Optimal Asset Allocation Strategies for International Equity Portfolios:
A Comparison of Country versus Sector Optimization

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Abstract.

Although most academic studies conclude that mutual funds cannot outperform a passive investment strategy in the long run, there is some recent empirical evidence that a persistent outperformance can be achieved in an out-of-sample framework when using more sophisticated optimization technique. These empirical findings are for equity-bond-commodity-portfolios, international equity-bond portfolios and US-industry portfolios. The latter can even be further improved when return predictions are included. Given these empirical findings, we analyze in this study whether an industry-based or a country-based optimization model performs best. We employ a variety of optimization- and weighting-techniques to compare the country- and the sector-based allocation strategies. These include naive 'equally weighted' (1/N) portfolio, the two risk-based asset allocation rules 'risk-parity' (RP) and minimum-variance (MinVar) as well as three portfolio optimization approaches mean-variance (MV), Bayes-Stein (BS) and the Black-Litterman (BL) model. We also include simple return prediction models. To determine whether one approach is persistently superior to the other approach, we analyze time varying effects based on the state of the economy, i.e. expansionary or recessionary periods. Moreover, we investigate investment style or investor clientele effects, the full period and different sub-periods, equity-only and equity-bond portfolios as well as aggressive and conservative investments styles. Ssummarizing of all analyzed cases, we find strong evidence for the fact that in the long run the sector-oriented asset allocation provided a higher performance than the country-allocation. In almost all the observed cases, no matter what aggressiveness category the investor belong to and whether fixed income bonds were included, the sector-based allocation achieved higher Sharpe ratios than the country-based allocation.

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1. Introduction

When investors implement an asset allocation strategy that first forecasts stock market returns, industry returns or individual stock returns and then includes these predicted values in a portfolio optimization model this is based on the assumption that they possess superior skills to generate abnormal risk-adjusted returns. However, generating superior risk-adjusted returns is not an easy task in that most of the empirical evidence and academic literature on mutual fund performance suggests that active asset managers hardly ever outperform a passive reference portfolio. Although some studies hint to some short-term persistence, in general it is widely documented and accepted in the academic literature that equity mutual funds cannot outperform a passive investment strategy in the long run.

In contrast to these arguments there is some empirical evidence that a persistent outperformance can be achieved in an out-of-sample framework when using the Back-Litterman optimization technique for an equity-bond-commodity-portfolio (Bessler and Wolff, 2016b) and for an international equity-bond portfolio (Bessler, Opfer and Wolff, 2016a). The performance is even further enhanced when using a return prediction model (out-of-sample) for estimating the input parameter for an US industry allocation model (Bessler and Wolff, 2016c). Although these conclusions are based on academic research, there is some evidence that similar models are implemented successfully in the quantitative asset management industry. Interestingly, there is also evidence that academic models do not work well in industry any longer when the approach is published. Consequently these academic models may work well only for a short period of time.

Given that some optimization models based either on US industry allocations or on international equity or equity-bond allocations outperform persistently an appropriate passive benchmark, it seems interesting to examine which of the alternative asset allocation approaches, i.e. an industry-based or a country-based optimization model, performs best. For many decades the global economy has become more and more integrated. The variety of political and trade agreements (FTAA, MCCA, the Development of the Single European Market etc.), the vast technical development of global communication and transportation systems as well as the overall integration and deregulation of the global financial markets caused a shift in the stock return generating factors. This globalization process with its shift from domestic to more global factors has far-reaching effects on the financial services industry and on the asset management industry in particular. Although economic and financial integration is advancing, it is not obvious what this means for asset allocation decisions and whether one approach is persistently superior to the other approach or whether this time varying, for example based on the state of the economy, i.e. expansionary or recessionary periods, or bear and bull markets.

In this study we address the question whether sector-based or country-based portfolio optimization is preferable and superior, i.e. generating a higher risk-adjusted performance for the investor. Thus, we investigate whether asset managers should orient their investments style on a country or sector allocation. For this we analyze the full-period and different sub-periods, equity-only portfolios and equity-bond portfolios, as well as different investments styles or investor types such as aggressive or conservative.

The rest of this study is organized as follows. In the next section we review the literature on country versus industry allocations and discuss the relevant portfolio optimization literature. In Section 3 we describe the methodology and in Section 4 we present the data. Our empirical results for stock-only portfolios for the full period as well as for sub-periods are presented and discussed in Section 5. Some robustness checks are performed in Section 6. Here we also test different investment styles or clientele effects as well as the performance changes when bonds are included in an equity portfolio. Section 7 summarizes our findings and concludes.

2. Literature Review

The research on sector versus country allocation has become more relevant with the internationalization of asset allocation decisions. An analysis of the changes in the portfolio optimization of university endowments in the US offers excellent insights how these changes proceeded.[i] Lessard (1974) and Solnik (1977) were among the first to study globalization and its effect on portfolio management. They concluded that country-based diversification has higher risk-reduction effect for the investor's portfolio than industry-based diversification. These results has been supported by a variety of other studies [(Grinold et al., (1989), Drummen and Zimmermann (1992), Heston and Rouwenhorst (1994), Griffin and Karolyi (1998), Brooks and Del Negro (2006), Ehling and Ramos (2006), Campa and Fernandes (2006), Bekaert et al. (2009), Catão and Timmermann (2010)].

It should be noted, however, that most of these studies investigated and compared these two effects always for the full sample period and neglected its time variation. Other studies like Baca et al. (2000) supported the dominance of the country effects for the period between 1983 and 1999. They also suggested that due to higher financial integration among developed countries these two effects became statistically indistinguishable towards the end of the observed period. This existence of this effect was also supported by Cavaglia et al. (2000). He reported that although the country-wide diversification provided greater risk reduction than the industry-wide diversification until the mid '90ies, the industry effects significantly dominated the country effect by the late 1996 and early 1997.

Vanroyen and Page (2002) investigated the influence of country and sector effects on the portfolio performance and found that both effects were equally important in terms of investment decisions since 2000. Similarly L'Her et al. (2002) reported that while the country effects dominated the industry effect for the whole period between 1992 and 2000, the opposite effects was observed for period between 1998 and 2000. Phylaktis and Xia (2006) examined the country and industry effects on equity returns between 1992 and 2001 and found that the country effects dominated the industry effects for that period. This difference weakened in the recent years as the industry effects intensified in the last two years of their observed time span. They also suggested that the importance of these two effects varies across geographical regions.

Isakov and Sonney (2002) analyzed the country and sector impacts on a large number of assets in 20 developed countries for the 1997 to 2000 period. They point out that on average the country effects are stronger than industry effects for stocks. A more detailed analysis of the time-varying effects, however, showed that more recently the industry effects surpassed the country impact. Ferreira and Ferreira (2006) investigated these effects for European equity markets and reported that county effects dominated industry effects for the 1975 to 2001 period, although the industry effects were higher toward the end of the sample period. Similarly, Hardouvelis et al. (2007) analyzed which consequence the financial and political integration of Europe had on the equity cost of capital. They concluded that higher market integration resulted in global risk factors became more dominant than local risk factors when determining the equity cost of capital.

The focus of this study and its contribution to the literature is twofold: First, we examine which effects the country and sector allocations have on the performance of equity portfolios. Thus, the focus is less on the statistical decomposition and explanation of particular stock returns as most other studies have done. We also simulate the behavior of investors by applying the most common portfolio optimization algorithms paired with relatively naïve forecasting techniques (cumulated and moving averages). Second, we investigate both the long and short term effects and then analyze the relation to the current state of the economy.

3. Methodology

In this section we provide a review of the asset allocation models and the out-of-sample estimation procedure. Based on the results of DeMiguel et al. (2009) that no portfolio construction technique is persistently superior, we use a variety of optimization- and weighting-techniques to compare the country- and the sector-based allocation strategies. These include naive ‘equally weighted’ (1/N) portfolio, the two risk-based asset allocation rules ‘risk-parity’ (RP) and minimum-variance (MinVar) as well as three portfolio optimization approaches mean-variance (MV), Bayes-Stein (BS) and the Black-Litterman (BL) model.

The general calculation process we use is as follows: the weights for each portfolio are determined at the last trading day each month, based on the information available until and including this day. To calculate the portfolio returns for the following month we then multiply the calculated weights with the component-returns of the corresponding month. Applied to the monthly data we use the data available until [t-1] to calculate the weights and multiply them with the component returns at [t]. The sum of these products represents the portfolio return for [t]. The process is repeated by moving the sample period one month forward and computing the optimized weights for the next month. Taking the forecast and optimization calibration periods into account, we compare the two allocation strategies for the 30 year period from January 1986 to December 2015.

Probably the most important part of the optimization process in terms of the allocation outcome is the return-forecast. To ensure the robustness of our results, we use different window lengths ranging from 12 to 60 months. We also simulate 3 different types of the investor behavior: conservative, moderate and aggressive. The properties of each behavior type are further explained in Chapter 6. Next we discuss the different asset allocation approaches we use for our investment strategy.

3.1. Asset Allocation Models

There exist a large number of different asset allocation models ranging from naive to extremely sophisticated. These models are discussed in the next sections.

3.1.1. Naive Diversification 1/N

As one of the most popular strategies among private investors (Benartzi and Thaler (2001)) we implement the 1/N wealth distribution strategy. Like all other portfolios in our study the 1/N portfolio is rebalanced every month.

3.1.2. Risk-Parity

Recently, the Risk-Parity (RP) approach has attracted great interest from both academia and practitioners alike. It is implemented by a growing number of mutual funds and index providers (e.g. Aquila Risk-Parity, Invesco Balanced Risk, MSCI) as well as by pension funds, endowments, and other long-term investors (Anderson et al. (2012); see Maillard et al. (2008) for a discussion of this class of models). The basic idea of risk-parity is that each portfolio component contributes equally to portfolio risk. In the simple risk-parity approach correlations between asset returns are neglected and assets are weighted anti-proportional to their sample variance $\hat{\sigma}_i{}^2$:

$$\omega_i = \frac{1/\hat{\sigma}_i^2}{\sum_{i=1}^{N}(1/\hat{\sigma}_i^2)}, \qquad (1)$$

Anderson et al. (2012) report that the risk-parity strategy performs well and usually outperforms 1/N, value-weighted, or 60/40 portfolios. This approach profits from the low-volatility anomaly, which denotes the empirical finding that low volatility assets usually earn a higher premium per unit of volatility than high-volatility assets (Baker et al. (2011); Frazzini and Pedersen (2014)).

3.1.3. Minimum Variance

The Minimum Variance (MinVar) approach is increasingly popular among investors and is implemented by various quantitative investment funds and in exchange-traded products.[ii] The objective of the MinVar strategy is to minimize portfolio risk measured as the variance of portfolio returns. The minimization problem is:

$$\min_{\omega} \omega' \Sigma \omega, \tag{3}$$

where ω is the vector of portfolio weights and Σ is the covariance matrix of the asset returns. The advantage of MinVar is that it does not require any return estimates, which are usually subject to large estimation errors. Just like RP, it benefits from the higher premium per unit of volatility of low-risk assets (low volatility anomaly). In contrast to the simple RP approach, the MinVar strategy also takes the correlation of assets into account.

3.1.4. Mean-Variance

In the Mean-Variance (MV) approach (Markowitz (1952)) the investor optimizes the tradeoff between risk and return. The mean-variance optimization problem is:

$$\max_{\omega} U = \omega' \mu - \frac{\delta}{2} \omega' \Sigma \omega, \tag{5}$$

where U is the investor's utility, μ is the vector of expected return estimates and δ is the coefficient of risk aversion. The Markowitz optimization framework assumes normally distributed returns or mean-variance preferences, focusing only on the two moments mean and variance of returns and ignoring higher moments. Although this seems to be a critical assumption, Landsman and Nešlehová (2008) show that it is sufficient that returns are elliptically symmetrically (ES) distributed so that all investor preferences are equivalent to mean-variance preferences. Therefore, it is reasonable to rely on the mean-variance framework for portfolio optimization even if asset returns are non-normal, but are symmetric. To implement the mean-variance strategy we employ the sample mean $\hat{\mu}$ and the sample covariance matrix $\hat{\Sigma}$ as described above. We include a budget restriction according to equation 1 and disallow short selling according to equation 2. The risk aversion coefficient is set to 5.

3.1.5. Bayes-Stein

The Bayes-Stein (BS) approach is one of the most prominent extensions of MV and therefore included in our analysis. The BS approach proposed by Jorion (1985) and Jorion (1986) is based on the idea of shrinkage estimation by Stein (1956) and James and Stein (1956). It attempts to reduce the estimation errors of the input parameters of MV by employing a Bayesian approach for estimating returns and the covariance matrix. The optimization procedure is the same as in the MV approach presented in equation (5). The intuition of BS is to reduce the estimation errors by shrinking the sample mean $\hat{\mu}$ towards the expected return of the minimum variance portfolio $\hat{\mu}^{min}$ with:

$$\hat{\mu}_{min} = \hat{w}_{min}'\hat{\mu} = \frac{\vec{1}'\Sigma^{-1}}{\vec{1}'\Sigma^{-1}\vec{1}}\hat{\mu}, \tag{6}$$

where $\vec{1}$ is a vector of ones and Σ is the covariance matrix. BS shrinks the sample estimates by using return estimates of the form:

$$\hat{\mu}_{BS} = (1-\hat{\gamma})\hat{\mu} + \hat{\gamma}\,\hat{\mu}_{min}\vec{1} \quad \text{with} \quad \hat{\gamma} = \frac{N+2}{(N+2) + K\left(\hat{\mu}-\hat{\mu}^{min}\vec{1}\right)'\,\Sigma^{-1}\left(\hat{\mu}-\hat{\mu}^{min}\vec{1}\right)}. \tag{7}$$

The BS approach estimates the covariance matrix as: $\Sigma = \frac{K-1}{K-N-2}\hat{\Sigma}$, where $\hat{\mu}^{min}$ is the expected return of the minimum variance portfolio, $\hat{\Sigma}$ is the usual unbiased sample covariance matrix, N is the number of assets included, and K is the sample size Jorion (1986). In addition to shrinking the return estimates, the Bayes-Stein approach also adjusts the covariance matrix that we implement as described in Jorion (1986). We employ the same optimization procedure, optimization constraints, and estimation windows as for the MV approach.

3.1.6. Black-Litterman

The Black-Litterman (BL) model has gained in popularity among quantitative portfolio managers (Satchell and Scowcroft (2000); Jones et al. (2007)). It is an important extension of MV and the Bayes-Stein approach as it aims to reduce the estimation errors in the input parameters. However, in contrast to Bayes-Stein, the Black-Litterman approach combines two sources of information: 'implied' returns that are derived from a market or benchmark portfolio using a reverse optimization technique and 'subjective' return estimates – also referred to as 'views' (Black and Litterman (1992)). One major advantage of the BL approach is that the reliability of each return estimate can be included. Black and Litterman (1992) compute the combined return estimates as:

$$\hat{\mu}_{BL} = \left[(\tau\Sigma)^{-1} + P'\Omega^{-1}P\right]^{-1}\left[(\tau\Sigma)^{-1}\Pi + P'\Omega^{-1}Q\right], \tag{6}$$

where Π is the vector of implied asset returns, Σ is the covariance matrix, and Q is the vector of the investor's return estimates. We measure the reliability of each return estimate as the variance of the historical forecast errors during the estimation window. The reliability measures are written on the diagonal in the matrix Ω. P is the identity matrix and τ is a parameter that can be used to calibrate the tracking error to the benchmark portfolio.[iii] The combined return estimate is a matrix-weighted average of 'implied' returns and 'views' (Lee (2000)) with respect to the correlation structure. The posterior covariance matrix is derived as (Satchell and Scowcroft (2000)):

$$\Sigma_{BL} = \Sigma + \left[(\tau\Sigma)^{-1} + P'\Omega^{-1}P\right]^{-1}. \tag{7}$$

After computing combined return estimates and the posterior covariance matrix we conduct a traditional risk-return optimization, maximizing the investor's utility as presented in equation (4). The utility function, risk-aversion coefficient, optimization procedure, and constraints are the same as for the MV approach. The BL model only differs in the input parameters. While for MV the sample mean returns $\hat{\mu}$ and the sample covariance-matrix $\hat{\Sigma}$ are used, the BL framework employs combined return estimates $\hat{\mu}_{BL}$ and the posterior covariance matrix Σ_{BL}. Most importantly, the BL approach additionally incorporates the reliability of return estimates. We implement a sample-based version of the BL model.[iv]

3.2. Performance Measures

To evaluate the performance of country versus sector allocations, we compute several performance measures net of transaction costs. We assume proportional transaction costs of 30 basis points of the transaction volume and vary transaction costs as robustness check. As in DeMiguel et al. (2009) we compute the portfolio turnover PT_i of strategy i as the average absolute change of the portfolio weights ω over the T rebalancing points in time and across the N assets:

$$PT_i = \frac{1}{T}\sum_{t=1}^{T}\sum_{j=1}^{N}\left(\left|\omega_{i,j,t+1} - \omega_{i,j,t+}\right|\right), \tag{8}$$

in which $\omega_{i,j,t}$ is the weight of asset j at time t in strategy i; $\omega_{i,j,t+}$ is the portfolio weight before rebalancing at $t+1$; and $\omega_{i,j,t+1}$ is the desired portfolio weight at $t+1$, after rebalancing. $\omega_{i,j,t}$ is usually different from $\omega_{i,j,t+}$ due to changes in asset prices between t and $t+1$.

We compute the portfolio's average out-of-sample net return and volatility as well as the net Sharpe ratio as the average net excess-return (average return after transaction costs less risk-free rate) divided by the volatility of out-of-sample net returns. Following Opdyke (2006) we test whether the difference in Sharpe ratios of two portfolios is significant.[v] Following Campbell and Thompson (2008), Ferreira and Santa-Clara (2011), and Neely et al. (2014), among others, we also compute the certainty equivalent return (CER) according to equation (5). A drawback of the Sharpe ratio and the CER gain is that both measures only use portfolio returns and volatility ignoring any higher moments. As an alternative, we calculate the Omega measure that is calculated as the ratio of average gains to average losses (Keating and Shadwick, 2002), where gains (losses) are returns above (below) the risk-free rate.

4. Data

Our analysis includes 10 country indices of developed economies and the main 10 sector indices. All country- and sector-indices are part of the DataStream "WORLD-DS Market"-benchmark. To put emphasis on different geographic area but still to select countries with developed capital markets and sufficient historical data, we include the following countries: United States, Canada, Germany, France, Italy, Belgium, Australia, Japan and South Africa. For sector indices we select the ten main WORLD-DS sector-sub-indices: Basic Materials, Consumer Goods, Consumer Services, Diversified Real Estate Investment Trusts (Diversified REITS), Financials, Health Care, Industrials, Oil and Gas, Technology, Telecom and Utilities. For the risk-free assets we use the "Barclays US Aggregate Bond Index". The monthly stock returns (based closing prices) are US-Dollar denominated and continuously compounded with dividends reinvested. The indices are available for the period from January 1975 to September 2015 (478 observations in total).

The descriptive statistics for the ten countries and ten sectors are reported in Tables 1 and 2, respectively. The mean stock returns for the observed countries range from 0,66% (Japan) to 1% (South Africa), which is slightly lower than both the lowest and the highest monthly mean return of the sector indices with a minimum of 0,71% (Basic Materials) and a maximum of 1,02% (health care). However, both groups of indices, countries and industries, have the same monthly mean return of 0.85%, on average. In terms of volatility, the standard deviations for the industry indices (4.95%) are lower than for the country indices (6.17%). Once again, both the minimum- and the maximum- standard deviation for the country returns (4.34% for US; 8.07% for South Africa) are higher than the sectors (3.71% for Health-Care and 6.41% for Technology). For analyzing the distributional characteristics of the returns we calculate skewness, kurtosis, and the joint hypothesis of normally distributed returns with the Jarque-Bera statistic. The latter is highly significant for all countries and sectors. As is usually observed for returns time series, the hypothesis of normal distributed returns can be rejected for all included indices.

Next we examine the correlation structure for both data sets as the set with the lower correlations should in theory provide higher diversification benefits, which, however, does not mean higher performance. Consistent with the literature (Asgharian et al. (2013)), we observe the highest correlations between the direct neighboring countries: USA and Canada (0.77), and Germany and France (0.75). In contrast, the lowest correlation we measure in the country-pairs is between US and Japan (0.37) as well as between Canada and Japan (0.38). Our findings for the sector indices are overall slightly higher than for the countries: For the sectors, the lowest correlation we observe is between Utility- and Technology-indices (0.39) and the highest between Consumer Services and Industrials (0.90).

Our descriptive data analysis suggests that over the full period both countries and sectors provide relatively similar mean returns. However, the lower volatility of the country indices combined with their lower correlation profile suggests that portfolio optimization along countries should result in a superior performance (risk-return) relative to a sector-oriented asset allocation.

5. Empirical Results for Stock-only Portfolios

Our main research question, whether country or industry portfolio optimization is more beneficial for an investor, is investigated from several different perspectives. We begin by analyzing the benefits of the two allocation approaches for the full sample period. Second, we divide the sample period into several sub-periods and compare these pair-wise. Analyzing sub-periods should offer new insights on time variation of dominance as previous results reported in the literature suggest that there is no persistent dominance of one over the other allocation approach. Third, to assure the robustness of our base results, we analyze 5 additional cases which can be classified in a 2-dimensional framework as presented in Table 3. The first dimension represents the decision of the portfolio manager to include bonds in the portfolio.

The purpose of the fixed income components is to provide the opportunity for a "safe haven"-investment during recessionary periods. This allows us to compare the performance between a pure equity and an equity-bond portfolio. The second dimension accounts for the aggressiveness of the investor's investment style. Here we focus on three different styles: unleveraged, capped, and leveraged portfolios. The unleveraged portfolios do not allow for any short selling. However, there is no restriction on the maximum weight a single component can take in the portfolio. In an extreme case the portfolio might consist of only a single asset. The components-weights of the caped portfolios are restricted between +30% and -30% of the portfolio value. This means that a single index weight cannot exceed 30% of the portfolio value. And the short position of a manager in one index cannot exceed 30% of the portfolio value. The third state, the leveraged portfolios, represents the behavior of an aggressive investor. Here, the investor is unrestricted to either include only one asset in the portfolio, as one extreme case, or as another extreme case, to short-sell by allocating the entire portfolio value in one asset.

5.1. Full Period Results

In Table 4 we summarize the performance measures for our base case of an equity only portfolio of a non-leveraged investor (Table 3, Case Nr.1). To account for possible forecast biases, we apply different combinations of forecast (moving average, window lengths ranging from 12 to 60 months) and optimization algorithm (Black-Litterman, Bayes-Stein; Mean-Variance). The performance evaluation in Table 4 reveals that in all observed cases a sector optimization is superior to a country optimization. Regardless of the applied optimization method and the length of the forecast window, the sector-based portfolios yielded higher Sharpe-ratios then the country-based portfolios. The Opdyke (2006) significance tests reveals that the observed differences are not always statistically significant. A more detailed analysis of the findings suggests that the significance of the results highly depends on the length of the forecast window. Thus, for all optimization techniques the 12-month averages shows the most significant (at 5%) difference between the two allocation strategies. Less significant is the effect for the cumulated and the 24-month moving average in combination with the mean-variance optimization algorithm.

The results and conclusions based on of the Sharpe ratios are also supported by our additional performance measures: Omega, CER and CER-gain- ratios. Regardless of the optimization method and the length of the forecast window, the sector indices provide superior results for all three additional measures.

5.2. Results for Sub-Periods

5.2.1. Determining ex-ante and ex-post sub-periods

To test for the time variability of the results and for the stability of our findings, we divide the full sample period into different sub-periods which we base on the state of the global economy. We distinguish between expansionary and recessionary periods and use different methodologies to determine the turning points. We also use different forecast windows and optimization techniques and compare the allocation strategies pair-wise.

To minimize errors and to provide robust results, we determine the states of the world economy in two different ways: ex-post and ex-ante. Our ex-post approach, which is often not labeled ex-post, is represented by the NBER recession indicator, which is calculated by the NBER's Business Cycle Dating Committee on a monthly basis after the relevant ‘event’, i.e. a recession, occurred. Obviously, the turning points can only be established in hindsight as a recession only begins when already three quarters of declining GDP were experienced, thus, introducing a look ahead bias into the results. Moreover, the data is sometimes even backward adjusted when new and more precise information becomes available. In contrast, and from our perspective the superior method, is the ex ante approach. It uses only stock market and monetary variables that are known at the time of the decision.[vi] Figures 1 and 2 illustrate the sub-periods determined with both approaches.

The reason for combining both monetary policy signals and stock market signals in the ex-ante approach is to minimize the number of sub-periods as well as the probability of declaring a wrong economy state which may occur when relying only on a single source of information. The indicator for the monetary cycle is the short-term interest rate of the central bank. As we take the perspective of a US investor, we use the US Federal Funds Target Rate. A monetary signal, positive or negative, is triggered when a rate change occurs in the direction opposite to its previous trend (Jensen and Mercer (2003)). For the stock market we use the MSCI World Index. A stock market signal is given when the actual index crosses its 24-months moving average from either below (expansionary state) or above (recessionary state). A new state of the economy is determined when both indicators provide a consistent signal of a turning point in the economy. The same economic state remains until the opposite signals occur. Figure 1 illustrates the states of the global economy derived from the combined monetary policy and stock market signals. The shaded areas represent the recessionary periods.

The first period begins in January 1986 and ends in March 1990. It includes several important global events such as the "Black Monday" and the Savings and Loan Crisis in the United States. This phase covers in total 50 months. Despite the negative events during this period, our model classifies it as a period of economical expansion, with predominantly rising stock markets and relatively high interest rates. The second sub-period is from April 1990 to January 1994 and is dominated by the Scandinavian (Swedish and Finish) bank crises. It covers 47 months and is declared “recessionary” with declining interest rates. The third and longest period consists of 97 months and ranges from February 1994 to January 2001. The most important global events during this period were the Russian debt crisis, the Asian crisis and the "New Economy" period with many companies going public. Given the increase in interest rates between 1994 and 1995 and the rising stock market valuations, this period is classified as "expansionary". The next sub-period begins in February 2001 and ends in June 2004. It includes the end of the new economy period and the subsequent recovery of global stock market valuations. It lasted 41 months and is declared “recessionary” due to the falling market and the historically low interest rates. Covering 44 months the fifth sub-period starts in July 2004 and ends in February 2008. The increase in stock market valuations and higher interest rates indicate an expansionary period. The last sub-period in our sample begins on March 2008 and lasts until the end of our observation period in October 2015. With a total length of 94 months it is the second longest period and contains several important events in the recent history of the global economy like the US subprime crisis, the European sovereign debt crisis and the subsequent recovery of the global economy. In this period, the risk free rate dropped to its historical minimum of 0.25 per cent.

5.2.2. Empirical Findings

We present the results from the different sub-sample analyses in Table 5. First, the differences of the Sharpe ratios between the country and industry portfolios in the respective period are provided and highlighted. The shaded cells mark those cases in which the country portfolios outperform the sector portfolios. Section “A” summarizes the results for the sub-periods as specified ex-post (NBER), while in section “B” the sub-period results are based on the ex-ante approach. As in the full period analysis, we apply all three optimization algorithms with the same forecasting methods: cumulative average and moving averages ranging from 12 to 60 months in length. Two important conclusions emerge from an analysis of the results: First, the performance advantage of either country- or sector-portfolios is not constant over time but time varying. Secondly, a relatively clear pattern emerges in that the country-optimization performed better during and around the "New Economy" period. The latter seems to be stable for both procedures (ex-post and ex ante), as well as optimization methods and forecast lengths. Another interesting observation is that in most cases outside the new economy period, the sector based portfolios seems to dominate their country counterparts. These findings contradicts previous research of Brooks and Del Negro (2004) and Kritzman and Page (2003) who reports that the rise of the industry effects is mostly driven by the volatility of the new economy stocks. In our study, the opposite seems to be the case: during the recent financial crisis, the country based allocation excels the performance of the sector portfolios.

One possible explanation for the better performance of the county portfolios during the new economy period is that particular shocks might spread easier through sectors than countries. While the sector index is focused on representing certain economic areas worldwide, ignoring any geographical factors, the county index indicates only the local economy without putting any emphasis on its sector representation. Thus, if a sector specific crisis emerges as during the new economy period, it will have a significantly higher impact on a sector-wide composed portfolio than on a country portfolio. In contrast, a country-specific shock would cause higher decline in a country portfolio than in a global sector portfolio.

6. Robustness Checks for different Investment Styles and Assets

In this section we first analyze whether different investment styles have any impact on our results and conclusions. The investor can either follow a more aggressive or a more conservative strategy. Then we test whether out base results change when we include bonds in the equity portfolio. Finally we test whether the results also hold for sub-periods.

6.1. Results for different Investor Types or Investment Styles

We test the stability of our main results by examining several additional cases. Table 6 summarizes the results for Case 2 in accordance to Table 3. Again, here we assume a cap at 30 percent (short or long) without fixed income components. The results are even more interesting than the base case. All Sharpe ratio comparisons in the Mean-Variance and Bayes-Stein optimized portfolios show a highly significant outperformance of the sector-portfolios. Even if insignificant, we also observe higher Sharpe ratios among the Black-Letterman optimized portfolios. The better performance of the sector portfolios is confirmed by most of the alternative measurements we applied such as Omega, CER, CER-Gain and BTC. The only exception is the turnover measure for which, depending on the optimization technique and the length of the forecast window, our results are inconclusive. The results for Case 3 (aggressive investor; no bonds) are presented in Table 7. Again, in all the observed case the sector based portfolios achieve higher Sharpe ratios than the country portfolios. However, none of these differences is significant. Table 8 summarizes the results for our Case 4, which is a moderate investor allowing bonds in the portfolio. Consistently with the results from the previous cases the sector portfolios deliver the better performance, but still, this difference is significant only for the forecasts based on a 12-months return-average, combined with all 3 optimization methods (Black-Litterman, Bayes-Stein, Mean-Variance). The Case 5 represents a moderate investor who also includes bonds in the portfolio. The results are presented in Table 9. Similar to the second investor type, all of the analyzed combinations of forecast- and optimization-methods confirm the superior performance of sector-portfolios. And again, similar to Case 3 these are significant only for the Mean-Variance and Bayes-Stein optimization techniques.

6.2. Results for Equity-Bond-Portfolios

Finally we are analyzing an aggressive investor (no constrains on the portfolio weights) but allow bonds as a low risk asset class to be included in the portfolio. First we analyze the full sample period and later on sub-periods. The results are represented in Table 9. Similarly to Case 3 (Table 7), we obtain to some extent negative Sharpe ratios for the country based allocation and no significant differences between the performance of the country and sector portfolios. However, consistently with all previous cases, we measure higher performance for the most of optimization techniques.

A summary of the 6 cases provides strong evidence for the fact that in the long run the sector-oriented asset allocation provided a higher performance than the country-allocation. In almost all the observed cases, no matter what aggressiveness category the investor belong to and whether fixed income bonds were included, the sector-based allocation achieved higher Sharpe ratios than the country-based allocation. Accounting for leverage seems to have strong effects on significance and the level of the measured performance. Comparing the results pairwise (regarding leverage or debt inclusion) leads to higher significance levels between both portfolio types when bonds are not included in the optimization process. Allowing for bonds in the optimization process, however, diminishes the portfolio risk, which then results in an overall rise of the Sharpe ratios. Comparing the results for the leverage case yields an interesting effect. While the leverage does not seem to influence the Black-Litterman optimized portfolios, it appears that it strongly affects the Mean-Variance and the Bayes-Stein-optimized portfolios. The overall performance of these portfolios once we allow short-selling improves.

6.3. Robustness-checks for the Sub-Periods

Similarly to the full period observations, we also stress the robustness of our sub-period observation. Once again we include bond components in the portfolio as well the aggressiveness of the investor. However, in order to keep these results parsimonious we only include the aggressive (full leverage) and the conservative (no leverage) investor types. Table 11 presents the sub-period results for Case 3 in accordance to our schema presented in Table 3. The pattern that appears is very similar to the one in Table 5 (conservative investor, no bonds). In the most of the observed periods the sector portfolios achieve higher Sharpe ratios regardless of the length of the forecast window. The period in which the country allocation appears to dominate the sector allocation is in the period around the new economy period, which seems to confirm our previous hypothesis in Chapter 5.2.2.

The sub-period results for Case 4, a conservative investor having equity and bonds in the portfolio, are presented in Table 12. While bonds clearly diminish the effects from the new economy bubble, which were observed in the previous 2 sub-period, another important effect becomes more evident. Now the outperformance of the sector allocation over the country allocation becomes more sustainable given the different forecast windows. Typical examples are the 12- and the 36-month averages for the ex-post (NBER) periods as well as the 24-months average for the ex-ante sub-periods. Nevertheless, the majority of comparisons presented in Table 12 still indicate that the sector portfolios generate a higher performance.

Table 13 presents the results for our final sub-period observation which is Case 6 in accordance to Table 3. Including bonds and simultaneously taking leverage in our optimization process into account lowers the outperformance of the sector portfolios. One possible explanation is that the major part of the portfolio is allocated to the low-risk fixed-income asset. This combined with the lower number of observations diminishes the statistical difference between the country- and sector- portfolios.

There are a number of conclusions we can draw from our sub-period analysis. The performance difference between both allocation strategies is more distinct when products neutral to our observation are left out of the optimization process. This effect is increased by the lower number of observations in the period compared to the full sample period. The aggressiveness of the investor (represented by the different levels of leverage) does not seem to influence the difference between both allocation strategies.

6. Conclusion

The main research question of this study is whether country-based or industry-based portfolio optimization is more beneficial for investors. In the empirical analysis we investigated this from several different perspectives. To determine whether one approach is persistently superior to the other approach, we analyze time varying effects based on the state of the economy, i.e. expansionary or recessionary periods. Moreover, we investigate investment style or investor clientele effects, equity-only and equity-bond portfolios as well as aggressive and conservative investments styles. We employ a variety of optimization- and weighting-techniques to compare the country- and the sector-based allocation strategies. These include naive ‘equally weighted’ (1/N) portfolio, the two risk-based asset allocation rules ‘risk-parity’ (RP) and minimum-variance (MinVar) as well as three portfolio optimization approaches mean-variance (MV), Bayes-Stein (BS) and the Black-Litterman (BL) model.

The empirical results suggest that for the full period the sector indices provide superior results for all performance measures, regardless of the optimization method and the length of the forecast window. From the sub-periods analysis two important conclusions emerge. First, the performance advantage of either country- or sector-portfolios is not constant over time but time varying. Second, for most periods the sector-based portfolios seems to dominate the country-based portfolios, except for the new economy period. These results seem to be stable for both procedures (ex-post and ex ante) as well as for optimization methods and forecast lengths. In summary of all analyzed cases, we find strong evidence for the fact that in the long run the sector-oriented asset allocation provided a higher performance than the country-allocation. In almost all the observed cases, no matter what aggressiveness category the investor belong to and whether fixed income bonds were included, the sector-based allocation achieved higher Sharpe ratios than the country-based allocation.

Table 1. Summary Statistics for the country indices

Panel A: Summary Statistics										
	JAPAN	**US**	**GERMANY**	**UK**	**SOUTH AFRICA**	**CANADA**	**FRANCE**	**AUSTRALIA**	**BELGIUM**	**ITALY**
Mean	0,66%	0,91%	0,77%	0,95%	1,00%	0,79%	0,92%	0,87%	0,91%	0,72%
Median	0,70%	1,24%	1,15%	1,06%	1,48%	1,11%	1,23%	1,04%	1,07%	0,72%
Max	23,98%	12,72%	17,67%	18,85%	18,05%	18,51%	21,80%	20,57%	21,85%	24,19%
Min	-19,30%	-23,26%	-23,13%	-23,87%	-43,61%	-30,79%	-25,76%	-56,66%	-39,05%	-26,28%
Std. Dev.	5,93%	4,34%	5,90%	5,48%	8,07%	5,53%	6,43%	7,07%	5,67%	7,31%
Skewness	0,069	-0,819	-0,674	-0,482	-0,987	-0,976	-0,534	-1,557	-1,029	-0,121
Kurtosis	3,826	5,922	4,618	4,867	6,1	7,183	4,298	12,676	9,303	3,767
Jarque-Bera	13,981	223,545	88,359	87,88	269,041	424,288	56,264	2057,712	875,749	12,879
(p-Value)	0,005	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,006
Obs	478	478	478	478	478	478	478	478	478	478
Panel B: Correlation Matrix										
JAPAN	1									
US	0,37	1								
GERMANY	0,4	0,6	1							
UK	0,46	0,65	0,63	1						
S. AFRICA	0,41	0,43	0,49	0,49	1					
CANADA	0,38	0,77	0,54	0,65	0,57	1				
FRANCE	0,45	0,6	0,75	0,67	0,5	0,58	1			
AUSTRALIA	0,39	0,57	0,49	0,62	0,56	0,69	0,53	1		
BELGIUM	0,4	0,55	0,72	0,64	0,48	0,51	0,71	0,49	1	
ITALY	0,4	0,44	0,59	0,55	0,41	0,48	0,63	0,41	0,54	1

Table 2. Summary Statistics of the sector indices

Panel A: Summary Statistics										
	Oil & Gas	**Basic Mats**	**Industrials**	**Consumer Gds**	**Health Care**	**Consumer Svs**	**Telecom**	**Utilities**	**Financials**	**Technology**
Mean	0,91%	0,71%	0,86%	0,80%	1,02%	0,83%	0,79%	0,86%	0,87%	0,86%
Median	1,19%	0,92%	1,36%	1,05%	1,30%	1,16%	0,84%	0,89%	1,24%	1,17%
Max	15,80%	19,23%	16,00%	12,75%	12,59%	11,92%	26,85%	22,49%	20,90%	19,99%
Min	-25,77%	-36,10%	-27,09%	-20,72%	-18,70%	-18,86%	-16,80%	-16,53%	-29,61%	-31,08%
Std. Dev.	5,42%	5,69%	5,00%	4,65%	3,71%	4,36%	4,93%	4,04%	5,33%	6,40%
Skewness	-0,608	-1,01	-1,033	-0,708	-0,587	-0,625	0,08	-0,005	-0,658	-0,716
Kurtosis	5,274	8,341	6,628	5,191	5,172	4,825	5,731	5,568	6,282	5,433
Jarque-Bera	132,469	649,375	347,156	135,564	121,372	97,48	149,111	131,345	248,989	158,707
(p-Value)	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001
Obs	478	478	478	478	478	478	478	478	478	478
Panel B: Correlation Matrix										
Oil & Gas	1									
Basic Mats	0,75	1								
Industrials	0,71	0,88	1							
Consumer Gds	0,62	0,79	0,89	1						
Health Care	0,53	0,66	0,71	0,66	1					
Consumer Svs	0,61	0,82	0,9	0,86	0,78	1				
Telecom	0,45	0,58	0,64	0,59	0,54	0,69	1			
Utilities	0,55	0,67	0,61	0,56	0,61	0,64	0,52	1		
Financials	0,64	0,82	0,83	0,77	0,72	0,84	0,62	0,75	1	
Technology	0,51	0,62	0,81	0,72	0,52	0,76	0,64	0,39	0,62	1

Table 3: Classification of the Empirical Framework

		risk averseness	
		Clean Portfolios (no bonds)	Bonds included
leverage	No leverage	Case 1	Case 4
	Capped Portfolios	Case 2	Case 5
	Full leverage	Case 3	Case 6

Table 4. Case 1 – Results (no leverage; clean portfolios)

Performance measure	**Return**		**Vola**		**Sharpe**		**Omega**		**CER**		**CER-Gain**		**Turnover**		**BTC**	
	SI	CI	SI	CI	**SI**	**CI**	SI	CI	SI	CI	SI	CI	SI	CI	SI	CI
Naive Portfolios																
1/N	9,20%	9,26%	15,17%	16,83%	**0,38**	**0,35**	1,33	1,31	0,03	0,02	0,00%	0,00%				
Risk Parity	10,00%	9,84%	14,21%	15,92%	**0,46**	**0,4**	1,42	1,37	0,05	0,04	1,51%	1,32%	0,34	0,41	4,47%	3,19%
Minimum Variance	10,03%	9,14%	12,57%	14,43%	**0,52**	**0,39**	1,48	1,36	0,06	0,04	2,63%	1,75%	1,12	1,12	2,35%	1,57%
Blsck Litterman																
Cumulative average	9,91%	9,49%	13,97%	15,29%	**0,46**	**0,4**	1,42	1,36	0,05	0,04	1,59%	1,46%	0,81	0,79	1,96%	1,86%
Moving average (12m)	12,32%	10,04%	14,42%	15,64%	**0,62 ****	**0,42 ****	1,58	1,38	0,07	0,04	3,68%	1,75%	3,77	3,27	0,98%	0,53%
Moving average (24m)	11,01%	9,65%	14,72%	15,38%	**0,51**	**0,4**	1,47	1,36	0,06	0,04	2,14%	1,55%	2,5	2,02	0,86%	0,77%
Moving average (36m)	10,98%	9,86%	14,64%	15,38%	**0,52**	**0,42**	1,47	1,37	0,06	0,04	2,18%	1,76%	1,93	1,58	1,13%	1,12%
Moving average (48m)	10,66%	9,85%	14,55%	15,33%	**0,5**	**0,42**	1,45	1,38	0,05	0,04	1,93%	1,79%	1,63	1,34	1,18%	1,34%
Moving average (60m)	10,40%	9,88%	14,73%	15,49%	**0,47**	**0,42**	1,43	1,38	0,05	0,04	1,53%	1,70%	1,48	1,18	1,04%	1,44%
Mean-Variance																
Cumulative average	10,60%	9,24%	13,11%	15,20%	**0,55 ***	**0,38 ***	1,51	1,33	0,06	0,03	2,85%	1,28%	0,88	0,95	3,25%	1,35%
Moving average (12m)	14,77%	8,61%	17,50%	20,88%	**0,65****	**0,25****	1,64	1,22	0,07	-0,02	3,67%	-4,47%	6,21	6,53	0,59%	-0,68%
Moving average (24m)	12,81%	7,67%	19,03%	18,28%	**0,49***	**0,23***	1,46	1,19	0,04	-0,01	0,32%	-2,87%	4,22	4,82	0,08%	-0,60%
Moving average (36m)	11,89%	9,01%	18,70%	17,19%	**0,45**	**0,32**	1,41	1,28	0,03	0,02	-0,29%	-0,56%	3,38	3,75	-0,09%	-0,15%
Moving average (48m)	12,62%	9,05%	17,91%	17,14%	**0,51**	**0,33**	1,47	1,27	0,05	0,02	1,16%	-0,48%	2,93	3,14	0,40%	-0,15%
Moving average (60m)	12,46%	10,02%	17,84%	17,10%	**0,51**	**0,38**	1,47	1,33	0,05	0,03	1,06%	0,52%	2,33	2,97	0,46%	0,18%
Bayes-Stein																
Cumulative average	9,91%	9,15%	12,56%	14,40%	**0,52**	**0,4**	1,47	1,36	0,06	0,04	2,53%	1,79%	1,04	1,12	2,43%	1,60%
Moving average (12m)	14,14%	9,19%	16,60%	19,19%	**0,64****	**0,30****	1,62	1,27	0,07	0	3,81%	-2,19%	5,9	5,81	0,65%	-0,38%
Moving average (24m)	12,18%	8,88%	17,33%	16,80%	**0,5**	**0,32**	1,47	1,28	0,05	0,02	1,23%	-0,36%	3,7	3,62	0,33%	-0,10%
Moving average (36m)	11,81%	9,82%	16,34%	15,90%	**0,51**	**0,4**	1,47	1,35	0,05	0,03	1,69%	1,31%	2,71	2,72	0,62%	0,48%
Moving average (48m)	11,73%	9,32%	15,38%	15,48%	**0,54**	**0,38**	1,49	1,33	0,06	0,03	2,38%	1,14%	2,27	2,25	1,05%	0,51%
Moving average (60m)	11,59%	9,89%	14,68%	15,59%	**0,55**	**0,41**	1,5	1,37	0,06	0,04	2,75%	1,63%	1,87	1,93	1,48%	0,84%

Table 5. Performance-comparison for the sub periods

Panel A: Subperiods declared by the NBER

Black-Litterman

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,32	0,06	0,08	-0,07	-0,03	0,21
Risk Parity	0,01	0,14	0,02	-0,05	0,06	0	0,26
Minimum Variance	0,27	0,2	0,14	-0,66	-0,25	0,07	0,39
Cumulative average	-0,06	0,34	0,15	0,02	-0,09	0,12	0,16
Moving average (12m)	-0,04	0,34	0,35	-0,71	0,01	0,21	0,33
Moving average (24m)	0,06	0,38	0,21	-0,66	0,01	0,05	0,21
Moving average (36m)	0,08	0,41	0,19	-0,3	-0,03	0,1	0,17
Moving average (48m)	-0,03	0,29	0,16	-0,28	-0,09	0,1	0,26
Moving average (60m)	-0,1	0,18	0,14	-0,21	-0,1	0,13	0,21

Mean-Variance

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,32	0,06	0,08	-0,07	-0,03	0,21
Risk Parity	0,01	0,14	0,02	-0,05	0,06	0	0,26
Minimum Variance	0,27	0,2	0,14	-0,66	-0,25	0,07	0,39
Cumulative average	0,1	0,22	0,09	-0,82	-0,09	0,4	0,42
Moving average (12m)	0,19	0,89	0,46	-0,46	0,08	0,12	1
Moving average (24m)	0,09	0,77	0,38	-0,52	0,07	0,13	0,59
Moving average (36m)	0,16	-0,01	0,13	-0,67	0,09	0,06	0,23
Moving average (48m)	0,18	0,87	0,09	-0,71	0,2	-0,02	0,44
Moving average (60m)	-0,36	0,87	0,04	0,09	0,25	0,12	0,31

Bayes-Steyn

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,32	0,06	0,08	-0,07	-0,03	0,21
Risk Parity	0,01	0,14	0,02	-0,05	0,06	0	0,26
Minimum Variance	0,27	0,2	0,14	-0,66	-0,25	0,07	0,39
Cumulative average	0,23	0,19	0,11	-0,73	-0,25	0,11	0,39
Moving average (12m)	0,1	0,88	0,4	-0,63	0	0,27	0,9
Moving average (24m)	0,06	0,53	0,26	-0,83	-0,03	0,05	0,5
Moving average (36m)	0,11	0,08	0,1	-0,65	0,07	0,04	0,34
Moving average (48m)	0,11	0,43	0,06	-0,97	0,16	0,16	0,46
Moving average (60m)	0	0,33	0,06	-0,77	0,1	0,25	0,4

Panel B: Subperiods according to Bessler / Kurman

Black-Litterman

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,08	0	-0,17	0,06	0,11
Risk Parity	0	-0,06	-0,07	-0,02	0,14	0,16
Minimum Variance	0,25	0,24	0,04	-0,32	-0,28	0,33
Cumulative average	-0,08	0,14	0,1	-0,18	0,07	0,16
Moving average (12m)	-0,06	0,32	0,2	-0,15	0,21	0,3
Moving average (24m)	0,03	0,2	0,14	-0,21	0,15	0,14
Moving average (36m)	0,05	0,16	0,16	-0,21	0,07	0,14
Moving average (48m)	-0,05	0,08	0,12	-0,25	0,12	0,19
Moving average (60m)	-0,09	-0,02	0,09	-0,23	0,11	0,18

Mean-Variance

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,08	0	-0,17	0,06	0,11
Risk Parity	0	-0,06	-0,07	-0,02	0,14	0,16
Minimum Variance	0,25	0,24	0,04	-0,32	-0,28	0,33
Cumulative average	0,08	0,2	-0,03	-0,2	-0,21	0,47
Moving average (12m)	0,14	0,82	0,26	-0,05	0,32	0,63
Moving average (24m)	0,06	0,16	0,39	-0,05	0,37	0,33
Moving average (36m)	0,14	-0,13	0,17	0,11	0,15	0,11
Moving average (48m)	0,15	0,32	-0,01	-0,28	0,53	0,22
Moving average (60m)	-0,41	0,21	-0,08	0,09	0,17	0,22

Bayes-Steyn

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,08	0	-0,17	0,06	0,11
Risk Parity	0	-0,06	-0,07	-0,02	0,14	0,16
Minimum Variance	0,25	0,24	0,04	-0,32	-0,28	0,33
Cumulative average	0,21	0,2	0	-0,32	-0,31	0,34
Moving average (12m)	0,02	0,81	0,2	-0,14	0,18	0,61
Moving average (24m)	0	0,07	0,24	-0,31	0,3	0,31
Moving average (36m)	0,09	-0,09	0,07	-0,09	0,14	0,22
Moving average (48m)	0,08	0,09	-0,02	-0,31	0,46	0,35
Moving average (60m)	-0,05	0,08	-0,03	-0,16	0,18	0,36

Tabelle 6. Case 2 – Results (moderate investor; no bonds)

Performance measure	**Return**		**Vola**		**Sharpe**		**Omega**		**CER**		**CER-Gain**		**Turnover**		**BTC**	
	SI	CI	SI	CI	**SI**	**CI**	SI	CI	SI	CI	SI	CI	SI	CI	SI	CI
Naive Portfolios																
1/N	9,20%	9,26%	15,17%	16,83%	**0,38**	**0,35**	1,33	1,31	0,03	0,02	0,00%	0,00%				
Risk Parity	10,00%	9,84%	14,21%	15,92%	**0,46**	**0,4**	1,42	1,37	0,05	0,04	1,51%	1,32%	0,34	0,41	4,47%	3,19%
Minimum Variance	10,26%	7,54%	11,62%	14,82%	**0,59**	**0,28**	1,54	1,24	0,07	0,02	3,44%	-0,13%	2,02	1,97	1,70%	-0,07%
BL																
Cumulative average	9,96%	9,46%	13,82%	15,34%	**0,47**	**0,39**	1,43	1,36	0,05	0,04	1,74%	1,39%	1,03	0,97	1,69%	1,43%
Moving average (12m)	12,78%	9,54%	14,57%	16,13%	**0,64****	**0,38****	1,61	1,34	0,07	0,03	4,03%	0,86%	5,19	4,03	0,78%	0,21%
Moving average (24m)	11,15%	9,41%	14,47%	15,62%	**0,53**	**0,38**	1,49	1,34	0,06	0,03	2,47%	1,12%	3,27	2,5	0,76%	0,45%
Moving average (36m)	11,35%	9,69%	14,40%	15,62%	**0,55**	**0,4**	1,51	1,36	0,06	0,04	2,73%	1,40%	2,63	1,94	1,04%	0,72%
Moving average (48m)	10,94%	9,82%	14,41%	15,58%	**0,52**	**0,41**	1,48	1,37	0,06	0,04	2,31%	1,57%	2,26	1,69	1,02%	0,93%
Moving average (60m)	10,46%	9,82%	14,73%	15,69%	**0,48**	**0,41**	1,44	1,37	0,05	0,04	1,59%	1,48%	1,93	1,51	0,83%	0,98%
MV																
Cumulative average	9,68%	7,65%	13,41%	16,18%	**0,47***	**0,26***	1,41	1,22	0,05	0,01	1,74%	-1,08%	2,35	2,13	0,74%	-0,51%
Moving average (12m)	17,46%	10,71%	17,35%	20,53%	**0,81*****	**0,35*****	1,83	1,31	0,1	0	6,49%	-2,01%	7,88	9,66	0,82%	-0,21%
Moving average (24m)	13,46%	8,67%	17,02%	20,59%	**0,59****	**0,25****	1,55	1,21	0,06	-0,02	2,77%	-4,11%	5,73	7,56	0,48%	-0,54%
Moving average (36m)	14,10%	9,32%	17,11%	20,29%	**0,62****	**0,29****	1,6	1,24	0,07	-0,01	3,33%	-3,16%	4,78	5,78	0,70%	-0,55%
Moving average (48m)	13,55%	8,69%	16,94%	19,69%	**0,60****	**0,27****	1,57	1,22	0,06	-0,01	2,93%	-3,18%	4,35	5,41	0,67%	-0,59%
Moving average (60m)	12,59%	9,09%	16,84%	20,52%	**0,54***	**0,28***	1,51	1,23	0,06	-0,01	2,06%	-3,62%	4,06	4,93	0,51%	-0,73%
BS																
Cumulative average	10,51%	7,50%	11,77%	14,82%	**0,60*****	**0,27*****	1,56	1,24	0,07	0,02	3,60%	-0,17%	2,14	1,98	1,68%	-0,09%
Moving average (12m)	17,21%	10,27%	17,15%	19,73%	**0,80*****	**0,35*****	1,82	1,31	0,1	0,01	6,41%	-1,64%	7,51	9,1	0,85%	-0,18%
Moving average (24m)	13,42%	8,18%	16,17%	18,81%	**0,62****	**0,25****	1,58	1,21	0,07	-0,01	3,44%	-2,85%	5,48	6,06	0,63%	-0,47%
Moving average (36m)	13,61%	8,76%	15,89%	17,26%	**0,64****	**0,31****	1,62	1,26	0,07	0,01	3,86%	-0,87%	4,49	4,59	0,86%	-0,19%
Moving average (48m)	13,60%	7,52%	15,20%	16,52%	**0,67*****	**0,25*****	1,65	1,2	0,08	0,01	4,38%	-1,49%	3,95	3,78	1,11%	-0,39%
Moving average (60m)	12,97%	8,14%	15,04%	16,44%	**0,63****	**0,29****	1,61	1,24	0,07	0,01	3,87%	-0,79%	3,61	3,25	1,07%	-0,24%

Table 7. Case 3 – Results (aggressive investor; no bonds)

Performance measure	**Return**		Vola		**Sharpe**		**Omega**		**CER**		**CER-Gain**		**Turnover**		**BTC**	
	SI	CI	SI	CI	**SI**	**CI**	SI	CI	SI	CI	SI	CI	SI	CI	SI	CI
Naive Portfolios																
1/N	9,20%	9,26%	15,17%	16,83%	**0,38**	**0,35**	1,33	1,31	0,03	0,02	0,0%	0,0%				
Risk Parity	10,00%	9,84%	14,21%	15,92%	**0,46**	**0,4**	1,42	1,37	0,05	0,04	2,0%	1,0%	0,34	0,41	4,00%	3,00%
Minimum Variance	9,98%	7,52%	11,71%	14,66%	**0,56**	**0,28**	1,52	1,24	0,07	0,02	3,0%	0,0%	4,45	3,53	1,00%	0,00%
BL																
Cumulative average	9,96%	9,45%	13,83%	15,28%	**0,47**	**0,39**	1,43	1,36	0,05	0,04	2,0%	1,0%	1,1	1,04	2,00%	1,00%
Moving average (12m)	12,39%	7,32%	16,27%	18,37%	**0,55**	**0,21**	1,54	1,2	0,06	-0,01	2,0%	-3,0%	7,86	5,51	0,00%	-1,00%
Moving average (24m)	11,09%	8,44%	14,98%	15,69%	**0,51**	**0,32**	1,47	1,28	0,05	0,02	2,0%	0,0%	4,38	3,06	0,00%	0,00%
Moving average (36m)	11,28%	9,30%	14,50%	15,41%	**0,54**	**0,38**	1,5	1,34	0,06	0,03	3,0%	1,0%	3,25	2,31	1,00%	1,00%
Moving average (48m)	10,82%	9,69%	14,46%	15,37%	**0,51**	**0,41**	1,47	1,37	0,06	0,04	2,0%	2,0%	2,7	1,95	1,00%	1,00%
Moving average (60m)	10,27%	9,77%	14,83%	15,53%	**0,46**	**0,41**	1,42	1,37	0,05	0,04	1,0%	2,0%	2,36	1,73	1,00%	1,00%
MV																
Cumulative average	5,34%	6,84%	21,49%	22,76%	**0,09**	**0,15**	-1	-1	-0,06	-0,06	-10,0%	-8,0%	10,29	8,23	-1,00%	-1,00%
Moving average (12m)	25,68%	-28,83%	176,37%	98,66%	**0,13**	**-0,33**	-1	-1	-7,52	-2,72	-755,0%	-274,0%	229,33	110,3	-3,00%	-2,00%
Moving average (24m)	19,69%	-11,45%	135,33%	66,39%	**0,12**	**-0,22**	-1	-1	-4,38	-1,22	-442,0%	-124,0%	142,41	54,74	-3,00%	-2,00%
Moving average (36m)	18,98%	0,18%	106,85%	54,98%	**0,15**	**-0,06**	-1	-1	-2,66	-0,75	-270,0%	-78,0%	102,33	38,41	-3,00%	-2,00%
Moving average (48m)	19,85%	-0,14%	92,91%	45,79%	**0,18**	**-0,08**	-1	-1	-1,96	-0,53	-199,0%	-55,0%	73,27	30,11	-3,00%	-2,00%
Moving average (60m)	12,80%	6,57%	98,03%	41,73%	**0,1**	**0,07**	-1	-1	-2,27	-0,37	-231,0%	-39,0%	276,48	26,08	-1,00%	-2,00%
BS																
Cumulative average	9,49%	7,49%	11,93%	14,81%	**0,51**	**0,27**	-1	-1	0,06	0,02	2,0%	0,0%	4,58	3,75	1,00%	0,00%
Moving average (12m)	37,68%	-5,88%	107,99%	57,95%	**0,32**	**-0,16**	-1	-1	-2,54	-0,9	-257,0%	-92,0%	115,47	58,91	-2,00%	-2,00%
Moving average (24m)	22,49%	0,14%	68,48%	34,84%	**0,28**	**-0,1**	-1	-1	-0,95	-0,3	-98,0%	-32,0%	58,85	24,96	-2,00%	-1,00%
Moving average (36m)	22,08%	6,45%	51,99%	26,67%	**0,36**	**0,11**	-1	-1	-0,45	-0,11	-49,0%	-14,0%	35,52	15,91	-1,00%	-1,00%
Moving average (48m)	18,20%	5,85%	42,99%	22,47%	**0,34**	**0,11**	-1	-1	-0,28	-0,07	-31,0%	-9,0%	26,87	11,91	-1,00%	-1,00%
Moving average (60m)	15,83%	7,95%	35,50%	20,50%	**0,35**	**0,22**	-1	-1	-0,16	-0,03	-19,0%	-5,0%	21,06	9,78	-1,00%	0,00%

Table 8. Case 4 – Results (conservative investor; bonds included)

Performance measure	**Return**		**Vola**		**Sharpe**		**Omega**		**CER**		**CER-Gain**		**Turnover**		**BTC**	
	SI	CI	SI	CI	**SI**	**CI**	SI	CI	SI	CI	SI	CI	SI	CI	SI	CI
Naive Portfolios																
1/N	9,03%	9,04%	14,34%	15,69%	**0,39**	**0,36**	1,34	1,32	0,04	0,03	0,0%	0,0%	0	0		
Risk Parity	8,61%	8,29%	6,96%	6,43%	**0,75**	**0,76**	1,78	1,78	0,07	0,07	3,5%	4,4%	0,37	0,35	9,56%	12,36%
Minimum Variance	6,83%	6,70%	4,21%	4,23%	**0,81**	**0,78**	1,84	1,81	0,06	0,06	2,5%	3,4%	0,34	0,28	7,40%	12,00%
BL																
Cumulative average	8,98%	9,15%	11,41%	11,92%	**0,49**	**0,48**	1,45	1,45	0,06	0,06	1,8%	2,7%	1,34	1,04	1,37%	2,60%
Moving average (12m)	13,01%	11,63%	11,32%	12,34%	**0,85****	**0,67****	1,94	1,71	0,1	0,08	5,9%	4,9%	3,86	3,35	1,53%	1,47%
Moving average (24m)	11,14%	10,19%	11,84%	12,10%	**0,65**	**0,56**	1,66	1,54	0,08	0,07	3,8%	3,7%	2,57	2,13	1,46%	1,71%
Moving average (36m)	10,84%	9,83%	11,73%	12,09%	**0,63**	**0,53**	1,63	1,52	0,07	0,06	3,5%	3,3%	2,14	1,74	1,64%	1,89%
Moving average (48m)	9,89%	9,31%	11,86%	12,34%	**0,55**	**0,48**	1,53	1,46	0,06	0,06	2,5%	2,6%	1,97	1,56	1,27%	1,68%
Moving average (60m)	9,46%	8,89%	12,33%	12,74%	**0,49**	**0,43**	1,47	1,41	0,06	0,05	1,8%	1,9%	1,82	1,42	0,97%	1,37%
MV																
Cumulative average	7,47%	6,96%	6,78%	7,03%	**0,59**	**0,5**	1,59	1,51	0,06	0,06	2,4%	2,8%	2,42	1,89	1,01%	1,50%
Moving average (12m)	15,00%	9,70%	15,07%	18,37%	**0,77****	**0,34****	1,87	1,35	0,09	0,01	5,4%	-1,6%	6,21	6,39	0,87%	-0,25%
Moving average (24m)	13,62%	9,18%	15,91%	14,34%	**0,64**	**0,4**	1,7	1,39	0,07	0,04	3,4%	1,2%	3,56	4,03	0,96%	0,29%
Moving average (36m)	12,40%	9,71%	15,22%	11,91%	**0,59**	**0,53**	1,63	1,53	0,07	0,06	2,7%	3,3%	2,77	3,2	0,98%	1,03%
Moving average (48m)	11,05%	8,39%	15,15%	12,04%	**0,5**	**0,41**	1,53	1,38	0,05	0,05	1,4%	1,9%	2,59	2,61	0,55%	0,72%
Moving average (60m)	9,13%	8,24%	14,71%	11,76%	**0,39**	**0,41**	1,39	1,39	0,04	0,05	-0,2%	1,9%	2,66	2,46	-0,06%	0,77%
BS																
Cumulative average	6,32%	6,22%	4,95%	4,56%	**0,58**	**0,61**	1,6	1,6	0,06	0,06	1,8%	2,8%	0,9	0,6	2,02%	4,66%
Moving average (12m)	13,84%	9,95%	13,70%	15,82%	**0,76***	**0,41***	1,87	1,45	0,09	0,04	5,3%	0,8%	5,76	5,33	0,91%	0,15%
Moving average (24m)	12,25%	8,71%	13,57%	11,47%	**0,65**	**0,46**	1,72	1,46	0,08	0,05	3,8%	2,5%	3,16	3,13	1,19%	0,81%
Moving average (36m)	10,78%	8,61%	12,03%	9,57%	**0,61**	**0,54**	1,68	1,57	0,07	0,06	3,3%	3,4%	2,25	2,23	1,46%	1,54%
Moving average (48m)	9,27%	7,21%	10,90%	8,87%	**0,53**	**0,43**	1,56	1,42	0,06	0,05	2,4%	2,4%	2,09	2,02	1,16%	1,17%
Moving average (60m)	7,63%	6,76%	9,37%	8,35%	**0,45**	**0,4**	1,44	1,41	0,05	0,05	1,6%	2,1%	1,91	1,79	0,81%	1,19%

Table 9. Case 5 – Results (moderate investor; bonds included)

Performance measure	**Return**		**Vola**		**Sharpe**		**Omega**		**CER**		**CER-Gain**		**Turnover**		**BTC**	
	SI	CI	SI	CI	**SI**	**CI**	SI	CI	SI	CI	SI	CI	SI	CI	SI	CI
Naive Portfolios																
1/N	9,03%	9,04%	14,34%	15,69%	**0,39**	**0,36**	1,34	1,32	0,04	0,03	0,0%	0,0%	0	0		
Risk Parity	8,61%	8,29%	6,96%	6,43%	**0,75**	**0,76**	1,78	1,78	0,07	0,07	3,5%	4,4%	0,37	0,35	9,56%	12,36%
Minimum Variance	8,99%	7,62%	8,18%	10,19%	**0,68**	**0,41**	1,64	1,37	0,07	0,05	3,4%	2,1%	2,09	1,91	1,64%	1,12%
BL																
Cumulative average	9,18%	9,14%	11,53%	12,29%	**0,5**	**0,46**	1,46	1,43	0,06	0,05	2,0%	2,5%	1,71	1,16	1,15%	2,13%
Moving average (12m)	13,28%	10,56%	13,94%	15,41%	**0,71**	**0,46**	1,75	1,45	0,08	0,05	4,5%	1,7%	5,45	4,32	0,83%	0,40%
Moving average (24m)	11,06%	9,31%	13,71%	14,63%	**0,56**	**0,4**	1,55	1,38	0,06	0,04	2,5%	1,1%	3,52	2,73	0,70%	0,39%
Moving average (36m)	11,10%	9,49%	13,46%	14,35%	**0,57**	**0,42**	1,55	1,4	0,07	0,04	2,7%	1,5%	3,05	2,26	0,88%	0,65%
Moving average (48m)	10,41%	9,28%	13,30%	14,01%	**0,53**	**0,42**	1,5	1,4	0,06	0,04	2,1%	1,5%	2,72	2,04	0,77%	0,73%
Moving average (60m)	9,56%	8,90%	13,63%	14,31%	**0,45**	**0,38**	1,42	1,36	0,05	0,04	1,0%	0,9%	2,54	1,81	0,40%	0,49%
MV																
Cumulative average	7,92%	6,88%	11,15%	13,59%	**0,4**	**0,25**	1,35	1,23	0,05	0,02	0,9%	-0,6%	3,16	2,32	0,29%	-0,27%
Moving average (12m)	17,55%	10,26%	16,92%	19,82%	**0,84***	**0,34***	1,92	1,32	0,1	0	6,5%	-2,4%	9,18	11,1	0,71%	-0,22%
Moving average (24m)	13,51%	8,55%	16,07%	19,40%	**0,63****	**0,26****	1,61	1,23	0,07	-0,01	3,2%	-3,7%	6,87	8,43	0,46%	-0,44%
Moving average (36m)	14,03%	9,10%	15,09%	19,08%	**0,70***	**0,30***	1,7	1,25	0,08	0	4,5%	-2,9%	5,61	6,69	0,79%	-0,43%
Moving average (48m)	12,87%	8,54%	15,17%	18,04%	**0,62****	**0,28****	1,59	1,24	0,07	0	3,2%	-2,5%	5,21	5,94	0,62%	-0,42%
Moving average (60m)	11,73%	8,17%	14,97%	18,64%	**0,55**	**0,25**	1,51	1,22	0,06	-0,01	2,3%	-3,4%	4,84	5,63	0,46%	-0,60%
BS																
Cumulative average	8,93%	7,72%	8,68%	10,29%	**0,63**	**0,42**	1,61	1,37	0,07	0,05	3,2%	2,2%	2,46	1,99	1,28%	1,10%
Moving average (12m)	17,43%	9,36%	16,11%	18,42%	**0,87***	**0,32***	1,98	1,31	0,11	0,01	7,1%	-2,0%	8,46	10,17	0,83%	-0,20%
Moving average (24m)	12,89%	7,52%	14,79%	17,33%	**0,64****	**0,24****	1,63	1,21	0,07	0	3,5%	-2,9%	6,35	7,23	0,56%	-0,40%
Moving average (36m)	13,09%	8,26%	14,00%	15,32%	**0,69***	**0,31***	1,69	1,28	0,08	0,02	4,3%	-0,5%	5,27	5,52	0,82%	-0,09%
Moving average (48m)	12,82%	6,57%	13,41%	14,32%	**0,70***	**0,22***	1,7	1,18	0,08	0,01	4,4%	-1,4%	4,79	4,68	0,93%	-0,31%
Moving average (60m)	11,77%	7,38%	12,93%	14,40%	**0,64**	**0,27**	1,63	1,24	0,08	0,02	3,7%	-0,7%	4,26	4,06	0,87%	-0,17%

Tabelle 10. Case 6 – Results (agressive investor; bonds included)

Performance measure	**Return**		**Vola**		**Sharpe**		**Omega**		**CER**		**CER-Gain**		**Turnover**		**BTC**	
	SI	CI	SI	CI	**SI**	**CI**	SI	CI	SI	CI	SI	CI	SI	CI	SI	CI
Naive Portfolios																
1/N	9,03%	9,04%	14,34%	15,69%	**0,39**	**0,36**	1,34	1,32	0,04	0,03	0,0%	0,0%	0	0		
Risk Parity	8,61%	8,29%	6,96%	6,43%	**0,75**	**0,76**	1,78	1,78	0,07	0,07	3,5%	4,4%	0,37	0,35	9,56%	12,36%
Minimum Variance	6,02%	6,75%	4,67%	4,66%	**0,55**	**0,72**	1,5	1,7	0,05	0,06	1,6%	3,3%	1,99	1,34	0,80%	2,49%
BL																
Cumulative average	8,94%	9,21%	11,38%	11,93%	**0,48**	**0,48**	1,44	1,45	0,06	0,06	1,8%	2,8%	1,74	1,15	1,04%	2,40%
Moving average (12m)	15,24%	12,82%	16,70%	16,20%	**0,71**	**0,58**	1,88	1,66	0,08	0,06	4,4%	3,4%	6,1	4,79	0,72%	0,71%
Moving average (24m)	12,18%	10,44%	15,27%	14,93%	**0,57**	**0,47**	1,65	1,5	0,06	0,05	2,5%	2,0%	3,68	2,76	0,67%	0,72%
Moving average (36m)	11,33%	10,14%	13,72%	13,89%	**0,58**	**0,48**	1,61	1,5	0,07	0,05	2,7%	2,4%	2,98	2,14	0,92%	1,14%
Moving average (48m)	10,38%	9,50%	13,16%	13,36%	**0,53**	**0,45**	1,53	1,45	0,06	0,05	2,2%	2,2%	2,61	1,86	0,83%	1,16%
Moving average (60m)	9,17%	8,76%	13,69%	13,87%	**0,42**	**0,38**	1,41	1,38	0,04	0,04	0,6%	1,1%	2,48	1,69	0,24%	0,63%
MV																
Cumulative average	-7,43%	1,63%	30,43%	24,42%	**-0,36**	**-0,07**	-1	-1	-0,31	-0,13	-34,5%	-16,2%	27,51	15,65	-1,25%	-1,03%
Moving average (12m)	35,01%	-11,55%	192,7%	153,4%	**0,16**	**-0,1**	-1	-1	-8,93	-6	-897,1%	-602,8%	253,98	163,49	-3,53%	-3,69%
Moving average (24m)	24,24%	-2,55%	138,9%	109,4%	**0,15**	**-0,05**	-1	-1	-4,58	-3,02	-462,1%	-304,4%	158,82	96,82	-2,91%	-3,14%
Moving average (36m)	17,80%	6,69%	121,4%	88,15%	**0,12**	**0,04**	-1	-1	-3,5	-1,88	-354,3%	-190,5%	120,61	63,13	-2,94%	-3,02%
Moving average (48m)	11,82%	-2,91%	99,54%	64,53%	**0,08**	**-0,1**	-1	-1	-2,36	-1,07	-239,8%	-109,9%	89,14	43,21	-2,69%	-2,54%
Moving average (60m)	2,39%	-2,74%	104,4%	76,85%	**-0,01**	**-0,08**	-1	-1	-2,7	-1,5	-273,8%	-153,3%	155,51	37,95	-1,76%	-4,04%
BS																
Cumulative average	2,56%	5,49%	9,19%	6,70%	**-0,1**	**0,3**	-1	-1	0	0,04	-3,4%	1,5%	6,79	3,37	-0,51%	0,44%
Moving average (12m)	25,50%	0,96%	141,6%	102,9%	**0,16**	**-0,02**	-1	-1	-4,76	-2,64	-479,7%	-266,8%	132,08	78,13	-3,63%	-3,41%
Moving average (24m)	17,58%	1,30%	102,3%	67,92%	**0,14**	**-0,03**	-1	-1	-2,44	-1,14	-248,1%	-116,9%	67,48	35,32	-3,68%	-3,31%
Moving average (36m)	17,12%	8,35%	55,91%	38,81%	**0,24**	**0,13**	-1	-1	-0,61	-0,29	-64,9%	-32,2%	42,92	21,41	-1,51%	-1,50%
Moving average (48m)	12,73%	6,01%	43,11%	26,17%	**0,22**	**0,1**	-1	-1	-0,34	-0,11	-37,6%	-14,0%	32,89	16,44	-1,14%	-0,85%
Moving average (60m)	9,83%	6,49%	36,07%	23,46%	**0,18**	**0,13**	-1	-1	-0,23	-0,07	-26,6%	-10,2%	27,54	13,79	-0,97%	-0,74%

Tabelle 11 Performance Comparisson for the Sub-Periods (aggressive Investor / bonds excluded)

Subperiods NBER

Black-Litterman

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,32	0,06	0,08	-0,07	-0,03	0,21
Risk Parity	0,01	0,14	0,02	-0,05	0,06	0	0,26
Minimum Variance	0,25	1,51	0,1	-0,63	0,16	0,65	0,35
Cumulative average	-0,06	0,36	0,16	0,02	-0,06	0,12	0,15
Moving average (12m)	-0,04	0,76	0,37	-0,98	-0,05	0,91	0,32
Moving average (24m)	0,04	0,49	0,25	-0,44	-0,07	0,43	0,18
Moving average (36m)	0,12	0,61	0,21	-0,12	-0,08	0,23	0,21
Moving average (48m)	-0,06	0,32	0,18	-0,16	-0,17	0,16	0,3
Moving average (60m)	-0,11	0,17	0,15	-0,12	-0,17	0,04	0,19

Mean-Variance

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,32	0,06	0,08	-0,07	-0,03	0,21
Risk Parity	0,01	0,14	0,02	-0,05	0,06	0	0,26
Minimum Variance	0,25	1,51	0,1	-0,63	0,16	0,65	0,35
Cumulative average	-0,38	0,78	0,5	-0,82	-0,63	-0,06	-0,17
Moving average (12m)	-0,07	1,03	0,69	-0,67	0,84	0,93	0,95
Moving average (24m)	0,44	1,82	0,46	-1,43	0,38	0,91	0,67
Moving average (36m)	0,6	1,39	0,34	-1,3	0,09	0,4	0,61
Moving average (48m)	0,52	1,52	0,33	-1,09	0,42	0,98	0,65
Moving average (60m)	0,13	0,88	0,16	-1,26	0,37	0,43	0,29

Bayes-Stein

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,32	0,06	0,08	-0,07	-0,03	0,21
Risk Parity	0,01	0,14	0,02	-0,05	0,06	0	0,26
Minimum Variance	0,25	1,51	0,1	-0,63	0,16	0,65	0,35
Cumulative average	0,15	1,46	0,23	-0,68	-0,03	0,57	0,24
Moving average (12m)	-0,07	1,26	0,82	-0,3	0,89	1,15	0,88
Moving average (24m)	0,35	2,05	0,45	-0,98	0,49	1,16	0,59
Moving average (36m)	0,44	1,41	0,34	-1,05	0,3	0,98	0,49
Moving average (48m)	0,34	1,69	0,21	-0,94	0,64	1,59	0,5
Moving average (60m)	0,13	1,09	0,26	-1,08	0,5	0,91	0,15

Subperiods Bessler / Kurman

Black-Litterman

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,08	0	-0,17	0,06	0,11
Risk Parity	0	-0,06	-0,07	-0,02	0,14	0,16
Minimum Variance	0,08	1	-0,22	-0,13	0,43	0,58
Cumulative average	-0,08	0,16	0,09	-0,15	0,1	0,16
Moving average (12m)	-0,09	0,59	0,19	-0,2	0,02	0,58
Moving average (24m)	0	0,39	0,12	-0,15	-0,01	0,31
Moving average (36m)	0,06	0,32	0,15	-0,17	-0,03	0,25
Moving average (48m)	-0,08	0,15	0,12	-0,22	-0,04	0,26
Moving average (60m)	-0,1	0,01	0,09	-0,17	-0,1	0,15

Mean-Variance

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,08	0	-0,17	0,06	0,11
Risk Parity	0	-0,06	-0,07	-0,02	0,14	0,16
Minimum Variance	0,08	1	-0,22	-0,13	0,43	0,58
Cumulative average	-0,38	0,01	0,7	-0,46	-0,7	-0,28
Moving average (12m)	-0,16	0,86	0,54	-0,13	1,25	0,5
Moving average (24m)	0,33	0,41	0,46	-0,66	1,17	0,35
Moving average (36m)	0,49	-0,18	0,33	-0,78	0,49	0,18
Moving average (48m)	0,41	-0,09	0,31	-1,04	0,86	0,32
Moving average (60m)	0,06	-0,39	0,03	-0,67	0,55	0,02

Bayes-Steyn

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,08	0	-0,17	0,06	0,11
Risk Parity	0	-0,06	-0,07	-0,02	0,14	0,16
Minimum Variance	0,08	1	-0,22	-0,13	0,43	0,58
Cumulative average	-0,01	0,9	0,02	-0,15	0,05	0,45
Moving average (12m)	-0,18	1,01	0,72	-0,09	1,23	0,46
Moving average (24m)	0,22	0,59	0,45	-0,56	1,18	0,35
Moving average (36m)	0,33	0,14	0,31	-0,69	0,6	0,28
Moving average (48m)	0,19	0,1	0,17	-0,65	0,9	0,41
Moving average (60m)	-0,02	0	0,18	-0,33	0,58	0,14

Tabelle 12 Performance Comparison for the Sub-Periods (conservative Investor / bonds included)

Panel A: Subperiods declared by the NBER

Black-Litterman

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,31	0,06	0,08	-0,07	-0,02	0,21
Risk Parity	0,03	-0,06	-0,08	-0,21	0,1	-0,04	0,14
Minimum Variance	-0,03	-0,19	0,01	0,16	0,25	-0,01	0,02
Cumulative average	-0,05	0,22	0,06	-0,05	-0,03	-0,14	0,15
Moving average (12m)	0,05	0,98	0,15	-0,81	0,21	0,19	0,36
Moving average (24m)	0,16	0,22	0,05	0,16	0,12	0,09	0,25
Moving average (36m)	0,18	0,1	0,07	0,02	0,12	0,17	0,23
Moving average (48m)	0,04	0,17	0,05	0,15	0,05	0,11	0,23
Moving average (60m)	0,03	0,17	0,05	0,07	0,03	0,06	0,16

Mean-Variance

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,31	0,06	0,08	-0,07	-0,02	0,21
Risk Parity	0,03	-0,06	-0,08	-0,21	0,1	-0,04	0,14
Minimum Variance	-0,03	-0,19	0,01	0,16	0,25	-0,01	0,02
Cumulative average	-0,23	0,38	0,16	0	-0,1	0,15	0,14
Moving average (12m)	0,17	1,24	0,3	0	0,29	0,6	1
Moving average (24m)	0,2	0,73	0,25	-0,05	0,3	0,07	0,57
Moving average (36m)	0,2	0,29	0,15	0,01	0,14	0,2	0,19
Moving average (48m)	0,12	0,45	-0,03	0,06	0,44	0,27	0,25
Moving average (60m)	-0,44	0,53	-0,07	-0,23	0,16	0,39	0,19

Bayes-Steyn

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,31	0,06	0,08	-0,07	-0,02	0,21
Risk Parity	0,03	-0,06	-0,08	-0,21	0,1	-0,04	0,14
Minimum Variance	-0,03	-0,19	0,01	0,16	0,25	-0,01	0,02
Cumulative average	-0,23	-0,05	0,19	0,13	0,16	-0,14	-0,02
Moving average (12m)	0,15	1,28	0,23	0	0,2	0,59	0,87
Moving average (24m)	0,23	0,87	0,13	-0,04	0,32	-0,05	0,39
Moving average (36m)	0,15	-0,31	0,06	0,06	0,25	0,04	0,26
Moving average (48m)	-0,05	0,06	0,07	0,09	0,55	0,2	0,13
Moving average (60m)	-0,33	-0,07	0,1	-0,09	0,31	0,31	0

Panel B: Subperiods according to Bessler / Kurman

Black-Litterman

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,07	0	-0,18	0,07	0,11
Risk Parity	0,03	-0,23	-0,13	-0,04	0,1	0,09
Minimum Variance	-0,05	-0,13	0,08	0,16	0,39	-0,02
Cumulative average	-0,03	-0,08	0,04	-0,29	0,06	0,01
Moving average (12m)	0,06	0,38	0,12	-0,28	0,2	0,29
Moving average (24m)	0,17	0,11	0,03	-0,25	0,2	0,13
Moving average (36m)	0,19	-0,02	0,08	-0,3	0,15	0,17
Moving average (48m)	0,05	-0,14	0,05	-0,29	0,18	0,17
Moving average (60m)	0,05	-0,19	0,06	-0,21	0,17	0,12

Mean-Variance

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,07	0	-0,18	0,07	0,11
Risk Parity	0,03	-0,23	-0,13	-0,04	0,1	0,09
Minimum Variance	-0,05	-0,13	0,08	0,16	0,39	-0,02
Cumulative average	-0,24	0,36	0,15	0,12	-0,25	0,17
Moving average (12m)	0,15	0,95	0,25	-0,07	0,32	0,84
Moving average (24m)	0,2	0,51	0,38	0,39	0,37	0,25
Moving average (36m)	0,21	0	0,31	0,12	0,14	-0,07
Moving average (48m)	0,1	0,42	0,05	0,02	0,54	0,03
Moving average (60m)	-0,46	0	0,03	-0,07	0,19	0,13

Bayes-Steyn

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,07	0	-0,18	0,07	0,11
Risk Parity	0,03	-0,23	-0,13	-0,04	0,1	0,09
Minimum Variance	-0,05	-0,13	0,08	0,16	0,39	-0,02
Cumulative average	-0,23	-0,03	0,25	0,13	0,17	-0,06
Moving average (12m)	0,11	0,85	0,19	-0,13	0,27	0,72
Moving average (24m)	0,23	0,3	0,23	0,21	0,46	0,22
Moving average (36m)	0,16	-0,11	0,17	0,13	0,14	0,05
Moving average (48m)	-0,07	0,17	0,16	0,04	0,48	0,13
Moving average (60m)	-0,37	-0,18	0,23	-0,01	0,25	0,13

Tabelle 13 Performance Comparison for the sub-periods (aggressive investor / bonds included)

Panel A: Subperiods declared by the NBER

Black-Litterman

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,31	0,06	0,08	-0,07	-0,02	0,21
Risk Parity	0,03	-0,06	-0,08	-0,21	0,1	-0,04	0,14
Minimum Variance	-0,65	-1,27	-0,1	0,55	0,16	0,81	-0,25
Cumulative average	-0,06	0,22	0,05	-0,11	-0,04	-0,19	0,14
Moving average (12m)	0,17	0,23	0,07	-0,19	0,23	0,08	0,32
Moving average (24m)	0,18	0,22	0,09	-0,01	0,19	0,22	0,21
Moving average (36m)	0,19	0,1	0,09	-0,06	0,24	0,03	0,17
Moving average (48m)	0,09	0,17	0,06	0,02	0,19	-0,04	0,22
Moving average (60m)	-0,01	0,17	0,05	-0,07	0,19	-0,1	0,14

Mean-Variance

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,31	0,06	0,08	-0,07	-0,02	0,21
Risk Parity	0,03	-0,06	-0,08	-0,21	0,1	-0,04	0,14
Minimum Variance	-0,65	-1,27	-0,1	0,55	0,16	0,81	-0,25
Cumulative average	-0,67	-1,06	0,78	0,9	-0,4	-1,4	-0,79
Moving average (12m)	-0,03	0,57	0,5	0,22	0,56	-0,36	0,9
Moving average (24m)	0,17	1,45	0,39	0,07	0,12	-0,63	0,78
Moving average (36m)	0,04	-0,14	0,31	0,24	-0,07	-1,11	0,69
Moving average (48m)	0,13	0,47	0,38	0,34	0,34	-1,17	0,64
Moving average (60m)	-0,03	1,21	0,25	-0,13	0,3	-1,67	0,32

Bayes-Steyn

Period	1/1986-8/1990	8/1990-4/1991	5/1991-4/2001	5/2001-12/2001	1/2002-04/2007	5/2007-7/2009	8/2009-12/2015
	Exp	Rec	Exp	Rec	Exp	Rec	Exp
1/N	-0,14	0,31	0,06	0,08	-0,07	-0,02	0,21
Risk Parity	0,03	-0,06	-0,08	-0,21	0,1	-0,04	0,14
Minimum Variance	-0,65	-1,27	-0,1	0,55	0,16	0,81	-0,25
Cumulative average	-1,14	-1,58	0,74	0,88	-0,24	-0,3	-0,28
Moving average (12m)	-0,09	0,75	0,7	0,33	0,63	-0,66	0,9
Moving average (24m)	0,18	1,37	0,32	0,1	0,18	-0,8	0,81
Moving average (36m)	0,06	-0,15	0,26	0,34	0,04	-1,12	0,62
Moving average (48m)	0,01	-0,04	0,27	0,48	0,43	-1,14	0,57
Moving average (60m)	-0,16	-0,06	0,35	0,1	0,38	-1,57	0,23

Panel B: Subperiods according to Bessler / Kurman

Black-Litterman

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,07	0	-0,18	0,07	0,11
Risk Parity	0,03	-0,23	-0,13	-0,04	0,1	0,09
Minimum Variance	-0,73	-0,03	-0,03	0,41	0,09	-0,11
Cumulative average	-0,05	-0,07	0,03	-0,31	0,09	0
Moving average (12m)	0,19	0,25	-0,01	-0,35	0,18	0,18
Moving average (24m)	0,2	0,13	0,07	-0,39	0,18	0,09
Moving average (36m)	0,21	-0,01	0,09	-0,38	0,17	0,06
Moving average (48m)	0,1	-0,14	0,07	-0,37	0,22	0,07
Moving average (60m)	0,01	-0,2	0,06	-0,26	0,12	0,01

Mean-Variance

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,07	0	-0,18	0,07	0,11
Risk Parity	0,03	-0,23	-0,13	-0,04	0,1	0,09
Minimum Variance	-0,73	-0,03	-0,03	0,41	0,09	-0,11
Cumulative average	-0,57	-0,82	1,34	0,38	-0,78	-1,07
Moving average (12m)	-0,06	0,67	0,37	-0,14	0,65	0,13
Moving average (24m)	0,15	0,12	0,52	-0,31	0,46	0,04
Moving average (36m)	0,03	-0,59	0,45	-0,34	-0,05	-0,09
Moving average (48m)	0,1	-0,46	0,52	-0,2	0,47	-0,05
Moving average (60m)	-0,06	-0,74	0,34	0,05	0,16	-0,38

Bayes-Steyn

Period	1/1986 - 4/1990	5/1990 - 3/1994	4/1994 - 2/2001	3/2001 - 6/2004	7/2004 - 2/2008	3/2008 - 10/2015
	Exp	Rec	Exp	Rec	Exp	Rec
1/N	-0,12	0,07	0	-0,18	0,07	0,11
Risk Parity	0,03	-0,23	-0,13	-0,04	0,1	0,09
Minimum Variance	-0,73	-0,03	-0,03	0,41	0,09	-0,11
Cumulative average	-1,16	-0,05	1,09	0,44	-0,71	-0,61
Moving average (12m)	-0,11	0,72	0,66	-0,05	0,52	-0,09
Moving average (24m)	0,17	0,09	0,5	-0,24	0,39	0,04
Moving average (36m)	0,06	-0,46	0,42	-0,25	-0,02	-0,06
Moving average (48m)	-0,01	-0,59	0,46	-0,12	0,43	-0,03
Moving average (60m)	-0,2	-0,94	0,61	0,2	0,08	-0,35

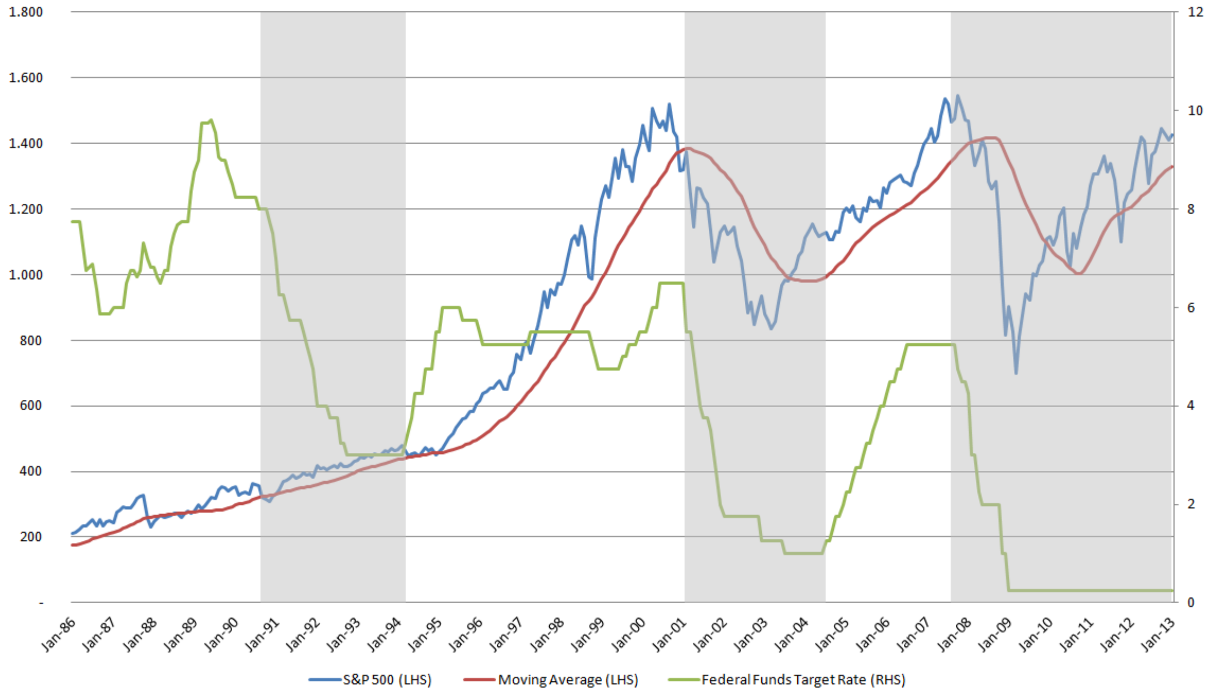

Figure 1 Expansionary and recessionary period according to Bessler et al. (2012)

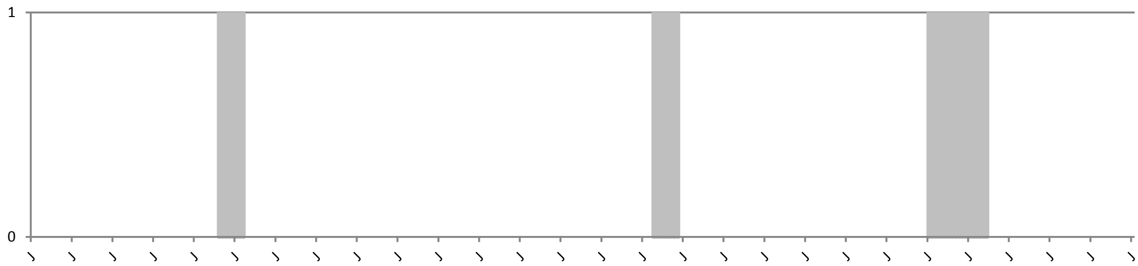

Figure 2 Expansionary and recessionary periods (gray shaded areas) according to NBER

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Endnotes

[i] The asset allocation changed from basically 66% domestic equities and 34% domestic bonds in 1980 to only 11% domestic equity and 12% domestic bonds in 2015. Foreign equities are now 11% and Private Equity 15%. Foreign bonds are now 15% and high-yield bonds 3%. The rest is invested in commodities and real estate.

[ii] Coqueret (2015) summarizes the most important reasons for the higher attention. First, in contrast to the 'classical' optimization methods, no return forecasting is necessary, which could have considerable effects on the allocation outcome (Kondor et al. (2007)). Second, in crisis-periods investors tend to buy lower-risk products. And lastly since Black (1970) and Haugen (1972) exposed the so-called low-volatility-paradox, a large body of literature concludes that lower-risk assets does not necessary perform worse than their higher-risk counterparts.

[iii] For a detailed exposition see Bessler, Opfer and Wolff (2016) and Bessler and Wolff (2015).

[iv] For an application, see Bessler, Opfer and Wolff (2016) and Bessler and Wolff (2015). In the sample-based version of the BL model 'views' are the sample means of the respective asset returns. The reliability of 'views' is measured as the variance of the historical forecast errors ε_i during the sample period 'Implied' returns are computed based on the strategic weights presented in table 2. The parameter τ is set to 0.05. Earlier studies use similar values ranging from 0.025 to 0.3 (Black and Litterman, 1992; He and Litterman, 1999; Idzorek, 2005).

[v] This test is applicable under very general conditions – stationary and ergodic returns. Most importantly for our analysis, the test permits auto-correlation and non-normal distribution of returns and allows for a likely high correlation between the portfolio returns with and without commodities.

[vi] For a detailed discussion and application of this approach see Bessler, Holler and Kurmann (2012) and Bessler and Wolff (2016a).