



UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

SEEKING ACTIVE RETURNS

A STUDY OF RESTRUCTURING STRATEGIES FOR EQUITY INDEX-LINKED NOTES

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ABSTRACT

- Authors:** Johan Edvardsson & Karl-Johan Ek
- Supervisor:** Anders Axvärn
- Title:** Seeking Active Returns – A Study of Restructuring Strategies for Equity Index-Linked Notes
- Keywords:** Equity index-linked notes, restructuring, structured products, index-linked products, GARCH (1,1), principal-protection, time series analysis
- Aim and purpose:** The aim of the study is to examine whether an active strategy for restructuring of equity index-linked notes can generate higher returns than a passive ‘buy-and-hold’ strategy.
- More specifically, the purpose of the study is to examine how an active restructuring strategy, using specific variables to govern market timing, for equity index-linked notes may affect the returns over a given time period, compared with a passive ‘buy-and-hold’ strategy.
- Questions at issue:** What variables affect the valuation of an equity index-linked note?
- What parameters could indicate an appropriate timing for EILN restructuring?
- How have strategies utilizing such parameters performed historically?
- Are there optimal levels for these parameters?
- How does the volatility of returns compare to the passive ‘buy-and-hold’ strategy?
- Methodology:** This study takes a positivist inductive approach in creating a MATLAB program that performs quantitative valuation of theoretically replicated EILNs from historical market data and a

time series analysis on a selection of market timing strategies in order to answer the main purpose.

Also, to answer some of the questions at issue, qualitative interviews are combined with literature studies in order to create a frame of reference.

Results:

Although not conclusive, the findings in the study indicate that a higher return can be achieved with an active strategy, using an option delta parameter as a lower limit for the relative exposure towards the underlying index and a risk-free rate factor as a relative profit taking parameter to limit relative exposure to the underlying index on the upside.

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1 INTRODUCTION

In order to provide a context to the study, this chapter aims to acquaint the reader with a background and an overview of the equity index-linked notes market in Sweden. Furthermore, the focus and limitations of the study are presented in detail and addressed to the target audience. Finally, the outline of the study is presented.

1.1 BACKGROUND

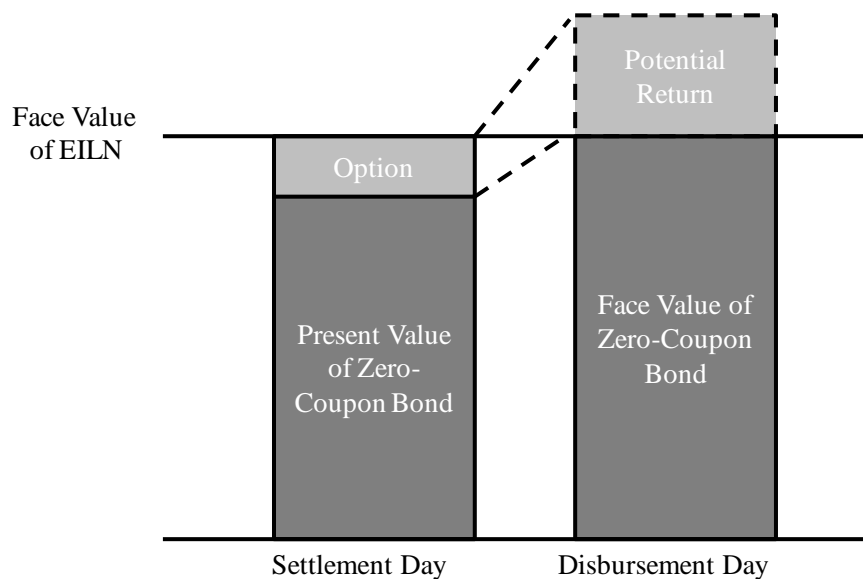
With the beginning of the twenty-first century being a “lost decade” for the Swedish stock market, due to the bust of the IT bubble and the recent global financial crisis, investors have found themselves in a difficult environment with increasing volatility and periods of sharp share price declines. During the period 31/12/1999-31/12/2009 the S&P 500 composite share index had a negative annual return of 1% and the Swedish blue chip share price index OMXS30 had a negative annual return of 2% (not adjusted for dividends). Meanwhile, as will be accounted for below, the market for structured notes in Sweden has virtually exploded, with principal-protected equity index-linked notes being the most popular variation. This suggests that investors are demanding more complex products in order to participate in the stock markets at a lower risk.

1.1.1 AN INTRODUCTION TO EQUITY INDEX-LINKED NOTES

A product of the developments in financial engineering, structured notes combine a fixed-income instrument, commonly a medium term zero-coupon bond, with a derivative, often an OTC call option, component tracking an underlying asset. When the derivative component is an equity index option, it is generally denominated as an equity index-linked note or simply EILN in its abbreviation. Typically, the note is structured as a principal-protected note with a participation rate that grants the investor a percentage of the return of an underlying equity index, or in some instances a basket of indexes. Thus, the instrument allows the investor to participate in stock market gains while providing a protection from stock market declines, in the base case that the face value is repaid in full at maturity¹. However, the potential gain comes at the expense of the foregone interest on the zero-coupon bond, which is financing the option premium. Exhibit 1.1 illustrates a conceptualized payoff schedule of an EILN.

¹ The investor is in fact also exposed to a credit risk related to the issuer of the bond.

Exhibit 1.1: Payoff schedule for an equity index-linked note



Source: Edvardsson and Ek

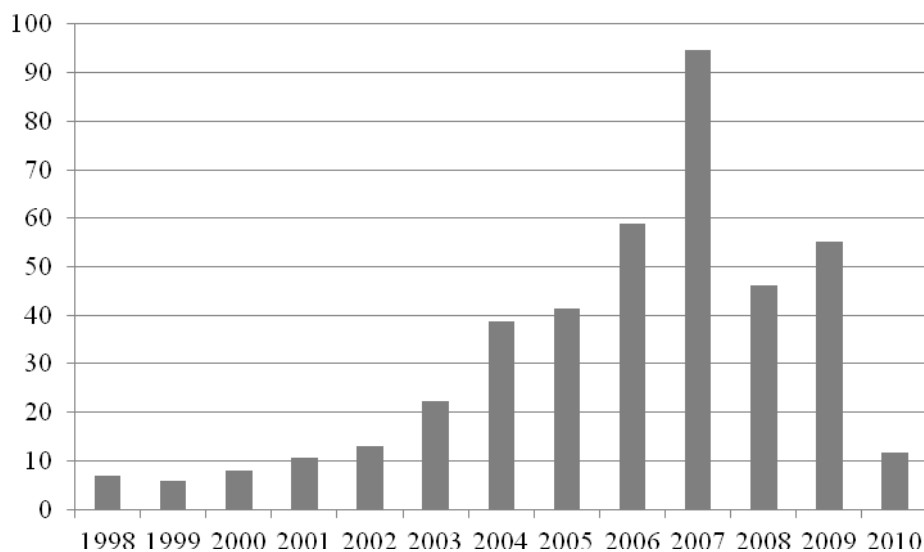
1.1.2 THE SWEDISH EILN MARKET

Since the introduction of equity index-linked notes to retail investors in Sweden during the early 1990s, the outstanding volume of these instruments increased to over SEK 175 billion in the beginning of 2010 (Exhibit A1.1). Data from Euroclear Sweden (Euroclear 1) show that annual issues grew at an annualized rate of 43% between 2000 and 2007 (Exhibit 1.2). The financial crisis did not leave this market unscathed but the issues at slightly more than SEK 55 billion in 2009 were still at a level seven times that in 2000.

As can be seen in Exhibit A1.2, the major Swedish bank quartet dominated the market with a combined market share of 69%. Other prominent market participants are large European investment banks such as UBS, RBS and Barclays, whom to a large extent are using local distributors.

While the recent development has largely been driven by retail investors, institutional investors have been an important participant in this market for a long time (HQ 1). They have specific asset allocation policies to which they must adhere, and view EILNs as a way to participate in the stock market while maintaining a specific risk level.

Exhibit 1.2: ELNs/EILNs: Issued volume in Sweden 1998-1Q2010, SEK billions



Source: Euroclear Sweden

1.1.3 CRITICISM AGAINST EQUITY INDEX-LINKED NOTES

EILNs are often marketed towards the Swedish retail investor as a “comfortable” investment that combines opportunity with safety (SHB 1, Nordea 1, SEB 2, Swedbank 1). However, the rationale for investing in these ostensibly foolproof products is not uncontested. In 2008, the Financial Supervisory Authority of Norway published a study of 350 EILNs issued on the Norwegian market by 15 banks between 1997 and the third quarter of 2007. The result of the study was that 137, or 39%, yielded a return of 0% or lower if held to maturity. Koekebakker and Zakamouline (2007) evaluated Norwegian EILNs held to maturity in the period 1998-2007 and came to the conclusion that EILNs provide a poor risk-return profile. Although there are limitations to these evaluations, which will be revisited in Chapter 3, their findings suggest that the opportunity of these products can be overshadowed by the costs of safety when held to maturity.

1.2 PROBLEM DISCUSSION

As accounted for above, the popularity of EILNs in Sweden has grown immensely during the last decade. Although some evaluations of their historical performance provide enough downbeat evidence to adopt a cautious attitude, the surging market suggests that EILNs appeal to the Swedish investor. This is most likely due to their characteristics of stock market participation combined with principal-protection.

One aspect of investing in EILNs that has received less attention is that of an active restructuring² strategy applied to these products, through the possibility of reinvesting the notes before maturity. According to Mats Söderberg, Head of Institutional Sales at HQ Structured Financial Products, most EILNs are restructured before maturity, making it an interesting area to explore further (HQ 1). An important facet of this action is that the principal-protection is only effectuated at the maturity date, resulting in the price of the EILN prior to maturity being subject to the valuation on the secondary market. Nevertheless, restructuring is commonly used as a means of taking profit when the product has increased in value, as investing in a new note yields a higher principal protection level. Conversely, when the value of the underlying index has decreased to such an extent that the market exposure of the note is negligible, giving the EILN the characteristic of a zero-coupon bond, the investor may want to restructure in order to increase market exposure towards the level initially acquired. In either way, the idea behind restructuring is to generate higher returns than a simple ‘buy-and-hold’ strategy through market timing.

Although the topic of market timing applied to the restructuring of EILNs has not attracted considerable interest in the academic world, market timing has been an area of interest for academics for a long time. In 1975, William Sharpe provided a rather pessimistic outlook; *“unless a manager can predict whether the market will be good or bad each year (e.g., be right at least seven times out of ten) he should probably avoid attempts to time the market altogether”*. Jeffrey (1984) expanded on Sharpe’s research and found that even if an investor was right two-thirds of the time, his downside risk would be nearly 50% greater than the upside reward. Even so, there are potential gains to extract from successful market timing. As Shilling (1992) illustrated, being out of the stock market during the 50 weakest months in the years 1946-1991 would have outperformed the ‘buy-and-hold’ scenario by 7.8% annually. Furthermore, some research evaluating mutual fund managers’ performance has found statistically significant timing abilities (Weigel, 1991; Bello and Janjigian, 1997; Bollen and Busse, 2001). However, these findings are not uncontested; Becker et al. (1999) found little evidence of market timing ability in their evaluation of 400 mutual funds. Furthermore, Estrada (2008) points out the effect of outliers on the long-term performance.

As there appears to be limited research on equity index-linked notes in general, and the application of market timing strategies using these securities in particular, this is the point of

² Restructuring implies a sale of existing EILN holdings on the secondary market in order to participate in new note issues.

departure for the study. With the intention to narrow down the problem, the following questions have been formalized:

Can an active strategy for restructuring of equity index-linked notes generate higher returns than a passive ‘buy-and-hold’ strategy?

To further isolate the variables affecting the main question, the following sub questions have been prepared:

What variables affect the valuation of an equity index-linked note?

What parameters could indicate an appropriate timing for EILN restructuring?

How have strategies utilizing such parameters performed historically?

Are there optimal levels for these parameters?

How does the volatility of returns compare to the passive ‘buy-and-hold’ strategy?

1.3 PURPOSE OF THE STUDY

The purpose of the study is to examine how an active restructuring strategy for equity index-linked notes, using specific variables to govern market timing of buy and sell orders ahead of maturity, affects the returns over a given time period, compared with a passive ‘buy-and-hold strategy’; i.e. holding the securities to maturity.

1.4 TARGET AUDIENCE

Although the focus lies on the perspective of the institutional investor active on the market for equity index-linked notes, the target audience of the study can be broadened to include the well informed retail investor as well as originators and arrangers of equity index-linked notes.

1.5 DELIMITATIONS OF THE STUDY

This study’s point of departure is a general evaluation of an active restructuring strategy for equity index-linked notes. In order to isolate the variables affecting the strategy and maintaining a general approach, the chosen method is that of a theoretically constructed EILN which is simulated through empirical ‘back testing’ of the strategy applied on historical data. This implies that the test is subject to the factors affecting the underlying market during the historical periods and that inferences regarding the implications in the future should be

made with caution. Additionally, the theoretical approach implies that the valuation is subject to certain valuation aspects, such as the accuracy of the chosen volatility forecasting model.

Furthermore, a number of assumptions regarding the market for, and construction of, the theoretical EILN have been made in order to isolate the major variables affecting the strategy:

1. Transaction costs and taxes are disregarded,
2. all issued notes have a structure with full principal protection,
3. constructions utilizing premiums in order to increase the participation rate are not considered,
4. the primary and secondary market is assumed to be fully liquid, meaning that transactions can be made at existing market conditions at any time during the period and at no cost related to the possible spread between bid and ask price quotations.³

Also, the simulations use the American S&P 500 composite index as the underlying index and US Treasury bills and bonds as the risk free rate when valuing the option and zero-coupon bond components of the EILN. Thus, the optimization is based on the historical conditions concerning the U.S. market and any conclusions are limited to the same.

³ Large institutional investors, through the large volumes managed, often have the possibility to tailor issues through 'private placements', implying that the timing constraint is less of an issue for some market participants (HQ 1).

2 METHOD

The following chapter describes the methodical approach of the study and introduces the models utilized. Criticism of the method, concerning validity and reliability, concludes the chapter.

2.1 TYPE OF STUDY

Eriksson and Wiedersheim-Paul (2001, p. 200) identify three categories of inference within the positivist tradition; induction, deduction and the hypothetico-deductive method. Thurén (2004, pp. 19-21) defines induction as general conclusions drawn from empirical facts while deduction implies logical conclusions based on logically coherent reasoning. The hypothetico-deductive method bases its conclusions on hypotheses that are subject to both deductive inferences and empirical tests.

The previous evaluations of EILN performance referred to elsewhere in this study have largely been conducted in studies on the return to maturity for issued EILNs, with conclusions derived through induction.⁴ This study continues the positivist inductive tradition, through a valuation of theoretically replicated EILNs from historical market data. Based on how the restructuring strategy has performed historically, generalized conclusions are drawn regarding the future applicability of the strategy.

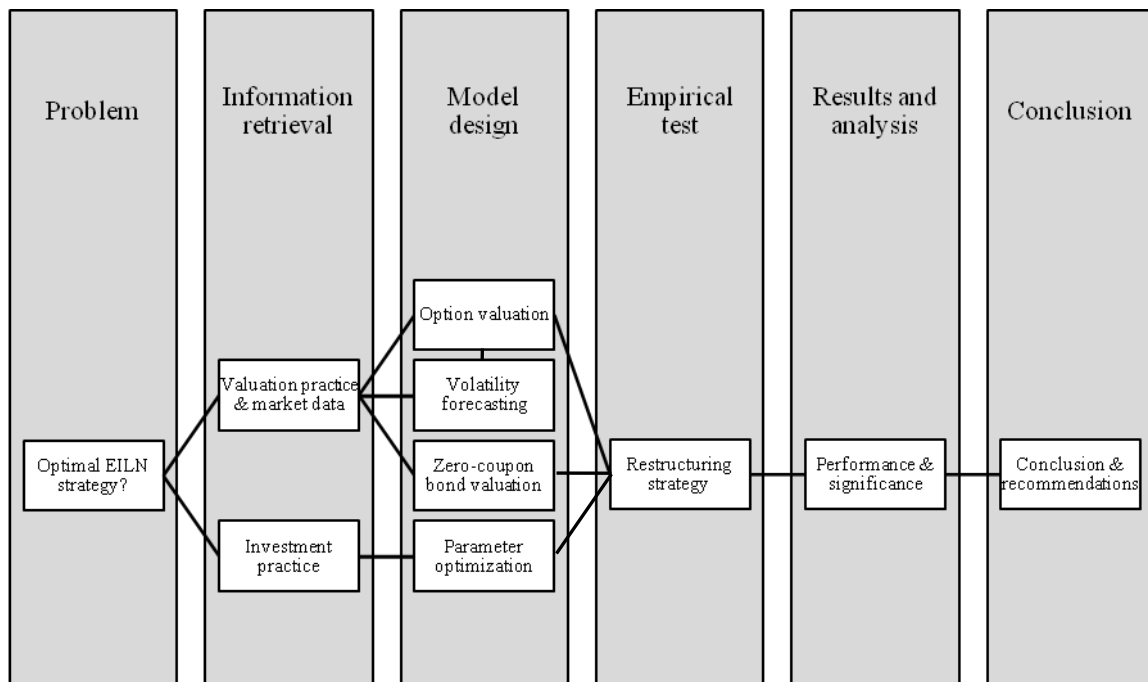
It should be noted that there are important limitations of the method on which this study is founded upon. Eriksson and Wiedersheim-Paul (2001, p. 200) point out that an inductive method is rarely based on all possible observations, implying that inferences can never be drawn with complete certainty. Furthermore, Thurén (2004, pp. 22-23) discusses the associated problems of validity and reliability, which are addressed at the end of the chapter.

2.2 DISPOSITION

In order to address the aim of the study and the associated questions formulated above properly, a methodical approach to the problem is crucial. The following sections introduce the reader to the systematic method underlying the study. Exhibit 2.1 illustrates a conceptualization of the problem approach.

⁴ Koekebakker and Zakamouline (2007) and Kredittilsynet (2008) are two examples of studies evaluating the annual return for EILNs on the Norwegian market.

Exhibit 2.1: Conceptualized problem approach



Source: Edvardsson and Ek

2.2.1 INFORMATION RETRIEVAL

An understanding of the EILN transaction and valuation process is imperative for the problem at hand. Furthermore, as the empirical test necessitates the use of theoretical valuation and forecasting models, it is important for the reader to be acquainted with the rationale behind, as well as the limitations associated with, the utilized models. Thus, a description of equity index-linked notes, together with a discussion regarding the relevant valuation models is accounted for in Chapter 3: *Theoretical framework*. Furthermore, this chapter provides an overview of previous research related to the subject. Consequently, Chapter 3 aims to answer the first sub question of what variables affect the EILN valuation.

With the foundation provided in Chapter 3, the historical market data used in the valuation model, together with the outcome of the data processing and the use of forecasting models, are presented and discussed in Chapter 4 *Data*. In addition to the literature review that forms the foundation of Chapter 3, information regarding market practice for valuation and investment in EILNs, underlying some of the model and strategy assumptions is presented in Chapter 5 *Model design and back testing*.

2.2.2 EILN VALUATION MODEL

In order to isolate the variables affecting the outcome of the restructuring strategy, a theoretical replication of EILNs is done. This approach allows for valuation of a similar note structure, with persistent characteristics over time. In reality, structural changes regarding underlying market, principal-protection, et cetera are common, making the application of a strategy on previously issued products complicated. Additionally, since the equity index-linked market is largely an over-the-counter market that is also relatively new, relevant market data for the timeframe necessary for a large enough sample, is hard to obtain.

As the theoretical valuation and back testing of EILNs are computationally intensive tasks, the commercial software MATLAB is used for the purpose of integrating the valuation model with the back testing of the restructuring strategy. Chapter 5 *Model design and back testing* provide an insight into how this is done, as well as a discussion of the valuation model and its underlying assumptions in detail.

2.2.3 RESTRUCTURING STRATEGY

The aim of the study is to examine how an active restructuring strategy for equity index-linked notes, using specific variables to govern market timing, affects the returns over a given time period, compared with a passive ‘buy-and-hold’ strategy. In order to draw conclusions through induction, a quantitative approach is warranted. However, information regarding market investment practice is attained through qualitative interviews, which provide the starting point to the answer of the second sub question of what parameters are suitable for a restructuring strategy. This information is subsequently combined with the theoretical base established in Chapter 3 in order to establish a set of parameters to be tested. The resulting hypotheses and the strategy construction are discussed in Chapter 5.

For the aim to be attained, the outcome of the active strategy must be set in relation to the passive ‘buy-and-hold’ scenario. Furthermore, the intent of the fifth sub question is to provide some understanding for how the volatility is affected.

2.3 COLLECTION OF DATA

2.3.1 PRIMARY DATA

Halvorsen (1992) defines primary data as information collected for a particular study. Primary data in this study stem from qualitative interviews with banking professionals active in the structuring and sales process. The interviews were informative in nature and were conducted in order to obtain information regarding valuation and structuring of notes as well

as market investment practice used to design the valuation model and formulate hypotheses about the restructuring strategy. Primary data is also generated by the EILN valuation and back testing procedure.

2.3.2 SECONDARY DATA

As opposed to primary data, secondary data is defined as searchable information available to the public (Halvorsen, 1992). As this study is predominantly focused on quantitative and empirical data processing, secondary data constitutes the main source of information. This comprises the market data used for EILN valuation, note prospects and issuance terms used to design the valuation model.

2.4 CRITICISM

2.4.1 VALIDITY

Validity is defined by Eriksson and Wiedersheim-Paul (2001, pp. 38-39) as an instrument's ability to measure the intended statistic. Furthermore, they distinguish internal from external validity and classify internal validity as the measurable definitions of a concept. External validity is defined as the correspondence between the measurement values resulting from the concept definition and the actual values.

As the empirical test of the restructuring strategy is based on a theoretical replication of EILNs, with omission of transactions costs and taxes, the valuation and returns of EILNs in the study fails to include an important aspect of reality. This affects the validity in the sense that the absolute values and results are not directly transferable from theory to practice. However, the purpose of the study refers to the dynamics of the valuation and strategy, and the conclusions concern this aspect. As stated above, the rationale behind the theoretical approach is to allow for isolation and measurability of the desired variables and obtain a satisfactory sample size. Nevertheless, prudence regarding the validity is warranted when interpreting the results.

2.4.2 RELIABILITY

Another important aspect of the study is the reliability of the results. This is defined as the ability of the instrument to provide reliable results (Eriksson, Wiedersheim-Paul 2001, p. 40). The valuation model and strategy back testing in this study are done in the commercial software MATLAB.⁵ A standardized program code in this software facilitates the repetition of the tests and allow for thorough error detection. The final program code is verified by

⁵ Excerpts of the code is available in Appendix 4

using input data for certain cases where the output is known. This procedure improves the reliability of the results.

3 THEORETICAL FRAMEWORK

Opening the chapter is an account of the previous research on which the study is based, followed by a more detailed description of EILNs and their construction. Thereafter, the reader is introduced to the models used in the valuation of EILNs and the active restructuring strategy, along with criticisms on the models.

3.1 PREVIOUS RESEARCH

Although equity index-linked notes were introduced in Sweden in the early 1990's, research on the topic of EILN restructuring strategies is scarce. Two evaluations of the performance of EILNs from a 'buy-and-hold' perspective on the Norwegian market have found that passive strategies applied on these products have performed poorly over the evaluated period (Kredittilsynet; Koekebakker and Zakamouline, 2007). Kredittilsynet concludes that a majority of the notes did not outperform the risk-free return in 2001 and the third quarter 2007. Koekebakker and Zakamouline (2007) argues that while the EILNs have provided protection during price declines, the limited potential they found during increases yields a meager risk-reward ratio. However, their findings are not uncontested, as the Norwegian bank DnB NOR (2007) question the method. They argue that the averaging of several products, the time period and sample used is deceptive. Despite the criticism of these evaluations, it can be noted that the view of reliance on 'buy-and-hold' strategies for investments in EILNs has been tarnished.

The question posed in this study has not been the topic of extensive research but it can be related to the well-known areas of market timing and tactical asset allocation. Market timing implies outperformance, through security and asset selection based on predictions of market movements, relative to the market portfolio of the efficient market hypothesis, and is thus doomed to fail in a perfectly efficient market (Sharpe, 1975). Philips and Lee (1989) distinguish tactical asset allocation from market timing by defining it as "*the process of tilting the strategic asset allocation to recognize valuations embedded in the financial markets at the current time*". Meanwhile, they view market timing as relying on quantitative forecasts of the equity market in order to allocate capital to or from the market. When looking at the academic research on the subject, the overall consensus is skeptical towards the likelihood of consistent out performance through market timing.

In his influential paper, Sharpe (1975) identifies the lure of market timing but concludes that it is unlikely to achieve long-term incremental returns higher than four per cent annually.

When comparing versus a ‘buy-and-hold’ strategy, the predictive ability of the “market timer” needs to be above 82% in order to generate an advantage. Sharpe based his research on data from 1933-1972 and was supported by Jeffrey (1984) who looked at the period 1926-1982. In that period, the worst case scenario would have returned -6.4% annually, compared to the best case of +12.1% and a real return of the S&P 500 of +6%. The conclusion was that the downside risk was greater than two times the upward reward. While Jeffrey (1984) expanded on Sharpe’s (1975) test by looking at quarterly timing for a separate period, Droms (1989) went even further and evaluated both quarterly and monthly timing in addition to the annual base case. Furthermore, three sub-periods were included. While Droms (1989) found that higher frequency in market timing increased potential returns and lowered necessary timing accuracy, the associated transactions costs reduced the advantage. Despite his findings, the conclusion was that the accuracies needed are so high as to be unlikely for most managers. Chua and Woodward (1987) pointed out that forecasting bull markets is relatively more important than forecasting bear markets, something that Droms (1989) too recognized. Recently, Estrada (2008) used the concept of “Black Swans” introduced by Taleb (2007) to explain the importance of market timing. Meanwhile, several studies evaluating the market timing skills of fund managers (e.g. Cheng and Lewellen, 1984; Becker et al., 1999; Chen et al.; 2000) find little or weak evidence that mutual funds are able to time the market.

Despite the convincing research above, there is research, such as Shilling (1992), that argues that because of the potential gains of staying out of or shorting the markets during a bearish sentiment, the investor should not overlook this option completely.

3.2 EQUITY INDEX-LINKED NOTES

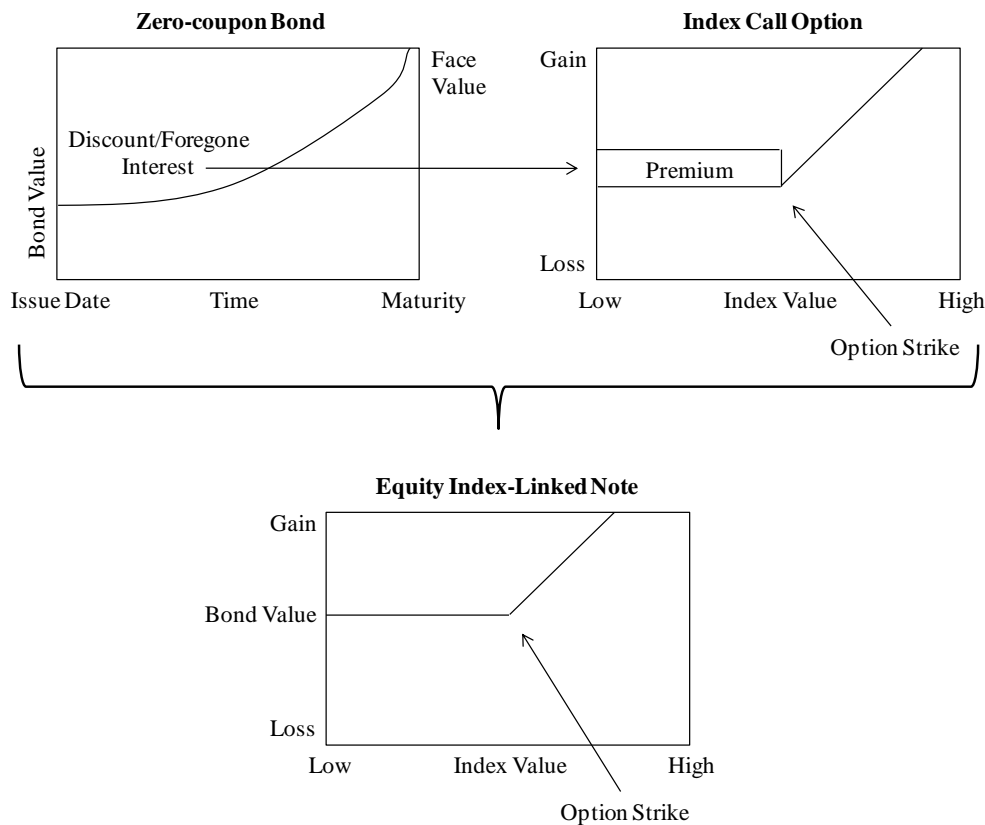
A structured note is a derivative-embedded, or hybrid, security combining a fixed-income component and a derivative component. Das (2001, p. 509) defines equity index-linked notes as “*fixed income securities where the interest coupons and/or principal of the instrument is linked to the movements in equity market indexes.*” As other structured notes, EILNs are considered a member of the general structured products family. Although many variations of EILNs exist, this study focuses on the principal-protected note often seen on the Swedish market at the time of writing. The following section serves as an introduction to the reader of the construction, transaction process and valuation of this particular case of EILN.

3.2.1 STRUCTURE

In essence, the principal-protected EILN is constructed through the combination of a zero-coupon bond and a call option. Due to the comparatively long duration and specific terms, the option component must be structured over-the-counter, as the standardized exchange traded options may not offer the conditions necessary. The note is targeted at investors that are risk averse and offers a low risk index exposure through foregone interest on the bond, as the interest that would otherwise be collected at maturity is used to finance the purchase of the call option (Das, 2001, pp. 536-537). The result is an asymmetric payoff structure, with participation on the stock market, while having a capital protection provided by the bond. See Exhibit 3.1 for a conceptualized illustration of the structural components of the note. Depending on how many options can be bought for the difference between the bond value at the issue date and its face value, the investor is entitled a percentage, or participation rate, of the return of the underlying index (Das, 2001, p. 540; Carnegie 1).

Structural variations including coupons, premiums, lower principal-protection and capped participation-level can be used to tailor the note based on the investors' attitude to risk. Aside from the principal-protection structure, there are also yield-enhancement structures, designed to enhance coupon yields (Das, 2001, pp. 521-536). These will not be elaborated upon, however, as the focus of this study is on the basic principal-protected structure described above.

Exhibit 3.1: Structural components of a principal-protected EILN



Source: Adapted from Das (2001, p. 542)

3.2.2 VALUATION

An equity-index linked note is a special case of structured notes, where the derivative component has an equity index as its underlying asset. Das (2001, pp. 899-904) argues that the isolation of credit and market risk affects the valuation through the combination of value drivers for the respective components, and that the correlation effect between the two should be incorporated in the valuation. However, Das also notes that this factor is not always reflected in the market prices. For the purpose of simplicity, possible correlation effects are assumed to be priced in throughout this study.

3.3 BONDS

The fixed income component is backed by a guarantor, most commonly a bank with an investment-grade rating. For institutional investors, policies dictate the demanded rating and dictate a rating of AAA, which in effect implies the guarantor being backed by a nation, which in Sweden applies to Kommuninvest of Sweden and the Swedish Export Credit Corporation (HQ 1). The guarantor is not necessarily the same institution representing the counterparty of the OTC option agreement.

3.3.1 EILN VALUATION

The valuation of an EILN can be done by valuing the separate constituents, namely the derivative and bond component. The potential effect of correlation discussed in Chapter 3 is overlooked in the valuation model described below, as market data constitutes the input. Furthermore, no distinction is made between the valuation of an EILN at issue and that on the secondary market. As stated in the delimitations section of the introduction, transactions costs and taxes are disregarded, with no effect on the valuation. These are measures taken in order to simplify the model, as an attempt to isolate the main variables affecting the restructuring strategy and mitigate the potential influence of residual factors. Consequently, the face value of an EILN in the valuation model follows by Equation 1:

$$FV_{EILN} = ZB + c \times N_c \quad \text{Equation 1}$$

Where ZB is the present value of the zero-coupon bond, c is the price of the call option and N_c is the number of options afforded by the difference between the face value of the EILN and present value of the zero-coupon bond. The principal-protection, which is assumed to be 100% at the date of issue throughout the sample periods, imply that face value of the EILN at issue equals the face value of the zero-coupon bond at maturity.

3.3.2 ZERO-COUPON BOND VALUATION

Valuation of the bond is calculated by discounting the future cash flow as a function of the time to maturity, t , and a discount rate, r , which is the risk free rate, r_f , plus a risk premium, rp , corresponding to the risk level of the bonds embedded in the EILNs issued on the market.

$$r = r_f + rp \quad \text{Equation 2}$$

As zero-coupon bonds do not provide a frequent coupon, but are priced at a discount at issue, they are valued according to Equation 3:

$$ZB = FV_{ZB} \times e^{-rT} \quad \text{Equation 3}$$

Where FV_{ZB} is the face, or par, value of the bond, r is the discount rate and T is time to maturity. Since the valuation needs to be done continuously during the duration of the bond, the discount rate at time t needs to be approximated for odd periods. This is done through linear interpolation, as explained in Chapter 4.

3.3.3 OPTION VALUATION

European call options on indexes are valued as calls on dividend-paying stocks (Hull, 2008, p. 332). Thus, the option component is valued through the Black-Scholes-Merton model for European dividend-paying options according to Equation 4 (ibid. p. 331):

$$c(t) = S_t e^{-q(T-t)} N(d_1) - K e^{-r(T-t)} N(d_2) \quad \text{Equation 4}$$

where

$$d_1 = \frac{\ln\left(\frac{S_t}{K}\right) + \left(r - q + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}}$$

$$d_2 = d_1 - \sigma\sqrt{(T-t)}$$

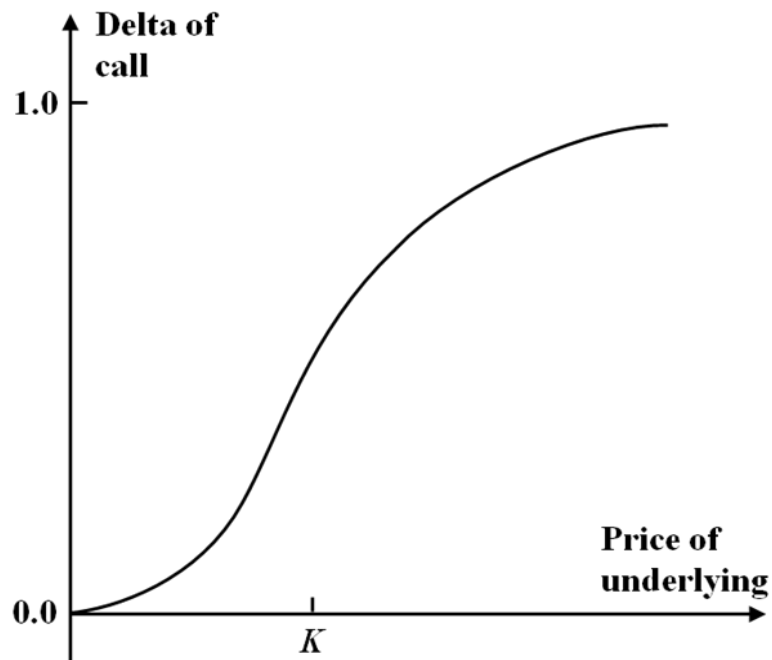
S_t is the value of the underlying index at time t , T is the duration, K is the strike price of the call option, q is the mean value of the yearly dividend from the constituent equities of the index, r is the risk free rate and σ is the volatility. For the purpose of the empirical test of the study, historical market data is used regarding r , K and S_t . As the option component of EILNs are generally issued at-the-money (ATM), it is assumed that $K = S_t$ at the time of issuance (Carnegie 1).

While European options are used in the valuation of the replicated note structure, it is more common to use Asian options in the issues observed at the time of writing (Carnegie 1). Thus, the results from the empirical test are not necessarily directly applicable on notes currently issued on the market.

3.3.4 DELTA

In order to control the risk related to index options, traders strive to manage the “Greek letters”, or simply the “Greeks” Hull (2008, p. 341), each of these letters measures the risk in one dimension of the option. The delta measures the rate of change of the option price in relation to the price change of the underlying index. Exhibit 3.2 illustrates how delta for a call option changes as the underlying index price changes.

Exhibit 3.2: Variation of call delta with price of underlying



Source: Adapted from Hull (2008, p. 362)

As the price of the underlying index increases, delta increases, and vice versa. An implication of this behavior is that the price of an index call option becomes more sensitive to further price changes in the underlying index if the index has performed well since the option was bought. Conversely, the price of an index call option becomes less sensitive to further price changes in the underlying index if the index has performed poorly since the option was bought.

3.4 VOLATILITY FORECASTING

If the volatility of the price of an asset is high today, it is more likely to be high tomorrow and, conversely, if the volatility is low today, low volatility can be expected tomorrow. This behavior has been confirmed in numerous studies and was one of the first documented features of the volatility process. Another property of volatility is mean reversion, meaning that volatility tends to go back to a certain “normal level” after periods with higher or lower volatility (Engle and Patton, 2000).

If a certain model is used to forecast volatility the above stated properties have to be taken into consideration in the model. When the BSM model is used for options pricing most parameters are observable through market data. However, volatility needs to be forecasted. Thus, an accurate forecasting model is essential in order to price an option correctly.

A commonly used method among traders is to use the implied volatility as input in the B&S model. Canina and Figlewski, (1993) found implied volatility to be a poor forecast of subsequent realized volatility in a study performed on the S&P 100 index options. One of their conclusions was that “*implied volatility has virtually no correlation with future volatility*”.

An OTC option in an EILN often has much longer time to maturity than a standardized index option. Therefore, implied volatility derived from exchange traded, standardized, index options should not be applied as a long-term volatility estimate for the OTC options. Furthermore, as Rubinstein (1985) noted, the market constantly distorts the implied volatility, into what is commonly referred to as a ‘volatility smile’, depending on the options strike price. Thus, it is warranted to use another approach than implied volatility when pricing the option component of an EILN (Carnegie 1). One approach is to use data of traded volatility on OTC options with similar duration and optimize a best fit function as a forecasting measure (SEB 2; Carnegie 1). However, as this is internal information often kept within the major investment banks, there are notable difficulties in obtaining sufficient data. Other approaches use historical, or realized, volatility to model implied volatility.

3.4.1 EXPONENTIALLY WEIGHTED MOVING AVERAGE

The exponentially weighted moving average (EWMA) is a commonly used⁶ model utilizing realized volatility. The model take into consideration that volatility is not constant. Equation 5 illustrates the predicted volatility by EWMA for a large number of observations, m :

$$\sigma_n^2 = (1 - \lambda) \sum_{i=1}^m \lambda^{i-1} u_{n-1}^2 \tag{Equation 5}$$

σ_n is the estimated volatility for day n , u_{n-1} is the most recent daily percentage change in the security and the weight factor λ is a constant number between 0 and 1. RiskMetrics, in its Technical Document from 1996, recommends a λ value of 0.94 for the best forecast of the variance.

3.4.2 GENERALIZED AUTOREGRESSIVE CONDITIONAL HETEROSKEDASTICITY MODEL

Apart from the non-constant volatility assumption, the generalized autoregressive heteroskedasticity model (GARCH) also considers the historical variance rate V_L and the

⁶ See RiskMetrics Technical Document (1996).

estimate that was made at the end of day $(n-2)$ of the volatility for day $(n-1)$. The GARCH(1,1) model is presented in Equation 6:

$$\sigma_n^2 = \gamma \mathcal{W}_L + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2 \quad \text{Equation 6}$$

where

$$\gamma + \alpha + \beta = 1$$

γ , α and β are the weights assigned to the each variable. Among different GARCH models Engle and Patton (2000) suggests the GARCH(1,1) model as the best volatility forecasting model in the GARCH family and Hull (2008, p.465) states that GARCH(1,1) is the far most popular GARCH model.

Equation 6 can be simplified to Equation 7, in order to facilitate estimation of the weight parameters.

$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2 \quad \text{Equation 7}$$

where

$$\omega = \gamma \mathcal{W}_L$$

Hull (2008, p.468) describes how the weights, based on a probability approach, can be estimated from historical data by means of the Maximum Likelihood Method. From a sample of m observations, i.e. trading days, the values for the parameters ω , α and β that represent the most likely estimate for tomorrow's volatility are those that maximize Equation 8:

$$\prod_{i=1}^m \left[\frac{1}{\sqrt{2\pi v_i}} \exp\left(\frac{-u_i^2}{2v_i}\right) \right] \quad \text{Equation 8}$$

where

$$v_i = \sigma_n^2$$

Maximizing an expression is the same as maximizing the logarithm of the expression. By ignoring constant multiplicative factors, the derivation is reached in Equation 9:

$$\sum_{i=1}^m \left[-\ln(v_i) - \frac{u_i^2}{v_i} \right] \quad \text{Equation 9}$$

3.4.3 CRITICISM OF THE GARCH(1,1) MODEL

The GARCH(1,1) model assumes that the volatility of an asset is affected symmetrically to increases and decreases in the value of the asset. Engle & Patton (2000) points out that due to leverage effects, and sometimes risk premium effects, negative shocks in stock prices will have more impact on the volatility than when a stock's prices dramatically increases. Engle & Patton (2000) suggest the Threshold GARCH model (TARCH) when these kinds of effect are taken into consideration. The criticism has been taken into consideration throughout the back testing, by using a five year period of historical data and a continuous optimization process. An additional point brought forward by Figlewski (1997) is the difficulties of estimating long-term volatility with GARCH models. Although no particular adjustment has been made to overcome this issue, the comparison with EWMA motivates the use of GARCH(1,1).⁷

⁷ See Chapter 4 and Appendix 3.

4 DATA

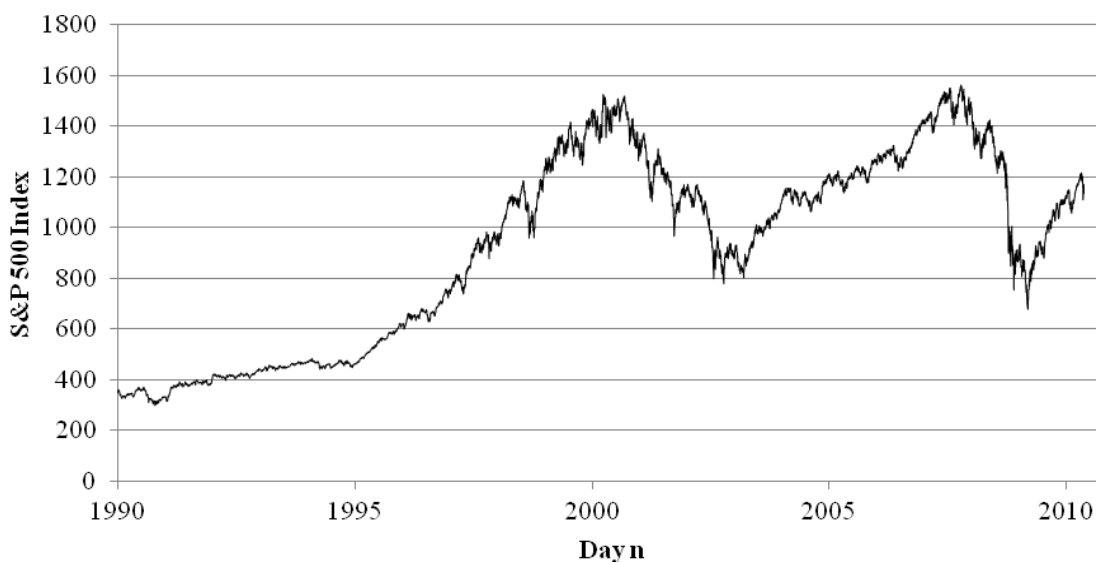
Data provided as input to the valuation model is presented in this chapter. Market quotes of the underlying index and relevant interest rates as well as the GARCH volatility forecasting method is discussed.

4.1 UNDERLYING INDEX

In a global perspective the Swedish stock market is relatively small. The US stock market, however, is the largest in the world, far more liquid than the Swedish, and provides a longer set of historical data (WFE 1). Thus, the study can subsequently easily be applied on other time periods or markets. Hence, an empirical study on the U.S. market is a natural point of departure. See Exhibit 4.1 for a time series of the S&P 500 Index.

When back testing historical performance generated by trading strategies, it is necessary to recreate the informational environment to the greatest extent possible. An example; yesterday we did not know what we know today and what was known 19 years ago was not known 20 years ago. This is why the history has to be modeled in a way that everything that has happened before a certain day is assumed to be known whereas everything that happened after this certain day is unknown. In this study, historical data is collected so that the history can be “recreated” for every trading day from 1990-01-02 to 2010-05-14. All Market data is gathered from the commercial software Thomson Reuters DataStream.

Exhibit 4.1: Time series of the S&P 500 Index



Source: Thomson Reuters DataStream

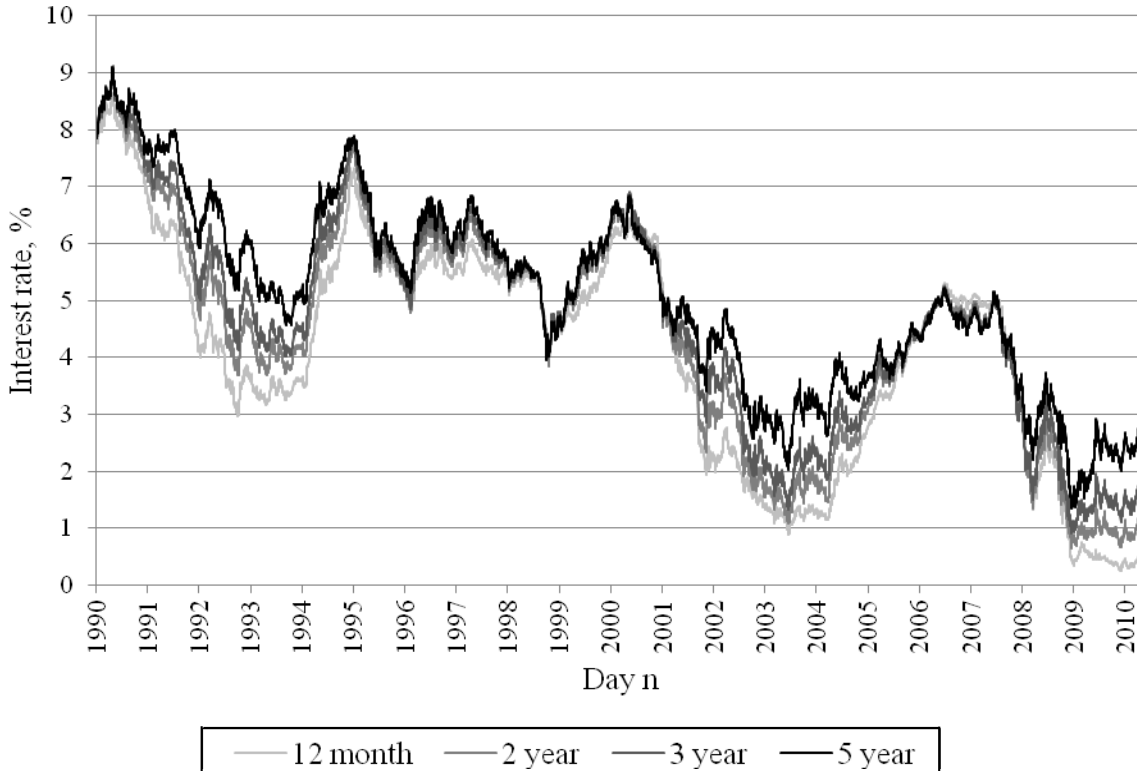
4.2 RISK FREE INTEREST RATE

4.2.1 TREASURY BILLS AND BONDS

Proper valuation of bonds and options require that the proper risk free interest rate is used. Treasury rates are commonly used benchmarks for the risk free rate. Hull (2008, p.76) claims, however, that derivative traders on AA-rated financial institutions, especially those on the OTC-market, use the LIBOR rate instead of treasury rate as risk free rate. This is because they regard the LIBOR rate as their opportunity cost of capital. As the primary target audiences of this study are institutional investors, often demanding an AAA-rated guarantor, the treasury rate is assumed to be the correct benchmark of risk free rate when valuing both bonds and options.

Daily market yields for US treasury bills with constant maturities of 3, 6 and 12 months and US treasury bonds with constant maturities of 2, 3 and 5 years constitute the basis for the interest rate interpolation. A time series of historical treasury rates for maturities of 1, 2, 3 and 5 years are from 1990 to 2010 are presented in Exhibit 4.2.

Exhibit 4.2: Time series of selected T-Bills and T-Bonds



Source: Thomson Reuters DataStream

4.2.2 LINEAR INTERPOLATION

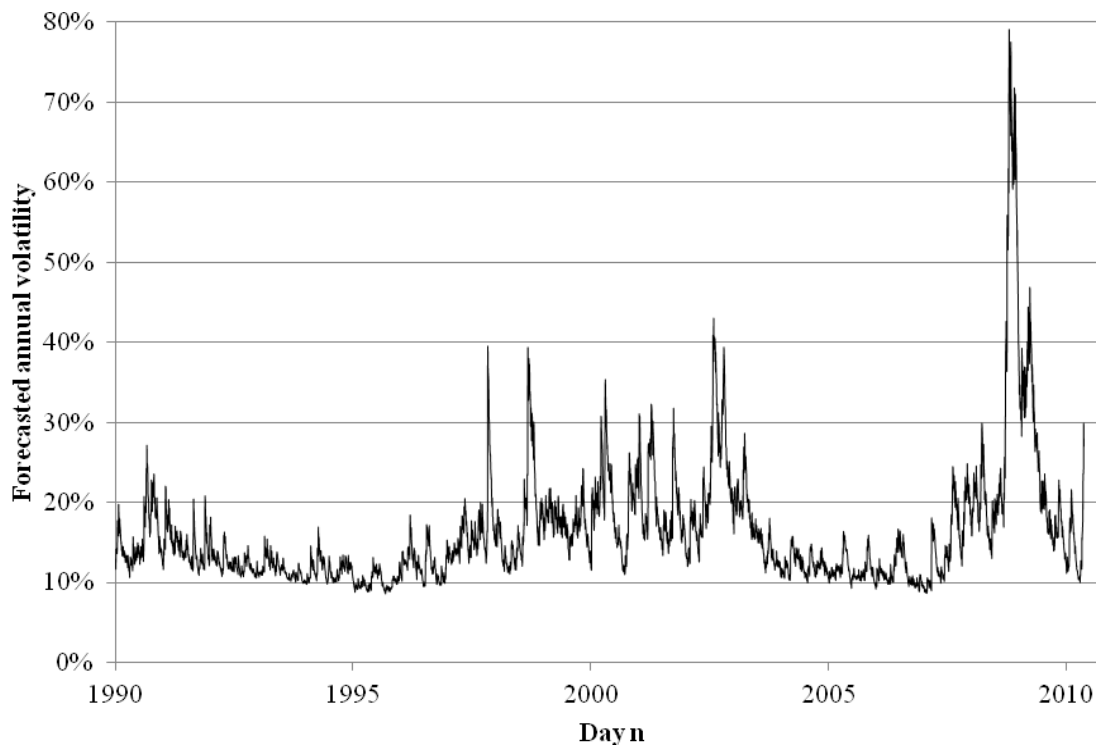
Linear interpolation is performed in-between the maturity intervals and yields with maturity of less than 3 month are assumed to have the same yield as the 3 month yield. This is, according to Hull (2008, p.84), a commonly used approach to solve for uneven maturities. Linear interpolation is essentially an averaging technique assuming a linear relationship between rates at $t_1 < t_2$ commonly used by financial market participants (ISDA, 2006). Equation 10 illustrates this concept.

$$r_t = \frac{r_1 \times (t_2 - t_t) + r_2 \times (t_t - t_1)}{t_2 - t_1} \quad \text{Equation 10}$$

4.3 VOLATILITY FORECASTING

In order to price an index option on a daily basis, the expected volatility has to be forecasted daily. Thus, the parameters ω , α and β has to be estimated for each day, which implies that Equation 9 in Chapter 3 has to be maximized each trading day from 1990-01-02 to 2010-05-14 based on historical data known up until the historical trading day. The optimization of the parameters in the GARCH(1,1) model is done in MATLAB, based on closing prices on the S&P 500 from 1982-01-01 up until each historical trading day from 1990-01-02 to 2010-05-14. For the engrossed reader, estimates of α , β and γ used in the back testing are available in Appendix 3. Exhibit 4.3 illustrates the volatility on an annual basis predicted for day n by the GARCH(1,1).

Exhibit 4.3: Time series of forecasted volatility using GARCH(1,1)



Comparing GARCH(1,1) with EWMA, it is shown that the two models give very similar predictions of the volatility.⁸ However, the EWMA model is not mean-reverting. As a consequence, the EWMA model does not offer the same possibilities as the GARCH(1,1) model when it comes to forecasting volatility several periods into the future.

The effectiveness of the GARCH model is judged by analyzing the autocorrelation of the derived values. A number close to zero indicate low autocorrelation, implying the model has succeeded in explaining the autocorrelation of u_i^2 . Although the results from the test⁹ show that some autocorrelation persists, the numbers are generally low, indicating that the model has helped explaining the autocorrelation of the stock price variance (Hull, 2008, pp.486-487).

⁸ For a graph over the EWMA forecast, see Exhibit A3.1 in Appendix 3.

⁹ See Exhibit A2.5 in Appendix 2.

4.3.1 VOLATILITY TERM STRUCTURE

GARCH(1,1) can not only be used to forecast the volatility of the next day, but also to forecast the volatility for a certain amount of days into the future (Hull, 2008, pp. 487-490). Since the model is mean reverting, a forecast of the future variance will get closer and closer to the long run variance as the number of time units increase. Based on the GARCH(1,1) model, Equation 11 can be used to calculate the annual volatility, used to price an option with a time to maturity of T trading days, on a daily basis:

$$\sigma(T) = \sqrt{252 \left(V_L + \frac{1 - e^{-AT}}{AT} [V(O) - V_L] \right)} \quad \text{Equation 11}$$

where

$$A = \ln \left(\frac{1}{\alpha + \beta} \right)$$

$V(O)$ is the forecasted variance on daily basis for the next day. As T increases $\sigma(T)$ will get closer to $\sqrt{252 \times V_L}$, which is exactly what can be expected from a mean reverting volatility forecast method.

5 MODEL DESIGN

This chapter provides the reader with a description of the valuation model, the restructuring strategy and the back testing procedure. Furthermore, the underlying assumptions are discussed and defined. Also, the MATLAB programming is commented.

5.1 VALUATION MODEL

With the framework for valuation established in Chapter 3, and the market data provided in Chapter 4, this section intends to provide the reader with an understanding of the model used for valuing the EILNs throughout the sample period.

5.1.1 EILN VALUATION

As noted in the introduction, and discussed in Chapter 3, the valuation of an EILN can be done by valuing the separate constituents, namely the derivative and bond component. The potential effect of correlation discussed in Chapter 3 is overlooked in the valuation model described below, as market data constitutes the input. Furthermore, no distinction is made between the valuation of an EILN at issue and that on the secondary market. As stated in the delimitations section of the introduction, transactions costs and taxes are disregarded, with no effect on the valuation. These are measures taken in order to simplify the model, as an attempt to isolate the main variables affecting the restructuring strategy and mitigate the potential influence of residual factors. Consequently, the face value of an EILN in the valuation model follows by Equation 12:

$$FV_{EILN} = ZB + c \times N_c \quad \text{Equation 12}$$

Where ZB is the present value of the zero-coupon bond, c is the price of the call option and N_c is the number of options afforded by the difference between the face value of the EILN and present value of the zero-coupon bond. The principal-protection, which is assumed to be 100% at the date of issue throughout the sample periods, implies that the face value of the EILN at issue equals the face value of the zero-coupon bond at maturity.

5.1.2 MARKET PRACTICE

According to Mats Söderberg, Head of Institutional Sales at HQ Structured Financial Products, a majority of the issued EILNs are restructured before maturity. Institutional investors commonly have internal policies regarding asset allocation and uses highly rated (often AAA, through Kommuninvest or the Swedish Export Credit Corporation) EILNs as a way to increase potential return on the bond portfolio. Accordingly, it is common to take

profit when these notes have performed better than the interest rate for bonds with equivalent rating and maturity. Due to their policies, institutional investors are arguably interested in risk-adjusted returns relative to the prevailing interest rate level to a larger extent than retail investors. Furthermore, institutional investors frequently analyse the potential of the underlying index, which, quite naturally, is a particularly important factor in restructuring scenarios where increased market exposure is the intent.

5.1.3 RESTRUCTURING PARAMETERS

With a starting point in the current market practices, previously described, parameters for restructuring in order to take profit and increase market exposure have been designed. Henceforth, the denotation for the parameters are ‘upper limit’, implying profit taking, and ‘lower limit’, implying increased market exposure. The back testing serves to find levels of these parameters that, with a certain degree of statistical significance, can be said to have generated an active risk adjusted return compared to a passive ‘buy-and-hold’ strategy, where EILNs are reinvested only at maturity. In order to relate these parameters to the prevailing mindset of institutional investors, the upper and lower limit have been adapted from the take profit and increased market exposure scenarios, where the upper limit consists of a risk-free rate multiplier and the lower limit a delta value. A conceptualized comparison of the restructuring strategy and the ‘buy-and-hold’ strategy is provided in Exhibit 5.1 below.

Exhibit 5.1: Restructuring strategy versus ‘buy-and-hold’

Restructuring strategy (active)	‘Buy-and-hold’ strategy (passive)
Restructures when: <ul style="list-style-type: none"> ▪ $V_{EILN} = FV_{EILN} (1 + X \times r_{f_{5yr}})^5$, or ▪ when $\Delta_c = D$, or ▪ when $t_n = T$ where <i>X</i> : upper limit, i.e. risk-free rate multiplier <i>D</i> : lower limit, i.e. delta value <i>t_n</i> : time since issue <i>T</i> : time to maturity at issue	Restructures at: <ul style="list-style-type: none"> ▪ maturity, $t_n = T$ where <i>t_n</i> : time since issue <i>T</i> : time to maturity at issue

5.2 TIME SERIES ANALYSIS

A combination of 9 different restructuring levels for the upper limit (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, and 4.0 times the risk-free interest rate + No Limit for upper side) combined with 7 levels for the lower limit (delta value of option: 0.05, 0.10, 0.15, 0.20, 0.25, 0.30 and No Limit) results in a total of 63 different strategies (9*7=63). One of these strategies, without limit on the upper side nor the lower side [NL,NL], is the ‘buy-and-hold’ strategy. The daily return of the 62 other strategies have been compared to the daily return of the ‘buy-and-hold’ strategy.

The comparison is based on 2,520 observations of the daily return since each strategy is tested in a span of ten year, i.e. 252*10=2,520 trading days. The first span of 2,520 trading days reaches from 1990-01-02 to 1999-12-21, the time span is then shifted in steps of five trading days ahead in time so that the second span reaches from 1990-01-09 to 1999-12-28. A total of 520 different time spans are tested¹⁰, see Appendix 3, where the last span reaches from 1999-12-14 to 2009-12-01. Each of the 63 strategies is applied in each time span so that the statistical test is performed for each strategy in each of the 520 spans.

5.3 STATISTICAL ANALYSIS

5.3.1 LINEAR REGRESSION ANALYSIS

The main purpose in a linear regression analysis is to relate two variables, x and y , to each other and to assign parameters α and β for the most likely linear relationship between the parameters according to Equation 13 below.

$$f(x) = y = \alpha + \beta x + e \quad \text{Equation 13}$$

From a sample of n observations of variable X , $x_i = (x_1, x_2, \dots, x_n)$, and variable Y , $y_i = (y_1, y_2, \dots, y_n)$, a linear regression line can be calculated by minimizing the squared deviations in Equation 13, according to Equation 14, in order to find the most likely values for α and β .

$$\sum_{i=1}^{i=n} [y_i - (\alpha + \beta x_i)]^2 \quad \text{Equation 14}$$

¹⁰ See Appendix 3 for a list of all evaluated time periods

The line that is obtained when α and β have been found is referred to as the least square line, or sample regression line (Devore & Farnum, 2005, pp. 116). A common way to determine the accuracy of the linear regression is to calculate the R^2 value where a value equal to 1 indicates 100 % accuracy, i.e. a straight line of the distribution.

5.3.2 STATISTICAL SIGNIFICANCE

Comparing daily return from an active to a passive strategy is an essential part in this study. The difference in daily returns between an active strategy and a ‘buy-and-hold’ strategy is defined in Equation 15.

$$R_{AP} = R_A - R_P \quad \text{Equation 15}$$

The null hypothesis, H_0 , is that R_{AP} is equal to zero (i.e. no difference in daily return) and the alternative hypothesis, H_1 , is that R_{AP} is not equal to zero.

$$H_0 \rightarrow R_{AP} = 0$$

$$H_1 \rightarrow R_{AP} \neq 0$$

Furthermore, Equation 16 is used in order to find the z-value.

$$z - stat = \frac{R_{AP\ mean} \times \sqrt{n}}{\sigma_{AP}} \quad \text{Equation 16}$$

Where $R_{AP\ mean}$ is the mean value of the difference in daily return for each day and σ_{AP} is the standard deviation for R_{AP} . These metrics are the constituents of the information ratio (*IR*), defined as $R_{AP\ mean} / \sigma_{AP}$; a common measure of risk adjusted return.

By means of tabulated data for two tailed tests, the P-value or the observed confidence level can be found.

A prerequisite for using Equation 16 is that the sampling distribution is approximately normally distributed. As highlighted in the quote by Lee et. Al. (2000) below, the definition of the central limit theorem allows for the assumption of a normal distribution in a ‘large enough’ population, which is the case in this study.

“As the sample size (n) from a given population gets “large enough” the sampling distribution of the mean can be approximated by a normal distribution regardless of the distribution of the individual values in the population”

Hence, as this study encompasses 2,520 observations the central limit theorem is considered to hold, implying that Equation 16 can be used.

5.4 MATLAB

A central part of this study has been to construct a program code in the commercial software MATLAB R2010a. MATLAB is a powerful tool when it comes to repetitive calculations with large amount of data.

The main purpose of the program code is to calculate the value of the replicated EILN and to measure the performance of a restructuring strategy for each trading day for a long time frame. The simulation should, at the same time, restructure the EILN when predefined conditions are met.

The entire simulation code is presented in Appendix 3. Understanding of the different steps in the code requires in deep knowledge about programming language, mathematical vector operations and about MATLAB itself. To give the reader an overview of how the simulation works, an overall summary of the steps in the code are presented in the following.

1. Initially, market data for each trading day in the entire test period is uploaded as vectors and matrixes such as:
 - Dates for each trading day in the test-period
 - Yields for Treasury bills and Treasury bonds for each trading day
 - Data for the volatility (earlier optimized in MATLAB according to the GARCH(1,1) model) so that the implicit volatility can be approximated for each trading day in the period as a function of the time to maturity of the option.
 - Market data for SP500 including data for dividend yield for each trading day.
2. The restructuring strategy is set with conditions for when the EILN should be restructured.
3. The “start date” and the “end date” of the test period are set so that the total length of the test period equals ten years.
4. The EILN is then constructed (“bought”) at the first day in the test period according to valuation models presented earlier in this study.
5. Once the EILN has been constructed, the code loops through and calculates the market value of the EILN each trading day in the test period. If predefined limits for

restructuring are reached, the EILN is “sold” to its market value and a new EILN is constructed (“bought”) in accordance with the market conditions for the actual trading day.

6. The simulation is ended when the predefined duration for the test period (after 10 years) is reached.
7. The “start date” and “end date” is then increased with 5 trading days (one week) and the simulation is once again performed according to step 3-6 above.
8. Once the strategy has been simulated in all test periods (520 different periods) a new strategy is chosen and step 2-7 is once again performed.

Required output data is gathered in vectors and matrixes each trading day of the simulation, for each strategy, in each test period.

5.4.1 VALIDATION OF THE PROGRAM CODE

Testing several strategies for several time periods with steps of one trading day requires quite a large amount of computer power. When 63 strategies are simulated each trading day in 520 different time periods, each containing 2,520 trading days, the valuation of the EILN is performed a total of 82,555,200 times ($63 \times 520 \times 2,520$). Each of these valuations requires, in turn, several calculations. Verifying each single calculation is of course impossible. However, since all calculations follow a repetitive pattern, it is still possible to verify the accuracy of the MATLAB code. The final simulation code is in fact a result of several smaller sub-codes. In each of these sub-codes, input data, with known outcome, has been used in order to verify the accuracy.

6 RESULTS ANALYSIS

The results of the study are summarized and commented in the following chapter.

6.1 RETURN AND VOLATILITY

Overall, it appears that the active strategies, described in Chapter 5, on average delivered a higher return at a lower volatility during the tested periods. A summary of each active strategy's average performance relative the passive strategy is displayed in Exhibit 6.1, which depicts each strategy's average annual return and its average annual volatility. The average annual return for the 'buy-and-hold' strategy for each of the studied time periods was 9.75% and the corresponding average annual volatility was 14.44%. Meanwhile, a majority of the average outcomes for each strategy over all time periods are positioned in the upper-left quadrant in the chart below; indicating that a majority of the active strategies on average have rendered higher returns with a lower standard deviation than a passive strategy in the studied time periods.

Exhibit 6.1: Realized annual return and volatility

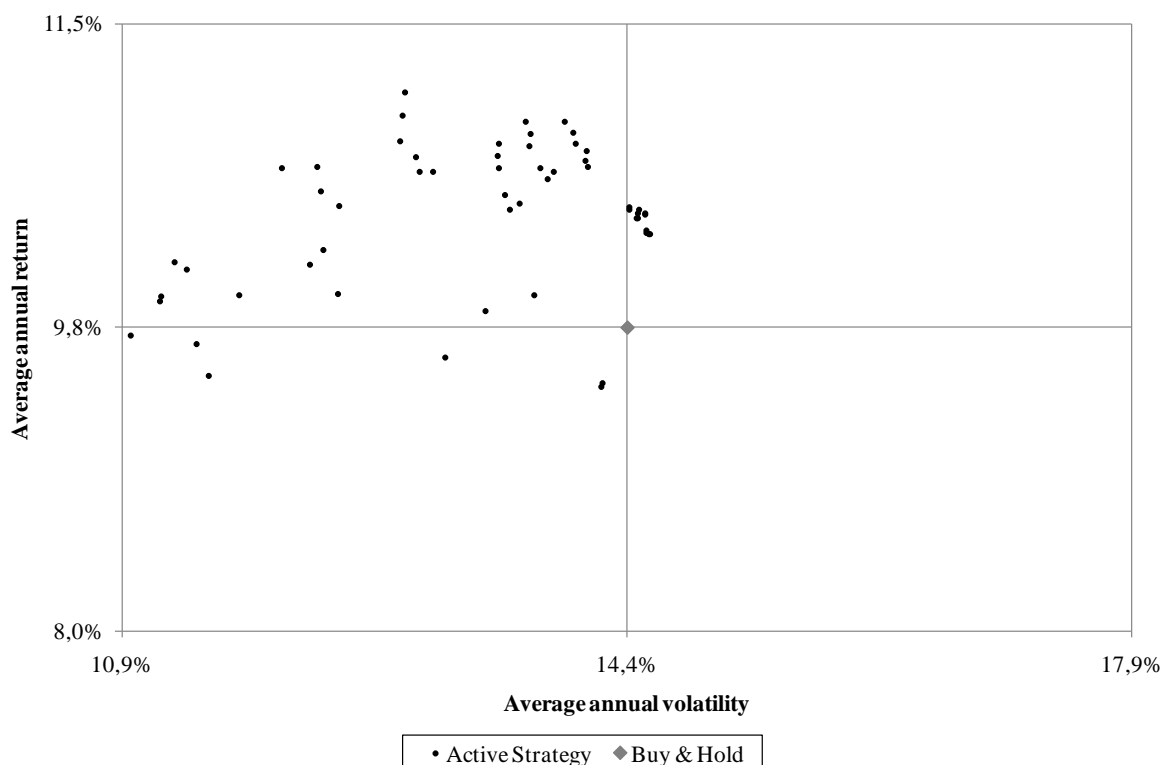


Exhibit 6.2 shows the average annual return for each active strategy in the 520 studied time periods as well as the passive strategy [UL=NL,LL=NL]. As the average returns for each strategy do not show any significant differences, it is difficult to draw any major conclusions from the data. However, it can be noted that having no lower restructuring limit at all, in this study, yielded a lower average annual return, compared to all the active strategies with a restructuring limit linked to the option delta. Meanwhile, it does not appear as if the value of the delta limit has affected the average annual return of the strategy significantly. Hence, it appears that having a limit linked to the option delta at all is more important than the magnitude of the delta limit. A small difference in average annual returns can also be discerned when the upper limit is set to 0.5 times the risk free rate.

Exhibit 6.2: Average annual return for back tested strategies

	UL 0.5	UL 1.0	UL 1.5	UL 2.0	UL 2.5	UL 3.0	UL 3.5	UL 4.0	UL NL	Average
LL NL	9,71%	9,93%	9,94%	9,58%	9,84%	9,93%	9,41%	9,43%	9,75%	9,72%
LL 0.05	9,93%	10,67%	11,10%	10,81%	10,93%	10,94%	10,43%	10,44%	10,74%	10,67%
LL 0.10	9,90%	10,68%	10,97%	10,74%	10,86%	10,87%	10,41%	10,43%	10,76%	10,62%
LL 0.15	10,13%	10,54%	10,82%	10,67%	10,79%	10,81%	10,38%	10,38%	10,73%	10,58%
LL 0.20	10,09%	10,45%	10,73%	10,51%	10,67%	10,71%	10,31%	10,29%	10,67%	10,49%
LL 0.25	9,66%	10,19%	10,65%	10,43%	10,60%	10,67%	10,29%	10,29%	10,63%	10,38%
LL 0.30	9,47%	10,11%	10,65%	10,46%	10,65%	10,77%	10,41%	10,40%	10,76%	10,41%
Average	9,84%	10,37%	10,70%	10,46%	10,62%	10,67%	10,23%	10,24%	10,58%	

In contrast to the small differences in average annual returns between the different strategies, there are quite pronounced differences in average annual volatility between the strategies that are using different upside (profit taking) limits, see Exhibit 6.3. It appears that the higher the upside limit is, the higher the volatility. This is not particularly unexpected as the design of the limit as a target return of a factor times the risk-free rate implies a higher tolerance to volatility with a higher limit.

Exhibit 6.3: Average annual volatility for back tested strategies

	UL 0.5	UL 1.0	UL 1.5	UL 2.0	UL 2.5	UL 3.0	UL 3.5	UL 4.0	UL NL	
LL NL	11,00%	11,75%	12,44%	13,18%	13,46%	13,80%	14,27%	14,27%	14,44%	13,18%
LL 0.05	11,21%	12,05%	12,90%	13,56%	13,74%	14,01%	14,45%	14,46%	14,63%	13,45%
LL 0.10	11,20%	12,29%	12,88%	13,54%	13,77%	14,07%	14,52%	14,53%	14,71%	13,50%
LL 0.15	11,30%	12,32%	12,87%	13,55%	13,77%	14,08%	14,51%	14,51%	14,70%	13,51%
LL 0.20	11,38%	12,44%	12,98%	13,59%	13,84%	14,15%	14,58%	14,58%	14,79%	13,59%
LL 0.25	11,46%	12,33%	13,00%	13,63%	13,89%	14,17%	14,59%	14,60%	14,82%	13,61%
LL 0.30	11,54%	12,25%	13,09%	13,69%	13,93%	14,16%	14,57%	14,57%	14,80%	13,62%
	11,30%	12,21%	12,88%	13,54%	13,77%	14,07%	14,50%	14,50%	14,70%	

For a detailed graphical presentation of each of the 63 strategies' annual return and annual volatility in each of the 520 time periods evaluated, see Appendix 5.

A generalized conclusion after studying the results in Exhibit 6.1, 6.2 and 6.3 is that an active strategy, conducted in the right manner, actually results in a higher risk-adjusted return than for the 'buy-and-hold' strategy. This is however only a true statement for future strategies if we assume that the future stock market and bond market will have exactly the same properties and dynamics as for the last twenty years.

One possible explanation why the active strategies generate higher risk-adjusted returns is that, compared to the 'buy-and-hold' strategy, market exposure is lower in times when the market experiences high volatility, often related to share price declines. One can however argue that the active strategies (with lower restructuring limits) should have higher exposure than the 'buy-and-hold' strategy, due to the restructuring on the lower side.

6.1.1 RETURN AND VOLATILITY - DISCUSSION

So why do we get these results? Is there a free lunch?

We probably find the answer to these two questions by studying the dynamics of the stock- and the bond market. That bull markets are usually more prolonged than bear markets is a common perception. If we accept this statement, a strategy where the investor tries to "catch" a bull market trend without taking too much risk should be a winning concept. A strategy with a certain limit for restructuring on the upper side and a certain limit on the lower side can be revised according to a risk-reward perspective. The results presented in this chapter should therefore not be seen as true when looking at the future. However, the result gives us

an increased understanding of how an EILN with different properties performs on the market, mainly how the strategies have performed during the last twenty years.

6.2 RESTRUCTURING FREQUENCY

Even if this study neglects the transactions costs that arise when an equity index-linked note is sold or bought, it is still of interest to evaluate the expected frequency of restructuring occasions associated with each strategy. It is most likely that a strategy with a high expected restructuring frequency should incur higher transaction costs and, consequently, lower the return.

Exhibit 6.4 presents the average number of restructuring occasions on the upper limit for each strategy. As would be expected, strategies with lower limits on the upside (profit taking) require more frequent restructuring than strategies with higher limits. The strategies that outperformed the passive strategy most frequently in the statistical test presented in section 6.3 requires approximately 1-2 restructuring occasions in a period of 10 years. Hence, although these strategies are referred to as “active strategies”, the frequency of active decision making by the investor is rather moderate.

Exhibit 6.4: Average frequency of restructuring triggered by upper limit

	UL 0.5	UL 1.0	UL 1.5	UL 2.0	UL 2.5	UL 3.0	UL 3.5	UL 4.0	NL	Average
NL	6,0	3,2	2,0	1,5	1,2	1,0	0,7	0,6	0,0	1,8
LL 0.05	6,7	3,6	2,4	1,8	1,4	1,1	0,7	0,6	0,0	2,0
LL 0.10	6,6	3,5	2,3	1,8	1,3	1,0	0,7	0,6	0,0	2,0
LL 0.15	6,8	3,4	2,3	1,7	1,2	1,0	0,7	0,6	0,0	2,0
LL 0.20	7,3	3,5	2,2	1,6	1,2	1,0	0,7	0,6	0,0	2,0
LL 0.25	7,0	3,6	2,4	1,7	1,3	1,0	0,7	0,6	0,0	2,0
LL 0.30	6,8	3,7	2,5	1,8	1,4	1,1	0,7	0,6	0,0	2,1
Average	6,7	3,5	2,3	1,7	1,3	1,0	0,7	0,6	0,0	

Exhibit 6.5 presents the average number of restructuring occasions on the lower limit for each strategy. None of the strategies require more than 2 restructuring occasions on average. Most of the strategies requires less than one restructuring occasion on average during an investment period of ten years. As with the required restructuring occasions on the upper side, the activity required from an investor in order to follow the strategies is rather moderate.

Exhibit 6.5: Average frequency of restructuring triggered by lower limit

	UL 0.5	UL 1.0	UL 1.5	UL 2.0	UL 2.5	UL 3.0	UL 3.5	UL 4.0	NL	Average
NL	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
LL 0.05	0,8	0,8	0,8	0,8	0,8	0,7	0,6	0,6	0,7	0,7
LL 0.10	0,9	0,8	0,8	0,8	0,8	0,7	0,6	0,6	0,7	0,8
LL 0.15	1,0	0,9	0,9	0,9	0,9	0,8	0,7	0,7	0,9	0,8
LL 0.20	1,5	1,0	0,9	1,0	0,9	0,9	0,8	0,8	0,9	1,0
LL 0.25	1,8	1,5	1,5	1,2	1,2	1,3	1,1	1,1	1,2	1,3
LL 0.30	2,0	1,9	1,9	1,7	1,7	1,7	1,6	1,6	1,7	1,7
Average	1,1	1,0	1,0	0,9	0,9	0,9	0,8	0,8	0,9	

6.3 SIGNIFICANCE TEST OF DAILY RETURNS

The results from the significance test of daily returns, described in Chapter 5, are presented in Exhibit 6.6 and 6.7. In each cell there is a percentage representing the share of the 520 studied time periods in which the null hypothesis could be rejected with a confidence level of 95% or more. Exhibit 6.6 shows the share of the total outcomes in which the returns of each active strategy were higher than the passive strategy. In general, there seem to be larger differences between the different upper limits, compared to the different lower limits. Once again it seems as if having no delta limit has an impact on the outcome, while there are small differences to the outcome depending on which value to ascribe the delta limit. The upper limits seem to have a higher importance for the outcome in this regard. Having an upper limit of three times the risk free rate at the time of issuance of the EILN appears to have rendered a significantly higher daily return in 65-82% of the 520 time periods studied for each strategy, when a delta limit is also used. Meanwhile, an upper limit of 0.5 times the risk free rate yields a significantly higher return than the passive strategy in 4-31% of the periods.

Exhibit 6.6: Share of total outcomes where $R_A > R_P$, at a confidence level of 95%

	UL 0.5	UL 1.0	UL 1.5	UL 2.0	UL 2.5	UL 3.0	UL 3.5	UL 4.0	NL	Average
NL	18%	13%	2%	5%	10%	27%	1%	6%	0%	9%
LL 0.05	20%	29%	52%	52%	71%	82%	58%	60%	45%	52%
LL 0.10	18%	38%	42%	53%	60%	75%	53%	62%	57%	51%
LL 0.15	31%	33%	34%	52%	58%	77%	52%	60%	62%	51%
LL 0.20	31%	29%	40%	45%	49%	70%	52%	62%	64%	49%
LL 0.25	16%	29%	38%	35%	47%	65%	47%	57%	56%	43%
LL 0.30	4%	18%	26%	26%	47%	75%	64%	68%	62%	43%
Average	20%	27%	34%	38%	49%	67%	47%	54%	50%	

While there was a rather high share of significantly higher returns, the share of significantly lower returns compared to the passive strategy was generally very low in the evaluated periods. Overall, an upper limit above one times the risk free rate generated very few significant outcomes while an upper limit below that had a significantly lower return in 7-17% of the outcomes in the evaluated time periods, depending on which lower limit that was used in combination with the upper limit. Having no delta limit seems to increase the probability of a significantly lower return compared with the passive strategy.

Exhibit 6.7: Share of outcomes where $R_A < R_P$, at a confidence level of 95%

	UL 0.5	UL 1.0	UL 1.5	UL 2.0	UL 2.5	UL 3.0	UL 3.5	UL 4.0	NL	Average
NL	17%	15%	9%	8%	1%	3%	6%	6%	0%	7%
LL 0.05	8%	7%	1%	0%	1%	1%	1%	0%	0%	2%
LL 0.10	8%	7%	1%	0%	0%	0%	0%	0%	0%	2%
LL 0.15	8%	7%	1%	0%	0%	0%	0%	0%	0%	2%
LL 0.20	8%	7%	1%	0%	0%	0%	0%	0%	0%	2%
LL 0.25	10%	7%	1%	0%	1%	0%	0%	0%	0%	2%
LL 0.30	9%	8%	1%	0%	0%	0%	0%	0%	0%	2%
Average	10%	8%	3%	1%	1%	1%	1%	1%	0%	

The strategy with no limit on the upper side or on the lower side, with a zero value both in Exhibit 6.6 and 6.7, equals the passive ‘buy-and-hold’ strategy. This comparison has functioned as an additional error detector while running the tests in MATLAB.

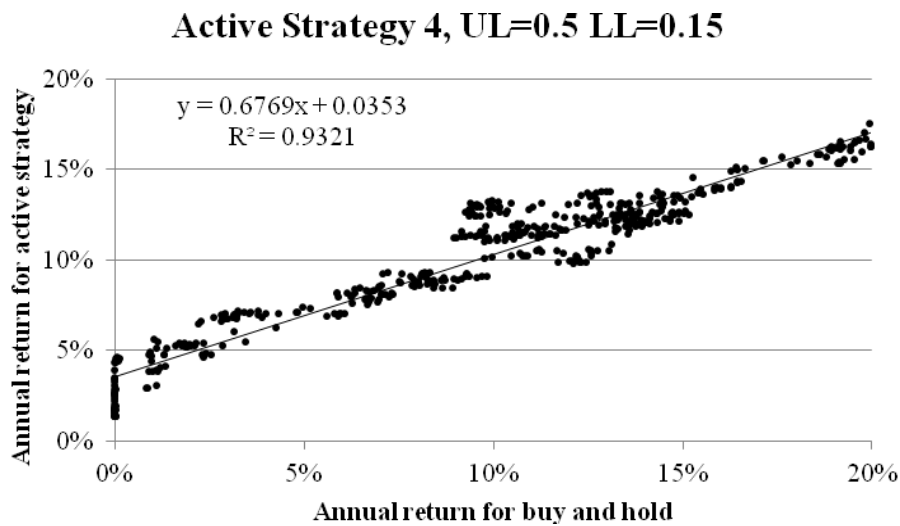
6.4 REGRESSION ANALYSIS

A linear regression analysis on the annual return for each strategy compared to the annual return from the passive strategy for each of the 520 tests shows that the alpha value (where the regression line crosses the y-axis) was larger than zero for all active strategies. Meanwhile, the beta values for all of the strategies were below one (the slope of the regression line). All data from the regression analysis can be found in Appendix 5. The results indicate that strategies with low limits on the upper side perform well when the underlying index has a low or moderate return while the same strategies are actually outperformed by the passive strategy in times with high return of the underlying index. This is actually very logical since a low limit for restructuring on the upper side results in a higher restructuring frequency, and consequently lower market exposure in periods when the equity market rises. Out of the evaluated strategies, Strategy 4, with an upper limit of 0.5 times the

risk free rate and a lower limit for delta at 0.15, had the highest alpha value out of the 62 tested active strategies at 3.53%.

Once again we find the strategies without limit on the lower side at the bottom of the list. Not surprisingly though, since their characteristic is the same as the 'buy-and-hold' strategy when it comes to restructurings on the lower side. A strategy with low alpha value (close to zero) in combination with a lower beta value than 1 for these strategies without restructuring limit on the lower side, sends however a clear message to an investor who considers to apply these strategies instead of the 'buy-and-hold' strategy.

Exhibit 6.8: Regression analysis for sample strategy



7 CONCLUSIONS

In this chapter the introduction is revisited and conclusions regarding the initially posed questions are drawn from the results and analysis presented in Chapter 6. Additionally, the results are criticized and topics for further research are suggested.

7.1 CONCLUSION

The aim of the study is to examine how an active restructuring strategy for equity index-linked notes, using specific variables to govern market timing, affects the returns over a given time period, compared with a passive ‘buy-and-hold’ strategy. To answer this question, the following sub questions will be addressed separately in the initially stated order.

What variables affect the valuation of an equity index-linked note?

As described by Das (2001), the principal protected equity index-linked note most common on the Swedish market at the time of writing can be valued as two separate components; the first being a call option on an underlying share price index and the second being a zero-coupon bond. Consequently, the valuation can be done by using the Black-Scholes-Merton option valuation model and determining the future value of the zero-coupon bond. The parameters affecting the value of the call option and the bond will be the same parameters affecting the value of the EILN. A complication arises when searching for the volatility variable needed for the Black-Scholes-Merton model as there is a lack of market data from call options with the same term that could indicate implied volatility. Thus, a volatility forecasting model is a suitable alternative. The Generalized Autoregressive Conditional Heteroskedasticity Model (GARCH) provides a tool for volatility forecasting. The GARCH(1,1) model enables volatility forecasting as a function of the term of the option which is a necessity in order to ensure a proper option valuation.

What parameters could indicate an appropriate timing for EILN restructuring?

While seemingly a largely unexplored terrain, interviews with market participants regarding the market practice for deciding parameters judging restructuring timing indicate that profit taking (upside) limits are largely based on a factor of the risk-free rate at the time of issuance of the equity index-linked note. Meanwhile, an idea of a (downside) limit for the option component’s delta value, implying a minimum participation rate for the underlying share price index before restructuring, seems to be present amongst both the sell-side and buy-side market participants.

How have strategies utilizing these parameters performed historically?

A generalized conclusion is that strategies with limit on the upper and lower side for restructuring, multiples of the risk-free interest rate and delta value of the option respectively, outperform the passive ‘buy-and-hold’ strategy. These were the results found in the regression test as well as when statistic wins and losses at a confidence level of 95% are compared. The active strategies are also well placed on the efficient frontier compared to ‘buy-and-hold’.

Are there optimal levels for these parameters?

The optimal profit taking level on the upside appeared to be three times the risk-free interest rate and the optimal restructure level on the downside appeared to be a delta value for the option of 0.05. The most obvious pattern all through the analysis was the importance of a lower limit for restructuring. The actual limit for restructuring itself seems to have less importance compared to when no limit exists.

How does the volatility of returns compare to the passive ‘buy-and-hold’ strategy?

The realized volatility for the active strategies was clearly lower compared to the passive strategy. This indicates that active strategies have less market exposure when the volatility is high, often occurring during stock market declines.

Can an active strategy for restructuring of equity index-linked notes generate higher returns than a passive ‘buy-and-hold’ strategy?

When risk is defined as realized volatility of the product, an active strategy did give higher return to a lower volatility than the passive strategy. One should however be aware that the strategies have been applied to the stock market and the bond market during the last twenty years, not the coming twenty years.

7.2 SUGGESTIONS FOR FURTHER RESEARCH

This study is subject to a number of delimitations, specified in section 1.5, and a continuation of the study with less restrictive assumptions is a welcome contribution in order to better understand the results. Furthermore, a study that can successfully evaluate the findings in a real-world setting would provide further information regarding the validity of the findings. Also, the introduction of further refined performance measures would provide additional dimensions to the results.

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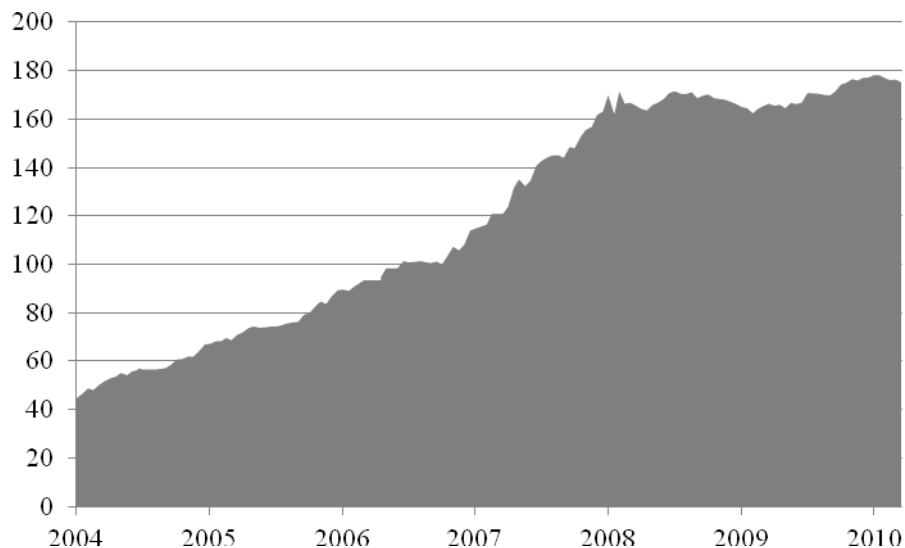
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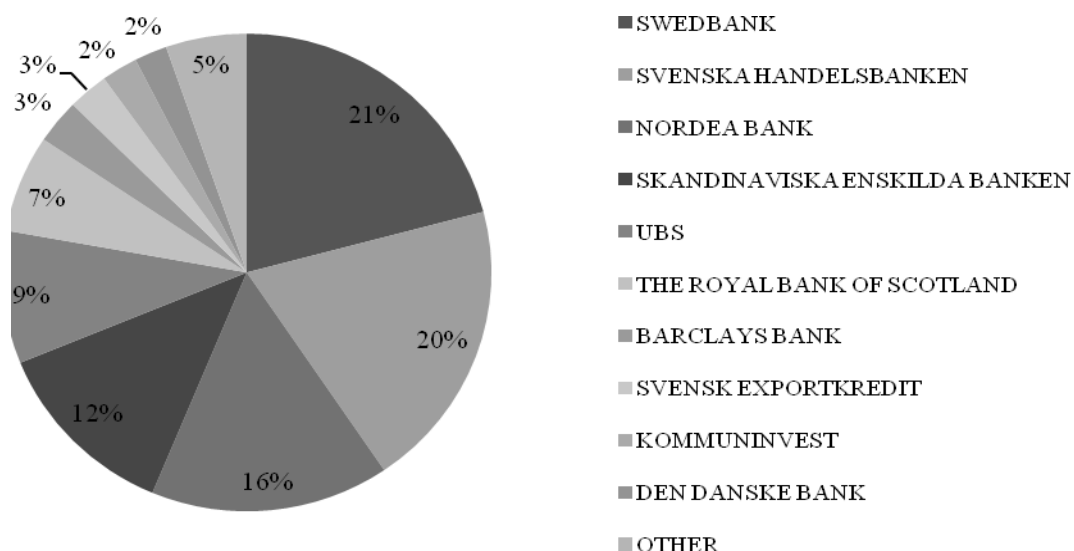
APPENDIX 1: THE SWEDISH EILN MARKET

Exhibit A1.1: ELNs/EILNs: Outstanding volume in Sweden 2004-1Q2010, SEK billions



Source: Euroclear Sweden

Exhibit A1.2: ELNs/EILNs: Market share of issuers in Sweden 2009, descending order



Source: Euroclear Sweden

APPENDIX 2: VOLATILITY FORECASTING

Exhibit A2.1: Time series of forecasted volatility of S&P 500 using EWMA¹¹

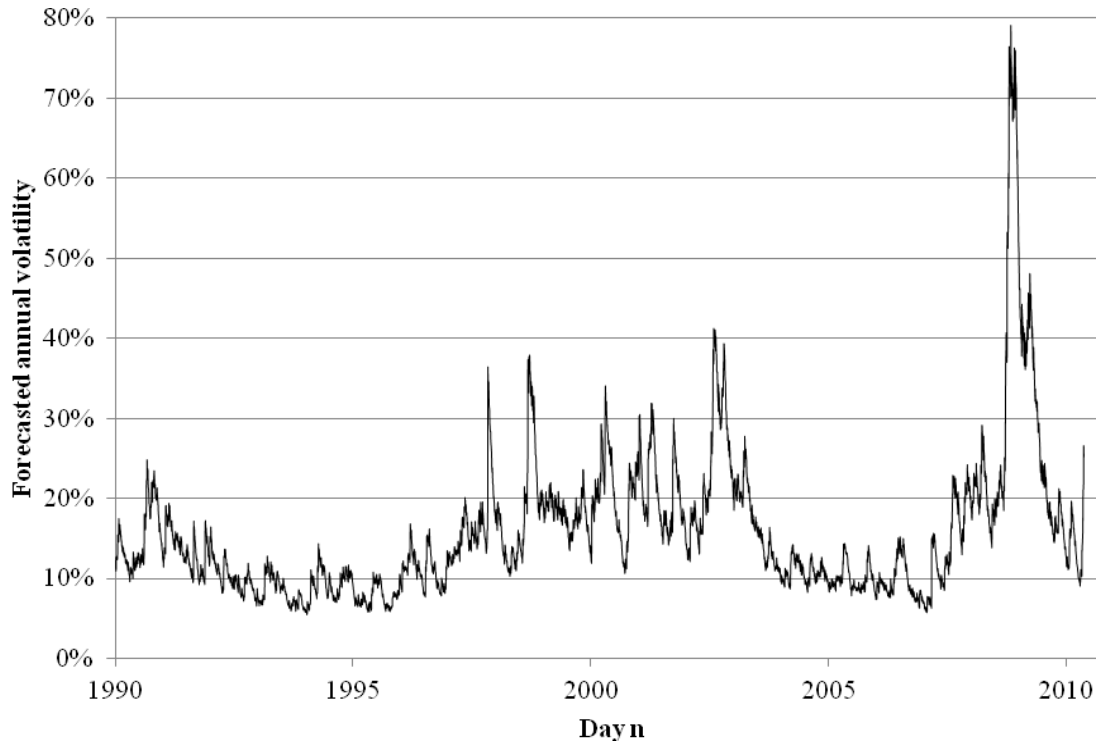
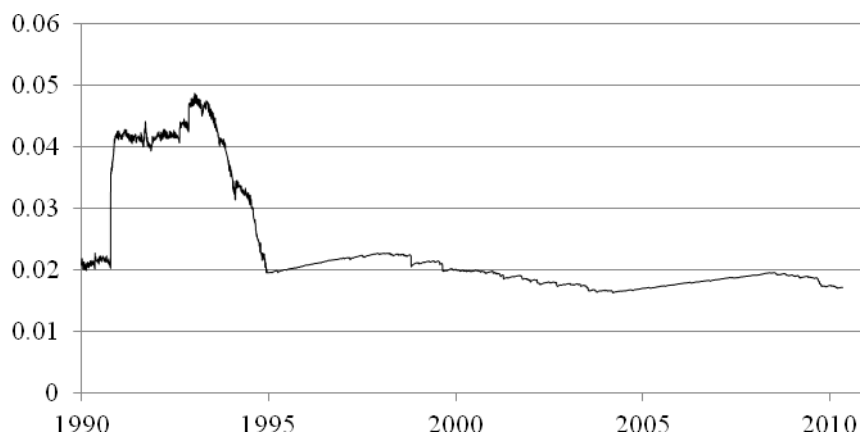


Exhibit A2.2: GARCH(1,1), maximum likelihood estimates for γ



¹¹ Using λ equal to 0.94 as recommended by RiskMetrics (1996)

Exhibit A2.3: GARCH(1,1), maximum likelihood estimates for α

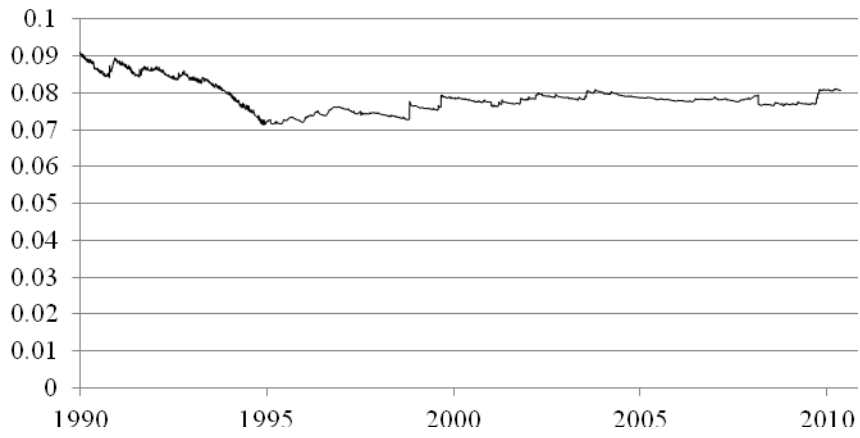


Exhibit A2.4: GARCH(1,1), maximum likelihood estimates for β



Exhibit A2.5: Autocorrelation test for GARCH(1,1) model

lags		u_i^2		σ^2_i/u_i^2
1		0.160		0.121
2		0.226		0.099
3		0.132		0.095
4		0.107		0.082
5		0.209		0.089
6		0.121		0.081
7		0.115		0.081
8		0.123		0.081
9		0.126		0.100
10		0.099		0.083
11		0.122		0.076
12		0.108		0.085
13		0.096		0.072
14		0.071		0.082
15		0.092		0.077

APPENDIX 3: TIME SPANS

Simulations of strategies have been performed in 520 different time spans, each containing 2,520 trading days (10 years). All time spans are presented below.

Time period						
period	Start			End		
	Y	M	D	Y	M	D
1	1990	1	2	1999	12	21
2	1990	1	9	1999	12	28
3	1990	1	16	2000	1	4
4	1990	1	23	2000	1	11
5	1990	1	30	2000	1	18
6	1990	2	6	2000	1	25
7	1990	2	13	2000	2	1
8	1990	2	20	2000	2	8
9	1990	2	27	2000	2	15
10	1990	3	6	2000	2	22
11	1990	3	13	2000	2	29
12	1990	3	20	2000	3	7
13	1990	3	27	2000	3	14
14	1990	4	3	2000	3	21
15	1990	4	10	2000	3	28
16	1990	4	17	2000	4	4
17	1990	4	24	2000	4	11
18	1990	5	1	2000	4	18
19	1990	5	8	2000	4	25
20	1990	5	15	2000	5	2
21	1990	5	22	2000	5	9
22	1990	5	29	2000	5	16
23	1990	6	5	2000	5	23
24	1990	6	12	2000	5	30
25	1990	6	19	2000	6	6
26	1990	6	26	2000	6	13
27	1990	7	3	2000	6	20
28	1990	7	10	2000	6	27
29	1990	7	17	2000	7	4
30	1990	7	24	2000	7	11
31	1990	7	31	2000	7	18
32	1990	8	7	2000	7	25
33	1990	8	14	2000	8	1
34	1990	8	21	2000	8	8
35	1990	8	28	2000	8	15
36	1990	9	4	2000	8	22
37	1990	9	11	2000	8	29
38	1990	9	18	2000	9	5
39	1990	9	25	2000	9	12
40	1990	10	2	2000	9	19
41	1990	10	9	2000	9	26
42	1990	10	16	2000	10	3
43	1990	10	23	2000	10	10
44	1990	10	30	2000	10	17
45	1990	11	6	2000	10	24
46	1990	11	13	2000	10	31
47	1990	11	20	2000	11	7
48	1990	11	27	2000	11	14
49	1990	12	4	2000	11	21
50	1990	12	11	2000	11	28
51	1990	12	18	2000	12	5
52	1990	12	25	2000	12	12
53	1991	1	1	2000	12	19
54	1991	1	8	2000	12	26
55	1991	1	15	2001	1	2
56	1991	1	22	2001	1	9
57	1991	1	29	2001	1	16
58	1991	2	5	2001	1	23
59	1991	2	12	2001	1	30
60	1991	2	19	2001	2	6
61	1991	2	26	2001	2	13
62	1991	3	5	2001	2	20
63	1991	3	12	2001	2	27
64	1991	3	19	2001	3	6
65	1991	3	26	2001	3	13

Time period						
period	Start			End		
	Y	M	D	Y	M	D
131	1992	6	30	2002	6	18
132	1992	7	7	2002	6	25
133	1992	7	14	2002	7	2
134	1992	7	21	2002	7	9
135	1992	7	28	2002	7	16
136	1992	8	4	2002	7	23
137	1992	8	11	2002	7	30
138	1992	8	18	2002	8	6
139	1992	8	25	2002	8	13
140	1992	9	1	2002	8	20
141	1992	9	8	2002	8	27
142	1992	9	15	2002	9	3
143	1992	9	22	2002	9	10
144	1992	9	29	2002	9	17
145	1992	10	6	2002	9	24
146	1992	10	13	2002	10	1
147	1992	10	20	2002	10	8
148	1992	10	27	2002	10	15
149	1992	11	3	2002	10	22
150	1992	11	10	2002	10	29
151	1992	11	17	2002	11	5
152	1992	11	24	2002	11	12
153	1992	12	1	2002	11	19
154	1992	12	8	2002	11	26
155	1992	12	15	2002	12	3
156	1992	12	22	2002	12	10
157	1992	12	29	2002	12	17
158	1993	1	5	2002	12	24
159	1993	1	12	2002	12	31
160	1993	1	19	2003	1	7
161	1993	1	26	2003	1	14
162	1993	2	2	2003	1	21
163	1993	2	9	2003	1	28
164	1993	2	16	2003	2	4
165	1993	2	23	2003	2	11
166	1993	3	2	2003	2	18
167	1993	3	9	2003	2	25
168	1993	3	16	2003	3	4
169	1993	3	23	2003	3	11
170	1993	3	30	2003	3	18
171	1993	4	6	2003	3	25
172	1993	4	13	2003	4	1
173	1993	4	20	2003	4	8
174	1993	4	27	2003	4	15
175	1993	5	4	2003	4	22
176	1993	5	11	2003	4	29
177	1993	5	18	2003	5	6
178	1993	5	25	2003	5	13
179	1993	6	1	2003	5	20
180	1993	6	8	2003	5	27
181	1993	6	15	2003	6	3
182	1993	6	22	2003	6	10
183	1993	6	29	2003	6	17
184	1993	7	6	2003	6	24
185	1993	7	13	2003	7	1
186	1993	7	20	2003	7	8
187	1993	7	27	2003	7	15
188	1993	8	3	2003	7	22
189	1993	8	10	2003	7	29
190	1993	8	17	2003	8	5
191	1993	8	24	2003	8	12
192	1993	8	31	2003	8	19
193	1993	9	7	2003	8	26
194	1993	9	14	2003	9	2
195	1993	9	21	2003	9	9

Time period						
period	Start			End		
	Y	M	D	Y	M	D
261	1994	12	27	2004	12	14
262	1995	1	3	2004	12	21
263	1995	1	10	2004	12	28
264	1995	1	17	2005	1	4
265	1995	1	24	2005	1	11
266	1995	1	31	2005	1	18
267	1995	2	7	2005	1	25
268	1995	2	14	2005	2	1
269	1995	2	21	2005	2	8
270	1995	2	28	2005	2	15
271	1995	3	7	2005	2	22
272	1995	3	14	2005	3	1
273	1995	3	21	2005	3	8
274	1995	3	28	2005	3	15
275	1995	4	4	2005	3	22
276	1995	4	11	2005	3	29
277	1995	4	18	2005	4	5
278	1995	4	25	2005	4	12
279	1995	5	2	2005	4	19
280	1995	5	9	2005	4	26
281	1995	5	16	2005	5	3
282	1995	5	23	2005	5	10
283	1995	5	30	2005	5	17
284	1995	6	6	2005	5	24
285	1995	6	13	2005	5	31
286	1995	6	20	2005	6	7
287	1995	6	27	2005	6	14
288	1995	7	4	2005	6	21
289	1995	7	11	2005	6	28
290	1995	7	18	2005	7	5
291	1995	7	25	2005	7	12
292	1995	8	1	2005	7	19
293	1995	8	8	2005	7	26
294	1995	8	15	2005	8	2
295	1995	8	22	2005	8	9
296	1995	8	29	2005	8	16
297	1995	9	5	2005	8	23
298	1995	9	12	2005	8	30
299	1995	9	19	2005	9	6
300	1995	9	26	2005	9	13
301	1995	10	3	2005	9	20
302	1995	10	10	2005	9	27
303	1995	10	17	2005	10	4
304	1995	10	24	2005	10	11
305	1995	10	31	2005	10	18
306	1995	11	7	2005	10	25
307	1995	11	14	2005	11	1
308	1995	11	21	2005	11	8
309	1995	11	28	2005	11	15
310	1995	12	5	2005	11	22
311	1995	12	12	2005	11	29
312	1995	12	19	2005	12	6
313	1995	12	26	2005	12	13
314	1996	1	2	2005	12	20
315	1996	1	9	2005	12	27
316	1996	1	16	2006	1	3
317	1996	1	23	2006	1	10
318	1996	1	30	2006	1	17
319	1996	2	6	2006	1	24
320	1996	2	13	2006	1	31
321	1996	2	20	2006	2	7
322	1996	2	27	2006	2	14
323	1996	3	5	2006	2	21
324	1996	3	12	2006	2	28
325	1996	3	19	2006	3	7

Time period						
period	Start			End		
	Y	M	D	Y	M	D
391	1997	6	24	2007	6	12
392	1997	7	1	2007	6	19
393	1997	7	8	2007	6	26
394	1997	7	15	2007	7	3
395	1997	7	22	2007	7	10
396	1997	7	29	2007	7	17
397	1997	8	5	2007	7	24
398	1997	8	12	2007	7	31
399	1997	8	19	2007	8	7
400	1997	8	26	2007	8	14
401	1997	9				

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66	1991	4	2	2001	3	20	196	1993	9	28	2003	9	16	326	1996	3	26	2006	3	14	456	1998	9	22	2008	9	9
67	1991	4	9	2001	3	27	197	1993	10	5	2003	9	23	327	1996	4	2	2006	3	21	457	1998	9	29	2008	9	16
68	1991	4	16	2001	4	3	198	1993	10	12	2003	9	30	328	1996	4	9	2006	3	28	458	1998	10	6	2008	9	23
69	1991	4	23	2001	4	10	199	1993	10	19	2003	10	7	329	1996	4	16	2006	4	4	459	1998	10	13	2008	9	30
70	1991	4	30	2001	4	17	200	1993	10	26	2003	10	14	330	1996	4	23	2006	4	11	460	1998	10	20	2008	10	7
71	1991	5	7	2001	4	24	201	1993	11	2	2003	10	21	331	1996	4	30	2006	4	18	461	1998	10	27	2008	10	14
72	1991	5	14	2001	5	1	202	1993	11	9	2003	10	28	332	1996	5	7	2006	4	25	462	1998	11	3	2008	10	21
73	1991	5	21	2001	5	8	203	1993	11	16	2003	11	4	333	1996	5	14	2006	5	2	463	1998	11	10	2008	10	28
74	1991	5	28	2001	5	15	204	1993	11	23	2003	11	11	334	1996	5	21	2006	5	9	464	1998	11	17	2008	11	4
75	1991	6	4	2001	5	22	205	1993	11	30	2003	11	18	335	1996	5	28	2006	5	16	465	1998	11	24	2008	11	11
76	1991	6	11	2001	5	29	206	1993	12	7	2003	11	25	336	1996	6	4	2006	5	23	466	1998	12	1	2008	11	18
77	1991	6	18	2001	6	5	207	1993	12	14	2003	12	2	337	1996	6	11	2006	5	30	467	1998	12	8	2008	11	25
78	1991	6	25	2001	6	12	208	1993	12	21	2003	12	9	338	1996	6	18	2006	6	6	468	1998	12	15	2008	12	2
79	1991	7	2	2001	6	19	209	1993	12	28	2003	12	16	339	1996	6	25	2006	6	13	469	1998	12	22	2008	12	9
80	1991	7	9	2001	6	26	210	1994	1	4	2003	12	23	340	1996	7	2	2006	6	20	470	1998	12	29	2008	12	16
81	1991	7	16	2001	7	3	211	1994	1	11	2003	12	30	341	1996	7	9	2006	6	27	471	1999	1	5	2008	12	23
82	1991	7	23	2001	7	10	212	1994	1	18	2004	1	6	342	1996	7	16	2006	7	4	472	1999	1	12	2008	12	30
83	1991	7	30	2001	7	17	213	1994	1	25	2004	1	13	343	1996	7	23	2006	7	11	473	1999	1	19	2009	1	6
84	1991	8	6	2001	7	24	214	1994	2	1	2004	1	20	344	1996	7	30	2006	7	18	474	1999	1	26	2009	1	13
85	1991	8	13	2001	7	31	215	1994	2	8	2004	1	27	345	1996	8	6	2006	7	25	475	1999	2	2	2009	1	20
86	1991	8	20	2001	8	7	216	1994	2	15	2004	2	3	346	1996	8	13	2006	8	1	476	1999	2	9	2009	1	27
87	1991	8	27	2001	8	14	217	1994	2	22	2004	2	10	347	1996	8	20	2006	8	8	477	1999	2	16	2009	1	23
88	1991	9	3	2001	8	21	218	1994	3	1	2004	2	17	348	1996	8	27	2006	8	15	478	1999	2	23	2009	1	30
89	1991	9	10	2001	8	28	219	1994	3	8	2004	2	24	349	1996	9	3	2006	8	22	479	1999	3	2	2009	2	17
90	1991	9	17	2001	9	4	220	1994	3	15	2004	3	2	350	1996	9	10	2006	8	29	480	1999	3	9	2009	2	24
91	1991	9	24	2001	9	11	221	1994	3	22	2004	3	9	351	1996	9	17	2006	9	5	481	1999	3	16	2009	3	3
92	1991	10	1	2001	9	18	222	1994	3	29	2004	3	16	352	1996	9	24	2006	9	12	482	1999	3	23	2009	3	10
93	1991	10	8	2001	9	25	223	1994	4	5	2004	3	23	353	1996	10	1	2006	9	19	483	1999	3	30	2009	3	17
94	1991	10	15	2001	10	2	224	1994	4	12	2004	3	30	354	1996	10	8	2006	9	26	484	1999	4	6	2009	3	24
95	1991	10	22	2001	10	9	225	1994	4	19	2004	4	6	355	1996	10	15	2006	10	3	485	1999	4	13	2009	3	31
96	1991	10	29	2001	10	16	226	1994	4	26	2004	4	13	356	1996	10	22	2006	10	10	486	1999	4	20	2009	4	7
97	1991	11	5	2001	10	23	227	1994	5	3	2004	4	20	357	1996	10	29	2006	10	17	487	1999	4	27	2009	4	14
98	1991	11	12	2001	10	30	228	1994	5	10	2004	4	27	358	1996	11	5	2006	10	24	488	1999	5	4	2009	4	21
99	1991	11	19	2001	11	6	229	1994	5	17	2004	5	4	359	1996	11	12	2006	10	31	489	1999	5	11	2009	4	28
100	1991	11	26	2001	11	13	230	1994	5	24	2004	5	11	360	1996	11	19	2006	11	7	490	1999	5	18	2009	5	5
101	1991	12	3	2001	11	20	231	1994	5	31	2004	5	18	361	1996	11	26	2006	11	14	491	1999	5	25	2009	5	12
102	1991	12	10	2001	11	27	232	1994	6	7	2004	5	25	362	1996	12	3	2006	11	21	492	1999	6	1	2009	5	19
103	1991	12	17	2001	12	4	233	1994	6	14	2004	6	1	363	1996	12	10	2006	11	28	493	1999	6	8	2009	5	26
104	1991	12	24	2001	12	11	234	1994	6	21	2004	6	8	364	1996	12	17	2006	12	5	494	1999	6	15	2009	6	2
105	1991	12	31	2001	12	18	235	1994	6	28	2004	6	15	365	1996	12	24	2006	12	12	495	1999	6	22	2009	6	9
106	1992	1	7	2002	12	25	236	1994	7	5	2004	6	22	366	1996	12	31	2006	12	19	496	1999	6	29	2009	6	16
107	1992	1	14	2002	1	1	237	1994	7	12	2004	6	29	367	1997	1	7	2006	12	26	497	1999	7	6	2009	6	23
108	1992	1	21	2002	1	8	238	1994	7	19	2004	7	6	368	1997	1	14	2007	1	2	498	1999	7	13	2009	6	30
109	1992	1	28	2002	1	15	239	1994	7	26	2004	7	13	369	1997	1	21	2007	1	9	499	1999	7	20	2009	7	7
110	1992	2	4	2002	1	22	240	1994	8	2	2004	7	20	370	1997	1	28	2007	1	16	500	1999	7	27	2009	7	14
111	1992	2	11	2002	1	29	241	1994	8	9	2004	7	27	371	1997	2	4	2007	1	23	501	1999	8	3	2009	7	21
112	1992	2	18	2002	2	5	242	1994	8	16	2004	8	3	372	1997	2	11	2007	1	30	502	1999	8	10	2009	7	28
113	1992	2	25	2002	2	12	243	1994	8	23	2004	8	10	373	1997	2	18	2007	2	6	503	1999	8	17	2009	8	4
114	1992	3	3	2002	2	19	244	1994	8	30	2004	8	17	374	1997	2	25	2007	2	13	504	1999	8	24	2009	8	11
115	1992	3	10	2002	2	26	245	1994	9	6	2004	8	24	375	1997	3	4	2007	2	20	505	1999	8	31	2009	8	18
116	1992	3	17	2002	3	5	246	1994	9	13	2004	8	31	376	1997	3	11	2007	2	27	506	1999	9	7	2009	8	25
117	1992	3	24	2002	3	12	247	1994	9	20	2004	9	7	377	1997	3	18	2007	3	6	507	1999	9	14	2009	9	1
118	1992	3	31	2002	3	19	248	1994	9	27	2004	9	14	378	1997	3	25	2007	3	13	508	1999	9	21	2009	9	8
119	1992	4	7	2002	3	26	249	1994	10	4	2004	9	21	379	1997	4	1	2007	3	20	509	1999	9	28	2009	9	15
120	1992	4	14	2002	4	2	250	1994	10	11	2004	9	28	380	1997	4	8	2007	3	27	510	1999	10	5	2009	9	22
121	1992	4	21	2002	4	9	251	1994	10	18	2004	10	5	381	1997	4	15	2007	4	3	511	1999	10	12	2009	9	29
122	1992	4	28	2002	4	16	252	1994	10	25	2004	10	12	382	1997	4	22	2007	4	10	512	1999	10	19	2009	10	6
123	1992	5	5	2002	4	23	253	1994	11	1	2004	10	19	383	1997	4	29	2007	4	17	513	1999	10	26	2009	10	

APPENDIX 4: MATLAB CODE

```

clear all                                % Clear all "old" data in MTLAB
load Rf.mat                               % Load data from the input-files
load SP500.mat
load Std.mat
=====
% Strat:  1    2    3    4    5    6    7
% Strat:  A1   A2   A3   A4   A5   A6   A7
%   UL:  0.5  0.5  0.5  0.5  0.5  0.5  0.5
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
% Strat:  8    9   10   11   12   13   14
% Strat:  B1   B2   B3   B4   B5   B6   B7
%   UL:  1.0  1.0  1.0  1.0  1.0  1.0  1.0
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
% Strat: 15   16   17   18   19   20   21
% Strat:  C1   C2   C3   C4   C5   C6   C7
%   UL:  1.5  1.5  1.5  1.5  1.5  1.5  1.5
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
% Strat: 22   23   24   25   26   27   28
% Strat:  D1   D2   D3   D4   D5   D6   D7
%   UL:  2.0  2.0  2.0  2.0  2.0  2.0  2.0
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
% Strat: 29   30   31   32   33   34   35
% Strat:  E1   E2   E3   E4   E5   E6   E7
%   UL:  2.5  2.5  2.5  2.5  2.5  2.5  2.5
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
% Strat: 36   37   38   39   40   41   42
% Strat:  F1   F2   F3   F4   F5   F6   F7
%   UL:  3.0  3.0  3.0  3.0  3.0  3.0  3.0
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
% Strat: 43   44   45   46   47   48   49
% Strat:  G1   G2   G3   G4   G5   G6   G7
%   UL:  3.5  3.5  3.5  3.5  3.5  3.5  3.5
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
% Strat: 50   51   52   53   54   55   56
% Strat:  H1   H2   H3   H4   H5   H6   H7
%   UL:  4.0  4.0  4.0  4.0  4.0  4.0  4.0
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
% Strat: 57   58   59   60   61   62   63
% Strat:  I1   I2   I3   I4   I5   I6   I7
%   UL: 100  100  100  100  100  100  100
%   LL:  0.0  .05  .10  .15  .20  .25  .30
=====
anttid=520;                               % Set amount of runs
antstrat=63;                              % Set amount of strategies
timeinterval=1;                          % Set time interval in days
% Create result matrixes:
StandRa=zeros(anttid,antstrat); YearlyReturn=zeros(anttid,antstrat);
Tabarea=zeros(anttid,antstrat); zvalue=zeros(anttid,antstrat);
RAPmean=zeros(anttid,antstrat); STandRAP=zeros(anttid,antstrat);
Partrate=zeros(anttid,antstrat);

```

```

%-----
for jj=1:anttid;      % Loop for each start time of the EILN
    start=1044+(jj-1)*timeinterval; % Set start time for EILN
    vector=zeros(length(SP500),1); % Create result vector
    Rp=vector; Ra=vector; % Define Empty vector for return
    for kk = 1:(1+antstrat); % Loop each strategy in each time step
        if kk==1; %Buy n Hold
            LL=-1;
        elseif kk==2; %Strategy 1
            LL=0.0 ; aa=0.5 ;
        elseif kk==3; %Strategy 2
            LL=0.05 ; aa=0.5 ;
        elseif kk==4; %Strategy 3
            LL=0.1 ; aa=0.5 ;
        elseif kk==5; %Strategy 4
            LL=0.15 ; aa=0.5 ;
        elseif kk==6; %Strategy 5
            LL=0.2 ; aa=0.5 ;
        elseif kk==7; %Strategy 6
            LL=0.25 ; aa=0.5 ;
        elseif kk==8; %Strategy 7
            LL=0.3 ; aa=0.5 ;
        elseif kk==9; %Strategy 8
            LL=0.0 ; aa=1.0 ;
        elseif kk==10; %Strategy 9
            LL=0.05 ; aa=1.0 ;
        elseif kk==11; %Strategy 10
            LL=0.1 ; aa=1.0 ;
        elseif kk==12; %Strategy 11
            LL=0.15 ; aa=1.0 ;
        elseif kk==13; %Strategy 12
            LL=0.2 ; aa=1.0 ;
        elseif kk==14; %Strategy 13
            LL=0.25 ; aa=1.0 ;
        elseif kk==15; %Strategy 14
            LL=0.3 ; aa=1.0 ;
        elseif kk==16; %Strategy 15
            LL=0.0 ; aa=1.5 ;
        elseif kk==17; %Strategy 16
            LL=0.05 ; aa=1.5 ;
        elseif kk==18; %Strategy 17
            LL=0.1 ; aa=1.5 ;
        elseif kk==19; %Strategy 18
            LL=0.15 ; aa=1.5 ;
        elseif kk==20; %Strategy 19
            LL=0.2 ; aa=1.5 ;
        elseif kk==21; %Strategy 20
            LL=0.25 ; aa=1.5 ;
        elseif kk==22; %Strategy 21
            LL=0.3 ; aa=1.5 ;
        elseif kk==23; %Strategy 22
            LL=0.0 ; aa=2.0 ;
        elseif kk==24; %Strategy 23
            LL=0.05 ; aa=2.0 ;
        elseif kk==25; %Strategy 24
            LL=0.1 ; aa=2.0 ;
        elseif kk==26; %Strategy 25
            LL=0.15 ; aa=2.0 ;
        elseif kk==27; %Strategy 26
            LL=0.2 ; aa=2.0 ;
        elseif kk==28; %Strategy 27

```

```
LL=0.25 ; aa=2.0 ;
elseif kk==29; %Strategy 28
  LL=0.3 ; aa=2.0 ;
elseif kk==30; %Strategy 29
  LL=0.0 ; aa=2.5 ;
elseif kk==31; %Strategy 30
  LL=0.05 ; aa=2.5 ;
elseif kk==32; %Strategy 31
  LL=0.1 ; aa=2.5 ;
elseif kk==33; %Strategy 32
  LL=0.15 ; aa=2.5 ;
elseif kk==34; %Strategy 33
  LL=0.2 ; aa=2.5 ;
elseif kk==35; %Strategy 34
  LL=0.25 ; aa=2.5 ;
elseif kk==36; %Strategy 35
  LL=0.3 ; aa=2.5 ;
elseif kk==37; %Strategy 36
  LL=0.0 ; aa=3.0 ;
elseif kk==38; %Strategy 37
  LL=0.05 ; aa=3.0 ;
elseif kk==39; %Strategy 38
  LL=0.1 ; aa=3.0 ;
elseif kk==40; %Strategy 39
  LL=0.15 ; aa=3.0 ;
elseif kk==41; %Strategy 40
  LL=0.2 ; aa=3.0 ;
elseif kk==42; %Strategy 41
  LL=0.25 ; aa=3.0 ;
elseif kk==43; %Strategy 42
  LL=0.3 ; aa=3.0 ;
elseif kk==44; %Strategy 43
  LL=0.0 ; aa=3.5 ;
elseif kk==45; %Strategy 44
  LL=0.05 ; aa=3.5 ;
elseif kk==46; %Strategy 45
  LL=0.1 ; aa=3.5 ;
elseif kk==47; %Strategy 46
  LL=0.15 ; aa=3.5 ;
elseif kk==48; %Strategy 47
  LL=0.2 ; aa=3.5 ;
elseif kk==49; %Strategy 48
  LL=0.25 ; aa=3.5 ;
elseif kk==50; %Strategy 49
  LL=0.3 ; aa=3.5 ;
elseif kk==51; %Strategy 50
  LL=0.0 ; aa=4.0 ;
elseif kk==52; %Strategy 51
  LL=0.05 ; aa=4.0 ;
elseif kk==53; %Strategy 52
  LL=0.1 ; aa=4.0 ;
elseif kk==54; %Strategy 53
  LL=0.15 ; aa=4.0 ;
elseif kk==55; %Strategy 54
  LL=0.2 ; aa=4.0 ;
elseif kk==56; %Strategy 55
  LL=0.25 ; aa=4.0 ;
elseif kk==57; %Strategy 56
  LL=0.3 ; aa=4.0 ;
elseif kk==58; %Strategy 57 Compare Buy n hold to BnH (control)
  LL=0.0 ; aa=100 ;
```

```

elseif kk==59; %Strategy 58
    LL=0.05 ; aa=100 ;
elseif kk==60; %Strategy 59
    LL=0.1 ; aa=100 ;
elseif kk==61; %Strategy 60
    LL=0.15 ; aa=100 ;
elseif kk==62; %Strategy 61
    LL=0.2 ; aa=100 ;
elseif kk==63; %Strategy 62
    LL=0.25 ; aa=100 ;
elseif kk==64; %Strategy 63
    LL=0.3 ; aa=100 ;
end
Dur=5 ; % Set duration for EILN in years

%=====
Dur=Dur*252; % Transform the duration to trading days
EilnTime=[start start+Dur];
Days=SP500(EilnTime(2),6)-SP500(EilnTime(1),6); % Count real days
if Days > 0 && Days <= 90; %find risk free interest rate
    r=Rf(start,4);
elseif Days > 90 && Days <= 180;
    r=Rf(start,4)+(Rf(start,5)-Rf(start,4))/(180-90)*(Days-90);
elseif Days > 180 && Days <= 365;
    r=Rf(start,5)+(Rf(start,6)-Rf(start,5))/(365-180)*(Days-180);
elseif Days > 365 && Days <= 730;
    r=Rf(start,6)+(Rf(start,7)-Rf(start,6))/(730-365)*(Days-365);
elseif Days > 730 && Days <= 1095;
    r=Rf(start,7)+(Rf(start,8)-Rf(start,7))/(1095-730)*(Days-730);
elseif Days > 1095 && Days <= 1831;
    r=Rf(start,8)+(Rf(start,9)-Rf(start,8))/(1095-1827)*(Days-
1095);
end
%buy EILN on start day for Peiln%
Peiln=SP500(start,4);
if kk==1; %Define upper limit
    UL=300;
else
    UL=aa*((1+(Rf(start,9)/100))^5-1);
end
%Repayment value for bond, Rpbond, is the same as price for EILN
Rpbond=Peiln;
% The price for the bond, Pbond, is the present value of the bond
Pbond=Rpbond*exp(-r/100*Days/365);
% We can now buy options for MOPT:
Mopt=Peiln-Pbond;
% spot price S is;
S=SP500(start,4);
% strike price K is
K=S;
q=SP500(start,7); % Divident yield
% Calculatate volatility based on Garch(1,1)
sigma=sqrt(252*(Std(start,2)+(1-exp(-log(1/(Std(start,3)...
+Std(start,4))))*Dur))*(Std(start,1)-
Std(start,2))/(Dur*log(1/(Std(start,3)+Std(start,4))))));
% Calculate price of option with B&S model
d1=(log(S/K)+(r/100-
q/100+(sigma^2)/2)*(Days/365))/(sigma*sqrt(Days/365));
d2=d1-sigma*sqrt(Days/365);
C=S*exp((-q/100)*(Days/365))*normcdf(d1)-K*exp(-
(r/100)*(Days/365))*normcdf(d2);

```

```

% The participation rate, PR, is now:
PR=((Mopt/Peiln)*(K/C));
if kk==1;
else
    Partrate(jj,(kk-1))=PR; %save result
end
AmOpt=Mopt/C; %Amount of options
Delta=exp((-q/100)*(Days/365))*normcdf(d1); % Delta value
t=0;
% Define result vectors
pbond=vector; amopt=vector; c=vector; popt=vector; rpbond=vector;
peiln=vector; pr=vector; delta=vector; k=vector;
pbond(start)=Pbond;          amopt(start)=AmOpt;          c(start)=C;
popt(start)=Mopt;
peiln(start)=Peiln;          pr(start)=PR;          delta(start)=Delta;
rpbond(start)=Rpbond;
k(start)=K;
T=Dur;
Tfinish=SP500(EilnTime(2),6);
Start=start;
omstned=0; % Set counter for restructure occasions on Lower limit
omstupp=0; % Set counter for restructure occasions on Upper limit
omstlop=0; % Set counter for restructure occasion if t=Dur
%plot(SP500(:,5),SP500(:,4),'k'); %Plott S&P500
%hold on
%plotta=vector;
for i = (start+1):(start+2*Dur) ; % Loop every trading day
    t=t+1; % counting trading days
    %T=SP500(EilnTime(2),6)-SP500(EilnTime(1),6);
    Days=(Tfinish-SP500(i,6)); % Count real days to maturity
    if Days > 0 && Days <= 90; % interpolate intereset rate
        r=Rf(i,4);
    elseif Days > 90 && Days <= 180;
        r=Rf(i,4)+(Rf(i,5)-Rf(i,4))/(180-90)*(Days-90);
    elseif Days > 180 && Days <= 365;
        r=Rf(i,5)+(Rf(i,6)-Rf(i,5))/(365-180)*(Days-180);
    elseif Days > 365 && Days <= 730;
        r=Rf(i,6)+(Rf(i,7)-Rf(i,6))/(730-365)*(Days-365);
    elseif Days > 730 && Days <= 1095;
        r=Rf(i,7)+(Rf(i,8)-Rf(i,7))/(1095-730)*(Days-730);
    elseif Days > 1095 && Days <= 1827;
        r=Rf(i,8)+(Rf(i,9)-Rf(i,8))/(1095-1827)*(Days-1095);
    end
    pbond(i)=Rpbond*exp(-r/100*Days/365); % Calculate bond price
    rpbond(i)=Rpbond;
    % spot price S is;
    S=SP500(i,4);
    % strike price K is
    k(i)=K;
    q=SP500(i,7);
    sigma=sqrt(252*(Std(i,2)+(1-exp(-
log(1/(Std(i,3)+Std(i,4)))*(Dur-t)))*(Std(i,1)-Std(i,2))/((Dur-
t)*log(1/(Std(i,3)+Std(i,4))))));
    d1=(log(S/K)+(r/100-
q/100+(sigma^2)/2)*(Days/365))/(sigma*sqrt(Days/365));
    d2=d1-sigma*sqrt(Days/365);
    C=S*exp((-q/100)*(Days/365))*normcdf(d1)-K*exp(-
(r/100)*(Days/365))*normcdf(d2);
    c(i)=C;
    delta(i)=exp((-q/100)*(Days/365))*normcdf(d1);
    amopt(i)=AmOpt;

```

```

popt(i)=amopt(i)*c(i);
peiln(i)=pbond(i)+popt(i);
% set if arguments for restructuring
if (peiln(i)/Peiln-1) >= UL || delta(i) <= LL || i==(Start+Dur-
1);
    if (peiln(i)/Peiln-1) >= UL;
        omstupp=omstupp+1;
%plotta([i:length(SP500)], (omstupp+omstned+omstlop))=peiln(i);
%plot(SP500(:,5),plotta(:, (omstupp+omstned+omstlop)), 'g');
    elseif delta(i) <= LL;
        omstned=omstned+1;
%plotta([i:length(SP500)], (omstupp+omstned+omstlop))=peiln(i);
%plot(SP500(:,5),plotta(:, (omstupp+omstned+omstlop)), 'r');
    elseif i==(Start+Dur-1);
        omstlop=omstlop+1;
%plotta([i:length(SP500)], (omstupp+omstned+omstlop))=peiln(i);
%plot(SP500(:,5),plotta(:, (omstupp+omstned+omstlop)), 'm');
    end
    if kk==1;
        UL=300;
    else
        UL=aa*((1+(Rf(i,9)/100))^5-1); %New upper limit
    end
    Start=i; % Reset start time
    t=0;
    if (i+Dur) > length(SP500);
        Tfinish=SP500(i,6)+Dur/252*365;
    else
        Tfinish=SP500((i+Dur),6);
    end
    % Create a new EILN as we did previously
    Days=(Tfinish-SP500(i,6));
    if Days > 0 && Days <= 90;
        r=Rf(i,4);
    elseif Days > 90 && Days <= 180;
        r=Rf(i,4)+(Rf(i,5)-Rf(i,4))/(180-90)*(Days-90);
    elseif Days > 180 && Days <= 365;
        r=Rf(i,5)+(Rf(i,6)-Rf(i,5))/(365-180)*(Days-180);
    elseif Days > 365 && Days <= 730;
        r=Rf(i,6)+(Rf(i,7)-Rf(i,6))/(730-365)*(Days-365);
    elseif Days > 730 && Days <= 1095;
        r=Rf(i,7)+(Rf(i,8)-Rf(i,7))/(1095-730)*(Days-730);
    elseif Days > 1095 && Days <= 1827;
        r=Rf(i,8)+(Rf(i,9)-Rf(i,8))/(1827-1095)*(Days-1095);
    end
    Peiln=peiln(i);
    Rpbond=Peiln;
    Pbond=Rpbond*exp(-r/100*Days/365);
    Mopt=Peiln-Pbond;
    S=SP500(i,4);
    K=S;
    q=SP500(i,7);
    sigma=sqrt(252*(Std(i,2)+(1-exp(-
log(1/(Std(i,3)+Std(i,4))))*(Dur-t)))*(Std(i,1)-Std(i,2))/((Dur-
t)*log(1/(Std(i,3)+Std(i,4))))));
    d1=(log(S/K)+(r/100-
q/100+(sigma^2)/2)*(Days/365))/(sigma*sqrt(Days/365));
    d2=d1-sigma*sqrt(Days/365);

```

```

        C=S*exp((-q/100)*(Days/365))*normcdf(d1)-K*exp(-
(r/100)*(Days/365))*normcdf(d2);
        % PR=(Mopt/Peiln)*(K/C);
        AmOpt=Mopt/C;
        Delta=exp((-q/100)*(Days/365))*normcdf(d1);
    end
    if kk==1;
        Rp(i)=log(peiln(i)/peiln(i-1)); %daily log return for
passive strategy
    else
        Ra(i)=log(peiln(i)/peiln(i-1)); %daily log return for
active strategy
    end
    end
    if kk==1
        Rp=Rp;
    else
        % Save results from Each strategy and time step
        StandRa(jj,(kk-
1))=(std(Ra((start+1):(start+2*Dur)))*sqrt(252));
        YearlyReturn(jj,(kk-
1))=(peiln(start+2*Dur)/peiln(start))^(1/10)-1;
        Rap=Ra-Rp;
        Rapmean=mean(Rap((start+1):(start+2*Dur)));
        RAPmean(jj,(kk-1))=Rapmean;
        sigmaRap=std(Rap((start+1):(start+2*Dur)));
        STandRAP(jj,(kk-1))=sigmaRap;
        n=((start+2*Dur)-(start+1));
        stat=Rapmean/(sigmaRap/sqrt(n));
        zvalue(jj,(kk-1))=stat;
        significans=normcdf(stat);
        Tabarea(jj,(kk-1))=significans;
    end
end
end
end

```

APPENDIX 5: REGRESSION ANALYSIS

Regression analysis based on 520 different results where the annual return from each strategy is compared to the annual return of the 'buy-and-hold' strategy.

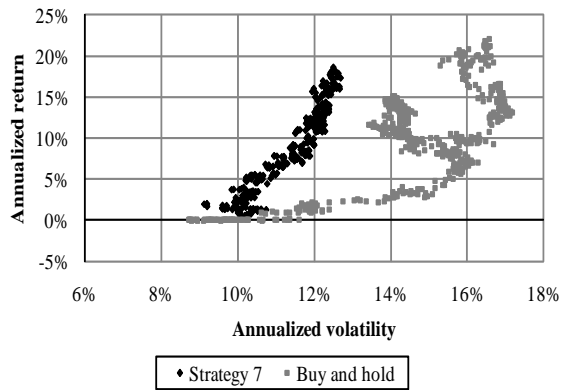
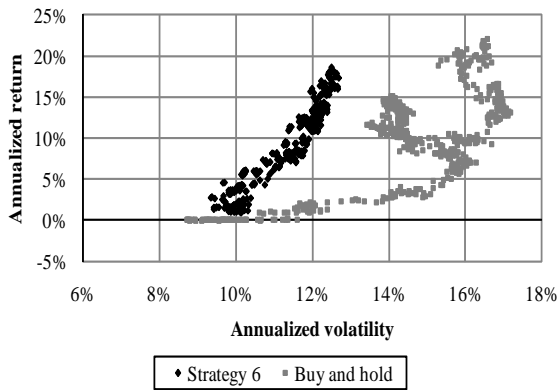
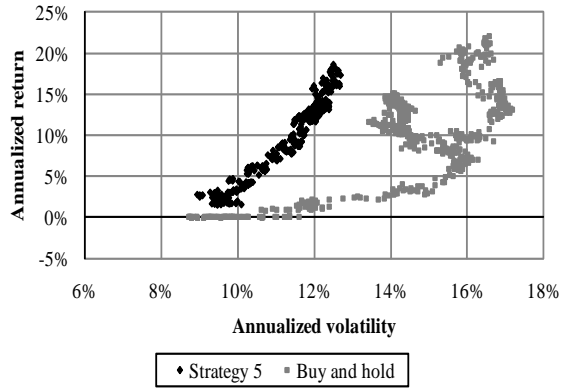
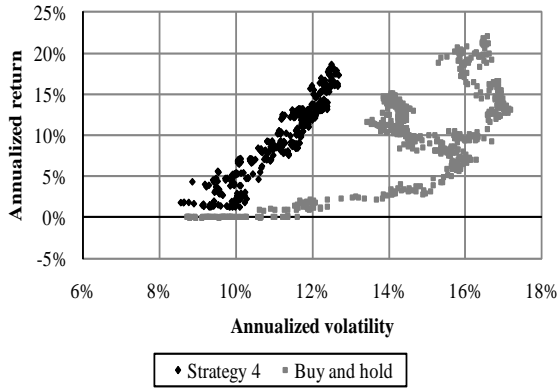
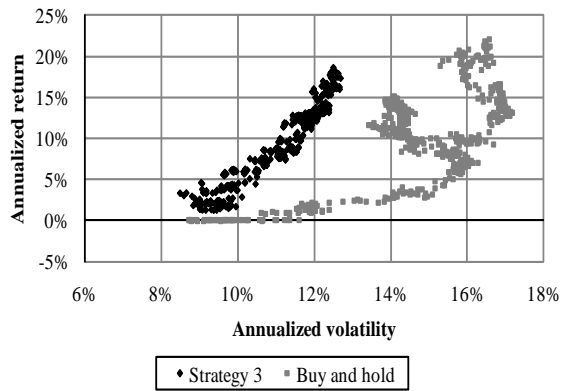
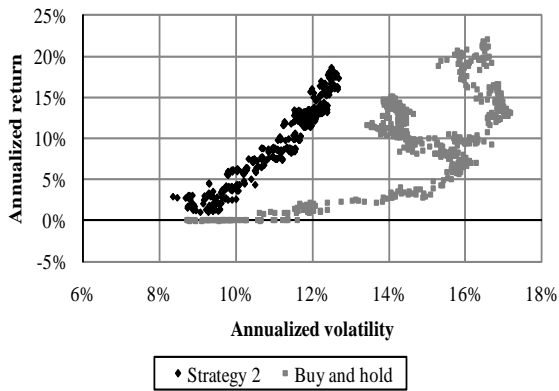
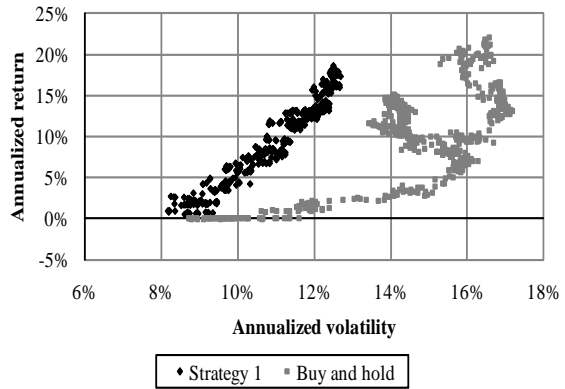
Exhibit A5.1: Results from regression analysis

Y=α+β*X					
Strategy	Upper limit	Lower limit	α	β	R ²
4	0.5	0.15	0.035	0.677	0.932
17	1.5	0.10	0.035	0.764	0.948
10	1.0	0.10	0.035	0.739	0.959
16	1.5	0.05	0.035	0.783	0.925
37	3.0	0.05	0.034	0.775	0.816
18	1.5	0.15	0.033	0.771	0.950
9	1.0	0.05	0.033	0.758	0.944
11	1.0	0.15	0.033	0.746	0.957
38	3.0	0.10	0.033	0.780	0.855
5	0.5	0.20	0.033	0.701	0.939
39	3.0	0.15	0.032	0.782	0.860
19	1.5	0.20	0.032	0.775	0.950
12	1.0	0.20	0.031	0.751	0.960
24	2.0	0.10	0.031	0.788	0.954
2	0.5	0.05	0.030	0.708	0.932
25	2.0	0.15	0.030	0.785	0.954
3	0.5	0.10	0.030	0.707	0.943
31	2.5	0.10	0.030	0.806	0.915
42	3.0	0.30	0.030	0.799	0.873
32	2.5	0.15	0.030	0.805	0.922
23	2.0	0.05	0.029	0.809	0.936
30	2.5	0.05	0.029	0.826	0.893
40	3.0	0.20	0.029	0.804	0.869
44	3.5	0.05	0.029	0.775	0.886
20	1.5	0.25	0.029	0.800	0.949
45	3.5	0.10	0.028	0.782	0.914
1	0.5	NL	0.028	0.710	0.918
49	3.5	0.30	0.027	0.786	0.914
51	4.0	0.05	0.027	0.790	0.897
21	1.5	0.30	0.027	0.811	0.943
46	3.5	0.15	0.027	0.785	0.916
41	3.0	0.25	0.027	0.815	0.874

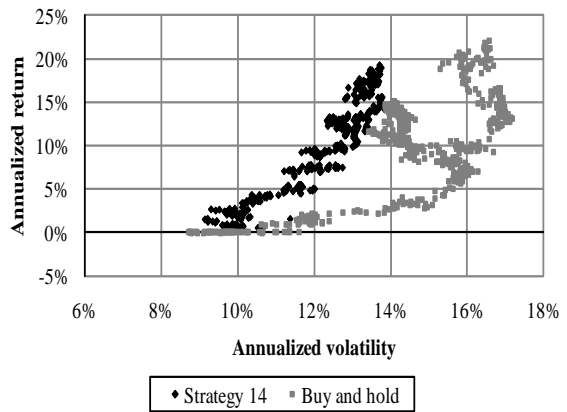
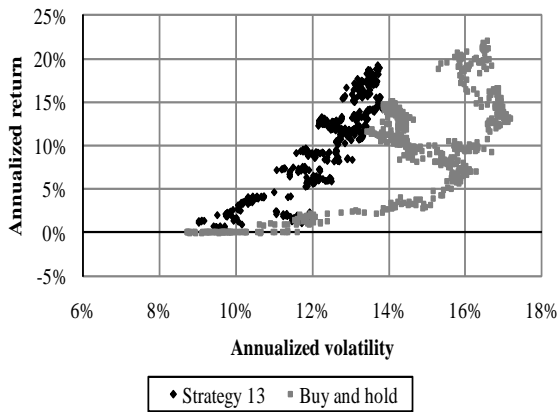
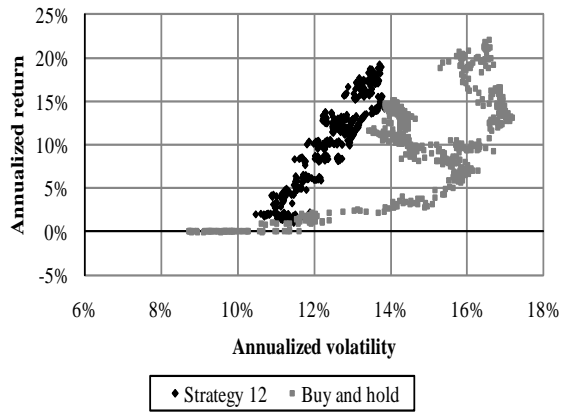
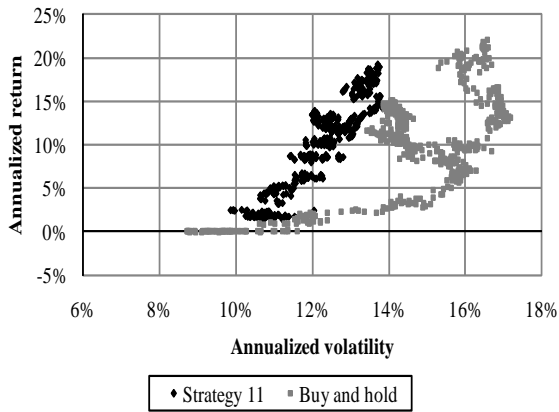
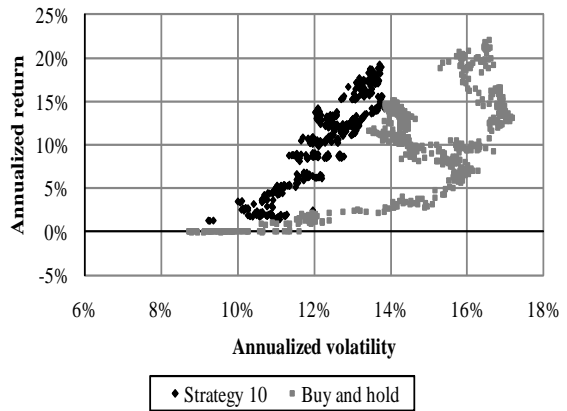
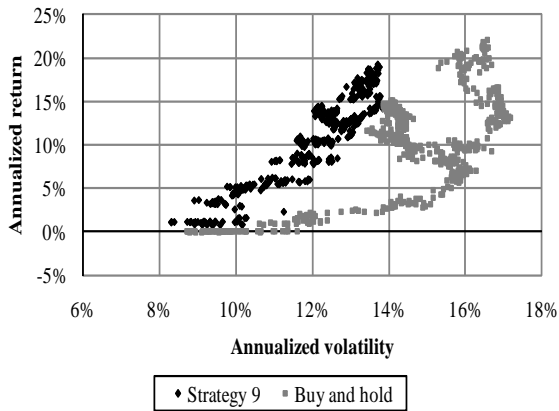
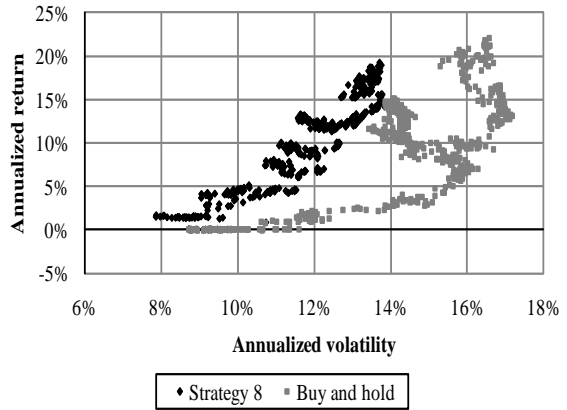
6	0.5	0.25	0.027	0.712	0.939
26	2.0	0.20	0.027	0.800	0.958
33	2.5	0.20	0.027	0.822	0.927
52	4.0	0.10	0.027	0.798	0.925
56	4.0	0.30	0.026	0.795	0.924
53	4.0	0.15	0.026	0.796	0.924
13	1.0	0.25	0.026	0.781	0.958
47	3.5	0.20	0.025	0.802	0.920
60	NL	0.15	0.025	0.846	0.978
27	2.0	0.25	0.025	0.816	0.959
63	NL	0.30	0.024	0.852	0.986
59	NL	0.10	0.024	0.854	0.974
34	2.5	0.25	0.024	0.840	0.928
35	2.5	0.30	0.024	0.846	0.928
14	1.0	0.30	0.024	0.792	0.956
48	3.5	0.25	0.024	0.810	0.924
54	4.0	0.20	0.024	0.810	0.931
28	2.0	0.30	0.024	0.830	0.955
55	4.0	0.25	0.023	0.817	0.933
58	NL	0.05	0.023	0.865	0.958
61	NL	0.20	0.023	0.860	0.987
7	0.5	0.30	0.023	0.739	0.942
62	NL	0.25	0.022	0.868	0.991
8	1.0	NL	0.022	0.798	0.933
15	1.5	NL	0.013	0.892	0.923
36	3.0	NL	0.007	0.950	0.873
22	2.0	NL	0.006	0.922	0.953
29	2.5	NL	0.004	0.969	0.936
43	3.5	NL	0.002	0.941	0.936
50	4.0	NL	0.002	0.947	0.944
57	NL	NL	0.000	1.000	0.000

APPENDIX 6: STRATEGY RESULTS

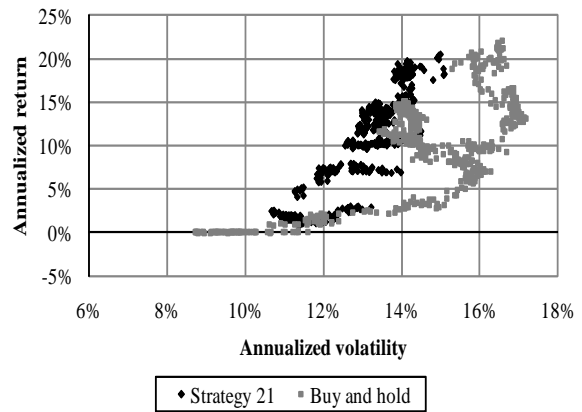
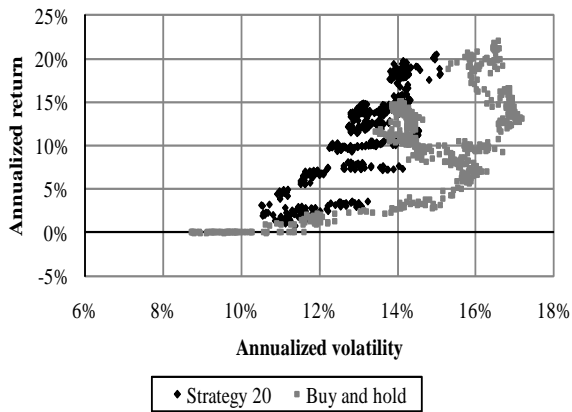
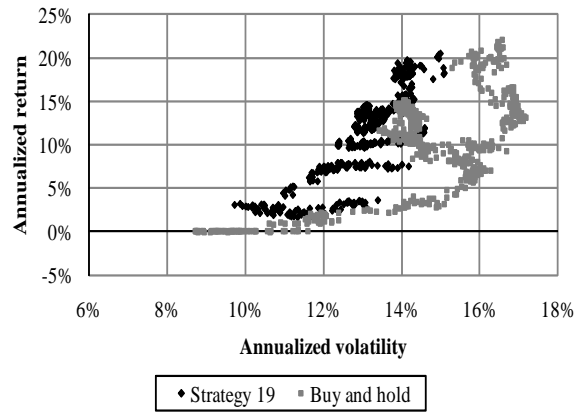
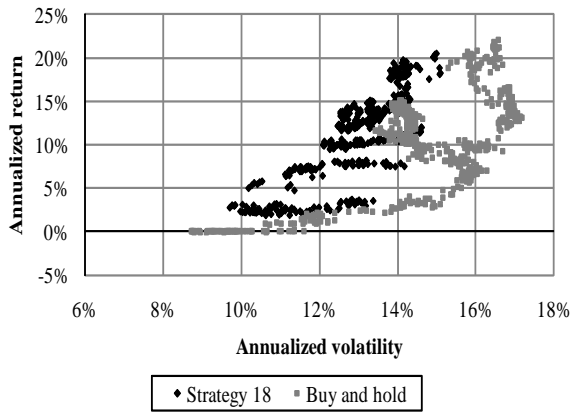
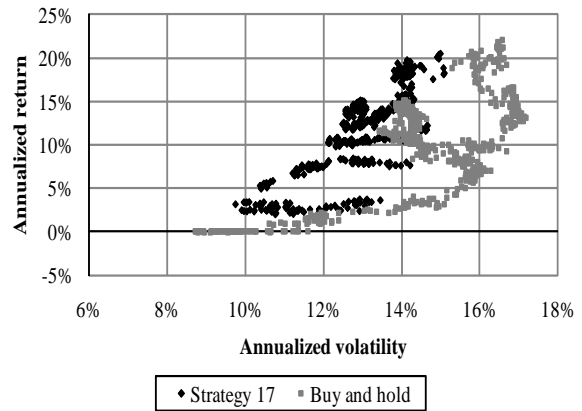
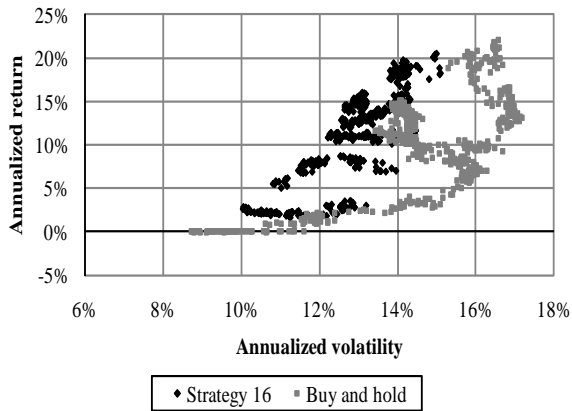
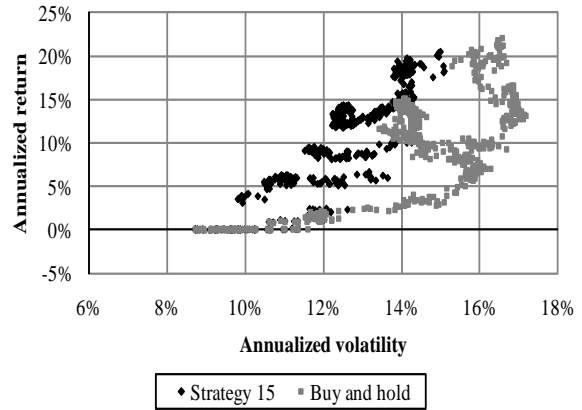
	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5	Strategy 6	Strategy 7
Upper (take profit) limit	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Lower (stop loss) limit	0	0,05	0,1	0,15	0,2	0,25	0,3
Average return	9,7%	9,9%	9,9%	10,1%	10,1%	9,7%	9,5%
Average volatility	11,0%	11,2%	11,2%	11,3%	11,4%	11,5%	11,5%
# restructuring occasions: upside	6,0	6,7	6,6	6,8	7,3	7,0	6,8
# restructuring occasions: downside	0,0	0,8	0,9	1,0	1,5	1,8	2,0



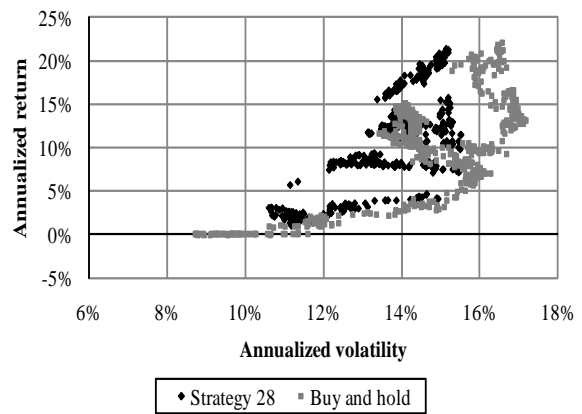
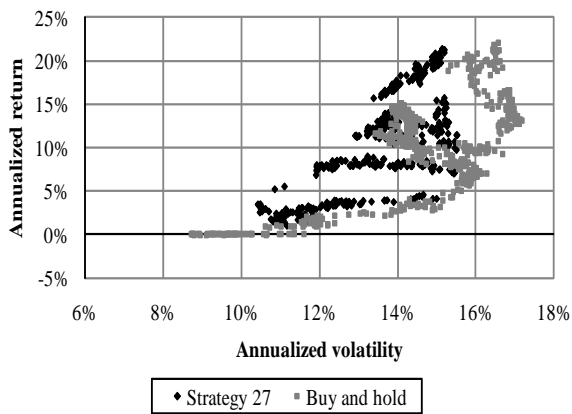
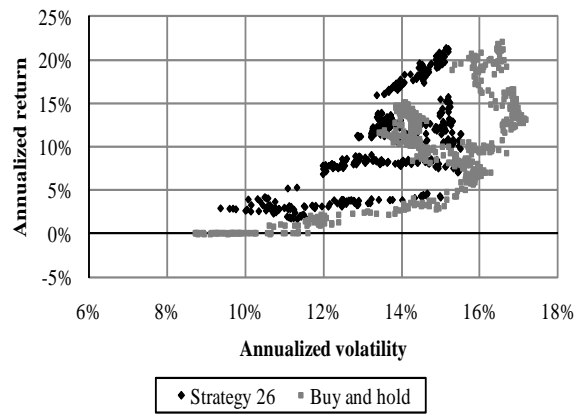
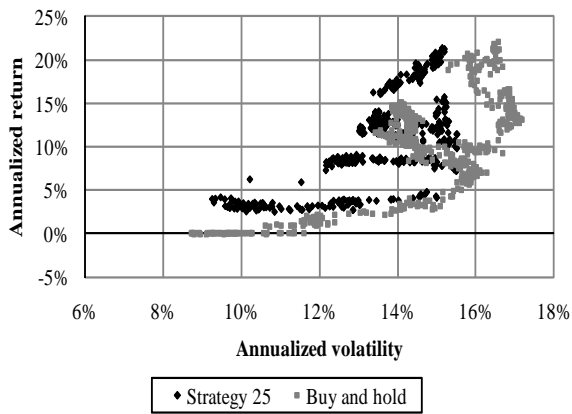
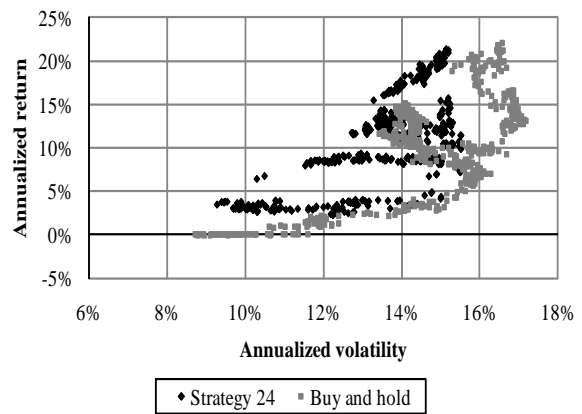
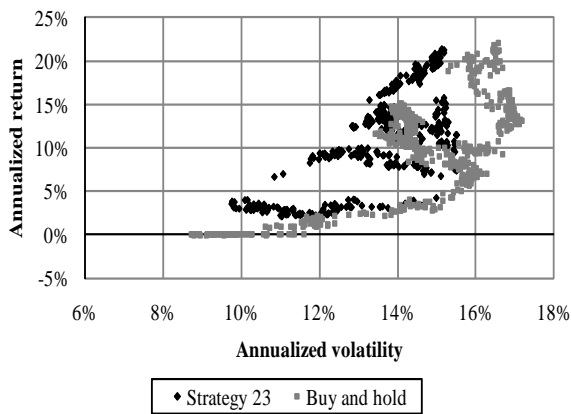
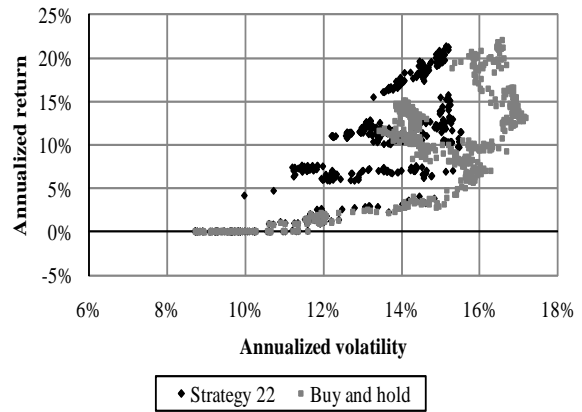
	Strategy 8	Strategy 9	Strategy 10	Strategy 11	Strategy 12	Strategy 13	Strategy 14
Upper (take profit) limit	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lower (stop loss) limit	0	0.05	0.1	0.15	0.2	0.25	0.3
Average return	9.9%	10.7%	10.7%	10.5%	10.4%	10.2%	10.1%
Average volatility	11.8%	12.0%	12.3%	12.3%	12.4%	12.3%	12.2%
# restructuring occasions: upside	3.2	3.6	3.5	3.4	3.5	3.6	3.7
# restructuring occasions:	0.0	0.8	0.8	0.9	1.0	1.5	1.9



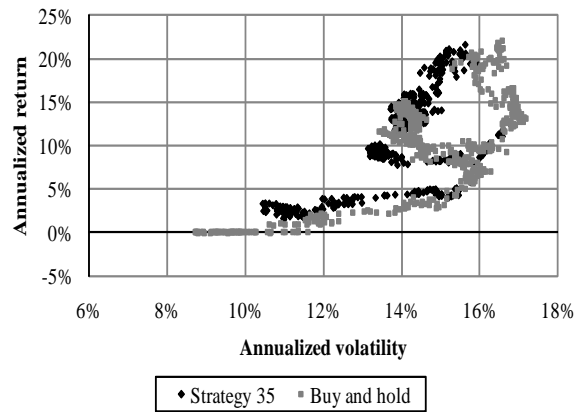
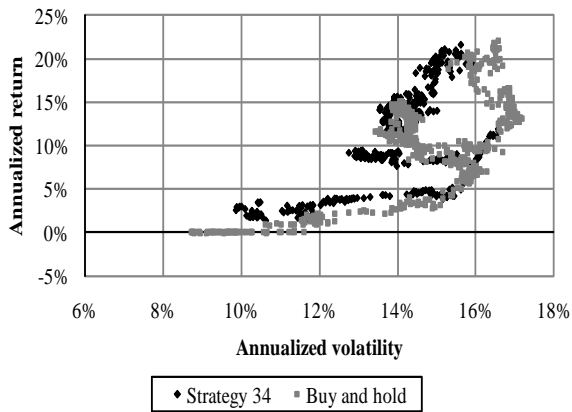
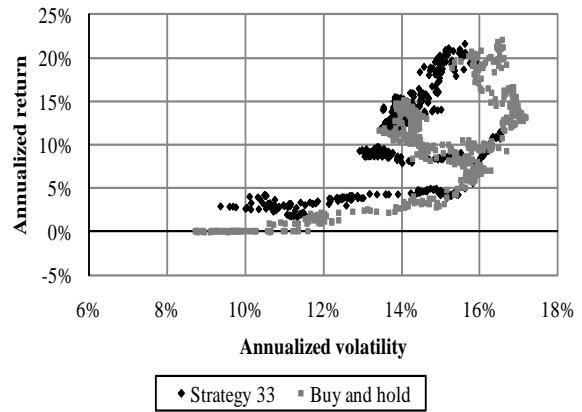
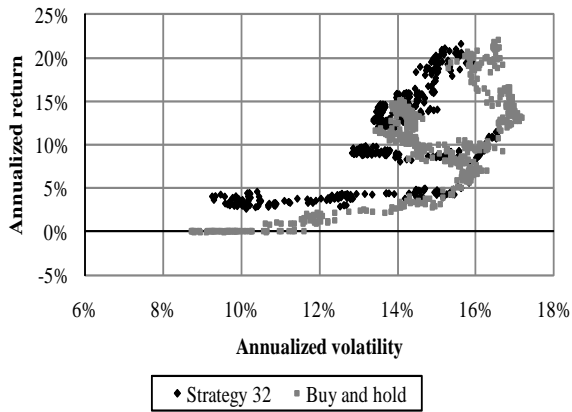
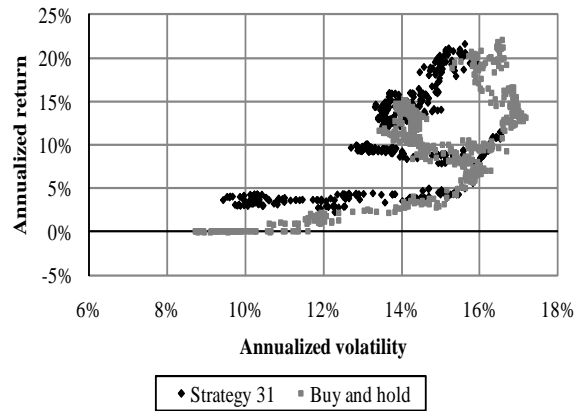
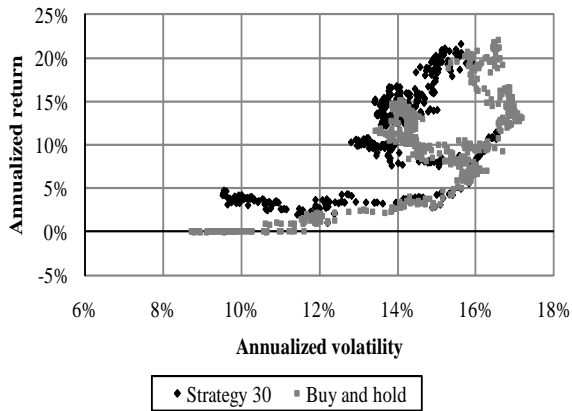
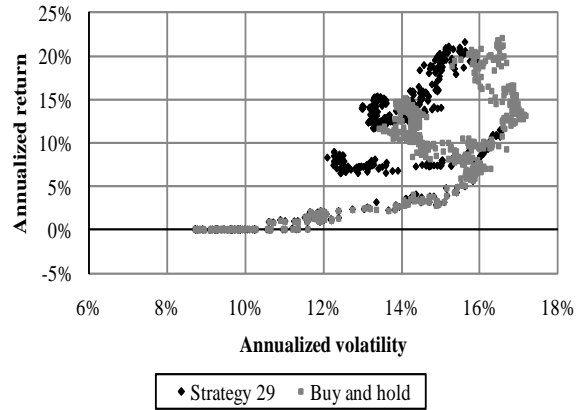
	Strategy 15	Strategy 16	Strategy 17	Strategy 18	Strategy 19	Strategy 20	Strategy 21
Upper (take profit) limit	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Lower (stop loss) limit	0	0,05	0,1	0,15	0,2	0,25	0,3
Average return	9,9%	11,1%	11,0%	10,8%	10,7%	10,6%	10,6%
Average volatility	12,4%	12,9%	12,9%	12,9%	13,0%	13,0%	13,1%
# restructuring occasions: upside	2,0	2,4	2,3	2,3	2,2	2,4	2,5
# restructuring occasions:	0,0	0,8	0,8	0,9	0,9	1,5	1,9



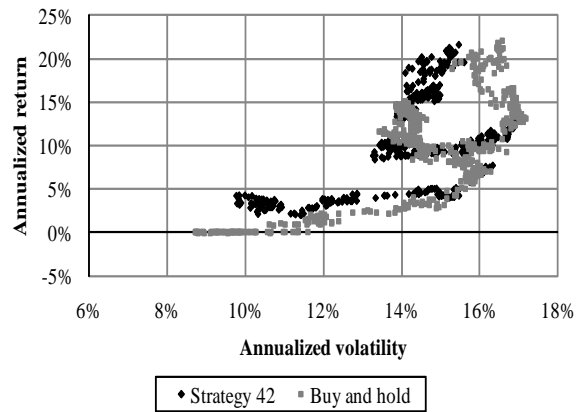
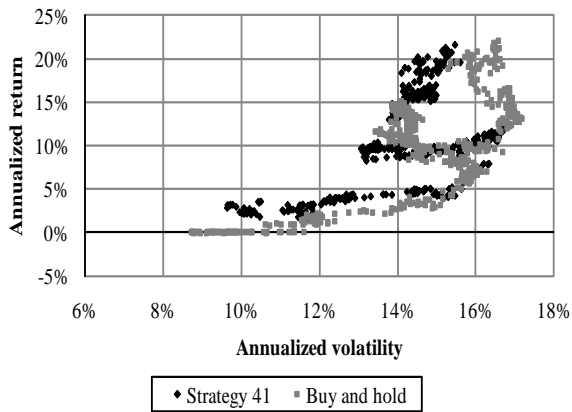
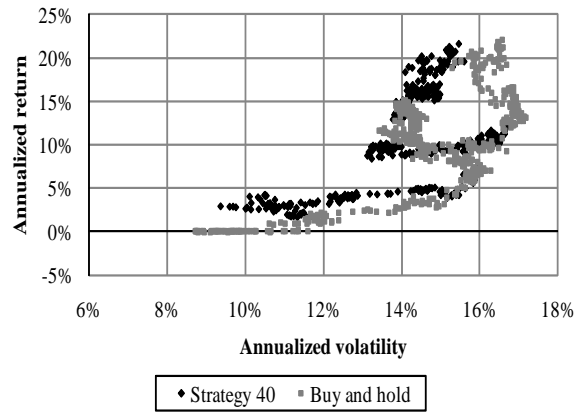
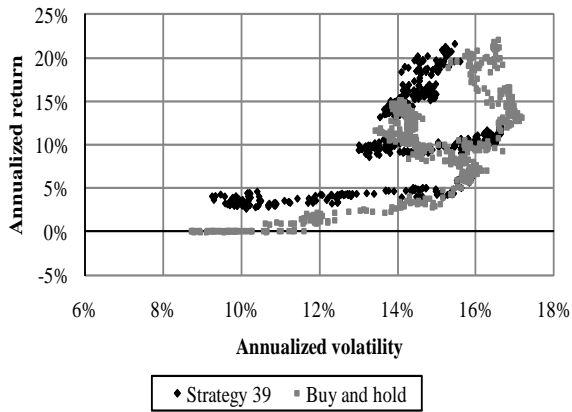
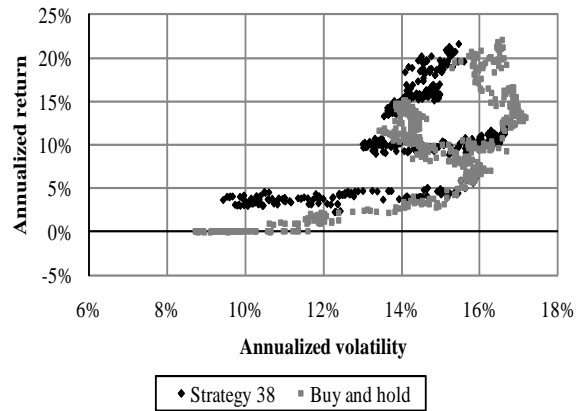
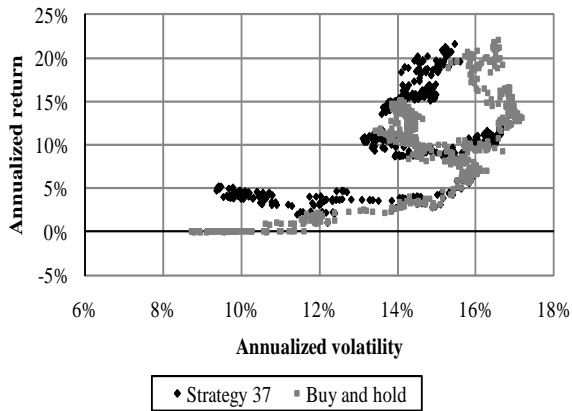
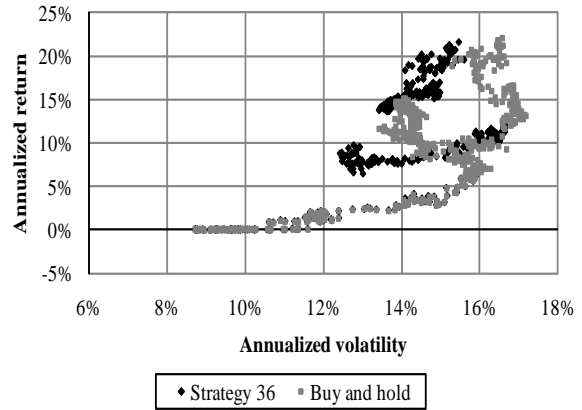
	Strategy 22	Strategy 23	Strategy 24	Strategy 25	Strategy 26	Strategy 27	Strategy 28
Upper (take profit) limit	2,0	2,0	2,0	2,0	2,0	2,0	2,0
Lower (stop loss) limit	0	0,05	0,1	0,15	0,2	0,25	0,3
Average return	9,6%	10,8%	10,7%	10,7%	10,5%	10,4%	10,5%
Average volatility	13,2%	13,6%	13,5%	13,5%	13,6%	13,6%	13,7%
# restructuring occasions: upside	1,5	1,8	1,8	1,7	1,6	1,7	1,8
# restructuring occasions:	0,0	0,8	0,8	0,9	1,0	1,2	1,7



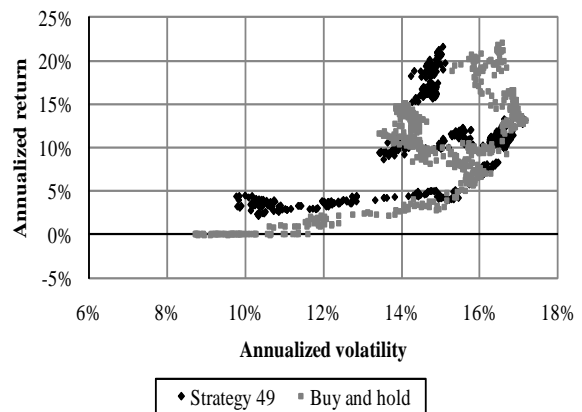
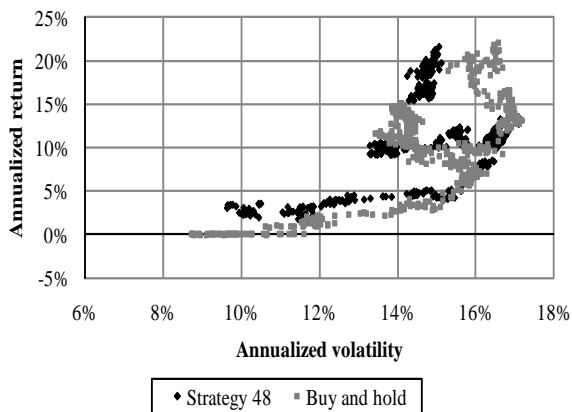
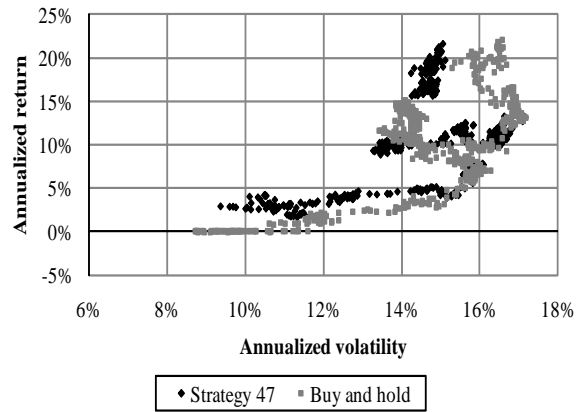
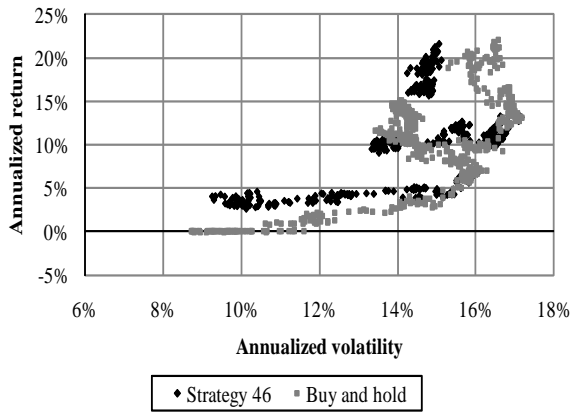
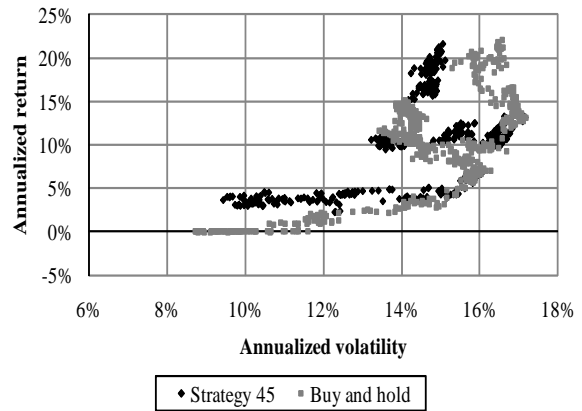
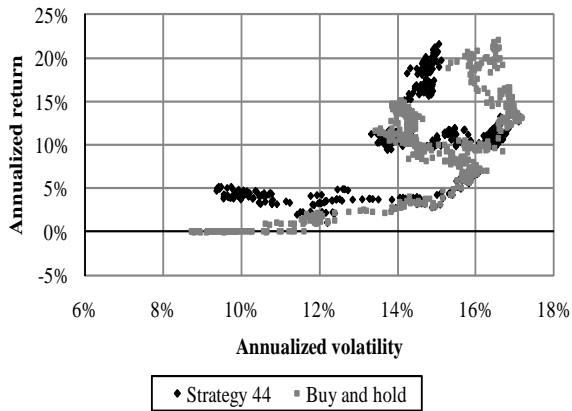
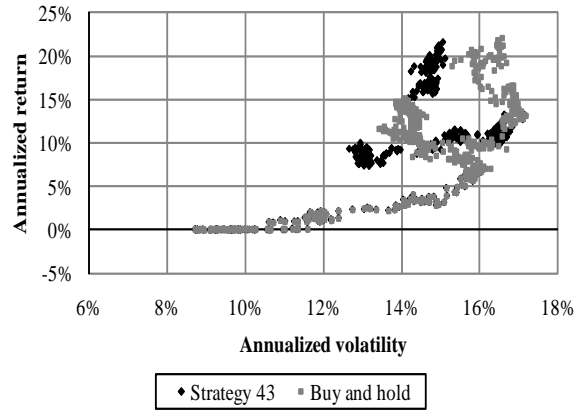
	Strategy 29	Strategy 30	Strategy 31	Strategy 32	Strategy 33	Strategy 34	Strategy 35
Upper (take profit) limit	2,5	2,5	2,5	2,5	2,5	2,5	2,5
Lower (stop loss) limit	0	0,05	0,1	0,15	0,2	0,25	0,3
Average return	9,8%	10,9%	10,9%	10,8%	10,7%	10,6%	10,6%
Average volatility	13,5%	13,7%	13,8%	13,8%	13,8%	13,9%	13,9%
# restructuring occasions: upside	1,2	1,4	1,3	1,2	1,2	1,3	1,4
# restructuring occasions:	0,0	0,8	0,8	0,9	0,9	1,2	1,7



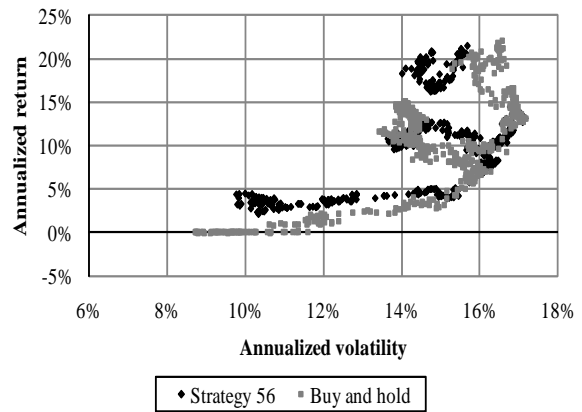
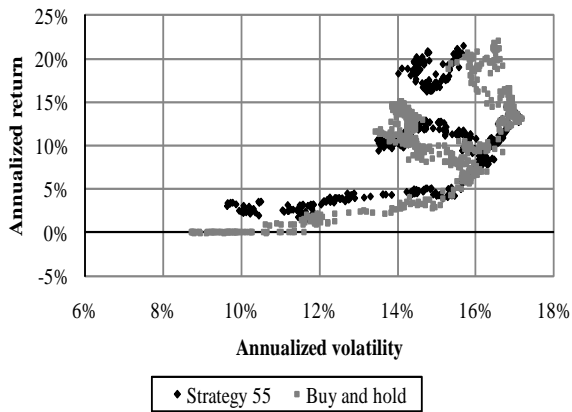
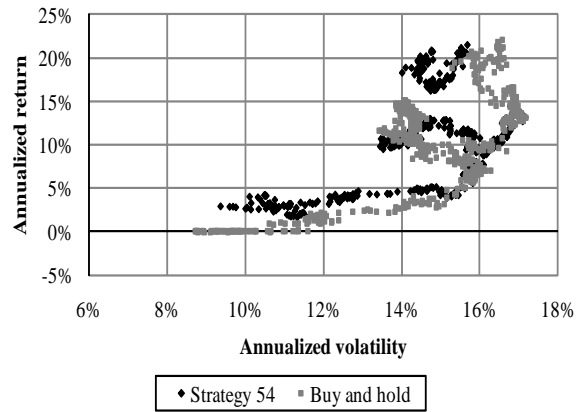
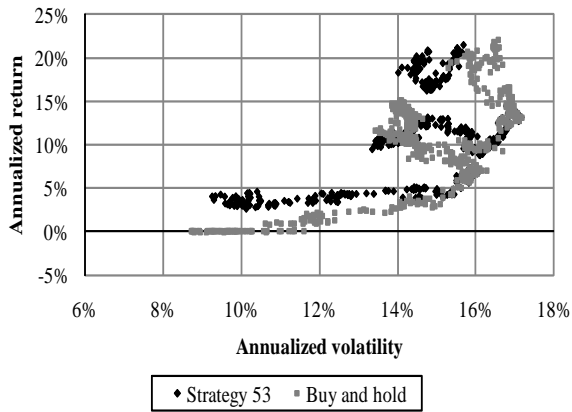
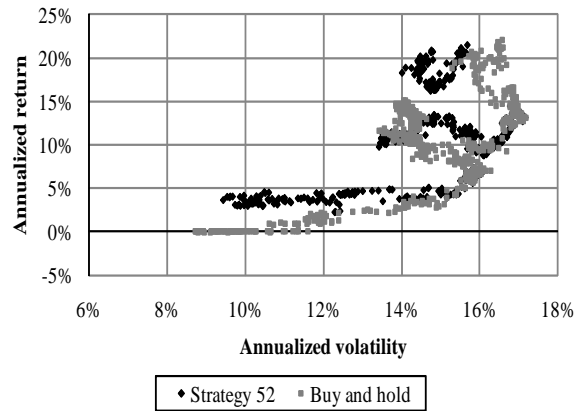
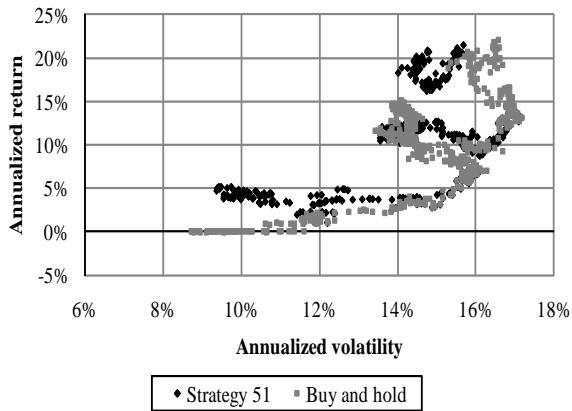
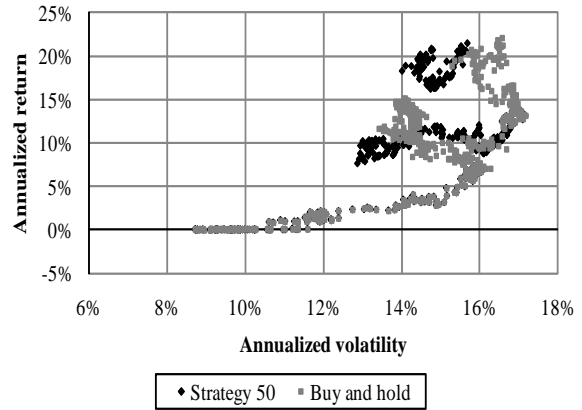
	Strategy 36	Strategy 37	Strategy 38	Strategy 39	Strategy 40	Strategy 41	Strategy 42
Upper (take profit) limit	3,0	3,0	3,0	3,0	3,0	3,0	3,0
Lower (stop loss) limit	0	0,05	0,1	0,15	0,2	0,25	0,3
Average return	9,9%	10,9%	10,9%	10,8%	10,7%	10,7%	10,8%
Average volatility	13,8%	14,0%	14,1%	14,1%	14,2%	14,2%	14,2%
# restructuring occasions: upside	1,0	1,1	1,0	1,0	1,0	1,0	1,1
# restructuring occasions:	0,0	0,7	0,7	0,8	0,9	1,3	1,7



	Strategy 43	Strategy 44	Strategy 45	Strategy 46	Strategy 47	Strategy 48	Strategy 49
Upper (take profit) limit	3,5	3,5	3,5	3,5	3,5	3,5	3,5
Lower (stop loss) limit	0	0,05	0,1	0,15	0,2	0,25	0,3
Average return	9,4%	10,4%	10,4%	10,4%	10,3%	10,3%	10,4%
Average volatility	14,3%	14,5%	14,5%	14,5%	14,6%	14,6%	14,6%
# restructuring occasions: upside	0,7	0,7	0,7	0,7	0,7	0,7	0,7
# restructuring occasions:	0,0	0,6	0,6	0,7	0,8	1,1	1,6



	Strategy 50	Strategy 51	Strategy 52	Strategy 53	Strategy 54	Strategy 55	Strategy 56
Upper (take profit) limit	4,0	4,0	4,0	4,0	4,0	4,0	4,0
Lower (stop loss) limit	0	0,05	0,1	0,15	0,2	0,25	0,3
Average return	9,4%	10,4%	10,4%	10,4%	10,3%	10,3%	10,4%
Average volatility	14,3%	14,5%	14,5%	14,5%	14,6%	14,6%	14,6%
# restructuring occasions: upside	0,6	0,6	0,6	0,6	0,6	0,6	0,6
# restructuring occasions:	0,0	0,6	0,6	0,7	0,8	1,1	1,6



	Strategy 57	Strategy 58	Strategy 59	Strategy 60	Strategy 61	Strategy 62	Strategy 63
Upper (take profit) limit	NL	NL	NL	NL	NL	NL	NL
Lower (stop loss) limit	0	0,05	0,1	0,15	0,2	0,25	0,3
Average return	9,7%	10,7%	10,8%	10,7%	10,7%	10,6%	10,8%
Average volatility	14,4%	14,6%	14,7%	14,7%	14,8%	14,8%	14,8%
# restructuring occasions: upside	0,0	0,0	0,0	0,0	0,0	0,0	0,0
# restructuring occasions:	0,0	0,7	0,7	0,9	0,9	1,2	1,7

