# The Global Multi-Asset Market Portfolio 1959-2012

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**Abstract**

The global multi-asset market portfolio contains important information for strategic asset-allocation purposes. First, it shows the relative value of all asset classes according to the global financial investment community, which one could interpret as a natural benchmark for financial investors. Second, this portfolio may also serve as the starting point for investors who use a framework in the spirit of Black and Litterman (1992), or for investors who follow adaptive asset-allocation policies as advocated by Sharpe (2010). We estimate the invested global market portfolio for the period 1990-2012 by estimating the market capitalization for the eight asset classes: equities, private equity, real estate, high-yield bonds, emerging-market debt, investment-grade credits, government bonds and inflation-linked bonds. For the main asset categories - equities, real estate, non-government bonds and government bonds - we extend the period to 1959-2012. We provide these annual historical estimates in tabular form so that practitioners and academics can easily use these historical data going forward. Next, we compare the asset allocations of institutional global investors to the market portfolio. To our knowledge, we are the first to document the global multi-asset market portfolio at these levels of detail for such a long period of time.

JEL classification: G11, G12

Key words: *strategic asset allocation, optimal portfolio, global multi-asset market portfolio*

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# 1. Introduction

In this paper, we contribute to the literature by documenting the invested global multi-asset market portfolio. This portfolio is the aggregate portfolio of all investors, where portfolio weights indicate the constitution of the average portfolio. It contains important information, as it represents the views of the global financial investment community with respect to the pricing of each asset class. Hence, it can serve as a benchmark for the strategic asset allocation of investors. As Sharpe (2010) advocates, the market portfolio can also be used as a starting point for portfolio construction.

An important application of the global multi-asset market portfolio lies in the Black and Litterman (1992) asset-allocation framework. Practitioners using this framework need the market portfolio to derive the expected returns implicitly priced-in by all market participants by reverse engineering the mean-variance optimization problem. In the next step, investors can express their own views and corresponding uncertainty to determine their optimal asset allocation. In addition, investors employing tactical asset-allocation strategies might use large deviations from long-term average market portfolio weights as a valuation indicator. But, aside from these practical considerations, the market portfolio is also interesting from a theoretical perspective.

The Capital Asset Pricing Model states that each investor should invest in exactly the same portfolio of risky assets, the market portfolio. How much is invested in the market portfolio depends on the amount of risk an investor is prepared to take. The CAPM is frequently used in modern-day finance to advocate passive index investing, see Goltz and Le Sourd (2011). An important application of our study is to determine the strategic asset-allocation weights of a CAPM investor who targets investing according to market capitalizations. As Rudd and Rosenberg (1980) have already indicated, it is useful in an environment of asset management to construct an invested market index.[1] This is the aim of our study, as we document the global invested multi-asset market portfolio. This does not imply that this market portfolio has been the optimal portfolio in practice. Asness, Frazzini and Pedersen (2012) indicate that assuming leverage aversion, the tangency portfolio formed on the idea of risk parity between asset classes leads to a higher risk-adjusted return than the market portfolio.

[1] Although the CAPM assumes that the market portfolio consists of invested and non-invested assets, both Rosenberg (1981) and Stambaugh (1982) recommend using the invested market portfolio in empirical applications to test the CAPM. Nevertheless, Athanasoulis and Shiller (2000) develop a theoretical model in which they show that making these non-traded assets tradable would increase social welfare.

In our study we distinguish eight established asset classes: equities, private equity, listed and unlisted real estate, high-yield bonds, emerging-market debt, investment-grade credits, government bonds and inflation-linked bonds.[2] These days, investors have easy access to these asset classes through mutual funds or index funds. In addition to providing an estimate of the world market portfolio for the end of 2012, we track the market portfolio for these eight asset classes over the period 1990 to 2012. For the four main asset classes - equities, real estate, non-government bonds and government bonds - we even extend the period back to 1959. To our knowledge, we are the first to document the global market portfolio at these levels of detail for such a long period of time.

We focus on the *invested* market portfolio. The invested portfolio contains all assets in which financial investors have actually invested. So we exclude durable consumption goods, human capital, private housing and family businesses, for example. The presence of an asset in the benchmark of leading index providers is generally an important criterion. We focus on the invested portfolio because we try to assess the aggregate portfolio of all financial investors, which can serve as a reference for strategic asset-allocation purposes. Our study differs from studies like Ibbotson and Siegel (1983), Ibbotson, Siegel and Love (1985) and Roxburgh, Lund and Piotrowski (2011) in the sense that we only include financial assets that are available to the general public.

Composing the historical market portfolio is a non-trivial exercise, as invested market capitalizations are not readily available for each of these asset classes over this historical period. Our experience is in this sense similar to Sharpe's (2010), in which he states: "*First and foremost, more data will need to be made available about the market values of the securities in each of the benchmarks designed to represent major asset classes. (…) Recent and historical monthly* returns *for most popular indices may be difficult but not impossible to obtain from such providers. But obtaining data for the* market values *of the securities in an index is much harder.*". We present the outcome of our efforts to obtain these data, and explain the procedure used to obtain them in Appendix I of this article. Where possible, our data come from leading index providers, whose indexes are often used as a benchmark for mutual funds or exchange-traded funds. In Appendix II, we also provide our annual historical estimates in

[2] Several other researchers have set out to use the invested market portfolio as a starting point for strategic asset allocation. For example, Brinson, Diermeier and Schlarbaum (1986) first develop an invested market-capitalization weighted benchmark for pension plans that contains nine asset classes: domestic large-cap equities, domestic small-cap equities, international equities, venture capital, domestic bonds, international dollar bonds, non-dollar bonds, real estate, and cash equivalents. In a second step, they improve upon the invested market-capitalization benchmark by constructing a mean-variance-efficient portfolio. Another example is Bekkers, Doeswijk and Lam (2009), who distinguish a wide range of global asset classes simultaneously in a mean-variance analysis and a market-portfolio approach, as well as a combination of both.

tabular form so that practitioners and academics can easily use these historical data for applications or future research.

While we are aware that our point estimates on the historical market portfolio are surrounded by uncertainty, we find indications that our data represent a good estimate. We backfill our data to 1984 and then append it to data from the study by Ibbotson, Siegel and Love (1985) to get back to 1959. It appears that our estimate for 1984 comes very close to their estimate of 1984, which indicates that our backfilling produces a realistic estimate for 1984. Also, a comparison of the weights of our 1985-2012 global market portfolio with the 1959-1984 estimates of the US market portfolio from Ibbotson, Siegel and Love (1985) suggests that our estimates make economic sense. Finally, in Appendix III we perform a robustness check with data from alternative data providers, which does not materially impact our estimates.

In the remainder of this study we first discuss the current market portfolio and follow this with a detailed analysis of the period 1990-2012 for eight asset classes. We then show the market portfolio for the four main asset classes for the period 1959-2012. Finally, we provide an overview of recent portfolio compositions of pension funds, sovereign wealth funds and endowments, to obtain an indication of the degree to which their allocation is a reflection of the market portfolio.

## 2. The global market portfolio 2012

In Appendix I we describe our data sources and methodology in detail. Here, once again, we stress that we focus on the *invested* market portfolio. This portfolio is the opportunity set that is available to financial investors.

Figure 1 displays the global market portfolio at the end of 2012. We estimate the total market capitalization of the invested global multi-asset market portfolio at USD 90.6 trillion at the end of 2012. Equities represent the largest asset class with a market value of USD 32.9 trillion, or 36.3% of the total market capitalization of all asset classes. Government bonds follow with USD 26.7 trillion, which equals 29.5% of the market portfolio. Investment grade credits, primarily consisting of corporate bonds and mortgage-backed securities, are worth USD 16.8 trillion or 18.5%. All other asset categories are relatively small compared to these three asset classes. They vary from USD 1.5 trillion

(1.7%) for high yield to USD 4.6 trillion (5.1%) for real estate. The market capitalization of these five relatively small asset categories adds up to USD 14.1 trillion (15.6%).[3, 4]

Our estimate for equities is in line with the study by Idzorek, Barad and Meier (2007). They estimate the market capitalization of equities to add up to USD 29.1 trillion in their market-value approach, which is in between our 2005 year-end estimate of USD 28.4 trillion and the USD 33.7 trillion figure for 2006.[5] Also, the MSCI data we use closely resemble market-capitalization data from FTSE.[6]

Idzorek, Barad and Meier (2007) estimate the combined market value of government bonds and investment-grade credits at USD 21.4 trillion, close to our 2005 and 2006 estimates of USD 21.6 and USD 23.6 trillion respectively. Our estimate for government bonds compares reasonably well to data from other index providers.[7] The 2012 global estimate for treasuries from JP Morgan is USD 23.1 trillion, which is in line with the USD 23.4 trillion amount of treasuries included by Barclays Capital. Barclays Capital's figure of 26.7 trillion is for government bonds, which also contains bonds from agencies and local authorities. The 2012 government-bonds estimate from Bank of America Merrill Lynch is USD 24.7 trillion. This is somewhat below our USD 26.7 trillion figure for government bonds obtained from Barclays Capital. The Bank of America Merrill Lynch estimate for non-sovereign large-cap high-grade credits is USD 1.9 trillion above the USD 16.8 trillion estimate of Barclays Capital for investment-grade credits that we use. These comparisons indicate that our estimates are robust for different index providers, but there is some uncertainty associated with the point estimates that we report. We present two validity checks on our market portfolio in the next two sections.

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[3] Here we do not take hedge funds into account. One could argue that hedge funds are not an asset class, but a group of active trading strategies. Also, double counting would take place as hedge funds invest in assets described in this section, next to derivatives that we disregard, as the net position in derivatives is zero by definition. To obtain an understanding of the size of hedge funds, we refer to data from Hedge Fund Research which show that (unlevered) assets under management at the end of 2012 amounted to USD 2.3 trillion. This figure represents 2.5% of the total global market portfolio.

[4] We also leave commodities out of the equation. A large part of commodity investing takes place through futures. As mentioned before, the net position in derivatives is zero. To the extent that long positions in futures are provided through commodity producers who fix their prices for future deliveries, one could see these future positions as a net long position for financial investors. But, following this reasoning, manufacturing companies that want to fix their commodities input prices provide short positions for investors. So the true position of investors is hard to grasp. Cooper, Luo, Norrish, Corsi and Staal (2013) estimate the assets under management in commodities at USD 424 billion at the end of 2012 based on the size of commodity-index swaps, exchange- traded products and medium-term notes. This figure represents 0.5% of the total global market portfolio. Erb and Harvey (2013) estimate that investors (as defined by the World Gold Council) hold about USD 1.8 trillion in physical gold, which would be approximately 2% of the market portfolio.

[5] Unfortunately, Idzorek, Barad and Meier (2007) do not explicitly mention whether their estimate is based on year end 2005, year end 2006, or an intermediate date.

[6] To illustrate this, MSCI 2012 market-capitalization data is 3% (USD 1.2 trillion) below the FTSE Global All Cap data, factoring in a correction for the presence of REITs, which we classify in the real-estate asset class. We use MSCI data, as they go back further in time.

[7] Note that all index providers impose certain investability requirements before bonds are included. For example, there are minimum issue sizes; in most cases the bonds are required to have at least one credit rating; their remaining maturity should be above one year; and the bonds should be publicly issued.

We now have a static estimate of the global multi-asset market portfolio. An estimate over a long period of time can provide insight into the dynamics of the market portfolio. These dynamics show the range and the volatility of historical asset-class weights. Such a reference might be useful in determining investors' own strategic asset weights. Next, tactical asset-allocation strategies might use large deviations from long-term average market portfolio weights as a valuation indicator. In the next two sections we discuss the historical dynamics of the market portfolio. First, we document the market portfolio for a range of eight asset classes over the 23-year period 1990-2012. Then we extend the analysis to the 54-year period 1959-2012 for the four main asset classes.

## 3. The global market portfolio 1990-2012

For the period 1990-2012 we have collected market-capitalization data for all eight asset classes. The further we go back in time, the less trivial it is to construct market capitalizations from standard data sources. A potential challenge is that several index providers did not cover as many assets historically as they do today. This could imply that the historical market portfolio weights are biased. On the other hand, the lower coverage of data providers in the past could also be related to the lower investability of some of the asset classes. This would not bias our invested market portfolio weights if we assume that the coverage by data sources grows at the same rate. Admittedly, this is a strong assumption. However, since index providers tended to put more effort into covering the market as benchmarks gained importance during the sample period, it seems reasonable to suppose that all asset classes are subject to an increased coverage.

As a reality check on the quality of our data, we try to establish whether the portfolio weights obtained through our data sources and methodology lead to reasonable outcomes. Therefore, we compare our estimated global market portfolio weights for the four main categories - equities, real estate, government bonds and non-government bonds - over the period 1985-2012 with the estimates of the US market portfolio by Ibbotson, Siegel and Love (1985) for the period 1959-1984. This comparison supposes that the market portfolio weights of these four main asset classes should resemble each other to some degree in two sub-periods during the 54-year sample period. With such a horizon one could argue this should be the case as (1) the liabilities side of corporate balance sheets from listed companies usually contains bonds and shareholders' equity, which are both available to investors, (2) the enterprise value of companies is related to the size of the economy, while the size of debt and the debt capacity of governments is related to the size of the economy and (3) the value of real estate is

also connected to the size of the economy. For example, we would be puzzled if this analysis showed that all four main categories have roughly equal weights in the first sub-period on average, while the second sub-period shows major differences between asset-class weights.

For the comparison, we prefer to use the US estimates of Ibbotson, Siegel and Love (1985) for the period 1959-1984 instead of their global estimates. This enables us to incorporate real estate in the reality check, as they do not provide estimates for real estate outside the US. For this purpose, we have extended our estimates for these four categories back to 1985, as described in Appendix I. A data extension before 1990 is also needed to compose data series for the four main asset categories from 1959 to 2012 that we discuss in the next section.

As Table 1 shows, our estimate for the average weight of global stocks in the period 1985-2012 (51.1%) is roughly 10% below the estimated weight of stocks in a US portfolio for the period 1959-1984 (61.0%).[8] For each of the other three asset classes, our estimates are somewhat higher. The weight of real estate relative to stocks and the weight of non-government bonds relative to government bonds closely resemble each other. The value of global real estate equals 8.7% of global stocks in 1985-2011. For the US this is 6.7% for the period 1959-1984. On average, the value of global non-government bonds is 50.3% relative to government bonds in the period 1985-2012, while this is 54.9% in the US from 1959 to 1984. Hence, a comparison of the weights of our global market portfolio with historical estimates on the US market suggests that our estimates make economic sense.

Figure 2 shows the global market portfolio from 1990 to 2012. The general picture is a declining weight for equities to the benefit of other asset classes, especially investment-grade credits. Equities fall from a 51.6% weight at the end of 1990 to 36.3% in 2012. Investment-grade credits rise from 11.4% to 18.5%. Next, private equity grows 2.7 percentage points to 3.6%. The weight of real estate, high-yield bonds, emerging-market debt and inflation-linked bonds rises between 1.0% and 2.2% to end-of-period weights between 1.7% and 5.1%. The total weight of the relatively small asset classes - anything other than stocks, investment-grade credits and government bonds - rises from 6.2% to 15.6% throughout the period 1990-2012. As indicated in the introduction, we checked whether the

[8] We divide the Ibbotson, Siegel and Love (1985) estimate for the value of business real estate by four to arrive at a proxy for the equity component of invested real estate, see the appendix. Next, Ibbotson et al. (1985) label corporate issued bonds corporate bonds, whereas we use the term non-government bonds for investment-grade corporate bonds, as this asset class also comprises mortgage-backed securities, as well as a minor weight of other asset-backed securities. We separately distinguish high-yield bonds, which we add here to non-government bonds for comparison with Ibbotson et al. (1985) data. Here, we add emerging debt and inflation-linked bonds to government bonds.

estimated weights are robust for data from alternative data providers in Appendix III. This check suggests that there is some uncertainty in the point estimates of the weights in the invested market portfolio, but using alternative sources results only in small deviations.

Figure 3 contains the estimated market values in absolute numbers in billions of US dollars. The global market portfolio in 1990 amounted to approximately USD 11 trillion; USD 38 trillion in 2000; and USD 91 trillion in 2012. These figures should be taken as a rough indication. On the assumption that the coverage of the data sources for all market segments grows at the same rate, the relative data are completely accurate. But, with increasing market coverage, absolute data underestimate the market capitalization in 1990 more than in the years thereafter. To illustrate this: suppose market coverage for all asset classes grows one percentage point a year from 76% in 1990 to 98% in 2012, then the global market portfolio in 1990 would have been USD 14 trillion instead of USD 11 trillion.

## 4. The global market portfolio 1959-2012

We determine the global market portfolio for the 54-year period 1959-2012 for the four main asset categories - equities, real estate, non-government bonds and government bonds. Here, we include high-yield bonds and investment-grade credits in the category non-government bonds, while we now classify emerging-market debt and inflation-linked bonds within government bonds. Private equity is not included in this analysis. We use the Ibbotson, Siegel and Love (1985) world market capitalizations data to show how the international financial markets developed from 1959 to 1984. As they do not provide data for real estate outside the US, we use their US estimates for business real estate to derive our global estimate of the market capitalization of invested commercial real estate.[9]

Before moving on, we will take a closer look at 1984, the year at which we merge the two datasets together. Table 2 shows the relative portfolio weights in 1984 for the world from Ibbotson, Siegel and Love (1985) and our global estimate.[10] Note that we cannot include real estate in this check, as they do

[9] It is possible that we underestimate the weight of real estate. We estimate the global weight of real estate at 2.2% in 1984, while Ibbotson, Siegel and Love (1985) end up with an estimated weight of real estate in the US of 4.3% in 1984. While we are aware that backfilling global data for real estate over the period 1959-1983 with US data might introduce a bias into our data, the US market was then the largest real-estate market in the world. In addition, real estate is an asset class that has a small weight in the market portfolio. So the impact of a bias would be limited for the total market portfolio.

[10] Note again that here we sum emerging-market debt, inflation-linked bonds and government bonds for the period 1984-2012 to arrive at an estimated weight for (more broadly defined) government bonds in the market portfolio. See our earlier remarks.

not include estimates for real estate outside the US. The data resemble each other, with differences in portfolio weights in 1984 for all three asset classes limited to a maximum of 2.5 percentage points.

Figure 4 shows the weightings of asset classes in the global market portfolio from 1959 to 2012. We refer to Appendix II for the underlying data for this figure. We use the annual percentage change in the market capitalization data from Ibbotson, Siegel and Love (1985) to backfill our 1984 estimates. During the 1959-2012 period, the weight of stocks declined 13.5 percentage points from 51.2% to 37.7%, as illustrated in Table 3. The weight of equities in 2012 is close to the record low in 2011 of 37.1%. In 2011, for the first time in our sample period, equities no longer outweighed government bonds. The maximum weight for equities was 64.0% in 1968. The weight in 1999 of 63.2% comes close to this maximum. The period average for equities is 52.0%. In 2012, at the end of the sample period, the weighting of 37.7% is 14.3 percentage points below this average.

On balance, the other three main asset categories are subject to a smaller change in portfolio weight during the sample period than equities. Also, their current weightings are closer to the period average than equities. During the sample period, the weighting for government bonds rises 6.4 percentage points from 29.7% to 36.1%, close to their 37.4% high in 1982. In 2012, their weight is 6.4% above the average of 29.6%. Non-government bonds increase 3.2 percentage points in weight from 17.7% in 1959 to 20.9% in 2012. At the end of the sample period, their weight is 5.8 percentage points ahead of their period average of 15.1%. Finally, the weight of real estate rises from 1.4% to 5.3% during the sample period, while the 5.3% weight in 2012 is 2.1% above the period average of 3.2%. However, as we have indicated before, it is possible that we underestimate the weight of real estate before 1984. Therefore, the weight in 2012 could well be closer to its average than these data suggest.

## 5. Strategic asset allocations of institutional global investors

At an aggregated level, all financial investors hold the market portfolio that we described in the previous sections. In this section, we analyze the strategic asset allocations of several groups of investors and compare these to the market portfolio. As the classification of assets is not completely identical for all sources, this is an indicative analysis.

Table 4 shows that pension funds are the largest group of institutional investors. Their assets under management were USD 21 trillion in 2011. This amount equals 26% of the value of the total invested market portfolio. The first part of Table 4 shows the asset allocations of pension funds in several large

countries, and the global average, as estimated by the OECD. It can be seen that the pension funds in Germany and Japan are typically underexposed to the equity markets, relative to the world market portfolio. They seem to be allocated more heavily to alternative assets or structured products, designated 'Other'. Pension funds in the UK and US have 45-48% exposure to the equity markets, with the remaining part invested in bonds or alternative assets. The global average allocation to equities comes in at 41% for 2011, above but close to the weight of 36% in the market portfolio.[11] Bonds (broadly defined by the OECD, but excluding investments in loans) represent 39% in total global pension funds' assets, which is below the corresponding figure of 56% for the market portfolio. The allocation to bonds seems low compared to the market portfolio. However, they may use fixed-income derivatives to increase that exposure; for example, for liability-hedging purposes. Our data do not include these derivatives exposures because the total net position in derivatives is zero.

Sovereign wealth funds are the second category in Table 4. We display the three funds that are believed to be among the largest in the world according to the Sovereign Wealth Fund Institute. Their allocations to equities tend to be higher than the average allocation of pension funds, at the expense of bonds. The China Investment Corporation has a relatively larger position in the category "Other" due to their "long-term investments", which does not seem to include public equities or public bonds, as those are separate categories. The final line in Table 4 shows that the strategic asset allocation of all endowments together contains substantially more alternative assets and fewer bonds than the market portfolio. As can be seen in the last column of table 4, the assets under management of sovereign wealth funds and endowments are relatively small compared to the size of the market portfolio.

## 6. Summary

The invested global multi-asset market portfolio is the aggregated portfolio of all investors, where portfolio weights indicate the constitution of the average portfolio. It contains important information, as it represents the views of the global financial investment community with respect to the pricing of each asset class. Hence, it can serve as a benchmark for the strategic asset allocation of investors. The market portfolio can also be used as a starting point for portfolio construction.

[11] Here we refer to the weight we derived in our 1990-2012 section based on the analysis with eight asset classes. The analysis with four main aggregated asset classes for the period 1959-2012 does not include private equity. Excluding private equity in the analysis, the weight of equities is 37.1% in 2011.

We focus on the invested global multi-asset market portfolio, which is relevant to financial investors. For the period 1990-2012 we determine the market capitalizations of eight asset classes: equities, private equity, real estate, high yield bonds, emerging market debt, investment grade credits, government bonds and inflation-linked bonds. At the end of 2012, we estimate the total market capitalization of the invested global multi-asset market portfolio at USD 90.6 trillion. Equities (36.3%) represent the largest asset class, followed by government bonds (29.5%). Investment-grade credits (18.5%) are also a major asset class. The market capitalization of the other five asset categories (15.6%) is relatively small. But, the total weight of the relatively small asset classes increased from 6.2% to 15.6% during the period 1990-2012.

For the four main asset categories - equities, real estate, non-government bonds (investment-grade credits and high-yield bonds) and government bonds (now more broadly defined and also including inflation-linked bonds and emerging-market debt) - we compile data series for the period 1959-2012. Here we do not take private equity into account. At the end of 2012, the market portfolio weights for these four main categories are 37.7%, 5.3%, 20.9% and 36.1% respectively, with 54-year period averages at 52.0%, 3.2%, 15.1% and 29.6% respectively. The weight of equities in 2012 is close to the record low in 2011 of 37.1%. In 2011, for the first time in our sample period, equities no longer outweighed government bonds.

We show that pension funds have an allocation to equities that is a little above the market portfolio. The sovereign wealth funds in our sample tend to allocate more to equities while endowments allocate more to alternative assets than is warranted by their weights in the market portfolio. Their allocation to bonds falls short of the market portfolio's weight of bonds.

The development of this new historical database on the global multi-asset market portfolio has important applications for strategic asset allocation in practice. Moreover, our study might serve as a fruitful resource for future research in this field. We hope this article sparks new applications, both theoretical as well as empirical.

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**Figure 1. Global market portfolio at the end of 2012 (USD trillion and as %)**

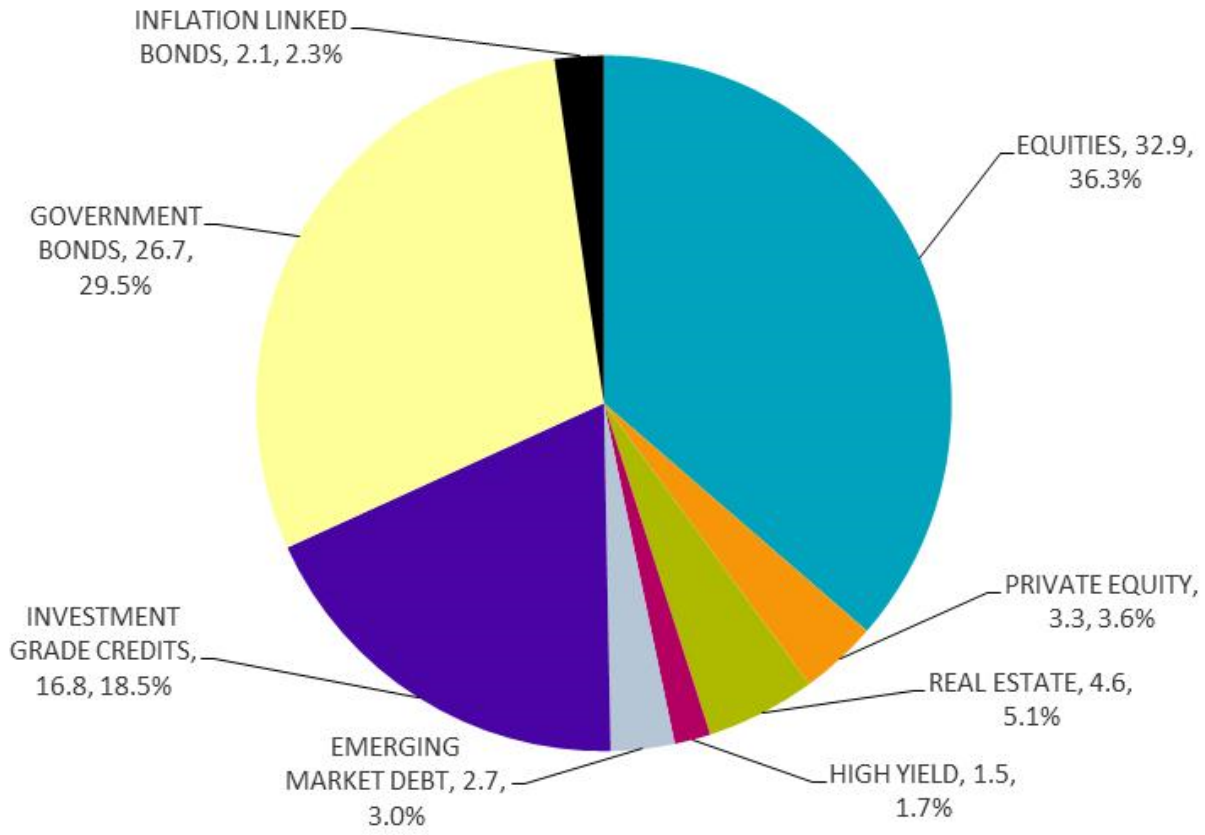


**Figure 2. Global market portfolio over the period 1990-2012 (%)**

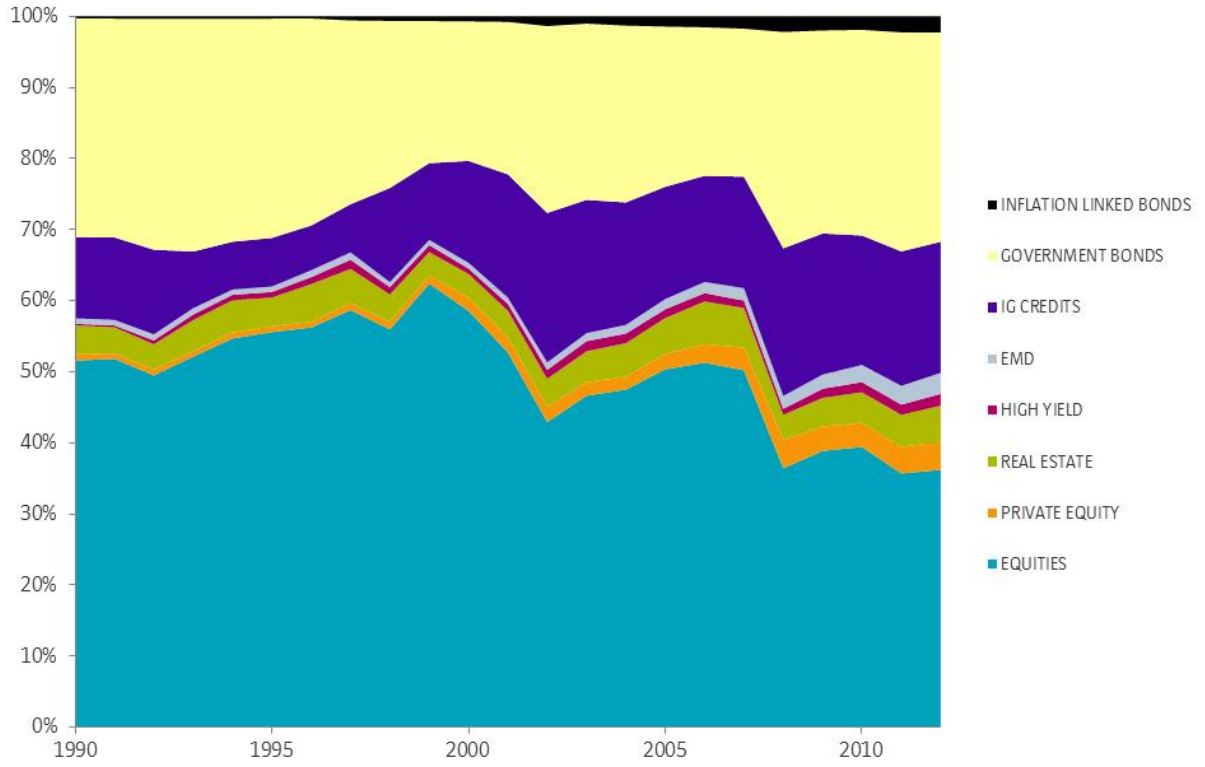


**Figure 3. Global market portfolio over the period 1990-2012 (USD billion)**

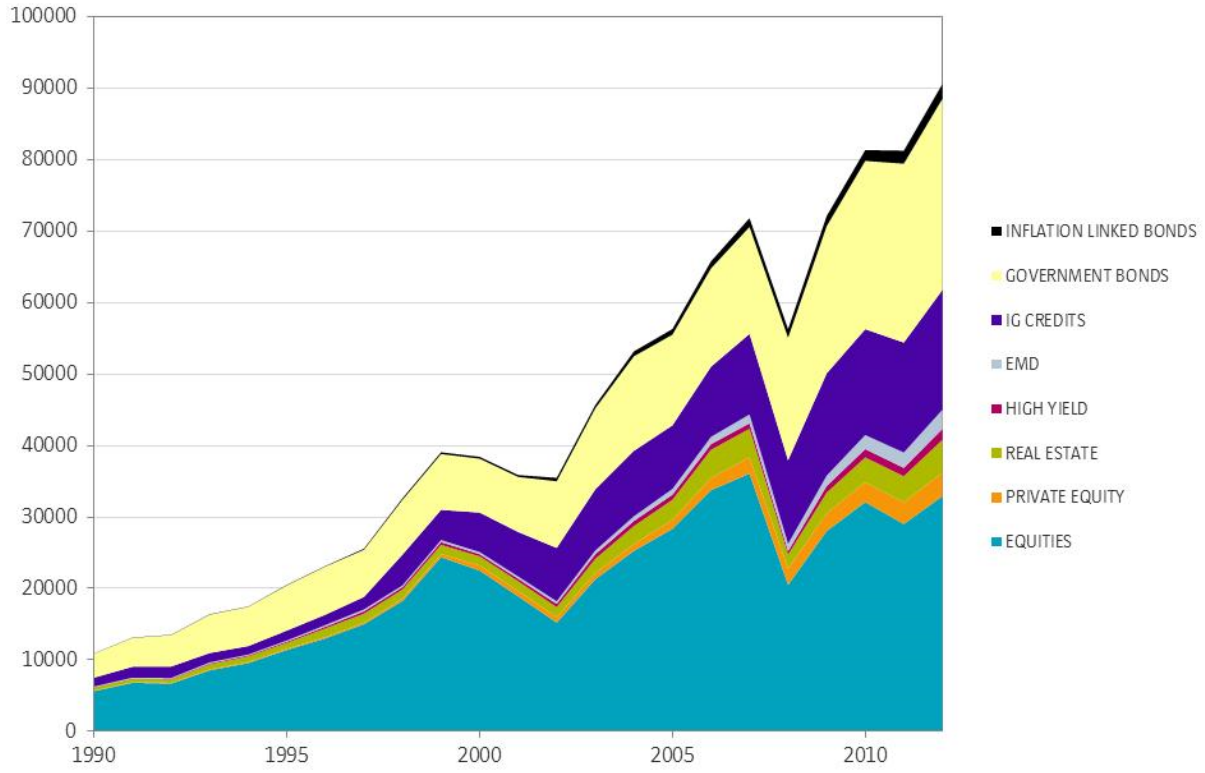


**Figure 4. Global market portfolio over the period 1959-2012 (%)**

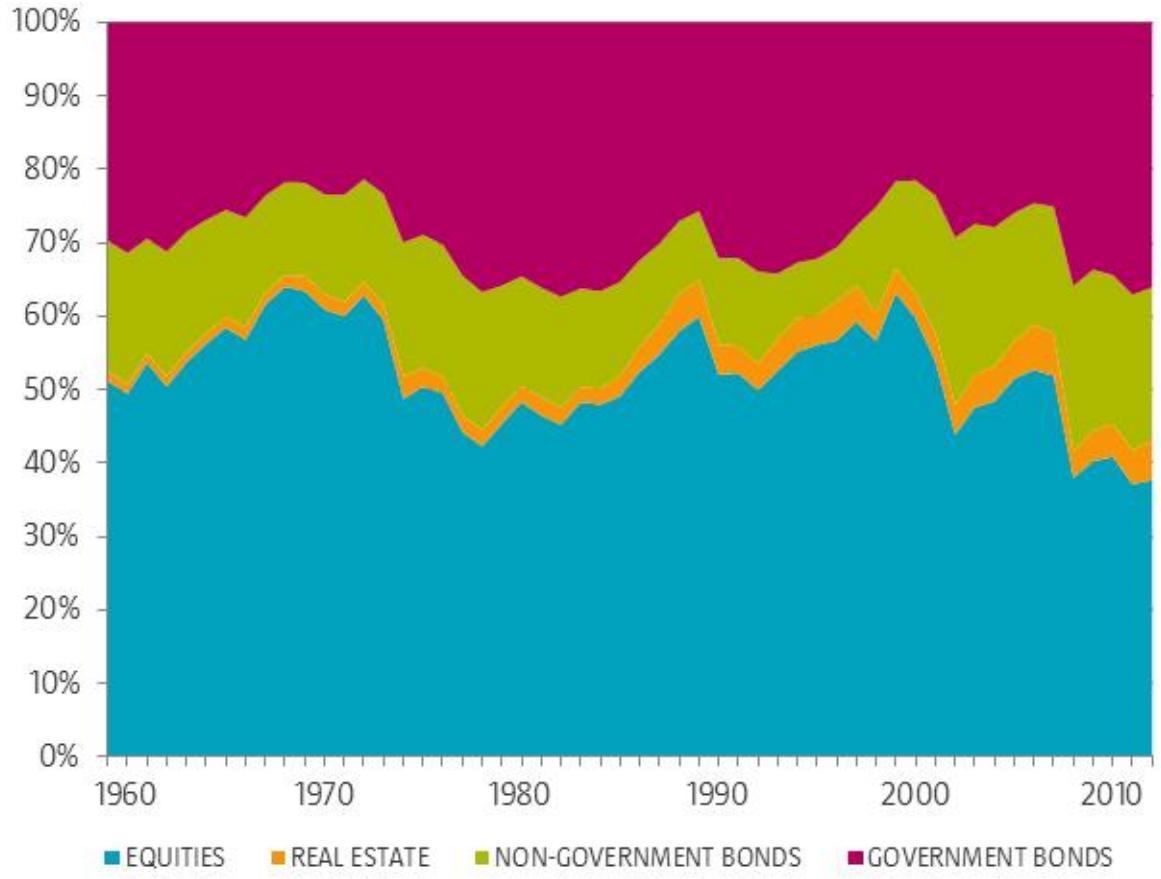


**Table 1. Weight of an asset class as a percentage of the total market value of four main asset classes (period averages)**

| | 1959-1984 (US) | 1985-2012 (global) |
|---|---|---|
| Stocks | 61.0% | 51.1% |
| Real estate | 3.9% | 4.4% |
| Non-government bonds | 12.0% | 14.7% |
| Government bonds | 23.1% | 29.8% |
| | | |
| Real estate relative to stocks | 6.7% | 8.7% |
| Non-government bonds relative to government bonds | 54.9% | 50.3% |

**Table 2. Global asset-class portfolio weights in 1984**

| | Ibbotson et al. (1985) | Our data |
|---|---|---|
| Stocks | 46.5% | 49.0% |
| Non-government bonds | 14.4% | 13.5% |
| Government bonds | 39.1% | 37.4% |
| Total | 100.0% | 100.0% |

**Table 3. Data characteristics for the four main asset categories 1959-2012**

| | 1959 | 2012 | Minimum | Maximum | Average | 2012-/-avg. |
|---|---|---|---|---|---|---|
| Equities | 51.2% | 37.7% | 37.1% | 64.0% | 52.0% | -14.3% |
| Real estate | 1.4% | 5.3% | 1.2% | 6.2% | 3.2% | 2.1% |
| Non-government bonds | 17.7% | 20.9% | 7.3% | 22.8% | 15.1% | 5.8% |
| Government bonds | 29.7% | 36.1% | 21.4% | 37.4% | 29.6% | 6.4% |

**Table 4. Strategic asset allocations of institutional global investors**

| Type | Specifics | Source | Time | Equities | Bonds | Other | AuM |
|---|---|---|---|---|---|---|---|
| | | | | % | % | % | USD bln |
| *Pension funds*[12] | | | | | | | |
| | Germany | OECD | 2011 | 4 | 43 | 53 | 195 |
| | Japan | OECD | 2011 | 9 | 41 | 50 | 1470 |
| | UK | OECD | 2011 | 45 | 41 | 14 | 2130 |
| | US | OECD | 2011 | 48 | 28 | 24 | 10584 |
| | World | OECD/TW | 2011 | 41 | 39 | 20 | 20719 |
| *Sovereign wealth funds*[13] | | | | | | | |
| Abu Dhabi Investment Authority | | SWFI | 2012 | 55 | 22 | 23 | 627 |
| Norwegian Pension Fund Global | | SWFI | 2012 | 60 | 35 | 5 | 716 |
| China Investment Corporation | | SWFI | 2011 | 25 | 21 | 53 | 482 |
| *Endowments*[14] | | | | | | | |
| | United States | NACUBO | 2012 | 31 | 11 | 58 | 406 |
| *Market portfolio* | | | | | | | |
| | | | 2010 | 39 | 53 | 8 | 81337 |
| | | | 2011 | 36 | 56 | 8 | 81239 |
| | | | 2012 | 36 | 55 | 9 | 90568 |

[12] The category "Other" includes cash, loans, land and buildings, unallocated insurance contracts, hedge funds, private equity funds, structured products, other mutual funds (i.e. not invested in cash, bills and bonds, shares or land and buildings) and other investments. We composed the pension funds part in this table with data from the OECD study 'Pension Markets in Focus No. 9' from September 2012, with the exception for the asset allocation for the world which we derived from 'Global Pension Assets Study - 2012' of Towers Watson.
[13] Data obtained from the Sovereign Wealth Institute at www.swfinstitute.org in February 2013. The allocation data for the Abu Dhabi Investment Authority is the midpoint of a broad allocation range obtained from the fund's website.
[14] The data is obtained from a press release on the "2012 NACUBO - Commonfund Study of Endowments" of 1 February 2013, available at www.nacubo.org.

## Appendix I: data sources and methodology

We derive the global multi-asset market portfolio from a variety of sources that we consider to be effective in providing an assessment of the market size of an asset class. Below we discuss our data sources and the methodology that we use to arrive at our estimates. We provide year-end estimates in US dollars. Table A1 contains the year-end estimates of 2012 together, if applicable, with the Thomson Reuters Datastream mnemonics, to facilitate replication and updating. In addition, each index mentioned here that we could access through Thomson Reuters Datastream contains the mnemonics between brackets in the text the first time the index is mentioned.

**Equities**

For stocks we use market capitalization data from MSCI. First, we take the market value of the MSCI All Country World Index (MSACWF$), often referred as MSCI AC World Index or MSCI ACWI. This is the standard index that contains large and mid caps. Second, we add the market value of the MSCI AC World Small Cap Index (MSSAWF$), which represents small caps. Both indices contain developed markets as well as emerging markets. They do not contain frontier markets, but the effect of inclusion would be small. According to MSCI, at the end of 2012 the market value of frontier markets was equal to only 0.4% of the market capitalization of the MSCI AC World Index.

Before 1987, there is no MSCI AC World Index data available. Therefore, we use the annual percentage change in the market capitalization of the MSCI World Index (MSWRLD$), which only contains developed markets, to backfill the market value of the standard index to 1984. According to MSCI, at the beginning of 1988 the market value of emerging markets was equal to 0.8% of the market capitalization of the MSCI World Index.

Before 2004, there is no market-capitalization data of the MSCI AC World Small Cap Index available. We proxy the market-capitalization data using the following formula

(1) $Mktcap_t^S = k_t \times Mktcap_t^L$

where asset S is the MSCI AC World Small Cap Index and asset L the MSCI AC World Index that contains large and mid caps. The multiplication factor k is known for 2004, as both market

capitalizations are available. Before 2004, we determine k from the relative price performance of both assets over the subsequent period as we backfill the data. We use the following formula

$$(2)\quad k_{t-1} = k_t \times (1 + Price\ Return_t^L)/(1 + Price\ Return_t^S)$$

where *t* starts in 2004, which is the first year in which *k* is calculated for the period 1994-2003. Price $Return_t$ is the price return in year t. With the aid of these estimates we derive the market value of small caps by multiplying these weights by the market value of large and mid caps. This is the methodology displayed in Equations (1) and (2). Subsequently, for the period 1988-2003, we use the relative performance of the Russell 2000 Index (FRUSSL2) to the Russell 1000 Index (FRUSSL1) to estimate the performance of small caps relative to large and mid caps; for the period 1984-1987 we use the SMB-factor from the online data library of Kenneth French[15] to do this. Again, we derive the market value of small caps by multiplying these weights by the market value of large and mid caps.

We now have a complete time series of the market capitalization of equities. But, we still make a final correction. We subtract the market value of REITs from the total estimated market value of equities as they are part of the real estate asset class in this study. We use the market value of the MSCI All Country World Real Estate Investment Trusts Index (M3AFRL$), which is the standard index for the MSCI industry REITs. It is available from 2006. Next, we use the MSCI All Country World Small Cap Real Estate Investment Trusts Index (C3AFRL$) which is the small cap index for REITs with data availability from 2007. To backfill 2006 for the small cap index, we suppose that the percentage change from the 2006 to 2007 market cap equals the change in the market value of the standard index. Then, for both the standard index and the small cap index, we backfill the REITs series for the period 1994-2005 with the percentage changes in the market value of the real-estate industry group of the MSCI AC World Index (M2AFR2$). For the period 1986-2003 we use the change in the market value of the MSCI Real Estate Index (MSREAL$), which represented real estate in developed markets, to do the same for that period. Finally, for 1984 and 1985, we use the percentage change in the price index of the MSCI Real Estate Index for real estate for backfilling, as market capitalization data are not available for the MSCI Real Estate Index prior to 1986.

[15] Data obtained from http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

**Private equity**

The estimate for private equity reflects the value of companies in private-equity portfolios and the sum of all uncalled commitments, the so-called dry powder. For the period 2000-2012 we use data from Preqin. To our knowledge, Preqin has the largest coverage of the private equity market. Preqin has no data available before 2000. For the period 1990-1999 we use Thomson Reuters data as published in Leitner, Mansour and Naylor (2007). A comparison between their data and data from Preqin over the period 2000 to 2002 shows that market values from Preqin are on average 12% ahead of Thomson Reuters data. This comparison suggests that we might underestimate the market value of private equity somewhat before 2000.

**Real estate**

Within the real-estate market, a distinction should be made when it comes to commercial and residential real estate. The residential market would be much bigger than the commercial market, were it not for the fact that a large portion of this market is the property of the residents. Hordijk and Ahlqvist (2004), as an extreme example, estimate that only five percent of all residential real estate in the UK is available to investors. Added to investability constraints, most individual investors already have an exposure to residential real estate that exceeds the money they have available for investments, simply because they own their homes.

This study focuses on commercial real estate only. The commercial real-estate market is valued by using data from RREEF Real Estate Research, see Hobbs and Chin (2007)[16]. RREEF divides the market estimate of real estate into the four quadrants of public equity, private equity, public debt and private debt. At the end of 2006, they estimate the investable market at USD 16.0 trillion. This figure includes owner-occupied real estate, which might become available to financial investors in the future. Their proxy for the invested real-estate market is USD 9.8 trillion. This figure is relevant for this study, but it includes both equity and debt. The equity component of invested real estate, which is the universe suitable for comparison in this framework, is USD 4.0 trillion. So this equals a quarter of the combined value of invested and owner-occupied real estate. Private equity represents by far the largest part with roughly 85%, leaving 15% to public equity. The USD 4.0 trillion estimate is reasonably close to the figure given by Idzorek, Barad and Meier (2007), who estimate this measure of the global

[16] We thank Peter Hobbs for providing detailed segmentation of the global real-estate market that supplemented their study.

real-estate market at USD 4.6 trillion. Real-estate debt, such as MBS, can be considered as part of the fixed-income asset class and is in fact largely captured by the estimate for credits.

We use the market capitalization of the GPR General PSI Global Index (GPRGLES) to backfill the period 1984-2005, as well as to fill the period 2007-2012. Here we use the 2006 estimate of USD 4.0 trillion as a starting point. Subsequently we use percentage changes in the market capitalization series to arrive at estimates for all other years.

**High-yield bonds**

For high-yield bonds we use the market capitalization of the Barclays Capital Global Corporate High Yield Index (LHGHYCO), available from 2000 onwards. These data are in line with data from Bank of America Merrill Lynch, although initially the market-capitalization figures of Barclays Capital are above those from Bank of America Merrill Lynch, while this is subsequently reversed due to index-inclusion rules that change over time. To illustrate this, the largest deviations are for 2001 (+8%) and 2012 (-11%). For the period 1990-1999, we base our estimates on the Barclays Capital Global High Yield Index (LHMGHYD). This index also includes sovereign high yield from emerging markets that we prefer to classify as emerging-market debt. To correct for this, we first calculate the weight of the Barclays Capital Global Corporate High Yield Index relative to the Barclays Capital Global High Yield Index for the period 2000-2012. It appears that the relative weight has on average grown 2% a year over that period. Subsequently, we suppose the 2% growth rate also applies to the 1990-1999 period. Our methodology here still uses Equations (1) and (2), but the multiplication factor $k$ is now divided by a constant, as represented by Equation (3)

$$(3)\ k_{t-1} = \frac{k_t}{1+c}$$

where the constant c = 2% for this asset class.

Before 1990 we suppose that the market capitalization of high yield as a percentage of the (estimated) market capitalization of the Barclays Capital Global Treasury Index (LHMGLOB) grows 8% a year, in line with the 1990-2012 growth rate. Subsequently, we multiply this percentage by the market capitalization of the (estimated) market capitalization of the Barclays Capital Global Treasury Index. We use the Barclays Capital Global Treasury Index as a reference index because it has the longest-dating history of market capitalizations available. Hence we employ Equation (3) with c = 8%.

**Emerging-market debt**

For emerging-market debt, we sum the JP Morgan Government Bond Index - Emerging Markets Global Composite (JGE$GCM) for local currency debt, the JP Morgan Emerging Markets Bond Index Global Composite (JPMGTOT) for external (hard currency) debt, the JP Morgan Corporate Emerging Markets Bond Index Broad for USD-denominated emerging-market corporate bonds and the Barclays Capital Emerging Markets Government Inflation-Linked Index (BCEMALL) for inflation-linked bonds.

The external debt data start in 1993. Before that period we assume that the growth rate equals the growth in the market capitalization of global treasury bonds. The data for the period 1993-2012 suggest that the growth of external emerging-market debt on balance roughly matches the growth of global treasury bonds. For local currency debt, data start in 2002. Before that period, we suppose that the growth rate relative to the market capitalization of external debt equals the 10% compounded growth rate of the period 2002-2012. The corporate emerging-market debt data start in 2001. Prior to that date we suppose that the growth relative to external debt equals the 9% compounded growth rate in the estimated market capitalization of external debt over the period 2002-2012. Hence, we employ Equation (3) with c = 10% and c = 9% for local currency emerging debt and corporate emerging debt, respectively. For inflation-linked bonds, the data series start in 2003. Before, we use data from Swinkels (2012).

For the period 1984-1989 we assume that the market capitalization of emerging-market debt has grown in line with our estimate for (developed markets) government bonds.

**Investment-grade credits**

Investment-grade credits primarily consist of corporate debt and mortgage-backed securities. We estimate the market capitalization of investment-grade credits by subtracting the (estimated) market capitalization of the Barclays Capital Multiverse Government Index (LHMVGVT) and the Barclays Capital Global High Yield Index from the (estimated) Barclays Capital Multiverse Index (LHMVALL).

**Government bonds**

We use the market capitalization of the Barclays Capital Multiverse Government Index as a proxy for the government-bonds market. These data are available from 2005 on. Before, we suppose that this index grew in line with the market capitalization of the Barclays Capital Global Treasury Bond Index which has data from 1987 on. For the period 1984-1986 we use the growth rate of the market capitalization of the Barclays Capital US Treasury Index (LHUSTRY) to backfill our estimates for the market capitalization of global government bonds. We have limited double counting, as some emerging markets qualify for the Barclays Capital Global Treasury Bond Index. However, emerging sovereign debt is small compared to sovereign debt in developed markets. Therefore, the double counting will result in just a marginal bias.

**Inflation-linked bonds**

For inflation-linked bonds we use the market capitalization of the Barclays Capital Global Aggregate Inflation-Linked Index (LHGREAL), available from 2000 on. For the period 1997-1999 we suppose that market capitalization developed in line with the combined market capitalization of the US (Barclays Global Index-Linked US 1-10 years (BCUS10L)) and UK (Barclays Sterling Index-Linked Overall All Maturities (BCSIFL0), which we backfill for the years 1996-1998 by using the percentage change in the market capitalization of the Barclays Sterling Index-Linked Gilt Index (BCSGLAY)) inflation-linked market. Before 1997 we only estimate the market capitalization of the UK inflation-linked market, as it was the only major country with a developed inflation-linked bond market. To derive these estimates for the UK for the period 1984 to 1995, we suppose that the market capitalization of inflation-linked bonds grew in line with the (estimated) market capitalization of the Barclays Capital Global Treasury Bond Index. This last step in backfilling the data seems to be reasonably accurate according to data from the UK Debt Management Office. To illustrate this, the nominal amount of outstanding inflation-linked debt was GBP 8 billion (USD 9 billion) in 1984 (start year) and GBP 18 billion (USD 34 billion) in 1990 (half way between 1984 and 1995), while our backfilling rule estimates the market value of inflation-linked debt at USD 15 billion and USD 32 billion respectively. The backfilling method before 2000 is of little relevance to the market portfolio. Inflation-linked bonds only had a 0.7% weight in the global market portfolio in 2000.

**Table A1. Composition of the global market portfolio by asset class at the end of 2012**

| Index name or source | Thomson Reuters Datastream mnemonic | USD bln | | USD bln |
|---|---|---|---|---|
| Equities | | | | 32920 |
| MSCI AC World Index | MSACWF$ | 29474 | + | |
| MSCI AC World Small Cap Index | MSSAWF$ | 4300 | + | |
| MSCI AC World REITs Index | M3AFRL$ | 558 | - | |
| MSCI AC World Small Cap REITs Index | C3AFRL$ | 296 | - | |
| Private equity | | | | 3270 |
| Preqin | -[17] | 3270 | + | |
| Real estate | | | | 4612 |
| GPR General PSI Global Index (2012) | GPRGLES | 1310 | | |
| GPR General PSI Global Index (2011) | GPRGLES | 1039 | ./. | |
| Real estate estimate 2011 | | 3659 | * | |
| High yield bonds | | | | 1523 |
| Barclays Capital Global Corporate High Yield Index | LHGHYCO | 1523 | + | |
| Emerging market debt | | | | 2681 |
| JPM Government Bond Index - Emerging Markets Global Composite | JGE$GCM | 953 | + | |
| JPM Emerging Markets Bond Index Global Composite | JPMGTOT | 579 | + | |
| JPM Corporate Emerging Markets Bond Index Broad | -[18] | 620 | + | |
| Barclays Capital Emerging Markets Government Inflation-Linked Index | BCEMALL | 530 | + | |
| Investment-grade credits | | | | 16761 |
| Barclays Capital Multiverse Index | LHMVALL | 45022 | + | |
| Barclays Capital Multiverse Government Index | LHMVGVT | 26739 | - | |
| Barclays Capital Global Corporate High Yield Index | LHGHYCO | 1523 | - | |
| Government bonds | | | | 26739 |
| Barclays Capital Multiverse Government Index | LHMVGVT | 26739 | + | |
| Inflation-linked bonds | | | | 2062 |
| Barclays Capital Global Aggregate Inflation-Linked Index | LHGREAL | 2062 | + | |
| **Global invested multi-asset market portfolio** | | | | **90568** |

[17] Provided by Preqin. Not available in Thomson Reuters Datastream.
[18] Provided by JP Morgan. Not available in Thomson Reuters Datastream.

# Appendix II: the global market portfolio weights from 1959 to 2012

**Table A2. Global market portfolio weights (1959-2012)**

| | Equities (%) | Real estate (%) | Non-government bonds (%) | Government bonds (%) |
|---|---|---|---|---|
| 1959 | 51.2 | 1.4 | 17.7 | 29.7 |
| 1960 | 49.4 | 1.3 | 17.9 | 31.4 |
| 1961 | 53.7 | 1.2 | 15.7 | 29.4 |
| 1962 | 50.4 | 1.4 | 17.0 | 31.2 |
| 1963 | 53.7 | 1.4 | 16.4 | 28.5 |
| 1964 | 56.2 | 1.4 | 15.5 | 26.9 |
| 1965 | 58.4 | 1.5 | 14.6 | 25.5 |
| 1966 | 56.8 | 1.7 | 15.0 | 26.5 |
| 1967 | 61.6 | 1.6 | 13.2 | 23.6 |
| 1968 | 64.0 | 1.6 | 12.6 | 21.8 |
| 1969 | 63.4 | 2.0 | 12.8 | 21.8 |
| 1970 | 60.9 | 2.1 | 13.6 | 23.4 |
| 1971 | 60.0 | 2.0 | 14.6 | 23.5 |
| 1972 | 62.9 | 1.8 | 13.9 | 21.4 |
| 1973 | 59.4 | 2.1 | 15.1 | 23.4 |
| 1974 | 48.8 | 3.1 | 18.2 | 30.0 |
| 1975 | 50.4 | 2.6 | 18.1 | 28.9 |
| 1976 | 49.6 | 2.2 | 17.9 | 30.3 |
| 1977 | 44.2 | 2.3 | 19.0 | 34.5 |
| 1978 | 42.2 | 2.3 | 18.8 | 36.7 |
| 1979 | 45.4 | 2.3 | 16.5 | 35.8 |
| 1980 | 48.3 | 2.2 | 14.9 | 34.6 |
| 1981 | 46.5 | 2.5 | 14.9 | 36.1 |
| 1982 | 45.2 | 2.4 | 15.0 | 37.4 |
| 1983 | 48.3 | 2.1 | 13.4 | 36.2 |
| 1984 | 48.0 | 2.2 | 13.2 | 36.6 |
| 1985 | 49.1 | 2.8 | 12.8 | 35.3 |
| 1986 | 52.4 | 3.5 | 11.7 | 32.4 |
| 1987 | 54.8 | 4.1 | 10.9 | 30.1 |
| 1988 | 58.0 | 5.2 | 9.8 | 27.1 |
| 1989 | 59.9 | 5.0 | 9.4 | 25.7 |
| 1990 | 52.0 | 4.1 | 11.7 | 32.1 |
| 1991 | 52.2 | 3.7 | 11.9 | 32.1 |
| 1992 | 49.9 | 3.6 | 12.6 | 33.9 |
| 1993 | 52.6 | 4.4 | 8.8 | 34.2 |
| 1994 | 55.2 | 4.6 | 7.6 | 32.7 |
| 1995 | 56.1 | 4.1 | 7.7 | 32.2 |
| 1996 | 56.7 | 5.3 | 7.3 | 30.6 |
| 1997 | 59.3 | 4.9 | 8.2 | 27.7 |
| 1998 | 56.6 | 3.9 | 14.4 | 25.1 |
| 1999 | 63.2 | 3.3 | 11.9 | 21.6 |
| 2000 | 59.7 | 3.4 | 15.4 | 21.5 |
| 2001 | 53.9 | 3.8 | 18.7 | 23.6 |
| 2002 | 43.9 | 4.0 | 22.8 | 29.3 |
| 2003 | 47.6 | 4.4 | 20.6 | 27.4 |
| 2004 | 48.4 | 4.8 | 18.9 | 27.9 |
| 2005 | 51.5 | 5.1 | 17.4 | 25.9 |
| 2006 | 52.7 | 6.2 | 16.5 | 24.6 |
| 2007 | 51.9 | 5.8 | 17.3 | 25.1 |
| 2008 | 38.0 | 3.6 | 22.5 | 35.9 |
| 2009 | 40.3 | 4.2 | 21.9 | 33.7 |
| 2010 | 40.8 | 4.4 | 20.3 | 34.4 |
| 2011 | 37.1 | 4.7 | 21.2 | 37.1 |
| 2012 | 37.7 | 5.3 | 20.9 | 36.1 |

## Appendix III: Robustness of our estimates

As we have indicated in the introduction, composing the historical market portfolio is a non-trivial exercise. Our point estimates of the asset class' weights in the historical market portfolio are surrounded by uncertainty. In the main text, we discussed evidence that suggests our estimates to be accurate. For example, back filling our data to 1984 resulted in estimated portfolio weights that came very close to the 1984 estimates of Ibbotson, Siegel and Love (1985). Also, throughout the main text we mentioned figures that we derived from other data providers for reasons of comparison.

Here, we compare our data to similar time series of alternative data providers. We do this for the three main asset classes equities, government bonds, investment grade credits, as well as for high yield and inflation linked bonds, as for these asset classes we do have data from alternative index providers readily available.

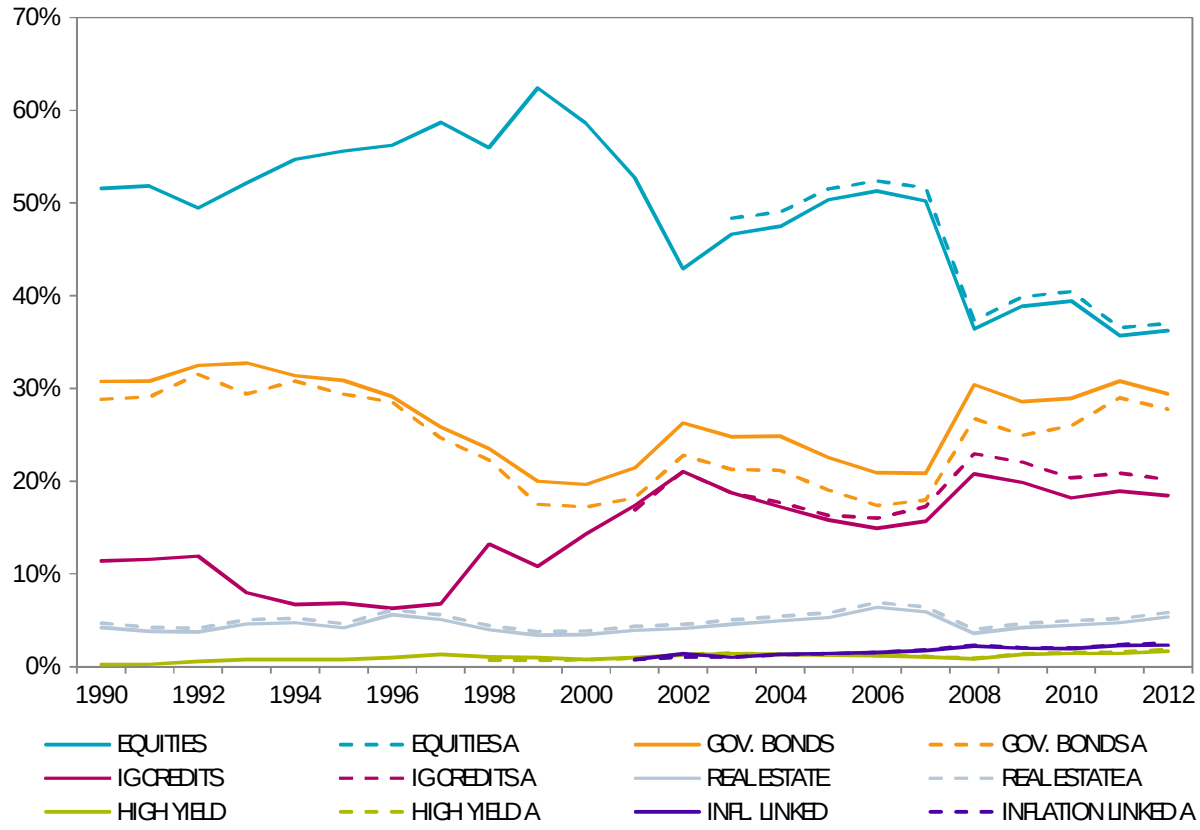
For equities, we compare our MSCI based estimates to the market value of the FTSE Global All Cap Index. The alternative for our Barclays based government bonds estimate is the Bank of America Merrill Lynch Global Government Index, for our Barclays based investment grade credits estimate we use the Bank of America Merrill Lynch Global Largecap Non-Sovereign Index in the comparison, our Barclays based high yield estimate we compare to the Bank of America Merrill Lynch Global High Yield Index and we compare our Barclays based inflation linked index to the Bank of America Merrill Lynch Global Government Inflation Linked Index.

To arrive at an alternative estimate for real estate, we follow another procedure for two reasons. First, the way we constructed our real estate estimate, the market portfolio weight is likely to be more sensitive for its base date estimate in 2006 than for an alternative time series of market capitalization data. Therefore, we take the alternative estimate by Idzorek, Barad and Meier (2007) who put the market size at USD 4.6 trillion instead of our USD 4.0 trillion figure that we base on Hobbs and Chin (2007). Subsequently, we derive market capitalization data for other years in the same way as we described earlier. Second, we lack alternative market capitalization time series that go back a long period in time. To illustrate, the FTSE EPRA/NAREIT Developed Index starts at the end of 1989 and is designed to track the performance of listed real estate companies and REITS worldwide. But, it contains market capitalization data only from 2005. Standard and Poor's Global Real Estate Investment Trusts Index has market capitalization data from 2006.

With these alternative estimates for market capitalization data, we calculated the weight for each of these six asset classes in the multi-asset portfolio we documented in the section with the global market portfolio for the period 1990-2012. [19] The inception date of the alternative weight depends on the start date of the data series.

As Figure A1 shows, the differences in market portfolio weights between our estimates and the data from alternative sources tend to be rather small. For equities, the weight differs on average 1.1%, for government bonds the average difference is 2.4%, for investment grade credits this is 1.1%, while for both high yield and inflation linked bonds the portfolio weights on average do not differ.[20] The alternative estimate for real estate results in a market portfolio weight that is on average 0.5% higher.

**Figure A1. Multi-asset market portfolio weights for our estimates and those from an alternative source (A) over the period 1990-2012 (%)**




[19] We leave private equity and emerging market debt out of this analysis as for these asset classes we do not have alternative data series readily available.
[20] Alternative data for high yield start in 1997, for inflation linked this is 2001. As portfolio weights are hardly affected by the change to the alternative data sources, this cannot be seen in the figure.

This robustness check as well as the other robustness checks we performed throughout this paper suggest that there is some uncertainty in the point estimates of the weights in the invested market portfolio, but that using alternative sources results only in small deviations.