Alternative indexation for listed real estate:

Is a GDP-weighted scheme a better investment strategy than a cap-weighted scheme?

Master thesis, Business Economics – Finance track

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ABSTRACT

The S&P 500 is a well-known index composed of 500 stocks that reflects the performance of the U.S. economy. Indices are used by practitioners as benchmark indices and as underlying for index-based vehicles. Hence, thousands of specialized indices exist which are developed by index providers and used by practitioners. Traditionally, stock constituent weights are based on market capitalization. However, alternative indexation methods are gaining popularity because cap-weighting is proven to be suboptimal. The aim of the study is to find out whether GDP-weighted indexation is a better investment strategy than cap-weighted indexation. This question is tested from the perspective of listed real estate. One argument for GDP-weighting is that literature has shown that real estate markets and macroeconomic variables are linked. Additionally, GDP-weighted listed real estate indices are constructed. CAPM and the Fama-French model are used to examine alpha and beta of the indices. The results of the study reveal that GDP-weighted indices offer higher risk-adjusted return than the cap-weighted counterpart. Also, the indices show positive excess alpha, although it is not statistically significant. The principal conclusion is that GDP-weighted indices are a suitable alternative for listed real estate investors that base their investment strategy on macroeconomic views. However, it is excepted that when management fees are taken into account, excess alpha becomes nil. To summarize, the GDP-weighted indices do not outperform nor underperform the cap-weighted counterpart.

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INTRODUCTION

Index construction has become an integral part of the financial market. Asset class indices that reflect the performance of particular markets provide information to investors. In particular, indices provide estimates of average returns, standard deviation and the correlation of returns across asset classes (Fisher, Geltner and Brian Webb, 1994). Indices are important because first of all, indices act as benchmarks for actively managed funds: a portfolio manager's performance is measured relative to a benchmark index. It informs investors about an actively managed fund's risk and performance relative to a benchmark index in terms of tracking error and lastly it provides information about volatility and correlation with other asset classes. Because passive investment strategies have lower costs (mainly because of lower management fees) and research shows that on average actively managed funds underperform passively managed funds (Gruber, 1996), index-based investing has become increasingly popular. Secondly, indices act as underlying for index-based investment strategies. Index-based vehicles like Exchange Traded Funds (ETFs) have grown in popularity as well.

The S&P 500 is one of the most widely used benchmark indices that reflects the overall U.S. stock market. It is composed of 500 stocks and measures the performance of the broad U.S. economy. Apart from the well-known S&P 500, there are many other specialized indices available which track the performance of specific markets, sectors or regions. Traditionally, as is the case for the S&P 500, the indexation methodology is based on market capitalization: the weight of each stock in an index is based on its market capitalization (market cap) relative to the sum of market cap of all stocks in the index. Additionally, stocks could be weighted based on free float market cap where the market cap is adjusted for strategic holdings (e.g. directors' holdings or block holdings). Thus, shares which are publicly available for trade are counted as free float market cap and used for calculating the weight of each individual stock.

Nowadays, there is some criticism on cap-weighting and in turn alternative indexation methodologies have become increasingly popular. Schoenfeld (2011, chapter 12) explains that country weights, which are based on a country's market cap relative to the total market cap, do not always represent the full set of investment opportunities in a country. As a consequence, institutional investors consider alternative weighting schemes offering better international diversification. Chow, Hsu, Kalesnik & Little (2011) already paid attention to equal weighting, minimum variance, Fundamental Indexation and risk efficient methodologies. In the literature, less attention has been paid to GDP-weighted indexation in which country weights are based on nominal Gross Domestic Product values instead of market cap.

Schoenfeld (2011) touches on the existence of GDP-weighted indices. During the 1980s, Japan's equity market experienced high growth and as a result Japan's weight in the MSCI World Index rose sharply; the market cap of Japan was 50% bigger than that of the United States. Investors became worried that Japan was experiencing an asset bubble which was going to burst. There was an increased appetite for a weighting scheme that was more stable over time and a better reflection of Japan's equity market. The MSCI World Index is the index which is most used for benchmark purposes by equity investors. In response, MSCI launched GDP-weighted indices. In doing so, Japan's weight was lowered from 65% to 35% approximately. As a consequence, Japan's downfall (36% in 1990), had less influence on the total performance of the index. In the 1990s, Japan's cap weight and GDP weight equalized and as a result many investors shifted back to traditional cap-weighted indices. MSCI developed several indices based on GDP and these seemed an appropriate alternative: over 32 years, the GDP-weighted indices outperformed their cap-weighted counterparts with 1% per year. Another argument for GDP-weighting is that GDP data are more stable over time. GDP values tend not to change much over the years.

Unfortunately, not much academic research has been done to alternative weighting schemes and in particular to GDP-weighted schemes. Dimson, Marsh and Staunton (2002) studied the link between equity returns and GDP in developed nations and found a positive but weak correlation of 0.4. This might be an explanation for investors shifting back to cap-weighted schemes after the Japan asset bubble during the 1990s. It seems that cap-weighted schemes are still mainstream. Other indexation schemes are therefore offered as alternative and not as substitute to cap-weighted schemes. It provides practitioners with a more varied set of market views and investment strategies. MSCI has already developed GDP-weighted indices for equities. Therefore, it is interesting to develop indices for another asset class. Existing literature shows that a country's real estate market is closely linked to the national economy (Eichholtz, 1996). Also, the value added of real estate in mixed-asset portfolios is proven (Fugazza, Guidolin and Nicodano, 2007). Hence, it is interesting to investigate GDP-weighted indexation from the perspective of listed real estate.

Purpose of the study

This study investigates GDP-weighted indexation for listed real estate. It contributes to existing literature because from the perspective of listed real estate markets, only the Fundamental Indexation methodology is discussed in prior research (Hsu, Li & Kalesnik, 2010). The purpose of the master thesis is to examine the appropriateness of GDP-weighting for listed real estate and to test whether GDP-weighted listed real estate indices have a more attractive risk-return profile than their cap-weighted counterpart.

Scope of the study

This master thesis is conducted on behalf of Global Property Research (GPR) which is an index provider of listed real estate indices for benchmarking purposes. All data and indices used in this master thesis are made available by GPR. GPR wants more insights in the reasons justifying listed real estate indices based on GDP and the performance of these indices compared to the cap-weighted counterpart. In my opinion it is worth to investigate the alternative indexation methodology for listed real estate. Nowadays, investors and portfolio managers more often base their strategies on passive index investing because it has a low cost. Thus, listed real estate indices are useful as underlying for index-based vehicles. At the same time, listed real estate is an important asset in investment portfolios (e.g. of institutional investors). These aspects are worthwhile arguments for investigating an alternative indexation methodology for listed real estate.

Because this study focuses on listed real estate, the results should be interpreted from the viewpoint of listed real estate and not from other asset classes.

Structure of the thesis

The master thesis can be split in two parts: a theoretical framework and an empirical part. In the theoretical framework, I firstly discuss the existing literature. In section 1.1, I describe the role of indices and answer the question why they are important. In section 1.2, I discuss the importance of real estate in asset allocation. Next, the features of market cap indexation are demonstrated. In particular, several biases of market cap, for instance insider holdings, skewness to highly indebted countries and the role of real estate legislation are highlighted. To justify my prediction that GDP is a good reflection of real estate markets, I review literature which affirms the link between a country's macro economy and real estate markets. In the second part of the master thesis, I conduct a quantitative analysis. Firstly, I construct new GDP-weighted listed real estate indices. Then, I describe how they are constructed and present descriptive statistics of these indices and their cap-weighted counterparts in section 3. In section 4, the methodology is explained and in section 5, I backtest the indices and present the results: I compare the risk-return characteristics with their cap-weighted counterpart. I use the capital asset pricing model (CAPM) to analyze whether the new indices have excess alpha over the cap-weighted counterpart. Thereafter I use a multi-factor model to decompose the returns. In section 6, I present the key research results and conclude.

I LITERATURE REVIEW

In this chapter I firstly discuss the role of indices. The usefulness of indices is not widely known; therefore I briefly describe their importance. Secondly, I demonstrate the importance of (listed) real estate. By this I want to show that real estate is a relevant asset class in portfolios. Thirdly, I discuss the features of market cap indexation and some related biases. Fourthly, the importance of stock liquidity is discussed. Thereafter I argue about the link between GDP and real estate markets and explain why GDP-weighting is an appropriate alternative to cap-weighting for listed real estate indices. Finally, I touch upon some minor characteristics of GDP-weighted indexation which are worthwhile to discuss.

1.1 The role of indices

An index is a theoretical "basket" of securities that is compiled to represent the performance of a particular market. Stock indices like the S&P 500 or the EuroStoxx 50 are well-known indices. These indices consist of equities and represent the largest and most liquid companies, in the United States and the Eurozone respectively. In addition to plain vanilla indices there are thousands of specialized indices developed by index providers, which represent a specific market, sector or region. I have already touched upon this, but the questions remain: why do so many indices exist and what is their usefulness? Schoenfeld (2011) extensively explains the role of indices: traditionally, indices serve as yardsticks for investors to measure the performance of active fund managers. Nowadays, investors and fund managers agree to an appropriate benchmark index to match their portfolio expectations and objectives. Generally, an active fund manager tries to beat its benchmark. Key is the appropriateness of the benchmark index: an apples-to-apples comparison is required to obtain reliable results. It is useless to compare a European listed real estate portfolio with the S&P 500 because the S&P 500 reflects the broad U.S. economy. The reason for the existence of many specialized indices is to meet investment portfolios with different asset classes, regional focus and market views.

Thus, fund managers use a benchmark index for making investment decisions. They constantly compare their investment portfolio to the benchmark index and base their investment decisions and portfolio changes on the strategic insights given by the benchmark index. One useful metric is tracking error. Tracking error is a measurement of how much the return on a portfolio deviates from the return of its benchmark index. A low tracking error means that the portfolio follows the index closely. Vice versa a high tracking error reflects an actively managed fund. The core of the business is making changes to the investment portfolio to strive a higher performance than the benchmark index. Another important reason for using a benchmark is risk assessment. Especially since the financial crisis, uncertainty and volatility became more important determinants of investment portfolios. As a consequence, investors demand greater transparency in each investment portfolio and its investment process. Fortunately, benchmark indices satisfy this need by giving investors greater control in managing risk, return and costs.

Then there is the growing popularity of index-based investing. Index-based investment vehicles are financial products which track the performance of an index. They are composed of stocks, in such a way the vehicle replicates the performance of an underlying index resulting in minimal tracking error. By this, investors can participate in the aggregate performance of a broad market (e.g. S&P 500) or a specific market, in some cases without buying all stocks in the index. What makes index-based investing so attractive is its transparency, broad market exposure and the cost framework. An index-based strategy has low cost because it tracks an index and therefore has low transaction costs. Moreover, empirical evidence shows that actively managed funds which charge higher fees record inferior performances to passively managed funds (Gruber, 1996). Because of its attractive cost-performance combination, index-based investment have vehicles gained popularity over the past few years. Hence, indices have an important role in this field: they act as underlying for the index-based vehicles.

Until today, the vast majority of index-based investment vehicles are based on cap-weighted indices. Because these indices are meant to track the “market” and market cap reflects the money invested in a specific market. Thus alternative indices, like GDP-weighted indices, are not yet used as underlying for index-based investment vehicles. But recently, a fresh wave of new index-based investment vehicles has been launched. The number of Exchange Traded Funds (ETFs) grew enormously. For example in the U.S.: to $992 billion in net assets in 2010 from $6 billion in net assets in 2000 (Investment Company Fact Book). Moreover, it is expected that more innovative index-based investment vehicles are developed in the next few years. This might be an opportunity for alternative indices to be used as underlying to these vehicles.

1.2 Importance of real estate

This master thesis is an investigation into GDP-weighted indexation from the perspective of listed real estate. Listed real estate is of a hybrid form: it has the characteristics of non-listed real estate and a security. A number of studies have considered the importance of (listed) real estate in asset allocation. Unfortunately, there is not always consensus on the optimal allocation of real estate and its usefulness. Hoevenaars, Molenaar, Schotman and Steenkamp (2008) analyze the term structure of risk of different asset classes. Term structure of risk reflects the asset price movements as a function of investment horizon. They find that the correlation of listed real estate with stock and bond returns is high for short horizons but decreases when investment horizons lengthen. They conclude that listed real estate does not offer substantial risk diversification benefits. In contradiction, the study of Fugazza et al. (2007) investigate optimal portfolio choice; in particular, the role of different asset classes and diversification in European portfolios. They use a Vector Autoregressive Framework to predict asset returns and subsequently determine optimal asset weights. Their analysis shows that long term investors with portfolios excluding listed real estate, miss about 200 to 400 basis points (bps) of return per year. Yet listed real estate should comprise a major part (23-44% in the predictability model) of an optimal portfolio because it offers an attractive risk-reward profile. Lee (2005) argues that real estate offers diversification benefits in mixed-asset portfolios. In addition, investors should not only look at the individual return of an asset, or in this case real estate, but to the risk and return of the whole portfolio. In particular, investors should be concerned about the terminal wealth of a portfolio (i.e. compound return), and less about past returns because terminal value determines whether or not an (institutional) investor is able to meet it future obligations. Generally, real estate is attractive because it has a relatively low correlation with other assets in the portfolio and therefore has a positive contribution to the terminal value of a portfolio. The results of the study of Brounen and Eichholtz (2003) are similar: they provide evidence that listed real estate offers diversification benefits for traditional equity investors. Moreover, they suggest that 10% of a mixed-asset portfolio should be allocated to real estate based on a mean-variance optimization model. Another study of Eichholtz (1996) shows that international diversification reduces risk of a listed real estate portfolio more than a portfolio of equities and bonds. Besides diversification benefits, Fama and Schwert (1977) find that private residential real estate is an appropriate hedge against either expected or unexpected inflation. While stocks perform poorly during inflationairy periods. In contradiction, Ely and Robinson (1997) reveal in their study that stocks do offer an inflation hedge over the long term. Thus, the argument for real estate as inflation hedge is ambiguous.

These studies underpin the importance of real estate in asset allocation. As a consequence, it is relevant that index providers offer listed real estate indices to practitioners. In particular, GDP-weighted listed real estate indices could provide practitioners with an alternative market view.

1.3 Is market capitalization indexation obsolete?

Traditionally, indexation is based on market cap. Indexation refers to the matter of how index providers determine the weights of stocks in the index. Market cap equals the number of outstanding shares times the share price. The weight of each stock in an index depends on its relative market cap compared to the total market cap in an index. The main argument for cap-weighting is that such a portfolio is mean-variance[1] efficient, under the assumption that markets are informationally efficient. The efficient market hypothesis (EMH) implies that security prices incorporate all information about a stock and the market without a delay (Fama, 1970). Assuming prices contain all available information, it is not possible to find a portfolio with the same volatility and better return, or same return and less volatility. Thus a market cap portfolio is optimal. In addition, a cap-weighted portfolio has other pros as discussed by Arnott, Hsu and West (2008). Firstly, it is a passive investment strategy which requires little trading and therefore has low transaction or rebalancing costs. Secondly, greatest weights are allocated to the largest companies. Because market cap is positively correlated with liquidity, the portfolio contains the most liquid stocks (explained in section 1.4). Thirdly, market capitalization and investability are positively correlated. Investability refers to the ease for fund managers to buy and sell stocks and subsequently replicate the index. In general the investability of cap-weighted portfolios is high. These factors (transaction and rebalancing costs, liquidity and investability) are important in examining the applicability of indices. Liquidity and investability of the newly created GDP-weighted indices are examined in section 3.

Besides the benefits of cap-weighted indices, others demonstrate the shortcomings of this indexation methodology. Several studies argue that cap-weighting is suboptimal, assuming the efficient market hypothesis (EMH) does not hold. The assumption that EMH does not hold is still widely discussed as brought up by Malkiel (2003). It implies that markets are inefficient and as a

1 Portfolio that has the highest expected return at a given level of risk, or lowest risk at a chosen level of expected return.

consequence, investors are able to distinguish mispriced stocks and select undervalued stocks. Under this assumption, Arnott and Hsu (2008) claim that market prices contain pricing errors which are positive or negative pricing errors. Positive pricing error means a share is overvalued, a negative pricing error refers to an undervalued share. In the context of cap-weighted indices, overvalued shares receive a larger weight than undervalued shares because the weights are driven by market prices. The crux of the matter is overvalued shares will underperform in the future because pricing errors will correct, while undervalued shares will outperform. It is exactly the opposite of "buy low, sell high". As a result, the overall performance of a cap-weighted index is considered as suboptimal in inefficient markets. Similar are the findings of Haugen and Baker (1991) who show that cap-weighted indices are inefficient: alternative portfolios with similar risk but higher return are available. In particular, they show that during the period 1972-1989 equity portfolios were available that offered higher return but lower volatility than the Wilshire 5000, considered to represent the U.S. equity market.

The aforementioned literature shows that efficiency of markets, which results in a cap-weighted portfolio as mean-variance efficient, is ambiguous. Assuming market inefficiency, Arnott et al. (2008) propose Fundamental Indexation as an alternative indexation methodology. Stock weights are based on fundamental variables, like book value, revenues, dividends and cash flow of the company. Their results reveal that a Fundamental Index offers a higher risk-adjusted return than the cap-weighted counterpart during the period 1962-2004. Specifically, Hsu et al. (2010) apply Fundamental Indexation to listed real estate. They construct new listed real estate indices (one for the U.S. and one global index excluding the U.S.) where stock weights are based on the four abovementioned accounting variables. The results show a higher Sharpe ratio[2] for the newly constructed indices compared to their cap-weighted counterparts. Besides, they use the capital asset pricing model (CAPM) and the Fama-French multifactor model to decompose the portfolio returns. The new indices have a higher beta (i.e. market risk exposure) than the cap-weighted indices. Alpha is positive but only statistically significant for the U.S. Fundamental Index. The study concludes with the notion that Fundamental Indexation adds value from the perspective of listed real estate. The methodology used by Hsu et al. (2010) will act as basis for the empirical part of my master thesis. In addition to the argument that cap-weighted portfolios are suboptimal, there are two more biases. Firstly, usually cap-weighted indices are based on free float market cap. Free float refers to shares which are publicly available for trade. In particular, insider holdings like director holdings and shares of major

[2] Sharpe ratio: excess return of portfolio over risk free rate of return / standard deviation of portfolio

shareholders like government institutions are not counted as free float. Consequently, countries with large insider holdings are assigned a lower weight in a cap-weighted index. This means that these indices are skewed away from countries with large insider holdings. Also, state-owned or privately held companies are not listed and therefore not counted in a cap-weighted scheme. For example, developing countries have relatively many state-owned and privately held companies, and are therefore not represented in indices. Gradually these countries open up their equity markets, this leads to capital inflows in the long run. What makes developing countries an attractive investment opportunity is that these countries are growing at a faster pace than developed nations. Several asian economies have become part of the largest economies in the world based on Gross Domestic Product (CIA World Fact Book). But at the same time, capital markets in developing economies lack this growth resulting in an economy size and market size disconnect (like during the asset bubble in Japan in the 1980s). Vice versa, well-developed countries like the U.S. have mature capital markets but GDP growth lacks behind. Table I (Appendix) lists countries which are constituents of the GPR 250 Index[3] and their accompanying market cap to GDP ratios. Low percentages represent countries with a relatively large economy size in comparison to market size and can be classified as countries with growth potential as explained above. On the other hand, countries with high percentages represent matured markets that have a lower chance of outperformance or which are overvalued. Those are, among others, Canada, Hong Kong, U.K. and the U.S (136.98%, 481.00%, 137.38% and 117.50% respectively). The percentage of Hong Kong is exceptionally high. This could be explained by the fact that the Hong Kong stock exchange serves the Hong Kong market and Mainland China. Less developed markets are Austria, Brazil, China, and Germany (17.86%, 74.03%, 80.36% and 43.58% respectively). Accordingly, cap-weighted indices underweight developing nations while these have growth potential and above average returns in the long run. By using the GDP-weighted indexation methodology, more weight is allocated to these developing countries in expectation of higher future returns (see section 3.2). A second bias is related to the indebtedness of countries. Generally, high market cap is associated with high debt levels. La Porta, Lopez-De-Silanes, Shleifer and Vishny (1997) confirm this view by investigating 'why some countries have much bigger capital markets than others?' Their results show that developed markets like the U.S. and U.K. have relatively high levels of external financing, both equity and debt. In addition, Demirgüç-Kunt and Maksimovic (1999) show that in developed countries large firms have more long term debt. Besides, firms in

[3] The GPR 250 Index is composed of the 250 most liquid listed property securities in the world. The index is provided by Global Property Research.

developing countries have less long term debt. Hence, cap-weighted portfolios which assign more weight on large cap stocks are biased to developed countries with high debt levels. GDP overcomes this issue because it generally underweights developed countries relative to a cap-weighted index (see section 3.2).

1.4 Liquidity

Liquidity is fundamentally important in financial markets. Liquidity refers to the ease with which an asset is traded and the related price impact. If demand and supply of a specific stock is out of balance, a trade impacts the price. For instance, if an investor wants to buy 5.000 shares of a stock but average daily volume equals 1.000 shares, the trade probably impacts the price because there are not enough sellers in the market. To prevent major price impact, it is important not to trade illiquid stocks. Generally, investors require a minimum of stock liquidity to avoid illiquid stocks. An important indicator of liquidity is average daily volume (ADV). ADV denotes the average number of shares traded on a trading day over the previous twelve months. In practice, traders use a rule of thumb to avoid significant price impact. For instance, they do not trade more than 25% of the ADV in one day. From the viewpoint of index construction, investors demand an index that consists of highly liquid stocks. Under the assumption that market capitalization is positively correlated with liquidity, cap-weighted portfolios contain liquid stocks because the stocks with largest market cap receive most weight. Still, cap-weighted indices contain some less liquid stocks but with a relatively small weight. Hence, the question is whether GDP-weighted listed real estate indices are liquid as well? For clarification, it is possible that Germany receives a relatively large weight in a GDP-weighted index while only a few stocks with a low market cap are listed on the stock exchange. In this case, each stock receives quite a large weight while their liquidity is relatively low. This is unattractive for investors; it is costly to buy or sell such stocks because of the price impact of trading. Consequently, liquidity is examined during the construction of the GDP-weighted indices. This topic is discussed more extensively in section 3.

1.5 Link between GDP and real estate markets

A macroeconomic variable is an indicator of the stance of the economy as a whole. Therefore, it does not focus on a specific company or individual. Gross Domestic Product (GDP) is a key macroeconomic variable which measures the total quantity of goods and services produced in a country over a period of time. It is a measure of economic activity in a country and is suitable for

international comparisons. Thus, GDP reflects the size of a country's economy in contradiction to market cap which reflects the size of a country's stock market. As aforementioned, this master thesis is a research to an indexation methodology for listed real estate based on GDP. It is therefore important to examine the relation between real estate markets and GDP.
There is no extensive literature available about the relationship between GDP and real estate markets. However, more is written about the relation between macroeconomic variables and real estate markets. Because GDP is a macroeconomic variable, I consider this literature to be relevant for my research. McCue and Kling (1994) explore the link between real estate returns and the macro economy and find that Real Estate Investment Trust (REIT) returns are explained for 60% by macroeconomic factors. These factors include prices, nominal rates, output and investment. They regress REIT returns on the returns of the S&P 500 and use the residuals to incorporate in a Vector Autoregressive Model to test the relationship with the macro economy. By this they control for the covariance between REIT returns and the overall stock market. Eichholtz (1996, pp.56-62) investigates international diversification from the perspective of listed real estate markets. Eichholtz states that '*National real estate markets are influenced by national economic factors that do not influence non- domestic real estate markets. […] In contrast, stock and bond markets are less influenced by local factors and are more influenced by global factors than are real estate markets.'* Hence, Eichholtz corroborates that real estate markets are more linked to the national economy than stock and bond markets are.

These studies argue about the effects of macroeconomic variables on real estate returns. At the same time, Zhu (2005) discusses the effect of fluctuations in real estate prices on the economy. There is reverse causality: do macroeconomic variables cause real estate returns to fluctuate or do real estate prices cause the macro economy to fluctuate? Obviously it works both ways. In this master thesis I assume that macroeconomic variables, i.e. GDP, cause real estate returns to change because this seems a reasonable realistic assumption.

1.6 Other characteristics of GDP-weighted indexation

Besides the foregoing merits, there are several other matters which are worthwhile to discuss. Firstly, listed real estate markets are dependent on specific real estate investment trust legislation. Differences in the presence of beneficial tax structures result in differences in sizes of listed real estate markets (Brounen and Eichholtz, 2004). For instance, REIT structures in the U.S. led to the rise of listed real estate companies in the U.S., while the open-ended non-listed real estate sector in Germany resulted in a lower representation of Germany in cap-weighted indices. As a consequence, cap-weighted schemes do not fully capture investment opportunities in some countries. GDP-weighted indices seem to be a better reflection of underlying real estate markets because GDP does not take real estate investment trust legislation into account but looks at the economy as a whole. Secondly, it is argued that GDP-weighted indices are more forward-looking than cap-weighted indices. In cap-weighted indices stock weights are determined based on their historical performance, thus it is backward-looking. In addition, GDP-weighted indices are based on lagged GDP figures but at the same time they overweight emerging markets with high future growth potential, compared to the cap-weighted counterpart. GDP-weighted indices provide investors with a macroeconomic view on where global markets will be in the future. Thirdly, GDP-weighted indices seem less prone to business cycles. This is confirmed by the historical performance of the GDP-weighted MSCI World Index. For example, the weight reduction of Japan from 65% to 35% resulted in less influence of the stock market burst on the total performance of the index.

At last, GDP-weighted indices have less attractive aspects as well. Firstly, GDP-weighted indices involve higher management costs than cap-weighted indices. Cap-weighted indexation is a passive investment strategy at a low cost because market cap data is instantly available. In addition, GDP-weighted indices demand more work because GDP values should be obtained from a reliable data source like International Monetary Fund (IMF) or Organisation for Economic Co-operation and Development (OECD). In particular, GDP values are always lagged values and are often not readily available for all countries at the same time. Secondly, according to the neoclassical growth model (Solow, 1956) it is expected that GDP values of developing countries and developed countries converge over time. Therefore in the long run, it is expected that stock weights in cap-weighted and GDP-weighted indices equalize. Consequently, this should be kept in mind when interpreting the results of this study.

II DATA

This section provides a description of the data used in this master thesis and the process by which the data is gathered.

2.1 Data selection

The GDP-weighted indices constructed in this thesis are compared to an existing cap-weighted index which in this case is the GPR 250 Index. The GPR 250 Index is composed of the 250 most liquid listed real estate stocks in the world. Before the indexation methodologies can be compared, the GDP-weighted indices need to be constructed. The composition of the GPR 250 Index acts as the basis for the construction of the GDP-weighted indices. As such, the GPR 250 Index constituents are constituents of the GDP-weighted indices as well, only the stock weights need to be changed subject to GDP values. In the construction of the GDP-weighted indices, weights are based on nominal GDP purchasing power parity values (PPP) of countries. Nominal GDP reflects the size of a country's economy thus incorporates unlisted and state-owned companies as well. Therefore, it is a reflection of investment opportunities in a country. Purchasing power parity is used because this measure eliminates differences in price level. Because of this, nominal GDP PPP is a good measure to compare differences in total economic output between countries. The weight of a stock in the indices is determined by multiplying the GDP weight with the market cap weight (explained more extensively in section 3). Thus market cap of the constituents is required as well before the indices can be constructed.

Besides abovementioned data, which is necessary for the construction of the indices, other data are relevant as well. For the benefit of testing the performance of the indices by a single-factor model and multifactor model, estimates of other variables are required. In the single-factor CAPM, the risk-free rate and market portfolio return should be obtained. The risk-free rate is estimated by the one-month U.S. Treasury bill rate, chosen as the indices are calculated in U.S. dollars. The market portfolio is presented by the MSCI All Country World Index. The MSCI ACWI measures the performance of developed and emerging markets. It is composed of 24 developed and 21 emerging markets country indices. Hence, the MSCI ACWI is a good representation of the global stock market. For the Fama-French factors, MSCI style indices are used (explained in section 4).

2.2 Data collection

The IMF provides data each year on previous year GDP values. The GDP data is available to the public through the website of the IMF. The nominal GDP PPP values are denoted in U.S. dollars. In this study annual GDP values are used because stock weights are typically reset in June each year. Some countries provide quarterly GDP data as well but in case of quarterly rebalancing, both the trading costs increase and the data is not available for most countries. If GDP data are not available for a country at the time of rebalancing, estimates are used as made available by the CIA World Factbook. In addition, GDP data are sometimes revised during the year. In this case, revisions are ignored so no changes to stock weights are made. Next, market cap of each company included in the GPR 250 Index is required on a monthly basis to calculate the stock weights. This data is provided by GPR which collected the data for listed real estate companies since 1989. After the indices are constructed, their performances can be calculated. The indices are calculated on a total return basis which means dividends are reinvested. Closing prices of the last trading day of the month are used to calculate the returns. Since GPR collected return data from 1989 onwards, the inception date of the GPR GDP Index is 30 June 1990; the GDP values from 1989 are used in the calculation of the stock weights. The GPR GDP Indices are calculated from 6/30/1990 until 5/31/2012; a total of 264 months. This results in return data for 263 months (observations). The database is free of survivorship bias because the companies which are included in the GPR GDP Indices over time are exactly the ones which are included in the GPR 250 Index. Hence, the backtested indices are a reliable representation of what they would have been in reality. In section 3 the construction of indices is explained.

Liquidity and investability are tested as well. In the analysis, full market cap, volume and share price data is required on a daily basis. This data is collected via Bloomberg which is made available by GPR as well. The linear regression models in the study require estimates of the risk-free rate and Fama-French risk factors. The risk-free rate is obtained via the Kenneth French Data Library website. Remaining variables are collected via Datastream. The market return is reflected by the MSCI ACWI. Fama-French factors are constructed with MSCI style indices; MSCI World Small Growth, MSCI World Mid Growth, MSCI World Large Growth, MSCI World Small Value, MSCI World Mid Value and MSCI World Large Value. All indices are calculated on a total return basis. The inception date of the MSCI value and growth indices is June 1994. Therefore the return data for the MSCI style indices is available since 31 July 1994 to 31 May 2012. This results in 215 months (observations). Hence, the Fama-French regression is carried out with fewer observations.

III INDEX CONSTRUCTION

In this section the process of index construction is explained in detail. Because the stock weights in the newly created GPR GDP Indices are based on GDP values and not on market cap, liquidity and investability is not assured. Hence, stock weights are calculated at three different GDP levels: country, zone and continent level. For these three levels liquidity and investability is tested before the indices are backtested.

3.1 Calculation of stock weights

In this master thesis I compare two weighting methods: cap-weighting and GDP-weighting. The GPR 250 Index is a free float cap-weighted index and serves as the basis for the construction of the new indices. The stocks which are included in the GPR 250 Index are included in the GPR GDP Indices as well to ensure apples-to-apples comparison (table II, Appendix). Only the weights for the three different GDP levels are changed subject to GDP values. This means that stock weights within a country, zone or continent are still based on free float market cap. Three global indices are constructed: a GPR GDP Index at country level, GPR GDP Index at zone level and a GPR GDP Index at continent level. In total there are 33 countries, 11 zones and 5 continents. Firstly stock weights are determined on country weight, then on zone weight and lastly on continent weight. Country weights are calculated as a country's GDP divided by the sum of GDP's of all countries included in the GPR 250 Index. Zone weights are calculated in a different manner: GDP values for countries which are allocated to a particular zone are collected, even if these countries are not included in the GPR 250 Index. This way of distribution of countries is determined according to the rules of GPR (Appendix, table III). Next, zone weights are calculated as the sum of GDP of all countries in the zone, divided by the sum of GDP values of all zones. This calculation procedure also counts for the calculation of continent weights. GDP values for all countries in the continent are collected and the weights are determined by dividing the sum of GDP values in the continent by the sum of GDP values of all continents. At these levels, GDP-weights and cap-weights are compared. The process of testing liquidity and investability is explained in section 3.2.

After GDP values are collected for the time period 1989-2011, the cap weights, country, zone and continent weights can be determined. For simplicity, country, zone and continent are denoted as region REG in the future.

The calculation of stock weights starts with the calculation of the weight *w* of an individual stock *i* in a cap-weighted index:

$$w_{i,t}^{MCAP} = \frac{MCAP_{i,t}}{\sum_{n=1}^{N} MCAP_{n,t}} \quad (1)$$

where *MCAP* represents the free float market capitalization of a stock *i* at time *t* and *N* is the total amount of stocks in a specific country (continent or zone) in the cap-weighted index. The weight of a stock in the GDP-weighted index is determined by multiplying the market cap stock weight by the weight of the region. The weight of a region in the index is:

$$REG_{j,t} = \frac{GDP_{j,t-1}}{\sum_{n=1}^{N} GDP_{n,t-1}} \quad (2)$$

where *REG* represents the region weight for region *j* at time *t. GDP* represents the nominal GDP PPP value of region *j* at the previous year. *N* is the total number of regions. Finally, the stock weight in the GDP-weighted index is calculated as follows:

$$w_{ij,t}^{GDP} = w_{i,t}^{MCAP} * REG_{j,t} \quad (3)$$

where *i* is an individual stock which is allocated to region *j* at time *t.* The inception date of the indices is 30 June 1990. Hence, GDP values of 1989 are used to determine the region weights. In June of each year, the indices are rebalanced. This means that region weights are reset to the GDP values of the previous year. Between the rebalancing dates, the region weights float on total return (i.e. the weights change on a monthly basis subject to the change in total return). Region weight on days other than rebalancing is defined by:

$$REG_{ij,t} = \frac{REG_{j,t-1} * (r_{i,t}/r_{i,t-1})}{\sum_{n=1}^{N} [REG_{n,t-1}(r_{i,t}/r_{i,t-1})]} \quad (4)$$

where *i* embraces the stocks which are allocated to region *j.* The return of a stock is calculated on a total return basis, therefore dividends are included:

$$r_{i,t+1} = \frac{P_{i,t+1} + D_{i,t+1} - P_{i,t}}{P_{i,t}} \quad (5)$$

where *r* is the return of stock *i* at time *t*, *P* represents the closing price of stock *i* at time *t* and *D* is the dividend on stock *i* at time *t.* The index is calculated on a monthly basis. The index value is calculated by making a sum of all contributions of all stocks in the index, multiplied by the index value of the last trading day in the previous month. The contribution of a stock is calculated by multiplying its return by its respective weight:

$$I_{t+1} = I_t\left(1 + \sum_{n=1}^{N} w_{i,t} * r_{i,t+1}\right) \tag{6}$$

where *I* is the value of the index at time *t.*

3.2 Testing liquidity and investability

After GDP values and free float market capitalizations of all stocks included in the GPR 250 Index for the time period 1989-2011 are collected, stock weights can be determined at the three levels. Table IV, V and VI (Appendix) summarize the differences in GDP-weights and cap-weights at country, zone and continent level respectively. Table IV shows the differences at country level. The largest overweighting is to China, Germany and Brazil at the rebalancing in June 2011. At the same time, the largest underweighting is to the United States, Australia and Japan. Figure 1 depicts the differences in country GDP-weight and cap-weight at the time of rebalancing in June 2011.

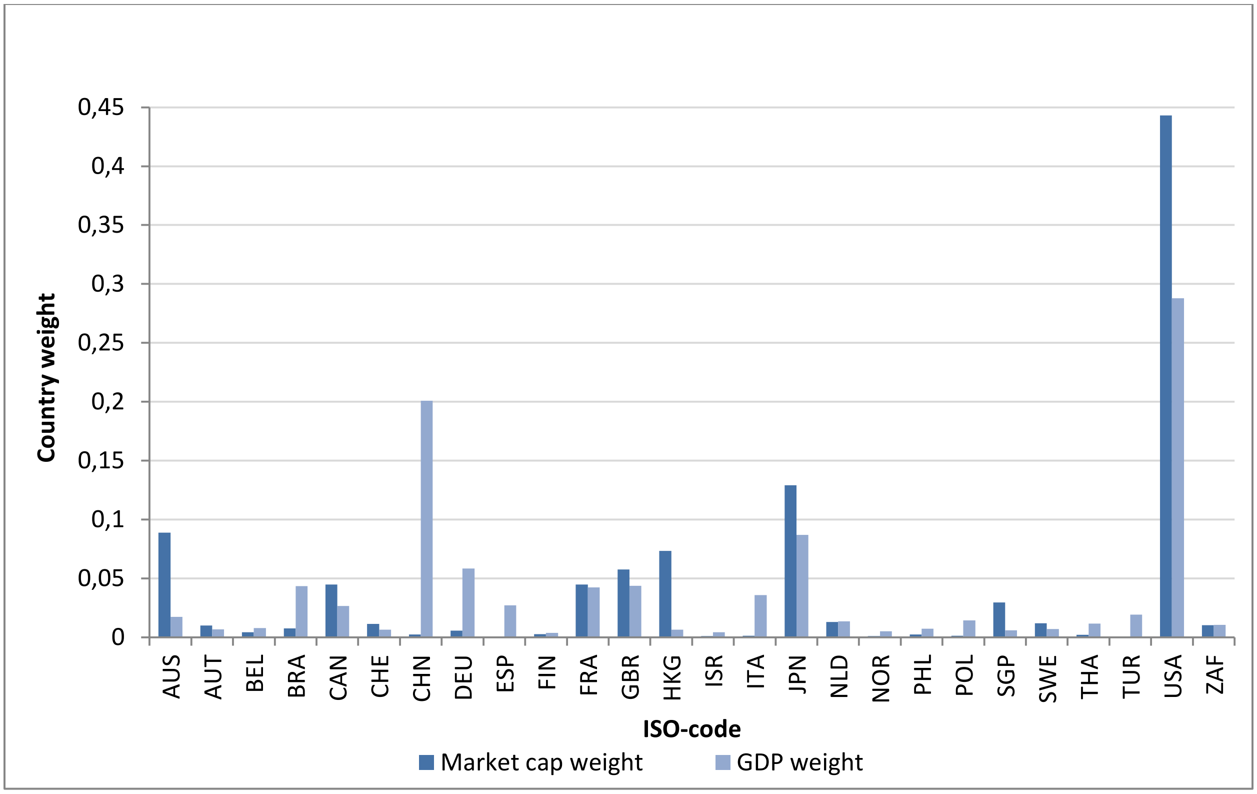

Figure 1: Country weights in market cap-weighted index (GPR 250 Index) and GDP-weighted index at 6/30/2011. Notes: The graph depicts the country weights in the GPR 250 Index and GPR GDP Index (country level). From left to right: Australia, Austria, Belgium, Brazil, Canada, Switzerland, China, Germany, Spain, Finland, France, United Kingdom, Hong Kong, Israel, Italy, Japan, The Netherlands, Norway, Philippines, Poland, Singapore, Sweden, Thailand, Turkey, United States and South Africa.

Besides the differences in country weights during the rebalancing at 30 June 2011, continents are underweighted and overweighed over time as well. Figure 2 shows the underweighting and overweighting at continent level for the time span 1990-2011. If the difference in weight is positive, the continent is said to be overweighed in the GDP-weighted index. Vice versa, if the difference is negative, the continent is said to be underweighted in the GDP-weighted index. Some continents show a more stable difference between cap-weights and GDP-weights over time while others do not. It appears that Europe is overweighed most of the time, while Americas is overweighed during 1990 until 1997 and underweighted since 1998 onwards. Asia is slightly underweighted during the subprime crisis but turned to be overweighed since 2010. Figure 1 in the Appendix shows the continent weights over time for both the cap-weighted and GDP-weighted index. It is shown that GDP-weighted indexation results in more stable continent weights over time.

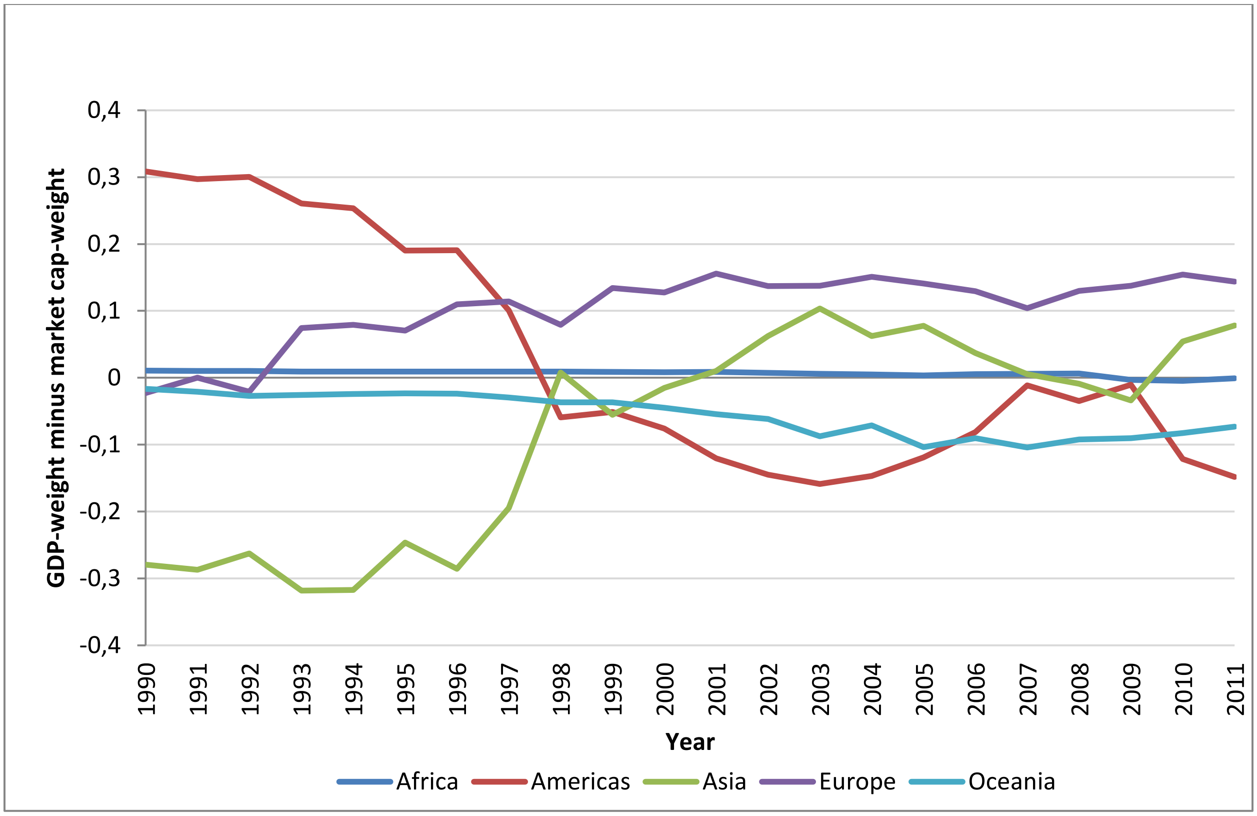

Figure 2: Difference between continent weights of GDP-weighted index and market cap-weighted index (GPR 250 Index) over the period 6/30/1990 to 6/30/2011.

Notes: The graph depicts the underweighting (negative value) and overweighting (positive value) of continents in the GPR GDP Index (continent level) versus the free float cap-weighted index over time.

From the tables and figures it is clear that GDP-weights and cap-weights differ over countries, zones and continents. The issue is whether stocks which are least liquid, receive a substantial weight in the GPR GDP Indices because some countries, zones or continents receive a relatively large weight. Consequently, it is necessary to analyze individual stock weights in the GDP-weighted indices to assure liquidity and investability. Liquidity and investability are closely linked but there is a difference: liquidity refers to the ease of which a stock is traded without significant price impact, therefore trading activity is important. Whereas, investability refers to the ease of which an index is replicated and thus relates to the investment capacity. Investability is tested using a rule of thumb: investors do not want to own more than 5% of the full market capitalization of a stock. Liquidity can be measured in a variety of ways. In this study it is measured in terms of average daily turnover (ADT) (as measured in U.S. dollars terms). As liquidity requirement, I use a general rule which is common practice in trading activity. The dollar value of a trade should not exceed a threshold of 25% of ADT of that particular stock. Moreover,

I assume a trader buys or sells the entire weight a stock is represented by in the GPR GDP Index in only one trade, i.e. he does not spread the trade over several days.
ADT is calculated as follows:

$$ADT_{i,t} = \frac{1}{252} * \sum_{t}^{t-252}(p_{i,t} * v_{i,t}) \quad (7)$$

where *t* is time in days. Also, I assume a year contains 252 trading days so I multiply by $\frac{1}{252}$, *p* equals closing price in U.S. dollars at time *t* and *v* represents volume, i.e. the number of shares traded at time *t.* I calculate the ADT for each stock at the rebalancing dates for the years 1990-2011. I multiply the ADT with 25% which results in the threshold for liquidity. I assume investors have a particular amount of U.S. dollars of assets under management which they invest in the index/portfolio. Next, the restriction requires:

$$\frac{AuM_{i,t} * w_{i,t}}{ADT_{i,t}} \leq 25\% \quad (8)$$

where, AuM represents assets under management in portfolio *i* at time *t* and *w* is the stock weight at the rebalancing date. With this formula I can derive the maximum amount of AuM for each stock, at each level and year, in which the liquidity threshold is not violated. Rewriting the formula results in:

$$AuM_{i,t}^{TR} = \frac{25\% * ADT_{i,t}}{w_{i,t}} \quad (9)$$

Next, I search for the stock which has the smallest amount of AuM each year because this is the stock which firstly violates the threshold if AuM increases. I calculate the same values for the GPR 250 Index. Finally, I compare both values in order to derive results:

$$liquidity\ ratio = \frac{Max\ AuM_{GPR\ GDP}}{Max\ AuM_{GPR\ 250}} \quad (10)$$

This ratio represents the liquidity of the GPR GDP Indices compared to the liquidity of the GPR 250 Index. These ratios are displayed in table VII in the Appendix. The most striking result is the ratio for the year 1990. The GPR GDP Indices have a liquidity of more than 200% of the liquidity of the GPR 250 Index. The reason for this is the difference in GDP and cap-weights for Japan. The stock with the smallest value of AuM is a Japanese stock, both in the GDP-weighted and GPR 250 Index. The weight of the stock is substantially lower in the GPR GDP Indices which result in a high ratio. At 30 June 2011, the GPR GDP Index offers lower liquidity when compared to the GPR 250 Index at country and zone level. At the continent level the GPR GDP Index offers 75% of liquidity of the GPR 250 Index. Because the GPR 250 Index is composed of the 250 most liquid stocks, the GPR GDP Index on continent level could be seen as a highly liquid index.

Next, investability is tested as well. Firstly, I assume an investor does not want to own more than 5% of a stock's shares because otherwise he is considered to be a beneficial shareholder. The rationale for this assumption is twofold: according to a survey of the OECD, institutional investors like pension funds have ownership limits on single securities, '*the ceiling ranges from 30% in Canada to 5% in Spain and Sweden.'* On the other hand, regulation in the U.S. advocates disclosure issues. According to the Securities and Exchange Commission (SEC) a listed company should disclose a list of its beneficial shareholders in a 10-K filing. Besides, beneficial shareholders itself should submit a SEC filing (Schedule 13D). I assume investors want to avoid the time-consuming disclosure of beneficial ownership and thus set up the 5% rule. The formula is as follows:

$$\frac{AuM_{i,t} * w_{i,t}}{Full\ MCap_{i,t}} < 5\% \tag{11}$$

Beneficial ownership is determined on the total number of shares a company has issued. Therefore, I use full market cap because this variable represents the total number of shares outstanding times share price. If I assume the 5% rule holds, I can derive the maximum amount of AuM for all stocks each year and at each level. I rewrite the formula as follows:

$$AuM_{i,t}^{TR} = \frac{5\% * Full\ MCap_{i,t}}{w_{i,t}} \tag{12}$$

Next, I search for the stock with the smallest amount of AuM at each year, because then I assure the 5% rule is not violated. The values are calculated for the GPR 250 Index as well for comparison reasons. The maximum amount of AuM in the GPR 250 Index is calculated as:

$$AuM_{i,t}^{TR} = \sum_{t}^{t-252} 5\% * Full\ MCap_{i,t} \tag{13}$$

where the maximum amount of AuM for the years 1990 until 2011 is the sum of 5% of stock *i*'s full market cap in year *t,* which contains 252 trading days. Thus, I assume an investor holds exactly 5% in each stock included in the index. Table VIII (Appendix) shows the ratio of the maximum amount of AuM in the GPR GDP Indices to the maximum amount of AuM in the GPR 250 Index. The ratios represent the relative investment capacity of the GPR GDP Indices. There are differences in ratios between country, zone and continent level. At 30 June 2011, the investability of the GPR GDP Index as percentage of the GPR 250 Index is 2.39% and 42.42% at country and continent level respectively.

The previous analysis shows that the GPR GDP Indices have lower liquidity and investment capacity than the GPR 250 Index. Taking into account the demand for liquidity and investability, stock weights which are based on GDP values of continents seems most appropriate in practice because liquidity and investability are 75% and 42% respectively of the GPR 250 Index. In section 5, I calculate the index values of the GPR GDP Indices and test their performance.

IV METHODOLOGY

In this section the methodology of the empirical test is explained. Firstly, summary statistics which encompass mean, spread, shape and dependence are denoted. Secondly, the CAPM and Fama-French regressions are explained. The section ends with four hypotheses which are tested in section 5.

4.1 Performance evaluation

After the index values (I) of the newly constructed GPR GDP Indices are calculated, the next step is to test the performance of the indices. Aspects which are of first interest are return and risk. Annual return is defined by:

$$r_{annual} = (I_t \ / \ I_{t-12}) - 1 \tag{14}$$

where *I* represents the index value at the last trading day of month *t* divided by the index value at the last trading day of month *t-12* in a specific year. Risk is measured in terms of standard deviation. Annualized standard deviation is calculated as follows:

$$s_{annualized} = s_{monthly} * \sqrt{12} \tag{15}$$

where,

$$s_{monthly} = \sqrt{\frac{\sum_{n=1}^{N}(r_i-\bar{r})^2}{(n-1)}} \tag{16}$$

where r_i is the return in month *i* and $\bar{r}$ is the mean of return and *n* equals the number of months in one year. The risk-adjusted return is calculated by the Sharpe ratio. The Sharpe ratio reflects the additional return an investor receives over additional volatility when holding a risky asset. The Sharpe ratio is defined by:

$$SR = \frac{r_i-r_f}{s_i} \tag{17}$$

where r_i equals the return of the portfolio *i* and r_f represents the risk-free rate (one-month Treasury bill rate). In addition, other characteristics of the indices are of interest as well. Firstly, correlation of the GPR GDP Indices with the cap-weighted index and other asset classes is examined. Correlation embraces the relation of the GPR GDP Indices with the GPR 250 Index, equities and bonds. The correlation coefficient *r* is used to obtain correlation values and is defined as:

$$r_{GDP,MCAP} = \frac{COV(GDP,MCAP)}{s_{GDP} * s_{MCAP}} \tag{18}$$

where the covariance of the monthly returns of the GPR GDP Indices and GPR 250 Index are divided by the product of the standard deviations. Measures of location and variability are skewness and kurtosis. Skewness measures the symmetry of the data. The normal distribution has a skewness equal to zero. If skewness is negative, most of the data is distributed on the right side of the distribution. Vice versa, if skewness is positive most of the data is on the left side of the distribution. Skewness is defined by:

$$s = \frac{E(X_i - \bar{X}^3)}{s^3} \tag{19}$$

On the other hand, kurtosis reflects the shape of the distribution. The normal distribution has a kurtosis equal to three. If kurtosis is higher, the distribution is said to be fat-tailed because it has higher probability mass in the tail areas. If kurtosis is lower, the distribution has thinner tails. Kurtosis is defined by:

$$k = \frac{E(X_i - \bar{X}^4)}{s^4} \tag{20}$$

4.2 Regression models

Besides abovementioned statistics, a more in-depth analysis of sensitivity of risk is required. I follow the methodology of Hsu et al. (2010) who investigate Fundamental Indexation for listed real estate. Firstly, the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) is used. CAPM shows under simplifying assumptions that the market portfolio is the mean-variance efficient portfolio. According to the CAPM, the return of a portfolio is linearly correlated with beta, i.e. the covariance of portfolio return with the return of the market portfolio over the variance of the market portfolio. It implies that beta completely explains the cross section of expected returns. Hence, there is no intercept. The CAPM formula is defined as:

$$E\left(r_{i,t}\right) = r_{f,t} + \beta_{im}(E\left(r_{m,t}\right) - r_{f,t}) \tag{21}$$

where *E* denotes an expectation, r_i equals the return of portfolio *i*, r_f represents the risk-free rate and r_m equals the return of the market portfolio. The implication can be tested with an Ordinary Least Squares (OLS) regression model. Rewriting the formula results in:

$$E\left(Z_{i,t}\right) = \beta_{im}E(Z_{m,t}) \tag{22}$$

where $E\left(Z_{i,t}\right)$ is the expected excess return on the portfolio and $E(Z_{m,t})$ is the expected excess return on the market portfolio. If (Z_i) is regressed on (Z_m), alpha (α) and beta (β) are obtained. Beta reflects the sensitivity of the portfolio's returns to market returns. CAPM implies that there should be no intercept, i.e. $\alpha = 0$. If alpha is positive, the portfolio return is higher than what CAPM predicts. Hence, higher alpha is attractive for investors. The significance of alpha is tested with a Student t-test.

CAPM is a simplified model which is despite evidence against it, still widely used in assessing the performance of portfolios. But literature shows that the single-factor does not completely explain asset returns. In addition, the Fama-French multifactor model is applied in the study of Hsu et al. (2010). The Fama-French multifactor model implies that expected returns are explained by multiple risk factors. The study identifies three common risk factors which explain stock returns. These risk factors are the overall market factor, firm size factor and book-to-market factor. Hence, the CAPM is extended with two risk factors. Explanatory variables are 'small minus big' (SMB) and 'high minus low' (HML) factors respectively. SMB represents the excess return of small capitalization stocks over big capitalization stocks. HML represents the excess return of high book-to-market ratio stocks over low book-to-market ratio stocks, i.e. value stocks over growth stocks. Because Fama & French (1992) focus on explaining U.S. stock returns, the Fama-French data is not appropriate as explanatory variables.

In line with Hsu et al. (2010) the risk factors are constructed with the use of MSCI style indices. The OLS regression is denoted by:

$$E(r_{i,t}) - r_{f,t} = \alpha_i + \beta_{im}(E(r_{m,t}) - r_{f,t}) + s_i SMB_t + h_i HML_t \qquad (23)$$

where E denotes an expectation, r_i is the return of portfolio *i*, r_f is the risk-free rate and r_m is the return on the market portfolio. The risk factors are constructed according to the methodology of Hsu et al. (2010):

$$SMB_t = 1/2(Small\ Value + Small\ Growth) - 1/2\ (Large\ Value + Large\ Growth) \qquad (24)$$

$$HML_t = 1/3(Small\ Value + Mid\ Value + Large\ Value) - 1/3(Small\ Growth + Mid\ Growth + Large\ Growth) \qquad (25)$$

Besides the three factor model the Carhart model is a multifactor model which includes an additional momentum factor. This model is not addressed in this study because the predictive power of this factor is ambiguous (Liew, Vassalou, 2000). Both the CAPM and Fama-French model are tested with an OLS regression model.

4.3 Hypotheses testing

The main question is whether a GDP-weighted scheme is a better investment strategy than a cap-weighted scheme from the viewpoint of listed real estate. In the end investors only care about the risk-adjusted return on investment. Hence, the research question is reflected into hypotheses which are measurable. My predictions are as follows: Firstly, I suppose that the GDP-weighted indices offer a higher return that the cap-weighted indices. Secondly, it is reasonable to think that the stock market is correlated with the overall economy, i.e. GDP. Hence, I expect the beta of GDP-weighted indices to be higher than the beta of cap-weighted indices. Finally, because I suppose GDP-weighted indices benefit from growth potential of developing countries which results in high returns, I expect alpha of the GDP-weighted indices to be higher than the alpha of the cap-weighted index.

Hypothesis 1

H_0: GDP-weighted indices have the same return distribution as the cap-weighted index.

H_1: GDP-weighted indices do not have the same return distribution as the cap-weighted index.

Hypothesis 2

H_0: The betas of the GDP-weighted indices and the beta of the cap-weighted index are equal.

H_1: The betas of the GDP-weighted indices and the beta of the cap-weighted index are not equal.

Hypothesis 3

H_0: The difference between the CAPM alpha of the GDP-weighted indices and the cap-weighted index is equal to zero.

H_1: The difference between the CAPM alpha of the GDP-weighted indices and the cap-weighted index is not equal to zero.

Hypothesis 4

H_0: The difference between the Fama-French alpha of the GDP-weighted indices and the cap-weighted index is equal to zero.

H_1: The difference between the Fama-French alpha of the GDP-weighted indices and the cap-weighted index is not equal to zero.

V EMPIRICAL RESULTS

In this section the results of the empirical tests are discussed. Section 5.1 describes the risk and return characteristics of the indices. The CAPM regression results are discussed in section 5.2 whereas the Fama-French regression is discussed in section 5.3. In addition, a robustness check is covered in section 5.4. The section ends with a discussion of the limitations of the regression models.

5.1 Performance evaluation

Firstly, the cumulative returns of the GPR GDP Index at country, zone and continent level and the GPR 250 Index are calculated. The cumulative returns with base date 30 June 1990 are displayed in figure 3 below. The figure shows that holding the stocks of the GPR GDP Index at country level, offers the highest return over the period 30 June 1990 until 31 May 2012. But this figure does not tell anything about the returns and volatilities over shorter periods.

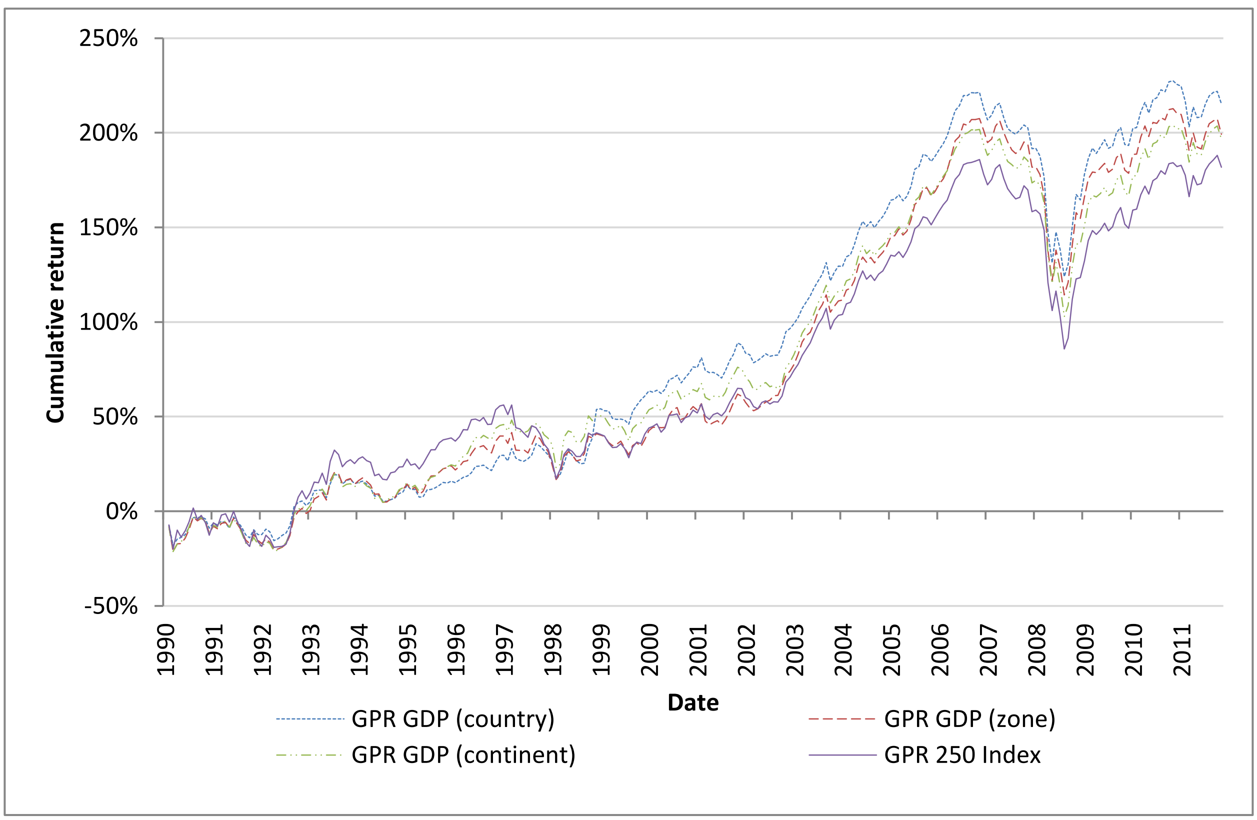

Figure 3: Cumulative total return performance of GPR GDP Indices and GPR 250 Index. Notes: The graph depicts the cumulative total return performance of the GPR GDP Index on country, zone and continent level and the GPR 250 Index. The base date is 6/30/1990. Cumulative return is calculated until 5/31/2012.

A more comprehensive analysis is required to derive reliable results about the performance and volatility of the indices. In table IX in the Appendix, annual returns and accompanying volatilities are displayed. The years in which the GPR GDP Indices underperform the GPR 250 Index are depicted with a grey background. It seems half of the time the GPR GDP Indices outperform and half underperform the benchmark GPR 250 Index. Years in which all three GPR GDP Indices underperform the GPR 250 Index are 1990, 1993, 1995 and 2008. 1995 is the start of rising stock markets which ends in the dot-com bubble in the early 2000s. On the contrary, 2008 is a year in which the financial crisis started. Both years were periods of rising stock market volatility. Still, there is no clear explanation for the underperformance of the GPR GDP Indices. Furthermore, volatility of the GPR GDP Indices is below the volatility of the GPR 250 Index most of the time. This is especially the case during the first ten years of the sample. Table X (Appendix) contains the return and risk values for sub periods. The results do not deviate much from the results displayed in table IX (Appendix). To get a better understanding of the performances, a summary of statistics is shown in table I. The arithmetic monthly return of the GPR GDP Indices is slightly above the return of the GPR 250 Index. Also, standard deviations are lower. The Sharpe ratio is a risk-adjusted return metric. The higher the Sharpe ratio, the better is the historical risk-adjusted performance of the portfolio. The Sharpe ratios of the GDP-weighted indices are all above the Sharpe ratio of the GPR 250 Index. The GPR GDP Index on zone and continent level are both 40 basis points above the Sharpe ratio of the GPR 250 Index. In addition, the GPR GDP Index on country level is 80 basis points above the benchmark's Sharpe ratio. Hence, GDP-weighted indices offer a higher historical risk-adjusted return. The results are similar to the results of Hsu et al. (2010). They also find that Fundamental Indexation listed real estate indices offer a higher Sharpe ratio than the cap-weighted counterparts.

Table I: Summary statistics of GPR GDP Indices and GPR 250 Index

The table contains a summary of statistics. The first two rows contain the average monthly returns and the associated standard deviations. Next the Sharpe ratios are displayed. The Sharpe ratio is calculated as follows: for each period *t* the difference between the index return and risk-free rate (one-month Treasury bill rate) is calculated. Next the average of the differences over the whole period is calculated. Finally, the average is divided by the annualized standard deviation of the index in question. Finally, skewness and kurtosis are calculated to examine the distribution of the returns.

	GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)	GPR 250 Index
Arithmetic monthly return	0.82%	0.76%	0.75%	0.69%
Standard deviation	5.13%	5.22%	5.10%	5.29%
Sharpe ratio	0.031	0.027	0.027	0.023
Skewness	-0.73	-0.79	-0.80	-0.80
Kurtosis	8.61	7.89	7.44	6.59

Besides, skewness is negative for all indices. Negative skewness implies more values are located at the right-side of the distribution and thus these values represent a return above 0%. On the other hand, kurtosis is above 3 for all indices. This means that all indices have a fat-tailed distribution. Consequently, it is more likely that there are extreme outcomes compared to a normal distribution with kurtosis of 3.

Besides summary statistics, other characteristics are of interest as well. Firstly, correlations with the GPR 250 Index and other asset classes are examined. A correlation close to 1 implies the GPR GDP Indices behave very similar to the other index or asset class. Of course correlation changes over time. Therefore a 36-months rolling correlation coefficient is calculated. Figure 4 shows the correlation coefficient of the GPR GDP Indices with the cap-weighted GPR 250 Index.

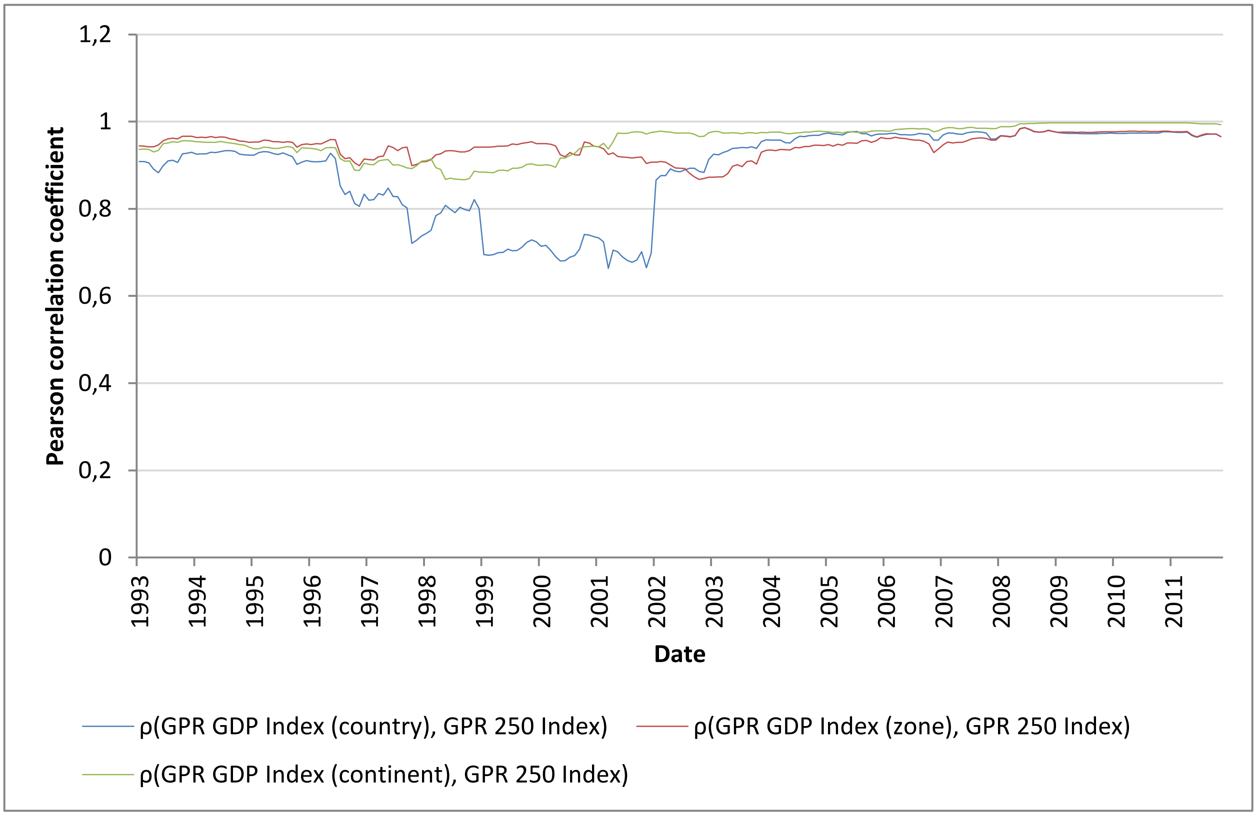

Figure 4: 36-months rolling correlation coefficient of GPR GDP Indices with GPR 250 Index. Notes: The graph depicts the correlation coefficients over a rolling window of 36-months from 7/31/1993 to 5/31/2012. A correlation coefficient close to 1 implies the return of the index behaves similar to the return of the other index.

The GPR GDP Index on country level behaves least similar as the GPR 250 Index. A remarkably motion is the jump in July 2002, during the stock market downturn. Return data show that the GPR GDP Index (country) encounters the downfall a little later, but then follows the return process of the other GPR GDP Indices. This certifies the spike. Besides looking at the correlation with the benchmark index, correlation with equities and bonds is examined as well. The MSCI ACWI reflects a broad range of worldwide equities and the JP Morgan Global Bonds Index is a good representation of bonds. The 36-months rolling correlation is shown in figure 5.

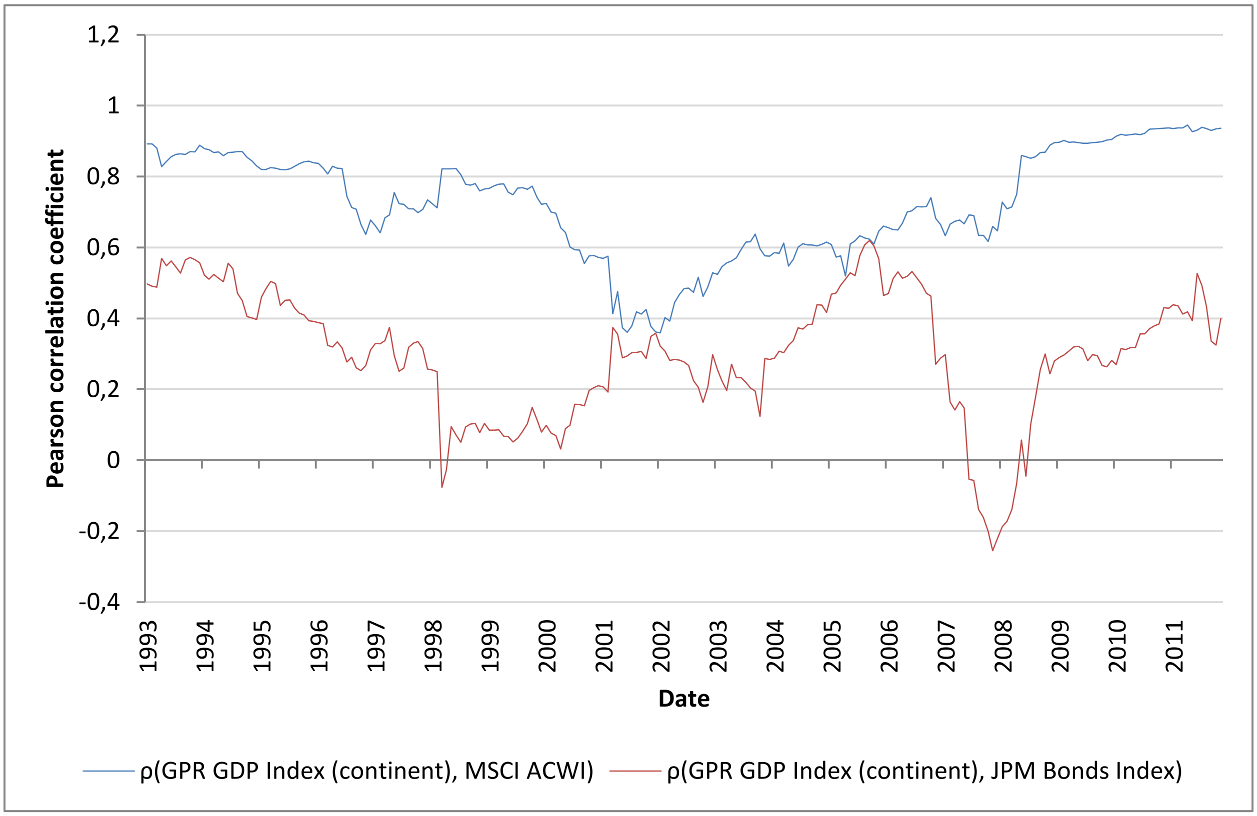

Figure 5: 36-months rolling correlation coefficient of GPR GDP Index at continent level with other asset classes. Notes: The graph depicts the correlation coefficient over a rolling window of 36-months from 7/31/1993 to 5/31/2012. A correlation coefficient close to 1 implies the return of the index behaves similar to the return of the other index. A negative correlation coefficient implies the index behaves exactly the opposite of the other index. The graph only includes the correlation of the GPR GDP Index on continent level with equities and bonds.

It is striking that correlations between the GPR GDP Index (continent) and MSCI ACWI decreases during 2001/2002 and 2007/2008, i.e. during stock market downturns. After a closer look at the return data, equity returns are more volatile than the GPR GDP Index (continent) returns. The correlation with bonds is low or even negative: it varies from 0.6 to -0.18 respectively. The spike in the correlation coefficient between July 2007 and January 2009 is due to a sharp decline in returns of the GPR GDP Index (continent). The index reaches a return of -27% in October 2008 whereas bonds show a -0.01% return. Figure 5 contributes to the argument that listed real estate has diversification benefits in mixed-asset portfolios. Correlation coefficients are displayed in table XI in the Appendix.

Preceding analysis discusses the performance characteristics of the GPR GDP Indices and GPR 250 Index. However, it is not formally tested whether the GPR GDP Indices offer a significantly better return than the GPR 250 Index. A non-parametric test is used to test the first hypothesis of the study. A non-parametric test is used because the assumption that returns are normally distributed is not very reliable. The values for skewness and kurtosis (table I) do not indicate a normal distribution. Moreover, a skewness test rejects the hypothesis that the returns of the four indices are normally distributed. Hence, the Wilcoxon signed-rank test is used to test the null hypothesis that both return distributions are the same. The results of the Wilcoxon signed-rank test are shown in table II.

Table II: Wilcoxon signed-rank test

The table shows the results of the Wilcoxon signed-rank test. W+ represents the sum of the positive ranks, W- represents the sum of the negative ranks. N is the number of observations. If the p-value is below a significance level of 5%, the null hypothesis that the GPR GDP Indices and GPR 250 Index have the same return distribution is not rejected.

	GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)
W+	17.734	17.590	18.383
W-	16.981	17.123	16.333
N	263	263	263
Z-statistic	0.305	0.189	0.830
p-value	0.760	0.850	0.407

The Z-statistics are very low whereas p-values are not close to significance levels. It can be concluded that the return distribution of the GPR GDP Indices and the GPR 250 Index are the same. Hence the first hypothesis that the GDP-weighted indices have the same return distribution as the cap-weighted index is not rejected.

5.2 Capital Asset Pricing Model

In the previous section, the indices are analyzed with respect to return, risk and other characteristics. In empirical studies, factor models are used to decompose and relate stock returns to risk factors. The CAPM implies that stock returns are completely explained by a single factor: the market risk factor. The sensitivity to the stock market is explained by beta. This means the intercept reflects abnormal return. I use the ordinary least squares (OLS) regression model to regress the excess returns (over the risk-free rate) of the index on the excess returns of the market. The regression equation is explained in section 4.2. After a simple regression, I consider the second OLS assumption which states that the error term is homoskedastic, i.e. the variance of the error term is constant. If error terms are heteroskedastic, the standard errors are biased and consequently the test statistics are biased. The Breusch-Pagan / Cook-Weisberg test is used to test for heteroskedasticity. The null hypothesis is that the variance of the error terms is constant. If the null hypothesis is rejected, heteroskedasticity is present. Both the chi-square statistic (which assumes a normal distribution) and the F-statistic (which drops the normality assumption) are large which implies heteroskedasticity. Consequently, I use an OLS regression with robust standard errors. The results of the OLS regression are shown in table III.

Table III: Regression results CAPM

The table presents the regression results for the single-factor CAPM. Monthly alphas and betas are estimated using robust standard errors which correct for heteroskedasticity. The ordinary least squares (OLS) regression equation equals: $E(r_{i,t}) - r_{f,t} = \alpha + \beta_{im}(E(r_{m,t}) - r_{f,t})$. Market return is calculated by the use of the MSCI All Country World Index. The risk-free rate is the one-month Treasury bill rate which is retrieved from Kenneth French Data Library. Heteroskedasticity-robust standard errors are in parentheses, ***, **, and * denote statistical significance at the 1, 5 and 10% level, respectively. The sample includes monthly return data from 07/31/1990 to 05/31/2012.

	GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)	GPR 250 Index
α	0.0025676	0.0017965	0.0017564	0.0010722
	(0.0021350)	(0.0020692)	(0.0019995)	(0.0020866)
t-statistic	1.20	0.87	0.88	0.51
β	0.8436617***	0.8914137***	0.8746638***	0.9088626***
	(0.071081)	(0.067861)	(0.063229)	(0.063039)
t-statistic	11.87	13.14	13.83	14.42
R-squared	0.5691	0.6134	0.6188	0.6192
Nr. observations	263	263	263	263
Prob (F)	0.0000	0.0000	0.0000	0.0000

The monthly alphas of the GPR GDP Indices range from 0.18% to 0.26%, whereas the alpha for the GPR 250 Index is equal to 0.11%. The alphas indicate there is some abnormal return for the four indices but it is not proved statistically because all four alphas are insignificant. The CAPM-betas range from 0.84 to 0.89 for the GPR GDP Indices and is 0.91 for the GPR 250 Index. The R-squared and significance of the F-statistic (Prob (F)) in table III are both indicators of the goodness of fit of the model. The F-statistic is highly significant which indicates that the null hypothesis that all slope coefficients are zero is rejected. The R-squared ranges from 0.57 to 0.62 and indicates that 57% or 62% of variance is explained by the market factor. Hence, the model is a reasonable good fit but including Fama-French variables probably increases the R-squared of the model. The third OLS assumption states that the residuals are uncorrelated and independent of each other. The Durbin Watson-statistic is displayed in table XII (Appendix). A DW-statistic close to 2 means there is no autocorrelation. The statistic ranges from 1.76 to 1.84. Hence, I reject the hypothesis that the residuals are autocorrelated. The fourth OLS assumption states that the OLS residuals are normally distributed. I use a Shapiro-Wilk test to test the null hypothesis that the residuals of the CAPM regression are normally distributed. Results are shown in table XII (Appendix) as well. Only the residuals of CAPM regression of the GPR 250 Index are normally distributed at a 5% significance level.

The next question is whether the betas differ significantly from one another. The second null hypothesis of the study is that the betas of the GDP-weighted indices are equal to the beta of the cap-weighted index. Because this hypothesis is not tested in Hsu et al. (2010) I have to find a methodology on my own. This hypothesis is tested with a parameter constancy test. I convert the dataset into panel data and use the Swamy random-coefficients regression to conduct the parameter constancy test. The results are shown in table XIII in the Appendix. The χ^2-statistics are low whereas the p-values are not below a significance level of 5%. Hence, the second null hypothesis that the betas of the GDP-weighted indices are equal to the beta of the cap-weighted index is not rejected.

In table III it is shown that the alphas are insignificant. But which is also of interest is whether the difference between the alphas of the GPR GDP Indices and the alpha of the GPR 250 Index is significant. Hsu et al. (2010) test the value added of the Fundamental Index over a cap-weighted index by the use of CAPM. I apply this methodology as well. Excess returns of each GPR GDP Index over the GPR 250 Index are regressed on the excess returns of the market over the risk-free rate. Results of the regression are displayed in table IV. It is shown that the monthly alphas of the GPR GDP Indices are 0.07% to 0.15% higher than the monthly alpha of the GPR 250 Index. Excess alphas of the three regressions are all statistically insignificant. The excess alpha of the GPR GDP Index on country level is highest and approaches significance levels the most. Altogether, the third null hypothesis that the difference between the CAPM alpha of the GDP-weighted indices and the cap-weighted index is equal to zero is not rejected.

Table IV: CAPM regression results of excess return

The table presents the regression results of the regression equation: $r_{gdp,t} - r_{mcap,t} = \alpha + \beta_{im}(r_{m,t} - r_{f,t})$. Market return is calculated by the use of the MSCI All Country World Index. The risk-free rate is the one-month Treasury bill rate which is retrieved from Kenneth French Data Library. Monthly alphas and betas are estimated using robust standard errors which correct for heteroskedasticity. Robust-heteroskedasticity standard errors are in parentheses, ***, **, and * denote statistical significance at the 1, 5 and 10% level, respectively. The sample includes monthly return data from 07/31/1990 to 05/31/2012.

	GPR GDP Index (country) over GPR 250 Index	GPR GDP Index (zone) over GPR 250 Index	GPR GDP Index (continent) over GPR 250 Index
α	0.0014954	0.0007243	0.0006841
	(0.0012941)	(0.0009955)	(0.0008603)
t-statistic	1.16	0.73	0.80
β	-0.0652008*	-0.017448	-0.0341987
	(0.033589)	(0.026448)	(0.022952)
R-squared	0.0194	0.0024	0.0123
Nr. Observations	263	263	263
Prob (F)	0.0533	0.5100	0.1374

Besides, the negative betas confirm the foregoing results of the CAPM regression. The betas of the GDP-weighted indices are lower than the cap-weighted beta, however not significant. Only the beta of the GPR GDP Index (country) is significant at a 10% significance level. The low R-squared shows there is no relationship between the excess return of the GPR GDP Indices over the GPR 250 Index and the excess return of the market. The regression results are close to the results of the CAPM regression results in Hsu et al. (2010). It turns out that their global ex. U.S. listed real estate Fundamental Index offers higher alpha than the cap-weighted benchmark. However, the excess is not statistically significant.

5.3 Fama-French model

The single-factor model showed that the GPR GDP Indices offer positive monthly alpha but not significantly different than the alpha of the GPR 250 Index. The Fama-French model incorporates two extra risk factors which explain variation in stock returns. Besides alpha and beta, the loadings of size (SMB) and value (HML) factors are of interest as well. The results of the Fama-French OLS regression are shown in table V.

Table V: Regression results Fama-French model

The table presents the regression results for the multifactor Fama-French model. The OLS regression equation equals: $E(r_{i,t}) - r_{f,t} = \alpha_i + \beta_{im}(E(r_{m,t}) - r_{f,t}) + s_i SMB_t + h_i HML_t$. Market return is calculated by the use of the MSCI All Country World Index. The risk-free rate is the one-month Treasury bill rate which is retrieved from Kenneth French Data Library. SMB and HML are constructed with MSCI style indices. $SMB_t = 1/2(Small\ Value + Small\ Growth) - 1/2\ (Large\ Value + Large\ Growth)$.
$HML_t = 1/3(Small\ Value + Mid\ Value + Large\ Value) - 1/3(Small\ Growth + Mid\ Growth + Large\ Growth)$
Monthly factor loadings are estimated using robust standard errors which correct for heteroskedasticity. Robust-heteroskedasticity standard errors are in parentheses, ***, **, and * denote statistical significance at the 1, 5 and 10% level, respectively. The sample includes monthly return data from 07/31/1994 to 05/31/2012.

	GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)	GPR 250 Index
α	0.0020455	0.001362	0.0013101	0.0001401
	(0.0018592)	(0.0018725)	(0.0016965)	(0.0017950)
t-statistic	1.10	0.73	0.77	0.08
β	0.9494825***	0.9781313***	0.9790933***	0.9568027***
	(0.055308)	(0.057894)	(0.049347)	(0.052239)
t-statistic	17.17	16.90	19.84	18.32
s	0.8170089***	0.7229966***	0.6724423***	0.680183***
	(0.077737)	(0.079873)	(0.074435)	(0.074546)
t-statistic	10.51	16.90	9.03	9.12
h	0.729324***	0.6758556***	0.7550459***	0.7074679***
	(0.059854)	(0.059786)	(0.059203)	(0.062948)
t-statistic	12.19	11.30	12.75	11.24
R-squared	0.7617	0.7642	0.7965	0.7757
Nr. Observations	215	215	215	215
Prob (F)	0.0000	0.0000	0.0000	0.0000

The results in table V show that the GPR GDP Indices offer positive monthly alphas ranging from 0.14% to 0.20% when the size and value factors are included. The alpha of the GPR 250 Index equals 0.014% which is substantially lower than the alphas of the GPR GDP Indices. While all indices show positive alphas, they are not statistically significant. The betas are higher than the betas in the single-factor CAPM. The size and value loadings are significant at a 1% significance level for all OLS regressions. Moreover, all three risk factors explain variation in stock returns. The F-statistic is highly significant which indicates that the null hypothesis that all slope coefficients are zero is rejected. The R-squared ranges from 0.76 to 0.80 and indicates that 76% or 80% of variance is explained by the three factor model. For comparison reasons I calculated the R-squared values of the CAPM with a smaller time frame of T=215. These values range from 54% to 59%. Hence, the three factor model is a more reliable model in explaining stock returns than the CAPM.

As in the CAPM analysis, the difference between the monthly alphas of the GPR GDP Indices and the GPR 250 Index is examined. The excess returns of the GPR GDP Indices over the

GPR 250 Index are regressed on the excess returns of the market over the risk-free rate. If the resulting alphas are significant, the GPR GDP Index in question has a significantly higher alpha than the GPR 250 Index. The results of the OLS regression are displayed in table VI.

Table VI: Fama-French regression results of excess return

The table presents the regression results of the regression equation: $r_{gdp,t} - r_{mcap,t} = \alpha + \beta_{im}(r_{m,t} - r_{f,t}) + s_{i,s}SMB_t + h_{i,h}HML_t$ Market return is calculated by the use of the MSCI All Country World Index. The risk-free rate is the one-month Treasury bill rate which is retrieved from Kenneth French Data Library. SMB and HML are constructed with MSCI style indices. $SMB_t = 1/2(Small\,Value + Small\,Growth) - 1/2\,(Large\,Value + Large\,Growth)$. $HML_t = 1/3(Small\,Value + Mid\,Value + \ Large\,Value) - 1/3(Small\,Growth + Mid\,Growth + Large\,Growth)$ Monthly factor loadings are estimated using robust standard errors which correct for heteroskedasticity. Robust-heteroskedasticity standard errors are in parentheses, ***, **, and * denote statistical significance at the 1, 5 and 10% level, respectively. The sample includes monthly return data from 07/31/1994 to 05/31/2012.

	GPR GDP Index (country) over GPR 250 Index	GPR GDP Index (zone) over GPR 250 Index	GPR GDP Index (continent) over GPR 250 Index
α	0.001905	0.001222	0.001170
	(0.0013507)	(0.0010189)	(0.0008047)
t-statistic	1.41	1.20	1.45
β	-0.0073202	0.0213285	0.0222905
	(0.0335496)	(0.0282979)	(0.0217410)
t-statistic	-0.22	0.75	1.03
R-squared	0.0223	0.0160	0.0158
Nr. observations	215	215	215
Prob (F)	0.0968	0.3572	0.0635

Monthly excess alphas range from 0.12% to 0.19%. Again the alphas are not statistically different from zero. However, the t-statistic is higher than in the CAPM regression. So the three factor model shows that the GPR GDP Indices produce excess alpha over the GPR 250 Index, even though not statistically significant. Hence, the fourth null hypothesis that the difference between the Fama-French alpha of the GDP-weighted indices and the cap-weighted index is not equal to zero is not rejected. The low R-squared shows there is no relationship between the excess return of the GPR GDP Indices over the GPR 250 Index and the excess return of the Fama-French risk factors. The results are corresponding with the regression results of Hsu et al. (2010). They carried out a Fama-French regression as well, however with an additional momentum factor. The results obtained from the regression show annualized alphas of 2.88% and 2.09% for a United States index and Global ex. U.S. index respectively. In line with my Fama-French regression results, these alphas are not significant because t-statistics are equal to 1.65 and 0.95 respectively.

5.4 Robustness check

To assess the initial results of the CAPM over the period 31 July 1990 to 31 July 2012, I divide the period into subsamples of 5 years. For the entire period, the CAPM beta is positive, yet smaller than the beta of the benchmark GPR 250 Index. In addition, the alphas of the GPR GDP Indices are positive and larger than the GPR 250 Index. However, the difference between the alphas of the GPR GDP Indices and the GPR 250 Index is not statistically different from zero. The results of the subsamples are shown in table XIV in the Appendix. The first striking result is that for some sub periods alphas are negative. When alpha is negative, according to the CAPM there is too little return for the risk involved in the investment. Hence, the index performed worse than CAPM predicted. During 1990-1994 and 1995-1999, the GPR GDP Indices show negative alphas ranging from -0.39% to -0.70%. However, during these periods, alphas of the GPR 250 Index are negative as well (-0.34% and -1.00% respectively). Hence, negative alpha seems time specific and not index specific. Furthermore, during 2000-2004, alpha is positive and significant at a 1% significance level for the GPR GDP Indices and the benchmark GPR 250 Index. Alpha ranges from 1.47% to 1.63% and is 1.41% for the GPR 250 Index. But another striking result is the low R-squared during this period. It implies that only around 30% of the excess returns are explained by the excess market return. Probably because of volatility in the stock market, which is due to the dotcom bubble. From 2005 to 2009, the GPR GDP Indices show a positive alpha yet not significant, while the GPR 250 Index shows a negative alpha. Lastly, during 2010-2012, the GPR 250 Index shows a positive and significant alpha (10% significance level) while the GPR GDP Indices contain positive alpha but not significant. Thus, from 1990 to 1999 both indexation methods show negative alpha, while during 2000-2009 the GPR GDP Indices performed better and show significant alphas during several years. In addition, since 2000 and onwards, beta of the GPR GDP Indices is larger than the beta of the GPR 250 Index in almost all cases. Hence, the results of the robustness test are mixed.

5.5 Limitations

Despite the reliable data used in the regression models, there are some limitations. Firstly, the CAPM regression covers the time frame 7/31/1990 to 5/31/2012, almost 22 years. In addition, the Fama-French regression covers the time frame 31/7/1994 to 31/05/2012. This decreases the time span to 18 years. In analyzing stock performance, these time spans are pretty small. Yet, it is interesting to analyze the differences in performance between the GDP-weighted and cap-weighted index over multiple market cycles. The sample only covers the market cycle at the start of the 2000s. Hence, a broader time span improves the reliability of the results. Secondly, OLS relies on four assumptions about the error term. I conduct an OLS regression in which I assume these assumptions are met. However, three assumptions are tested in section 5.2 and it is shown that not all assumptions are satisfied. In particular, a test shows that the OLS residuals are not normally distributed. Consequently, the coefficients are still unbiased whereas the t-test becomes imprecise. At last, both regression models show positive alpha for the GPR GDP Indices. Positive alpha reflects abnormal returns, i.e. an investment strategy with higher than predicted returns. However, GDP-weighted indexation involves higher management fees than a traditional low cost cap-weighted scheme. These costs are ignored in this study. To get a better understanding of its magnitude, I take the Kempen Global Property Fundamental Index Fund® as an example. Investors pay a yearly fee ranging from 0.45% to 0.75% (depends on type of shares) of money invested in the fund. If I annualize the alphas of the previous CAPM and Fama-French regression, they range from 0.45% to 0.87%. Hence, it is good to keep in mind these costs have a large negative impact on alpha.

VI CONCLUSIONS

The purpose of the study was to investigate whether GDP-weighted indexation is a better investment strategy than conventional market capitalization-weighted indexation from the perspective of a listed real estate investor. Existing literature mainly focuses on other alternative indexation methods like Fundamental Indexation and other asset classes. This study extends the existing research to GDP-weighted indexation and listed real estate markets.

The answer to the research question is twofold. Firstly, the literature review shows there are good reasons to pursue an alternative indexation methodology. Assuming the Efficient Market Hypothesis does not hold, a cap-weighted portfolio is proven to be suboptimal. On the other hand, existing literature confirms the view that listed real estate markets are linked to macroeconomic variables including GDP. Assuming return is equivalent to macroeconomic outlook, listed real estate is an attractive asset class. Hence, listed real estate investors which base their investment strategy on macroeconomic views should consider a GDP-weighted scheme. Secondly, quantitative research examines the justification for the use of GDP-weighted indices. Three GDP-weighted indices are constructed in which stock weights are based on country GDP, zone GDP and on continent GDP. The indices are backtested to 31 July 1990 and are compared to the cap-weighted GPR 250 Index. A liquidity and investability test examine the implementability of the indices. Taking into account both features, a GDP-weighted index on continent level is most appropriate in practice. At this level, mainly Europe and Asia are overweighed whereas Americas is underweighted since June 1997 compared to the cap-weighted counterpart. Performance metrics reveal that the risk-adjusted return of all GDP-weighted indices is larger than the cap-weighted counterpart. However, a statistical test does not confirm that the GPR GDP Indices offer a significantly higher return than the GPR 250 Index. Additionally, both the CAPM and Fama-French model are used to decompose the indices returns. The linear regression results show both indexation methods have positive alpha. In particular, the GDP-weighted indices offer a higher monthly alpha than the GPR 250 Index. However, the positive difference in alpha is not statistically significant. Also, the conjecture that the beta of the GDP-weighted indices is larger than the cap-weighted index beta is not confirmed. In contradiction, the regression results reveal that the values of the betas are slightly below the cap-weighted index beta. Though, a statistical test shows the betas of the indices have the same distribution. Altogether, the outperformance of the GDP-weighted indices cannot be proven with statistical significance. Nevertheless, the GDP-weighted indices do not outperform nor underperform the cap-weighted counterpart from the perspective of listed real estate.

Suggestions for further research are as follows: the GDP-weighted indices which are constructed and backtested in this study are global indices. It is interesting to construct GDP-weighted indices with regional focus (e.g. Europe or Asia) and carry out the same analysis as in this study. On the other hand, I used the constituents of the GPR 250 Index universe as constituents of the GDP-weighted indices. Therefore, I recommend constructing GDP-weighted indices which are based on another index universe. For example an index which is composed of highly liquid constituents or an index with a larger amount of constituents. Finally, management fees are ignored in this study. It is interesting to gain more insights in the management costs and the resulting alpha.

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CIA World Factbook, https://www.cia.gov/library/publications/the-world-factbook/rankorder/2003rank.html, (visited on 11 April 2012)

Global Property Research, https://www.globalpropertyresearch.com

Investment Company Fact Book, http://www.icifactbook.org/fb_ch3.html (visited on 17 april 2012)

Kenneth R. French Data Library, http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/ (visited on 4 June 2012)

The World Bank, http://data.worldbank.org/indicator/CM.MKT.LCAP.GD.ZS (visited on 11 April 2012)

APPENDIX

Table I: Market capitalization-to-GDP ratios

The table presents the market capitalization-to-GDP ratios (%) for the year 2010. This level is an indicator of the maturity of a market. A low percentage can be seen as a country with growth potential because its market size is smaller than its economy size. Vice versa, a high percentage can be seen as a matured market with lower future growth rates. Data retrieved from The World Bank.

Country	2010
Australia	128.54
Austria	17.86
Belgium	57.38
Brazil	74.03
Canada	136.98
Switzerland	232.87
China	80.36
Germany	43.58
Finland	49.64
France	75.25
United Kingdom	137.38
Hong Kong	481.00
Israel	100.33
Italy	15.51
Japan	75.10
Netherlands	84.84
Norway	60.10
Philippines	78.82
Poland	40.52
Singapore	177.28
Sweden	126.74
Turkey	41.76
United States	117.50
South Africa	278.24

Table II: ISO-code of countries included in indices over time period 1990-2011

The table contains the ISO-codes of the countries which are included in the GPR GDP Indices over time. Argentina, Australia, Austria, Belgium, Brazil, Canada, Switzerland, China, Germany, Spain, Finland, France, United Kingdom, Hong Kong, Indonesia, Ireland, Israel, Italy, Japan, Malaysia, Mexico, The Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Singapore, Sweden, Thailand, Turkey, United States and South Africa.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AUS	AUS	AUS	AUS	AUS	ARG	ARG	ARG	ARG	ARG	ARG	ARG	ARG	AUS	AUS	AUS	AUS	AUS	AUS	AUS	AUS	AUS
BEL	BEL	BEL	AUT	AUT	AUS	AUS	AUS	AUS	AUS	AUS	AUS	AUS	AUT	AUT	AUT	AUT	AUT	AUT	AUT	AUT	AUT
CAN	CAN	CAN	BEL	BEL	AUT	AUT	BEL	BEL	BEL	BEL	BEL	AUT	BEL	BEL	BEL	BEL	BEL	BEL	BEL	BEL	BEL
CHE	CHE	CHE	CAN	CAN	BEL	BEL	CAN	CAN	CAN	CAN	CAN	BEL	CAN	CAN	CAN	CAN	CAN	CAN	BRA	BRA	BRA
DEU	DEU	DEU	CHE	CHE	CAN	CAN	CHE	CHE	CHE	CHE	CHE	CAN	CHE	CHE	CHE	CHE	CHE	CHE	CAN	CAN	CAN
ESP	ESP	ESP	DEU	DEU	CHE	CHE	DEU	DEU	DEU	DEU	DEU	CHE	DEU	DEU	DEU	DEU	DEU	CHN	CHE	CHE	CHE
FRA	FRA	FRA	ESP	ESP	DEU	DEU	ESP	ESP	DNK	DNK	ESP	DEU	ESP	ESP	ESP	DNK	DNK	DEU	CHN	CHN	CHN
GBR	GBR	GBR	FRA	FRA	ESP	ESP	FRA	FRA	ESP	ESP	FIN	ESP	FIN	FIN	FIN	ESP	ESP	FIN	DEU	DEU	DEU
HKG	HKG	HKG	GBR	GBR	FRA	FRA	GBR	GBR	FRA	FIN	FRA	FIN	FRA	FRA	FRA	FIN	FIN	FRA	FIN	FIN	ESP
ITA	IDN	IDN	HKG	HKG	GBR	GBR	HKG	HKG	GBR	FRA	GBR	FRA	GBR	GBR	GBR	FRA	FRA	GBR	FRA	FRA	FIN
JPN	ITA	ITA	IDN	IDN	HKG	HKG	IDN	IDN	HKG	GBR	HKG	GBR	HKG	HKG	HKG	GBR	GBR	GRC	GBR	GBR	FRA
MYS	JPN	JPN	ITA	ITA	IDN	IDN	ITA	JPN	ITA	HKG	IRL	HKG	ITA	ITA	ITA	HKG	GRC	HKG	GRC	GRC	GBR
NLD	MYS	MYS	JPN	JPN	IRL	IRL	JPN	MYS	JPN	ITA	ITA	IRL	JPN	JPN	JPN	ITA	HKG	ITA	HKG	HKG	HKG
NOR	NLD	NLD	MEX	MEX	ITA	ITA	MEX	NLD	MYS	JPN	JPN	ITA	NLD	NLD	NLD	JPN	ITA	JPN	ITA	ITA	ISR
NZL	NOR	NOR	MYS	MYS	JPN	JPN	MYS	NOR	NLD	MYS	NLD	JPN	NOR	NZL	NZL	NLD	JPN	NLD	JPN	JPN	ITA
PRT	NZL	SGP	NLD	NLD	MEX	MEX	NLD	NZL	NOR	NLD	NOR	NLD	NZL	PHL	PHL	NZL	NLD	NOR	MYS	NLD	JPN
SGP	PRT	SWE	PHL	PHL	MYS	MYS	NOR	PHL	NZL	NOR	PHL	NOR	PHL	SGP	SGP	PHL	PHL	PHL	NLD	NOR	NLD
SWE	SGP	USA	SGP	SGP	NLD	NLD	NZL	PRT	PHL	PHL	PRT	NZL	SGP	SWE	SWE	POL	POL	POL	NOR	NZL	NOR
USA	SWE		SWE	SWE	NZL	NOR	PHL	SGP	PRT	PRT	SGP	PHL	SWE	USA	USA	SGP	SGP	SGP	NZL	PHL	PHL
	USA		USA	USA	PHL	NZL	PRT	SWE	SGP	SGP	SWE	SGP	USA	ZAF	ZAF	SWE	SWE	SWE	PHL	POL	POL
					PRT	PHL	SGP	USA	SWE	SWE	USA	SWE	ZAF			TUR	TUR	TUR	POL	SGP	SGP
					SGP	PRT	SWE		USA	USA		USA				USA	USA	USA	SGP	SWE	SWE
					SWE	SGP	USA			ZAF		ZAF				ZAF	ZAF	ZAF	SWE	THA	THA
					USA	SWE													TUR	TUR	TUR
						USA													USA	USA	USA
																			ZAF	ZAF	ZAF

Table III: Allocation of countries to zone and continent

Allocation of countries to a zone or continent. Global Property Research distinguishes 11 zones: Australia and New Zealand, Central America, Eastern Asia, Eastern Europe, Northern America, Northern Europe, Southern Africa, Southern America, South-Eastern Asia, Southern Europe and Western Europe. Continents are divided in Africa, Americas, Asia, Europe and Oceania. Countries are displayed only if GDP values were available.

Country	Zone	Continent
Albania	Eastern Europe	Europe
Andorra	Southern Europe	Europe
Argentina	Southern America	Americas
Australia	Australia and New Zealand	Oceania
Austria	Western Europe	Europe
Belarus	Eastern Europe	Europe
Belgium	Western Europe	Europe
Belize	Central America	Americas
Bermuda	Northern America	Americas
Bolivia	Southern America	Americas
Bosnia and Herzegovina	Eastern Europe	Europe
Botswana	Southern Africa	Africa
Brazil	Southern America	Americas
Brunei Darussalam	South-Eastern Asia	Asia
Bulgaria	Eastern Europe	Europe
Cambodia	South-Eastern Asia	Asia
Canada	Northern America	Americas
Chile	Southern America	Americas
China	Eastern Asia	Asia
Colombia	Southern America	Americas
Costa Rica	Central America	Americas
Croatia	Eastern Europe	Europe
Czech Republic	Eastern Europe	Europe
Democratic Republic of Timor-Leste	South-Eastern Asia	Asia
Denmark	Northern Europe	Europe
Ecuador	Southern America	Americas
El Salvador	Central America	Americas
Estonia	Eastern Europe	Europe
Faeroe Islands	Northern Europe	Europe
Finland	Northern Europe	Europe
Former Yugoslav Republic of Macedonia	Eastern Europe	Europe
France	Western Europe	Europe
Germany	Western Europe	Europe
Greece	Southern Europe	Europe
Greenland	Northern America	Americas
Guatemala	Central America	Americas
Guinea	Southern America	Africa
Guyana	Southern America	Americas
Honduras	Central America	Americas
Hong Kong SAR	Eastern Asia	Asia
Hungary	Eastern Europe	Europe
Iceland	Northern Europe	Europe
Indonesia	South-Eastern Asia	Asia
Ireland	Northern Europe	Europe
Isle of Man	Northern Europe	Europe
Italy	Southern Europe	Europe
Japan	Eastern Asia	Asia

Country (continued)	Zone (continued)	Continent (continued)
Korea	Eastern ASIA	Asia
Lao People's Democratic Republic	South-Eastern Asia	Asia
Lesotho	Southern Africa	Africa
Liechtenstein	Western Europe	Europe
Lithuania	Eastern Europe	Europe
Luxembourg	Western Europe	Europe
Malaysia	South-Eastern Asia	Asia
Malta	Southern Europe	Europe
Mexico	Central America	Americas
Moldova	Eastern Europe	Europe
Monaco	Western Europe	Europe
Mongolia	Eastern ASIA	Asia
Montenegro	Eastern Europe	Europe
Myanmar	South-Eastern Asia	Asia
Namibia	Southern Africa	Africa
Netherlands	Western Europe	Europe
New Zealand	Australia and New Zealand	Oceania
Nicaragua	Central America	Americas
Norway	Northern Europe	Europe
Panama	Central America	Americas
Paraguay	Southern America	Americas
Peru	Southern America	Americas
Philippines	South-Eastern Asia	Asia
Poland	Eastern Europe	Europe
Portugal	Southern Europe	Europe
Romania	Eastern Europe	Europe
Russia	Eastern Europe	Europe
San Marino	Southern Europe	Europe
Serbia	Eastern Europe	Europe
Singapore	South-Eastern Asia	Asia
Slovak Republic	Eastern Europe	Europe
Slovenia	Eastern Europe	Europe
South Africa	Southern Africa	Africa
Spain	Southern Europe	Europe
Suriname	Southern America	Americas
Swaziland	Southern Africa	Africa
Sweden	Northern Europe	Europe
Switzerland	Western Europe	Europe
Taiwan Province of China	Eastern ASIA	Asia
Thailand	South-Eastern Asia	Asia
Turkey	Eastern Europe	Europe
Ukraine	Eastern Europe	Europe
United Kingdom	Northern Europe	Europe
United States	Northern America	Americas
Uruguay	Southern America	Americas
Venezuela	Southern America	Americas
Vietnam	South-Eastern Asia	Asia

Table IV: Difference in GDP-weights and cap-weights, country level (1990-2011)

The table represents the overweighing and underweighting of countries in the GPR GDP Index for the time period 1990-2011. The values displayed are the differences between GDP-weights and cap-weights. When the values are negative, the country is said to be underweighted in the GPR GDP Index. Vice versa, when the value is positive, the country is said to be overweighed in the GPR GDP Index compared to the GPR 250 Index. In case the value is not available (N/A), the country is not included in the GPR 250 Index and consequently not included in the GPR GDP Index as well.

ISO-code	6/30/1990	6/30/1991	6/30/1992	6/30/1993	6/30/1994	6/30/1995	6/30/1996	6/30/1997	6/30/1998	6/30/1999	6/30/2000
ARG	N/A	N/A	N/A	N/A	N/A	1.23%	1.11%	1.15%	1.30%	1.30%	1.20%
AUS	-1.29%	-1.71%	-2.38%	-2.20%	-2.06%	-1.98%	-1.96%	-2.49%	-2.97%	-3.12%	-4.00%
AUT	N/A	N/A	N/A	0.85%	0.84%	0.82%	0.83%	N/A	N/A	N/A	N/A
BEL	1.02%	0.98%	0.99%	0.96%	0.94%	0.92%	0.96%	0.99%	0.82%	0.63%	0.79%
BRA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CAN	0.63%	0.49%	2.01%	2.63%	2.81%	2.82%	2.85%	2.81%	1.28%	1.89%	2.36%
CHE	0.71%	0.65%	0.59%	0.60%	0.50%	0.41%	0.40%	0.49%	0.41%	0.79%	0.79%
CHN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DEU	8.67%	8.73%	9.07%	8.75%	8.57%	8.23%	8.29%	8.30%	9.05%	8.65%	7.88%
DNK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.55%	0.52%
ESP	2.97%	2.74%	2.95%	2.99%	2.85%	2.82%	2.86%	2.93%	3.00%	2.72%	2.65%
FIN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.44%
FRA	-3.91%	-3.90%	-5.79%	-3.69%	-2.54%	-2.02%	-0.79%	1.10%	1.96%	2.83%	3.68%
GBR	-9.19%	-8.18%	-7.57%	-7.13%	-7.11%	-7.88%	-6.41%	-7.74%	-9.39%	-5.40%	-6.99%
GRC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HKG	-5.89%	-7.39%	-16.27%	-14.06%	-15.66%	-13.60%	-16.10%	-15.47%	-7.78%	-14.91%	-9.10%
IDN	N/A	1.67%	1.59%	1.64%	1.68%	1.86%	1.97%	2.00%	2.52%	N/A	N/A
IRL	N/A	N/A	N/A	N/A	N/A	0.21%	0.17%	N/A	N/A	N/A	N/A
ISR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ITA	5.07%	4.93%	4.76%	5.27%	5.36%	5.24%	5.34%	5.38%	N/A	5.47%	5.27%
JPN	-25.37%	-25.21%	-13.33%	-21.25%	-18.39%	-13.21%	-14.62%	-7.74%	1.56%	3.07%	-0.60%
MEX	N/A	N/A	N/A	3.60%	3.24%	3.66%	3.53%	3.70%	N/A	N/A	N/A
MYS	-0.07%	0.09%	0.16%	0.18%	-0.04%	0.01%	0.11%	0.33%	0.79%	0.76%	0.77%
NLD	-5.37%	-4.23%	-4.74%	-3.60%	-3.38%	-3.31%	-2.40%	-2.34%	-2.16%	-1.60%	-0.52%
NOR	0.57%	0.57%	0.62%	N/A	N/A	N/A	0.61%	0.62%	0.53%	0.52%	0.61%
NZL	0.26%	0.24%	N/A	N/A	N/A	0.24%	0.20%	0.18%	0.17%	0.23%	N/A
PHL	N/A	N/A	N/A	0.31%	0.13%	-0.17%	-0.83%	-0.45%	-0.33%	0.14%	0.42%
POL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
PRT	0.62%	0.68%	N/A	N/A	N/A	0.63%	0.63%	0.65%	0.70%	0.70%	0.69%
SGP	-1.53%	-1.48%	-2.16%	-1.77%	-3.21%	-4.58%	-4.68%	-3.91%	-0.21%	-2.31%	-1.51%
SWE	0.74%	0.70%	0.84%	0.79%	0.69%	0.71%	0.75%	0.70%	0.26%	0.03%	-0.56%
THA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TUR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
USA	31.35%	29.63%	28.65%	25.15%	24.77%	16.94%	17.18%	8.78%	-1.49%	-2.94%	-5.88%
ZAF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.09%

Continued											
ISO-code	6/30/2001	6/30/2002	6/30/2003	6/30/2004	6/30/2005	6/30/2006	6/30/2007	6/30/2008	6/30/2009	6/30/2010	6/30/2011
ARG	1.24%	1.24%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AUS	-4.92%	-5.60%	-8.06%	-6.40%	-9.55%	-8.40%	-9.82%	-8.93%	-8.67%	-7.87%	-7.14%
AUT	N/A	0.59%	0.48%	0.22%	-0.33%	-1.34%	-2.53%	-1.64%	-0.37%	-0.30%	-0.34%
BEL	0.89%	0.65%	0.46%	0.62%	0.66%	0.65%	0.67%	0.39%	0.20%	0.36%	0.37%
BRA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4.00%	3.78%	3.57%
CAN	1.52%	1.83%	1.48%	1.73%	1.33%	0.93%	1.07%	0.27%	-0.36%	-0.83%	-1.84%
CHE	0.70%	0.42%	0.20%	0.21%	0.26%	0.25%	0.42%	0.16%	-0.31%	-0.28%	-0.50%
CHN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	17.32%	17.65%	19.46%	19.83%
DEU	8.37%	8.32%	8.13%	7.88%	7.71%	6.96%	6.60%	5.93%	5.61%	5.55%	5.28%
DNK	N/A	N/A	N/A	N/A	N/A	0.49%	0.53%	N/A	N/A	N/A	N/A
ESP	3.02%	2.84%	3.11%	3.34%	3.03%	2.53%	3.34%	N/A	N/A	N/A	2.67%
FIN	0.45%	0.46%	0.47%	0.39%	0.36%	0.41%	0.26%	0.21%	0.14%	0.21%	0.11%
FRA	3.68%	3.49%	3.12%	3.42%	3.49%	3.94%	1.90%	-0.05%	-0.90%	-0.27%	-0.23%
GBR	-4.86%	-5.34%	-3.97%	-3.41%	-2.74%	-3.37%	-3.60%	-1.97%	-1.87%	-0.95%	-1.40%
GRC	N/A	N/A	N/A	N/A	N/A	N/A	0.78%	0.63%	0.66%	0.67%	N/A
HKG	-9.64%	-7.74%	-5.30%	-6.12%	-6.10%	-5.94%	-6.72%	-8.68%	-7.36%	-6.97%	-6.69%
IDN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IRL	0.13%	0.11%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ISR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.34%
ITA	5.39%	5.25%	5.30%	5.34%	5.16%	4.83%	4.70%	4.09%	3.76%	3.59%	3.44%
JPN	2.04%	3.45%	4.68%	0.99%	2.25%	-2.69%	-4.77%	-7.07%	-11.50%	-4.84%	-4.23%
MEX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MYS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.66%	N/A	N/A
NLD	-0.31%	-0.62%	-0.77%	-0.34%	-0.59%	-0.41%	0.14%	-0.32%	-0.25%	-0.05%	0.05%
NOR	0.64%	0.62%	0.66%	N/A	N/A	N/A	N/A	0.51%	0.51%	0.44%	0.40%
NZL	N/A	0.22%	0.19%	0.20%	0.16%	0.23%	N/A	N/A	0.13%	0.05%	N/A
PHL	0.50%	0.53%	0.55%	0.66%	0.66%	0.63%	0.48%	0.44%	0.29%	0.48%	0.49%
POL	N/A	N/A	N/A	N/A	N/A	1.48%	1.44%	1.25%	1.27%	1.36%	1.32%
PRT	0.71%	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SGP	-1.19%	-0.08%	-0.10%	-0.26%	-0.46%	-0.98%	-1.97%	-1.96%	-2.69%	-2.97%	-2.37%
THA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.97%	0.96%
TUR	N/A	N/A	N/A	N/A	N/A	2.29%	2.35%	2.07%	1.92%	1.84%	1.89%
USA	-8.23%	-11.48%	-11.22%	-9.38%	-5.83%	-3.24%	3.76%	-3.47%	-2.27%	-13.04%	-15.51%
ZAF	N/A	1.04%	0.91%	0.84%	0.75%	0.89%	0.96%	0.83%	-0.16%	-0.30%	0.02%

Table V: Difference in GDP-weights and cap-weights, zone level (1990-2011)

The table represents the overweighing and underweighting of regional zones in the GPR GDP Index for the time period 1990-2011. The values displayed are the differences between GDP-weights and cap-weights. When the values are negative, the zone is said to be underweighted in the GPR GDP Index. Vice versa, when the value is positive, the zone is said to be overweighed in the GPR GDP Index compared to the GPR 250 Index. In case the value is not available (N/A), the zone is not included in the GPR 250 Index and consequently not included in the GPR GDP Index as well.

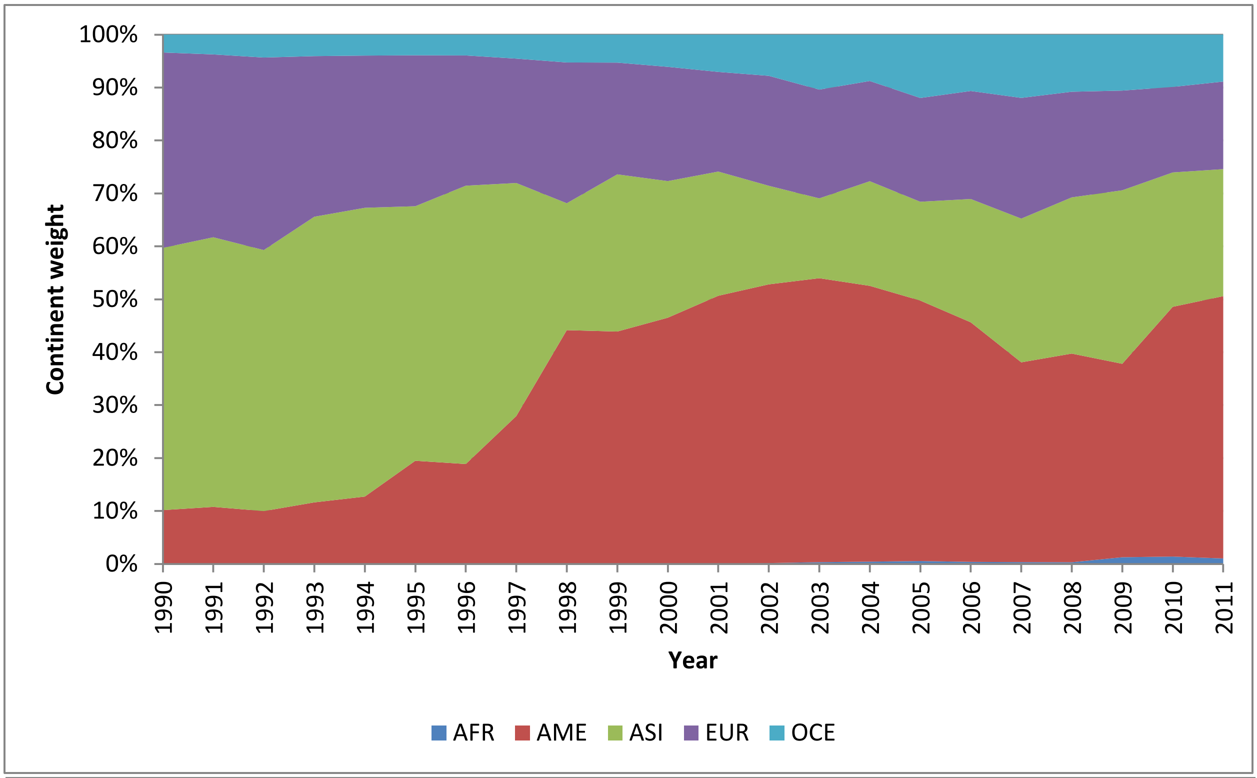
Zone-code	6/30/1990	6/30/1991	6/30/1992	6/30/1993	6/30/1994	6/30/1995	6/30/1996	6/30/1997	6/30/1998	6/30/1999	6/30/2000
AUSNZL	-1.37%	-1.77%	-2.41%	-2.23%	-2.10%	-2.18%	-2.21%	-2.79%	-3.47%	-3.46%	-4.26%
C-AME	N/A	N/A	N/A	3.48%	3.10%	3.29%	3.22%	3.32%	N/A	N/A	N/A
E-ASI	-25.55%	-26.53%	-23.28%	-28.46%	-26.52%	-20.04%	-23.33%	-15.54%	1.20%	-3.34%	-0.64%
E-EUR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N-AME	25.97%	24.81%	24.78%	22.24%	21.66%	11.97%	12.16%	3.03%	-11.97%	-11.15%	-13.61%
N-EUR	-7.70%	-6.60%	-5.94%	-5.53%	-5.68%	-6.95%	-5.54%	-6.85%	-9.55%	-5.52%	-7.65%
S-AFR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.90%
S-AME	N/A	N/A	N/A	N/A	N/A	7.53%	7.52%	7.45%	7.71%	7.65%	7.20%
SE-ASI	1.60%	1.82%	1.13%	1.18%	-0.60%	-2.30%	-2.83%	-1.49%	2.95%	1.07%	2.12%
S-EUR	7.89%	7.73%	7.66%	8.25%	8.12%	7.40%	7.50%	7.50%	7.57%	7.14%	6.91%
W-EUR	-0.85%	0.54%	-1.93%	1.06%	2.03%	1.27%	3.50%	5.38%	5.56%	7.61%	9.04%
Zone-code	6/29/2001	6/28/2002	6/30/2003	6/30/2004	6/30/2005	6/30/2006	6/29/2007	6/30/2008	6/30/2009	6/30/2010	6/30/2011
AUSNZL	-5.22%	-5.98%	-8.41%	-6.78%	-10.00%	-8.89%	-10.23%	-9.07%	-8.97%	-8.24%	-7.27%
C-AME	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
E-ASI	1.80%	5.61%	11.56%	7.60%	9.52%	3.41%	1.44%	-0.06%	-3.44%	5.35%	7.22%
E-EUR	N/A	N/A	N/A	N/A	N/A	9.56%	9.72%	9.93%	9.46%	9.07%	8.95%
N-AME	-17.66%	-20.40%	-19.17%	-17.82%	-15.09%	-14.63%	-7.71%	-10.21%	-9.65%	-20.54%	-23.13%
N-EUR	-5.42%	-6.05%	-4.07%	-3.31%	-3.03%	-4.05%	-4.30%	-1.83%	-1.98%	-1.05%	-1.82%
S-AFR	N/A	0.83%	0.74%	0.65%	0.54%	0.62%	0.67%	0.70%	-0.31%	-0.43%	-0.09%
S-AME	7.26%	7.19%	N/A	N/A	N/A	N/A	N/A	N/A	6.65%	6.51%	6.41%
SE-ASI	2.60%	3.74%	4.17%	4.20%	4.06%	3.09%	1.98%	2.18%	0.94%	0.98%	1.66%
S-EUR	7.26%	6.99%	7.69%	7.82%	7.26%	5.95%	6.47%	6.81%	6.28%	6.12%	5.87%
W-EUR	9.40%	8.07%	7.49%	7.65%	6.74%	4.93%	1.96%	1.54%	1.01%	2.22%	2.19%

Table VI: Difference in GDP-weights and cap-weights, continent level (1990-2011)

The table represents the overweighing and underweighting of continents in the GPR GDP Index for the time period 1990-2011. The values displayed are the differences between GDP-weights and cap-weights. When the values are negative, the continent is said to be underweighted in the GPR GDP Index. Vice versa, when the value is positive, the continent is said to be overweighed in the GPR GDP Index compared to the GPR 250 Index. In case the value is not available (N/A), the continent is not included in the GPR 250 Index and consequently not included in the GPR GDP Index as well.

Continent	6/30/1990	6/30/1991	6/30/1992	6/30/1993	6/30/1994	6/30/1995	6/30/1996	6/30/1997	6/30/1998	6/30/1999	6/30/2000
AFR	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-0.07%
AME	31.30%	30.12%	30.45%	26.38%	25.67%	19.35%	19.41%	10.41%	-5.57%	-4.75%	-7.23%
ASI	-27.71%	-28.47%	-26.01%	-31.63%	-31.52%	-24.43%	-28.36%	-19.22%	1.02%	-5.30%	-1.28%
EUR	-1.92%	0.39%	-1.75%	7.78%	8.25%	7.39%	11.30%	11.74%	8.23%	13.71%	13.04%
OCE	-1.66%	-2.05%	-2.69%	-2.53%	-2.40%	-2.32%	-2.35%	-2.94%	-3.67%	-3.66%	-4.45%

Continent	6/29/2001	6/28/2002	6/30/2003	6/30/2004	6/30/2005	6/30/2006	6/29/2007	6/30/2008	6/30/2009	6/30/2010	6/30/2011
AFR	N/A	0.74%	0.58%	0.48%	0.37%	0.54%	0.59%	0.62%	-0.32%	-0.44%	-0.10%
AME	-11.70%	-14.49%	-15.89%	-14.66%	-11.88%	-8.14%	-1.11%	-3.48%	-1.04%	-12.14%	-14.81%
ASI	1.25%	6.23%	10.34%	6.24%	7.76%	3.71%	0.53%	-0.89%	-3.40%	5.42%	7.84%
EUR	15.88%	13.70%	13.74%	15.08%	14.11%	12.94%	10.39%	12.99%	13.77%	15.44%	14.38%
OCE	-5.43%	-6.18%	-8.76%	-7.13%	-10.35%	-9.05%	-10.39%	-9.24%	-9.02%	-8.28%	-7.31%



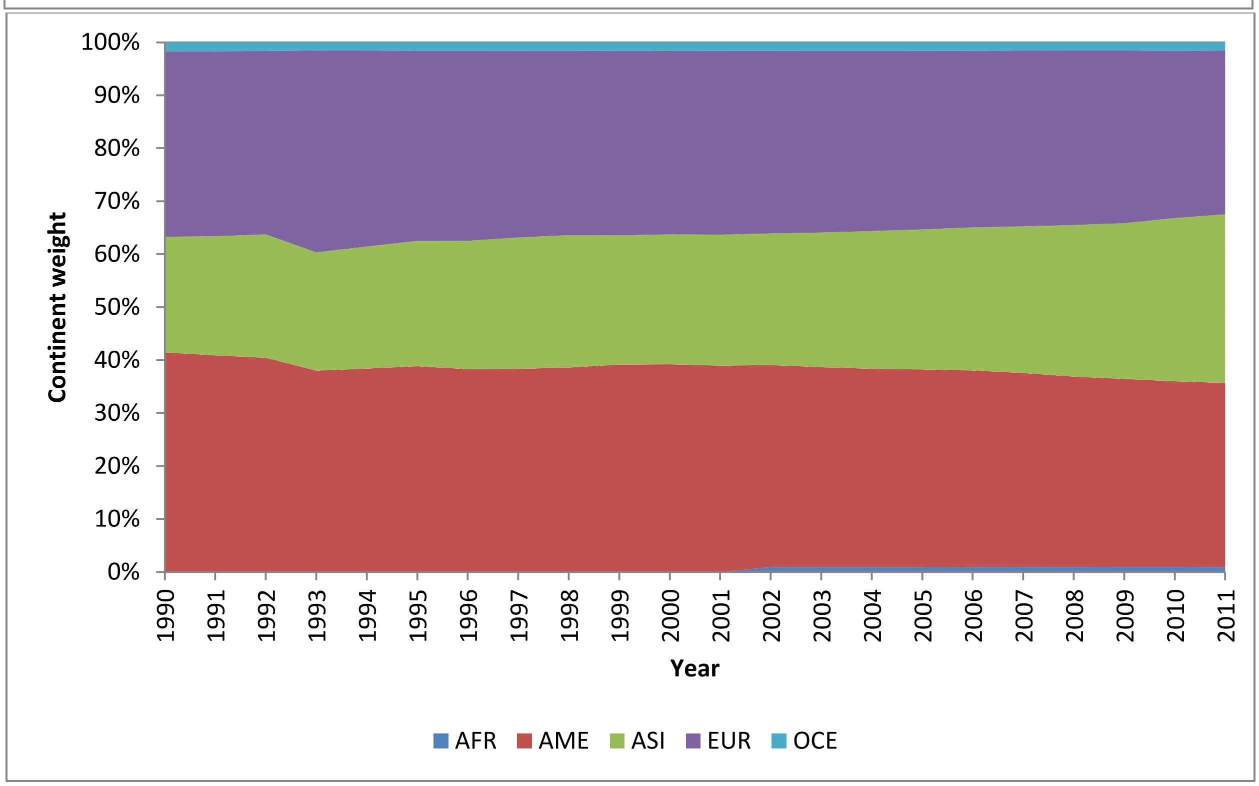


Figure 1: Difference in continent weights
The graphs depict the continent weights of the GPR 250 Index (upper graph) and the GPR GDP Index on continent level (bottom graph) over the period 6/30/1990 to 6/30/2011.

Table VII: Liquidity test

The table shows the ratio of liquidity of the GPR GDP Index compared to the GPR 250 Index at country, zone and continent level for the time period 1990-2011.

Date	Country level	Zone level	Continent level
06/30/1990	267.18%	218.72%	226.94%
06/30/1991	82.52%	189.41%	165.59%
06/30/1992	186.39%	110.43%	105.05%
06/30/1993	158.44%	93.94%	79.59%
06/30/1994	141.26%	88.05%	77.71%
06/30/1995	30.75%	91.73%	79.42%
06/30/1996	61.28%	66.98%	68.53%
06/30/1997	3.45%	3.85%	66.68%
06/30/1998	43.82%	145.66%	329.51%
06/30/1999	21.34%	179.45%	60.62%
06/30/2000	7.59%	39.24%	62.56%
06/29/2001	16.91%	11.55%	54.24%
06/28/2002	8.66%	2.24%	60.25%
06/30/2003	5.18%	13.98%	59.92%
06/30/2004	10.50%	36.97%	55.67%
06/30/2005	30.65%	63.96%	94.88%
06/30/2006	22.20%	4.82%	67.80%
06/29/2007	18.29%	5.70%	49.17%
06/30/2008	1.99%	14.38%	60.57%
06/30/2009	1.55%	9.41%	65.88%
06/30/2010	0.84%	7.19%	82.40%
06/30/2011	4.61%	13.26%	75.05%

Table VIII: Investability test

The table shows the ratio of investment capacity of the GPR GDP Index compared to the GPR 250 Index at country, zone and continent level for the time period 1990-2011.

Date	Country level	Zone level	Continent level
06/30/1990	5.00%	16.81%	19.52%
06/30/1991	5.08%	17.79%	20.95%
06/30/1992	5.49%	17.75%	19.00%
06/30/1993	4.17%	7.35%	24.08%
06/30/1994	3.69%	8.02%	25.30%
06/30/1995	4.08%	2.10%	38.12%
06/30/1996	1.38%	1.51%	36.79%
06/30/1997	0.35%	0.39%	50.75%
06/30/1998	0.21%	3.12%	56.81%
06/30/1999	1.04%	2.61%	45.57%
06/30/2000	4.95%	2.42%	48.76%
06/29/2001	5.39%	1.53%	42.13%
06/28/2002	1.97%	0.35%	13.67%
06/30/2003	4.18%	13.14%	29.03%
06/30/2004	4.98%	9.18%	38.22%
06/30/2005	5.82%	12.70%	47.44%
06/30/2006	2.70%	2.75%	33.70%
06/29/2007	3.12%	3.64%	27.95%
06/30/2008	0.43%	3.41%	25.13%
06/30/2009	0.54%	3.06%	44.65%
06/30/2010	0.43%	2.50%	40.00%
06/30/2011	2.39%	3.68%	42.42%

Table IX: Risk and return characteristics of GPR GDP Indices and GPR 250 Index

The table contains the annual return percentages of the GPR GDP Index calculated for stock weights based on country GDP, zone GDP and continent GDP. Annual return percentages for the cap-weighted GPR 250 Index are displayed as well. On the other hand volatility of the indices is displayed. Standard deviations are calculated as annualized standard deviations.

1990-2012		GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)	GPR 250 Index
Annualized return		7.58%	6.55%	6.55%	5.42%
Annualized risk		0.17	0.18	0.17	0.18
1990	Return	-12.53%	-14.61%	-13.90%	-11.51%
	Volatility	0.20	0.24	0.24	0.28
1991	Return	5.03%	5.40%	3.61%	4.31%
	Volatility	0.11	0.13	0.13	0.18
1992	Return	-7.35%	-11.77%	-11.44%	-12.70%
	Volatility	0.10	0.10	0.11	0.16
1993	Return	28.27%	37.80%	35.72%	51.25%
	Volatility	0.14	0.15	0.13	0.19
1994	Return	-10.44%	-11.08%	-11.25%	-12.52%
	Volatility	0.09	0.10	0.10	0.13
1995	Return	5.87%	10.64%	11.72%	12.28%
	Volatility	0.08	0.10	0.09	0.09
1996	Return	12.84%	15.76%	23.09%	17.13%
	Volatility	0.04	0.06	0.05	0.07
1997	Return	1.98%	-2.53%	2.65%	-7.63%
	Volatility	0.11	0.14	0.12	0.17
1998	Return	0.55%	-2.22%	-2.78%	-8.52%
	Volatility	0.17	0.18	0.21	0.18
1999	Return	22.26%	10.45%	8.49%	6.25%
	Volatility	0.19	0.12	0.14	0.12
2000	Return	23.16%	18.25%	20.32%	18.18%
	Volatility	0.09	0.12	0.13	0.13
2001	Return	1.15%	-6.33%	-2.19%	0.48%
	Volatility	0.11	0.14	0.11	0.11
2002	Return	8.58%	9.01%	4.71%	5.22%
	Volatility	0.12	0.10	0.11	0.11
2003	Return	42.37%	48.74%	45.99%	43.78%
	Volatility	0.08	0.07	0.11	0.08
2004	Return	34.82%	31.27%	33.13%	30.43%
	Volatility	0.15	0.15	0.15	0.16
2005	Return	22.75%	24.30%	21.79%	21.19%
	Volatility	0.11	0.11	0.11	0.11
2006	Return	38.38%	41.54%	34.79%	32.25%
	Volatility	0.12	0.13	0.11	0.10
2007	Return	-16.99%	-9.97%	-14.19%	-12.79%
	Volatility	0.17	0.17	0.15	0.16
2008	Return	-46.34%	-46.61%	-44.84%	-44.49%
	Volatility	0.39	0.40	0.35	0.35
2009	Return	68.18%	64.29%	58.97%	54.89%
	Volatility	0.35	0.35	0.36	0.36
2010	Return	26.79%	27.61%	28.68%	28.20%
	Volatility	0.20	0.21	0.22	0.20

(Continued)		GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)	GPR 250 Index
2011	Return	-11.71%	-14.47%	-8.61%	-4.53%
	Volatility	0.22	0.20	0.20	0.20
2012	Return	-0.42%	-0.91%	0.76%	1.18%
	Volatility	0.11	0.14	0.12	0.11
Cumulative return		215.20%	199.15%	196.58%	181.78%
Maximum return		19.84%	19.84%	20.81%	20.36%
Minimum return		-29.42%	-29.42%	-27.29%	-27.71%
	Grey = GPR GDP Index underperforms benchmark GPR 250 Index				

Table X: Risk and return characteristics of sub periods

The table contains return percentages and annualized volatilities of the GPR GDP Indices and benchmark GPR 250 Index over 5-year sub periods (except for 2010-2012).

		GPR GDP Index – country level	GPR GDP Index – zone level	GPR GDP Index – continent level	GPR 250 Index
1990-1994	Return	4.96%	4.42%	3.60%	12.32%
	Volatility	0.13	0.15	0.14	0.19
1995-1999	Return	48.18%	33.16%	44.28%	15.23%
	Volatility	0.13	0.12	0.13	0.13
2000-2004	Return	174.03%	162.28%	154.04%	144.19%
	Volatility	0.12	0.12	0.13	0.12
2005-2009	Return	227.09%	217.12%	196.43%	182.99%
	Volatility	0.27	0.27	0.26	0.26
2010-2012	Return	20.57%	16.50%	28.51%	34.33%
	Volatility	0.20	0.21	0.20	0.19
	Grey = GPR GDP Index underperforms benchmark GPR 250 Index				

Table XI: Correlation coefficients of GPR GDP Indices with GPR 250 Index and other asset classes

The table contains the correlation coefficients of the GPR GDP Indices with the GPR 250 Index and MSCI ACWI which represents a broad range of equities and the JP Morgan Global Bonds Index which represents the worldwide bond market. Time frame 7/31/1990 to 5/31/2012.

	GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)	GPR 250 Index	MSCI ACWI	JPM Global Bonds Index
GPR GDP Index (country)	1					
GPR GDP Index (zone)	0.9546	1				
GPR GDP Index (continent)	0.9472	0.9691	1			
GPR 250 Index	0.9151	0.9526	0.9636	1		
MSCI ACWI	0.7535	0.7823	0.7858	0.7859	1	
JPM Global Bonds Index	0.2757	0.2857	0.2935	0.3105	0.1758	1

Table XII: Testing OLS assumptions

Testing assumptions about error term in CAPM regression. Firstly, the Breush-Pagan / Cook-Weisberg test is used to test for homoskedasticity. The null hypothesis is that the error terms are homoskedastic. Secondly, the Durbin-Watson test is used to test for autocorrelation. A DW-statistic close to 2 indicates no autocorrelation. Thirdly, the Shapiro-Wilk test is used to test for normality of residuals. W denotes the Shapiro-Wilk test statistic, V reports the departure from normality. A normal distribution has a median value of 1 for V. The null hypothesis is that the residuals are normally distributed. The sample includes monthly return data from 07/31/1990 to 05/31/2012.

	GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)	GPR 250 Index
Breusch-Pagan / Cook-Weisberg homoskedasticity test				
χ2-statistic	6.52	11.92	8.41	14.36
Prob(χ2)	0.0107	0.0006	0.0037	0.0002
Durbin-Watson autocorrelation test				
DW-statistic	1.7643	1.7825	1.7932	1.8495
Shapiro-Wilk normal distribution test				
W	0.9764	0.9811	0.9889	0.9912
V	4.4790	3.5880	2.0970	1.6630
Z-statistic	3.4970	2.9800	1.7270	1.1860
Prob(Z)	0.00024***	0.00144***	0.04209***	0.1178
Nr. observations	263	263	263	263

Table XIII: Swamy random-coefficents test for equal betas

The table presents the results of the Swamy random-coefficients regression. The null hypothesis denotes $H_0: \beta_{gdp} = \beta_{MCAP}$.The regression equation equals $E(Z_{i,t}) = \beta_{im}E(Z_{m,t})$. Where $Z_{i,t}$ is the excess return of the index *I* over the risk-free rate and $Z_{m,t}$ is the excess return of the market. Market return is calculated by the use of the MSCI All Country World Index. The risk-free rate is the one-month Treasury bill rate which is retrieved from Kenneth French Data Library Standard errors are in parentheses, ***, **, and * denote statistical significance at the 1, 5 and 10% level, respectively. The Wald test contains the joint significance of the betas. The sample includes monthly return data from 07/31/1990 to 05/31/2012.

	GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)
α	0.0018101	0.0014366	0.0014238
	(0.0016384)	(0.0014766)	(0.0014504)
Z-statistic	1.10	0.97	0.98
β	0.8766891***	0.9000824***	0.8912873***
	(0.0454445)	(0.0322860)	(0.035062)
Z-statistic	19.29	27.880000	25.42
Nr. Of observations	526	526	526
Nr. Of groups	2	2	2
Obs. Per group	263	263	263
Wald test	372.16	777.20	646.18
Prob(χ2)	0.0000	0.0000	0.0000
Test of parameter constancy			
χ2-statistic	1.25	0.13	0.35
Prob(χ2)	0.535	0.9357	0.8385

Table XIV: Robustness check – CAPM regression results of sub periods

The table presents the regression results of the regression equation: $E(r_{i,t}) - r_{f,t} = \alpha + \beta_{im}(E(r_{m,t}) - r_{f,t})$. Market return is calculated by the use of the MSCI All Country World Index. The risk-free rate is the one-month Treasury bill rate which is retrieved from Kenneth French Data Library. Monthly alphas and betas are estimated using robust standard errors which correct for heteroskedasticity. Robust-heteroskedasticity standard errors are in parentheses, ***, **, and * denote statistical significance at the 1, 5 and 10% level, respectively. The sub sample includes monthly return data.

		GPR GDP Index (country)	GPR GDP Index (zone)	GPR GDP Index (continent)	GPR 250 Index
1990-1994	α	-0.0043151*	-0.0045465*	-0.0046622*	-0.0034121
		(0.0023428)	(0.0025619)	(0.0025644)	(0.0032457)
	t-statistic	-1.84	-1.77	-1.82	-1.05
	β	0.8056956***	0.9285429***	0.9073974***	1.205808***
		(0.069312)	(0.079565)	(0.077025)	(0.086735)
	t-statistic	11.62	11.67	11.78	13.90
	R-squared	0.7758	0.7962	0.7909	0.8046
	Nr. observations	54	54	54	54
	Prob (F)	0.0000	0.0000	0.0000	0.0000
1995-1999	α	-0.0039334	-0.0070202*	-0.0061149**	-0.0100213***
		(0.0034939)	(0.0032813)	(0.0030786)	(0.0035311)
	t-statistic	-1.13	-2.14	-1.99	-2.84
	β	0.5707635***	0.6644711***	0.7258274***	0.7547282***
		(0.1014697)	(0.0859509)	(0.1059054)	(0.0966249)
	t-statistic	5.62	7.73	6.85	7.81
	R-squared	0.3515	0.5178	0.5292	0.5514
	Nr. observations	60	60	60	60
	Prob (F)	0.0000	0.0000	0.0000	0.0000
2000-2004	α	0.0162888***	0.0151611***	0.01478***	0.0141436***
		(0.0037328)	(0.0038972)	(0.0039720)	(0.0039563)
	t-statistic	4.36	3.89	3.72	3.58
	β	0.3968247***	0.4303732***	0.4528051***	0.4251566***
		(0.0785507)	(0.0867708)	(0.0828381)	0.0785771
	t-statistic	5.05	4.96	5.47	5.41
	R-squared	0.2829	0.2965	0.3147	0.2883
	Nr. observations	60	60	60	60
	Prob (F)	0.0000	0.0000	0.0000	0.0000
2005-2009	α	0.0020949	0.0031383	0.0002036	-0.0007278
		(0.0048356)	(0.0045608)	(0.0045449)	(0.0044023)
	t-statistic	0.43	0.69	0.04	-0.17
	β	1.310356***	1.327014***	1.234798***	1.239415***
		(0.1029627)	(0.0951340)	(0.1050044)	(0.1054635)
	t-statistic	12.73	13.95	11.76	11.75
	R-squared	0.7793	0.8021	0.7819	0.7949
	Nr. observations	60	60	60	60
	Prob (F)	0.0000	0.0000	0.0000	0.0000
2010-2012	α	0.0028558	0.001556	0.0051384	0.0068055*
		(0.0035408)	(0.0035078)	(0.0033797)	(0.0033561)
	t-statistic	0.81	0.44	1.52	2.03
	β	1.018234***	1.032712***	1.016349***	0.9470922***
		(0.0685665)	(0.0526602)	(0.0514537)	(0.0573809)
	t-statistic	14.85	19.61	19.75	16.51
	R-squared	0.9067	0.9061	0.9109	0.8994
	Nr. observations	29	29	29	29
	Prob (F)	0.0000	0.0000	0.0000	0.0000