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# Financial Risk Monitoring by Control Strategies

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# Financial Risk Monitoring by Stability Control Strategies

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## Abstract

In this article we give a brief overview and examples on enhanced risk monitoring using recent developed stability control strategies. These are new useful tools for a better capital protection, risk and stability management in life insurance and pension fund companies. Two new risk control strategies are explained: *Binary Switching Stability Monitoring*, and *Stability Weighted Rating and Ranking*. The strategies presented here are tailored to value risk by a steady increase, by low volatilities, by small drawdowns and by short recovery times.

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## 1 Introduction

In this paper we introduce new risk management and stability monitoring strategies which were created with emphasis on life insurance and pension funds companies to help them for doing better risk control and investment decisions.

Such strategies were developed and investigated by Diethelm Wuertz et al.. Our risk control concepts are build on a capital protecting and stability preserving strategy to conserve the overall performance of an underlying investment. The goals are to achieve a steady increase of the wealth, to decrease the volatility, to improve the Sharpe Ratio or any other performance measure, to lower the drawdowns, and to shorten their recovery times. Taking care of both aspects performance and stability at the same time, we can create common rules for better indices as benchmarks for investments.

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The expectations are the following:

- High Performance and high Stability - we expect a market increase
- High Performance and high Instability - we expect a market decrease (mean reversion)
- Low Performance and high Stability - we expect a further decrease of the market
- Low Performance and high Instability - we expect a mean reversion in the direction of better market conditions

There are several options to measure market performance. The most natural one is to measure mean sample returns over a given period. We can improve this approach when we consider stability weighted returns and volatilities. Even more the Sharpe ratio [1994] and many other performance measures, see Bacon [2006], allow us to include explicitly performance variabilities into the measurement process. In the case of the Sharpe ratio we measure performance by the ratio of sample means and sample variations of the returns. We can consider as an alternative to the sample Sharpe ratio stability weighted Sharpe ratios which will be our choice in the following performance measurements. There exist also different options to measure stability from different kinds of views on the dynamic process, see Wuertz et al. [2012]: Bayesian changepoint analytics, robust principal component outlier analytics, or Morlet Wavelet analytics amongst other views. Here we use stability probabilities and convex transformations of these probabilities as a stability indicator. Our performance/stability indicator concatenates the outcome of the stability weighted performance measure with the outcome of the stability measure and follows the above described stability rules.

The data used in the show cases for the stabilization of major asset classes and indices and their equity components include small cap stocks (SCAP), large cap stocks (SCAP), high yield corporate bonds (HYCORP), and long term corporate bonds (LTCORP). For the low risk component, here we use long term (LTGOV) Government bonds. Note we can also use intermediate term Government bonds, or bills and cash. The abbreviations we use in the following to refer to the financial index and return series are given in parentheses. The data sets are generated from total return values, monthly recorded, and range back until December 1969. They were taken from iShares ETF database [2012] and can be updated on a monthly base. In previous time periods where ETF investments were not yet available we used total return index data from the SBBI Ibbotson database [2010]. For the large cap segment we used the *SP500 Total Return Index* represented by iShares' IVV ETF, for the small cap investment we used the *RUSSELL2000 Total Return Index* represented by iShares' IWM ETF, for the long term corporate bond index we used the *iBoxx USD Liquid Investment Grade Index* represented by iShares' LQD ETF, and for the high yield corporate bond index we used the *iBoxx USD Liquid High Yield Index* represented by iShares HYG ETF. For the investigations of stocks we used the constituents of the SP100. These stocks are also part of the SP500. All data are recorded end of month.

This document is organized in the following way: In section 2 we introduce and explain *Stability Analytics* and how it can be used to detect and quantify structural changes and breaks as drivers for the occurrence of instabilities in financial return series. In section 3 we introduce *Binary Switching Stability Indices*. The goal of this investment style is to stabilize an asset class by an admixture of a low risk or riskless asset to generate a more stable outcome. In section 4 we show how stability monitoring can be used to rate and rank components. We call this approach *Stability Based Rating and Ranking*. The selection of the most stable subset from the original universum will achieve a much better investment with lower volatility, smaller drawdowns, and shorter recovery times. In Section 5 we summarize our results and give a brief outlook of further

research.

## 2 Stability Analytics

Before we start we like to inspect the properties of the data used in this investigation. Figure 1 shows the logarithm of the wealth indices (indexed to December 1969 = 1) of the SCAP, LCAP, HYCORP, LTCORP, and LTGOV indices. Figure 2 shows the logarithmic returns of the five indices. The highest volatility comes with the small caps, and the lowest with the long term Government bonds. There exists higher correlations between the equity indices and also between the bond indices. As expected they are lower when we compare equity with bond indices.

To measure the stability of the individual indices we use the Bayesian change point method, introduced by Barry and Hartigan [1993]. Their product partition approach allows to identify structural changes and breaks in a time series process and to determine the probability if there being a change point at a given location in the series. A *Monte Carlo Markov Chain* approximation was implemented by Erdman and Emerson [2008] to compute the probability information. An overview about stability analytics including other methods and approaches was recently given by Würtz et al. [2010, 2011]. They used stability analytics based on volatility, on extreme and outlying values, on non-stationarities and on the analysis of non-stationary and multifractal behaviour. We can also think of other approaches making use of weighted trimmed likelihood methods, the generalized lambda distribution and optimally-biased robust estimators. Each of the approaches takes a different view on the instabilities which may occur in a financial time series most likely representing an index, prices, cumulated returns, or a wealth index.

In the following we use stability analytics based on change points and structural breaks. Such instabilities are often caused by changes in the underlying dynamics of the financial returns. These become visible as structural changes and/or structural breaks. To detect them we apply Bayesian statistical analytics which measures the probability to which degree a point in the financial returns is not part of the regular dynamical behavior but influenced by structural changes and breaks. We call this approach in the following *BCP analytics*.

To show how BCP stability analytics works we have analyzed the LCAP, SCAP, LTCORP, and HYCORP total return indices. The results in figures 3 to 6 show an retroactive turnpoint analytics and the retroactive BCP analytics. Retroactive computations are based on the whole regime of data points. Note, for risk control we use later out-of-sample stability analytics on rolling windows which are used in the computation for performance/stability forecasts.

## 3 Binary Switching Stability Indices

*Binary switching stability indices* describe investments build from two components. The first component is a high performing investment instrument (the index), the second a capital protecting and stability preserving admixture. As (risky) high performing instruments we consider for example large cap stock market investments (LCAP). Others may build from small cap investments (SCAP), or (less risky) long term corporate (LTCORP), and high yield corporate bond market investments (HYCORP). As capital protecting and stability preserving admixtures we

can consider here long term government bonds (LTGOV), but we can also rely on intermediate term government bonds, or bills and money market instruments, or just cash. In principle binary switching stability indices can be constructed from any risky underlying: Applications include the stabilization of high yield dividend equity indices, high fundamental quality equity indices, or sustainable equity indices.

#### *Wealth Stabilization of Major Asset Classes:*

We have built and investigated stability control indices for the LCAP, SCAP, LTCORP, and HYCORP indices combined with a less risky component. Here we use the long term government bonds, LTGOV, to protect and risk control the capital of the investment. The stability indicator is a combination of a BCP stability weighted Sharpe ratio and the BCP probabilities that a point in the financial returns is a change point or structural break and is not part of the regular underlying dynamical process.

To better understand how the stability approach works, figure 7 shows the log wealth and the drawdowns for the stability protected LCAP investment (SP500) since December 1997 until today (as of June 2012). In figure 8 the stability weighted performance indicator and our measure for the instabilities is shown.

Figures 9-12 show the results derived from the performance/stability protection rules for all 4 indices SCAP, LCAP, HYCORP, and LTCORP. Each chart consists of 4 graphs showing back to December 1969 the following curves:

- Chart 1: Wealth series for the equity index, for the risk controlled index, for the premium, and the benchmark series.
- Chart 2: Positions and stability indicator which serves as the rebalancing trigger.
- Chart 3: 12 months rolling mean of returns series for the equity index, the risk controlled index and the premium.
- Chart 4: 12 months rolling maximum drawdowns of returns series for the equity index, the risk controlled index and the premium.

As an additional benchmark we have introduced what we called *No-Loss/Half Gain Benchmark*. This benchmark is constructed as: For index returns lower than the low risk or risk free rate, we count the returns from the admixture, in the opposite case we count half of the (risky) index returns. This reflects our expectation that we can avoid all negative returns in unstable periods, and that we can at least realize half of the returns during the stable periods. This benchmark is also added to the performance/stability charts. During the first 36 months the risk control process equilibrates. Therefore we have displayed the charts starting with a delay of 3 years from starting point of the data.

#### *Equal Weights Indices:*

Evenmore, binary switching indices can easily be combined together to create new indices, funds or portfolios. We prefer to use equal weighted combinations since these investments are usually better diversified compared to portfolios on the efficient frontier.

Figures 13 and 14 compare the logarithm of the wealth index for several portfolios. The investigation starts in December 1969 (figure 13) and in December 1997 (figure 14). Shown are the LCAP index, a balanced 50/50% of a LCAP/LTGOV blend, and the LTGOV index. Added are

the stabilized index of an equal weight portfolio composed from the LCAP, SCAP, HYCORP, and LTCORP components and the stabilized LTCAP index. The stabilizing component is again for all computations the LTGOV index.

## 4 Stability Based Rating and Ranking of Stocks

Our methodology can also be used for scoring, rating and ranking indices or other investments according to the stability weighted performance of individual members of an index, fund or portfolio. In the case of stability ranked investments we start from an index and its components. Here we can consider any type of index, e.g. large or small cap stock indices, style or theme indices, or indices composed from bonds or other interest rate instruments. The concept in this approach is to rate the components of the considered index by a measures which assigns scores to each component in the index. The scores are computed from stability weighted performance and stability protective indicators and a rating process which orders the components. The ordering is then related to the ranking. Similar calculations have been presented by Artico [2011] who ranked stocks by company attractiveness factors.

As a first example we look at the SP 100 Index and generate a dynamic stability based rating and ranking process. From the 100 components of the index we selected the 80 series which have the longest history. We are aware that this selection process may produce a survivor bias. We divide the stocks in four groups (quartiles). The first group will be assigned to the 20 best performance/stability rated stocks, the second and third group each to the next 20 best intermediate performing stocks, and the last group to the 20 worst performance/stability weighted stocks. This process is rebalanced every end of month. The result is shown in figure 15. The Quartile separation is quite impressive with a perfect ordering of the performance from the stabilized subindices. The equal weighted index composed from the 80 stocks separates clearly the first two from the last two quartiles. To be fair, the chart will depend on the starting point. The reason is that stocks which lost more in a declining market have a higher potential for recovery.

In figure 16 we did a comparison of the stability ranked index with alternative investment decisions. Comparison for the stability protected quartile investment is made with the best quartile SP 100 investment, with the equal weights SP 100 portfolio from the 80 selected stocks, and with the SP500. The improvement in the increase in the stability becomes evident.

## 5 Summary and Outlook

*Stability Control Strategies* provide a new and powerful concept of designing new indices which figure out to be much better capital protected compared to traditional capitalized indices. From a risk management point of view stabilized investments have lower volatilities, smaller draw-downs, and shorter recovery times. In overall they offer a much better diversification than other investment styles. Our new stability design process allows to optimize *Binary Switching Stability Indices* and to design *Stability Based Ratings and Rankings* for a better risk control and more reliable investment decisions.

## Description of the US Data Sets

In this appendix we briefly describe the time series we used for the analyses of the US long term data sets.

The first set of data are 7 monthly recorded index series from the U.S. market.

- *LCAP*: As a proxy for the U.S. large cap stocks we use the *SP500* total return index. Index levels are calculated from iShares' investable ETF Fund IVV ranging back until March 2001. For earlier dates we refer to the Standard and Poors, SBBI and GFD databases. We abbreviate this time series in the following by *LCAP*.
- *SCAP*: As a proxy for the U.S. small cap stocks we use the *Russell2000* total return index. Index levels are calculated from iShares' investable ETF Fund IWM ranging back until March 2001. For earlier dates we refer to SBBI and GFD databases. We abbreviate this time series in the following by *SCAP*.
- *HYCORP*: As a proxy for the U.S. high yield corporate bonds we use the *iBoxx USD Liquid High Yield Index*. Index levels are calculated from iShares' investable ETF Fund HYG ranging back until May 2007. For earlier dates we refer to the Morningstar database. We abbreviate this time series in the following by *HYCORP*.
- *LTCORP*: As a proxy for the U.S. long term corporate bonds we use the *iBoxx USD Liquid Investment Grade Index*. Index levels are calculated from iShares' investable ETF Fund LQD ranging back until August 2002. For earlier dates we refer to the SBBI database. We abbreviate this time series in the following by *LTCORP*.
- *LTGOV*: As a proxy for the U.S. long term government bonds we use *Barclays Capital U.S. 10 to 20 Years Treasury Bond Index*. Index levels are calculated from iShares' investable ETF Fund TLH ranging back until May 2007. For earlier dates we refer to the SBBI database. We abbreviate this time series in the following by *LTGOV*.

The second data set are monthly price and equity data representing U.S. stock market by the Standard & Poors index SP100 (OEX) and its components. The data set used contained dividend adjusted end-of-month closing prices starting in December 1991. They were downloaded from Yahoo's finance web site.

## Indices of Major U.S. Asset Classes

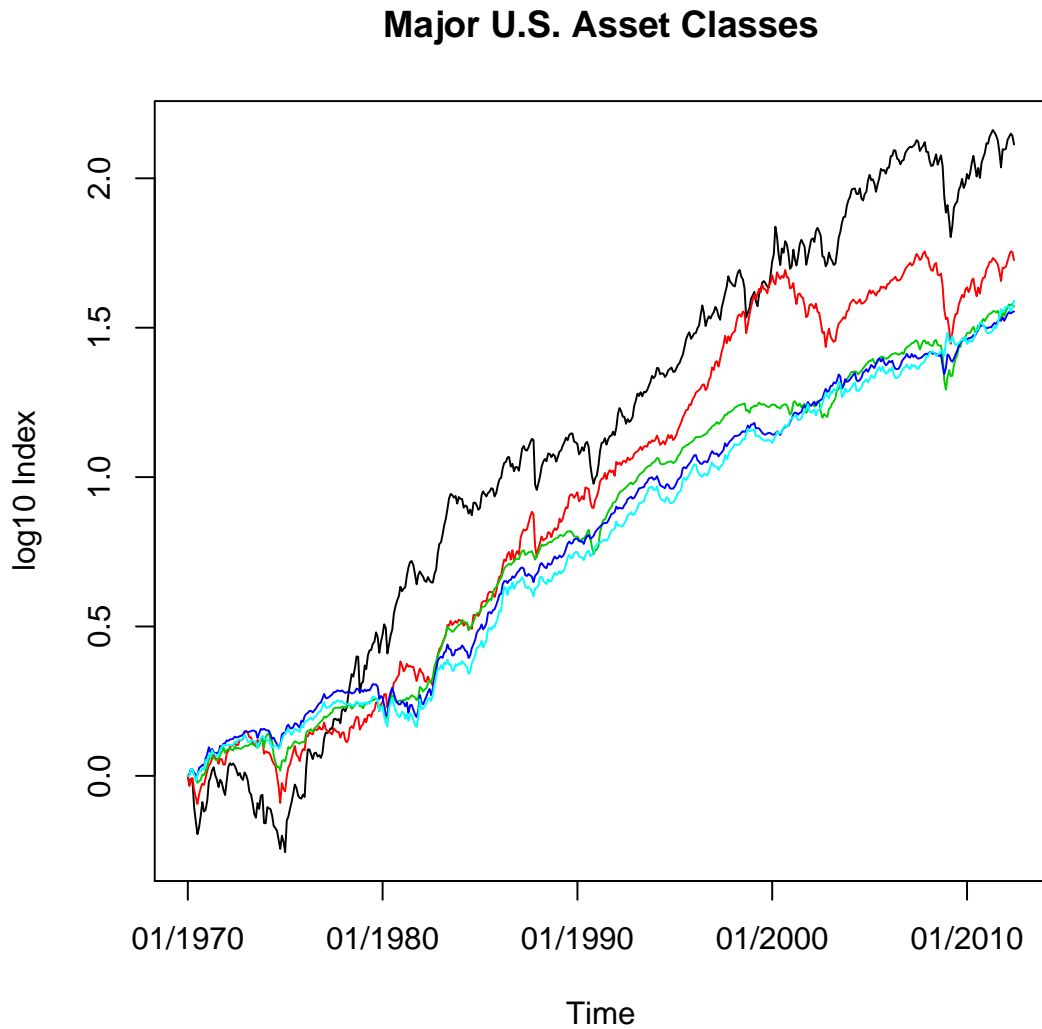


Figure 1: Logarithm of the index values of major US asset classes. The series are indexed to January 1998 = 1. The indices include small (SCAP, black) and large capitalized (LCAP, red) stocks, high yield (HYCORP, green) and long term corporate (LTCORP, blue) bonds, and long term Government (LTCORP, cyan) bonds.



## Returns of Major U.S. Asset Classes

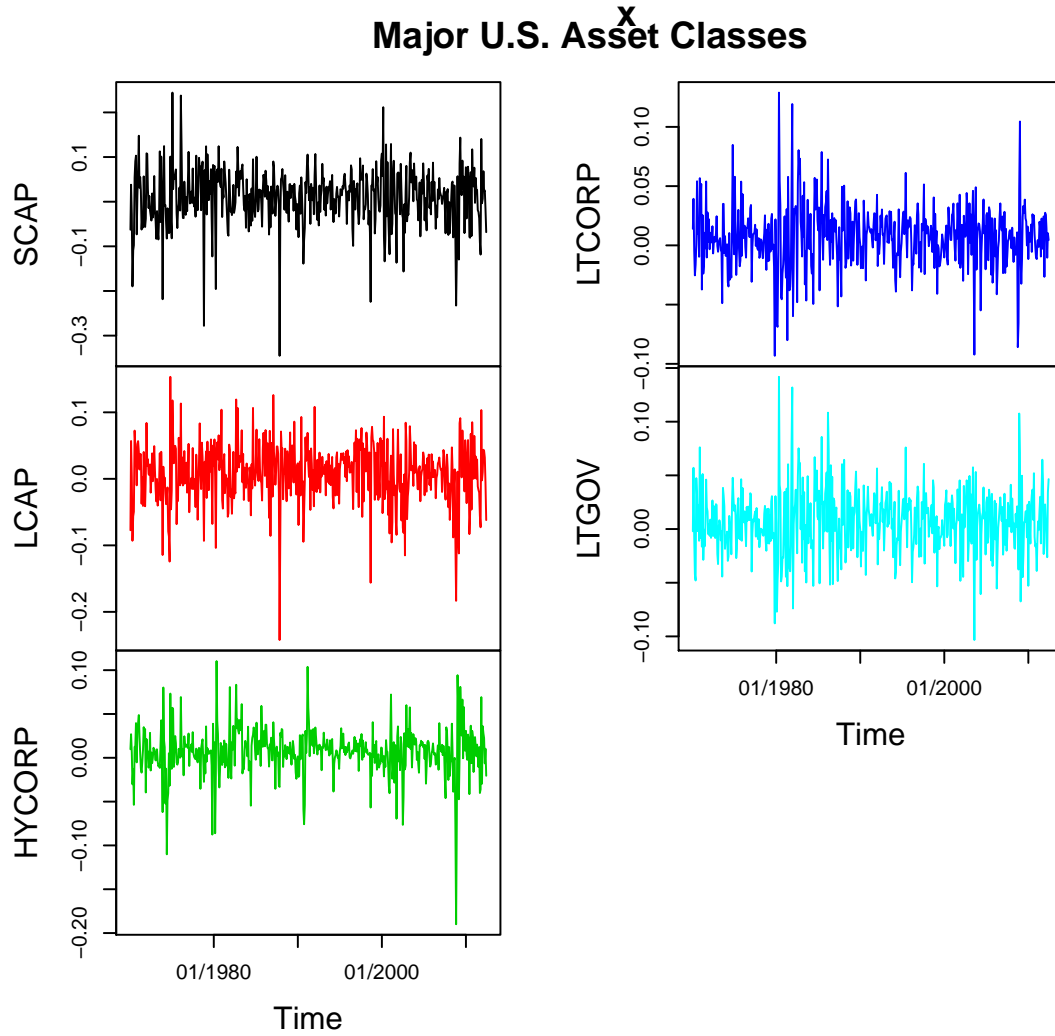


Figure 2: Monthly log-return values of major US asset classes. The series are the same as in Figure. 1.S mall (SCAP, black) and large capitalized (LCAP, red) stock indices, high yield (HYCORP, green) and long term corporate (LTCORP, blue) bond indices, and long term Government (LTCORP, cyan) bond.

## Large Capital Stocks Bayesian Change Point Analytics

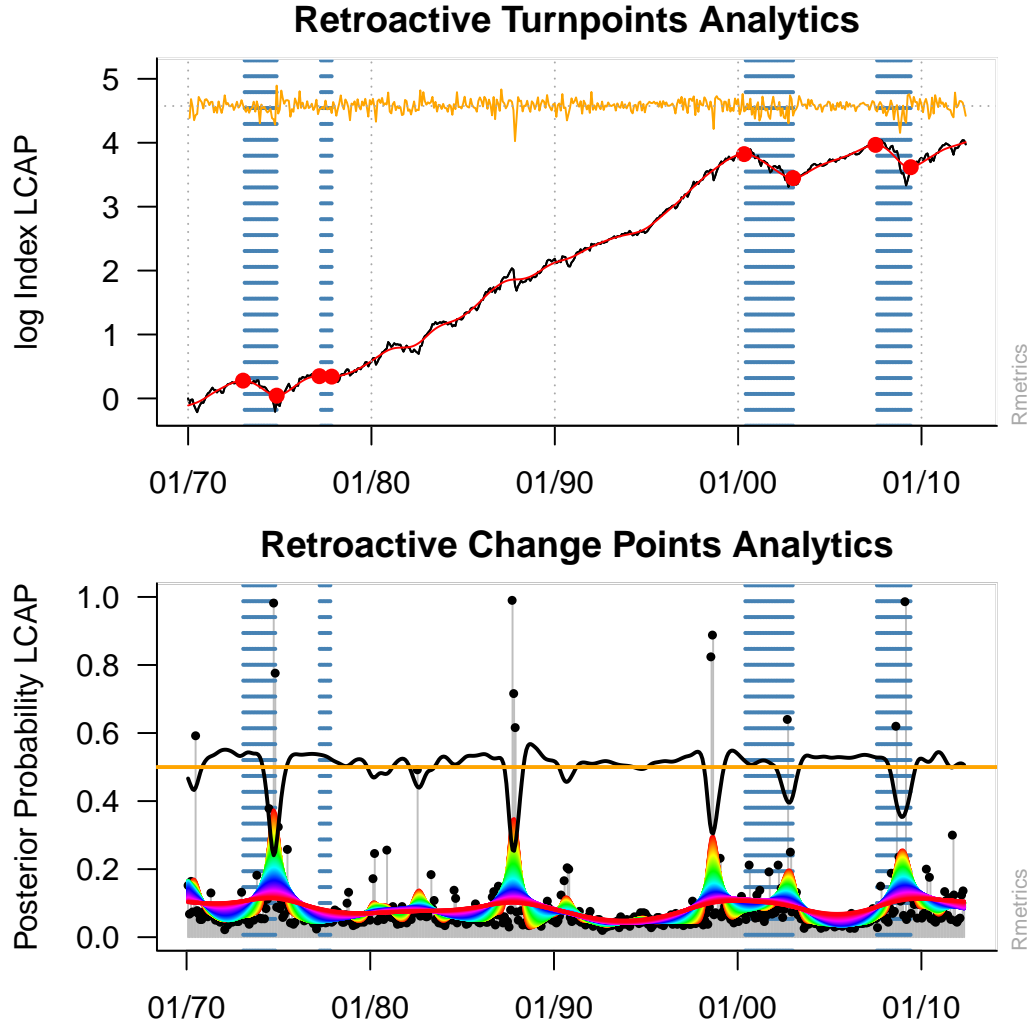


Figure 3: LCAP (SP 500) Bayesian Change Point Analytics. The upper graph displays a retroactive turning point analysis. The black curve shows the end of month values of the logarithm of the wealth index, the red curve is filtered by a spline smoother. The red dots mark the turning points, the blue horizontal bars mark the down periods. The orange curve shows the structure of the returns. The lower graph displays the results from the retroactive BCP analytics. The gray bars with a black dot on top mark the probabilities for each time series points. These probabilities are smoothed on a whole bundle of curves with different degrees of smoothness dyed by rainbows colors. From their peaks and divergencies we can identify more stable, less stable or even unstable regions. The black curve twisting around  $1/2$  is a measure for the extraction or divergence of the stability.

## Small Capital Stocks Bayesian Change Point Analytics

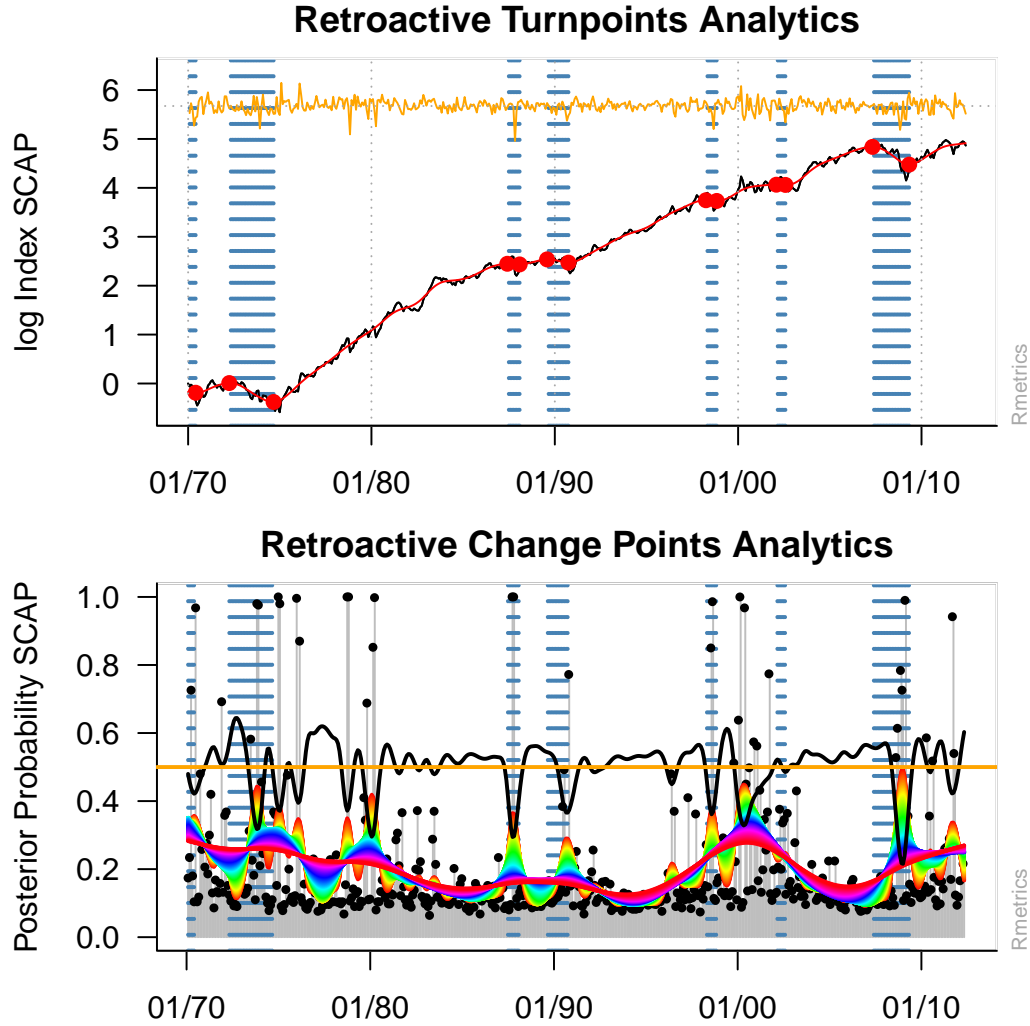


Figure 4: SCAP (Russel 2000) Bayesian Change Point Analytics. The upper graph displays a retroactive turning point analysis. The black curve shows the end of month values of the logarithm of the wealth index, the red curve is filtered by a spline smoother. The red dots mark the turning points, the blue horizontal bars mark the down periods. The orange curve shows the structure of the returns. The lower graph displays the results from the retroactive BCP analytics. The gray bars with a black dot on top mark the probabilities for each time series points. These probabilities are smoothed on a whole bundle of curves with different degrees of smoothness dyed by rainbows colors. From their peaks and divergencies we can identify more stable, less stable or even unstable regions. The black curve twisting around  $1/2$  is a measure for the extraction or divergence of the stability.

## Long Term Corporate Bonds Bayesian Change Point Analytics

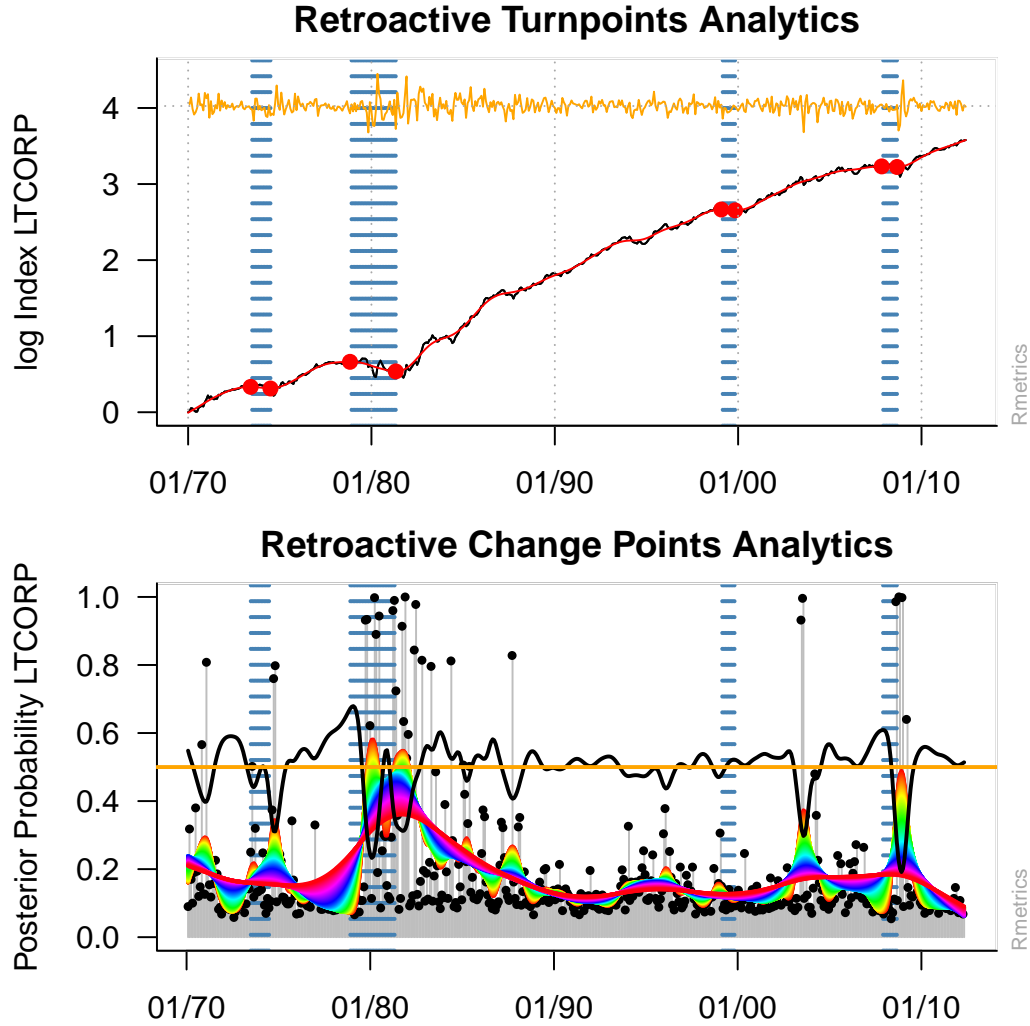


Figure 5: LTCORP Bayesian Change Point Analytics. The upper graph displays a retroactive turning point analysis. The black curve shows the end of month values of the logarithm of the wealth index, the red curve is filtered by a spline smoother. The red dots mark the turning points, the blue horizontal bars mark the down periods. The orange curve shows the structure of the returns. The lower graph displays the results from the retroactive BCP analytics. The gray bars with a black dot on top mark the probabilities for each time series points. These probabilities are smoothed on a whole bundle of curves with different degrees of smoothness dyed by rainbows colors. From their peaks and divergencies we can identify more stable, less stable or even unstable regions. The black curve twisting around 1/2 is a measure for the extraction or divergence of the stability.

## High Yield Corporate Bonds Bayesian Change Point Analytics

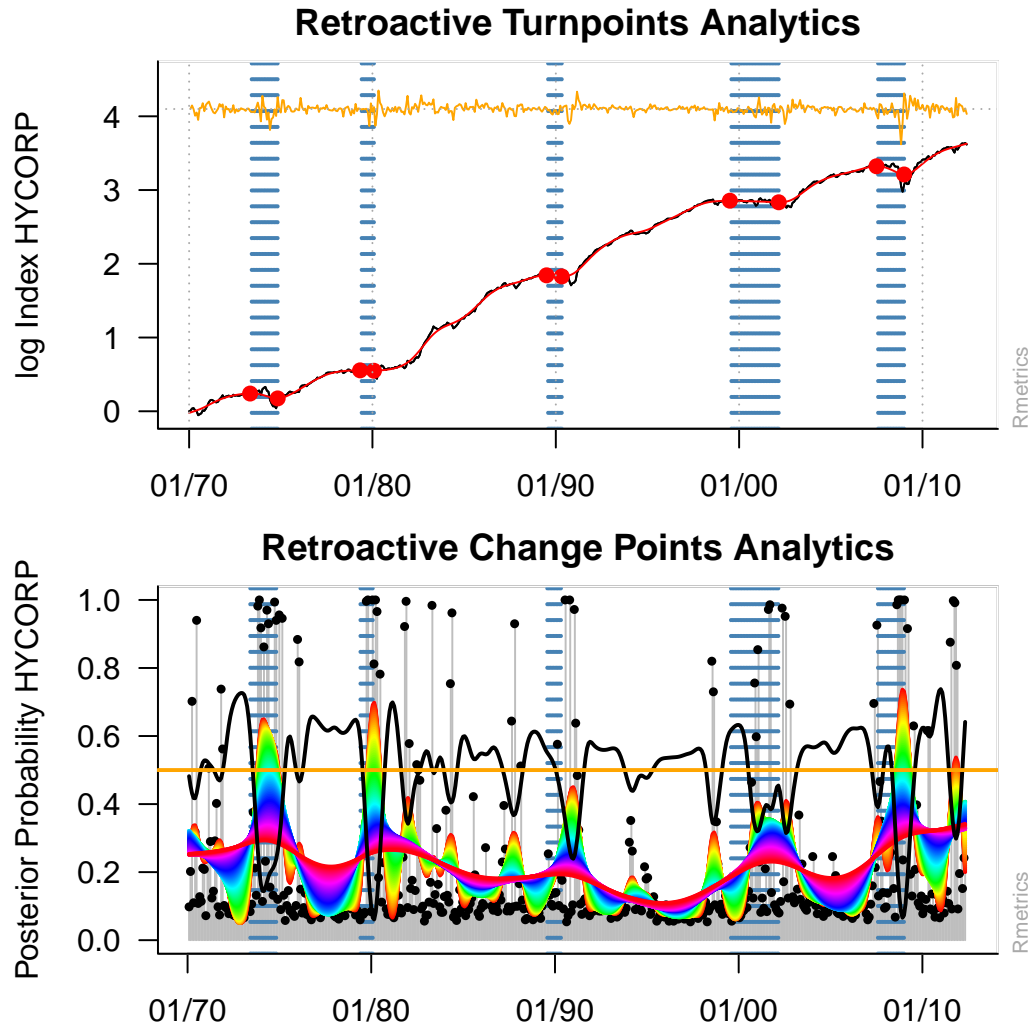


Figure 6: HYCORP Bayesian Change Point Analytics. The upper graph displays a retroactive turning point analysis. The black curve shows the end of month values of the logarithm of the wealth index, the red curve is filtered by a spline smoother. The red dots mark the turning points, the blue horizontal bars mark the down periods. The orange curve shows the structure of the returns. The lower graph displays the results from the retroactive BCP analytics. The gray bars with a black dot on top mark the probabilities for each time series points. These probabilities are smoothed on a whole bundle of curves with different degrees of smoothness dyed by rainbows colors. From their peaks and divergencies we can identify more stable, less stable or even unstable regions. The black curve twisting around  $1/2$  is a measure for the extraction or divergence of the stability.

## LCAP Stability protected by LTGOV

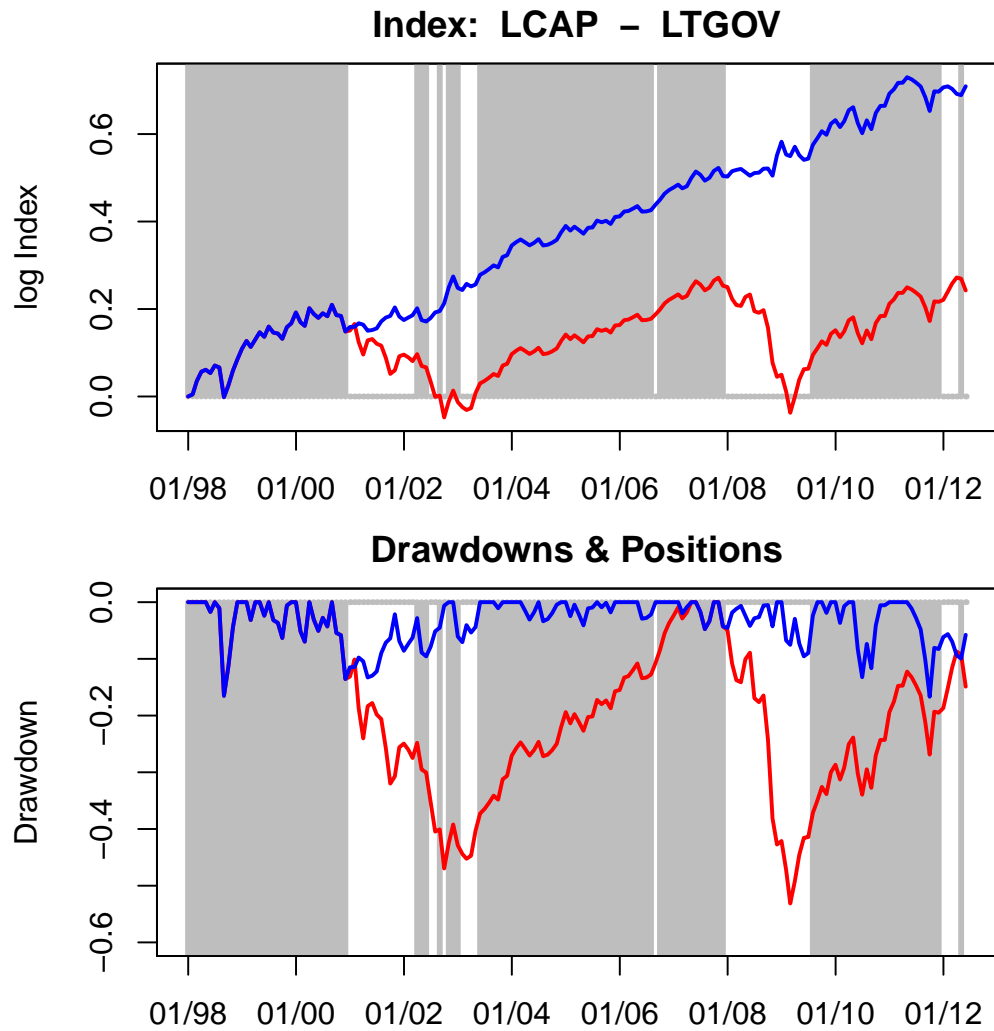


Figure 7: LCAP Stability Protection: The graphs show the log10 wealth index and the drawdowns for the unprotected and the stability protected SP500 index. The investigation starts January 1998. The first 12 months are used as warmup period.

## LCAP Performance and Stability Indicators

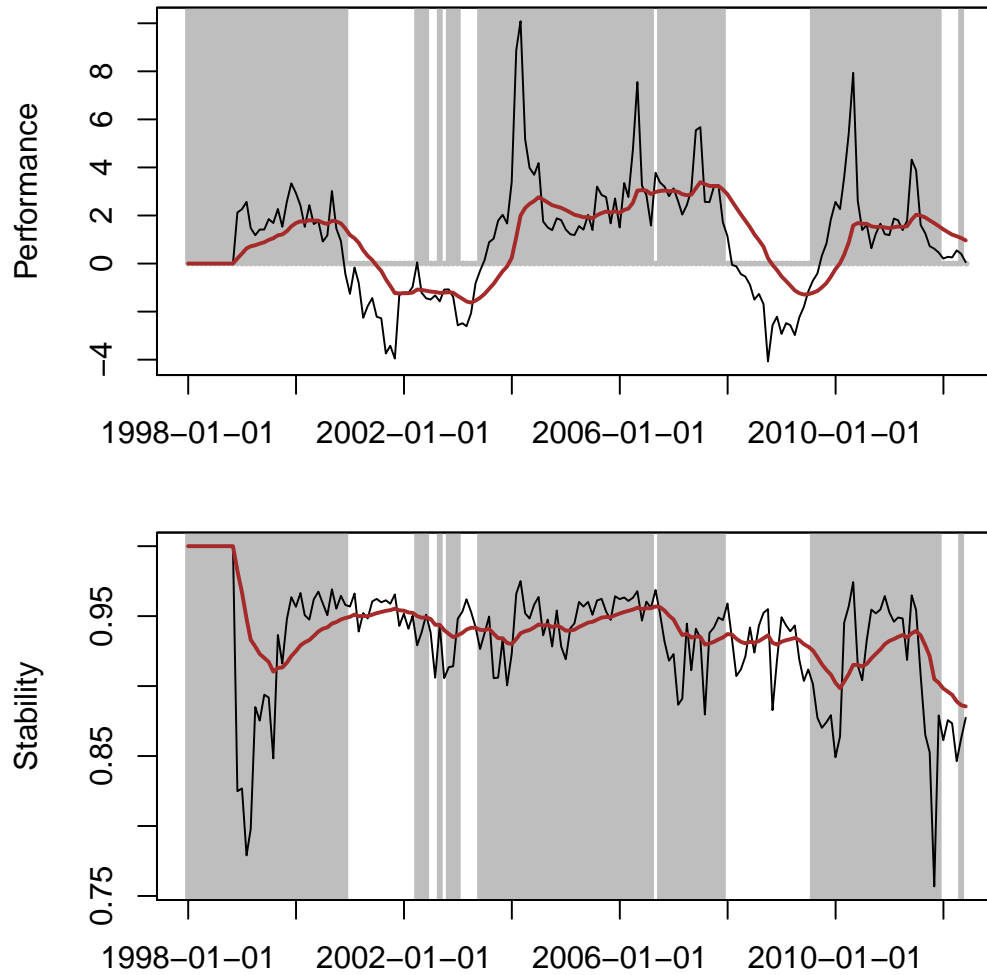


Figure 8: Performance and stability indicator for the large cap stock segments starting January 1998. Note, the first 12 months are used as warmup period. The upper graph shows the stability weighted Sharpe ratio measuring performance and the lower graph measures instability. From these two indicators the rebalancing signals are created.

## LCAP Stability protected by LTGOV

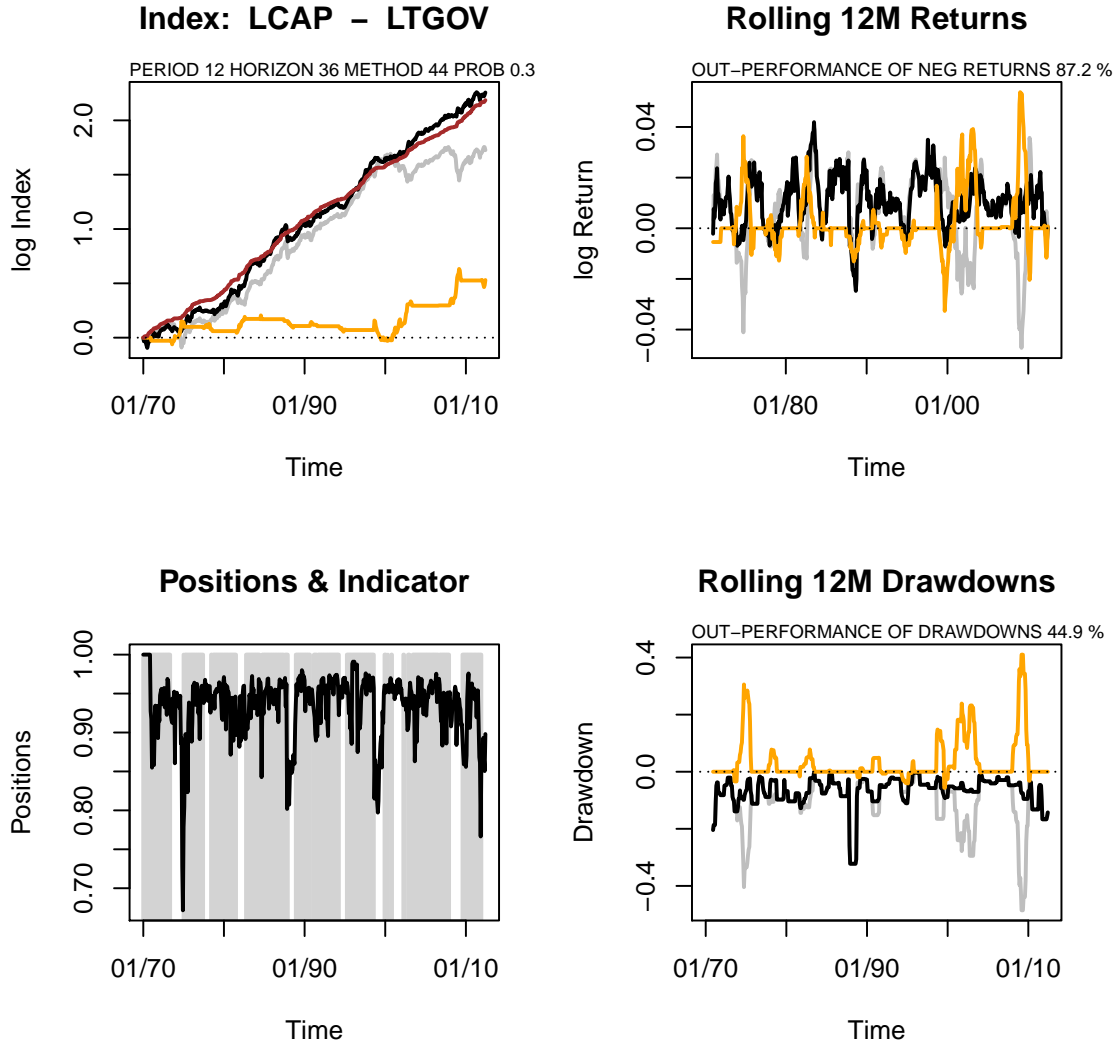


Figure 9: LCAP stability controlled indexation: Chart 1 (upper left) displays the wealth series for the equity index (grey), for the risk controlled index (black), for the premium (orange), and for the benchmark series (brown). Chart 2 (lower left) shows the positions and the stability indicator trigger. Chart 3 (upper right) displays the 12 months rolling mean of the returns series for the equity index (grey), the risk controlled index (black), and the premium (orange). Chart 4 (lower right) displays the 12 months rolling maximum drawdowns of returns series for the equity index (grey), the risk controlled index (black), and the premium (orange).



## SCAP Stability protected by LTGOV

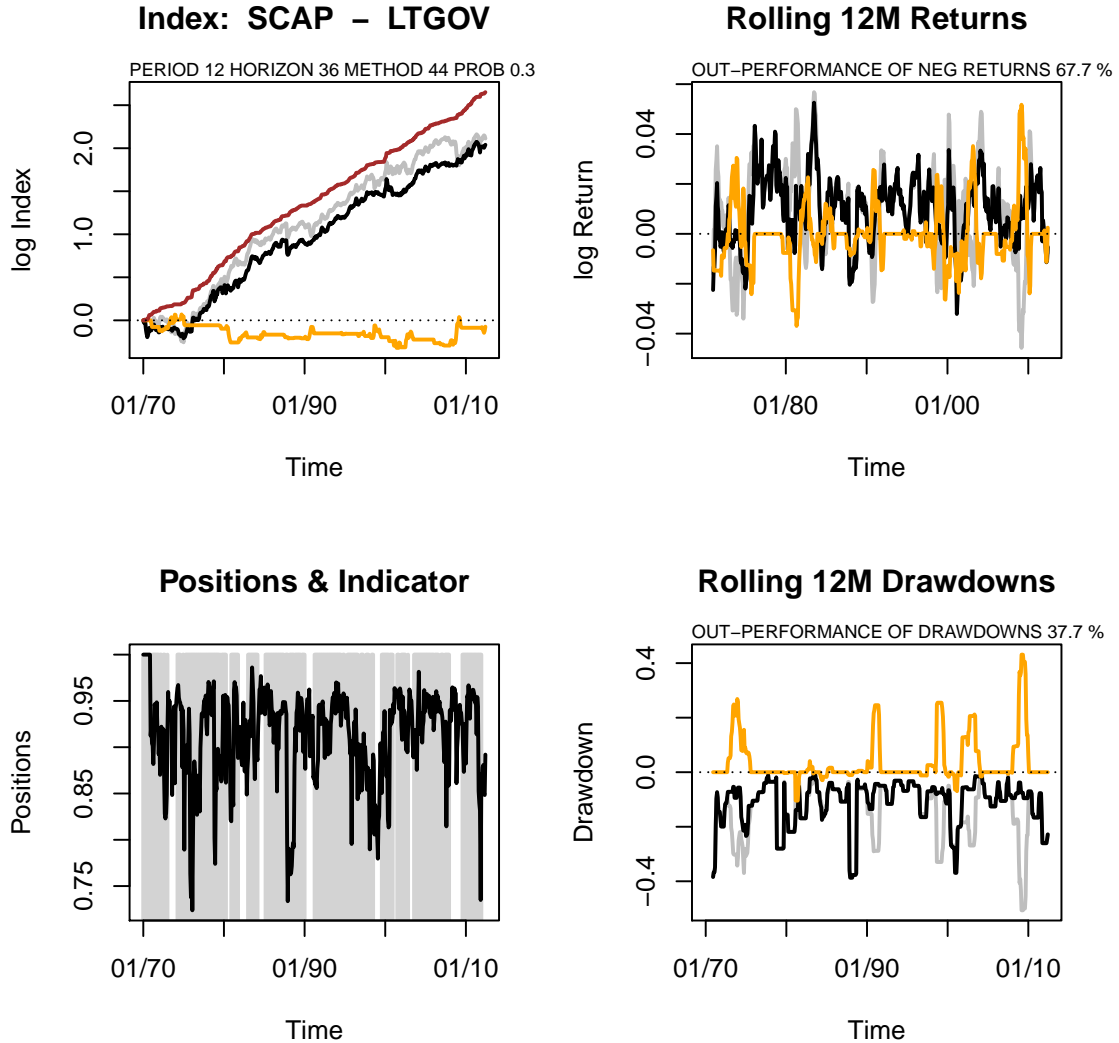


Figure 10: SCAP stability controlled indexation: Chart 1 (upper left) displays the wealth series for the equity index (grey), for the risk controlled index (black), for the premium (orange), and for the benchmark series (brown). Chart 2 (lower left) shows the positions and the stability indicator trigger. Chart 3 (upper right) displays the 12 months rolling mean of the returns series for the equity index (grey), the risk controlled index (black), and the premium (orange). Chart 4 (lower right) displays the 12 months rolling maximum drawdowns of returns series for the equity index (grey), the risk controlled index (black), and the premium (orange).

## HYCORP Stability protected by LTGOV

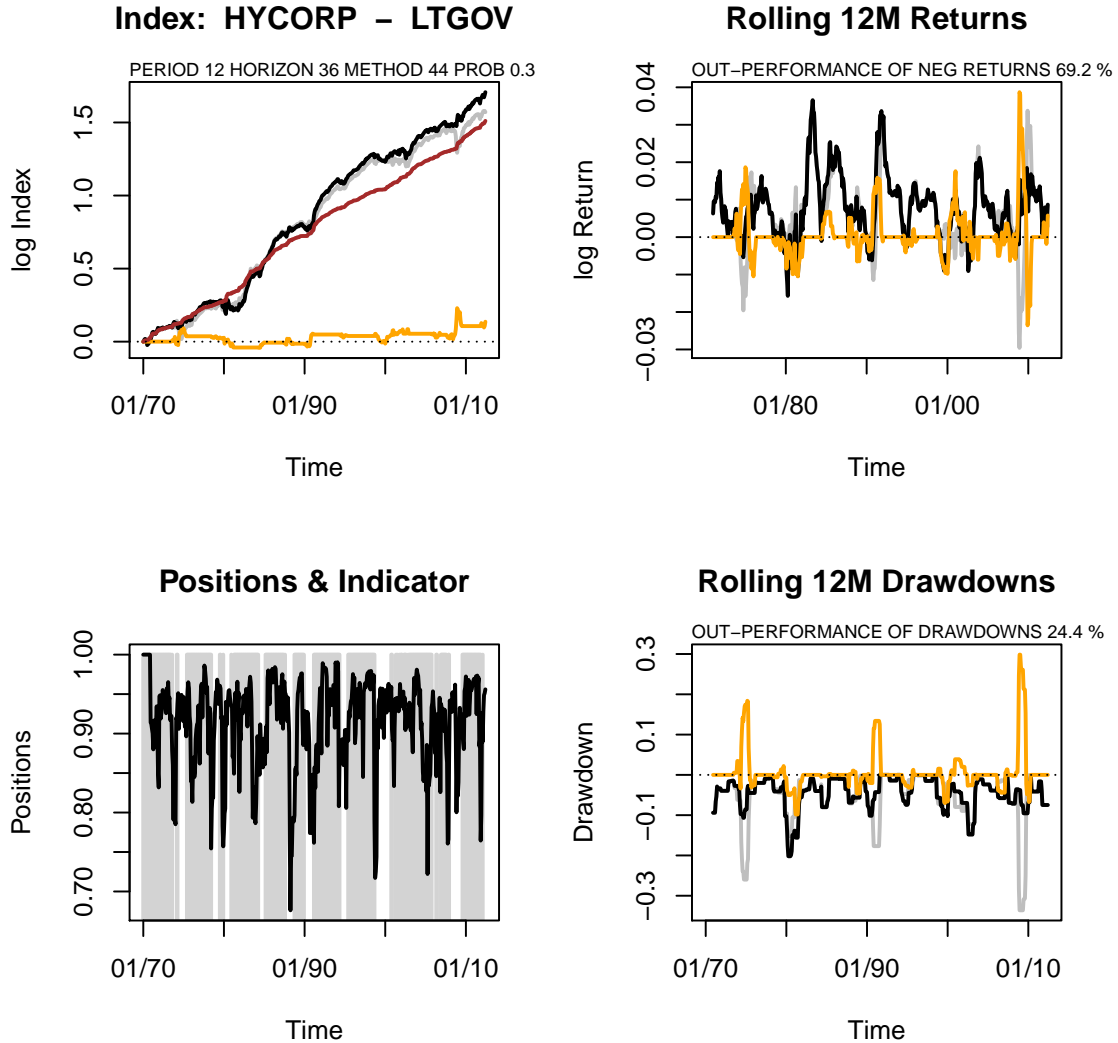


Figure 11: Hycorp stability controlled indexation: Chart 1 (upper left) displays the wealth series for the equity index (grey), for the risk controlled index (black), for the premium (orange), and for the benchmark series (brown). Chart 2 (lower left) shows the positions and the stability indicator trigger. Chart 3 (upper right) displays the 12 months rolling mean of the returns series for the equity index (grey), the risk controlled index (black), and the premium (orange). Chart 4 (lower right) displays the 12 months rolling maximum drawdowns of returns series for the equity index (grey), the risk controlled index (black), and the premium (orange).

## LTCORP Stability protected by LTGOV

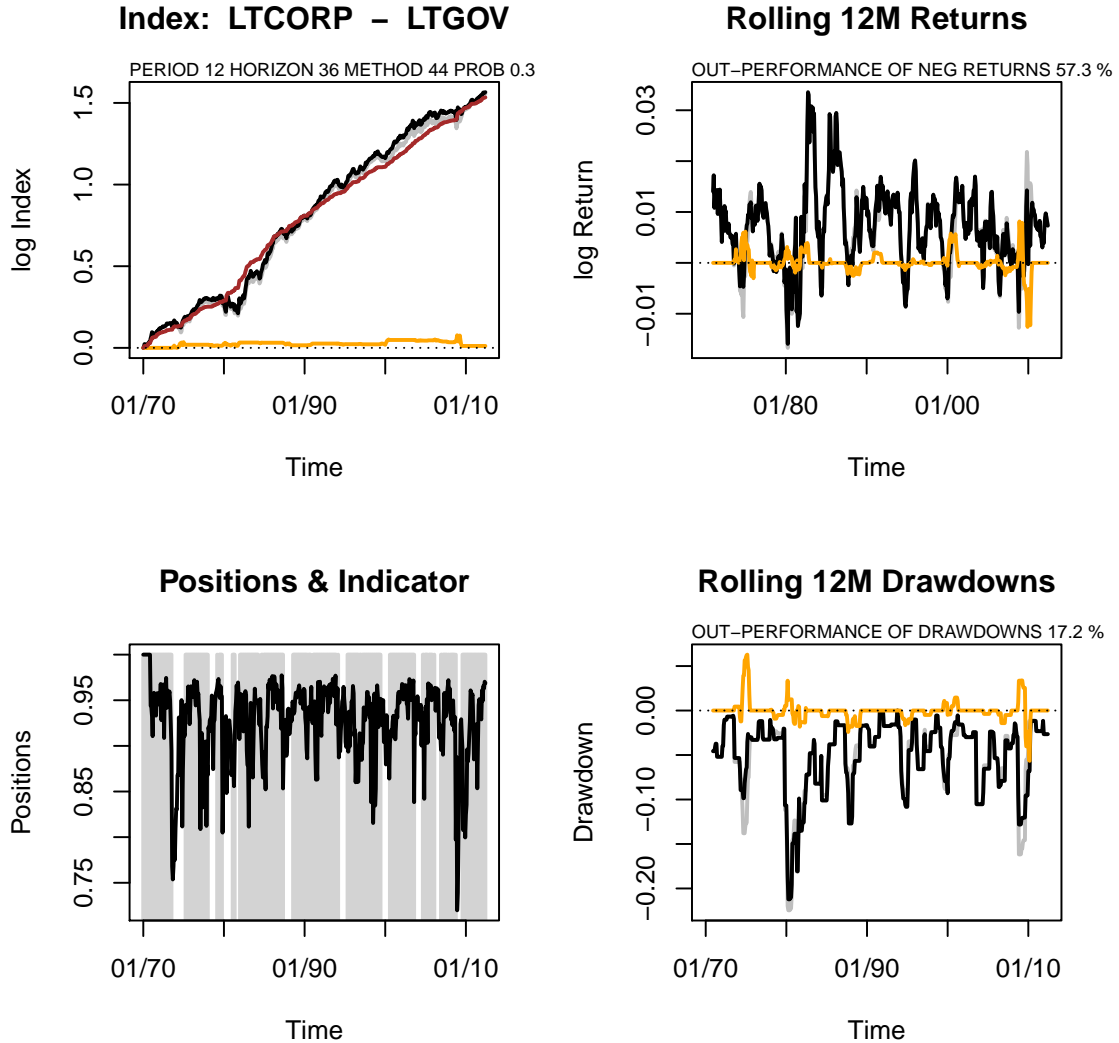


Figure 12: LTCORP stability controlled indexation: Chart 1 (upper left) displays the wealth series for the equity index (grey), for the risk controlled index (black), for the premium (orange), and for the benchmark series (brown). Chart 2 (lower left) shows the positions and the stability indicator trigger. Chart 3 (upper right) displays the 12 months rolling mean of the returns series for the equity index (grey), the risk controlled index (black), and the premium (orange). Chart 4 (lower right) displays the 12 months rolling maximum drawdowns of returns series for the equity index (grey), the risk controlled index (black), and the premium (orange).

## Comparison of Balanced Portfolios Charts Since 1970

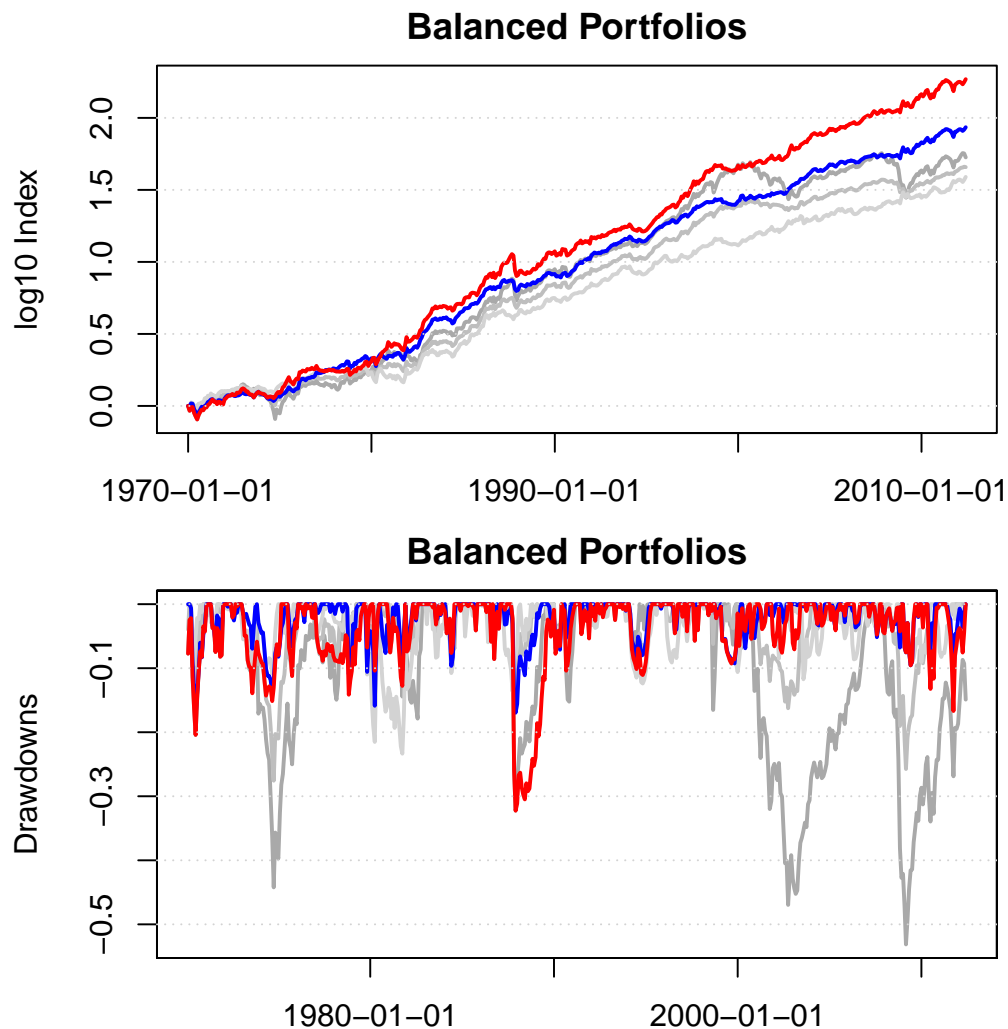


Figure 13: The graphs compare the logarithm of the wealth index for several portfolios. The investigation starts in 1970. Shown are the LCAP index (darkgrey), a balanced 50/50% of a LCAP/LTGOV blend (grey), and the LTGOV index (light grey). The blue line presents the stabilized index of an equal weight portfolio composed from the LCAP, SCAP, HYCORP, and LTCORP components. The red line presents the stabilized LTCAP index. The stabilizing component is the LTGOV index.

## Balanced and Stabilized Portfolios Charts Since 1998

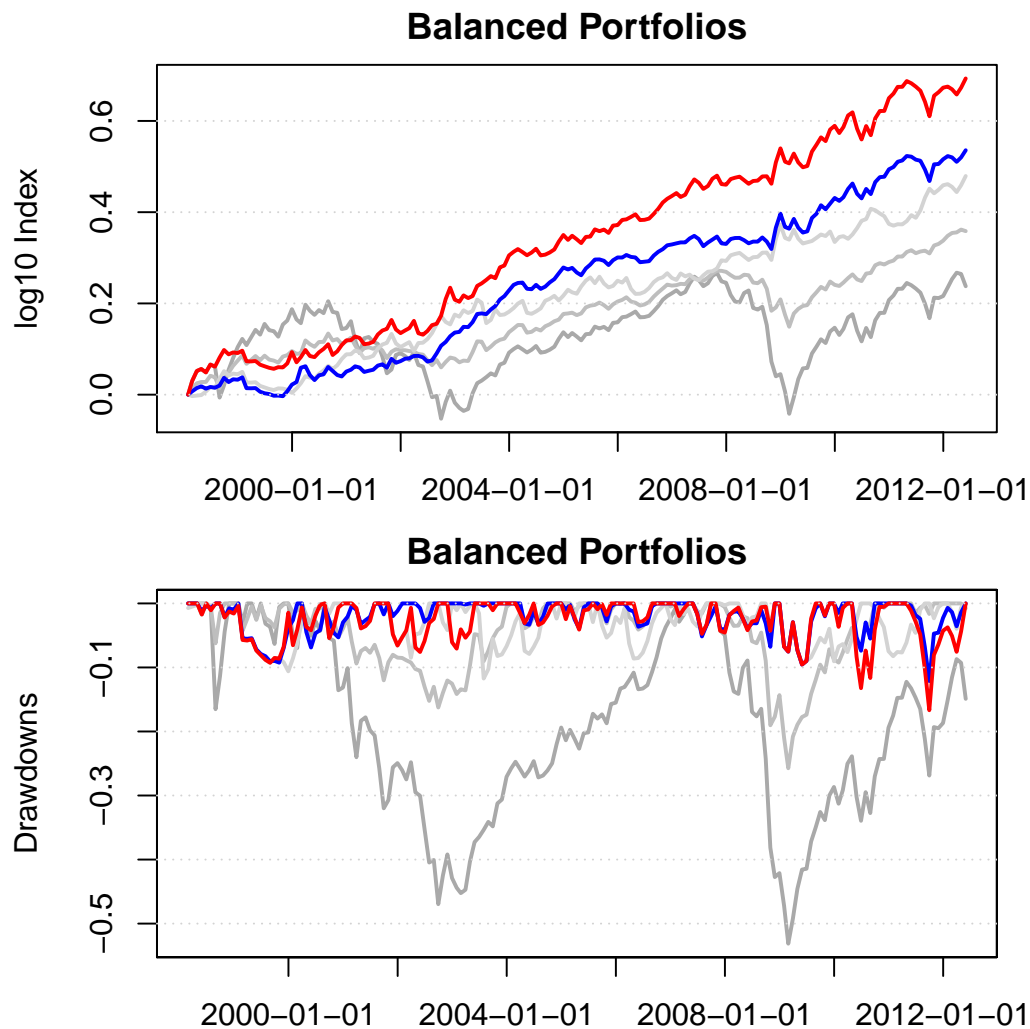


Figure 14: The graphs compare the logarithm of the wealth index for several portfolios. The investigation starts in 1999. Shown are the LCAP index (darkgrey), a balanced 50/50% of a LCAP/LTGOV blend (grey), and the LTGOV index (light grey). The blue line presents the stabilized index of an equal weight portfolio composed from the LCAP, SCAP, HYCORP, and LTCORP components. The red line presents the stabilized LTCAP index. The stabilizing component is the LTGOV index.

## SP100 Stability Ranking

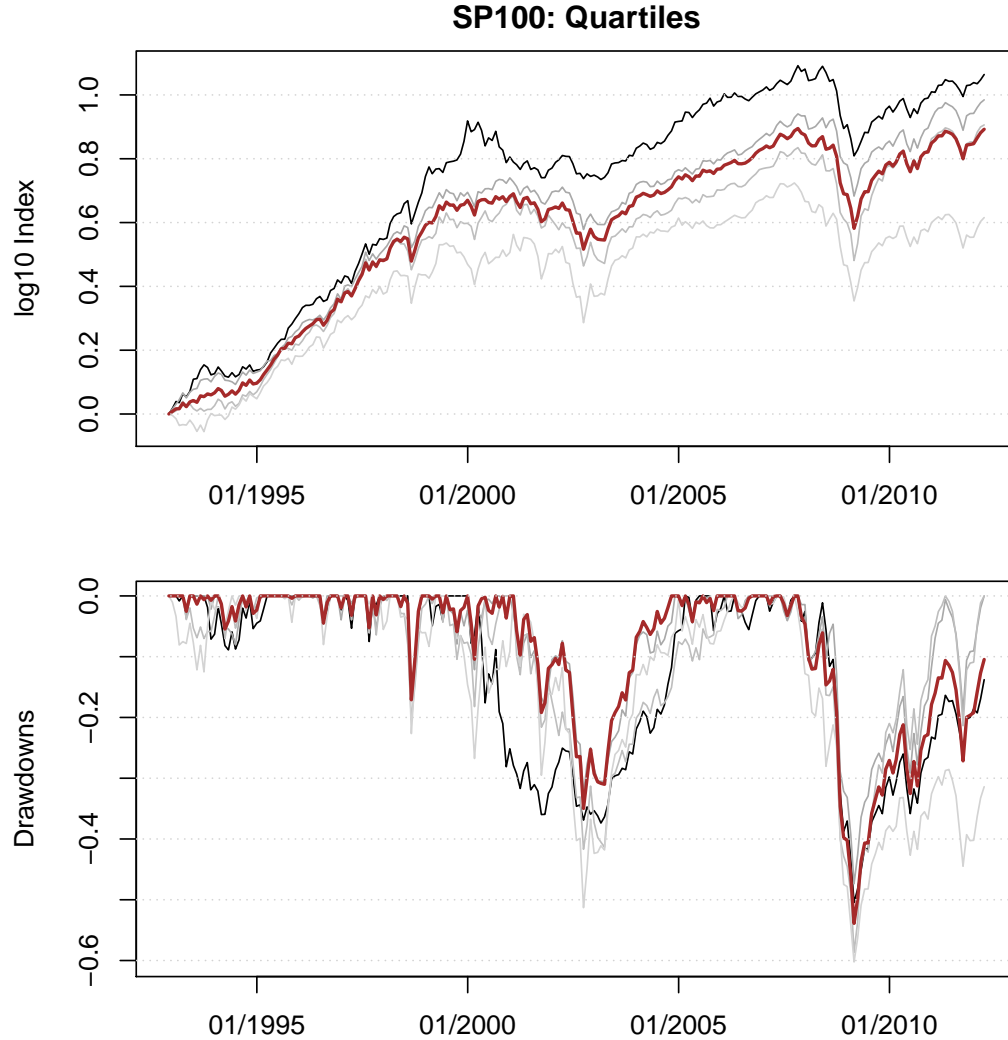


Figure 15: SP100 Stability Ranking of the 80 stocks with the longest history in the index. The four groups contains the 20 best, the second and third 20 best, and finally the worst 20 performance/stability weighted stocks from the index. The colors of the for groups are black, dark grey, grey, and light grey. The Quantile separation is quite impressive with a perfect ordering of the performance stabilized subindices. The equal weighted index composed from the 80 stocks is shown by the thick brown line.

## Stabilized SP100 / SP500 Comparison

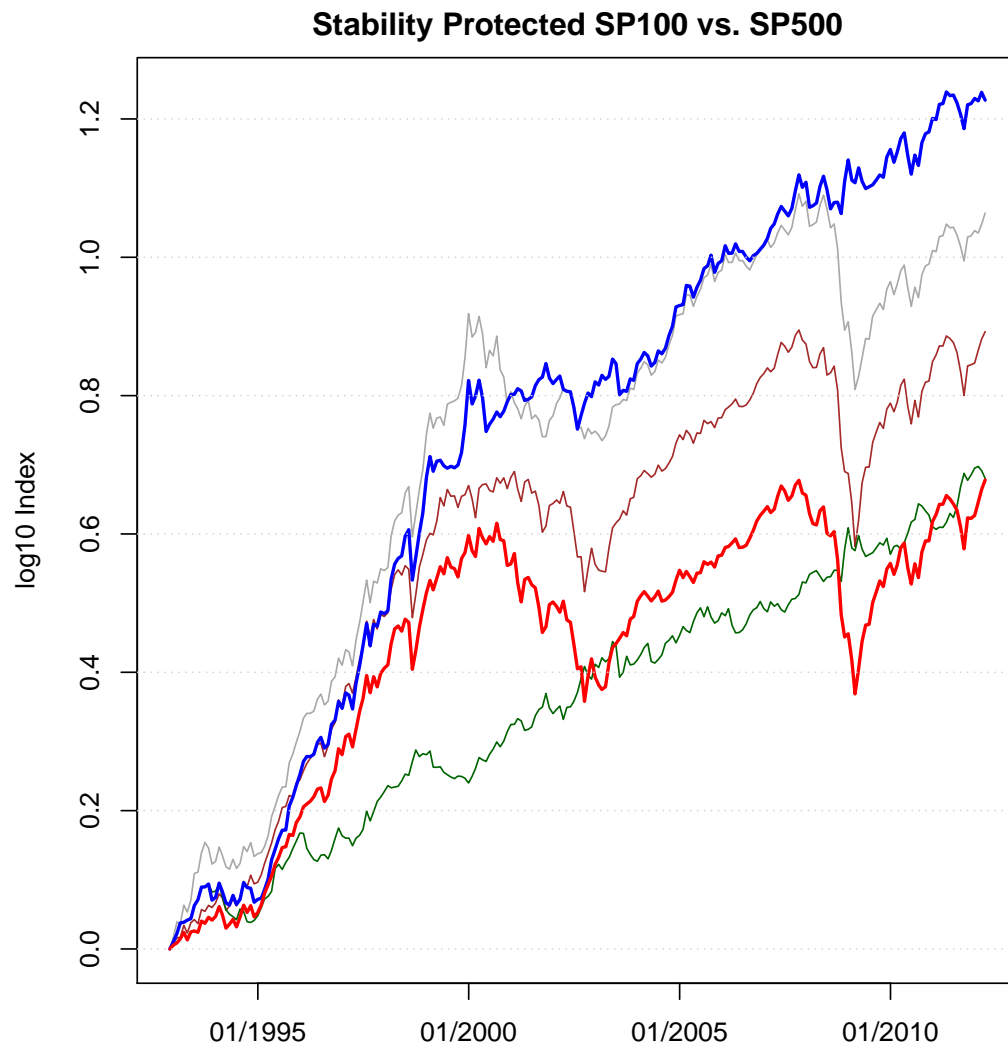


Figure 16: The graphs show comparisons of the logarithmic wealths of the SP500 (red), of the equally weighted SP100 of the 80 stocks with the longest history, of the best quartile performance stability selected index, and of the stability protective index of the best quartile index. The lowest curve (darkgreen) shows the log return of the protective component, the long term Government Bond Index LTGOV.

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