer them as alternatives to nominal government bonds to the public. The United States created Treasury inflation-protected securities (TIPS) in 1997.

A.4.3. Emerging market debt

The asset class emerging market debt (EMD) requires an approach different from the other asset classes in this study, because it contains four subasset classes with different characteristics, following Doeswijk, Lam, and Swinkels (2014a). We outline four subasset classes: external hard currency debt, hard currency corporate debt, local currency nominal government debt, and inflation-linked debt. A global index that contains all these four categories is not available. 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,[44] the JP Morgan Corporate Emerging Markets Bond Index Broad (CEMBI) for U.S.-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 Emerging Markets Government Inflation-Linked Index (EMGILI) for inflation-linked bonds.

Figure A5 illustrates the relative market capitalization weights for all four categories in our EMD index. The figure uses the methodology of Doeswijk, Lam, and Swinkels (2014a) to estimate the market capitalization of each category and also shows the availability of return data. Dotted data

[44] Recently, Meyer, Reinhart, and Trebesch (2019) have compiled an extensive historical database on external sovereign bonds over the period 1815 to 1990. We only include the returns of the period that they label as their "modern period." For the period 1960–1993, the size of the total market is small compared to the market portfolio. Based on the data Meyer, Reinhart, and Trebesch (2019) provide, we estimate their weight to be between 0.0% and 0.5% of our market portfolio before we include them.

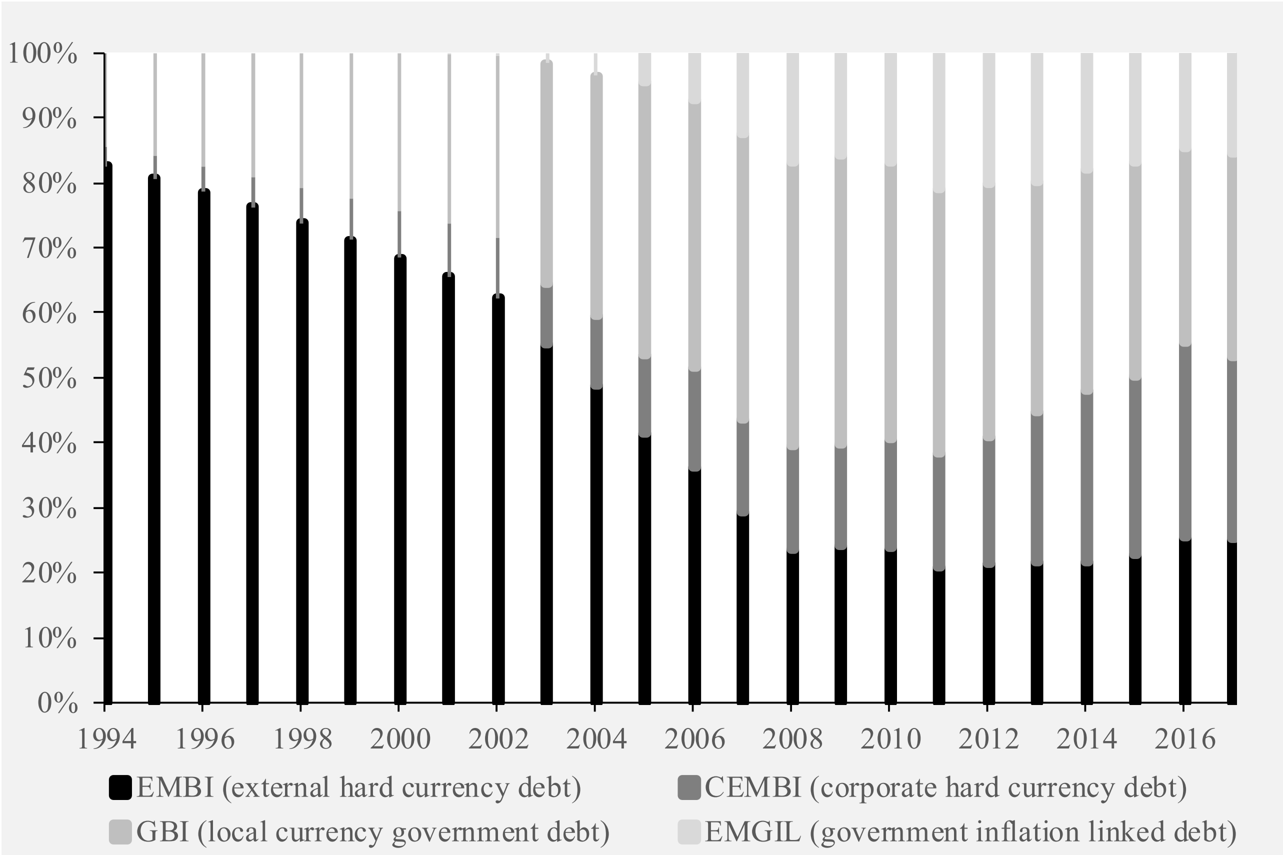

Figure A5
Relative market capitalizations and the availability of return data for emerging market debt
The graph shows previous year-end relative market capitalizations and the availability of return data in a year for each category of emerging markets debt. Dotted data indicate that return data are not available for that year.

indicate that return data are not 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 covered 83% of the EMD index at that time, because there were no return data for the other three indices.[45] Afterward, the coverage gradually fell to 65% until return data for CEMBI and GBI became available in 2002. Then the market coverage of our EMD index jumps to almost 100%. When return data for EMGILI became 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 monthly total returns of EMBI are positively correlated to CEMBI (0.86) and to GBI (0.71) in the 2002–2017 period, our EMD seems to be a reasonable proxy for the 1994–2001 period. In any case, the impact of any bias in our EMD index on the global multiasset market portfolio will be marginal as EMD represented 0.8% of the market portfolio at the end of 1993. This also applies to its impact on our government broad index with a weight of 2.4%.

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

For each year t from 1994 to 2017, 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.

A.5. Commodities

An external market-capitalization-weighted commodities index is not available. However, we can compose it ourselves. We discuss doing so separately in Appendix B as constructing the index requires a somewhat lengthy description that also discusses the market capitalization of the asset class. We combine investments of financial investors in both physical commodities and their net investments in index-linked commodity derivatives.

Appendix B. Market Capitalizations

We use the market capitalizations from Doeswijk, Lam, and Swinkels (2014a) but update them for the period 2013–2017 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 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.[46,47] For all other data details and a description of our methodology for the composition of the invested market portfolio, we refer readers to Doeswijk, Lam, and Swinkels (2014a).[48,49,50] As that study does not include leveraged loans and commodities, we describe below how we estimate the size of the invested leveraged loans and commodities market.

B.1. Leveraged Loans

For leveraged loans, we use the combined market capitalization of the Credit Suisse Leveraged Loan Index and the Credit Suisse Western European Leveraged Loan Index. Appendix A indicates that this relatively new market is dominated by the U.S. market, and we are not aware of other regional leveraged loan indices, except for those in the United States and Europe.

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[46] 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 U.S. Treasuries, U.S. 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."

[47] We do not take ECB holdings into account. Adjustments for ECB holdings bring a lot of uncertainty as one has to work with estimates because of a lack of details. Doing so would also introduce a hindsight bias because the data are not available on a timely basis.

[48] One difference from this study is that we combine the asset classes equities and private equity into the asset category equities broad for the entire 1960–2017 period. Doeswijk, Lam, and Swinkels (2014a) estimate the market capitalization for the asset class private equity from 1990 onward. 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.

[49] From 2016, Preqin redefines their old term "private equity" into "private capital." They also introduce their new definition of private equity, which focuses on the buyout and venture capital industry, together with other closely related strategies. It no longer extends to, for example, investments in mezzanine, infrastructure, and natural resources. In this study we continue with the broader definition, which we continue to label "private equity," despite the redefinition.

[50] More recently, both Dimson, Marsh, and Staunton (2018b) and Kuvshinov and Zimmermann (2018) provide insight into the history of equity market capitalizations of individual countries with a sample of 23 and 17 countries, respectively. The different sample size and a lack of detail hinder us making a rigorous comparison. However, they both provide a 100% stacked column chart that illustrates the relative weights of 12 and 5 individual countries, respectively, and the combined weight of the remaining countries. An inspection since 1959 of these two charts for the five overlapping countries suggests no large differences between the relative country weights from both sources. As our global return series for equites are in line with the series of Dimson, Marsh, and Staunton (2017), this further validates our data source for equities.

B.2. Commodities

Investing in commodities is possible by holding physical commodities or by taking a position in derivatives. Derivatives are the appropriate instrument for financial investors to gain exposure as they usually do not store physical barrels of oil, pork bellies, or other commodities. Precious metals, however, are an exception, because they are relatively easy to store. [51] Below, we first discuss physical investments followed by derivatives-based investments in commodities.

B.2.1. Physical investments in commodities

Gold

To estimate the size of gold holdings by financial investors, we start with a data series for 2008 to 2016 that we received from the Gold Fields Mineral Services (GFMS) team of Thomson Reuters. We add investments in 2017 from the World Gold Council (2018) to the 2016 value to arrive at gold holdings at the end of 2017. For the period 2001 to 2007, we use holdings data from GFMS, as reported in World Gold Council (2011, p. 15). GFMS (2001) contains holdings data by financial investors from 1981 to 2000. We backfill the holdings data from 1981 to year-end 1959 by subtracting the change in gold holdings for each year. We use annual (dis)investments data from Haugom (1990).[52] We now have a complete data series of gold holdings by financial investors since 1959. We exclude holdings by central banks and jewelry as our study focuses on assets owned by financial investors.

To finalize, we multiply the private holdings by the price of gold. We use year-end fixing prices in U.S. dollars in the London Bullion Market, which are available from 1968. Before 1968, we use prices from www.macrotrends.net. We refer readers to Erb and Harvey (2013) for a detailed description of the financial characteristics of gold.

Silver

For estimating silver investments, we start with the CPM Group (2014). That study estimates the cumulative investor holdings of silver by summing private stocks of bars, coins, and physically backed exchange-traded products for the period 1996–2013.

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[51] We disregard investments in diamonds, which differ from other commodities, because they are not fungible. Differences in carat, cut, clarity, and color cause pricing differences between stones, and pricing is less transparent than in other financial markets. Private funds and retail platforms manage a very marginal amount of money invested in diamonds compared to the commodity investments that we consider.

[52] Following this methodology, we arrive at an estimate for gold holdings in 1968 that is in the middle between estimates from Haugom (1990) and Machlup (1968). Machlup (1968, p. 788) mentions that "thus $20 billions would not seem to be a unreasonable figure for private stocks in March 1968." When we interpolate holdings data of year-end values for 1967 and 1968, we arrive at 4,551 tons for Haugom (1990) and 10,007 tons for our holding series at the end of March 1968, which translates into US$5.8 billion and US$12.8 billion, respectively.

For the period after 2013, we use flow data from Thomson Reuters (2018). We miss coin melt data for these years. This omission is unlikely to significantly affect our estimates for these years, as the silver price has been relatively constant, and coin melt was particularly high after price spikes (Silver Institute 1990, p. 26).

Before 1996, we backfill the data using annual flow data. For each year we sum coin and medals demand, coin melt, and implied (dis)investments, meaning we suppose investors to balance any surpluses or deficits in the market based on demand and supply data.[53] We use GFMS (2000) for the flow data for the period 1990–1996 and the Silver Institute (1990) for the flow data from 1960 to 1989. We lack coin melt data for the period 1990–1995; therefore, we extended the 1989 value to 1995. Also, for this period, coin melt is unlikely to matter significantly. For silver prices, we use the same data sources as for gold prices.

Platinum and palladium

Estimates for platinum are available from Johnson Matthey.[54] We estimate the total investment holdings by the cumulative annual (dis)investments in platinum since 1982.[55] We source prices from the Web site of London platinum and palladium market since 1990[56] and from www.macrotrends.net before 1990.

For palladium, we apply the same methodology, and we use the same data sources as for platinum, starting in 2003. Data from John Matthey suggest there are no investments by financial investors in other platinum group metals like rhodium or iridium.

B.2.2. Derivatives investments in commodities

Derivatives are a zero-sum game as the net position is zero. However, for the part that long positions in derivatives are provided through commodity producers who want to fix their prices for future deliveries, there is an opportunity for a net long position by investors. On the other hand, manufacturing companies that want to fix their commodities input prices play a role in the commodity derivatives market by potentially providing short positions to investors. Tang and Xiong (2012)

[53] The Silver Institute (1990) indicates that reliable data are not readily available for investment demand up to 1960. Although one should always take a margin of error into consideration, particularly for data in the distant past, from 1960, we assume that these data are reliable.

[54] See http://www.platinum.matthey.com/services/market-research/market-data-tables for data up to 2013. Afterward, we use Johnson Matthey (2016) for the 2014 value and Johnson Matthey (2018) for the 2015, 2016, and 2017 values. Little evidence of significant bar and coin sales is available before 1982.

[55] Here, we do not consider the difference between supply and demand to be the implied annual (dis)investment. As a stand-alone value for the market imbalance in each year, the data may be a reasonable estimate. But cumulative market imbalances for platinum result in a data inconsistency, that is, increasingly negative physical holdings by investors. Figure C1 shows this data issue has little relevance for our estimates of the market size of commodities or its return, because gold is the dominating commodity in the invested commodity market.

[56] See http://www.lppm.com/

remark that commodity futures became a popular asset class after 2000. This is also known as the "financialization of commodities."

Estimates are available on the assets under management in the index-linked commodity market, as well as the benchmark shares of S&P GSCI and the Bloomberg Commodity Index (BCOM).[57] From December 2007, the CFTC itself provides data on the index-linked commodities market, measured in U.S. dollars, in their Index Investment Data reporting series.[58] This service was discontinued after October 2015 because of declining interest. We use their year-end data for the size of the index-linked market from 2007 to 2014. After 2014, we use data from Barclays (2018). Before 2007 we use estimates of Barclays (2013) for the period 2004–2006. Before 2004, Barclays data are not available, and we use Masters' (2008) data from its inception in 1995 to 2003.[59] For determining the market shares (and values) of assets managed with the S&P GSCI and BCOM benchmarks, we use Barclays (2018) for 2010 to 2017, Barclays (2013) for 2004 to 2009, and Masters (2008) for 1995 to 2003. According to the Barclays data, these two benchmarks have on average a market share of 95% in the period 2004–2017.

Data from Barclays (2018) and Barclays (2013) show that index-linked investments cover a significant part of assets under management in the commodities market, on average 57% in the period 2004–2017. Next to commodity derivatives, Barclays' definition of assets under management in the commodities market includes physical investments that are held through an exchange-traded product

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[57] It seems likely that net long positions in index-linked commodity futures are primarily or exclusively from financial investors as processors are likely to buy long positions in futures of the commodity they use in manufacturing. Still, it remains unknown to what extent the long positions are provided by commodity producers or by (positions in futures that are not index-linked of) financial investors. However, the estimates for index-linked investments are below estimates of net long positions of investors in commodity derivates based on the data we refer to in footnote 58 and which we further discuss in the text. Nevertheless, as a robustness check, we also perform an analysis that excludes derivatives from our analysis. Then the compounded nominal annual return on our commodity index for the period 1960–2017 (1996–2017) would be 6.3% instead of 6.0% (5.7% instead of 5.1%). Actually, apart from both 2006 and 2008, when the commodity index excluding index-linked investments returns 7 percentage points more than the commodity index that includes them, absolute differences for the commodity indices are limited to at most 2.7 percentage points in any annual return. These differences are small given the standard deviation of annual returns on our commodity index of 16% in the period 1996–2017. So, even if other financial investors would provide a significant part of the long position of index-linked investments, which would lead us to overestimate the net investments in index-linked investments, this would have a limited effect on our commodity returns, whereas the effect on our return series for the market portfolio is negligible given the small weight of commodities in the market portfolio.

[58] Apart from the Investment Data Series, the U.S. Commodity Futures Trading Commission (CTFC) classifies all futures holdings into five categories of traders: producer/merchant/processor/user; swap dealers; managed money; other reportables; and nonreportable positions. But it still is ambiguous to arrive at values for the size of financial investments in commodity futures in combination with the corresponding returns on such investments. First, an investor that takes an over-the-counter (OTC) position in commodities does not show up in these statistics. Next, the reporting frequency is on a weekly basis without insight into the expiration dates of the futures. So there is no clear visibility at the timing of future transactions between commercial parties and financial investors (this differs from, e.g., the equity market, where trading primarily takes place among financial investors) or on (roll) returns.

[59] Sanders and Erwin (2013) point out that Master's (2008) methodology overestimates index-linked investments in commodity futures, mainly because of estimates based on gross, not net long, positions, with on average an absolute deviation of 26% for the WTI oil future. Master's estimate implies only a 6% weight of index-linked investments in our total invested commodities index at the end of 2003, so these differences will only marginally affect the returns on our invested commodity index.

(ETP). However, because we already cover investments in physical commodities, we need to adjust for that to obtain the relevant figure. Once adjusted for physical commodity holdings in ETPs, the S&P GSCI and BCOM index-linked investments in commodities cover on average 77% of derivative investments in commodities in the period 2004–2017.[60] Because of data limitations, which are discussed in footnote 57, we disregard the remaining 23% of the derivatives commodity market and solely focus on index-linked investments.

B.2.3. Composition of the total invested commodities market

Figure B1 shows the composition of the invested commodities market. Gold dominates the market with an average index weight of 88% over the period 1960–2017. The relatively high index weight of silver in 1969 is supported by both silver buying and the doubling of the silver price in the sixties. Another spike in 1979 is attributable to cornering the silver market by the Hunt brothers, an act that

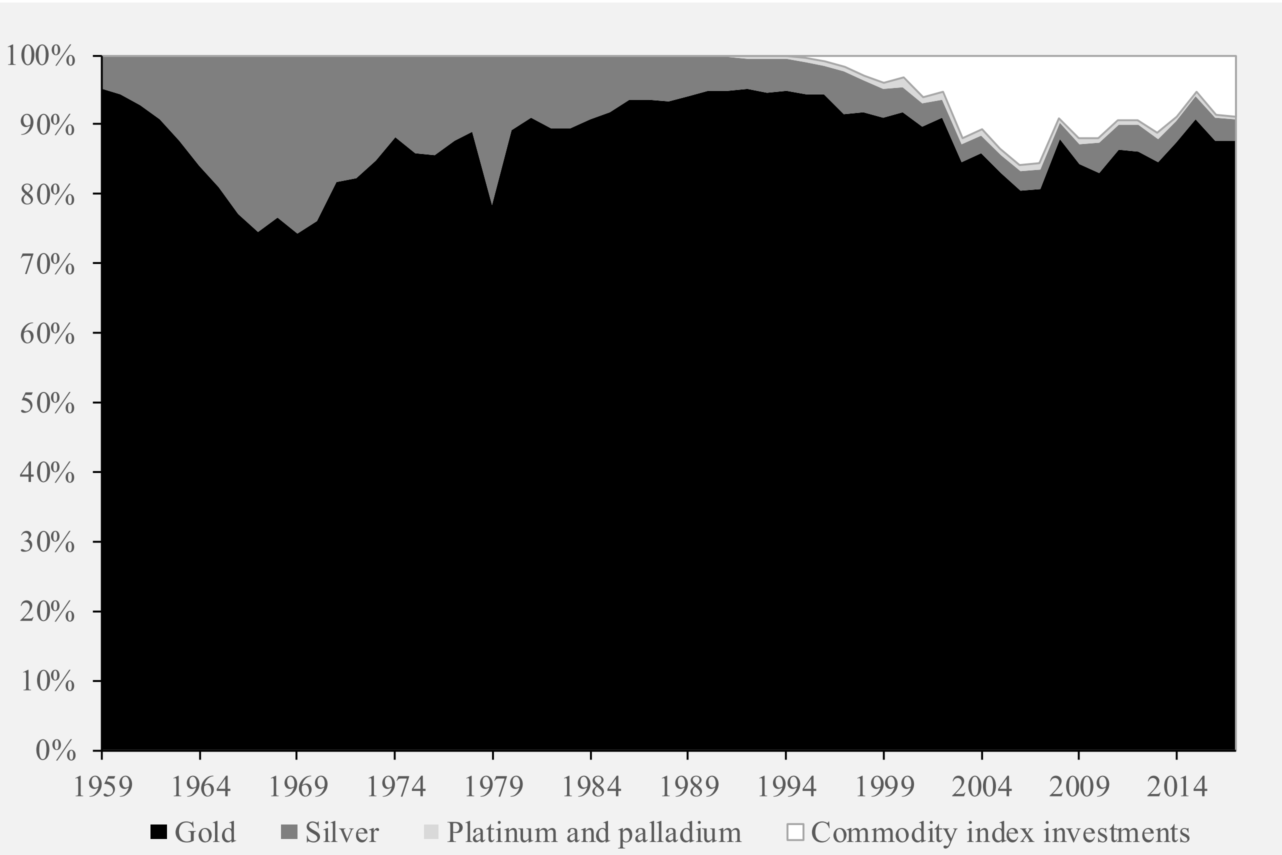

Figure B1
Composition of the invested commodities market, 1959–2017

[60] We adjust the Barclays assets under management in the commodity market by subtracting the market values of ETPs in physical gold from the World Gold Council and in physical silver from the Silver Institute to derive this value. Just to illustrate the importance of physically backed ETPs in the ETP commodity segment: at the end of January 2018, the ETF Database (www.etfdb.com) lists 151 commodities ETPs in the United States with a combined market capitalization of US$74 billion. The ten physically backed ETPs (all in precious metals) count for US$56 billion, or 76%, of the total ETP commodity market capitalization. Our adjustment implies that Barclays' total assets under management values are corrected by about 20% because of physically backed ETPs.

resulted in a more than fivefold increase in the silver price in 1979. During our whole sample period, the market share of gold versus silver benefits from the return on gold versus silver. The gold price experienced a thirty-seven-fold price increase compared to an eighteenfold price rise of silver. Since 2000, the average weight is 86% for gold, 3% for silver, 1% for platinum and palladium, and 10% for commodity index-linked derivates investments.[61]

[61] The nominal compounded return of 6.03% that we report for commodities *prices* differs from the cross-sectional average of compounded returns of individual commodity *futures* of 0.1% (0.5%) that Levine et al. (2018) document for the period 1946–2015 (1877–2015). Also, our excess return of 1.18% on commodities *prices* is below the 4.5% (3.1%) excess return for their equally weighted index of commodity *futures* for the period 1946–2015 (1877–2015). We stress that this study focuses on market-capitalization-weighted returns, as we estimate the return of the market portfolio. This differs from other commodity studies. Therefore, our index predominantly contains physical gold.

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Online Appendix

to

Historical Returns of the Market Portfolio

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Online Appendix

In this Online Appendix, we compare our data to alternative data sources to gain insight into the sensitivity of the results against other sources. We perform this robustness check for asset class equities, real estate, government bonds, and investment-grade credits only. For these asset classes, we have decades-long data available from alternative data sources. This sample enables our robustness checks.

1. Equities

For equities, the return series that we compose with data from Ibbotson et al. (1985) and MSCI closely resembles data from Dimson et al. (2017). Table OA1 shows the average annualized compounded returns for the period 1960–2016 are 9.47% and 9.28%, with standard deviations of 17.4% and 16.9% and a correlation of annual returns of 1.00. The average difference in annual returns is 0.26%, and the average absolute difference in annual returns is 1.22%. The maximum absolute return difference in a year is 4.62%. The differences are small given the standard deviations of the annual returns. In addition, we performed a Cusum test in which we relate our actual index to the alternative index. If, at any time, the relationship between the two indices structurally breaks down, the break would be recognizable by the cumulative sum of the residuals exceeding the critical values. In other words, this test detects systematic deviations from constancy (see Brown, Durbin, and Evans 1975). Both tests do not result in a rejection of the null hypothesis, suggesting no structural breaks in the relationship between the actual and alternative index.

Table OA1
Statistics for the actually used and an alternative global equity index (US$, 1960–2016)

	Compounded return (%)	Standard deviation (%)	Correlation	Average annual difference (%)	Average absolute difference (%)	Maximum annual difference (%)
Actually used index	9.47	17.4	1.00	0.26	1.22	4.62
Alternative index	9.28	16.9				

We compose the actually used index using data from MSCI and Ibbotson et al. (1985). The alternative index comes from Dimson et al. (2017).

2. 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. Figure OA1 shows that both have a market value that is clearly below the market value of the GPR General World Index. On balance, both perform roughly in line with the GPR General World Index

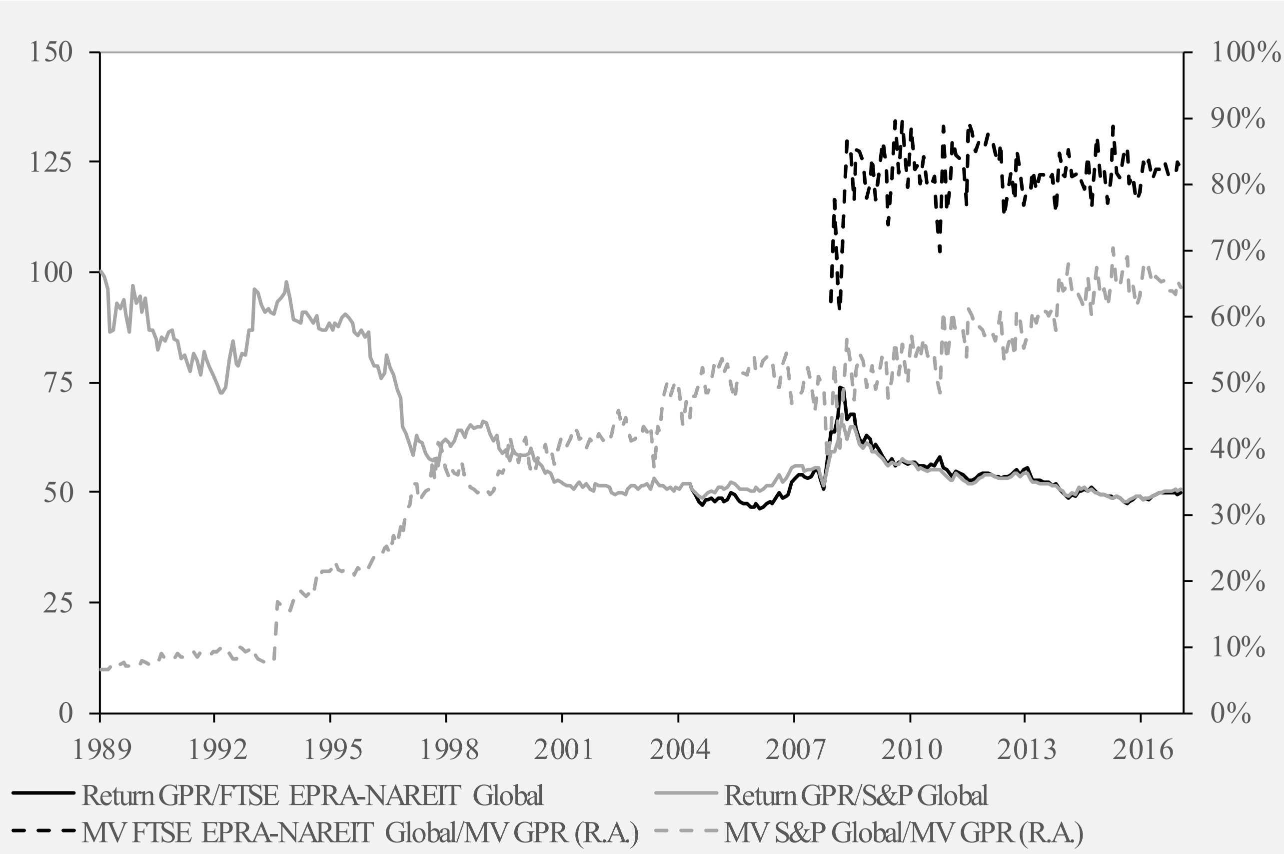

Figure OA1
GPR General World Index relative to the alternative indices
This figure plots the performance for the GPR General World Index relative to the FTSE EPRA/NAREIT Global Index and the S&P Global REITs Index. It also shows the market capitalization of the FTSE EPRA/NAREIT Global Index and the S&P Global Real Estate Investment Trusts Index relative to the GPR Index.

in the period 2005–2017, although returns differ from 2008 to 2010 as a result of different universes. At the end of 2008, the market capitalization of GPR is 1.3, or 1.9 times as large as the other two index providers.

Table OA2 illustrates that long-term returns of the GPR General World Index differ from those of the S&P Global REITs Index, the alternative index with the longest history. The compounded returns differ by 1.95 percentage points, and the maximum difference in annual returns is 29.57%. This finding is no surprise, because, back in 1990, the market capitalization of the S&P Global REITs Index equaled 7% of GPR's market capitalization.[62] The GPR General World Index seems to be the best-suited index for this study since its inception in 1984, because it has the largest market capitalization and an extensive history.

[62] A Cusum test rejects the null hypothesis of a constant relationship between the GPR General World Index and the S&P Index for two observations, namely, 2003 and 2005.

Table OA2

Statistics for the actually used and an alternative real estate index (US$, 1990–2017)

	Compounded return (%)	Standard deviation (%)	Correlation	Average annual difference (%)	Average absolute difference (%)	Maximum annual difference (%)
Actually used index	7.02	19.9	0.89	-1.85	6.13	29.57
Alternative index	8.98	18.7				

The actually used index is the GPR General World Index, and the alternative index is the S&P Global REITs Index.

Before 1973, we use the intrinsic values of our synthetic residential REIT for the United States instead of stock market prices, and, before 1970, we use five stocks for the non-U.S. part of our global real estate index. As stock market prices tend to deviate from intrinsic values and a portfolio of five stocks is usually not optimally equipped to represent an international index, we additionally check the reliability of the return series that we use. Actually, we extend this data check to the whole 1960–1983 period, to also examine our combination of the MSCI Real Estate Index and the FTSE/NAREIT Equity REIT Index that we use until 1983. For all data checks we proceed by comparing the returns that follow from our methodology with returns that become available at a later stage. For this purpose, we extend the return series that we actually use with another 10 years just for comparison purposes.

The columns "Global 1984–1993" and "U.S. 1972–1981" of Table OA3 show the comparison between our combination of the MSCI Real Estate Index and the FTSE/NAREIT Equity REIT Index and the (U.S.-weight-adjusted) GPR General World Index. Over the period 1972–1983, we use the former, and afterward we use the latter. The average annual compounded return differs by 58 basis points (bps). The standard deviations of 28.9% and 26.7%, both of which point to volatile returns, and the series has a high correlation of 0.96. The average difference in absolute annual returns is 6.20 percentage points, whereas the maximum difference is 15.15 percentage points.

We use our synthetic U.S. residential REIT Index from 1960 to 1971 and replace it with the FTSE/NAREIT Equity REIT Index afterward. Their annual compounded returns over the period of 1972–1981 differ by 4.71 percentage points. The correlation of 0.03 shows that annual returns are uncorrelated, a finding that does not come as a surprise, because relatively stable intrinsic values and more volatile stock market prices tend to differ in the short term, but converge over the long term. This is underlined by the standard deviations of 11.0% and 21.2% for synthetic and actual REITs, respectively. Also, the maximum difference in annual returns runs up to 45.38%.

Next, our portfolio of five real estate stocks lags the compounded return of the MSCI Real Estate Index by 3.59 percentage points in the 10-year period after we switch to using the MSCI Real Estate Index. This may seem like a rather large difference, but it is no excessive difference, given the

Table OA3

Comparison of the extended constructed return series and the return series that starts at a later stage

	Mix MSCI RE & FTSE NAREIT	GPR	Synthetic U.S. REIT	FTSE NAREIT Equities REITs	Portfolio of five RE stocks	MSCI RE	Mix synthetic REIT & five stocks	Actual mix MSCI & NAREIT
Region	Global		U.S.		Non-U.S.		Global	
Test period	1984–1993		1972–1981		1970–1979		1972–1979 (8 yr)	
Compounded return (%)	17.67	17.09	16.52	11.82	10.32	13.90	12.31	11.20
Difference (%)		0.58		4.71		-3.59		1.12
Average return (%)	20.81	19.82	16.98	13.70	14.48	19.78	14.14	14.20
Standard deviation (%)	28.9	26.7	11.0	21.2	31.9	37.6	21.6	26.0
Correlation		0.96		0.03		0.92		0.84
Average difference (%)		0.98		3.28		-2.17		-0.06
Avg. absolute difference (%)		6.20		17.38		11.66		10.77
Maximum difference (%)		15.15		45.38		23.42		21.38

We extend the constructed return series that we actually use by 10 years (8 years in the last case) just for comparison purposes. We compare the extended return series with returns from data sources that become available at a later stage.

standard deviations of 31.9% and 37.6%. Moreover, the correlation between the return series is high at 0.92. The maximum difference in annual returns is 23.42 percentage points.

Finally, we examine the series that we use from 1960 to 1969; the series is a combination of our synthetic U.S. REIT and the five real estate stocks.[63] The annual compounded returns differ by only 1.12% with the combination of the MSCI Real Estate Index and the FTSE NAREIT Equity REIT Index. The standard deviation is a little bit lower; the correlation is high at 0.84; and the maximum difference in the annual return is 21.38%.

For all four comparisons we also perform a Cusum test, to examine potential structural breaks in the relationship between the series. Perhaps partially because of the relatively short sample periods of comparison, we do not reject any of the null hypotheses of constancy of the relationship.

The comparison analyses suggest that compounded returns for the global series are similar to the series that we use with their replacement in the decade after the switch. The global series that combines the synthetic U.S. REIT with five international stocks (see the final two columns of Table OA3) benefits from diversification, because it reduces the difference in compounded returns, standard deviations, and the maximum annual return difference compared with both individual series. The differences in compounded real estate returns for the global series could result in a marginal bias of 1 to 2 bps in the compounded return of the market portfolio in the early part of our sample period. Year-on-year differences can be substantial, especially between the intrinsic-value-based and market-based series. Given the average index weight of real estate in our invested market portfolio of 1.4%

[63] We limit this comparison to 8 years. One of the five real estate companies used in our analysis, has its last full year of data in the MSCI books in 1979.

in the sixties, one should take into account that our estimate of the return for the market portfolio can contain a maximum estimation error of around 28 bps in a given year, that is, 1.4% multiplied by 21.38 percentage points. Such potential differences are due to data limitations for real estate.[64] For the subsequent period up to 1982, when the weight of real estate in the market portfolio averages 2.2%, the analysis suggests this maximum to be around 33 bps, that is, 2.2% multiplied by 15.15 percentage points.

As an additional robustness check of our return data based on intrinsic values and five international stocks, we examine the longer-term return figure for the period 1960–1972 by comparing this 13-year period starting in 1960 to all other 13-year periods to ensure estimation errors add to realistic returns. Figure OA2 shows statistical characteristics relative to equities broad, the closest related asset category. The 13-year cumulative (multiplicative) return premium of our global real estate index over equities broad amounts to 51% at the end of 1972. This value is not unusual. The correlation of 0.42 over the period 1960–1972 is at the low end of all observations in our sample period, although we have seen lower correlations for the 13-year periods ending in 2005, 2006, and 2007. Obviously, it seems likely that we underestimated the standard deviation in the period 1960–1972 as it is on the low side over the first 13 years with 0.84 times the standard deviation of equities broad. The average standard deviation for real estate over 13-year periods from 1985 onward (so we do not include any year from the 1960–1972 period) is 1.2 times the standard deviation of equities broad. However, as we have mentioned before, we partly have to use intrinsic values instead of market prices until 1972, so this lower value does not come as a surprise. Finally, Figure OA3 illustrates that the relative total return index of real estate versus equities broad shows a similar picture as the FTSE NAREIT Equity REIT Index versus the S&P 500.

To conclude, both the comparison analyses and the check for the 13-year periods suggest that our estimates for compounded returns fairly reflect the global real estate market in the early part of our sample. The results also show that estimation errors of annual returns can be significant, varying from up to 21% for the methodology we use in the sixties to as high as 15% for the methodology we use in the period until 1983. But these errors only marginally affect the reported annual returns for the invested market portfolio. The reported calendar decade returns for real estate also are likely to be a fair representation because estimation errors cancel out over longer horizons.

[64] Ibbotson et al. (1985), who also estimate real estate returns for this period, report U.S. returns for business real estate. However, these returns are not based on transaction or market prices. For the period 1960–1974, their returns are the sum of a capital gains estimate and an estimated annual rental income. The capital gains estimate is an increase in the building cost index, less a fixed rate of depreciation. The authors do not provide a return estimate for global real estate.

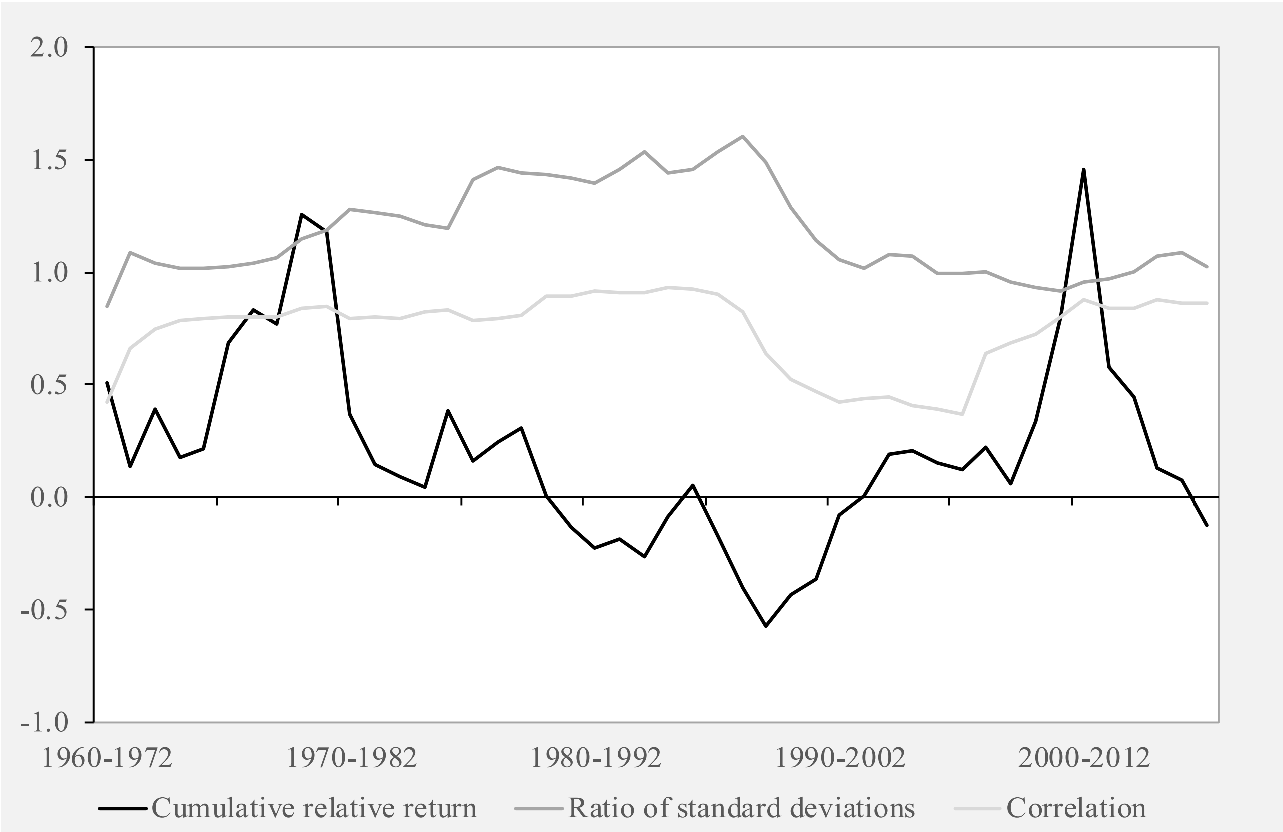

Figure OA2
Real estate versus equities broad
This figure shows the cumulative relative real return of real estate relative to equities broad, the ratio of their standard deviations, and their correlation (data for 13-year periods since year-end 1972).

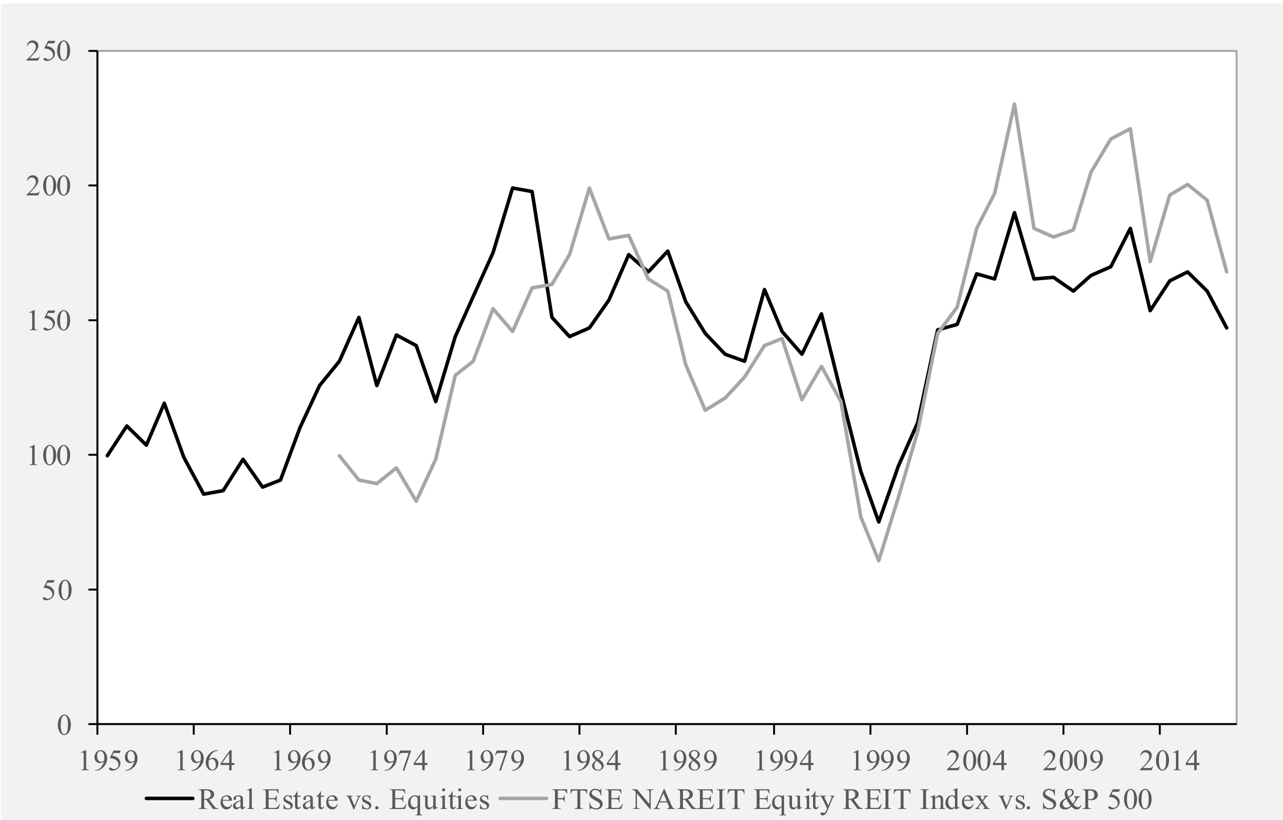

Figure OA3
Relative return index for real estate versus equities, global, and United States only

3. Investment-Grade Credits

For investment-grade credits, we start by comparing the series we use for the period 2001–2017 to an alternative series, which is the extended series that we actually use for the period 1997–2000. Table OA4 shows the results. The compounded returns differ by 17 bps; standard deviations are close to each other; and the maximal absolute difference in annual returns is limited to 1.17%. Here, the Cusum test fails to reject the null hypothesis of a constant relationship between the actual and the alternative index. So the series are quite similar.

Table OA4

Statistics for the actually used and alternative investment-grade credits index (2001–2017)

	Compounded return (%)	Standard deviation (%)	Correlation	Average annual difference (%)	Average absolute difference (%)	Maximum annual difference (%)
Actually used index	5.19	4.9	1.00	-0.18	0.43	1.17
Alternative index	5.36	5.1				

The actually used index is based on the market-capitalization-weighted average return of the Bloomberg Barclays Global Aggregate Corporate Index and the Bloomberg Barclays Global Aggregate Securitized Index, with a free-float correction from 2010. The alternative index is based on the market-capitalization-weighted average return of the ICE BofAML Global Broad Market Corporate Index and the ICE BofAML Global Broad Market Collateralized Index.

As an indicator of the performance of investment-grade credits, we construct an investment-grade corporate bond index from 1960 to 1996. Figure OA4 illustrates the performance of our index at the global level, the U.S. level, and non-U.S. level. Also, it contains the indices for the Ibbotson et al. (1985) study. We are not aware of an index provider or any other study documenting *global* corporate bond returns before 1997.

At global level, for the period 1960–1984, the returns of our index have a correlation of 0.94 to those of Ibbotson et al. (1985), whereas average annual compounded returns are 6.44% and 7.21% . For the United States, we use the Ibbotson et al. (1985) data for the period 1960–1984 and Bloomberg Barclays data afterward.[65] Differences at global level are due to the non-U.S. series. For non-U.S. corporate bonds, we compare our corporate index that we composed for the period 1960–1996 with the Ibbotson et al. (1985) data for the period 1960–1984. The annual compounded returns are 7.17% and 8.35%. Standard deviations are 7.9% and 7.4%, with a correlation of annual returns of 0.89. The average absolute difference in annual returns is 2.6%, with a maximum of 10.1%.

[65] The Bloomberg Barclays U.S. Aggregate Corporate Index starts at the beginning of 1973, so we compare both indices for the period 1973–1984. The Ibbotson et al. (1985) data show a compounded return of 7.96% for that period versus 7.78% for the Bloomberg Barclays data; the return series have a correlation of 1.00; and, at worst, their annual returns differ by 1.50 percentage points, which is low given the standard deviations of annual returns of 12.0% and 12.7%. In short, the return series mirror each other.

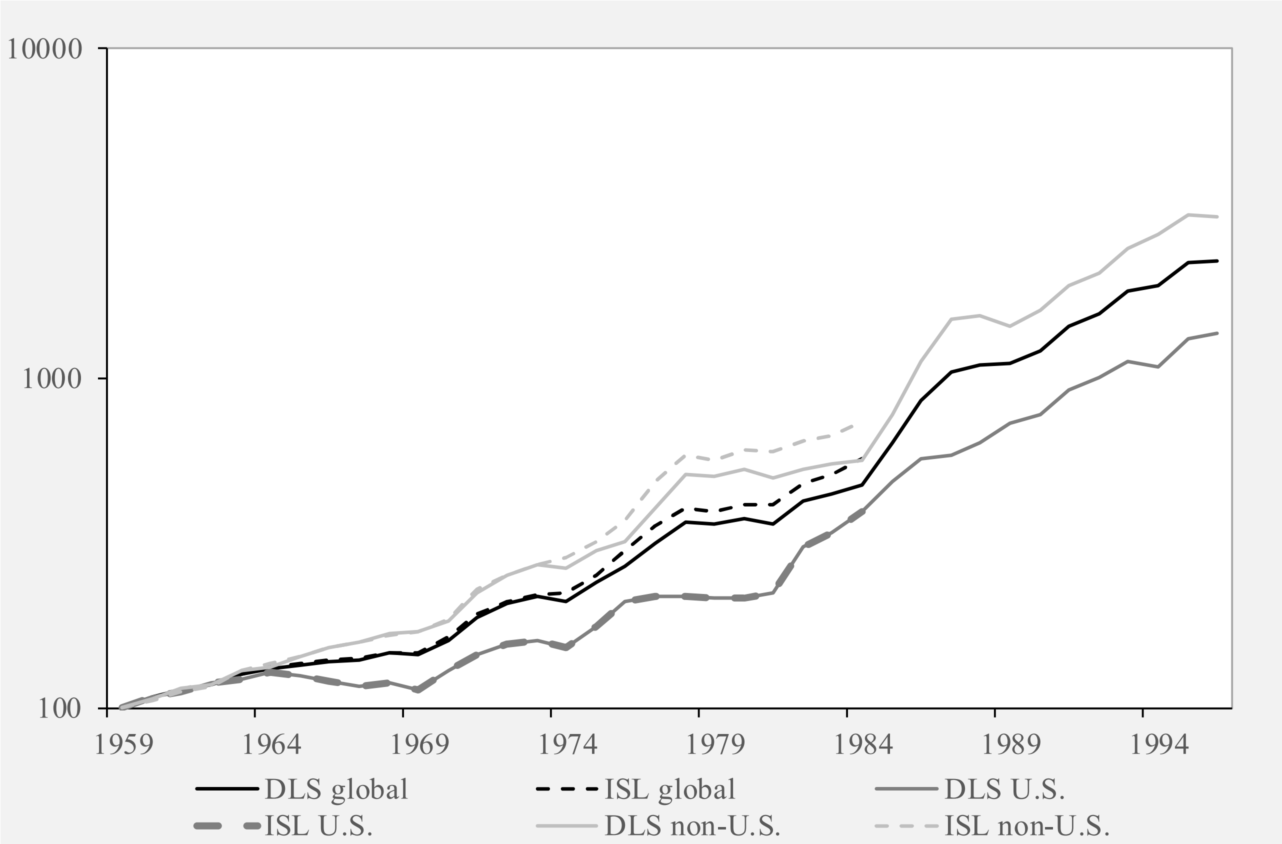

Figure OA4
Total return indices for investment-grade corporate bonds
This graph plots total return indices for investment-grade corporate bonds with data from Doeswijk, Lam, and Swinkels (2014, DLS) and Ibbotson, Siegel, and Love (1985, ISL).

We also examine the total return performance of corporate bonds relative to government bonds for our data set and for Ibbotson et al. (1985). Figure OA5 graphically illustrates the differences. For the period 1960–1984, we report an average compounded default premium of global corporate bonds compared to government bonds of 50 bps a year, whereas Ibbotson et al. (1985) report an outperformance of 123 bps. Both default premium series have a correlation of 0.75. The annual compounded return of U.S. corporate bonds is 25 bps below U.S. government bonds during this period. The standard deviation of annual return premiums is 4.5%. For the non-U.S. region, we report an average compounded return premium of corporate bonds over government bonds of 131 bps a year. Ibbotson et al. (1985) document an annual outperformance of 242 bps. The standard deviations of the annual premiums are 3.8% and 3.4%. The correlations between the annual default premium of corporate bonds in the United States and in the non-U.S. region are 0.10 and 0.09, respectively.

Finally, we examine the global return premium of corporate bonds for the entire sample period of 1960–2017 and for the subsample periods to understand how the return premium has developed. Table OA5 shows that both premiums for the periods 1960–1996 and 1997–2017 are close to the premium of 83 bps for the entire sample period; this finding also applies to the standard deviations of the annual premiums and the correlation between returns on corporate bonds and government

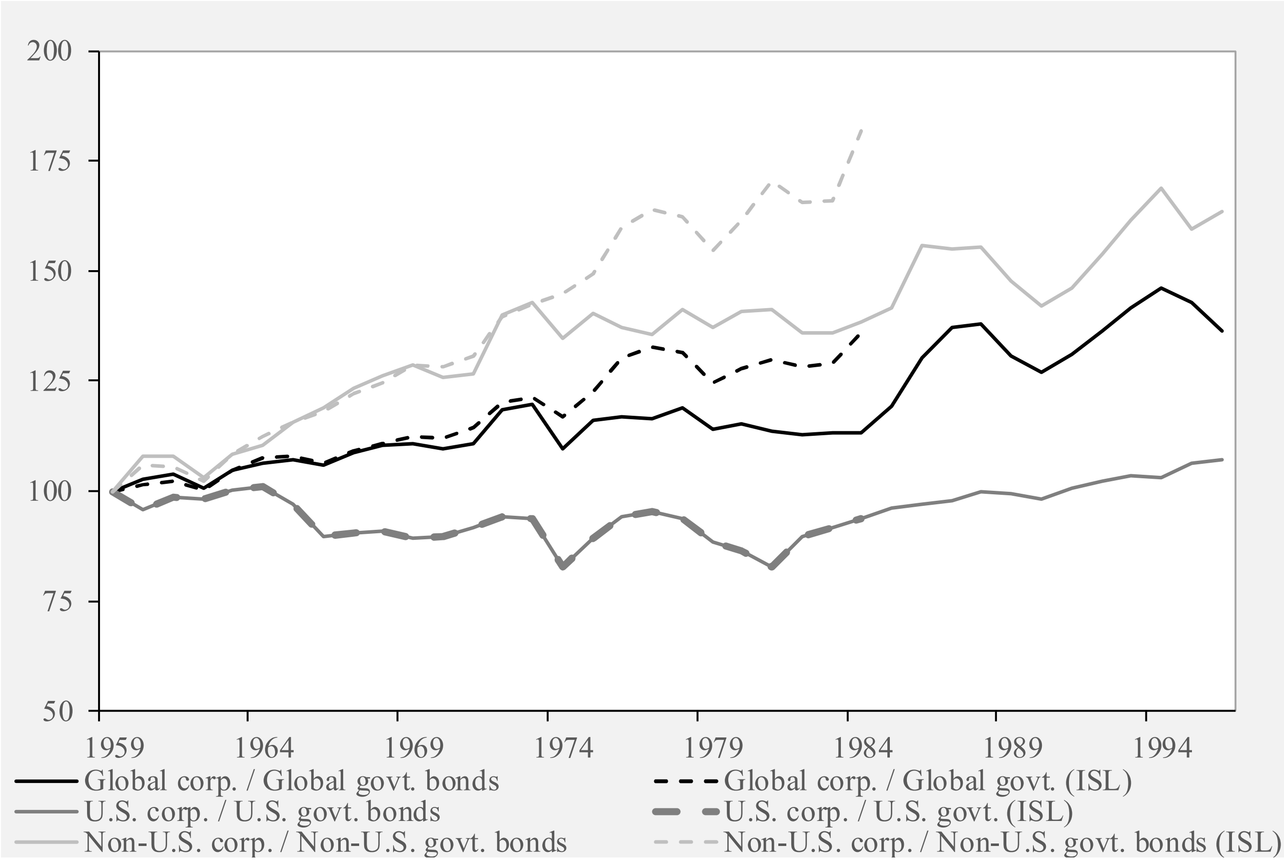

Figure OA5
Investment-grade corporate bonds versus government bonds
This graph plots the total return of investment-grade corporate bonds relative to the total return of government bonds with actually used returns and with returns from Ibbotson, Siegel, and Love (1985). The latter series are labeled ISL.

bonds. When we perform the same check using non-U.S. data from Ibbotson et al. (1985), the premium for 1960–1996 of 137 bps appears to be above the premium of 81 bps for the period 1997–2017, lifting the premium for the total sample period to 114 bps. Standard deviations of the premiums are similar, and the rounded correlations are equal to the ones of the return data we actually use.

We do not know where the differences in non-U.S. corporate bond returns and corporate bonds' default premiums over government bonds arise from. Unfortunately, we do not have source data available for the Ibbotson et al. (1985) study to facilitate a more detailed comparison.[66] However, on balance, we are comfortable with our data. The non-U.S. 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. Also, the non-U.S. premium in our data of 131 bps for the period 1960–1984 is closer to the U.S. premium of -25 bps than for the Ibbotson et al. (1985) non-U.S. data, which results in a 242 bps premium. Finally, in our data set the

[66] As we have indicated before, the authors informed us that the appendix with the data details of Ibbotson et al. (1985), as well as the data, have unfortunately been lost during the past 30 years.

Table OA5
Statistics for the global default premium of investment-grade credits versus government bonds

	Actually used return data			With non-U.S. data from ISL, 1960–1984		
	Annual compounded return (%)	Standard deviation (%)	Correlation credit-gov	Annual compounded return (%)	Standard deviation (%)	Correlation credit-gov
1960-2017	0.83	3.90	0.85	1.14	3.82	0.85
1960-1996	0.86	3.53	0.91	1.37	3.39	0.91
1997-2017	0.81	4.57	0.72	0.81	4.57	0.72
1997-2017, ex 2008/2009	1.00	3.48	0.91	1.00	3.48	0.91

global return premium for both subsamples 1960–1996 (composed series based on OECD data) and 1997–2017 (external data from benchmark providers) are more or less equal to each other at 86 and 81 bps, respectively. However, incorporating non-U.S. data from Ibbotson et al. (1985) for the period 1960–1984 would result in premiums of 137 bps in the subperiod 1960–1996. Our global default premiums in both subperiods are also remarkably similar to the 80 bps default premium estimated by Giesecke et al. (2011) for the United States over the period 1866 to 2008. This underlines the robustness of our corporate bond series.

The arithmetic average real return of our global nongovernment bond series is 3.96%, which is above the unweighted average for the post-1950 period of around 3.3% that we derive from figure 2 in Kuvshinov (2018). However, these values are not that easy to compare. The start dates not only differ—1960 versus 1950—but also the end dates differ—2017 versus a variety of end dates ranging from 1988 to 2016 for the sixteen country series in Kuvshinov (2018). Moreover, we use one market-capitalization-weighted return series to calculate the arithmetic mean, not an unweighted average, across countries. Finally, we report all results in the same base currency, whereas Kuvshinov (2018) uses local currency returns.

4. Government Bonds

As a robustness check we compare the government bond index that we use in this study, composed from several data sources, with an alternative bond index for the period 1978–2017. For the alternative index we compose a global government bond index with country government bond indices from Salomon Brothers for the period 1978 to 1986,[67] which we subsequently complement with the FTSE World Government Bond Index for the period 1987–2017. This way, the use of FTSE data does not overlap with 1985 and 1986 when we actually use the FTSE World Government Bond Index.

[67] We did not find a full description of the indices, but, according to Eun and Resnick (1994), these indices are based on intermediate bonds. The (eight) countries are Canada, France, Germany, Japan, the Netherlands, Switzerland, the United Kingdom, and the United States. We compose a central government debt-weighted index. We calculate government debt with U.S. dollar gross domestic product (GDP) data from the World Bank and central government debt-to-GDP ratios from Reinhart and Rogoff (2010).

We are not aware of international indices or return series that enable us to compose an alternative international government bond index before 1978.[68]

Table OA6 shows that the annual compounded return for the period 1978–2017 is 6.95% for the index we actually use and 7.08% for the alternative index, an arithmetic difference of 13 bps. Standard deviations of annual returns are 8.0% and 8.8%, and the correlation is 0.98. However, differences are larger with our Salomon-Brothers-based global government bond index than with the FTSE World Government Bond Index, as follows from the subsample analyses. The Salomon-Brothers-based government bond index differs from both the Ibbotson et al. (1985) data (which we actually use until 1984) and the FTSE World Government Bond Index (actually used in 1985 and 1986). As an illustration, in 1978 the difference with the actual index of Ibbotson et al. (1985) is 6.7% and in 1985 the difference with the actual index (FTSE) is 5.5%. This suggests that our Salomon-Brothers-based global government bond index might have some limitations in its representativeness of the global bond market, thereby blurring this robustness check. Even though the difference in annual returns can run up to 6.7% in the period 1978–1984, the difference in compounded returns is limited to 55 bps. From 1987, the differences between the actual index we use and the alternative index are marginal. Compounded returns are nearly identical, whereas differences in absolute annual returns average 72 bps, and, at worst, they can reach 247 bps. A Cusum test does not reject the null hypothesis that both series have a constant relationship. To conclude, our government bonds series does not structurally differ from an alternative data source, although the match is clearly better after 1987.

5. Estimation Errors in the Returns of the Market Portfolio

From the previous comparison analyses between the actual indices we use and the alternative indices it appears that, despite annual compounded returns being close together, annual returns can differ. Particularly the maxima of these annual differences stress that our series and those from alternative sources are not identical. However, for the market portfolio, these maximum differences should be mitigated by diversification, because outliers in return differences of different asset classes would unlikely coincide in a same year (and would unlikely also have the same direction). Also, differences in compounded returns should become smaller, because it is likely that they have different directions. Therefore, the returns of the market portfolio should be less sensitive to differences in returns from different data sources, which we label "estimation errors".

[68] The Dimson et al. (2017) database contains a global bond index. However, this index is a GDP-weighted index, which primarily contains bonds with a maturity of around 20 years. Therefore, this index is not suitable for comparison purposes. Dimson et al. (2017) document an annual compounded return of 8.06% for the period 1960–2016, with a standard deviation of 8.8%. For the index we compose, these figures are 6.52% and 7.3%, respectively. The average absolute difference in annual returns is 3.0% with a maximum of 12.6%. The government bond index we compose is market capitalization weighted and is an all-maturity or close to all-maturity index, as we describe in Appendix A.

Table OA6

Statistics for the actually used and alternative global government bond index (1978–2017)

	Compounded return (%)	Standard deviation (%)	Correlation	Average annual difference (%)	Average absolute difference (%)	Maximum annual difference (%)
1978–2017						
Actually used index	6.95	8.0	0.98	-0.19	1.28	6.65
Alternative index	7.08	8.8				
1978–1986						
Actually used index	10.39	9.4	0.96	-0.74	3.22	6.65
Alternative index	10.94	11.5				
1987–2017						
Actually used index	5.97	7.1	0.99	-0.03	0.72	2.47
Alternative index	5.99	7.3				

The actually used index follows from Bloomberg Barclays government bond indices data for the period 1987–2017, the FTSE World Government Bond Index for 1985 and 1986, and Ibbotson et al. (1985) for 1978–1984. For the alternative index we compose a global government bond index with country government bond indices from Salomon Brothers for the period 1978 to 1986, and we subsequently complement the data with the FTSE World Government Bond Index for the period 1987–2017. This way, the use of FTSE data does not overlap with 1985 and 1986 when we actually use the FTSE World Government Bond Index.

As an illustration, for the period 1978–2016, we compare market-capitalization-weighted portfolios with equities and government bonds with, on the one hand, the actual return series that we use in this study and, on the other hand, the alternative return series from other data sources. Hereby, we get an indication of how sensitive the returns of the market portfolio are for estimation errors. These two largest asset classes have an average weight of 75% in the market portfolio during this period. Next, we perform a similar analysis in which we include investment-grade credits as a third asset class for the period 2001–2016. Then these three asset classes have an average weight of 85% in the market portfolio. The start of these subsamples periods is based on the availability of reliable alternative data sources.

Panel A in Table OA7 shows that the compounded return of the portfolio with the actual return series that we use is 9.04% for the period 1978–2016, whereas it is 8.94% for the portfolio based on the alternative returns series. The standard deviations of annual returns are both 12.6%, and they have a correlation is 1.00. The average absolute difference in annual returns is 0.94%, and the maximum difference is 3.50%. However, this outlier is in 1979, when we use the Salomon-Brothers-based global government bond index that might blur the robustness check as discussed before. Excluding 1979, the maximum difference is 2.06%. Most importantly, the estimation errors of equities and government bonds are uncorrelated with a correlation of -0.14, which mitigates estimation errors at the aggregate level. The differences between the compounded returns and the maximal difference in annual returns are indeed smaller for the market portfolio than for the individual asset classes.

Table OA7

Statistics for portfolios with a market-capitalization-weighted asset mix

	Compounded return (%)	Standard deviation (%)	Correlation	Average annual difference (%)	Average absolute difference (%)	Maximum annual difference (%)
A. Portfolios with equities and government bonds (1978–2016)						
Portfolio, actual	9.04	12.6	1.00	0.10	0.94	3.50
Portfolio, alternative	8.94	12.6				
Equities, actual	10.57	17.7	1.00	0.31	1.21	3.78
Equities, alternative	10.28	17.5				
Government bonds, actual	6.92	8.1	0.98	-0.21	1.30	6.65
Government bonds, alternative	7.07	8.9				
B. Portfolios with equities, government bonds, and optionally investment-grade credits (2001–2016)						
Two asset classes portfolio, actual	4.77	13.5	1.00	0.15	0.67	2.04
Two asset classes portfolio, alternative	4.65	13.3				
Three asset classes portfolio, actual	4.78	11.4	1.00	0.07	0.53	1.40
Three asset classes portfolio, alternative	4.73	11.2				
Equities - actual	5.50	20.7	1.00	0.26	0.87	3.14
Equities, alternative	5.29	20.4				
IG credits, actual	5.05	5.0	1.00	-0.22	0.43	1.17
IG credits, alternative	5.26	5.2				
Government bonds, actual	4.32	7.0	1.00	-0.09	0.50	1.24
Government bonds, alternative	4.40	7.3				
C. Portfolio that includes real estate as the fourth asset class (2001–2016)						
Four asset classes portfolio, actual	4.97	11.8	1.00	0.01	0.54	1.32
Four asset classes portfolio, alternative	4.98	11.6				
Real estate, actual	8.95	20.8	0.97	-1.58	3.73	13.09
Real estate, alternative	10.28	21.5				

For market-capitalization-weighted portfolios, we calculate portfolio returns with the actual returns series we used and the alternative return series. In each panel we increase the number of asset classes.

For the other asset classes in our market portfolio, we are not able to conduct similar robustness checks for such an extensive period because of the limited historical data availability of the alternative indices. But we can include investment-grade credits for a shorter period, as show in panel B of Table OA7. The results between the actual return series and the alternative return series are larger for the individual asset classes than for the portfolios. The differences are smallest for the portfolio with three asset classes. Then the difference in compounded returns falls from 12 bps for the portfolio with two asset classes to 6 bps, whereas the maximum difference between annual returns drops from 2.04% to 1.40%. In 13 of the 16 years, the difference in annual returns decreases.

This analysis in panel B does not include all asset classes that make up our asset categories or cover the whole sample period. But, even in the case that estimation errors would be somewhat larger for other asset categories or in earlier periods, these effects also would be mitigated at the aggregate level. Diversification is also in place for the other asset classes. Moreover, that the other asset classes have smaller weights in the market portfolio dampens the effect of estimations errors for the market portfolio.

To illustrate the combined effect of adding smaller asset classes with returns that are surrounded by more uncertainty, on the one hand, and increased diversification, on the other hand, we add real estate to the portfolio as a fourth asset class. The four asset classes have an average weight of 90% in the invested market portfolio from 2001 to 2016. However, as we have discussed before, no other real estate index has a long-term history and a market capitalization like the GPR index. This somewhat hinders the comparison of an index with the GPR. Panel C of Table OA7 illustrates the comparison. For the period 2001–2016, the annual compounded returns for real estate differ by 133 bps between both indices. But, more importantly, the maximum absolute difference in annual returns is 13.09%. That is not the only outlier in the 16-year period; other years show differences of 10.73% and 8.33%.[69] Despite the divergent characteristics of the two real estate indices, the two portfolios with four asset classes with actual return series and alternative return series are even closer together than are the portfolios with three asset classes. Again, the estimation errors between the actual and the alternative return series are uncorrelated for the asset classes, with an average correlation of 0.07. The difference in compounded returns drops from 5 bps to 1 bp, and the maximum difference in annual returns decreases from 1.40 percentage points to 1.32 percentage points.[70]

The above exercise suggests that at the aggregate level the estimation error in the annual compounded return might be smaller than 10 bps, whereas outliers in estimation errors for annual returns might be limited to well within 2 percentage points. Therefore, we conclude that estimation errors in compounded returns of the market portfolio seem to be marginal.[71] Estimation errors in annual returns are small when related to the standard deviation of annual returns. Cusum tests on the relation between the actual and the alternative multiasset portfolios with two, three, or four asset classes do not reject the null hypotheses, further indicating that both series have a constant relationship.

Finally, we point out two reasons the estimation errors are conservative. First, in the comparison analyses, we use alternative indices that in some cases seem to be less suitable for the purpose of using it in this study. For example, the alternative government bond index for the period 1978–1986 or the alternative real estate index for almost the entire period. Second, we label the whole difference an estimation error. Doing so assumes that the alternative index contains the true returns. This is

[69] These results look similar to those from for our real estate methodology up to 1983, as we discussed earlier in this appendix. The difference is that compounded returns in our test differed less, whereas maximum differences in annual returns were larger.

[70] Although we do not discuss other small asset classes in this appendix as they do not have a decades-long history of alternative indices available, we also performed this same analysis, including alternative indices for high-yield and inflation-linked bonds from ICE BofAML. The portfolios with six asset classes also have a 1-bp difference in compounded returns. The maximum difference in annual returns slightly falls from 1.32 percentage points to 1.30 percentage points. For emerging market debt and commodities, no alternative market-capitalization-weighted indices are available that cover the whole asset class.

[71] We use the estimation errors of the multiasset portfolios as an indication for the uncertainty surrounding the returns of the market portfolio, although we cannot perform comparison analyses over the entire sample period for asset classes other than equities. This is because of a lack of alternative return series.

highly unlikely. In cases in which the alternative index has good market coverage, the estimation error is on average likely to be around half the difference, as the true returns are likely to be close to the middle between the two estimates. For indexes with poorer coverage, it is more likely that our estimate is closer to the truth than the alternative. So the figures we mention regarding the estimation errors are conservative.

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