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DYNAMIC ASSET ALLOCATION IN EMERGING MARKETS

Bachelor's thesis

Supervisor: Professor Karsten Staehr, Ph.D.

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I declare I have written the bachelor’s thesis independently.

All works and major viewpoints of the other authors, data from other sources of literature and elsewhere used for writing this paper have been referenced.

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ABSTRACT

The objective of this thesis was to provide a clear overview of the dynamic asset allocation theory, different strategies, and the possibilities and limitations involved with the implementation of the dynamic strategies in emerging markets. In addition to the latter, to evaluate the effectiveness and verify, if portfolio based on dynamic strategy can generate higher long-term gains and limit more efficiently short-term losses, than portfolio based on static asset allocation.

In order to compare the dynamic asset allocation to static allocation, expected shortfall risk-based strategy was implemented. The dataset for this empirical analysis included four different asset class indices through more than 12 years.

While transaction costs are often dependent on negotiated terms and counterparties, different transaction costs were tested. The results of the empirical analysis clearly indicated the outperformance of dynamic asset allocation, compound annual growth rate was 2.46% - 2.51% higher than on static portfolio, depending on whether transaction costs were included, or not.

The results can be implemented by institutional investors – the expected shortfall probability method would help to reduce the negative returns during economic downturns. However, it is important to emphasize, that further research is required in order to find the most suitable and profitable dynamic asset allocation strategy for emerging markets.

Keywords: dynamic asset allocation, asset allocation, portfolio management, emerging markets, risk-based strategy, expected shortfall

INTRODUCTION

The old cliché „Don't put all your eggs in one basket" can be also applied in investing through asset allocation. The latter is an investment strategy where portfolio is divided among different asset classes. The main purpose of asset allocations is to diversify risks. The majority of investors and asset managers acknowledge the existence of the risk, which arises from not allocating assets – expected return, is depending on one particular asset, and there is the risk of losing everything. Thus, it is a common practice to use asset allocation between various asset classes as a part of an investment strategy. Moreover, investment funds generally have an obligation to allocate assets between different asset classes.

In addition to allocation between various asset classes, there is also a possibility to allocate assets between different markets, countries and regions. In this context, there are three distinguishable main market types: developed, emerging and frontier. Most of the countries are either classified as developed or emerging markets. Although emerging markets might not be efficient capital markets, several of them have a fast growing economy, thereby providing great investment opportunities. In case investing wisely and properly, this provides an excellent opportunity to gain high returns. Furthermore, assets can be more diversified which in turn might reduce portfolios' overall risk.

Investing in emerging markets is often complex and expensive – it is difficult to access to exotic markets, because making agreements with local brokers might be high cost and time consuming activity, which in turn, puts individual investors into unfavorable situation and creates entry barriers. Institutional investors, however, are not so much concerned about these additional costs, because investing volumes are greater and costs proportion among the expected profit is relatively small compared to individual investors. The latter is the reason, why this paper is targeted to institutional investors, more precisely to investment funds.

The last major crises, in 2002, 2008 and 2011, have shown that the traditional static asset allocation may not be rational for investors, who does not wish to receive short-term losses in different phases of the economic and business cycles. Even though, if portfolios are generating positive relative returns, absolute returns might be negative. During the recessions, most of static portfolios lose the value of underlying assets. However, it is important to mention that, all asset classes might not lose value during recessions. Here arises the relevance and the necessity for an asset allocation strategies, where the asset composition varies over time, commonly known as dynamic asset allocation strategies.

This thesis considers dynamic asset allocation strategies. Despite of the fact, that there exist many research studies on this topic, it is worthy of investigation and needs further development. Precisely because of the absence of the studies with an emphasis on dynamic asset allocation implementation opportunities in emerging markets. Until today, most of studies focused solely on developed markets, therefore, most of the known dynamic models are applicable and tested only in these markets. The models may not be suitable for use in emerging markets, because of inputs may have different characteristics, i.e. asymmetry of volatility, correlation coefficients may vary in different ranges, and etc. In addition to all the above, one major issue, what asset managers have to face in emerging markets, is the possible liquidity problem. Considering the above, it appears to be a worthy endeavor to investigate in more thoroughly dynamic asset allocation in emerging markets.

The purpose of this thesis is to provide a clear overview of the dynamic asset allocation theory, different strategies, and the possibilities and limitations involved with the implementation of the dynamic strategies in emerging markets. In addition to the latter, to evaluate the effectiveness and verify, if portfolio based on dynamic strategy can generate higher long-term gains and limit more efficiently short-term losses, than portfolio based on static allocation. In order to carry out the latter aim of this thesis, one dynamic asset allocation strategy will be chosen out, based on previous studies, and implemented in emerging markets. If necessary, the strategy will be adjusted.

Solely one dynamic strategy will be implemented, because this thesis does not attempt to contribute to the science. The main emphasis is on theory and discussion over previous studies, in order to establish a strong foundation for further research. In addition, it would be out of the scope of this thesis to implement all dynamic asset allocation strategies, because it is rather extensive undertaking.

Regardless of the latter, the aim of the empirical analysis is to verify, if the dynamic portfolio based on the chosen strategy, can outperform the static portfolio. The area of study consists of emerging markets equity and fixed-income indices, commodities, and cash.

The thesis is divided into three chapters. Chapter one starts with a review of foundational and current literature of modern portfolio theory. After, there is an overview of asset allocation in general, including different strategies and the importance.

The second chapter is about dynamic asset allocation. Following an overview of the dynamic asset allocation approach and classification of different strategies, there are also included discursive comparison of different dynamic strategies, and a section about the importance and possible application of dynamic asset allocation.

Chapter three covers empirical analysis. At the beginning there are descriptions of the data and the model used, followed by the empirical results. Finally it closes with a concluding discussion of the results, including interpretation of the results, limitations, and possible perspective for future research.

The appendices offer a variety of figures and tables, which help to describe the data and the empirical model. In addition, appendices include example about shortfall risk-based method and visual basic code for expected shortfall probability calculations.

1. THE ASSET ALLOCATION

According to Ferri (2010), successful investing requires well though-out design, implementation, and maintenance of a long-term investment strategy that is based on investors' individual and unique needs (2010, 22). Asset allocation is a central component of that plan. It determines most of assets risk and return over time.

The future is uncertain, likewise returns from investments. Nobody knows with certainty what will happen in the financial markets from now on. Yet we need to invest into the future. Asset allocation does not solve hereinbefore named problem, but it reduces the need to forecast further asset returns. The aim of asset allocation is to design an investor specific asset allocation mix, which has expected return and acceptable risk level, so that investors' needs are satisfied. The asset allocation policy paradigm, in which a portfolio is divided up among a various asset classes, and then separately managed within each asset class, is an integral part of the asset management.

The financial crisis of 2008 to 2009 cast doubt on the investment funds' fixed asset allocation restrictions between asset classes. In order to understand the theoretical framework for the identification and measurement of risk, and the relationships between expected return and risk, it is necessary to explain the modern portfolio theory. It also establishes a foundation for understanding Chapter 2, how dynamic asset allocation allows investors to move efficient frontier. These are the reasons, why this chapter begins with modern portfolio theory, including main concepts and assumptions on which this theory is based on. After that there is section about asset allocation main strategies, and lastly, an overview of empirical studies, explaining the importance of the asset allocation.

1.1. The Modern Portfolio Theory

According to Fabozzi *et al.* (2002), the essence of modern portfolio theory, is to guide the selection and construction of investment portfolios. If all other factors being equal, there is the risk and return trade-off. In other words, investments with a higher expected return are more risky, than investments with lower expected return. According to modern portfolio theory, diversified portfolios' total risk, measured as volatility, in some cases is lower than the sum of all individual portfolios' assets risk. In order to a better understanding of the selection and construction processes of an investment portfolio, it is a necessary to understand the concepts on which modern portfolio theory is based on.

1.1.1. The Portfolio Selection Theory

Modern portfolio theory was first introduced in 1952 by Harry Markowitz. According to Markowitz, investors act rationally and consequently want to maximize the discounted value of future returns. Nevertheless, those expected future returns involve an allowance of investment risk. The principle that expected return rises with an increase in risk is applied. Therefore, there is always risk and return trade-off. (Markowitz 1952; Fabozzi *et al* 2002, 15)

Markowitz (1952) measured the risk by the standard deviation of its expected value, and the expected return by the discounted value of uncertain future returns. Thus, if the investor increases the number of securities within a portfolio, then their covariance relationships creates a diversification effect.

Suppose there are N securities, portfolio expected return is denoted by r_p, portfolio variance is denoted by σ_p^2, portfolio weight of security i is denoted by w_i, expected return of security i is denoted by r_i and its standard deviation is denoted by σ_i, covariance between securities i and j is denoted by σ_{ij}, and correlation coefficient is denoted by ρ_{ij}. Markowitz showed that under the above made denotations, the expected return and variance of the expected return on portfolio are (Markowitz 1952, 78-80):

$$r_p = \sum_i^N w_i r_i, \qquad \sigma_p^2 = \sum_i^N \sum_j^N w_i\, w_j \sigma_{ij} \tag{1.1}$$

where,

$$\sum_{i}^{N} w_i = 1, \qquad \sigma_{ij} = \rho_{ij}\sigma_i\sigma_j \tag{1.2}$$

Furthermore, Markowitz demonstrated that a quadratic program with an objective function of maximizing an optimal portfolio, through mean-variance optimization. The portfolio selection problem can be described with the following formula (Markowitz 1952, 81-83):

$$Max\left(r_p - \lambda\sigma_p^2\right) \tag{1.3}$$

where, λ denotes risk aversion, because the correlation coefficient between securities pair is in range -1 and 1, the standard deviation on portfolio is always less than the simple weighted average standard deviation of these securities. (Markowitz 1952, 78 - 83) Therefore, through r_p and σ_p is possible to plot risk and return on each portfolio in the mean-variance plane (Appendix 1). Although, an investor can invest into any given portfolio which plots inside the circle in the mean-variance plane, then rational investor prefers portfolios which are less risky and have higher expected return (Markowitz 1952, 82).

Markowitz' another mean-variance portfolio selection model key concept was the efficient frontier. All portfolios, which are set on the efficient frontier, show higher expected return for a given level of risk than any other portfolio.

Markowitz measured the risk component by using mathematical formulations and found that risk can be reduced through the concept of diversification. According to many economists, including Megginson (1996), diversification is the most important aspect of Markowitz' portfolio theory. Diversification aims to properly select a weighted collection of assets that together exhibit a better trade-off between expected return and risk than investment in any individual asset or singular asset class (Mangram 2013, 60-61).

1.1.2. The Capital Market Line and the Optimal Portfolio

James Tobin (1958) expanded the portfolio theory using Keynesian liquidity preference theory and added a risk-free asset to the analysis. He considered bonds to be risk-free assets which have obligations to pay stated cash amounts at future dates, with no risk of default (Tobin 1958, 66).

The investors' asset selection choices are represented by indifferent curve, which maximizes the expected value of utility. Assume, that an investor prefers a higher expected return and exhibits risk aversion, and that the probability distribution between standard deviation and mean is normally distributed, the shape of the investors' indifference curves will be settled by utility of return function and show a concave upward slope. Suppose the portfolio consisting of a risk-free asset and of a risky asset. In that case the expected return is:

$$E(R_a) = wr_f + (1 - w)r_p \tag{1.4}$$

where, return of risk-free asset is denoted by r_f, return of risky asset is denoted by r_p, and standard deviation can be described by following formula

$$\sigma_a = \sqrt{w^2\sigma_f^2 + (1 - w)^2\sigma_p^2 + 2w(1 - w)\sigma_{fp}} \tag{1.5}$$

where, the standard deviation of risk-free asset is denoted by σ_f, the standard deviation of risky asset is denoted by σ_p, the covariance between risk-free asset and risky asset is denoted by σ_{fp}. (Sharpe 1964, 428-432)

Because of standard deviation of risk-free asset is zero and covariance between risk-free asset and risky asset are equal to zero, the portfolios' standard deviation can be simplified into a following form:

$$\sigma_a = (1 - w)\sigma_p \tag{1.6}$$

Examining the relationship between $E(R_a)$ and σ_a, it is possible to derive an equation:

$$E(R_a) = wr_f + \frac{r_p}{\sigma_p}\sigma_a \tag{1.7}$$

Hence, Tobin drew linear line (Appendix 2) in the mean-variance plane and defined this as the opportunity locus. The tangent point between the opportunity locus and the indifference curve is optimal portfolio allocation between risk-free and risky assets. (Tobin 1958, 79-84; Sharpe 1964, 428-432)

In Figure 1, Markowiz' and Tobin' findings are combined. There are no opportunity locuses above the efficient frontier. Although there are more than one opportunity locuses below efficient frontier, nevertheless, the rational investor prefers always portfolio on the top opportunity locus. Because portfolios below efficient frontier, have a lower expected return according to same level of risk, or same expected return with higher level of risk.

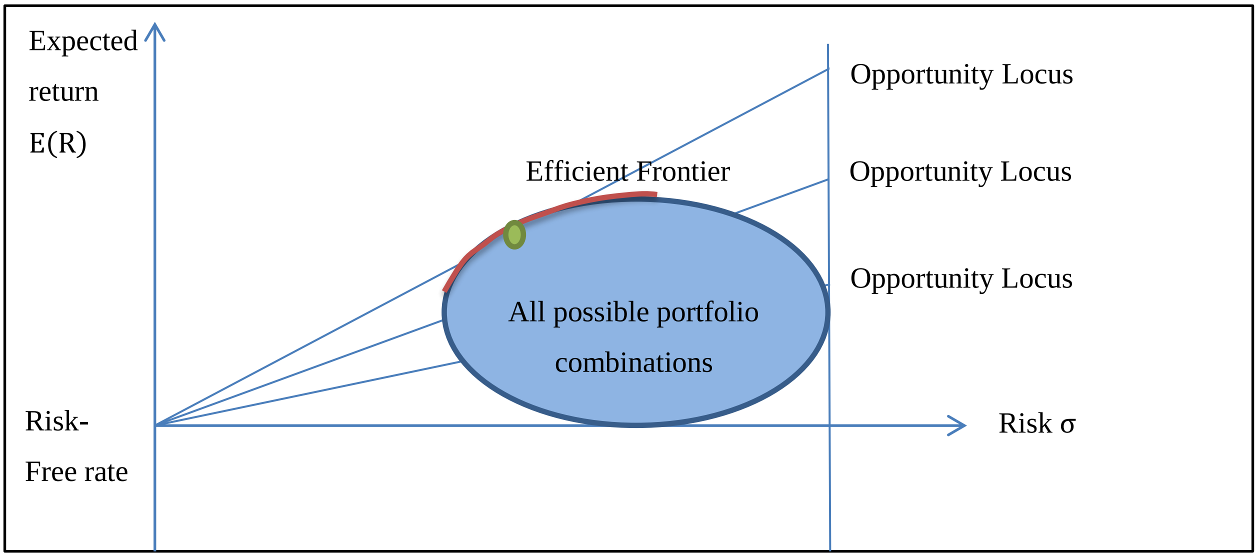

Figure 1. Efficient portfolio combinations and opportunity locuses
Source: Markowitz (1952, 82); (Tobin 1958, 80); compiled by the author

According to Tobin, the levels of investors risk tolerance does not matter, investors will maintain stock portfolios in the same proportions as long as they maintain identical expectations regarding the future. Investors portfolios will differ only in their relative proportions of asset classes, because asset classes have different risk levels. (Tobin 1958, 85-86)

1.1.3. The Capital Asset Pricing Model

Based on Markowitz (1952) and Tobin (1958) studies, the Capital Asset Pricing Model (CAPM henceforth) was independently developed in the 1960s by William Sharpe (1964), Jack Treynor (1962), John Lintner (1965a, 1965b) and Jan Mossin (1966). They were all developing the same model for describing individual asset returns. More precisely, they all derived Capital Market Line concept. The latter is an inverse relationship between the demand for risk-free asset and interest bearing asset and the opportunity locus (Sharpe 1964, 320). Sharpe defined the upper opportunity locus as the capital market line and tangent point between capital market line and efficient frontier as the optimal portfolio. In the equilibrium point, where markets are perfectly efficient and all investors behave rationally, there is no reason to invest in a different portfolio.

Arguably, in 1962, Treynor wrote the earliest draft on CAPM, but never had his article published until recently. (Sullivan 2006, 207). In 1964 Sharpe significantly advanced the capital market line and efficient frontier concepts and derived the CAPM. A year later, in 1965, Lintner derived the CAPM from the perspective of a corporation issuing shares of stock. In 1966, Mossin also derived the CAPM, particularly specifying quadratic utility functions (Megginson 1996, 327). Later on, there have been numerous iterations and expansions of modern portfolio theory.

The CAPM, as it later became known, revolutionized the modern portfolio theory and practice of investments by simplifying the asset allocation and selection processes (Sullivan 2006, 207). The CAPM provided an important evolutionary step in the theory of capital market equilibrium, better enabling investors to value securities as a function of systematic risk.

According to CAPM, the expected return on an asset can be divided into two parts: a compensation for bearing risk, and the return for deferring consumption. The return for deferring compensation is the return on the risk-free asset. Hence the return for bearing risk is the difference between total return and risk-free return. (Viswanath 2001)

CAPM formula is derived from the regression of the rate of return on the individual asset

$$E(R_p) = R_f + (E(R_m) - R_f) * B_p \tag{1.8}$$

where, expected return on individual asset is denoted by $E(R_p)$, risk-free rate is denoted by R_f, expected market risk premium is denoted by $(E(R_m) - R_f)$, and correlation coefficient between the individual asset and the market portfolio is denoted by B_p, which is calculated by following formula:

$$B_p = \frac{Cov\ (r_p, r_m)}{Var(r_m)} \tag{1.9}$$

Pursuant to CAPM formula, the expected return on individual asset is determined by risk-free rate, market risk premium and beta. (Dempsey 2013, 12-15)

Under the assumptions that investors have similar future return expectations and risk tolerance, and markets are efficient, there is no excess return and investors prefer market portfolio. In case when all assumptions are applied and valid, this concept denies the existence of active portfolio management.

According to Mangram (2013), Markowitz' portfolio selection theory is a normative theory. Fabozzi *et al.* (2002) defined a normative theory as the one that describes how investors should behave. In contrast to, CAPM, as an asset pricing theory, is considered as a positive theory, the one that hypothesizes how investors actually behave. Together, these theories provide a theoretical framework for the identification and measurement of risk and the relationships between expected return and risk (Mangram 2013, 61). At this point, it is once again important to emphasize, these theories assume that investors behave rationally and market are perfectly efficient.

There are many theoretical and empirical studies about behavioral finance and market efficiency, however this is very wide and paradoxical topic and not that relevant from the perspective of asset allocation. This is the reason why this paper does not consider these issues thoroughly and focuses more on asset allocation strategies.

To summarize, modern portfolio theory attempts to maximize portfolio expected return for a given amount of portfolio risk, or equivalently minimize risk for a given level of expected return, by carefully choosing the proportions of various assets. In other words, this framework attempts to find the best expected risk and return trade-off combination.

1.2. The Asset Allocation Strategies

Asset allocation strategy is an investment strategy, that aims to balance reward and risk by apportioning a portfolios' assets according to an investors' goals, risk tolerance and investment horizon (Royston 2011, 25). There are many different ways how to classify asset allocation strategies. One of the options is to use time-horizon based classification: long-term, medium-term and short-term asset allocation. Alternatively, it is possible to classify strategies by different investment decision processes and rules. The latter also forms the basis for Ferri (2010) classification of asset allocation strategies, which claims that there are three different main types of asset allocation strategies (2010, 15): strategic asset allocation, tactical and dynamic asset allocation, and market timing.

Strategic asset allocation is a long-term strategy and does not require making accurate short-term predictions about the markets in order to be successful. Tactical and dynamic asset allocation, and market timing, in order to be successful, however require short-term accurate market predictions. (Ferri 2010, 15)

Strategic asset allocation combines the investor risk and return objectives with market expectations in order to establish the exposure to the permissible asset classes. At the center of referred strategy is selecting suitable asset classes and investments to be held for the long-term. In case of implementation of this strategy, an asset allocation will not be changed based on the alternating economic and business cycle phases. (Ferri 2010, 15) Expectation that systematic risk is compensated in the long run speaks in favor of strategic asset allocation. This strategy provides a framework to systematic risk exposure.

Tactical asset allocation presumes temporary divergences from strategic asset allocation weights, based on short-term market forecasts and views. These predictions are generally outputs of a function of fundamental, economic or technical variables. For instance, fundamental variables might be such as earnings or interest-rate forecasts, economic variables such as the outlook for economic growth in different countries, or technical variables such as recent price trends and charting patterns. (Ferri 2010, 15) Dynamic asset allocation will be discussed in the Chapter 2.

In general, tactical asset allocation has a monthly or quarterly horizon, while strategic asset allocation is done on a five to ten year horizon. The distinction is important from a governance point of view. Tactical asset allocation can be seen as a short term correction of strategic asset allocation, taken into account contingent market situation and involves people dealing with it on a daily basis. Strategic asset allocation involves implementing once set in place long-term goals.

Market timing is for investors who believe they can consistently forecast major movements in the market and thus beat the market by trading. It is tactical asset allocation in the extreme. (Ferri 2010, 15) There are no restrictions on asset class weights, and this strategy is certainly not for spreading risk. This strategy can be very profitable when timing the market correctly, as well as vice versa.

1.3. The Importance of Asset Allocation

Determining investments performance point of view, asset allocation is supposedly very important. How much does actually asset allocation policy influence assets return performance? More precisely, how many percent of portfolios' return characteristics and risk level are determined by the asset allocation? Based on empirical studies, this chapter attempts to find an answer to these questions.

The literature on the importance of asset allocation is quite large. Most studies in this area focus on analysis of mutual and pension funds, and explore how big percentage of the portfolios' total return is explained by deviations from an institutions' policy asset class weights. Probably one of the first attempts to determine the asset allocation importance was conducted by Brinson *et al.* (1986). They analyzed 91. U.S pension funds' underlying assets returns in period 1974 to 1983 by regressing monthly portfolio total returns against to the monthly returns to each funds' policy portfolio. As a result, they concluded that the portfolio asset allocation policy explains 93.6% of the monthly variance in pension funds' total returns during this period. Further studies, which will be described below, highlight that the coefficient of determinations should vary probably between 33-75%. Brinson *et al.* (1986) got higher coefficient because the results depended from aggregated market movements instead of pension funds' specific asset allocation mix.

Ibbotson and Kaplan (2000) developed Brison *et al.* (1986) empirical analysis further by exploring the degree to which funds' asset allocation mix explained the cross-sectional differences in absolute returns across several funds, and whether it is an asset managers' competence that drove assets performance or asset allocation policy. Their study was based on two earlier reports by Brinson *et al.* (1986) and Brison *et al.* (1991). They carried out cross-sectional regression, using annualized cumulative returns over a 10-year observation period and found as a result that approximately 40 percent of the variation of returns was determined by asset allocation. They concluded, that the majority of pension funds' performance can be explained by the funds' decision to choose asset classes (including holding cash) to invest. The latter creates the need for explicit rules and indicators or forecasts for choosing between asset classes.

Vardharaj and Fabozzi (2007) applied similar techniques used in Ibbotson and Kaplan (2000) report for investment funds and found out that the determination coefficients were sensitive to observation time and the asset allocation mix determined approximately 33 to 75 percent of the variance in asset returns. Also, in a recent study, Xiong *et al.* (2010) showed that the variations of returns among assets what can be determined by asset allocation policy are dependable of the sample.

All found determination coefficients in exact percentage points are results of some sort of study and therefore, consequently depending on the specific inputs and methods used. Actually for any given investment fund, the necessity and the importance of asset allocation depends on the asset owner preferences, expectations and risk tolerance.

Returning back to the initial question about asset allocation policy influence over assets return performance, it has a fairly trivial answer. Asset allocation provides the passive return, beta return, and the remainder of the return is the active return, in other words excess or alpha return. The alpha sums to zero because on average, asset managers do not beat the market. Thus, on average, the passive asset allocation determines 100 percent of the return, only at the aggregate level. (Ibbotson 2010, 18) Active fund management reduces the importance of asset allocation, but it is difficult to say exactly how much. Depending on the asset managers' objectives, asset allocation can provide in addition to return also an opportunity to optimize mean variance and to diversify risks.

2. THE DYNAMIC ASSET ALLOCATION

The crisis in 2007 through 2008 made it clear that static strategies with fixed asset class weights are too risky for investors who does not wish to receive short-term losses. Tactical asset allocation has not worked, as performance results are by construction highly dependent on the forecast accuracy of investors or managers. Also, one major stumbling block in the implementation of efficient mean-variance strategies is the assumption of constant means and covariances. In addition, portfolios' strategic asset allocation mix is ordinarily too similar to the benchmark and allowed tactical positions are too small, thus, the portfolios' will behave more or less identically with the benchmark.

Investors want to hold their assets in rising markets over the long run, but it is also in their interest to not to fall with markets and avoid large negative returns in shorter periods. According to Herold *et al.* (2007), this has led to renewed interest in portfolio selection and asset allocation strategies, which produce absolute returns and that particularly control downside risk, commonly known as a dynamic asset allocation.

This chapter is about dynamic asset allocation. Following an overview of the dynamic asset allocation approach and classification of main distinguishable strategies, there are also included discursive comparison of different dynamic strategies and a section about the importance and possible application of dynamic asset allocation strategies.

2.1. The Dynamic Asset Allocation Approach

Dynamic asset allocation determines an optimal portfolio asset allocation mix in accordance with changing market expectations and conditions (Wang *et al.* 2012, 26). This strategy involves systematic capital re-allocation among different asset classes. While strategic and tactical asset allocation use static expectations of asset allocation policy, this framework provides flexible approach, which is capable of capturing the dynamics in risk and return expectations, across an array of asset classes (Li and Sullivan 2011, 31).

According to Herold *et al.* (2007), the main characteristic of the dynamic asset allocation approach is that the weights of different asset classes are allowed to change significantly, depending on changes in the economic climate and activity. Since, generally dynamic asset allocation does not involve market timing, then asset classes weights changes are driven by a set of predefined rules and indicators (Lawrence and Singh 2011, 49).

While dynamic asset allocation is implemented for individual asset management as well as for institutional asset management, there are different dynamic asset allocation definitions. For individual asset management, probably the most important criteria for doing asset allocation is the time-horizon. Risk-aversion increases as the individual investor ages. At the moment, these strategies[1] are out of the scope of the thesis, herein thesis are concerned asset allocation strategies which can be adapted by institutional investors. However, it is worth to mention, that according to Herold *et al.* (2007), most of dynamic asset allocation strategies, which are aimed for institutional investors, can be also applied a for individual asset management. According to them, generally, the aim of dynamic asset allocation is to protect the portfolio value from falling below a pre-specified floor. Which is an extremely important criterion for an individual asset management, as well as for institutional asset management.

The mechanism for dynamic asset allocation is not the same as that for modern portfolio theory. For modern portfolio theory investments are diversified to reduce risk through a covariance term. Even though the volatility is reduced, the long-term return might not. In the dynamic asset allocation, an investment choice is made between a different asset classes. The essential difference between modern portfolio theory and dynamic asset allocation is that, the latter is a dynamic process that presents the opportunity to increase return, while modern portfolio theory uses averaged statistics and portfolios to allocate resources across different investments at the same time. Dynamic asset allocation seeks to increase risk and return trade-off by investing in a better asset classes. (Harloff 1998, 7)

[1] For example, based on Xiong and Idzorek (2011) article, the most important investment decision, whether to take risk and how much, will change when the investor ages.

Besides, portfolio with fixed asset classes weights imply, that the expectations used to set the optimal asset allocation mix between asset classes, will not change, regardless of the subsequent information. Invariable expectations limit investors to implement portfolio along one efficient frontier (Section 1.1.2, Figure 1). While dynamic asset allocation allows the investor to move the efficient frontier according modified expectations, when the new information becomes available. This can be achieved by dynamically adjusting the return, risk and correlation expectations, as shown in Figure 2, where risk and correlation expectations are constant and expected return is changed in both directions by a few percentages. (BNY Mellon AM 2012, 2-3)

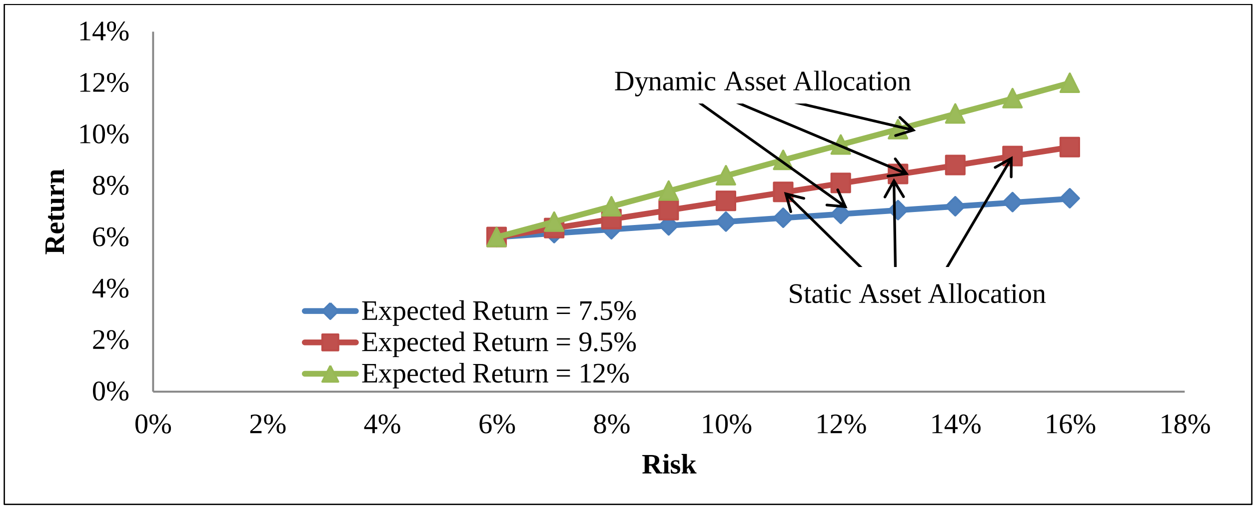

Figure 2. Efficient Frontier: Dynamic Asset Allocation

Source: BNY Mellon AM (2012, 3); compiled by the author

Even though there are strategies which involve return and correlation forecasts, then most of dynamic asset allocation strategies are either rules-based or risk-based. Classification of dynamic asset allocation strategies is more specifically explained in the section 2.2.

2.2. Classification of Different Dynamic Asset Allocation Strategies

Perold and Sharpe (1988) found that fluctuations in risky assets values will cause the value of the portfolio, in which these assets are held, to change. In that case, the portfolios' asset allocation will also change. If the risky assets values increases, then the proportion of the portfolio they comprise is also increasing. In that case, portfolio needs to be rebalanced. Dynamic asset allocation strategies are explicit rules for doing so.

There exists many classifications of the dynamic asset allocation strategies and economists have not reached to a consensus. One criterion to distinguish the dynamic asset allocation strategies is the amount of input data is needed. Some strategies, like stop loss and constant proportion portfolio insurance, involve only observable parameters, while the shortfall risk-based strategy makes distributional assumptions and requires estimating several parameters (Herold et al. 2007, 62). This classification is used relatively infrequently.

Another criterion, which is more commonly used, to distinguish the dynamic asset allocation strategies, are the methods and detailed rules, which are used. The latter criterion will be used in this thesis. The same method was used in Perold and Sharpe (1988) article, which is one of the earliest, and till today a lot referred, classification of dynamic strategies. According to them, there are four distinguishable dynamic strategies (Perold and Sharpe 1988, 16): buy-and-hold, constant-mix, constant-proportion portfolio insurance (CPPI), and option-based portfolio insurance.

For today, there have arisen more than four dynamic asset allocation strategies, than Perold and Sharpe (1988) concerned in their article. One of the most attention drawn, and much referred to in subsequent studies, related to dynamic asset allocation strategies, is conducted by Herold *et al.* (2007), divides dynamic asset allocation strategies, see Figure 3, into a two groups: strategies where forecasting is primary and which are rules-based or risk-based. This is probably the most important criterion to classify dynamic asset allocation strategies concepts.

As shown in the Figure 3, in the first column are forecast-based strategies. These involve forecasts to achieve absolute returns. This includes many alternative investments, for example, this strategy is often applied by global macro hedge funds, which are based on forecasts and want to either time the market or exploit market inefficiencies through the skills of their managers (Herold *et al* 2007, 61). Forecast-based strategies do not have minimum return.

In the second, third and fourth column are rules- and risk-based strategies. These can be divided into three groups: portfolio insurance, rainbow options, and shortfall risk-based strategies.

Portfolio insurance includes three more distinctive strategies: stop loss, synthetic put and CPPI. Rainbow options include two strategies: best-of-two and best-of-n plus floor. Shortfall risk-based strategies, i.e. value at risk-based strategies, can be divided into two: forecast-free and incorporation market views. All these rules- and risk-based strategies aim at dynamically managing portfolio risk through asset allocation decisions, in order to protect the portfolios' total value from falling below a target floor.

<table>
<tr><th colspan="5">Dynamic Asset Allocation Strategies</th></tr>
<tr><th colspan="5">(Total return/Absolute return strategies)</th></tr>
<tr><td>Forecast-based strategies</td><td colspan="4">Rules-based/risk-based strategies</td></tr>
<tr><td>Alternative Investments</td><td>Portfolio Insurance</td><td>Rainbow Options</td><td colspan="2">Shortfall risk-based strategies (Value at Risk-based)</td></tr>
<tr><td rowspan="3">e.g. Global Macro Hedge funds</td><td>Stop Loss</td><td>[Best-of-Two]</td><td rowspan="3">Forecast-free</td><td rowspan="3">Incorporating market views</td></tr>
<tr><td>Synthetic Put</td><td rowspan="2">Best-of-N plus floor</td></tr>
<tr><td>CPPI</td></tr>
<tr><td>No minimum return</td><td colspan="4">Protecting a pre-specified portfolio value</td></tr>
</table>

Figure 3. Dynamic Asset Allocation Strategies

Source: Herold *et al.* (2007, 62); compiled by the author

It appears that the classification of dynamic asset allocation strategies in Herold *et al.* (2007), excludes two strategies, which Perold and Sharpe (1988) consider as dynamic strategies. These are buy-and-hold and constant-mix. In order to understand why these two strategies have been excluded it is useful to consider the concepts of these strategies.

First, the essence of buy-and-hold strategy is to hold initial assets during the investment horizon. According to Perold and Sharpe (1988, 150) buy-and-hold strategy is „do nothing strategy“ – no matter what happens with relative values, no rebalancing is required.

Second, the constant-mix strategy means to hold an initial asset classes weights. The idea is of this strategy is to maintain constant exposure to initially selected asses classes, whenever the relative values of assets change, sales and purchases are required to restore the initial asset classes weights. (Perold and Sharpe 1988, 151)

Perold and Sharpe (1988) considered buy-and-hold and constant-mix strategies as dynamic strategies because they defined dynamic asset allocation differently. According to them, every strategy is dynamic, where is necessary to „do something“. This thesis, as well as Herold *et al.* (2007) article, and many others, are based on approach according to which dynamic asset allocation strategies allow asset classes weights to change significantly, depending on changes in the economic activity and climate, investor expectations, and etc.

Since forecasting is a subjective activity and the coincidence of favorable events might often be the reason for success, this thesis focuses on strategies that that do not rely on forecasts or where forecasts do not play a dominant role, which are risk- or rules-driven strategies.

It is also worth to mention that, the terms „total return“ or „absolute return“ are used, because the risk-based strategies are designed to produce either positive returns or total returns above a predetermined minimum return.

Hereinafter, this section is divided into three sub-sections, which explain the concepts of the following rules- and risk-based strategies: portfolio insurance, rainbow option and shortfall risk-based.

2.2.1. The Portfolio Insurance Strategies

Portfolio insurance techniques includes strategies such as stop loss, protective puts or synthetic puts if the put option is replicated, and constant proportion portfolio insurance (CPPI). The objective of portfolio insurance strategies is to maintain the portfolio value above a certain predetermined floor, while allowing some upside potential.

Stop loss strategy is probably the most intuitive and simplest strategy, but it is difficult to quantify in practice. In case of this strategy, the entire portfolio is initially invested into the risky asset. As soon as the risky asset drops below the predetermined floor, the entire portfolio is rebalanced totally into the risk-free asset. When the market rebounds above the floor, the entire portfolio will be rebalanced back into the risky asset. (Tankov 2009, 7-9) Stop loss strategies are not much in use in practice, because it is unrealistic to carry out transactions instantly. If portfolios' assets under management are large, then liquidation of open positions may take days, weeks or even months, depending on the assets liquidity and market depth.

Leland and Rubinstein (1976) introduced the concept of option based portfolio insurance tactics, based on using either traded or synthetic options. Option based portfolio insurance is based upon the work of Black and Scholes (1973) who showed that under certain assumptions, the payoff of an option, can be replicated through a continuously-revised combination of the underlying asset and a risk-free bond. Leland and Rubinstein (1976) extended this insight by showing that a dynamic asset allocation method, that increased (or decreased) the stock allocation of a portfolio in rising (or falling) markets and reinvested the remaining portion in cash would duplicate the payoffs to a call option on an index of stocks. (Lummer and Riepe 1994, 4)

The price behavior of a call option is similar to a combined position, involving the borrowing and underlying stock. In case of market normal functioning, the call option price and the stock price will change in the same direction. Rubinstein and Leland (1981) found that the effect on the call price is related to the change in the stock price, and the number of shares of stocks in the replication portfolio must equal to the slope of the call price curve at that price curve at that price. (1981, 63) Their concept permits to replicate, not only calls, but also other option positions. Investors and institutions can create themselves covered calls and protective puts on stocks, which do no have options available, by using replicating portfolios.

Black and Jones (1987) and Perold and Sharpe (1988) developed the constant proportion portfolio insurance (CPPI) method. This method also became popular with practitioners (Karoui *et al.* 2005, 450). In case of this method, all asset allocation decisions are made based on the floor value of portfolio, which the investors initially have to set. Two asset classes are used: risk-free assets and risky assets. Generally, fixed income assets or money-market funds are considered as risk-free assets, and equities or mutual funds as risky assets. The asset allocation weights depends on the cushion value and multiplier coefficient, where cushion value is defined as the current portfolio value less the floor value, and a multiplier coefficient denotes the aggression of the strategy. The floor on the portfolios' value grows at the risk-free rate over time and the exposure to the risky asset is calculated as a multiplication of the cushion value and multiplier coefficient. (Black and Jones 1987, 48)

2.2.2. The Rainbow Option Strategies

Rainbow options, also know as basket option, is a derivative exposed to two or more sources of uncertainty. As opposite, regular options are exposed to one source of uncertainty, price movements in the underlying asset. In general, rainbow options are calls or puts on the best or worst of N underlying assets. Or options which pay the worst or best of N assets. (Chantnani 2010, 169) The aim of rainbow option strategy is to provide to the investor right to rebalance portfolio into better performing asset class. The difference between the performance of this strategy and the better performing asset class is called the rainbow option premium. Payoff depends on the relative price performance of chosen asset class.

Suppose, an investor uses best of stocks and bonds method and purchases a 100% bond portfolio and an exchange option at the beginning of the year. The option gives to the investor a right, to exchange the performance of bonds with the performance of stocks at the end of the year. Similarly to the protective put method, this strategy is implemented by replication the exchange option. In practice, this amounts to start with portfolio allocated equally between asset classes each year, and at the end of the year, the portfolio will be invested 100% into the better performing asset class. (Herold *et al* 2007, 61-62)

As a matter of fact, best-of-two strategy cannot protect the portfolios' value from falling below a predetermined floor, this is also the reason why this strategy is show in Figure 3 in parentheses. However, Merton *et al.* (1978), Merton *et al.* (1982) and Stulz (1982) enhanced best-of-two strategy by a floor, which protects portfolios' value from falling. Particular strategy is called best-of-two plus floor below. Suppose, there is a portfolio, which invested 80% of its assets in money-market instruments and 20% in a diversified portfolio of stock call options, provided equity exposure on the upside with a guaranteed „floor" on the value of the portfolio.

2.2.3. The Shortfall Risk-Based Strategies

Investors who uses fixed asset classes weights, ignores the fact that expected returns, volatilities, and correlations change over time. The overall idea of shortfall risk-based strategies is to enter these parameters into the calculation of shortfall probability. Even though Perold and Sharpe (1988) claimed that return forecasts are not a part of these strategies, as the overall target is to protect the portfolio value from falling below a pre-specified floor, then more recent studies, including Herold *et al.* (2007), classify shortfall risk-based strategies into two groups, depending on whether the method is forecast free or incorporates market views.

Herold *et al.* (2005) investigated a rules-based and not benchmark related shortfall risk-based approach, which can accommodate a wide variety of asset classes and at the same time, keep control for downside risk. They applied this particular approach using two asset classes: fixed-income and cash. Their empirical study indicated substantial shifts in asset classes weights over time. They found that shortfall risk-based strategy control portfolio risk more efficiently than standard static strategies. (2005, 40)

Two years later Herold *et al.* (2007) extended the shortfall risk approach to the multi-asset case and compared results with different alternative dynamic asset allocation strategies. In addition, to quantify short-run hedging effectiveness and long-run hedging costs, they also provided an extensive simulation study. In conclusion they found that shortfall risk-based strategy offers downside risk protection much the same as insurance concepts, moreover, this strategy uses the available risk budget in an effective way and thus can enhance portfolios' performance in the long-term (2007, 72). More detailed explanation of the shortfall risk-based strategy methodology and an example are presented in the Chapter 3.

2.3. Comparison of Different Dynamic Asset Allocation Strategies

As mentioned hereinbefore, probably the most important criterion to compare, as well as to classify, dynamic asset allocation concepts, is whether forecasts are involved to achieve absolute returns, or not. In case, when forecasts are involved, investors want to either exploit market inefficiencies through the skills of investment fund managers, or time the market. The success of strategies, that rely heavily on return forecasts or portfolio manager claims that they can choose asset classes that will perform best in the future, depends on managers' forecast accuracy (Herold *et al.* 2005, 33). While an absolute return investor is often highly risk-averse, this thesis focuses on the strategies, in which forecasts are not principal. Due to latter, hereinafter are discussed only a rules-driven and a risk-based strategies. These include portfolio insurance techniques, rainbow options and shortfall risk-based approaches.

The common characteristic of all these mentioned strategies is dynamically manage portfolio risk in order to protect the assets value from falling below a pre-specified floor. Also these strategies might need asset classes weights to vary largely and sharply.

Generally, portfolio insurance tactics are not good for implementing in emerging markets. While there might be liquidity problems and derivatives might not exist for all indices in emerging markets, the benefits from portfolio insurance techniques might not be attained. For example, implementing stop loss strategy market is required to be extremely liquid, because when risky assets value drops below the pre-specified floor, entire portfolio needs to be sold and replaced with risk-free assets. In case, when markets are illiquid, the sale of large portfolio might take weeks, or even months.

Likewise option based portfolio insurance strategies, such as synthetic put, require the absence of liquid options for long maturities and there is counterparty risk if the option is bought over-the-counter. Common solution to exclude counterparty risk is to replicate the option with a self-financing portfolio containing stocks, but in that case, there arise a problem, because replication is only approximate, especially in incomplete markets (Tankov 2009, 16-17). Latter unfortunately excludes implementing this strategy in emerging markets.

Even though constant proportion portfolio insurance strategy is very flexible, floor and multiplier can be changed over time, which also allows locking profit, by increasing the floor when market rises, this strategy is still probably not suitable for emerging markets. This for several reasons, first if there is a drop in the asset prices and investor is not able to rebalance his portfolio adequately, whether it is caused by the sudden market fall or market illiquity, the floor can be breached. Also this strategy is often accompanied by high transaction costs, because revision interval becomes shorter when multiplier is high or markets are volatile. (Ermini 2006, 36)

Rainbow options include „best of“ concepts. Best-of-two method is left out, because it can not protect portfolio value from falling below a floor, which is a relatively important factor in investing into unpredictable assets, because forecasts are not involved.

In case of best-of-N plus floor method, portfolio is divided between equity options and money-market investments. While expected return is coming from equity options, which are bought based on asset manager intuition and forecasts, this method is also left out.

Shortfall risk-based strategies take into account fluctuations in expected returns, volatilities, and correlations over time. All these parameters are entered into the calculation of shortfall probability. (Herold *et al.* 2005, 33) Exactly the same way as investors' risk profile and market conditions change, also shortfall probability changes. Shortfall risk-based strategies are emphasized due to their high degree of adaptability and flexibility. These strategies can be applied in many asset classes, including those for which are no liquid hedging instruments available. (Herold *et al.* 2007, 61) The latter is a topical matter related to emerging market assets and also the reason why shortfall risk-based strategy is taken into use in Chapter 3.

In general, many dynamic strategies outperform the market in bull or bear environments, but fall behind either in volatile markets without a clear trend, or markets with steady growth.

2.4. The Importance and Possible Applications of Dynamic Asset Allocation

Dynamic asset allocation enables the possibility to protect the portfolio value falling during a period when markets are moving down. Unlike strategic and tactical asset allocation approaches, in which asset classes are more or less static and revised not so often, dynamic asset allocation is much more flexible, allowing dramatically change asset classes weights when necessary. Of course, strategic and tactical asset allocation are not about absolute, but relative returns. Dynamic asset allocation strategies are generally designed to produce absolute returns, either total returns above a pre-specified target or either positive returns.

It is important to emphasize, that the fact, that even dynamic strategies allow dramatic changes in asset classes weights, these might not be necessary to make. To illustrate the latter, accordingly to Elston (2013), in the case of Australia, only four years out of 23 would have required an investment fund using dynamic asset allocation to look very different from a static balanced fund (2013, 21). However, this may not always be like this, Herold *et al.* (2005) conducted empirical study, which results, opposite to Elston (2013) study, showed substantial shifts in asset weights over time.

Actually, it is not important, whether or not dramatic changes in asset weights are made. To maintain the value of a portfolios', it is important to allow for shifts in the portfolios' asset allocation when necessary, not to bound it by a static asset allocation.

The strategic asset allocation approach is to review asset allocation weights on a periodic basis, using assumptions of expected asset class returns, risks, and correlations derived from long-term historic averages (Knutzen 2011, 1). Tactical asset allocation allows the portfolio manager to take active positions with respect to a strategic benchmark in order to generate risk adjusted excess returns. In that case, investors usually diverge only within a narrow range from the strategic benchmark, e.g. they change weights by a couple of percentage points when they expect falling or rising prices. (Herold *et al.* 2007, 61).

Such approaches to asset allocation assume that underlying estimations and assumptions are relatively stable over time, that valuation, risks, and correlations do not change substantially. Yet the reality of markets, as the events occurred in 2007 and 2008 remind us, is quite different. The market conditions might change rapidly and the necessity to dynamic is becoming more topical (Knutzen 2011, 2) Dynamic asset allocation approach involves more frequent adjustment and review of asset allocation, and employing flexible strategies.

Most likely, there will be periods when the best asset allocation mix for dynamic portfolios will be similar to a traditional balanced portfolios. Their strength of dynamic asset allocation occurs however in relation to unique features, more precisely in the ability to diversify into alternative asset classes as well as to, at times, dramatically increase or decrease certain asset class exposures. (Elston 2013, 21) In conclusion, absolute return portfolios that target a certain margin above inflation can maintain and grow underlying assets value much more likely than relative return portfolios that target at some composite benchmark.

3. THE EMPIRICAL ANALYSIS

In order to identify the appropriate dynamic asset allocation strategy for emerging markets, it would be arguably be the best solution to replicate all different strategies. This would give a good opportunity to compare the different strategies in the context of emerging markets, and it would provide the answer to the question, whether it would be necessary to adjust some of the dynamic strategies or develop an entirely new dynamic asset allocation strategy for emerging markets. Unfortunately, it is currently out of the scope of this thesis. The purpose of this thesis is to implement one dynamic strategy for emerging markets. The dynamic strategy what will be implemented in empirical analysis is expected shortfall risk-based strategy.

The goal of this chapter is to provide evidences, whether dynamic asset allocation based on shortfall risk-based strategy will outperform static asset allocation, or not. In order to achieve the goal set, hereinafter both strategies are implemented, backtested, and compared. Some of the results might be relative, because they are based on assumptions concerning the transaction costs.

This chapter is divided into four sections. The first section includes the description of the data. Following an overview of the model evaluation method, there are presented empirical results. At the end of this chapter there is a discussion of the results, including limitations of the conducted empirical analysis and suggestions for further research.

3.1. Describing the Data

The dataset that serves as a foundation for this empirical analysis includes data of four different asset class indices from Nov. 1, 2001 to May 1, 2014. Asset classes which are used are following: equities, fixed income, commodities and cash. Equities are presented by the MSCI Emerging Market Index (EM Equity), fixed income assets by the Morningstar Emerging Market Composite Bond Index (EM Bond), and commodities by the Bloomberg Gold to U.S. dollar exchange rate (Gold to USD). Cash is used as a non-interest bearing asset, which does not provide any gain or loss.

All the data are presented in closing quotes, which are obtained through the Bloomberg database and the time-series start date is selected Nov. 1, 2001, because earlier The EM Bond Index data is not available, it was launched in Oct. 31, 2001. In addition, all data used in empirical analysis are not adjusted.

The EM Equity Index is a free float-adjusted market capitalization index that is designed to measure equity market performance in the global emerging markets. This index was launched in 1988. In 1988, there were just 10 countries in the index, representing less than 1% of world market capitalization. Today it covers over 800 securities across 21 markets and represents approximately 13% of world market capitalization. (MSCI Inc. 2014)

The EM Bond Index includes the most liquid sovereign and corporate bonds issued in US Dollars (USD) by the governments and corporations of the emerging markets. This index is a combination of the Emerging Markets Sovereign and Emerging Markets Corporate Bond indices. (Morningstar Inc. 2013)

The Gold to USD is the price of one troy ounce (equals approximately 31.10 grams) of gold pure gold in U.S. dollars. (Bloomberg L.P. 2014) There are several exchange traded funds (ETFs) trading based on this exchange rate, which make possible to invest indirectly in gold.

In order to compare indices return over the period under consideration[2], indices compound annual growth rate (CAGR) is calculated, by using the following formula:

$$CAGR = \left(\frac{X_{t_n}}{X_{t_0}}\right)^{\frac{1}{t_n - t_0}} - 1 \tag{3.1}$$

where, last observation value of index is denoted by X_{t_n}, first observation value of index is denoted by X_{t_0}, last year of observation is denoted by t_n, first year of observation is denoted by t_0. The EM Equity Index, EM Bond Index and Gold to USD compound annual growth rates are respectively 11.07%, 9.92% and 12.97% (Appendix 4).

Since indices have a different magnitude of level, henceforth returns are used for the data processing. In order to calculate returns, following formula is used:

[2] See Appendix 3 for indices performance. It appears, all three indices performance looks similar, except during last three years.

$$\Delta X = \frac{X_t - X_{t-1}}{X_{t-1}} \quad (3.2)$$

where, return (price percentage change) at time t is denoted by ΔX, index level at time t is denoted by X_t, index level at time t-1 is denoted by X_{t-1}. Indices returns' descriptive statistics are presented in the Table 1 (Appendix 5). It appears, mean returns are slightly different, and as expected, fixed income has lowest mean return and standard error.

Table 1. Indices Descriptive Statistics

Index	Gold to USD	EM Equity Index	EM Bond Index
Mean	0.054%	0.048%	0.037%
Standard Error	0.021%	0.022%	0.006%
Kurtosis	4.531	8.349	17.017
Skewness	-0.810	-0.327	-1.403

Source: Bloomberg (2014); compiled by the author

As it is shown on the Table 1, none of the returns of the asset classes are normally distributed (considering kurtosis 3 and skewness 0). It appears that during the economic downturn the amplitude of returns becomes bigger – deviations from the average rise significantly (Appendix 6). All returns are negatively skewed, which means there is a long left tail (Appendix 7), which for investors can might mean a greater chance of extremely negative outcomes – there are more frequent small gains and less big losses. The kurtosis is also higher than 3, which means that the distribution is leptokurtic – meaning „fatter" tails, which in turn, decreases the risk of extreme outcomes.

In order to give an overview about correlations between different chosen asset classes, there are rolling 6-months correlations used. There is an assumption made, that there are 252 trading days in one year, so for a 6-month, there is rolling 126-day correlation calculated (Appendix 8).

It appear that the correlation between Gold to USD and other asset classes has a tendency to fall below zero during the crises of 2008 and 2011. Otherwise the correlations vary significantly over the period, and at first sight it is difficult to notice some other regularities.

3.2. Describing the Model

3.2.1. The Expected Shortfall Method

The methodology of implementing shortfall risk-based strategy is based on work by Herold *et al.* (2005) and Herold *et al.* (2007). In order to understand the concept behind the expected shortfall risk-based method, it is necessary to define before Value at Risk (VaR). The mathematics that underlies VaR was largely developed in the context of portfolio theory by Harry Markowitz. VaR refers to the loss risk caused by uncertain changes in asset prices. (Angelovska 2013, 85)

According to Jorion (2001), VaR measures the worst expected loss over a given time horizon under normal market conditions at a given level of confidence. The fundamental variables of VaR are: confidence level, forecast horizon, and volatility. The confidence level is the probability that the expected loss is not greater than predicted. Forecast horizon is the time framework that VaR is estimated, in calculation, it is generally assumed, that during that horizon, portfolio holdings does not change. (Nylund 2001, 9) The mathematical definition of VaR can be described by following formula (Angelovska 2013, 85):

$$VaR = -k(a) * P * \sigma_p \quad (3.3)$$

where, the portfolios' standard deviation is denoted by σ_p, the value of the portfolio is denoted by P, and the desirable level of confidence is denoted by $k(a)$.

Figure 4 illustrates the latter. On the left side there is a probability density function. In the middle of the density function is the mean return and on the left there is VaR. Between the mean return and VaR is investors' minimum acceptable return (MAR). MAR location between VaR and mean return, depends on the investor risk aversion, more risk averse investors' MAR is closer to mean return, and conversely, less risk averse investors' MAR is closer to VaR.

On the right side of the Figure 4, there is a fictional asset historical price shown from time zero to time t. After time t, further expected return is described by the probability density function.

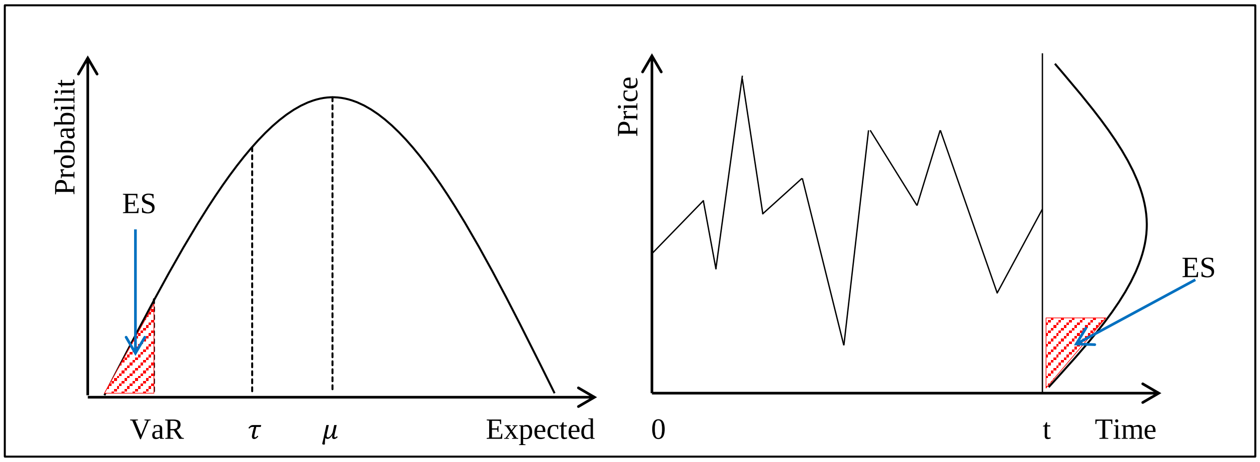

Figure 4. Value-at-Risk and Expected Shortfall Example

Source: Compiled by the author

Painted red area on the Figure 4, presents the expected shortfall (ES) probability. The basic idea of shortfall risk-based strategy is to control shortfall risk probability. In order to do that, lower partial moment of order minimum acceptable return is calculated (Herold *et al* 2005, 34). In simpler terms, the red area is calculated by using integration.

To simplify the calculation, it is assumed that returns are normally distributed, $X \sim N(\mu, \sigma^2)$. The Assumption does not concern mean expected return and volatility, but particularly skewness and kurtosis (there is assumed skewness 0 and kurtosis 3). In that case, expected shortfall probability is calculated by using the following formula (Herold *et al.* 2005, 34):

$$ES(R) = \phi\left(\frac{\tau - \mu}{\sigma}\right) \tag{3.4}$$

where, the portfolio return is denoted by R, the cumulative standard normal distribution is denoted by ϕ, the minimum acceptable return is denoted by τ, the mean return is denoted by μ, denotes the volatility of the return distribution is denoted by σ.

Based on expected shortfall risk probability portfolio asset allocation will be constantly revised, and if necessary, specific asset exposure will be adjusted to hold pre-specified shortfall risk probability[3]. In case, when the shortfall risk probability is below pre-specified target, is possible to increase exposure over 100%, by using leverage, additional free cash, and etc.

3.2.2. Implementation of the Expected Shortfall Method

As pointed out in the Section 2.2.3, shortfall risk-based strategies can be implemented either with or without forecasts. In this thesis forecast free method is used, to make further comparisons with alternative strategies available.

In order to implement expected shortfall risk-based strategy, suppose there is launched a portfolio with an inception value of 100. The initial asset classes weights are the following: 40% equities, 40% fixed income, 20% commodities and 0% cash. If necessary, assets are reallocated with monthly intervals, based on the expected shortfall probability for each asset class.

Even tough, expected shortfall strategy assumes, that the data are normally distributed with skewness 0 and kurtosis 3, and the data used in this empirical analysis has different skewness and kurtosis (presented in Table 1), the adjustment of integration formula 3.4 for expected shortfall probability would be out of the scope of this thesis. Thus, the formula will keep the same form for calculations[4] in this empirical analysis, although it may reduce the effectiveness of the strategy.

Before implementation of the model, the inputs must be calculated and defined. An important decision that can severely affect the results is the time horizon. It determines, for how long period the expected shortfall probability is calculated, as well as how often assets are allocated.

Annual and quarterly periods might be too long, with that time market conditions can vary a lot, which in turn, changes the models' inputs – expected returns, volatility, and correlations (Appendices 6 and 8). However, to reallocate assets too often might cause higher transaction costs, which in turn, reduce the return of these assets. Considering the latter, fictional transaction costs will be used, and the observation period is set to one month – in order to simplify the calculations, an approximation is made for 30 days. Since the raw data are presented in business days, not in calendar days, it is necessary to make another approximation. There are on average

[3] To illustrate latter, an example is compiled based on fictional data (Appendix 9).
[4] In order to carry out the calculations, expected shortfall probability function is created in MS Excel (Appendix 10).

252 business days per year, so in order to get one-month period, 21 business days are used (Maymin 2013, 4). Formula 3.2 is used to calculate 21 business day average returns (Appendix 11) and volatility is calculated by using the following formula:

$$\sigma = \sqrt{t * \frac{\sum_{n=1}^{n}(X_i - \bar{X})^2}{n-1}} \tag{3.5}$$

where, the standard deviation is denoted by σ, the number of business days is denoted by t, the number of returns is denoted by n, the each return is denoted by X_i, the mean return is denoted by $\bar{X}$. The Formula 3.5 differs from the normal standard deviation formula by the multiplier t under the square root. A multiplier is used to calculate the monthly standard deviation instead of daily[5].

While transaction costs are often dependent on negotiated terms and counterparties, these are chosen randomly, in general, transaction costs are probably below 1%. The chosen transaction costs are following: 0%, 0.5%, and 1% of trading volume.

The minimum acceptable return is set to -10%, because the emerging markets can be volatile, and if we want to gain high positive returns, some risk have to be taken. The purpose of the minimum acceptable return -10% is to limit short-term losses (highest monthly loss was -24%, Appendix 11), without preventing high returns by being overly conservative.

The return -10% or above is required over the next month at a 95% confidence level. Then the minimum return is -10%, investment horizon is one month, and the probability of producing a return below -10% must not exceed 5%.

Based on the objectives of this thesis, using correlations between the asset classes are not relevant in terms of expected shortfall risk-based strategy. Expected shortfall probability is calculated for each asset class separately, and a decision, how big exposure (allocation) will be set for a specific asset class, is independent from other asset classes, until it does not exceed the initial exposure. From the perspective of expected shortfall strategy, it is unreasonable to aggregate assets risk to portfolios' risk, because in this case it is not possible to distinguish which is the riskiness of a particular asset class. This in turn, would eliminate the possibility of dynamic asset allocation. Thus, expected shortfall probabilities are calculated for each asset class, except cash. Therefore, it is possible to exclude or decrease exposure to these asset classes where

[5] In order to convert daily volatility to monthly, daily volatility is multiplied by square root of 21 (Ederington and Guan 2004, 6).

expected shortfall probability is larger and to reallocate that released capital to other asset classes, which have a less expected shortfall probability.

The initial allocations between asset classes are increased under two conditions: there is released capital (cash) and expected shortfall probability will stay under a pre-specified floor after additional investment.

3.3. The Empirical Results

Since the minimum acceptable return is -10%, the results show that expected shortfall probability mean is close to the predetermined floor, 5% (Appendix 12). By assessing visually the expected shortfall probabilities, it is possible to highlight common tendencies (Appendix 13). All asset classes had shortfall probability higher than 50% during the crisis of 2008. In this period, according to this dynamic strategy, it was expedient to exit investments and hold cash. In addition to the crisis of 2008, higher shortfall probability for equities and bonds appeared during the crisis of 2002.

In general, most of the time bonds shortfall probability has remained within acceptable limits. Gold and equities shortfall probability has been highly volatile during the period, common tendencies appear to the latter periods in June 2004, June 2006, the second half of 2011, and June 2013.

Taking into account the expected shortfall probability there is compiled a dynamic asset allocation. As it is shown on the Figure 5, most of the time the dynamic asset allocation is similar to the static asset allocation. If the shortfall probability of the asset class is reduced through the reduction of allocation, other asset classes with less risk are leveraged. Cash is held only if all asset classes are considered as highly risky.

Based on previously presented dynamic asset allocation, backtest of the expected shortfall method was carried out. As stated in the Section 3.2.2, six portfolios with an inception value of 100 were launched[6].

[6] Three dynamic and three static portfolios were launched, with transaction costs 0%, 0.5% and 1% of traded value.

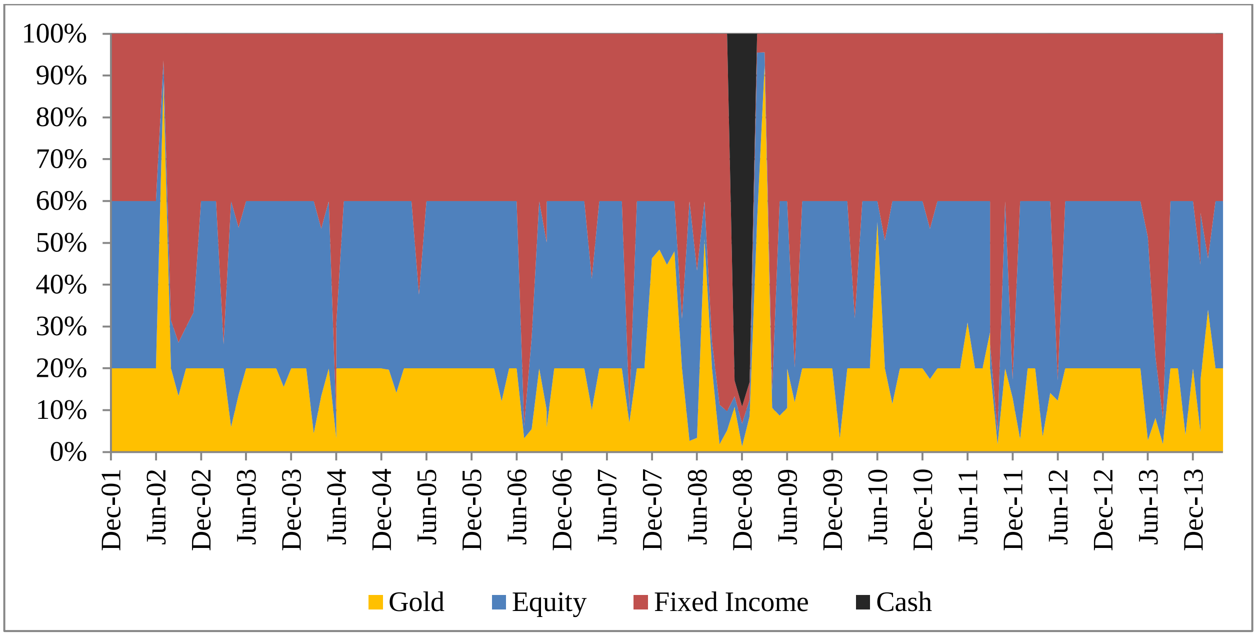

Figure 5. The asset allocation of the dynamic portfolio from 28/12/2001 to 1/05/2014

Source: Compiled by the author

Table 2 presents the descriptive statistics of dynamic and static portfolios' returns (Appendix 14). It appears that, the dynamic strategy mean returns are higher than on static strategy and returns vary less in case of dynamic strategy. If transaction costs are included, then mean returns decreases and sample variance stays at the same level.

Table 2. Dynamic and static portfolio descriptive statistics from 28/12/2001 to 1/5/2014

Strategy	Dynamic	Static	Dynamic	Static	Dynamic	Static
Transaction Cost	0%		0.50%		1%	
Mean	1.18%	1.02%	0.69%	0.52%	0.20%	0.02%
Variance	0.10%	0.13%	0.10%	0.13%	0.10%	0.13%
Range	20.94%	24.57%	20.94%	24.57%	20.94%	24.57%
Minimum	-9.77%	-11.56%	-10.27%	-12.06%	-10.77%	-12.56%
Maximum	11.17%	13.01%	10.67%	12.51%	10.17%	12.01%

Source: Compiled by the author

All portfolios were launched with initial value of 100 in 28 December 2001. At the end of the observation horizon, 1 May 2014, dynamic and static portfolio without transaction costs respectively reached to 576.3 (CAGR 15.04%) and 437.4 (CAGR 12.53%), with 0.5% transaction costs applied respectively reached to 273.36 (CAGR 8.38%) and 204.53 (CAGR 5.89), and with 1% transaction costs applied respectively reached to 129.18 (CAGR 2.07%) and 95.27 (CAGR -0.39%) (Appendices 15 and 16[7]).

In order to understand the effect of the expected shortfall probability method for the portfolios' short and long-term return, relative performance (Figure 6) and excess return (Appendix 17) were calculated. This also simplifies the further comparison of the strategies.

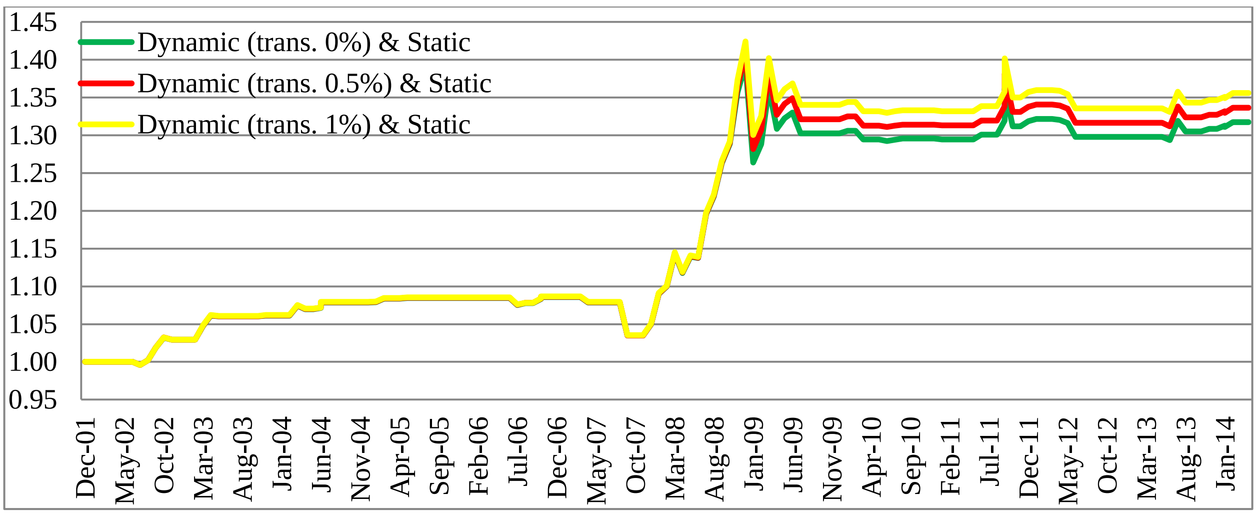

Figure 6. The performance of the dynamic portfolio relative to the static portfolio from 1/11/2001 to 1/05/2014

Source: Compiled by the author

At the time of the crisis of 2008 dynamic strategy outperformed static strategy 1.36 times within one year horizon. In case, if transaction costs were included, then the outperformance of dynamic strategy decreased immediately for a month after the end of the crisis in 2009. During the rest of the observation period, there are no major fluctuations in relative performance.

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[7] Appendix 16 is presenting static and dynamic portfolios performance during the observation period.

3.4. Discussion of the Results

3.4.1. Interpretation of the Results

The purpose of the empirical analysis is to clarify whether shortfall risk-based strategy outperform static strategy during the observation period, or not. The results indicate that the dynamic strategy meets the expectations.

The shortfall risk-based strategy outperform static strategy, the compound annual growth rate is 2.46% - 2.51% higher, depending on whether transaction costs are included, or not. To compare absolute return at the end of time horizon, then dynamic portfolios' assets are valued 31.8% more highly than static portfolios' assets. In addition, the results show that the dynamic strategy is slightly more stable, and prevents high negative returns.

As a dynamic strategy involves continuous re-allocation between asset classes, there is high trading volume, accompanied by transaction costs, which reduce return. As well as the transaction costs reduce the profitability of the dynamic strategy, they affect also the static portfolio. The latter is because, in case of static asset allocation weights, the values of asset classes are do not necessarily move in sync. This means, asset allocation might have to be constantly reviewed to hold initial weights over the time horizon.

Even though, it can be assumed, that the transaction costs that accompany dynamic strategy are higher than on static strategy, it appears that the transaction costs are relatively similar. Mostly because the fact, that dynamic portfolios' asset allocation is most of the time very similar to the static portfolio asset allocation.

The results show, that a dynamic strategy is proven capable of outperforming static strategy during recessions, while static portfolio relatively loses more gained value. There is no doubt that the dynamic strategy works well during the economic downturn. During the crisis of 2008, dynamic portfolio reduced risky positions which made possible to mitigate the highest losses. During this period, dynamic portfolio outperform static portfolio approximately 1.36 within couple of months.

The shortfall risk-based strategy minimum return is kept above the predetermined floor (if transaction costs are low or zero). So, besides achieving higher average returns, dynamic strategy also avoids major losses.

During the rest of the time, stable growth period, dynamic and static strategies performances are relatively similar, whether or not transaction costs are included. Except, immediately after the crisis of 2008, static portfolio outperformed dynamic portfolio for a short period.

3.4.2. Limitations of the Results and Suggestions for Further Research

The implementation of one dynamic asset allocation strategy is not enough to make general conclusions. To find the most suitable and profitable dynamic strategy for emerging markets, all different dynamic strategies should be implemented and compared. As well as the emerging markets are behaving differently than in developed markets, it would be wise to adjust some of the dynamic models, or perhaps to link some of the model inputs to the economic leading indicators.

While volatility influences expected shortfall probability extremely, then it might improve shortfall risk-based method performance, if autoregressive daily volatility is used rather than monthly volatility. Also in further analyses of dynamic asset allocation strategies, it would make sense to divide the observation period to bull, bear and flat – thus it is possible to distinguish the dynamic strategy behavior during the different market cycles.

It is important to emphasize that during interpretation of the results, it must be considered that empirical analysis is based on one observation period, and only with three asset classes. In order to strengthen the results, the empirical analysis should be repeatedly replicated with other assets, it would also be useful to switch the asset classes.

It must be taken into account that the implementation of a dynamic strategy does not take into account liquidity problems. However, since in this empirical analysis, the major indices were used, there should not occur liquidity problems.

It is worth further research, whether the expected shortfall probability method performance can be improved, while the changes in the initial asset class weights are executed in condition, when the rate of change exceeds a certain level. Therefore, small insignificant trades will be eliminated and transaction costs reduced, and at the same time, the major changes in asset allocation will be still applied.

CONCLUSION

This thesis considered dynamic asset allocation in emerging markets. The purpose of this thesis was to provide a clear overview of the dynamic asset allocation theory, different strategies, limitations, possibilities, and to evaluate the effectiveness and verify, if portfolio based on dynamic strategy can outperform a portfolio based on static asset allocation. Based on the discursive discussion, the shortfall risk-based strategy was chosen for implementation.

The majority of the goals were covered and achieved in the first half of the thesis. Review of dynamic asset allocation theory and strategies were presented, as well as there were discussed different limitations and possibilities. In the second half of this thesis, empirical analysis was conducted.

The results of the empirical analysis clearly indicated the outperformance of a portfolio based on dynamic asset allocation, compound annual growth rate was 2.46% - 2.51% higher than on static portfolio, depending on whether transaction costs were included, or not. Most of the outperformance was made during the recession in 2008. During the rest of the period, dynamic and static portfolios' performances were approximately similar.

These results were partially in accordance with the literature, in which it was mentioned that dynamic strategies outperform the market in bull or bear environments, but fall behind during markets steady growth. The first half of the allegation was true, most of the outperformance was made during the recession. But during the markets stable growth, even though there occurred slight differences, in general, dynamic and static strategy performance was more or less the same.

It is important to emphasize that, the results are based on this study, and certainly there cannot be made any solid general conclusions, like shortfall risk-based strategy is always either outperforming portfolios based on static allocation, or equal to those. Random walk during the markets stable growth period might cause unnecessary changes in allocation, and in turn cause extra costs and reduce the portfolios' profitability.

Exactly the same way, as there is a trade-off between expected return and risk, there is a trade-off between choosing the period, how often portfolio allocation will be reviewed and how minor changes will be executed. Frequent overview might help to protect portfolio value from falling, but there also arises risk, that portfolio value will fall because of the transaction costs, as it appeared while trading costs 1% of traded value were applied.

However, based on empirical analysis, it can be concluded with certainty, that shortfall risk-based strategy makes the returns to vary less. Also, whether or not transaction costs are included, then the returns of the dynamic portfolio were higher than on static portfolio. Also, if transaction costs were not included, then the minimum return (-9.77) was above a predetermined target (-10%). This indicates that the expected shortfall risk-based strategy was working without deflections.

The purpose of this thesis was filled and inferences were made as much as the results permitted. It is worth further investigation, whether the shortfall risk-based strategy performance can be improved, if changes in the initial asset class weights are executed in condition, when the rate of change exceeds a certain level. Thus, it is possible to eliminate the small insignificant trades, which also in turn reduces transaction costs during stable periods in the economy. At the same time, if the economic climate becomes markedly worse, the expected shortfall probability increases significantly and the portfolio will be radically re-allocated, and hopefully, the major losses will be avoided. In addition, the empirical analysis should be extended, that all dynamic strategies would be involved in.

In conclusion, portfolio based on shortfall risk-based strategy controlled downside risk more efficiently, than static portfolio. More precisely, it offers downside risk protection. The profitability of the shortfall risk-based strategy, as well as static strategy, is highly dependent on the transaction costs applied. If transaction costs increase, the profitability reduces drastically. Therefore, while implementing dynamic strategies, it is important to choose extremely carefully the period, how often asset allocation will be reviewed, and whether all minor changes will be executed, or not. During the correct implementation of this strategy, it is a very effective way for controlling the risk budget and to enhance portfolios' performance in the long-term.

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KOKKUVÕTE

DÜNAAMILINE VARADE ALLOKATSIOON ARENEVATEL TURGUDEL

Veiko Niinemäe

Vana klišeed „Ära pane kõiki mune ühte korvi" on võimalik rakendada ka investeeringute tegemisel läbi varade allokatsiooni. Tegemist on strateegiaga, mille käigus jaotatakse portfellis olevad varad erinevate varaklasside vahel, peamise eesmärgiga riske hajutada.

Lisaks erinevatele varaklassidele on võimalik varasid jaotada ka erinevate turgude vahel. Investeeringute kontekstis peetakse turgude all üldjuhul silmas riikide jaotamist vastavalt arengutasemele: arenenud, arenevad ja vähearenenud. Enamik turge klassifitseerivad kas arenenud või arenevateks turgudeks. Erinevalt arenevatest turgudest, on varade allokatsiooni arenenud turgudel suhteliselt palju ja põhjalikult uuritud. Kuigi kõik arenevad turud ei pruugi olla efektiivsed kapitaliturud, on paljud nendest kiirelt kasvava majandusega ning pakuvad seeläbi investoritele häid võimalusi varade investeerimiseks. Eelpool nimetatud põhjuste tõttu on käesoleva töö fookuses on arenevad turud.

Viimased suuremad majanduskriisid aastatel 2002, 2008 ja 2011 on selgelt näidanud, et portfell, mis põhineb traditsioonilisel fikseeritud varaklasside jaotusel, ei ole ratsionaalne investori jaoks, kes ei soovi, et portfelli väärtus majandustsükli langusfaasis väheneks. Isegi kui portfelli tootlus on võrdlusindeksi suhtes positiivne, võib absoluutne tootlus olla negatiivne. Mainitud kitsaskoht on ajendiks, miks portfelli valiku ja varade allokatsiooni strateegiaid, mis põhinevad absoluutsel tootlusel ja kontrollivad languse riski, pidevalt täiendatakse ning edasi arendatakse.

Käesolev lõputöö käsitleb varade allokatsiooni strateegiad, mis lubavad varade jaotusel ajas muutuda ehk dünaamilisi varade allokatsiooni strateegiaid. Lõputöö eesmärgiks on anda ülevaade dünaamilise varade allokatsiooni teooriast, erinevatest strateegiatest ning nende rakendamisega kaasnevatest võimalustest ja piirangutest. Lisaks on lõputöö eesmärgiks empiirilise uuringu abil hinnata dünaamilisel strateegial põhineva portfelli tulemuslikkust ning võrrelda portfelli pikaajalist tootlust ja lühiperioodide languseid portfelliga, mis põhineb fikseeritud varaklasside jaotusel.

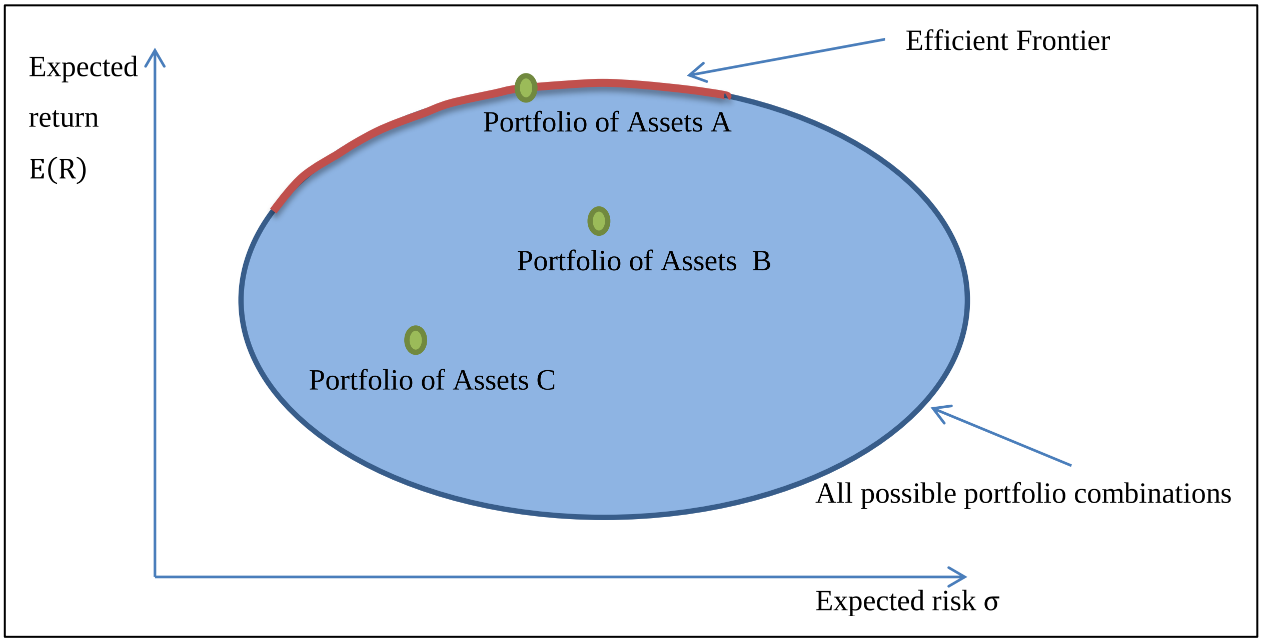
Eesmärgi saavutamiseks antakse esmalt ülevaade erinevatest dünaamilistest varade jaotamise strateegiatest ning valitakse diskursiivse arutelu põhjal välja üks, mida hiljem empiirilise analüüsi käigus rakendatakse. Valituks osutus oodataval langusriskil põhinev strateegia. Dünaamilisel strateegial põhineva portfelli tulemuslikkuse hindamiseks kasutatakse fikseeritud jaotusega portfelli. Kuna tehingukulud on varade pideva ümberjaotamise korral teguriks, mis võivad portfelli tootlust märkimisväärselt vähendada, rakendatakse nii dünaamilisel kui fikseeritud strateegial põhinevatele portfellidele järgnevaid tehingukulusid: 0%, 0.5% ja 1% teostatavast tehingust. Erinevaid tehingukulusid kasutatakse nende varieeruvuse tõttu, tehingukulud sõltuvad tihti läbiräägitud tingimustest, tehingu vastaspooltest ja teostatava tehingu mahust. Uuringus kasutatakse nelja järgnevat varaklassi: arenevate turgude aktsiad ja võlakirjad, kuld ning deposiidil asuv raha. Vaatlusalune periood on üle 12 aasta pikk.

Empiirilise analüüsi tulemused viitavad selgelt, et dünaamilisel strateegial põhineva portfelli keskmine tootlus on kõrgem, kui staatilistel strateegiatel põhinevatel portfellidel (diskonteeritud aastane keskmine tootlus on 2.46-2.51% kõrgem, sõltuvalt rakendatud tehingukuludest). Lisaks ilmneb tulemustest, et valdav osa kõrgemast tootlusest tekkis 2008. aastal esinenud majanduslanguse ajal. Kõnealusel perioodil langes mõlema portfelli varade väärtus märkimisväärselt, kuid dünaamilise jaotusega portfellil oli varade väärtuse langemine väiksem, tänu varade ümber jaotamisele väikesema oodatava langusriskiga varaklassidesse.

Edaspidistes uuringutes tasuks parema võrdluse saamiks rakendada ka teisi dünaamilisi strateegiaid arenevatel turgudel. Nõnda oleks võimalik strateegiaid omavahel võrrelda ning leida arenevatele turgudele sobivaim. Käesolevas empiirilises uuringus rakendatud oodataval langusriskil põhineva strateegia osas tasuks edasi uurida, kas väiksemate muudatuste ignoreerimine varade jaotuses vähendaks tehingukulusid ning suurendaks seeläbi diskonteeritud aastast keskmist tootlust.

APPENDICES

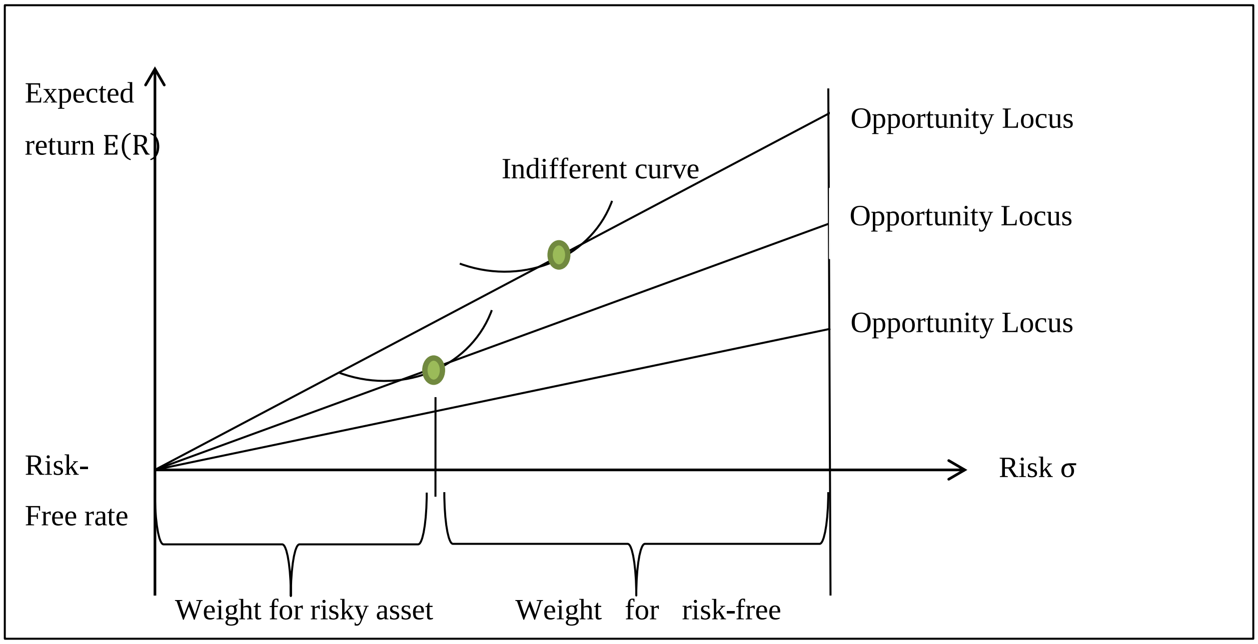
Appendix 1. Efficient Portfolio Combinations



Source: Markowitz (1952, 82); compiled by the author

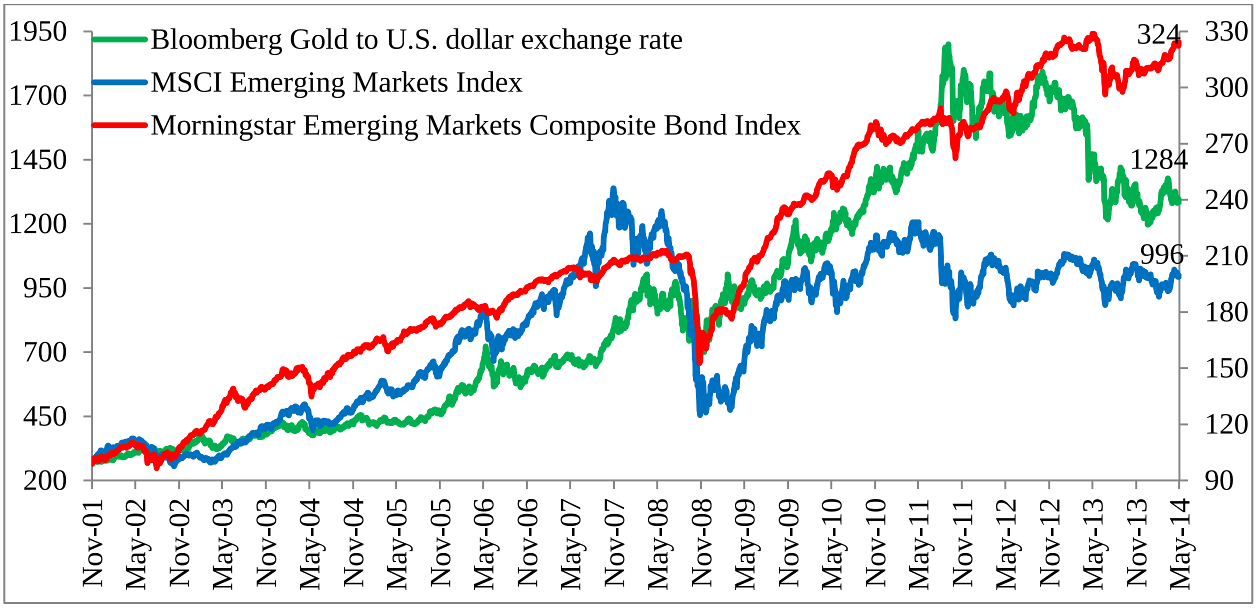
The rational investor prefers portfolio A rather than B, because portfolio A is less risky and has higher expected return.

Appendix 2. Indifferent Curve and Opportunty Locus



Source: Tobin (1958, 80); compiled by the author

Appendix 3. Indices Performance



Source: Bloomberg (2014); compiled by the author

Appendix 4. Indices CAGR

Name	Gold to USD	MSCI EM Index	Morningstar EM Bond Index
Value at 1/11/2001	279.85	268.10	99.30
Value at 1/5/2014	1284.5	996.01	324.02
CAGR	12.97%	11.07%	9.92%

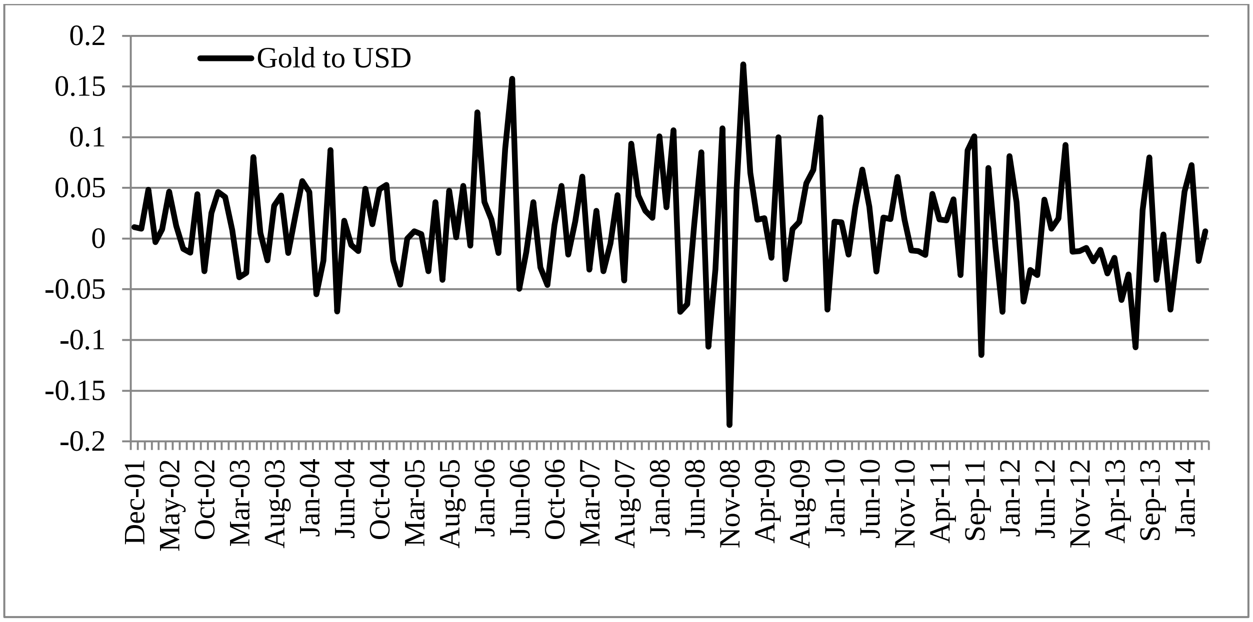
Source: Compiled by the author

Appendix 5. Indices Daily Returns Descriptive Statistics

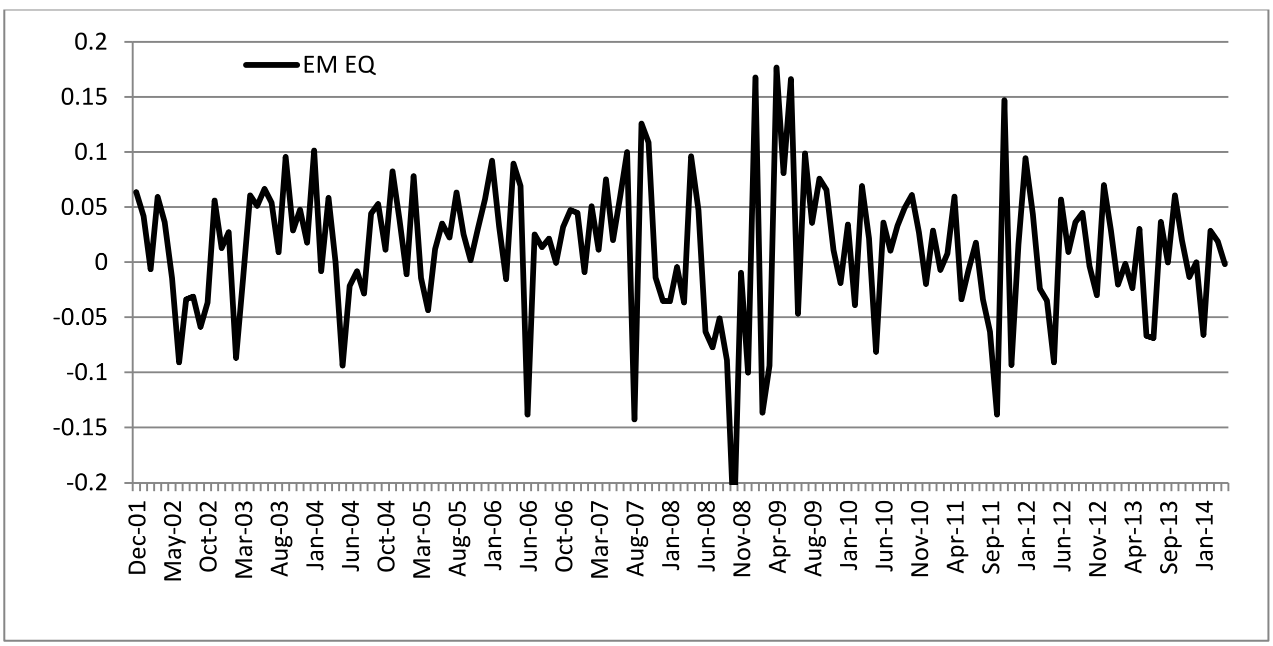
Index (1/11/2001 to 1/5/2014)	Gold to USD	MSCI EM Index	Morningstar EM Bond Index
Mean	0.05%	0.05%	0.04%
Standard Error	0.02%	0.02%	0.01%
Median	0.08%	0.11%	0.04%
Mode	-	-	-
Standard Deviation	1.19%	1.28%	0.35%
Sample Variance	0.01%	0.02%	0.00%
Kurtosis	4.531	8.349	17.017
Skewness	-0.281	-0.327	-1.403
Range	16.63%	20.11%	6.97%
Minimum	-8.97%	-9.51%	-4.23%
Maximum	7.67%	10.60%	2.73%
Sum	175.48%	157.88%	120.31%
Count	3256	3256	3256

Source: Compiled by the author

Appendix 6. Indices Returns

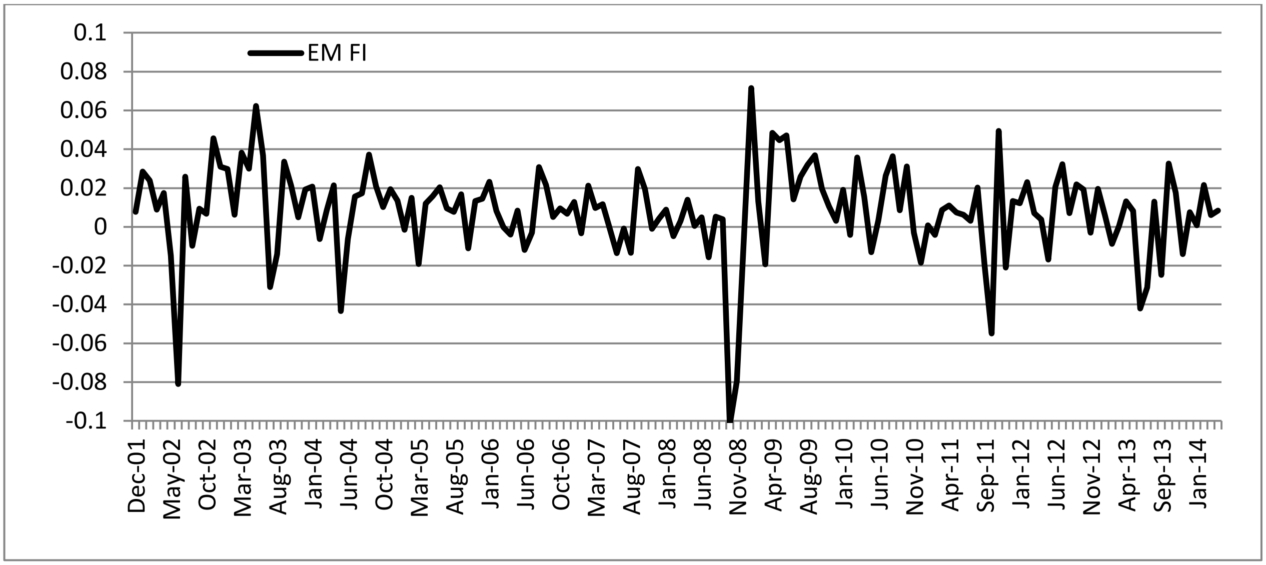


Source: Compiled by the author



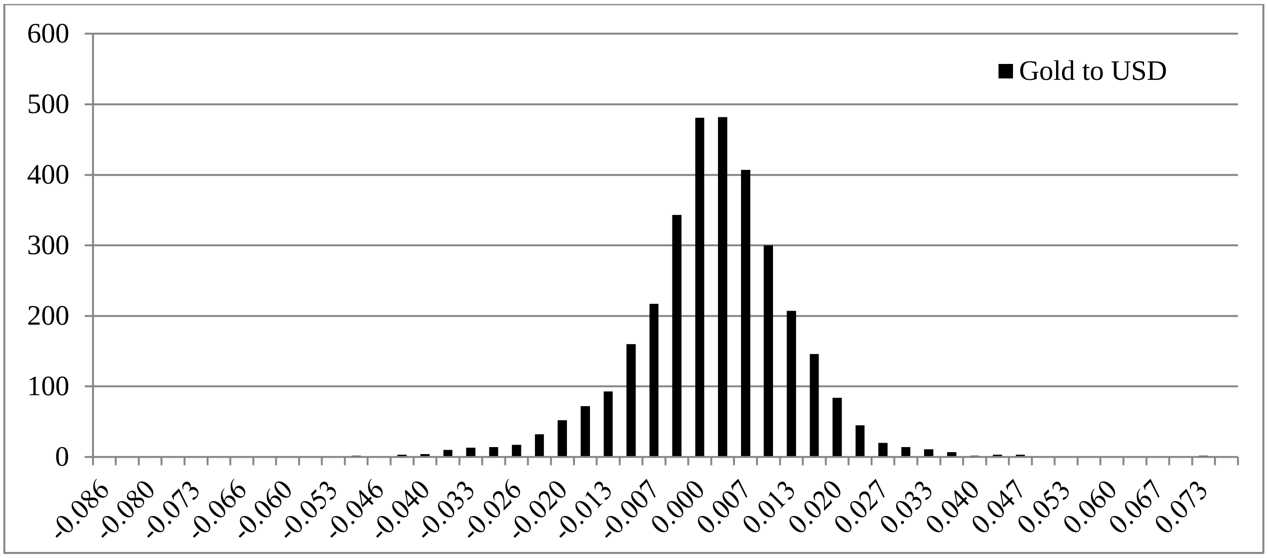
Source: Compiled by the author

Appendix 6. continues

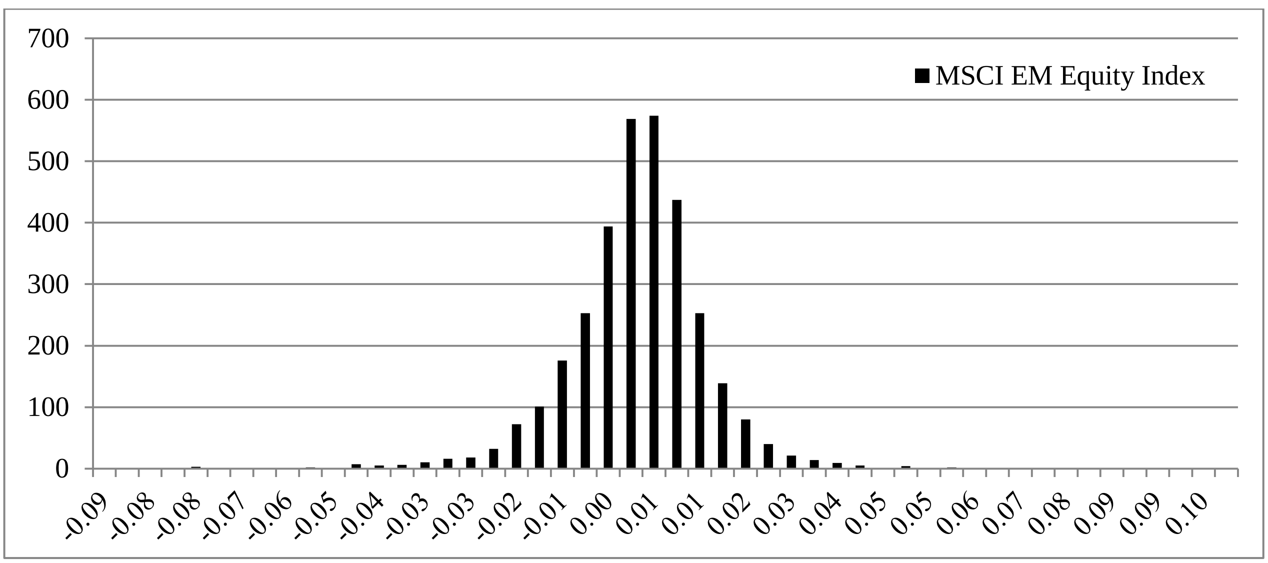


Source: Compiled by the author

Appendix 7. Frequency of Indices Daily Returns

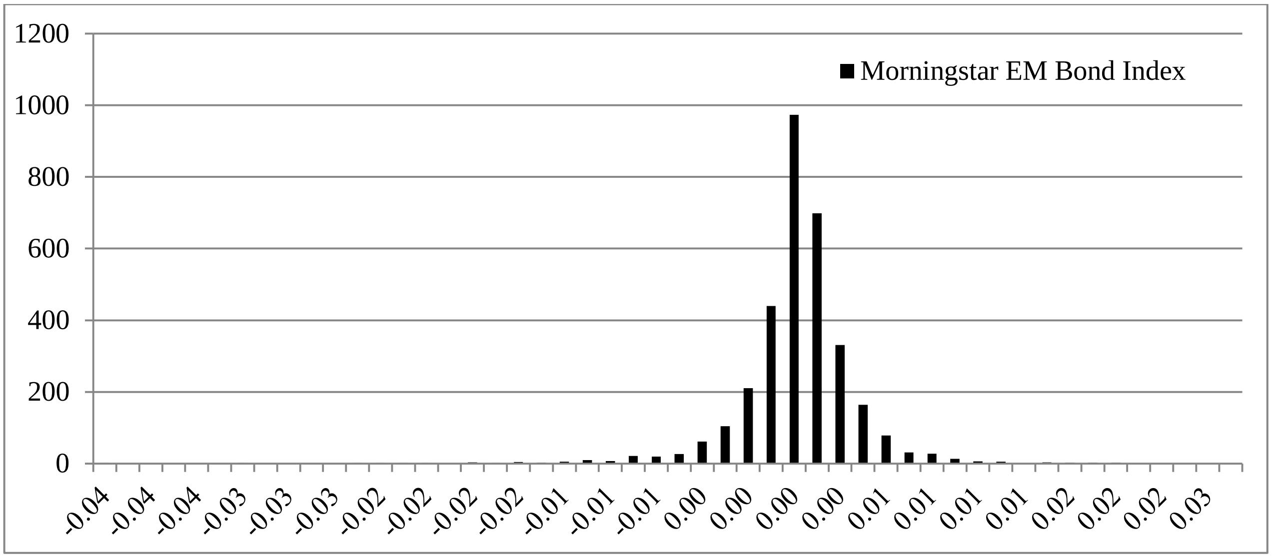


Source: Compiled by the author



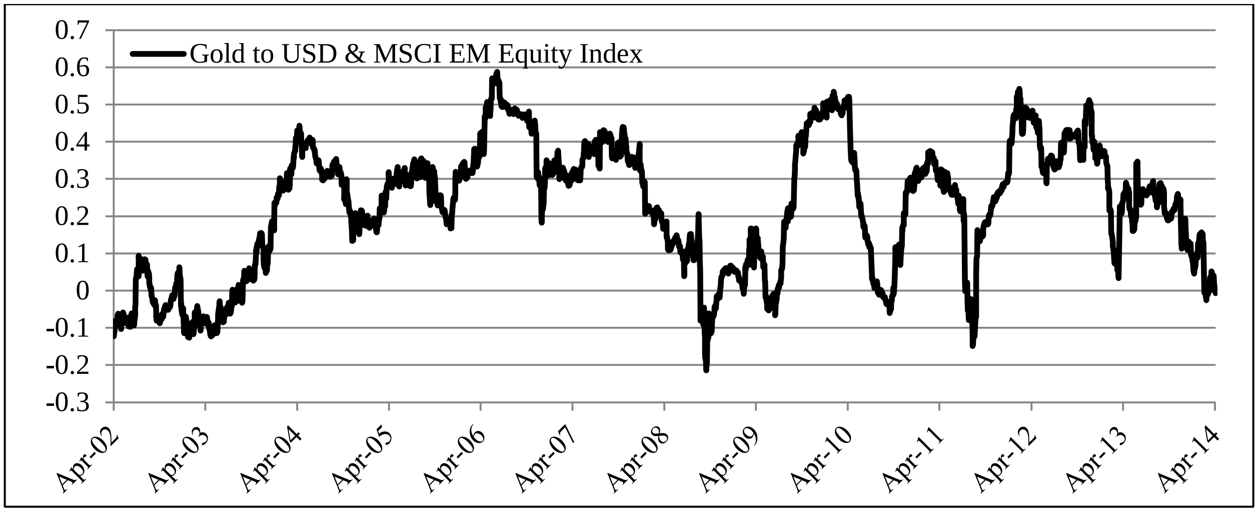
Source: Compiled by the author

Appendix 7. continues

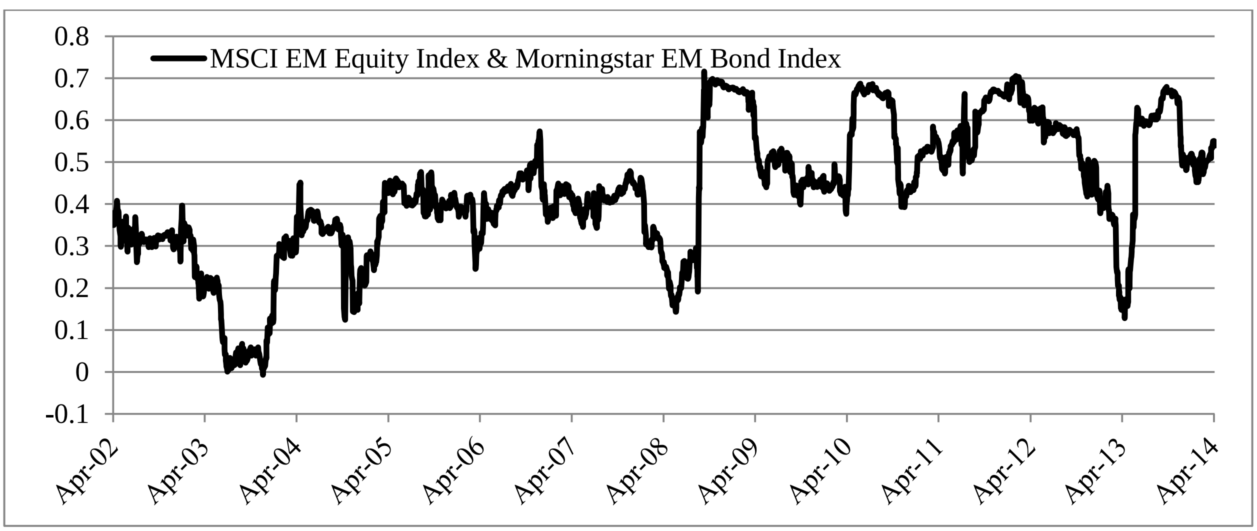


Source: Compiled by the author

Appendix 8. Rolling 6-Month Correlations between Indices Daily Returns

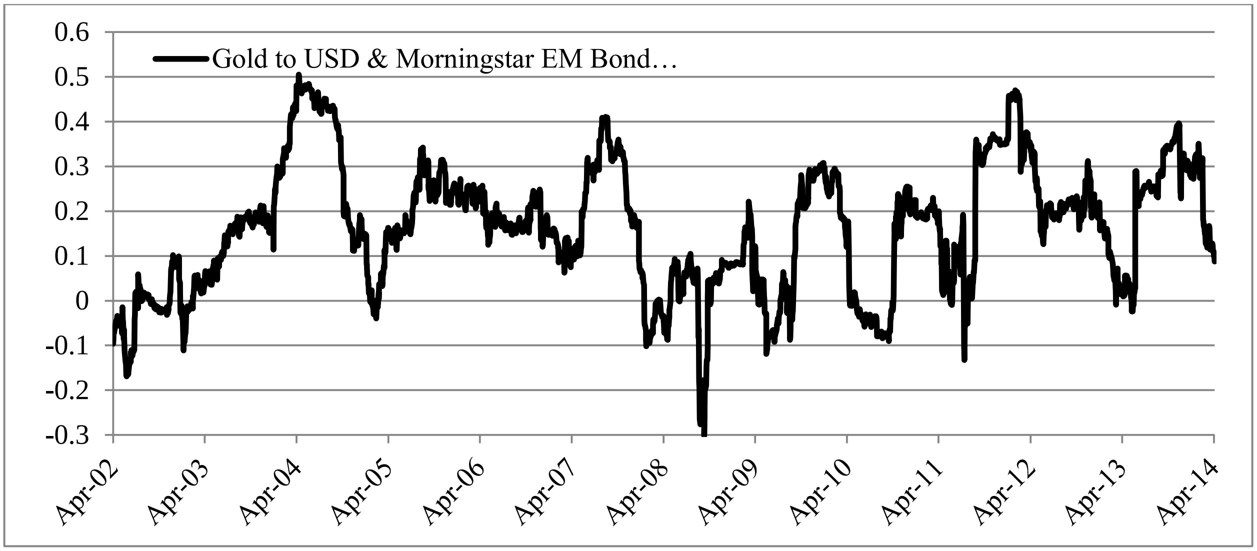


Source: Compiled by the author



Source: Compiled by the author

Appendix 8. continues



Source: Compiled by the author

Appendix 9. Example: Implementation of the Expected Shortfall Method

On the Figure 7. asset weight is fixed to 100% and expected shortfall probability is fluctuating over the period. Fluctuations are caused of the changes in inputs – expected volatility and return.

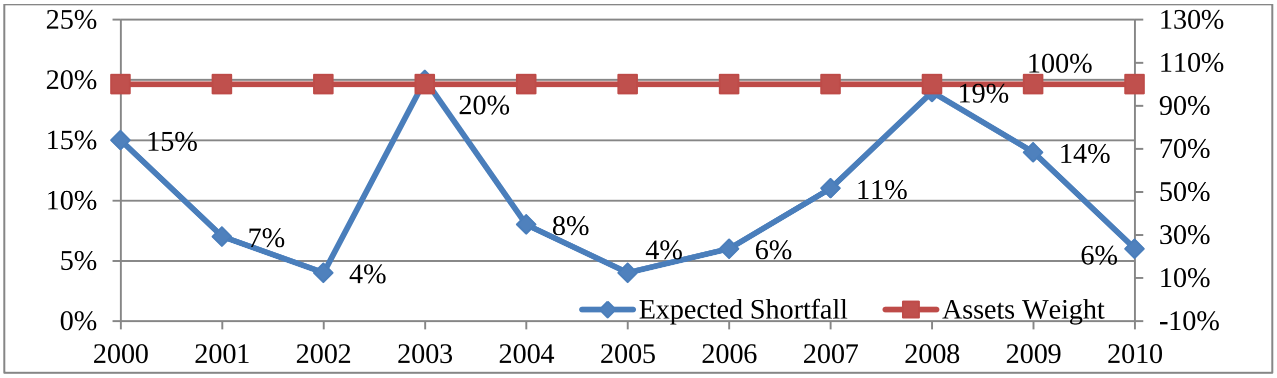


Figure 7. Example: Dynamic expected shortfall risk probability vs static asset weight

Source: Compiled by the author

If investor is risk averse and wants to hold expected shortfall risk probability constant over time, for example 5, then it can be done by changing asset weight (exposure) as show on the Figure 8.

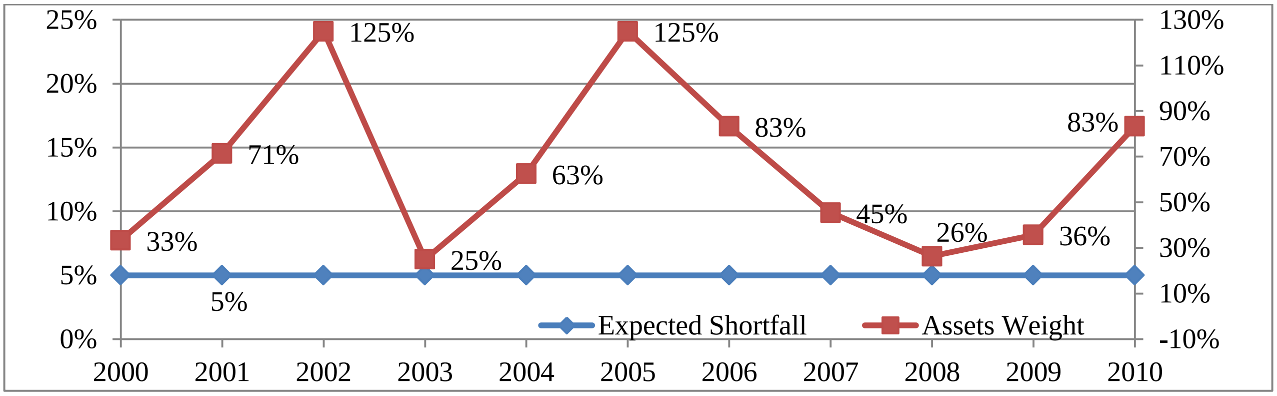


Figure 8. Example: Static expected shortfall risk probability vs dynamic asset weight

Source: Compiled by the author

Appendix 10. VBA Code: Expected Shortfall Probability

```
Function ExpectedShortfall(MAR. Mean. Sigma)
   ER = MAR - Mean
   z = ER / Sigma
   If z > 0 Or z = 0 Then
      w = 1
   Else
      w = -1
   End If
   y = 1 / (1 + 0.2316419 * w * z)
   ES = 0.5 + w * (0.5 - (Exp(-z * z / 2) / 2.506628) * _
         (y * (0.3193815 + y * (-0.3565638 + y * _
         (1.7814779 + y * (-1.821256 + y * 1.3302744))))))
         'cumulative normal distribution (Vince 1990, 199)
   ExpectedShortfall = ES
End Function
```

Source: Vince (1990, 199); compiled by the author

Appendix 11. Indices 21-Day Returns Descriptive Statistics

Index (1/11/2001 to 1/5/2014)	Gold to USD	MSCI EM Index	Morningstar EM Bond Index
Mean	1.24%	1.15%	0.80%
Standard Error	0.42%	0.51%	0.19%
Median	1.37%	1.79%	0.89%
Mode	-	-	-
Standard Deviation	5.27%	6.31%	2.34%
Sample Variance	0.28%	0.40%	0.06%
Kurtosis	1.143	1.513	5.016
Skewness	-0.058	-0.489	-1.326
Range	35.58%	41.81%	17.37%
Minimum	-18.38%	-24.12%	-10.21%
Maximum	17.19%	17.69%	7.16%
Sum	191.02%	177.60%	123.10%
Count	154	154	154

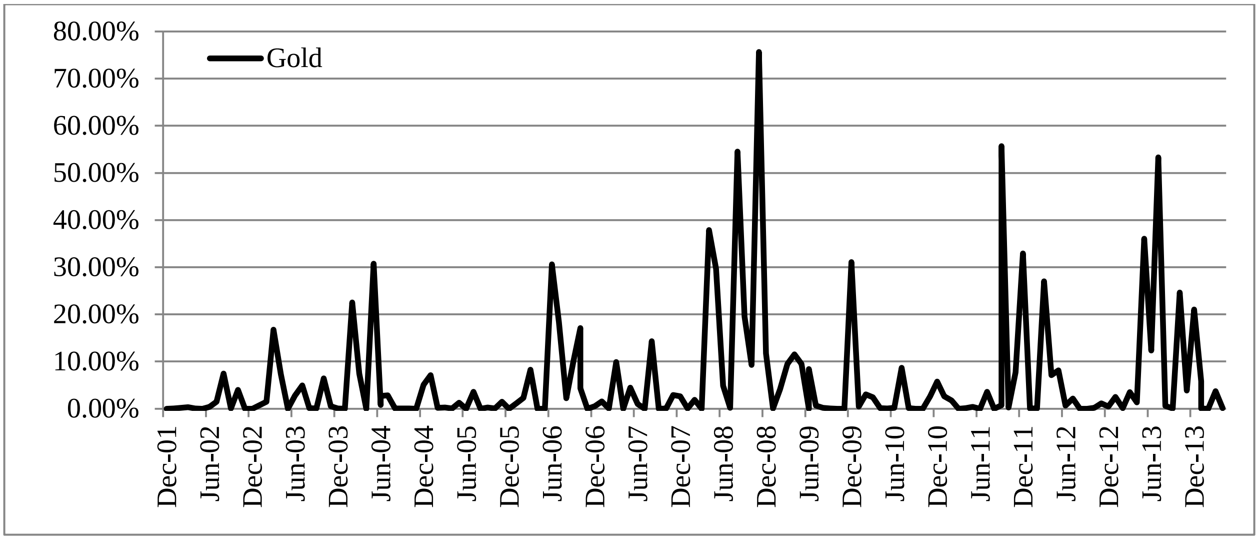
Source: Compiled by the author

Appendix 12. Expected Shortfall Probability Descriptive Statistics

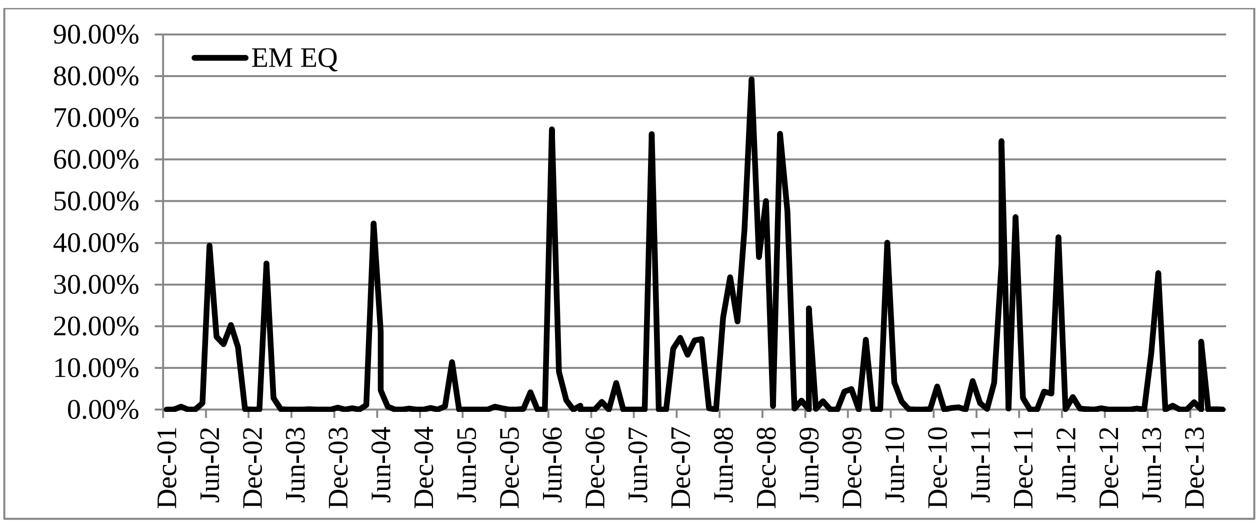
Index (1/11/2001 to 1/5/2014)	Gold to USD	MSCI EM Index	Morningstar EM Bond Index
Mean	6.09%	8.19%	1.82%
Standard Error	0.97%	1.31%	0.71%
Median	0.89%	0.23%	0.00%
Mode	-	-	-
Standard Deviation	12.05%	16.27%	8.85%
Sample Variance	1.45%	2.65%	0.78%
Kurtosis	11.288	5.397	23.259
Skewness	3.14	2.406	4.95
Range	75.69%	79.26%	52.86%
Minimum	0.00%	0.00%	0.00%
Maximum	75.69%	79.26%	52.86%
Sum	937.72%	1261.27%	280.62%
Count	154	154	154

Source: Compiled by the author

Appendix 13. Expected Shortfall Probability

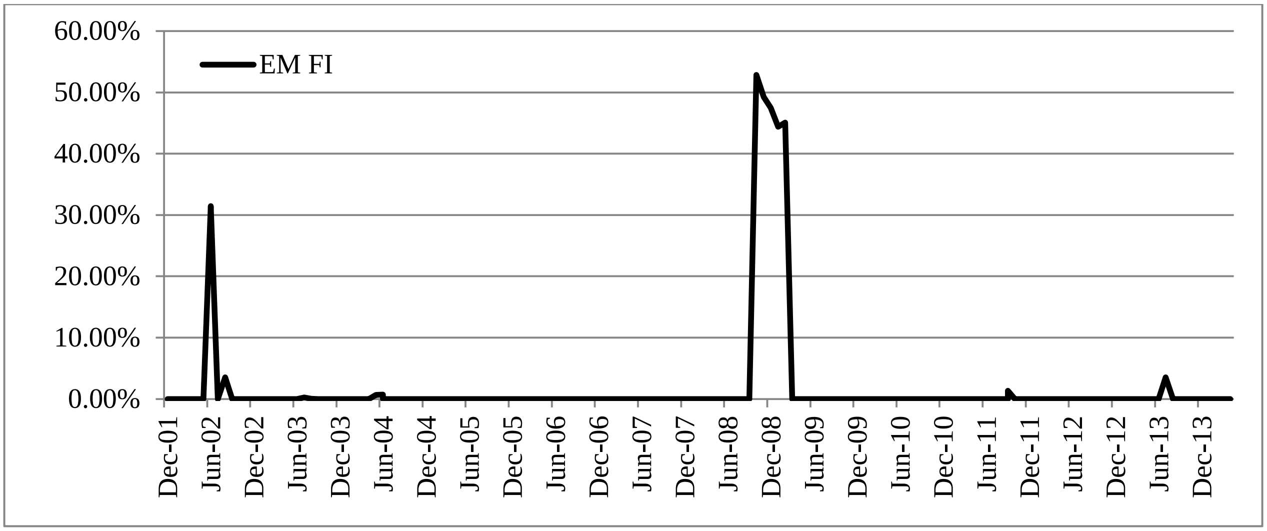


Source: Compiled by the author



Source: Compiled by the author

Appendix 13. continues



Source: Compiled by the author

Appendix 14. Dynamic and Static Portfolios Despcriptive Statistics

Strategy*	Dynamic	Static	Dynamic	Static	Dynamic	Static
Transaction Cost	0%		0.50%		1%	
Mean	1.18%	1.02%	0.69%	0.52%	0.20%	0.02%
Standard Error	0.25%	0.30%	0.25%	0.30%	0.25%	0.30%
Median	1.47%	0.96%	0.97%	0.46%	0.47%	-0.04%
Mode	-	-	-	-	-	-
Standard Deviation	3.14%	3.66%	3.13%	3.66%	3.13%	3.66%
Sample Variance	0.10%	0.13%	0.10%	0.13%	0.10%	0.13%
Kurtosis	1.34	1.51	1.36	1.51	1.37	1.51
Skewness	-0.59	-0.27	-0.59	-0.27	-0.6	-0.27
Range	20.94%	24.57%	20.94%	24.57%	20.94%	24.57%
Minimum	-9.77%	-11.56%	-10.27%	-12.06%	-10.77%	-12.56%
Maximum	11.17%	13.01%	10.67%	12.51%	10.17%	12.01%
Sum	180.58%	155.40%	105.35%	78.90%	30.13%	2.40%
Count	153	153	153	153	153	153

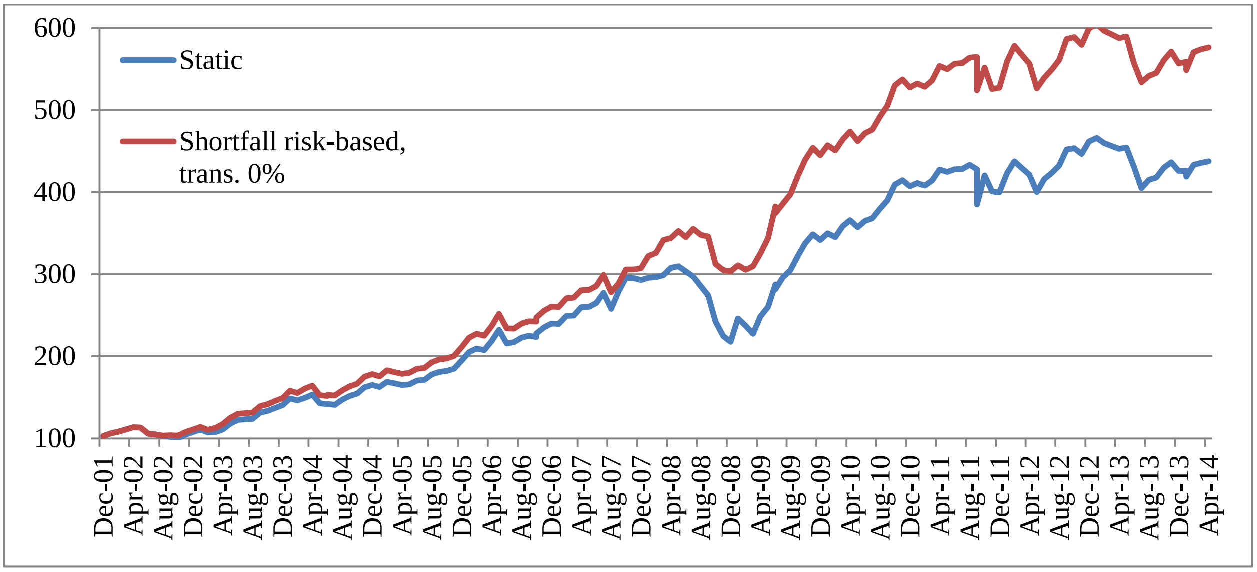
Source: Compiled by the author

Appendix 15. Dynamic and Static Portfolios CAGR

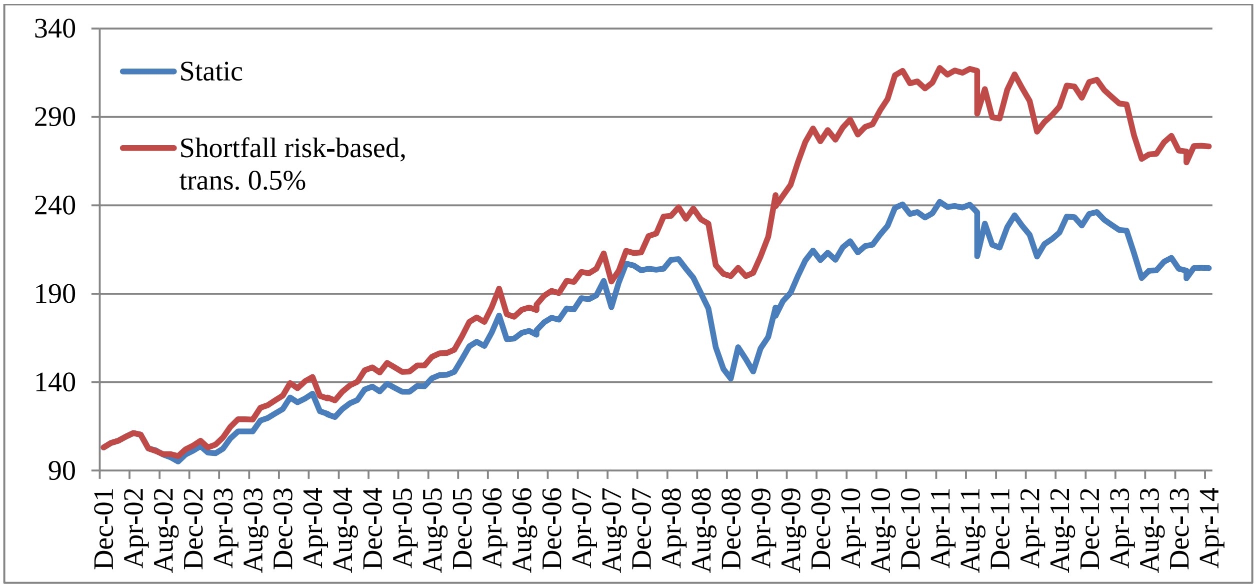
Strategy	Dynamic	Static	Dynamic	Static	Dynamic	Static
Transaction Cost	0%		0.50%		1%	
28.12.2001	100	100	100	100	100	100
1.05.2014	576.32	437.43	273.36	204.53	129.18	95.27
CAGR	15.04%	12.53%	8.38%	5.89%	2.07%	-0.39%

Source: Compiled by the author

Appendix 16. Dynamic and Static Portfolio Performance

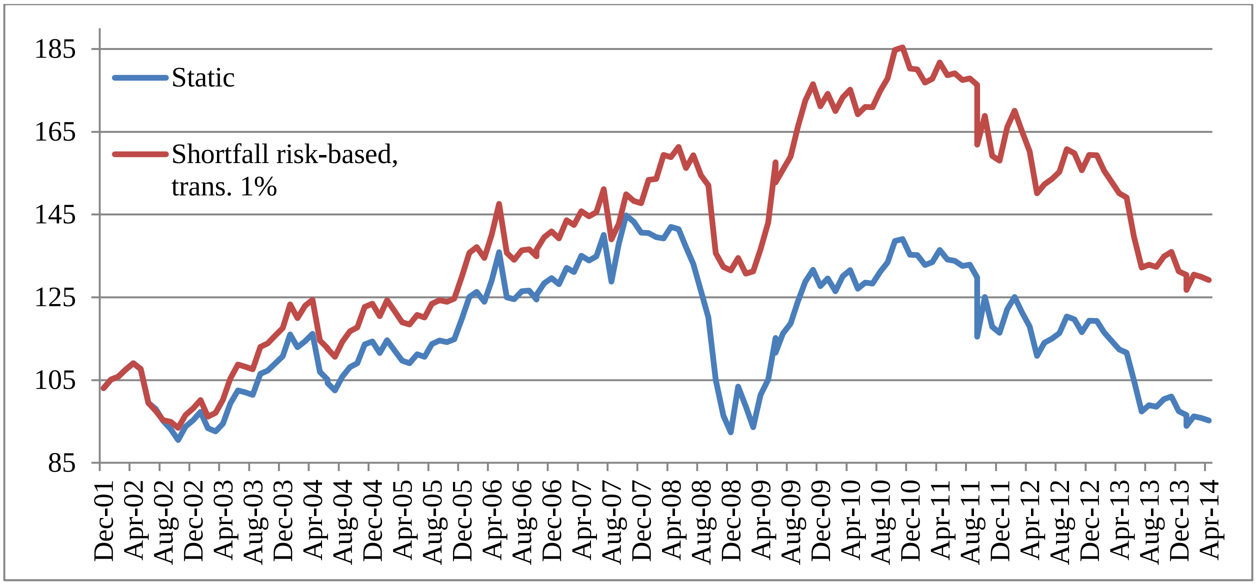


Source: Compiled by the author



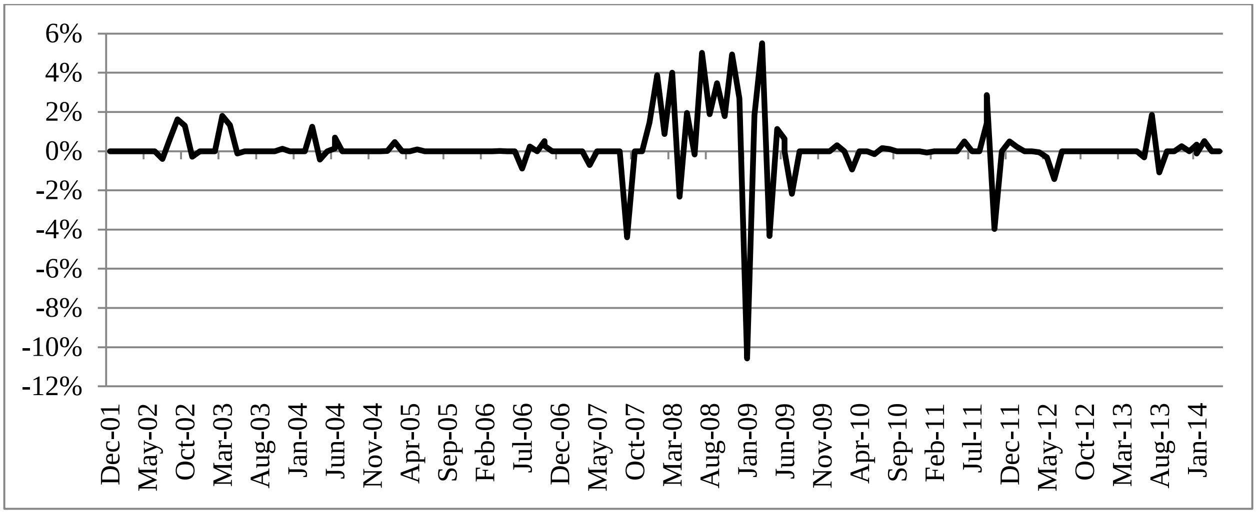
Source: Compiled by the author

Appendix 16. continues



Source: Compiled by the author

Appendix 17. Dynamic and Static Portfolio Excess Return



Source: Compiled by the author