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How reliable are portfolio insurance strategies during economic crises?

A comparative analysis between different risk reducing strategies and risk measurement instruments

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PREFACE AND ACKNOWLEDGEMENTS

This thesis has been written as a final assignment for graduation in the Masters degree of Science in Economics & Business, with a specialisation in Financial Economics, at the Erasmus University Rotterdam. The subject of this paper has attracted me ever since I followed the seminar Risk Management during this Masters course. The particular outline for this thesis has been chosen, because I wanted to add new information with respect to the ongoing discussion on the reliability of portfolio insurance. Specifically, the performance of portfolio insurance strategies has never been evaluated during crises. Moreover, two new portfolio insurance strategies have been proposed. Unfortunately, the performances of these new strategies have not fulfilled my expectations. However, it has been interesting to experience for myself the invention and model-building of new theories. My appreciation goes to my supervisor dr. Remco Zwinkels, who has provided me with helpful comments and insights.

ABSTRACT

The performance of portfolio insurance strategies is usually evaluated under random market conditions. Furthermore, value at risk and expected shortfall are used to evaluate the riskiness of portfolio insurance strategies in relatively few papers. This paper has evaluated the performance of widely used portfolio insurance strategies particularly during the two most recent experienced crises. Synthetic put portfolio insurance, constant proportion portfolio insurance and stop-loss portfolio insurance are evaluated in this paper. Stop-loss portfolio insurance turns out to provide the highest returns during crises. Because the common believe is that the stop-loss strategy would be outperformed by other strategies under random market conditions and/or bull markets, also a third period covering a total business cycle of ten years has been used to evaluate the portfolio insurance strategies. Also, two alternative versions of the stop-loss strategy have been proposed and evaluated during all three sample periods, which are stop-loss 95-105 and stop-loss/start-gain. Unexpectedly, the normal stop-loss strategy also provides the highest return during the total business cycle that has been used. This can be explained with the fact that the markets did not recover aggressively enough to outperform the lead that the stop-loss strategy has acquired over the other strategies during the bear market. Overall, the stop-loss strategy has turned out to be the best insurance strategy during the past ten years for investors who are very risk-averse. Investors who are more risk tolerant should use the CPPI strategy.

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1. Introduction

Risk management is a general topic in financial economics that has proved to be important more and more since the current credit crisis, which has evolved to a worldwide recession. An important aspect of risk management is portfolio insurance, which considers the defence of the value of investment portfolios against declines in the stock market. According to Doherty (1984), the demand for portfolio insurance arises from the fact that investors unsatisfactorily diversify risk away. It originated after the crisis of 1976, and its first intention was to re-attract investors to the market. Leland and Rubinstein (1983) write that although portfolio insurance has developed to much more complex strategies than when it originated, it was widely adopted on relative short notice after its introduction. The most widely used portfolio insurance strategies are option-based portfolio insurance (OBPI), constant proportion portfolio insurance (CPPI) and synthetic put portfolio insurance. A relatively new insurance strategy is stop-loss portfolio insurance (see Annaert, Osselaer & Verstraete, 2007). There are also other methods of portfolio insurance, which are used less in practice, see for example Gould (1988).

There have been performed more researches on the reliability of portfolio insurance. Black and Rouhani (1989) have compared the OBPI and the CPPI with respect to their payoffs, when the put has to be synthesized. Their findings show that OBPI outperforms CPPI under moderate market increases. Under small or large increases, as well as market declines, the CPPI method outperforms the OBPI method. Bertrand and Prigent (2002) compared OBPI and CPPI and found that when the insured amount at maturity increases, the CPPI method becomes more relevant than OBPI. By analyzing the dynamic properties of both methods they also showed that OBPI can be considered as a generalized CPPI method. Annaert et al. (2007) compared the synthetic put and CPPI strategies to the stop-loss strategy. They used a sample period covering more than 30 years. The insurance strategies have been reviewed by making use of value at risk and expected shortfall. They conclude that stop-loss portfolio insurance is dominated by the other two strategies. Daily rebalancing appears to be the only viable rebalancing frequency, and the floor that has to be chosen still allows for some scope. Garcia and Gould (1987) also confirm that daily rebalancing provides the most accurate portfolio insurance, but they also conclude that profits are limited by transaction costs.

However, it has not been evaluated how effective portfolio insurance is during a crisis. Still no consensus has been reached about the effectiveness of portfolio insurance between theory and practice, which has been confirmed by Annaert et al. (2007). This research will attempt to add proof on the reliability of portfolio insurance to the still ongoing discussion, but from a different perspective than the current literature. While other papers are focussed on the returns of portfolio insurance strategies under random market circumstances, this paper will focus on portfolio insurance strategies' performance during crises. This makes sense, as this is exactly when portfolio insurance is needed. The perspective in this paper is from a European (or Dutch) investor who invests 100.000 Euros in an investment portfolio. A lot of different scenarios will be evaluated. Each scenario considers a portfolio in which the constituents differ from each other, varying from combinations of risky and risk-free assets to portfolios consisting of merely risky or risk-free assets. The model uses stock market indices from different countries around the world as risky assets in the investment portfolios. This will reveal whether it makes a difference if an investor invests domestically or abroad. Furthermore the situation will consider the entry of an investor in the market during one of the worst moments for investments, namely on the eve of a crisis. The investment periods in this paper are based on the AEX index, from the highest values before the crises to the lowest values during the crises. How reliable is portfolio insurance when the investment period covers exactly a crisis?

The different portfolio insurance techniques that will be examined are synthetic put portfolio insurance (which is an alternative version of the OBPI strategy), CPPI and stop-loss portfolio insurance. These will all be compared to a naive buy & hold strategy, in which all the wealth from an investment portfolio is allocated to risky assets. In order to evaluate the effectiveness of the different portfolio insurance strategies, different value at risk (VaR) methods will be used. The value at risk methods that will be used are delta-normal, historical simulation and Monte Carlo simulation. The value at risk levels will be evaluated using back testing. In addition, expected shortfall, which considers losses beyond the VaR levels, will be used.

The main objective of this paper is to comment on the reliability of portfolio insurance during crises, but there will also be elaborated on whether there is an insurance strategy that dominates the others.

In anticipation to the conclusion; the results indicate that the synthetic put strategy is outperformed by CPPI and stop-loss portfolio insurance. At the highest floor levels, the stop-loss strategy also outperforms CPPI. Because the stop-loss strategy is a rather rigorous strategy that has proved to perform exceptionally well during crises, there also has been looked at the stop-loss strategy's performance during random market conditions. For this, a period of ten years is subject to research. Two alternative versions of the stop-loss strategy have been evaluated. In one strategy, the stop-loss portfolio is again rebalanced to risky assets after the value of risky assets has risen five percent above the original value at the start of the investment period. Another alternative strategy that has been proposed in this paper, is the stop-loss/start-gain strategy, in which an investor sells his entire risky portfolio after a day of decline, and re-buys it after a day of increase. With this strategy, investors try to catch a flow of positive returns, while avoiding a flow of negative returns. Because increasing the floor values for insurance strategies during crises has proved to make sense, not every different floor value has been used in the evaluation during the third period. Only the floor value of 95 percent has been used.

The next chapter shortly explains the crises during which the effectiveness of portfolio insurance has been evaluated, and how the different portfolio insurance techniques work in practice. After that, chapter 3 explains which data and time frames have been used in this paper. Also the methodology for this research has been established and explained in chapter 3. In chapter 4 the results are presented and discussed, from which conclusions on the effectiveness of portfolio insurance are drawn in chapter 5.

2. Theory

This chapter will cover the most relevant literature on portfolio insurance strategies and its evaluation techniques. First the importance of decent risk management and portfolio insurance will be emphasized using brief descriptions of the most relevant crises for this research, after which the developments and principles of portfolio insurance will be discussed. Furthermore, the way in which the different insurance techniques work, as they have been used in past studies, will be described. Based on the different methods used in past studies, the methodology for this research will be established.

2.1 The crisis of 1987

The crisis of 1987 is not subject to research in this paper, because during this crisis the portfolio insurance strategies of today were not available. Portfolio insurance did already exist, but it had not evolved to the same modern techniques that are used nowadays. Hence it does not make sense to analyze how successful the modern insurance strategies would have been. However, it is relevant to briefly discuss this crisis, because it adds insight to the development of crises and the need for decent portfolio insurance. The crisis of 1987 started with the sudden crash in the stock market on October 19th. The market, i.e. several stock indices, on average suffered a loss of 20 percent in one day. What exactly triggered the crisis has never been understood indisputably. According to Bodie, Kane and Marcus (2005), economists tend to refer to the crash of 1987 as a Black Swan, an event that could not have been foreseen. However, there are possible explanations for the 1987 crash. Portfolio insurers are sometimes blamed for the crash, as they could have profited from it to a large extent, by using derivatives that were waiting for 'an accident' to happen. Another reason why portfolio insurers are blamed for the crash of 1987 is because they are thought to have forecasted the possibility of a crash, which is why they had anticipated to it. By shorting stocks and going long in put options, a signal to the market was extended which triggered the crash eventually, yielding huge profits for the portfolio insurers. Markham and Stephanz (1987) point to the fact that portfolio insurers used computerized sell orders. Although each computerized insurance strategy differs from the others, they share a lot of characteristics. When stock prices changed, this would have triggered a sell order for a lot of computerized insurance programs, which enlarged the change in the stock price, causing the crash of October 19th. However, what really triggered the crash never became undoubted.

Portfolio insurance was already available at that time, but it had not evolved to the modern techniques that are used nowadays. Also, not every investor was familiarized with portfolio insurance enough to be able to resist the 1987 crash. Actually, most investors, even if they had their portfolios insured to a certain extent, suffered huge losses. This was not only due to the state of portfolio insurance at that time, but also due to lacking technology and increasing betas across the market, according to Roll (1988). Bodie et al. (2005) argue that several aspects of portfolio insurance failed during the crash of 1987. The market volatility on October 19th 1987 was higher than ever encountered before. Put option deltas were too low, because they were based on historical experience. This resulted in the fact that insurers underhedged and held too much equity, which made them suffer excessive losses. When the crisis continued, prices were moving at such a large speed that insurers were unable to keep up with the volatility with respect to the rebalancing of their portfolios. This was worsened by a gap opening, which meant that opening prices were not occasionally but rather very often ten percent below previous days' closing prices. This prevented insurers from updating their hedge ratios in time. Moreover, the computation of correct hedge ratios was impossible, because the price quotation system was hours behind. Furthermore, trading in stocks and futures was ceased during several periods, which also undermined insurers' capabilities of proper rebalancing their portfolios. Finally, substantial losses were suffered due to futures. Futures were to a large extent underpriced, which caused insurers to buy futures, hoping that their prices would soon recover to their usual premium over the stocks and stock indices. However, as this did not happen, portfolio insurers remained underhedged (Bodie et al., 2005).

2.2 The collapse of the dot-com bubble

The widely adopted and relatively new concept called internet rapidly developed during the second half of the '90s. A new commercial sector evolved from this new technology, which moved many entrepreneurs to start their own business in internet-related activities. As a result of a huge money inflow from Asia and the Middle-East, interest rates were relatively low in the US around 1998. Start-up capital for entrepreneurs was therefore relatively cheap, which stimulated the number of entrepreneurs and investors in the dot-com sector. New huge companies evolved in short time, such as Google and Amazon. Hendershott (2004) finds that what rapidly was created was a technology bubble, which had been seen before, for example in the 1840's with railroads and in the 1920's with radio and television. Such booms are notably created by speculators, who buy shares in such technology related businesses in anticipation of future growth, rather than anticipating the fact that they are undervalued. The companies themselves also played important roles in the development of the bubble, with strategies devoted to growth rather than profit. Profit was a concern for the future; the initial phase in the development of the IT sector was to acquire market share. Finally, Brunnermeier and Nagel (2004) find that hedge funds played an important role. At a certain point during the boom, shares were priced as high as the average future earnings growth would exceed the highest individual future growth ever experienced. This was stimulated by the large amount of shares that were bought by hedge funds.

In 1999 and 2000 the US Federal Reserve raised interest rates six times, which slowed down the economy. At the start of 2000 the tide turned and the rapidly created internet bubble collapsed. There are several possible explanations for what triggered the collapse of this bubble. On March 13, 2000, the NASDAQ opened four percent lower than its pre-weekend closing value. This resulted from the largest pre-market selloff in the entire year. De Long and Magin (2006) argue that this would have triggered a chain reaction, causing the NASDAQ to decline with ten percent in one week. Another possible explanation for the sudden trigger of the collapse of the dot-com bubble was that the pre-anticipated millennium bug omitted, which made investors realise that the market was turning in to saturation. A third possible explanation is the disappointing results of internet retailers in December 1999. After several years of development, investors may have been expecting the first positive returns on their investments, which did not occur. The internet hype was starting to turn out disappointing for investors. The worsening market sentiment was accelerated by the attacks on September 11, 2001, which caused a recession lasting until halfway 2003.

2.3 The credit crisis

In September 2008 the financial world triggered the most severe recession since the Great Depression during the '30s of the previous century. The first direct signs of the upcoming crisis were visible in March 2008, when Bear Stearns revealed the problems it was involved in. After a bailout by the Federal Reserve (Fed) and JP Morgan Chase, Bear Stearns was eventually taken over. There has been an attempt to rescue Bear Stearns because the bank was considered 'too big to fail', according to the Fed's chairman Ben Bernanke. This first huge bailout by the Fed was followed by the bailouts of the largest US mortgage lenders, Fannie Mae and Freddy Mac, after their share values had dropped over 90 percent. In September 2008, the investment bank Lehman Brothers was declared bankrupt, because the Fed had denied a bailout to this purely investment bank. Merrill Lynch and Morgan Stanley also were not able to cope with their financial problems and had to be taken over.

What had started as problems in the United States mortgage market has spread out to the world wide economy. The effects can be found everywhere. A huge amount of businesses has gone bankrupt, consumer wealth has dropped severely, and the overall economic activity has also been slowed down. Moreover, the huge amount of bankruptcies and cutting of expenses has led to a rising unemployment at a speed that has not been experienced for a long time. Especially the sector of financial institutions has been hit by the credit crisis, although some say that the crisis has been caused by those institutions themselves to a large extent.

After the collapse of the dot-com bubble in 2000 and the attacks on New York and the Pentagon in 2001, interest rates in the US were low, in order to soften the effects of the collapse and to stimulate economic recovery. Diamond and Rajan (2009) state that there was also risk of deflation that was attempted to be mitigated with easy money. Money in the US was also cheap as a result of the still huge amounts of foreign money flowing in to the US from fast growing economies, mostly in the Middle-East and Asia. The huge amount of cheap money available changed the morale of financial institutions from service oriented to profit oriented even more than before. By creating mortgage-backed securities (MBS's) investors were attracted to the market of mortgages, because it became possible for them to generate profits from mortgages. MBS's are complicated packages of mortgages. Normally, mortgages are extended by mortgage lenders through brokers. Brokers receive a fee and mortgage lenders receive mortgage payments from the families that buy houses. Courhy et al. (2008) find that when money became abundant, banks were looking for new investments and decided to interfere in the mortgage markets. Banks started to buy mortgages from mortgage lenders. These mortgages were put into a large pool, in which they were repackaged in a complicated way and were sold to private and institutional investors. As long as the mortgage payments were made by homeowners there was no problem, because mortgage lenders and banks made their profits, and investors could be paid with mortgage rents. However, as investors became greedier, they were asking for more structural products, which they were granted by banks. This was possible by providing mortgages to more people, even to people who were actually not suitable for homeownership. The subprime mortgages were born.

For years these developments in the financial market were not problematic, because house prices had been increasing for many years. Since the houses served as collateral in the mortgage extensions, defaults on mortgage payments were not necessarily problematic, because the house prices had almost always increased and hence the collateral value of the houses could compensate for the defaults on mortgage payments. However, when more and more people started to default on their mortgage payments, house prices started to decrease. Banks were starting to get in trouble, because the value of their collaterals was decreasing, and the demand for houses was also declining, which enlarged the problem of decreasing house prices. The problem became even bigger when more and more people were failing their mortgage payments, because the mortgages were higher than the actual house prices, and people refused to fulfil their mortgage payments that were too high relative to the value of their house. Due to lacking regulation in the US it was relatively easy for homeowners to simply abandon their houses and move across state borders to buy a new house. In this way, banks were left with lower priced collateral and payments to investors in MBS's could not be fulfilled anymore. These problems in the US house market have infected the worldwide financial system and the real economy because not only American investors had invested in mortgage-backed securities, but structural investors, such as banks, insurers and pension funds, worldwide. Stock values have dropped almost everywhere due to the risky attitude that banks had started to adapt in the past few years. This did not only influence structural investors and their investment portfolios, but also private investors. Private investors are affected by the mortgage market because most banks were involved in mortgage-related activities and banks are publicly owned by investors. The defaults of many banks has caused a systemic breakdown because consumer confidence has been affected significantly. An interesting question is whether portfolio insurers have been able to protect their investment portfolios from decreasing severely due to the market declines. The next sections will describe the history of portfolio insurance techniques, and the different strategies that have been used in this paper will be described briefly.

2.4 History of portfolio insurance in a nutshell

The history of portfolio insurance has been described by Leland and Rubinstein (1988). Portfolio insurance first came to use after the economic decline of 1973-1974, which forced many pension funds to withdraw from the market. The risk averse conduct of pension funds prevented them from benefiting from the subsequent rally on the market in 1975. It was Hayne Leland who came to think of a manner in which pension funds could be re-attracted to the market. By means of insurance for investment portfolios the losses could be reduced, while the upward potentials of investments would mostly be kept intact (in the absence of transaction costs). This could be achieved via the use of derivatives. In short, this works as follows. Stocks' losses can be reduced by using put options. In this case, there are two possibilities. One can either buy put options, or replicate put options by using dynamic strategies, which include the underlying stock and a risk-free asset. If this can be used for single stocks, it can also be applied to investments portfolios, with any desired strike price and maturity. Fortunately for Leland, few years earlier the pricing model of options had been developed by Fischer Black and Myron Scholes. In addition, during the '70s the first personal computers became available, although they were still far too expensive for regular consumers. However, Mark Rubinstein, a colleague from Leland, had recently purchased a personal computer and was an expert in the field of options. Together Leland and Rubinstein founded Leland-Rubinstein Associates, a company that focussed only on developing and evolving the techniques that are required to construct decent ways of portfolio insurance.

2.5 Principles of portfolio insurance

Achieving reduced downward risk while keeping upside potential unaffected is in theory more realistic than in practice. Portfolio insurance usually consists of creating a portfolio with risky and risk-free assets. Protective puts and dynamic hedging both are accompanied with transaction costs, which are in theory hard to determine for portfolios consisting of various stocks. Therefore, in researches about portfolio insurance, assumptions have to be made regarding transaction costs. Besides that, a portfolio can only be fully insured if a put option on the whole portfolio is issued. Therefore an investment portfolio should ideally consist of all the stocks that are traded within a market index. Market indices are widely used in research to the effectiveness of portfolio insurance for the representation of risky assets. For risk-free assets Treasury bills or other liquid money market instruments are used, according to Bertrand and Prigent (2001). Bodie et al. (2005) write that it is not optimal to insure a non-indexed portfolio with index puts, because this would result in a tracking error, which would limit the investors' freedom to pursue active stock selection. Consider for example the situation in which the value of the insured portfolio falls, while the market index rises. In this case, the insurance that should have been given by the non-indexed put option is not sufficient. The investors' freedom of active stock selection would decline, since the tracking error would become larger if the active selection would result in an increasing gap between the market index and the investment portfolio. Also important is the insurance horizon. The desired insurance horizon should match the maturities of put options that are being used; without these matching with each other, the insurance would not be optimal. Fortunately for investors, there are long term options on market indices available nowadays. These LEAPS[1] have maturities of numerous years, so that they can fulfil the desires of investors with long term horizons.

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[1] Long-term equity anticipation securities

There are also other problems regarding portfolio insurance. Lizieri and Finlay (1994) describe other problems such as heterogeneity, liquidity and information. The heterogeneity problem arises when a portfolio consists of different assets with low mutual correlations. In such cases specific risks must be eliminated. The liquidity problem arises as a result of a time delay when buying or selling assets. Although evolving technology has been able to reduce the liquidity problem, it is still not possible to trade at real-time speed. Also the information problem affects the effectiveness of portfolio insurance. Although the stocks' and derivatives prices are formed based upon demand and supply, which itself is based on information, not all information can be transferred to investors. This causes specific risks that cannot be diversified away fully. There always remains some market or systemic risk which is not possible to diversify away.

There are different opinions about the influence of portfolio insurance on the market volatility. Basak (1995) finds that the volatility and risk premium are decreased by the presence of portfolio insurance. This would be due to the fact that demand for risky assets is lowered by the use of portfolio insurance. This is contrary to what was found in majority in literature before; it was generally assumed that portfolio insurers caused market volatility to increase, as portfolio insurers would all generally respond similarly to market movements and hence accelerate market movements. Consider for example a situation with negative market sentiment. With portfolio insurers all responding simultaneously and similarly by selling their risky assets, the decline of the prices of risky assets would severely be enlarged.

2.6 Portfolio insurance strategies

This paragraph will cover the different insurance techniques that will be subject to research in this paper. There will be described how the insurance strategies work generally, and what their advantages and disadvantages are.

2.6.1 Synthetic put portfolio insurance

A synthetic put option can be created if the characteristics of normal put options are not in line with investors' desires. Bodie et al. (2005) and Hull (2008) state that the key part in using synthetic puts is to create a portfolio that contains a quantity of stocks that has the same net exposure to market volatility as the hypothetical protective put. A position has to be created in which the delta of the position in the underlying asset is equal to the delta of the required option. The deterministic variable in this insurance strategy is the option delta, or hedge ratio, which represents the change in the price of the protective put option per change in the value of the underlying stock portfolio. It may be more attractive for traders to use synthetic puts instead of normal puts that are available on the market for two reasons. First, option markets do not always have the liquidity to absorb all the trades that are required by large funds' managers. Second, fund managers require different strike prices and maturities that are not available on the options market (Hull, 2008). To illustrate how this strategy applies to portfolio insurance, consider a hypothetical stock portfolio with a delta of -.5. If the portfolio value falls by 5 percent, the net loss on the portfolio would only be 2.5 percent, as the loss of the stock value is compensated by the gain on the put value. The synthetic option position is created by selling a proportion of the stocks, which is based on the option delta. In this example, 50 percent of the stocks would be sold and invested in the risk-free T-bills. Selling a proportion of stocks equal to the put option's delta and placing the proceeds in risk-free assets provides the same exposure to the stock market as one would have when using protective puts (Bodie et al., 2005).

However, there are some difficulties when using synthetic puts instead of protective puts, that are described by Bodie et al. (2005). If stock prices decline, the hedge ratio increases, which calls for additional selling of stocks and placing more capital in risk-free assets. As such, market decline calls for additional hedging and constantly updating the hedge ratio. The constant rebalancing of a portfolio based on updating the hedge ratio is called dynamic hedging. Furthermore, there is a multiplier effect on the market when using delta hedging. The market downturns are exaggerated because the original market decline calls for adjusting the portfolio according to the new option delta, which means that more stocks have to be sold, which leads to a decline in stock demand and hence a further decline in stock prices. In order to reduce transaction costs, investors usually do not trade with stocks directly when a portfolio is rebalanced according to a new hedge ratio. Substitutes for stocks are used in the form of stock index futures, which are closely correlated to individual stocks, according to Bodie et al. (2005).

2.6.2 Constant proportion portfolio insurance

Constant proportion portfolio insurance can be used for fixed income instruments and for equity instruments. Both applications have been introduced shortly after each other, by Perold in 1986 and Black and Jones in 1987. Via the use of a simplified strategy assets can be allocated to risky and risk-free assets dynamically over time (Bertrand & Prigent, 2001). The advantage of this method compared to other portfolio insurance techniques is that the CPPI method is very simple to implement and flexible to adjust. CPPI is implemented using the following process. An investor first sets a floor, which equals the lowest acceptable value of the portfolio. Logically, the floor can never be greater than the initial portfolio value. Investors who do not want to tolerate any risk at all can set a floor equal to 100 percent of the initial portfolio value. This does not allow much for benefiting from market risings, because this would imply that all the wealth is directly allocated to risk-free investments. The floor is used to compute the cushion, which is the excess of the portfolio value over the floor. An investor also needs to choose a predetermined multiple. Both variables i.e. the floor and the multiple, are determined based on the willingness of an investor to take risk and are exogenous to the model.

Bertrand and Prigent (2002) explain that the exposure i.e. the total amount allocated to risky assets is determined by multiplying the multiple with the cushion. The higher the multiple, the higher the potential for investors to profit from rising stock prices. Low multiples provide better protection against declining markets than high multiples. When stock prices decrease the predetermined floor will be approached faster, which decreases the cushion. When the cushion approaches zero, the exposure also approaches zero, which would mean that the total amount invested would be allocated to risk-free assets. Under normal market conditions, this strategy would result in a portfolio value that is not lower than the floor level at the end of the investment period. However, Bertrand and Prigent (2001) emphasize that during crises investors might not respond in time to stock prices declines and hence portfolio values could still drop below the floor values. Intermediate profits (or losses) are not protected nor relevant for the final portfolio value, according to Annaert et al. (2007). CPPI investors always face a gap risk in which the portfolio value breaks through the floor. If the portfolio is managed by a third party, such as a bank, the losses can be reimbursed. This adds an optional component to the CPPI strategy if it is being managed by a third party. In this case, the option value does not rely on the underlying value and is not sensitive to small movements of the underlying. The CPPI-embedded option is a gap risk and volatility product. Because not all investors have their insurance strategies managed by banks who can reimburse losses, the gap risk has been subject to research by Cont and Tankov (2007). By adding risk jumps to the dynamics of the underlying in the traditional models, gap risks can be measured. The model can then be adjusted with respect to the multiplier which is based on the investors' risk aversion.

A final important aspect of CPPI is the rebalancing frequency. In a world with no transaction costs, continuously rebalancing would be optimal. A huge drawback is that with the implementation of transaction costs the profits will be limited severely by transaction costs. Moreover, rebalancing happens every time after a move in the stock value, which means that if one wants to rebalance his or her portfolio after a decrease in the stock values, the investor is already too late. Therefore it is best to use regular time intervals after which rebalancing is done. Daily rebalancing is then most accurate according to Annaert et al. (2007).

2.6.3 Stop-loss portfolio insurance

In a leveraged stock position the downside risk can be eliminated to a large extent by using stop-loss portfolio insurance. Stop-loss portfolio insurance is seen as the simplest way to insure an investment portfolio. At the start of an insurance programme all the wealth from the portfolio is invested in risky assets, in this case in stock market indices. An investor chooses a floor value, which is lower than the initial invested amount. As soon as the portfolio value drops below the floor value, all the assets are transferred at once to risk-free assets. This means that there can only be one rebalancing moment, and there will be suffered from transaction costs only once. A huge setback of this insurance method is that in upward markets the portfolio will still be invested in risk-free assets only for the entire investment horizon, which could reduce profits severely. Also, the complete rebalancing from the total portfolio from risky- to risk-free assets could be accompanied with substantial transaction costs according to Annaert et al. (2007). A great advantage of the stop-loss portfolio insurance strategy is that it does not take in to account the market volatility, which the synthetic put insurance strategy does for example. The sensitivity from estimation errors is thereby eliminated. This does not imply that the insured portfolio is resistant to market volatility anymore, since the market volatility could cause the rebalancing from risky- to risk-free assets.

2.6.4 Stop-loss 95-105 portfolio insurance

In addition to the normal stop-loss portfolio insurance strategy, two alternative versions are proposed and evaluated. One of the new strategies is the stop-loss 95-105 portfolio insurance strategy. The stop-loss 95-105 strategy works the same as the normal stop-loss 95 strategy in principle. However, the difference in this strategy is that it allows for benefiting from the market's recovery after a crisis. While the normal stop-loss strategy has no rebalance moment during which all the assets are reallocated from risk-free to risky assets, the stop-loss 95-105 strategy does allow for this. The key element in this strategy is the portfolio value level, that is chosen by an investor prior to the investment period, at which the reallocation to risky assets occurs. Because investors never know in advance whether the end of a crisis has been reached, the rebalancing to risky assets must occur at a higher level than the level at which the initial rebalancing occurred. In this paper this level is at 105 percent of the initial value of the risky asset. The idea is that when an investor insures his portfolio at a predetermined floor value, thereby anticipating to the occurrence of a crisis, the risky assets from the portfolio are sold at the stop-loss level of 95 percent. The value of risky assets then drops further, while this does not affect the investor's portfolio anymore. However, once the value of the risky assets has recovered to a higher level than the initial stop-loss level, namely 105 percent, then this would indicate that the stock market has recovered from the crisis, hence the risky assets can be bought back. It would seem logical to indicate a stop-loss level where the portfolio is reallocated to risky assets that is similar to the initial stop-loss level. However, this could cause a period of frequent rebalancing when the value of the risky assets is fluctuating around the stop-loss level for a while. Therefore, in order to be sure that the stock market has recovered from the crisis, the stop-loss level at which risky assets are re-bought should be higher than the initial stop-loss level at which the risky assets are sold. However, this ensures that investors miss part of a potential bull market after a crisis, because the investor only starts to benefit once the 105 percent value has been reached.

2.6.5 Stop-loss/start-gain portfolio insurance

The second newly proposed insurance strategy is the stop-loss/start-gain portfolio insurance strategy. Stop-loss/start-gain portfolio insurance is basically the same as stop-loss 95-105 portfolio insurance, however, no floor levels are used. With this method, investors trigger an order in which the entire portfolio is reallocated from risky- to risk-free assets after a day during which the value of risky assets has dropped. In addition, the entire portfolio will be reallocated from risk-free to risky after a day of increasing stock prices. Because daily rebalancing is used, investors always have a delay of one day. Rebalancing occurs only *after* a day of increase or decline. Via this method, investors try to capture the benefits of a positive market wave (i.e. several consecutive days of increasing stock prices), while investor attempt to prevent to suffer losses due to consecutive days of declining stock prices). Theoretically, this strategy seems beneficial when market increases during series of consecutive days exceed the transaction costs. If not, then the transaction costs are the largest threat to this strategy. Also, during bull and bear markets there is not a continuous positive or negative flow in the value of stocks. If trading days during which substantial losses have been suffered are followed by trading days with only marginal gains, then this strategy could be very risky. Since no other literature is available on this strategy, it will be interesting to evaluate how profitable this strategy would have been during the latest two crises individually and the total past decade as single sample period.

2.7 Value at risk, back testing and expected shortfall

Value at risk is an important risk management tool with which investors can quickly review the size of their exposure with respect to the maximum losses that can be suffered given a certain confidence. It focuses merely on the downside risk of a portfolio. Value at risk can be seen as a tool for measuring the effectiveness of portfolio insurance. During the 90's it was widely adopted as a risk measurement tool, after it was adopted in the Basel II accord. JP Morgan introduced RiskMetrics in 1996. VaR has provided an important contribution to the RiskMetrics methodology. RiskMetrics computes the VaR using only a few unknown parameters, according to Christofferson et al. (1999). However, VaR is not undisputed. Taleb (1996) states that VaR is attempting to predict market volatility and thereby extreme events of risk. Since this is scientifically impossible, value at risk ought to give false confidence to investors. Jorion (1997) admits that VaR is not an ideal risk measurement tool, but it is reliable to a large extent, and better than having no risk measurement instrument at all. Breder (1995) concurs with the fact that VaR should not be taken too strictly, because it is not necessarily representing reality due to its large dependence on input parameters. Sinha and Chamu (2000) proved that VaR methods are suitable not only for stable markets such as America and Europe, but also for emerging economies with more volatile markets such as Mexico.

There are several methods to apply the value at risk technique, and the most widely used methods are delta-normal, historical simulation and Monte Carlo simulation, which will also be the three methods that will be used to evaluate the insurance strategies in this paper. VaR was developed to provide a single number that represents a portfolio's or business' risk instead of thousands of different delta's, gamma's, vega's etcetera. Risk managers are interested in making a statement in the following form: 'I am X percent certain that there will not be a loss of more than V dollars in the next N days' (Hull, 2008). V represents the VaR of a portfolio, which is a function of two parameters: N days and X percent confidence. Value at risk thus is a future oriented risk analysis instrument. Graphically, a return distribution for a VaR that is based on a normal distribution looks as follows:

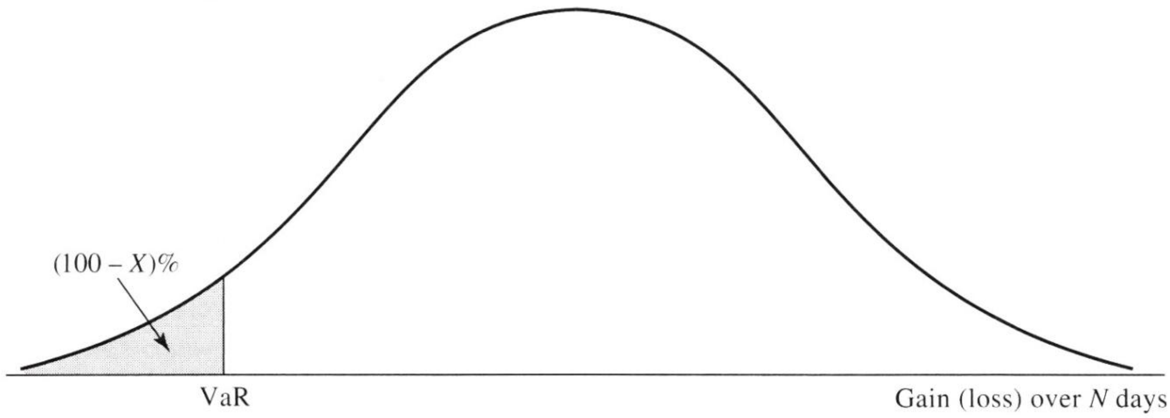

Figure 1. Value at risk calculation from normal distribution (Hull, 2008).

The problem with calculating value at risk is that investors may be tempted to choose a VaR level that is equal to the one in the figure above, which is based on a normal distribution. The normal distribution has the disadvantage that is does not account for tail risk. Figure 2 shows a VaR level equal to the VaR level in figure 1, but with higher tail risk.

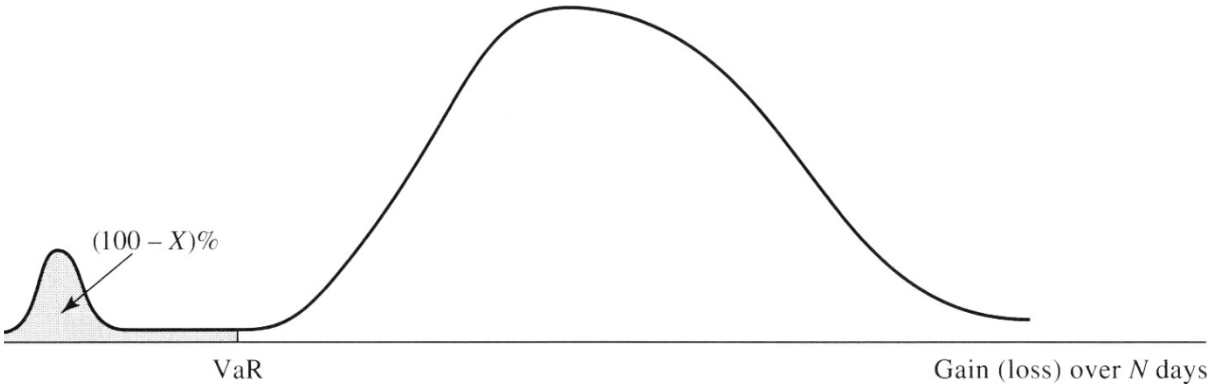

Figure 2. Value at risk with higher loss potential due to tail risk (Hull, 2008).

Figure 2 clearly illustrates the main weakness of value at risk, which is that it does not consider the magnitude of losses beyond the VaR level. According to Einhorn (2008) VaR would encourage for excessive risk taking because it does not consider tail risk. Expected shortfall could be used to estimate the losses beyond the VaR level (Angelidis & Degiannakis, 2006). Expected shortfall considers the magnitude of the expected losses when the VaR level has been exceeded. This eliminates the tail risk that is faced with VaR, and can serve as an additional risk indicator to VaR. In order to avoid the tail risk in the evaluation of the insurance strategies, the expected shortfall method will be used in this paper in addition to VaR.

The easiest method for calculating the VaR level is the delta-normal method, which assumes that the returns of assets in a portfolio are normally distributed. The delta-normal method is considered fast and efficient, especially for large portfolios and when the frequency of recalculating the VaR is high. A disadvantage is that it does not account for non-linear risk. When options are being used, the delta-normal method is not very accurate (Martens, 2008). For this research this would mean that the VaR levels are the lowest when using the delta-normal method, because the VaR level would be underestimated due to the assumption of normally distributed returns.

A more accurate way for estimating the value at risk is when a full valuation is performed. Two commonly used methods of full valuation that also will be used in this research are historical simulation and Monte Carlo simulation. Historical simulation uses the daily returns of a certain investment period in order to estimate the future sample path of returns. The returns are then ranked from the highest loss to the highest gain, from which the value at risk can be selected at the relevant percentage. The advantages of this method are that a full valuation is used based on actual returns, and that volatility does not have to be predicted. This method assumes that past results are relevant to predict the future, which is also a disadvantage of historical simulation. Furthermore, only one sample path is used to predict future returns, which is limited. The quality of this method depends on the length of the historic period that is used to predict the future. Final disadvantage of this method is that it is cumbersome for large portfolios, but this does not apply to the portfolios used in this research.

The second full valuation method for calculating value at risk is Monte Carlo simulation. This method uses different sample paths to predict the future losses. It can take several distributions into account, the choice of which one to use is up to the investor. The most widely used distribution for financial data is the Geometric Brownian motion, which will be used in this paper. Monte Carlo simulation is

considered to be the most accurate way of estimating value at risk, because it simulates a huge amount of price paths, hence it could include extreme losses. This is not likely to happen with the delta-normal and historical simulation methods, while it could occur in reality. However, the computational costs of this method are a huge disadvantage. Monte Carlo simulation uses too much information to implement on a frequent basis for large investment portfolios (Martens, 2008).
Value at risk can be evaluated with the use of back testing, see for example Hull (2008). Back testing considers the number of observations in which the VaR levels have been exceeded in reality. Satisfactory exceed ratios are correspondent to the percentage VaR. This means that for example an exceed ratio of five percent for a five percent VaR level is satisfactory. However, if there are substantial more exceeds during the period of investments, then the VaR method cannot be considered adequate.

2.8 Summary

Firstly, this chapter has discussed the developments during the crises that are subject to research in this paper. Both crises have been triggered by the collapse of a bubble; the dot-com bubble in 2000 and the house bubble in 2008. After that, the principles and difficulties of portfolio insurance have been discussed. Portfolio insurance serves as a protective instrument against negative market sentiments. Difficulties in portfolio insurance consist mostly of assumptions that have to be made in order to execute portfolio insurance, such as transaction costs and the extent to which protective tools are in line with the underlying risky assets.

Secondly, the different insurance techniques that are subject to evaluation in this paper have been discussed briefly. Put options can be replicated with synthesized puts, which provides more freedom to investors regarding the investment horizon than normal put options. With CPPI a floor is chosen and the portfolio value should not drop below the floor, because once the floor has been reached, all the investments should be allocated to risk-free assets. Between the floor value and the portfolio value is the cushion that determines the amount of the total exposure. With stop-loss portfolio insurance also a floor value for a portfolio is chosen. Once the floor has been reached all the assets are allocated to risk-free assets. There is only one rebalancing moment, which limits the upside potential if the market would rise during the investment period. There is still no overall consensus on the dominance of certain insurance strategies over others. There are circumstances under which an investment strategy dominates another, but this is not general under different market conditions.

Thirdly, two new portfolio insurance strategies have been proposed in this paper. The stop-loss 95-105 is similar to the normal stop-loss strategy, but it also allows for reallocation of the portfolio to risky assets. It thereby allows for benefiting from bull markets after crises. Also, the stop-loss/start-gain strategy has been proposed. This strategy lets investors rebalance their portfolio after each day during which the course changes from positive to negative and vice versa. Investors attempt to catch a flow of consecutive positive returns day of stocks, while avoiding consecutive negative return days of stocks.

Finally, portfolio insurance can be reviewed by using value at risk. If losses of insured portfolio have exceeded the VaR level significantly more often than expected, either the insurance technique or the VaR method are flawed. This can be tested with the use of back testing. Because one of the characteristics of VaR is that it neglects tail risk, also expected shortfall has been used in order to estimate the magnitude of the losses beyond the VaR levels.

3. Data description and methodology

In this chapter first the description of the data will be provided accompanied with the motivation for the use of the chosen data. After that, the methodology for the implementation of the research will be provided.

3.1 Data description

In this research four different market indices are subject to research. The different indices are from various places in the world, so that one can see how the markets have developed roughly during the past ten years. Not every stock market (index) has responded in the same way to the burst of the dot-com bubble in 2000 and the credit crisis of 2008 and their corresponding recessions. The data have been obtained on a daily frequency via Thomson DataStream at the Erasmus University Rotterdam.

Normally, indices are represented in local currency. In this paper all indices that are not originally denominated in Euros have been converted to Euros. This has been done by DataStream itself, using actual daily exchange rates. This was necessary for the clarity and consistency of this research, and because this paper considers the perspective of a European (or Dutch) investor. There are three sample periods in this paper. The sample period for the recession after the dot-com bubble collapse starts on September 4, 2000 and ends on July 4, 2003. This period will be referred to as period 1. The sample period for the recession after the credit crisis starts on July 16 2007 and ends on March 9 2009 (period 2). These data have been chosen based on the values of the Dutch AEX index. The first days of these periods represent the last day before the crisis hit the stock markets as far as it concerns the AEX index. The last day of each period represents the lowest index value of the AEX during the crisis. For the crisis after 2008 it is not clear whether the lower boundary has been reached yet, so the last day of the second period represents the last day of the decline of the AEX index in the past six months. The third sample period which covers a random investment period over roughly the past decade, starts on July 16, 1997 and ends on July 16, 2007 (period 3).[2]

The volatility has been estimated based on market fluctuations during the 90 days previous to the current trading day. Only a daily frequency of rebalancing will be used because it has already been proved by several researchers that daily rebalancing is the most relevant rebalancing frequency for portfolio insurers (see for example Annaert et al., 2007). In addition, higher frequency of rebalancing results in lower returns or higher losses, because with most insurance strategies action needs to be taken as soon as possible after market declines. This is especially relevant during crises. Hence it would not make sense to consider other rebalancing frequencies (i.e. weekly, monthly etc.). The returns on each strategy have been indexed, so that they can easily be shown in graphs. The two newly proposed portfolio insurance strategies are only provided in the graphs with the floor level of 95 percent, in order to prevent the graphs from becoming messy due to the large number of lines per graph.

3.1.1 AEX index

The first index that will be used is the AEX index, from which the name has been derived from Amsterdam Exchange Index. The AEX index is composed of the 25 most traded stocks on the Amsterdam exchange, measured with respect to last year's calendar. On the 3rd of January 1983 the AEX index was first launched at a base value of 100. The index peaked at the top of the dot-com bubble on September 5th 2000, when its value was at 703,18. It is currently struggling around 320 points. The index is a market value time weighted index, which means that the weights of the

[2] The period numbers are provided here because in the figures and tables the periods are referred to as p1, p2 and p3.

different stocks that form the index are capped at 15 percent. This is because the exchange board does not want individual companies to have a too large impact on the AEX index. These weights can change during the year according to daily closing prices of stocks and are recapped at 15 percent in March every year. The Amsterdam exchange has been included in the Pan-European exchange group Euronext that has been formed in 2000 after a merger of the Amsterdam Stock Exchange, Brussels Stock Exchange and Paris Bourse (Euronext official website).

3.1.2 FTSE-100

The FTSE-100 or 'footsie' consists of the hundred most highly capitalized companies that have their shares traded at the London Stock Exchange. It is free-float market capitalization weighted with only public limited companies. Founded in 1984 at a base value of 1.000 points, it increased to a historical value of 6.950 in December 1999, which might indicate that this index does not evolve perfectly synchronic with the former discussed index. It is currently trading at approximately 5.100 points (Yahoo Finance).

3.1.3 NASDAQ 100

The NASDAQ 100, not to be mistaken with the NASDAQ composite index, includes companies that are incorporated outside the USA and excludes financial corporations. Thereby, it distinguishes itself from for example the Dow Jones index and the S&P 500 index. In the rest of this paper, there will be referred to this index as the NASDAQ. The overall focus of the NASDAQ is on technology-based companies, which is why it is interesting to include this American stock market index. It was established in 1985 by the NASDAQ stock exchange in order to compete with the New York Stock Exchange (NYSE). The NASDAQ 100 is a market-value weighted index. Rebalancing of the index occurs once a year. The base was set at 250 points, after which it grew to nearly 800 points in 1993. After that the base was reset to 125 points. It achieved the historical high value of little over 4.700 points in 2000, after which it declined to what it is currently trading at; approximately 1.675 points (NASDAQ official website).

3.1.4 Nikkei-225

The Nikkei-225 index is the stock market index for the Tokyo Stock Exchange (TSE). Since 1950 the Nikkei newspaper has calculated the prices of the index daily. The Nikkei-225 is a price weighted index which is being rebalanced yearly. The highest value ever achieved for the Nikkei-225 is 38.915 in December 1989, while it is currently trading at 9.600 points. These values are in local currency, the Japanese Yen. In this paper the values have been converted to Euros, which is why the Euro values are much lower (Yahoo Finance).

3.1.5 Risk-free rate

As a proxy for the risk-free investment rate different rates can be used, such as the LIBOR rate, US Treasury bills or the Euribor rate. A risk-free investment is considered as an investment that provides a minimum return on investments without bearing risk. Risk adds additional returns on investments as these additional returns compensate for the risks investors are willing to tolerate. However, there is a difference between nominal and real risk-free return. With nominal risk-free rates of return the purchasing power of the initial amount invested could be lower, especially when dealing with long maturities. Inflation could lower the purchasing power if nominal rates of return are offered (Bodie et al., 2005). This problem is limited when short term maturities are used, such as in this research. In this paper the 3-month US Treasury bill rate of return from the secondary market will be used. The secondary market represents the market where T-bills are sold forward by brokers who bought them initially at competitive auctions. These investment opportunities are assumed to be risk-free because they are covered by the US government, which has almost zero possibility of defaulting. In theory governments could go bankrupt, which has almost occurred in Iceland during the credit crisis of 2008. However, in practice the chances of this happening are very limited.

3.2 Methodology

In the following paragraphs the methodology for the different insurance strategies as used in this paper will be discussed. First the different assumptions that have been made will be discussed. After that, the different techniques will be elaborated, both for the insurance strategies and the value at risk methods.

3.2.1 Portfolio insurance strategies

The next subparagraph will discuss the different assumptions that have been made for this research. After that, the methodology of the different insurance strategies will be elaborated.

3.2.1.1 Assumptions

Although on average it is hard to determine how high transaction costs are, they can amount for a percentage of the value of the purchase or sell. Most researchers exclude transaction costs for simplicity, but for the sake of realism transaction costs are included in this research. This is done in order to avoid high profits for certain strategies due to the absence of transaction costs. Transaction costs will amount 0,5 percent of the total transaction amount. Dividends will not be included. Dividends differ from each other at different moments and are therefore too hard to estimate, hence they will be excluded.

The effectiveness of different insurance strategies will be measured using three different floor levels, which determine the risk tolerance of investors. The floors are 99, 95 and 80 percent of the initial portfolio value, allowing for a maximum loss of 1, 5 and 20 percent respectively. The CPPI strategy requires a predetermined multiple. Only one multiple will be used, which is a multiple of 5. There has been chosen to use a multiple of 5 because the investor’s conduct towards risk in this paper is neutral, and a multiple of 5 is generally considered as risk-neutral.

To be able to invest the exact amount of 100.000 Euros in stocks and options, it is necessary to assume that assets are infinitely divisible. The amount of shares that are bought by an investor at the beginning of the investment periods, is calculated by dividing 100.000 by the index value on day one of the investment period. Up to eight decimals are used to determine the exact number of stocks that are bought. The transaction costs do not apply to the first day of the investment period. The total amount of 100.000 Euros can be invested without transaction costs. Transaction costs only apply to the rebalancing of the investment portfolios.

3.2.1.2 Synthetic Put Portfolio Insurance

Synthetic put options should be created if the listed put options on the underlying do not match the desires of investors. With synthetic puts, the payoffs from normal protective put options are replicated. The delta is the key element in creating synthetic puts. It represents the change in the price of the protective put option per change in the value of the underlying stock portfolio. The synthetic option is created by selling a proportion of shares equal to the delta and placing the proceeds in risk-free assets. The following formulas, obtained from Hull (2008) will be used:

$$\Delta = e^{-qT}\left[N(d_1) - 1\right] \quad (1)$$

$$d_1 = \frac{\ln(S_0 / K) + (r - q + \sigma^2 / 2)T}{\sigma\sqrt{T}}$$

The delta represents the proportion of stocks that will be sold in order to replicate the payoffs from a protective put. The q represents a dividend yield. It is assumed that no dividend is included in this research, because it cannot be included in the Black & Scholes model, and because dividends are hard to estimate, especially during crises. Therefore, the dividend yield is set equal to zero in this equation. This is not necessarily unrealistic, because Croughy et al. (2008) also have written about the fact that companies often do not pay dividends during crises. This is because most of the time losses are suffered, or the profits could better be reinvested in the companies.

The delta changes every day according to fluctuations in the price of risky assets. Based on the daily changing delta, the new proportion of the portfolio value that should be allocated to risky assets is calculated. The faster the values of the risky assets decrease, the less proportion of the portfolio wealth will be allocated to risky assets.

3.2.1.3 Constant Proportion Portfolio Insurance

The CPPI strategy considers an amount invested in risky assets equal to the predetermined multiple times the cushion, which is based on the predetermined floor. The rest of the portfolio is invested in risk-free assets. To determine how much should be invested in risky assets the following formula from Annaert et al. (2007) will be used:

$$\max\{\min[m(W_t - F_t), W_t], 0\} \quad (2)$$

In this formula *Wt* denotes the portfolio value at time t, *m* denotes the multiple and *Ft* denotes the floor value. In order to apply this formula to the CPPI method a floor value and a multiple have to be chosen. The floor values will be similar to the ones that are used for other strategies, being 99, 95 and 80 percent. The multiple will be equal to 5. The multiple represents the risk tolerance of investors. According to the founders of this strategy, Black and Perold (in their paper from 1992), this insurance strategy would be similar to the stop-loss strategy if the multiple would be infinitely high, because all the wealth would then be invested in risky assets. Daily rebalancing can be done according to the following formula from Annaert et al. (2007):

$$W_t = Be^{rf*T} + [(wA_{t-1} / Index_{t-1}) * Index_t] \quad (3)$$

Wt represents the portfolio value at time t, *B* is the amount allocated to risk-free investments, *Rf* is the risk free 3-month t-bill rate, *wA* is the invested amount in the risky asset and *Index* is the stock market index.

The investor starts with allocating all the wealth to the risky assets on day 1. After day 1 rebalancing starts according to the CPPI method.

3.2.1.4 Stop-loss portfolio insurance

For the stop-loss portfolio insurance strategy the only methodology that can be used is by implementing a stop-loss order that fulfils the needs of portfolio insurers. Risk-averse portfolio insurers are likely to set a high floor in order to reduce downside risk. Since there is only one rebalancing moment, an investor should wisely choose the appropriate stop-loss level, because if the market drops through the stop-loss level, all the assets will be allocated to risk-free investments. Potential rising markets cannot be profited from anymore. The different floor levels that will be used are 99, 95 and 80 percent. This means that the entire portfolio consisting of risky assets will be reallocated to risk-free assets when the value of the risky assets have dropped below the floor values of 99, 95 and 80 percent respectively.

3.2.1.5 Stop-loss 95-105 portfolio insurance

The methodology for the stop-loss 95-105 strategy is similar to the normal stop-loss strategy methodology, except for the fact that there is potentially more than one rebalancing moment. During crises, when the prices of stocks are in a downward trend and are not likely to recover to their initial value (or higher), the returns from this strategy are similar to the normal stop-loss portfolio insurance strategy. Only during normal market conditions, such as in the third period in this research, there will be more rebalancing periods, because the value of the risky assets will move below and above the upper and lower stop-loss levels. Because investors will only rebalance their portfolios back to risky assets when the initial risky assets' values have broken through the upper floor of 105 percent, the risk of missing huge parts of the market's recovery is substantial.

3.2.1.6 Stop-loss/start-gain portfolio insurance

The methodology of the stop-loss/start-gain strategy is almost similar to the stop-loss 95-105 strategy methodology. The only difference is that there are no stop-loss floor levels. Each decline in the value of risky assets is reason for allocating all the risky assets to risk-free assets. In this way, an investor can attempt to evade consecutive series of days during which the value of risky assets drop. Only the losses from the first day of decline are endured. Each increase in the value of risky assets is reason for reallocating all the assets from risk-free to risky. When series of consecutive days during which the values of risky assets continuously increase occur, an investor is able to benefit. Because rebalancing occurs *after* the increase, the investor would only miss the profits from the first day of increasing values of risky assets.

3.2.1.7 Buy & hold

All the insurance methods can best be reviewed if they are compared to an investment strategy in which an investor invests the same initial amount as in the insurance methods in an investment portfolio. The difference is that the investor does not rebalance his portfolio. At the end of the investment periods during crises the insured portfolios should have higher returns than the naive buy & hold strategy. Interesting is to consider if the total portfolio value of the buy & hold strategy is higher than the insured portfolios in the third period, because it can be expected that portfolio insurance eliminates part of the profits.

3.2.2 Value at risk

In this research, three different methods of estimating value at risk are used. The methodology of each used method will be described in the following sections. The confidence levels that are used for VaR and expected shortfall are 95 percent. This means that there will be looked at the worst observations with a chance of five percent.

3.2.2.1 Delta-normal VaR

The delta-normal method assumes normally distributed underlying risk factors. If these factors are normally distributed, then the returns can also be assumed to be normally distributed. The returns from the different insurance methods can be used for the calculation of the standard deviation of the returns. The formula, obtained from Hull (2008), that is commonly used to calculate the standard deviation, is:

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{N=1}^{N}(r_y(t)\,| - \bar{r}_y)^2} \qquad (4)$$

Due to the assumption of normally distributed returns, the 95 percent confidence level can be calculated by taking the 5 percent quintile for each strategy. The corresponding number for the first quintile is -1,645 according to:

If X ~ N (0,1), P (x ≤ - 1,645) = 0,05

The interpretation is that the probability is set in such a way that in five percent of the observations the return will exceed the value at risk critical value, if the returns are normally distributed. The critical VaR value can be calculated by multiplying the quintiles with the standard deviation of the returns and the final portfolio value. The result from this should be interpreted as the maximum amount that cannot expected to be lost the day after the final day of the investment horizon with a certainty of 95 percent. The VaR level is based on the mean returns and standard deviations from the final 90 days of each investment period.

3.2.2.2 Historical simulation VaR

For historical simulation data from the past is used to predict the future. By looking at the returns from the last 90 days from each sample period, a simulation of all the possible future values of the investment portfolio can be performed. All the possible portfolio values tomorrow are simulated by multiplying the final day value with all the different returns that have been obtained. In this way, 90 possible future portfolio values are simulated in each insurance strategy. These possible values are then compared to the final day portfolio value, which yields 90 possible profits or losses. By ranking these returns from low to high, the five percent worst loss can be selected by taking the fifth observation out of 90 observations.

3.2.2.3 Monte Carlo simulation VaR

Monte Carlo simulation is the only full valuation method in which different price paths are simulated. In this paper, the Monte Carlo simulation has been performed by simulating 1.000 90-day price paths of the portfolio value after the final day of the investment periods that are subject to research. One random variable is included in the simulations, and the simulations follow a Geometric Brownian motion distribution. The price paths have been simulated using the following formula from Martens (2008):

$$S_{t+\Delta t} = S_t \exp\ (\mu \Delta t + \ \sigma \varepsilon \sqrt{\Delta t}) \qquad (5)$$

The ε represents the random variable or noise that is obtained from the normal distribution with N(0,1). The full valuation is then performed by simulating 1.000 times 90-day noise variables and 1.000 times 90-day asset values. The portfolio values and returns are then calculated, which results in 1.000 times 90-day portfolio values and returns. The Monte Carlo VaR is then the negative return observation that has been exceeded in five percent of the observations.

3.2.2.4 Back testing

The value at risk methods can be examined with back testing. The actual losses from the final 90 days of each investment period are compared to the predicted value at risk levels, which results in a number of exceeds. The number of exceeds relative to the number of observations results in the exceed ratio. Should the value at risk levels have exceed ratios substantially higher than five percent, then the predicted VaR level is too low, which means that the used VaR method is not appropriate for the strategy under consideration.

3.2.3 Expected shortfall

Because a main weakness of VaR is that it does not consider the magnitude of the losses if the situation in which the VaR level is exceeded occurs, expected shortfall is also used to evaluate the effectiveness of the portfolio insurance strategies. Expected shortfall can be used to estimate how large the losses would be in the case when the VaR confidence level would have been exceeded. The formula that expresses the method for estimating the expected shortfall from Acerbi and Tasche (2001) looks as follows:

$$ES^{(a)}(X) = -\frac{1}{a}\left(E[X1_{\{X \leq x^{(a)}\}} - x^{(a)}(P[X \leq x^{(a)}] - a)\right) \quad (6)$$

X represents the profit/loss on a portfolio on a specified horizon T. A is a probability level obtained from the normal distribution with N(0,1). What the formula implicitly says is that the expected shortfall is calculated by taking the average of the observations beyond the VaR level. This means that expected shortfall in this research considers the average of the five percent lowest observed observations.

In the next chapter the results are presented, accompanied with their interpretation for this research.

4. Results

In this chapter the results are discussed. Because the results based on the returns are generally consistent among the different used indices, the AEX index will be discussed and presented in the main body of the paper. The results from the other indices serve as support for the results derived from the AEX index based strategies. For the third period there is less consistency between the different index based strategies. Therefore, there will also be referred to the results based on the other indices which can be found in the appendices. By applying the different strategies to more indices than the AEX index, the chances of coincidence are reduced. The different portfolio insurance strategies will first be discussed according to the portfolio values during the investment periods, followed by their final return at the end of the investment periods. After that, the strategies will be evaluated according to their riskiness, which is provided by the VaR levels and expected shortfall. The VaR levels have also been evaluated with the use of back testing. Based on the results, a conclusion will be drawn on which portfolio insurance strategy provides the best returns in relation with its accompanying risk during periods of systemic breakdowns.

4.1 Portfolio insurance strategy returns

On the next two pages figures 3 and 4 are presented. These figures show the conduct of the values of the portfolios which are insured using different strategies. The stop-loss/start-gain strategy has only been provided in the graph with the floor level of 95 percent, because the stop-loss/start-gain strategy does not use a floor level. Providing this strategy in each graph would undermine the clarity of the graphs. Also the stop-loss 95-105 strategy is only provided in the 95 percent floor level graphs. Because there is no recovery of the risky assets to 105 percent of the initial value during crises, the plot of the stop-loss 95-105 strategy is similar to the stop-loss 95 strategy. At the floor level of 80 percent, the returns on the buy & hold strategy are hard to observe graphically, because they are almost similar to the synthetic put strategy's returns.

A quick look at the figures reveals that portfolio insurance works most of the times, because the returns on all the insurance strategies are higher than for the naive buy & hold strategy. The returns on the buy & hold strategy show how severe the crises have been and to which extent the stock market indices have been affected by these crises. Furthermore, the figures show that increasing the portfolio floor value is relevant, as the losses are reduced when floor levels are increased. The graphs also show optically that there are large differences between the different portfolio insurance strategies. These differences in returns per strategy also seem to increase when the floor level decreases.

The synthetic put strategy seems to perform the worst of all strategies. When the lowest floor level of 80 percent is used, the synthetic put strategy yields a returns that is slightly higher than the buy & hold strategy. This applies to both periods and for all used indices. After the synthetic put strategy the stop-loss/start-gain strategy is worst performing, according to the AEX index based strategies. This is consistent with most other indices in both periods, except for the Nikkei-225 and NASDAQ strategies in the second period. This can be seen in figures 9 and 11 in appendix B. In these figures it can be seen that the stop-loss/start-gain strategy is outperformed by all the other strategies, including the buy & hold strategy. The CPPI and stop-loss strategies both perform better than the synthetic put and stop-loss/start-gain strategies. Whether the CPPI strategy outperforms the stop-loss strategy depends on the floor level. At a floor level of 80 percent the CPPI strategy outperforms the stop-loss strategy, but at the floor levels of 95 and 99 percent the CPPI strategy is outperformed by the stop-loss strategy. The graphs indicate that CPPI and stop-loss portfolio insurance are the only two strategies that are able to maintain portfolio values above or at the predetermined floor levels.

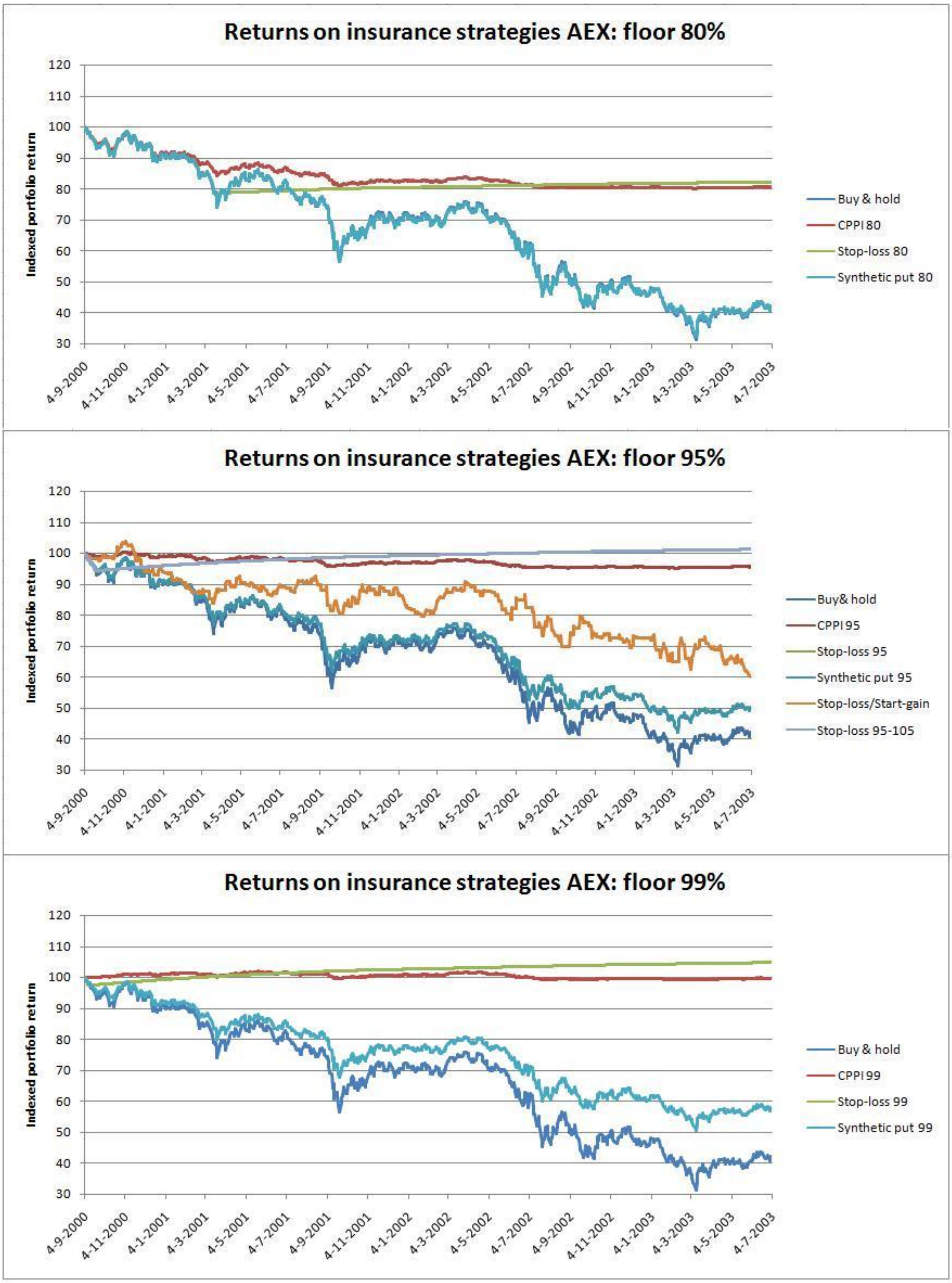

Figure 3: Returns on insured portfolios containing the AEX index as risky asset: period 1

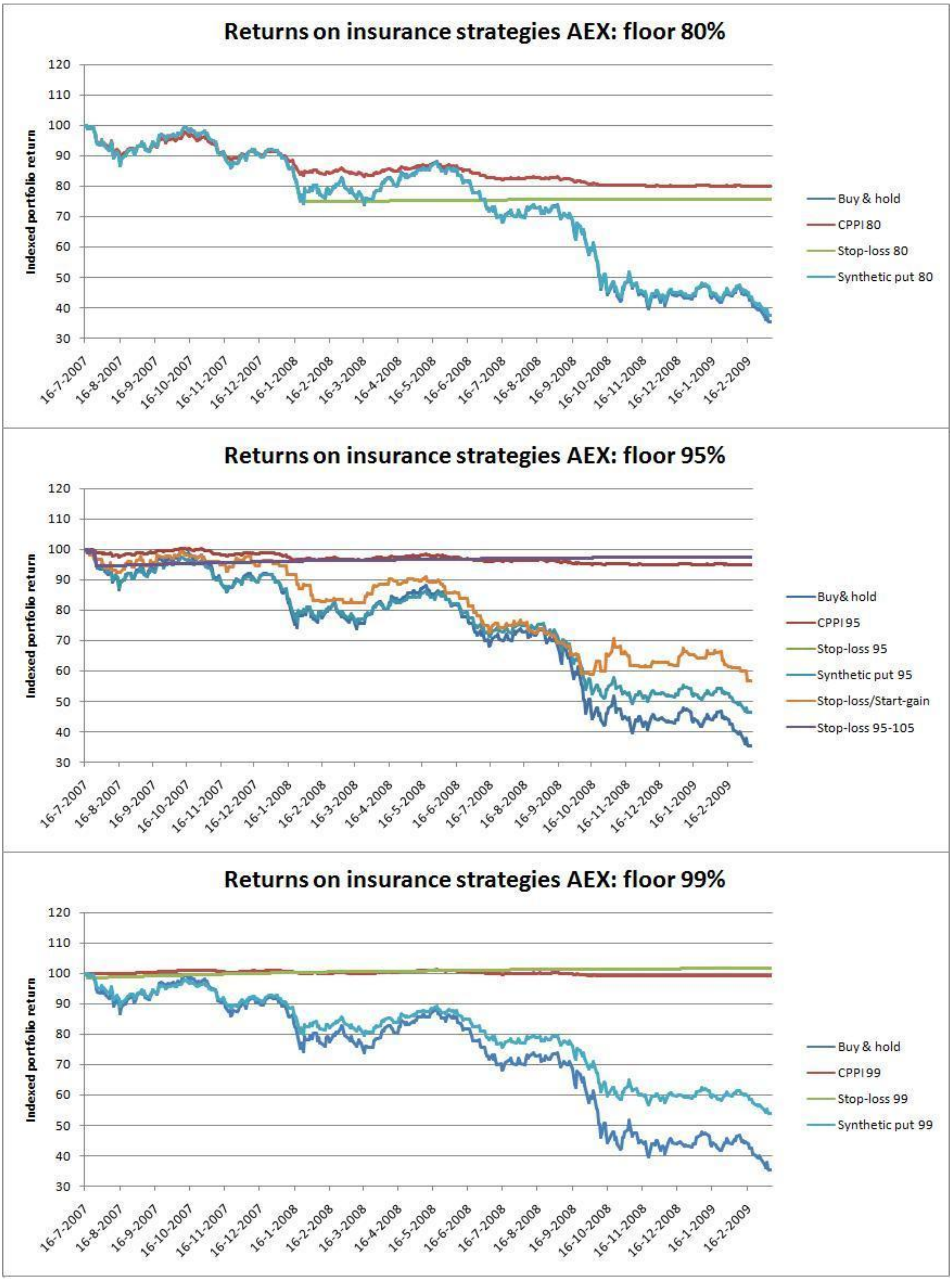

Figure 4: Returns on insured portfolios containing the AEX index as risky asset: period 2

It is interesting to consider why the used insurance strategies perform differently and why the consistency among the data is sometimes undermined by the Nikkei-225 and NASDAQ indices. First of all, why does the synthetic put strategy performs only slightly better than the buy & hold strategy? A reasonable argument for this could be that transaction costs eliminate part of the profits from the synthetic put strategy, because every day transactions have to be made in order to maintain the appropriate delta level. However, a self-performed sample in which transaction costs have been excluded from the synthetic put strategy has revealed that transaction costs are not the cause of the bad performance of this strategy. This could also have been expected, since CPPI provides satisfactorily protection, while it also endures transaction costs every day as a result of rebalancing the portfolio. Overall, it appears that transaction costs affect the returns only to a marginal extent.

Another possible explanation for the disappointing results of the synthetic put strategy is that investors are not able to respond adequately to declines in the risky assets' prices. Because intraday prices have not been used, investors can only react to declining prices at the beginning of the next day, because closing values have been used. It is not before the opening of the stock exchange the next day that investors are able to respond to previous days' declines. By then, a lot of damage has been done, because the investor could not act during the day that a decline was occurring. This could imply that an investor rebalances his portfolio *after* a bad day i.e. sells part of the risky assets and puts the proceeds into risk-free assets, while on the day the investor does this the value of the risky assets is increasing again. This means that an investor has lost a substantial part of the portfolio value on a bear day, and misses part of the recovery on a bull day because the exposure to risky assets has decreased due to rebalancing. As a result of this delay, investors are never able to adequately update their portfolios.

It is striking that the NASDAQ based synthetic put strategy at the floor value of 80 percent (in figure 8) is the only observation in which the synthetic put outperforms the buy & hold strategy to a relatively large extent (8 percent as opposed to 3 percent approximately for this strategy based on other indices). The relatively high return might seem as an optical illusion, because the axis-scales of figure 8 differ from the other figures. However, the relatively high return is also provided in table 6. Although the synthetic put strategy is still the worst performing insurance strategy in figure 8, there is a relatively higher return than the buy & hold strategy compared to the other figures. This could have been caused by the fact that the investment period in this paper is based on the AEX index values. The collapse of the dot-com bubble could have hit the NASDAQ prior to the AEX index, however, a look at the index values prior to the investment period in this paper reveals that the NASDAQ started to decline simultaneously with the AEX index. However, the volatility of the NASDAQ was much higher than for the AEX index. The yearly volatility of the AEX index on the first day of the investment period was 13,4 percent, while this was 48,9 percent for the NASDAQ. This could indicate that the higher volatility for the NASDAQ would have caused higher option delta levels, leading to higher proportional sales of risky assets. A self-performed sample in which the NASDAQ volatility has been implemented in the AEX index based synthetic put strategy leads to reduced losses of 4 percent. This indicates that the volatility is to a certain extent responsible for the disappointing performance of the synthetic put portfolio insurance strategy. However, even with a higher estimated volatility the synthetic put strategy is not able to provide satisfactory protection. This is contradictory with the statement from Annaert et al. (2007), who assume that the accuracy of volatilities have large impact on the performance of the portfolio insurance strategies.

Another potential cause of the disappointing returns from the synthetic put strategy is the speed at which the portfolio value declines. An experiment has revealed that the speed at which the value of the risky asset drops is not deterministic for the total return of the insurance strategy. In the experiment, which has been performed in the model used for this paper, the value of the risky asset artificially dropped by the same rate every day, by such an amount that it reached the same value at the end of the period as it did in reality. The final portfolio value remained unaffected, which implies that the speed at which the value of the risky asset drops is not relevant; that is when an investor is not able to intervene intraday. Apparently, the key element in the synthetic put strategy is for an investor to act immediately during a day if the value of the risky asset declines. An investor should attempt to act before the damage is done or has become too large. This would imply a continuous rebalancing frequency, which is utterly impossible for private investors. It would also imply that if an investor rebalances his portfolio immediately after the first decline during a trading day, he faces the risk that the value of the risky asset increases again later during the same day. However, since this research focuses on crises in particular, the chances of increasing values of risky assets is rather small. The assumption is that the market performs badly. The synthetic put strategy appears to be a bad strategy for investors who are not able to update their portfolio continuously during bear markets.

The stop-loss/start-gain strategy also turns out to be an unreliable form of portfolio insurance. The AEX index based stop-loss/start-gain strategy outperforms the buy & hold and synthetic put strategies, which can be seen in figure 3. Right after the start of period 1 the value of the stop-loss/start-gain insured portfolio rises above all other strategies. This indicates that this strategy is able to profit from a series of consecutive days during which the value of risky assets continuously increases, while avoiding the losses from consecutive series of days of negative index returns. After that, the value of the stop-loss/start-gain based portfolio is unstable, and the trends of the synthetic put and buy & hold portfolios are roughly followed. Finally, the stop-loss/start-gain insured portfolio ends with a loss of 40 percent, which indicates that this insurance strategy is not reliable during crises. A similar trend can be observed in figures 6 and 10. In some figures the final portfolio values based on the stop-loss/start-gain strategy are higher than the synthetic put and buy & hold strategies. However, there are also figures that reveal the instability of this strategy, because the final portfolio values are even lower than with the naive buy & hold strategy. The stop-loss/start-gain insurance strategy has not only performed disappointingly at the end of the investment periods during crises. In figures 4, 7 and 8 it can be observed that the stop-loss/start-gain strategy is performing disappointing during the whole investment period. In figures 9 and 11 the stop-loss/start-gain strategy is even outperformed by the synthetic put and the buy & hold strategies. Hence, based on the conduct of the portfolio values and the final portfolio values it can be concluded that this strategy is not reliable during crises.

Remarkable is that CPPI and stop-loss perform relatively well during the crises that are subject to research in this paper. In all different scenarios, the returns on the CPPI strategy have never broken through the predetermined floor. The AEX index based CPPI strategy came closest to breaking through the floor level of 80 percent in the second period, with a decline of 19,97 percent. The CPPI strategy turns out to be a very reliable insurance strategy, regardless of the index that is used or the time frame that is chosen. In all the figures 3-11 it can be observed that the CPPI strategy performs exactly as it should. As was already mentioned before, transaction costs only have a marginal effect on the total return of the insurance strategies that have been used in this paper. This is also illustrated with the CPPI strategy. Although there occurs rebalancing of the investment portfolio each consecutive day, transaction costs do not severely affect the total return of this strategy, as the final portfolio value is still higher than the predetermined floor value. This is straightforward during crises, because the value of the risky assets is in a downward trend. According to the CPPI strategy, this forces the investor to sell part of the risky assets and put the proceeds into risk-free assets each day. The transaction costs apply to a relatively small amount of the portfolio. Because there are only few days on which the investor has to repurchase small proportions of risky assets, the total transaction costs are limited to approximately 0,5 percent of the total portfolio value. Hence the total transaction costs during crises are approximately 500 Euros, a relatively small amount compared to the losses that are endured with for example the synthetic put. The returns from this strategy are relatively high during crises as a result of the assumption of transaction costs. If for example there would also be a basis fee besides the percentage transaction costs, then the returns would be excessively lower.

The stop-loss 95-105 strategy is performing exactly similar to the stop-loss 95 strategy during crises, because the value of the risky assets does not recover and grow to 105 percent of its original value. The stop-loss strategy performs relatively well. At a floor level of 80 percent, the stop-loss strategy outperforms the CPPI strategy in period 1, but is outperformed by CPPI in period 2 (figures 3 and 4). For the FTSE-100 based strategies, stop-loss also outperforms CPPI at the floor level of 80 percent in period 1 (figure 6). For the NASDAQ and Nikkei-225 based strategies the stop-loss strategy is outperformed by CPPI at a floor level of 80 percent in period 2 (figures 9 and 11). Although the stop-loss strategy appears to be a reliable strategy for portfolio insurance during crises, there seems to be some noise around the stop-loss level. Because daily rebalancing is used (which is a relatively high rebalancing frequency), the investor is only able to rebalance his portfolio at the end of the day. The chances that at the end of a random trading day the portfolio value lies exactly at the floor value of 80 percent, hence allowing the trader to sell his risky assets exactly at their floor value, are very limited. The result is that investors rebalance at the end of the day, when the losses on the portfolio are probably larger than the predetermined floor level. After the rebalancing of the portfolio from risky to risk-free assets, returns are generated with the risk-free assets. At high floor levels (95 and 99 percent), the portfolio value breaks through these levels at an early stage during the crises, because portfolio values drop almost every day. Because at an early stage the rebalancing occurs, part of the losses can be compensated with profits from the risk-free investments. There still is a relatively long period ahead during which the portfolio that is completely allocated to risk-free assets can generate interest profits. This is why positive returns on the stop-loss strategy are observed quite often, for example with the FTSE-100 at both 95 and 99 floor levels in period 1 (see table 4). An exceptional situation occurs in table 8 with the Nikkei-225 index. The returns on the stop-loss strategy with floor levels of 95 and 99 percent are similar. This is due to an extreme shock in the value of the Nikkei index, which had a profit of 2 percent on one day, after which the index suddenly dropped more than 5 percent below the initial value. This example clearly illustrates the noise with the stop-loss strategy that has been explained above. In certain situations, investors simply are not able to adequately rebalance their portfolio according to the stop-loss level, simply because daily rebalancing is not accurate enough under extreme circumstances.

4.2 Portfolio insurance strategy risk

Not only the returns are important to investors. Another important determinant in the effectiveness of portfolio insurance strategies is the associated risk. As has already been stated in this paper, the risk can be expressed with value at risk and expected shortfall. Below, the tables presenting the return and risk of the different insurance strategies based on the AEX index, are provided. Table 1 provides the returns and risks for period 1, table 2 does this for period 2. The tables 3-9 provide the returns and risk for the strategies based on the other used indices can be found in appendix A. The first column in the tables represents the different portfolio insurance strategies with their corresponding floor levels. The second column presents the percentage of returns from an initial investment of 100.000 Euros in portfolios with AEX index stocks (and options) as risky assets. The third column shows the value at risk levels at 95 percent confidence, which have been calculated using the delta-normal method (see section 3.2.2.1). The fifth and seventh columns show the VaR levels at 95 percent confidence, calculated with the historical simulation (see section 3.2.2.2) and Monte Carlo simulation (see section 3.2.2.3) methods respectively. The fourth, sixth and eighth columns provide the exceed ratios, which represent the back testing results of the value at risk levels (see section 3.2.2.4). The ninth columns represent the expected shortfall level, which considers the losses beyond the 95 percent confidence VaR levels (see section 3.2.2.5). All the return and risk levels have been provided in percentage losses. The returns percentages are relative to the initial portfolio value. The VaR and expected shortfall percentages are relative to the final portfolio value of the strategies. The exceed ratios are relative to the number of observations.

AEX P1	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-58,29%	-4,34%	0,033	-3,55%	0,067	-5,81%	0,011	-6,07%
CPPI 80	-19,49%	-0,08%	0,056	-0,08%	0,056	-0,10%	0,044	-0,11%
CPPI 95	-4,40%	-0,08%	0,056	-0,08%	0,056	-0,09%	0,044	-0,11%
CPPI 99	-0,38%	-0,08%	0,056	-0,08%	0,056	-0,09%	0,044	-0,11%
Synthetic put 80	-58,14%	-3,90%	0,033	-3,27%	0,056	-5,07%	0,011	-5,54%
Synthetic put 95	-50,16%	-2,50%	0,033	-2,16%	0,067	-3,10%	0,011	-3,69%
Synthetic put 99	-42,41%	-1,97%	0,033	-1,71%	0,067	-2,43%	0,011	-2,90%
Stop-loss 80	-17,85%	-	-	-	-	-	-	-
Stop-loss 95	1,18%	-	-	-	-	-	-	-
Stop-loss 99	4,71%	-	-	-	-	-	-	-
Stop-loss 95-105	-17,85%	-	-	-	-	-	-	-
Stop-loss/start-gain	-40,07%	-3,78%	0,056	-3,26%	0,078	-3,93%	0,044	-5,40%

Table 1: results portfolio insurance AEX: 04-09-2000 to 04-07-2003

AEX P2	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-64,54%	-4,80%	0,122	-5,75%	0,056	-5,75%	0,056	-7,38%
CPPI 80	-19,97%	-0,03%	0,067	-0,03%	0,056	-0,04%	0,033	-0,05%
CPPI 95	-4,97%	-0,02%	0,067	-0,02%	0,056	-0,03%	0,033	-0,03%
CPPI 99	-0,97%	-0,02%	0,078	-0,02%	0,056	-0,02%	0,033	-0,03%
Synthetic put 80	-62,47%	-4,05%	0,122	-4,75%	0,056	-4,83%	0,044	-6,04%
Synthetic put 95	-53,66%	-2,85%	0,100	-3,16%	0,056	-3,38%	0,044	-4,01%
Synthetic put 99	-46,03%	-2,35%	0,100	-2,54%	0,056	-2,80%	0,033	-3,22%
Stop-loss 80	-24,23%	-	-	-	-	-	-	-
Stop-loss 95	-2,70%	-	-	-	-	-	-	-
Stop-loss 99	1,53%	-	-	-	-	-	-	-
Stop-loss 95-105	-24,23%	-	-	-	-	-	-	-
Stop-loss/start-gain	-43,12%	-2,65%	0,067	-4,43%	0,056	-3,19%	0,056	-5,11%

Table 2: results portfolio insurance AEX: 16-07-2007 to 09-03-2009

There are certain expectations that one could have prior to observing the results in the tables. Firstly, financial data usually is not normally distributed. Hence, the delta-normal VaR levels, which are based on a normal distribution, are likely to be lower than the historical simulation and Monte Carlo simulation VaR levels. This is because the delta-normal VaR levels are underestimated when the returns are not normally distributed. However, there appears to be a general trend in the results that the delta-normal VaR levels are higher than the historical simulation VaR levels in period 1, while it is vice versa in period 2. This might indicate that the returns in period 1 are actually normally distributed. However, since this has not been tested, it cannot be concluded firmly. Secondly, expected shortfall estimates the losses beyond the VaR levels, so these losses should exceed or at least equal the VaR levels. This can be observed in every table. Thirdly, the stop-loss strategies have no VaR levels, exceed ratios, nor expected shortfall levels. This is due to the fact that the stop-loss levels have been exceeded during the crises, which led to reallocating the entire portfolio value to risk-free assets. Since these strategies bear no risk after the rebalancing anymore, it is useless to calculate VaR levels and expected shortfall. Finally, the Monte Carlo simulation VaR levels are calculated by running 1.000 simulations of 90-day price paths. Because a huge amount of returns is considered, the Monte Carlo simulation VaR levels are expected to be the most accurate, which is confirmed by the lowest exceed ratios.

It can also be expected that the VaR levels and the accompanying expected shortfall levels are higher for unsatisfactorily performing insurance strategies. This is also ratified by the tables. Since the buy & hold strategy suffers the highest losses in the majority of the observations, the according VaR levels are also the highest. Although the synthetic put strategy is not able to reduce losses to a large extent, the VaR levels indicate that this strategy suffers less risk than the buy & hold strategy to a certain extent. To illustrate this, see tables 1 and 2, where the VaR levels decrease substantially when the floor levels are increased, regardless of the method used for calculating the VaR. In table 1 the VaR levels are reduced with 50 percent (from -5,07 to -2,43, Monte Carlo simulation) when the floor value is increased from 80 to 99 percent, while the losses are only reduced with 30 percent (from -58,14 to -42,41). However, the synthetic put VaR levels are still higher than the CPPI VaR levels. This indicates that the synthetic put portfolio insurance strategy is riskier than the CPPI strategy.

The stop-loss/start-gain strategy VaR levels also indicate the riskiness of this strategy. Although the returns of this strategy are higher than from the synthetic put strategy (even at the highest floor level), the VaR levels are higher, regardless of the method for calculating the VaR. This applies to the AEX based strategies. When other index based strategies are used, the stop-loss/start-gain method is even outperformed by synthetic put strategies. In table 7 the unreliability and riskiness of the stop-loss/start-gain strategy is illustrated explicitly. The total return in period 2 on the NASDAQ based strategy is -70,15 percent, while the buy & hold strategy has a return of -43,89 percent. The buy & hold strategy VaR in table 7 is best represented by the Monte Carlo simulation, because that VaR level is higher than the delta normal and historical simulation VaR's, while the exceed rate is lower. The Monte Carlo simulation VaR for the buy & hold strategy in table 7 has an acceptable exceed ratio of 4,4 percent, while the delta normal and historical simulation VaR levels have unacceptably high exceed ratios of 10 percent and 6,7 percent respectively. In general, it can be observed that the Monte Carlo simulation VaR levels are the most reliable, because the exceed ratios are at acceptable levels, below 5 percent. This can be observed for the AEX index based Monte Carlo VaR levels in tables 1 and 2, and for the other index based Monte Carlo VaR levels. An exception can be found in table 7, where the Monte Carlo simulation VaR level has an exceed ratio of 12,2 percent. The delta normal VaR level has the same exceed ratio, and the historical simulation VaR has an exceed ratio of 5,6 percent. The fact that even the Monte Carlo simulation VaR has an unacceptable high exceed ratio indicates that VaR is not always a reliable risk measurement instrument, and that expected shortfall is a necessary additional risk measurement instrument to value at risk. Besides that, the underestimated VaR level for the stop-loss/start-gain strategy in table 7 indicates that this strategy is not a reliable strategy to insure a portfolio with during crises.

The CPPI VaR levels are the lowest of all strategies, which indicates the safeness of this strategy. In most observations, the CPPI VaR levels per strategy are equal to each other, regardless of the floor level that has been used. This indicates that with the CPPI strategy, the same maximum amount relative to the final portfolio value can be expected to be lost with a confidence of 5 percent, regardless of which floor value is used. Not only does the CPPI strategy guarantee a minimum portfolio value at the end of the investment period, also the maximum amount to be lost in 5 percent of the observations is the lowest, either relative and absolute. Again the trend can be observed that the Monte Carlo simulation VaR levels are higher than the delta normal and historical simulation VaR levels, and the exceed ratios are lower. This confirms the reliable performance of the Monte Carlo simulation method for calculating the VaR levels. The losses beyond the VaR level, measured with the expected shortfall, are also lower for the CPPI strategy than for other strategies. Based on the returns, VaR levels, exceed ratios and expected shortfall, the CPPI strategy appears to be a reliable method of portfolio insurance during crises.

Unfortunately, the stop-loss strategy can not be evaluated using value at risk and expected shortfall, because at the end of the investment period, this strategy does not bear risk anymore. Based on the returns, this strategy turns out to give the highest returns during crises. However, investors can hardly know when a crisis is about to occur. Therefore, portfolio insurance strategies are used continuously. Since the stop-loss strategy is riskless at a certain point in time during a crisis, it is not likely to benefit from bull markets that usually occur after crises. Therefore, it is interesting to also consider the performances of the different used insurance strategies during a random investment period. A third investment period has been selected and evaluated, which will be discussed in the next paragraph.

4.3 Portfolio insurance strategy performance during a random investment period

So far, only the results from the portfolio insurance strategies' performances during crises have been discussed. Because the returns on the stop-loss strategy are exceptionally satisfying, it is interesting to consider the performance of this strategy under normal market circumstances. The performance of all strategies has again been evaluated in period 3, but only the floor value of 95 percent has been used. This has been done because the 99 percent floor level might be considered extremely tight, while the 80 percent floor level might be considered too loose. The 95 percent floor allows for a substantial amount of risk, although the amount of allowed risk is contained.

In figure 5, which is presented below, the conduct of the AEX index based portfolio values using the different strategies is presented. The third period represents a complete business cycle, covering the boom market during which the dot-com bubble was created, followed by the collapse of the bubble, the subsequent recession and the recovery until the credit crisis was about to occur. In this period, the stop-loss strategy with a floor level of 95 percent is not similar to the stop-loss 95-105 strategy anymore. The initial rebalancing to risk-free assets occurs at the same time. This can be observed in figure 5 at the beginning of the investment period. However, as time passes, the stop-loss 95-105 strategy has more rebalancing moments, because the value of the risky assets rises to 105 percent of its initial value. The stop-loss 95-105 portfolio is then rebalanced to risky assets again. The allowance for rebalancing to risky assets also allows for benefiting from the boom market between 1998 and 2000. However, the stop-loss 95-105 portfolio value is lower than the buy & hold strategy, because the benefits from a boom market only start when the value of risky assets is at 105 percent of its initial value. The potential profits before the 105 percent has been reached are not captured with the stop-loss 95-105 strategy.

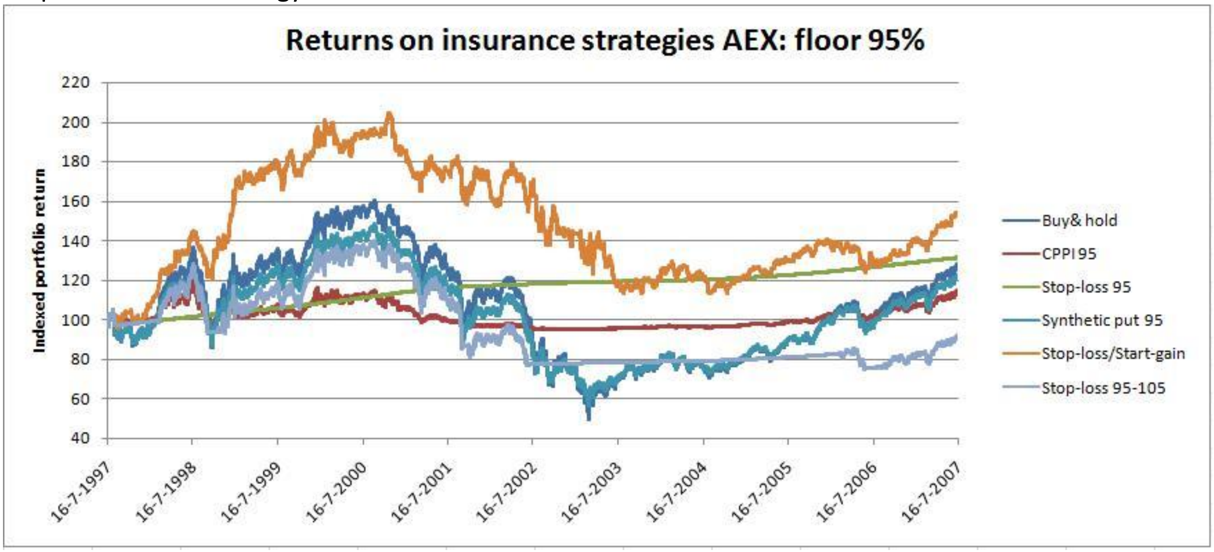

Figure 5: Returns on insured portfolios containing the AEX index as risky asset: period 3

It could be expected that the value of the stop-loss 95-105 portfolio would not be able to drop below the floor value of 95 percent. Although the final portfolio value is not excessively lower than five percent (7,87 percent, see table 3), the portfolio value has reached much lower levels. This is due to the previously observed fact that there is some noise around the stop-loss level. Investors are never able to sell the whole portfolio consisting of risky assets when is has suffered a loss of exactly 5 percent. Moreover, the frequently rebalancing of the complete portfolio is accompanied with high transaction costs. Each time when rebalancing occurs, 0,5 percent of the total portfolio value is lost to transaction costs. The stop-loss 95-105 strategy does not seem to work as properly as was expected. This is also confirmed by the VaR levels and expected shortfall, which are higher for the stop-loss 95-105 strategy than for other strategies (see table 3). The lowest returns from the stop-loss 95-105 strategy compared to the other strategies can also be observed for other index based strategies in tables 10 and 11. Only the Nikkei-225 based stop-loss 95-105 strategy seems to perform well in period 3, where it achieves a return of 10,4 percent (see table 12). However, this is due to the fact that the Nikkei-225 index was performing substantially worse than the other used indices during this period. Therefore, the stop-loss 95-105 portfolio consisted merely of risk-free assets at the end of the investment period. Hence there are no VaR levels and expected shortfall to be observed for the stop-loss 95-105 strategy in table 12. The final rebalancing occurred already in 2001, allowing this strategy to generate interest profits for a relatively long time. The relatively good performance of this strategy is merely due to coincidence, since the returns of this strategy, based on other indices, are the lowest of all strategies. Hence the stop-loss 95-105 strategy is not a good insurance strategy for investment portfolios during random market circumstances.

AEX P3	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	28,28%	-1,26%	0,022	-0,89%	0,067	-1,46%	0,011	-1,69%
CPPI 95	14,89%	-0,80%	0,022	-0,65%	0,056	-0,91%	0,022	-1,00%
Synthetic put 95	22,84%	-1,15%	0,022	-0,83%	0,067	-1,33%	0,011	-1,68%
Stop-loss 95	24,92%	-	-	-	-	-	-	-
Stop-loss 95-105	-7,87%	-1,26%	0,022	-0,90%	0,056	-1,49%	0,011	-1,69%
Stop-loss/start-gain	53,38%	-0,80%	0,022	-0,67%	0,044	-0,89%	0,022	-1,08%

Table 3: results portfolio insurance AEX: 16-07-1997 to 16-07-2007

The stop-loss/start-gain strategy returns are the highest in figure 5 and table 3. The total return over the investment period of ten years is 53 percent, which makes it the only strategy outperforming the buy & hold strategy. However, the VaR levels and expected shortfall are not unilaterally the lowest for this strategy. This indicates that the strategy bears a substantial amount of risk. When observing the stop-loss/start-gain returns based on the other used indices, then it can be concluded that the outperformance of the AEX index based stop-loss/start-gain strategy is due to coincidence. In figure 12, the FTSE-100 based stop-loss/start-gain strategy outperforms the other strategies during large part of the investment period, but the satisfactory performance is not maintained towards the end of the investment period. The NASDAQ and Nikkei-225 based stop-loss/start-gain strategies are already outperformed by other strategies in an early stage of the investment period. The VaR levels indicate that the stop-loss/start-gain strategy is to some extent less risky than the buy & hold strategy, but it is disputable whether investors would accept such a reduction in returns for a relatively small reduction of risk.

The synthetic put strategy appears to move closely with the buy & hold strategy again, similar to during the crisis periods. The final value of this strategy based on the AEX index is marginally lower than the buy & hold strategy, which is logical, because portfolio insurance is accompanied with costs. The VaR levels and expected shortfall are little lower than for the buy & hold strategy, which indicates that this strategy bears little less risk. This is unilateral for each used index, except for the NASDAQ based historical simulation VaR. However, the performance of the synthetic put strategy was already found unsatisfactorily during crises. Since even during a random business cycle the synthetic put strategy is outperformed by the buy & hold strategy, this strategy is not likely to be popular with investors. Again, this is probably due to the fact that daily rebalancing is not accurate enough for this strategy. The returns may be completely different when continuously rebalancing would have been used.

Based on the returns, it can be stated that the CPPI strategy is outperformed by most other strategies during period 3. The return for the AEX index based CPPI strategy (in table 3) is 50 percent lower than the buy & hold strategy. For the FTSE-100 CPPI strategy the return is only 30 percent of the buy & hold strategy (table 10). For the NASDAQ based CPPI strategy the return is even negative, which can be seen in table 11. Only for the Nikkei-225 index the CPPI return is higher than the buy & hold strategy, but it still is negative. This is due to the relatively bad performance of the Nikkei index compared to the other used indices during period 3. It is not surprising that the CPPI strategy is outperformed by the buy & hold strategy during bull markets. This is due to the fact that part of the investment portfolio is invested in risk-free assets, hence this strategy does not fully benefit from increasing stock values. From the VaR levels it can again be concluded that the CPPI strategy bears the lowest risk compared to the other strategies. This is confirmed by the strategies based on all used indices. Again, the Monte Carlo simulation VaR levels are higher than the VaR levels calculated with the other two methods. Also the expected shortfall is on average lower for the CPPI strategy than for the other strategies. The CPPI strategy was outperforming the other strategies during crises, except the stop-loss strategy. During random market circumstances, it turns out that the CPPI strategy is bearing low risk, but in return relatively large parts of the returns have to be sacrificed.

Finally, the stop-loss strategy again appears to perform relatively well compared to the other insurance strategies during period 3. The return on this strategy with the AEX index as risky asset is close to 25 percent, which is only marginally lower than the return of 28 percent with the buy & hold strategy, as can be seen in table 3. The high return of this strategy is due to the relatively high floor level. When a floor level of 80 percent is implemented in the stop-loss strategy in period 3, the total return would be a loss of 5 percent. This shows that the stop-loss strategy is not capable to benefit from market's recovery. Similar to during crises, the high floor level allows for a relatively long remainder of time during the investment period, which allows for substantial interest gains that lead to a high return. Also for the other index based stop-loss strategies the returns are relatively high, because the floor level has been exceeded relatively early in the investment period, which allows for substantial interest gains. It can be seen from figure 5 that during the bull market the stop-loss strategy is outperformed by the other strategies. However, the other strategies are severely affected by the recession after the collapse of the dot-com bubble. This enables the stop-loss strategy to acquire a lead over the other strategies. Although the other strategies manage to benefit from the bull market that starts in 2003, the stop-loss strategy already has such a large lead over the other strategies, that the other strategies are not capable to keep up with the stop-loss strategy portfolio value. One might argue whether the stop-loss strategy can be considered an investment insurance strategy, because the portfolio becomes risk free after the only rebalancing period. However, since this strategy is part of the evaluated strategies, it must be acknowledged that this strategy is outperforming the other investment strategies. This not only occurs during crises, but also during the random business cycle of period 3. These findings would be different when another time frame would have been used. If the investment period would have ended in 2000, then the stop-loss strategy would have been outperformed by the other strategies, except CPPI.

5. Conclusions

The main goal of this paper is to comment on the effectiveness of several portfolio insurance strategies during crises. The portfolio insurance strategies that are subject to research are synthetic put portfolio insurance, constant proportion portfolio insurance and stop-loss portfolio insurance. These are regular evaluated portfolio insurance strategies in the current literature. In order to draw firm conclusions with respect to the performance of the different insurance strategies, four different stock indices from all over the world have been used. The performance of the insurance strategies has been evaluated during two different periods of crisis, which reduces the possibility of performances based on coincidence. The periods during which the crises occurred are after the collapse of the dot-com bubble in 2000 and the housing bubble in 2007. These are the most recent crises during which the evolved portfolio insurance strategies could have been used by investors. Also, these periods have not been used for the evaluation of the performance of insurance strategies yet.

Based on the methodology from previous papers about the performance of portfolio insurance strategies, a model has been built, which has been used to calculate the course of the values of insured investment portfolios. The courses of the portfolio values were then used to optically show the performance of the different insurance strategies in graphs. However, the performance during the total investment periods can best be evaluated based on the final return at the end of both investment periods. Not only the final portfolio value is determinant for drawing conclusions about the effectiveness of portfolio insurance strategies, also the accompanying risks are important. These risks can be expressed with the use of value at risk, and additionally with expected shortfall.

The results from the investment periods during crises show that the crises have been severe. This can be concluded based on the returns from the naive buy & hold strategy. The synthetic put strategy outperforms the buy & hold strategy only to a marginal extent. This indicates that the synthetic put portfolio insurance strategy works, although this strategy is outperformed by the other portfolio insurance strategies. In addition, the synthetic put strategy bears relatively much risk compared to the other strategies. CPPI and stop-loss portfolio insurance both outperform the synthetic put strategy with respect to their returns and risk. Depending on which floor level and stock market index as risky asset is used, the CPPI strategy outperforms the stop-loss strategy in infrequent occasions, while the stop-loss strategy outperforms the CPPI strategy on a more frequent basis. The safest portfolio insurance strategy during crises appears to be the stop-loss strategy, which is closely followed by the CPPI strategy.

Because the stop-loss strategy is a rather rigorous strategy that performs exceptionally well during crises, there also has been evaluated how well the performance of this strategy is during a random business cycle. It could be expected that the returns from this strategy would then be disappointing, because the strategy does not allow for benefiting from bull markets after crises, since the complete portfolio is allocated to risk-free assets. The stop-loss portfolio value would then only grow at the speed of the risk-free rate. Therefore, two modified versions of the stop-loss strategy have been proposed: stop-loss 95-105 portfolio insurance and stop-loss/start-gain portfolio insurance. Also a third period has been added, which covers a random business cycle with a boom, a crisis and a subsequent period of recovery.

The two newly introduced insurance strategies have also been evaluated during the crises, along with the other portfolio insurance strategies. Stop-loss 95-105 turns out to be similar to the normal stop-loss strategy with a floor level of 95 percent, because the market does not recover to 105 percent of its original value during the crises. Stop-loss/start-gain portfolio insurance turns out to be an unreliable portfolio insurance strategy during crises, because the results per crisis and per used index differ to a large extent. Also, the risk that this strategy bears is excessively large compared to the other strategies. Therefore, this strategy is not likely to be coveted by investors during crises.

During the third investment period that has been subject to evaluation, the results are slightly different from during the crises. The stop-loss 95-105 strategy is not similar to the normal stop-loss strategy anymore, because the value of risky assets shifts both below the 95 percent floor level and above the 105 percent floor level. However, due to the noise and the high transaction costs that are accompanied with this strategy, it turns out to be outperformed by most other strategies. The stop-loss/start-gain strategy performs relatively well when it is based on the AEX index, but this appears to be due to coincidence, as the performance based on the other indices differs excessively from the AEX index based stop-loss/start-gain strategy. The synthetic put strategy moves closely with the buy & hold strategy. It even outperforms the CPPI strategy when it is based on the AEX, FTSE-100 and NASDAQ indices, but fails to achieve this for the Nikkei-225 based strategy. Because the Nikkei index performs worse than the other used indices during period 3, it has been revealed that the synthetic put strategy outperforms the other strategies due to coincidence. The risk that this strategy bears is relatively high, although the return outperforms most other strategies in most observations. The CPPI strategy is outperformed by most other strategies, but is accompanied with the lowest risk, similar to periods 1 and 2. Stop-loss portfolio insurance provides the highest returns, similar to during the crises. While the other strategies endure substantial losses during the recession, the stop-loss strategy is able to generate returns continuously from interests, even though the interest rate was lowered excessively between 2001 and 2004. This way, the stop-loss strategy had acquired a lead over the other strategies. The recovery after the recession that lasted until halfway 2003 was not expansively enough to enable the other strategies to achieve portfolio values above those from the stop-loss insurance strategy.

Overall, it can be concluded that the stop-loss strategy achieves the highest return during crises. When markets do not recover aggressively after crises, the stop-loss strategy also outperforms other portfolio insurance strategies, while its portfolio value only grows at the speed of the risk-free rate. Investors who do not tolerate much risk should choose this portfolio insurance strategy. Investors that are more tolerant towards risk, should choose the CPPI strategy. The findings from this paper are in line with Black and Rouhani (1989), who find that CPPI outperforms OBPI (option based portfolio insurance, in this research with a synthesized put) under market declines. The outperformance of the stop-loss strategy is contradictive with the findings of Annaert et al. (2007) that stop-loss portfolio insurance is outperformed by synthetic put portfolio insurance and CPPI. However, Annaert et al. (2007) have not focused on crises in particular, but instead used one sample period covering more than 30 years. Such a long period does not seem realistic as investment period for modern investors. Hence it is straightforward that the stop-loss strategy has been outperformed by the other strategies. From the moment the floor value had been exceeded, the stop-loss strategy insured portfolio merely grew with the risk-free rate, while the stock market expanded more rapidly. This paper has proved that during crises and a shorter random sample period the stop-loss strategy outperforms the other commonly used portfolio insurance strategies.

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Appendices

Appendix A - Tables

FTSE-100 P1	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-47,12%	-2,86%	0,044	-2,11%	0,056	-3,51%	0,011	-3,56%
CPPI 80	-19,11%	-0,10%	0,044	-0,10%	0,056	-0,12%	0,022	-0,14%
CPPI 95	-4,03%	-0,09%	0,044	-0,09%	0,056	-0,11%	0,022	-0,13%
CPPI 99	-0,01%	-0,09%	0,044	-0,09%	0,056	-0,10%	0,022	-0,11%
Synthetic put 80	-47,09%	-2,75%	0,044	-2,02%	0,056	-3,42%	0,011	-3,50%
Synthetic put 95	-40,32%	-1,83%	0,044	-1,39%	0,056	-2,18%	0,022	-2,48%
Synthetic put 99	-34,10%	-1,46%	0,044	-1,13%	0,056	-1,75%	0,022	-1,90%
Stop-loss 80	-16,88%	-	-	-	-	-	-	-
Stop-loss 95	1,27%	-	-	-	-	-	-	-
Stop-loss 99	5,10%	-	-	-	-	-	-	-
Stop-loss 95-105	1,27%	-	-	-	-	-	-	-
Stop-loss/start-gain	-38,41%	-2,06%	0,067	-2,26%	0,056	-2,45%	0,033	-3,14%

Table 4: results portfolio insurance FTSE-100: 04-09-2000 to 04-07-2003

FTSE-100 P2	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-61,05%	-4,36%	0,111	-5,38%	0,067	-5,02%	0,067	-7,32%
CPPI 80	-19,96%	-0,05%	0,067	-0,06%	0,056	-0,06%	0,033	-0,08%
CPPI 95	-4,96%	-0,03%	0,067	-0,03%	0,056	-0,04%	0,033	-0,05%
CPPI 99	-0,96%	-0,02%	0,067	-0,03%	0,056	-0,03%	0,033	-0,04%
Synthetic put 80	-58,78%	-3,70%	0,100	-4,46%	0,067	-4,29%	0,067	-6,07%
Synthetic put 95	-50,33%	-2,65%	0,078	-3,03%	0,067	-3,15%	0,044	-4,09%
Synthetic put 99	-43,70%	-2,23%	0,078	-2,50%	0,067	-2,66%	0,044	-3,35%
Stop-loss 80	-19,74%	-	-	-	-	-	-	-
Stop-loss 95	-5,10%	-	-	-	-	-	-	-
Stop-loss 99	1,23%	-	-	-	-	-	-	-
Stop-loss 95-105	-5,10%	-	-	-	-	-	-	-
Stop-loss/start-gain	-48,72%	-2,72%	0,056	-3,06%	0,056	-3,30%	0,033	-4,31%

Table 5: results portfolio insurance FTSE-100: 16-07-2007 to 09-03-2009

NASDAQ P1	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-76,47%	-3,24%	0,033	-2,16%	0,067	-4,10%	0,022	-5,10%
CPPI 80	-19,02%	-0,12%	0,044	-0,10%	0,056	-0,14%	0,022	-0,16%
CPPI 95	-3,84%	-0,12%	0,044	-0,10%	0,056	-0,14%	0,022	-0,16%
CPPI 99	0,21%	-0,12%	0,044	-0,10%	0,056	-0,14%	0,022	-0,16%
Synthetic put 80	-68,33%	-2,19%	0,033	-1,50%	0,056	-2,70%	0,022	-3,54%
Synthetic put 95	-56,22%	-1,20%	0,033	-0,86%	0,056	-1,43%	0,033	-2,02%
Synthetic put 99	-52,71%	-1,00%	0,033	-0,72%	0,067	-1,19%	0,033	-1,19%
Stop-loss 80	-17,09%	-	-	-	-	-	-	-
Stop-loss 95	0,99%	-	-	-	-	-	-	-
Stop-loss 99	5,74%	-	-	-	-	-	-	-
Stop-loss 95-105	0,99%	-	-	-	-	-	-	-
Stop-loss/start-gain	-52,42%	-2,44%	0,022	-1,73%	0,056	-3,03%	0,011	-5,58%

Table 6: results portfolio insurance NASDAQ: 04-09-2000 to 04-07-2003

NASDAQ P2	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-43,89%	-4,94%	0,100	-5,77%	0,067	-6,16%	0,044	-7,17%
CPPI 80	-19,87%	-0,11%	0,056	-0,13%	0,056	-0,14%	0,044	-0,20%
CPPI 95	-4,92%	-0,05%	0,056	-0,06%	0,056	-0,07%	0,044	-0,09%
CPPI 99	-0,93%	-0,04%	0,056	-0,05%	0,056	-0,05%	0,044	-0,07%
Synthetic put 80	-41,95%	-4,18%	0,100	-4,81%	0,056	-4,96%	0,044	-6,01%
Synthetic put 95	-36,30%	-3,20%	0,100	-3,64%	0,056	-3,81%	0,044	-4,49%
Synthetic put 99	-31,51%	-2,81%	0,100	-3,18%	0,056	-3,36%	0,044	-3,90%
Stop-loss 80	-21,50%	-	-	-	-	-	-	-
Stop-loss 95	-3,02%	-	-	-	-	-	-	-
Stop-loss 99	0,84%	-	-	-	-	-	-	-
Stop-loss 95-105	-3,02%	-	-	-	-	-	-	-
Stop-loss/start-gain	-70,15%	-3,79%	0,122	-7,40%	0,056	-4,20%	0,122	-9,14%

Table 7: results portfolio insurance NASDAQ: 16-07-2007 to 09-03-2009

Nikkei-225 P1	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-59,87%	-2,43%	0,011	-2,15%	0,067	-2,98%	0,011	-3,54%
CPPI 80	-18,91%	-0,08%	0,033	-0,07%	0,056	-0,10%	0,022	-0,12%
CPPI 95	-3,72%	-0,08%	0,033	-0,07%	0,056	-0,09%	0,022	-0,12%
CPPI 99	0,33%	-0,08%	0,033	-0,07%	0,056	-0,09%	0,022	-0,12%
Synthetic put 80	-58,19%	-2,29%	0,011	-2,04%	0,067	-2,82%	0,011	-3,36%
Synthetic put 95	-46,62%	-1,34%	0,033	-1,27%	0,067	-1,59%	0,011	-2,11%
Synthetic put 99	-41,58%	-1,04%	0,033	-0,99%	0,056	-1,24%	0,011	-1,62%
Stop-loss 80	-18,22%	-	-	-	-	-	-	-
Stop-loss 95	1,44%	-	-	-	-	-	-	-
Stop-loss 99	1,44%	-	-	-	-	-	-	-
Stop-loss 95-105	1,44%	-	-	-	-	-	-	-
Stop-loss/start-gain	-36,96%	-1,71%	0,067	-1,98%	0,056	-2,03%	0,033	-2,12%

Table 8: results portfolio insurance Nikkei-225: 04-09-2000 to 04-07-2003

Nikkei-225 P2	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-47,71%	-4,31%	0,089	-5,01%	0,056	-5,22%	0,044	-7,15%
CPPI 80	-19,85%	-0,15%	0,078	-0,18%	0,056	-0,18%	0,056	-0,24%
CPPI 95	-4,90%	-0,08%	0,078	-0,10%	0,056	-0,10%	0,044	-0,13%
CPPI 99	-0,91%	-0,06%	0,078	-0,08%	0,056	-0,08%	0,044	-0,10%
Synthetic put 80	-0,4676	-3,81%	0,089	-4,30%	0,056	-4,65%	0,044	-6,17%
Synthetic put 95	-40,41%	-2,87%	0,089	-3,15%	0,056	-3,44%	0,044	-4,47%
Synthetic put 99	-34,46%	-2,46%	0,067	-2,67%	0,056	-2,96%	0,044	-3,77%
Stop-loss 80	-20,01%	-	-	-	-	-	-	-
Stop-loss 95	-6,37%	-	-	-	-	-	-	-
Stop-loss 99	1,36%	-	-	-	-	-	-	-
Stop-loss 95-105	-6,37%	-	-	-	-	-	-	-
Stop-loss/start-gain	-63,12%	-2,94%	0,122	-5,05%	0,056	-3,39%	0,122	-6,87%

Table 9: results portfolio insurance Nikkei-225: 16-07-2007 to 09-03-2009

FTSE-100 P3	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	30,19%	-1,22%	0,033	-1,00%	0,056	-1,42%	0,033	-1,96%
CPPI 95	9,87%	-0,68%	0,033	-0,52%	0,056	-0,78%	0,033	-1,16%
Synthetic put 95	24,77%	-1,12%	0,033	-0,93%	0,056	-1,32%	0,033	-1,93%
Stop-loss 95	26,79%	-	-	-	-	-	-	-
Stop-loss 95-105	-2,26%	-1,22%	0,033	-1,01%	0,056	-1,46%	0,022	-1,96%
Stop-loss/start-gain	11,29%	-0,79%	0,056	-0,81%	0,033	-0,91%	0,011	-1,06%

Table 10: results portfolio insurance FTSE-100: 16-07-1997 to 16-07-2007

NASDAQ P3	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	45,94%	-1,35%	0,033	-1,20%	0,056	-1,58%	0,011	-2,36%
CPPI 95	-0,28%	-0,29%	0,033	-0,27%	0,033	-0,28%	0,033	-0,45%
Synthetic put 95	40,53%	-1,35%	0,028	-1,37%	0,028	-1,40%	0,011	-2,20%
Stop-loss 95	29,40%	-	-	-	-	-	-	-
Stop-loss 95-105	-10,19%	-1,34%	0,033	-1,21%	0,056	-1,59%	0,011	-1,84%
Stop-loss/start-gain	-2,92%	-0,96%	0,033	-1,21%	0,028	-1,12%	0,044	-1,35%

Table 11: results portfolio insurance NASDAQ: 16-07-1997 to 16-07-2007

Nikkei-225 P3	Return	Delta-normal	Exceed ratio	Hist. Simulation	Exceed ratio	Monte Carlo	Exceed ratio	Expected Shortfall
Buy & hold	-32,18%	-1,49%	0,078	-1,72%	0,056	-1,79%	0,044	-2,32%
CPPI 95	-0,21%	-0,38%	0,056	-0,43%	0,056	-0,47%	0,033	-0,61%
Synthetic put 95	-23,06%	-1,08%	0,072	-1,42%	0,033	-1,30%	0,056	-1,76%
Stop-loss 95	27,82%	-	-	-	-	-	-	-
Stop-loss 95-105	10,39%	-	-	-	-	-	-	-
Stop-loss/start-gain	-30,14%	-1,03%	0,067	-1,26%	0,056	-1,26%	0,044	-2,59%

Table 12: results portfolio insurance Nikkei-225: 16-07-1997 to 16-07-2007

Appendix B - Figures

Figure 6: Returns on insured portfolios containing the FTSE-100 index as risky asset: period 1

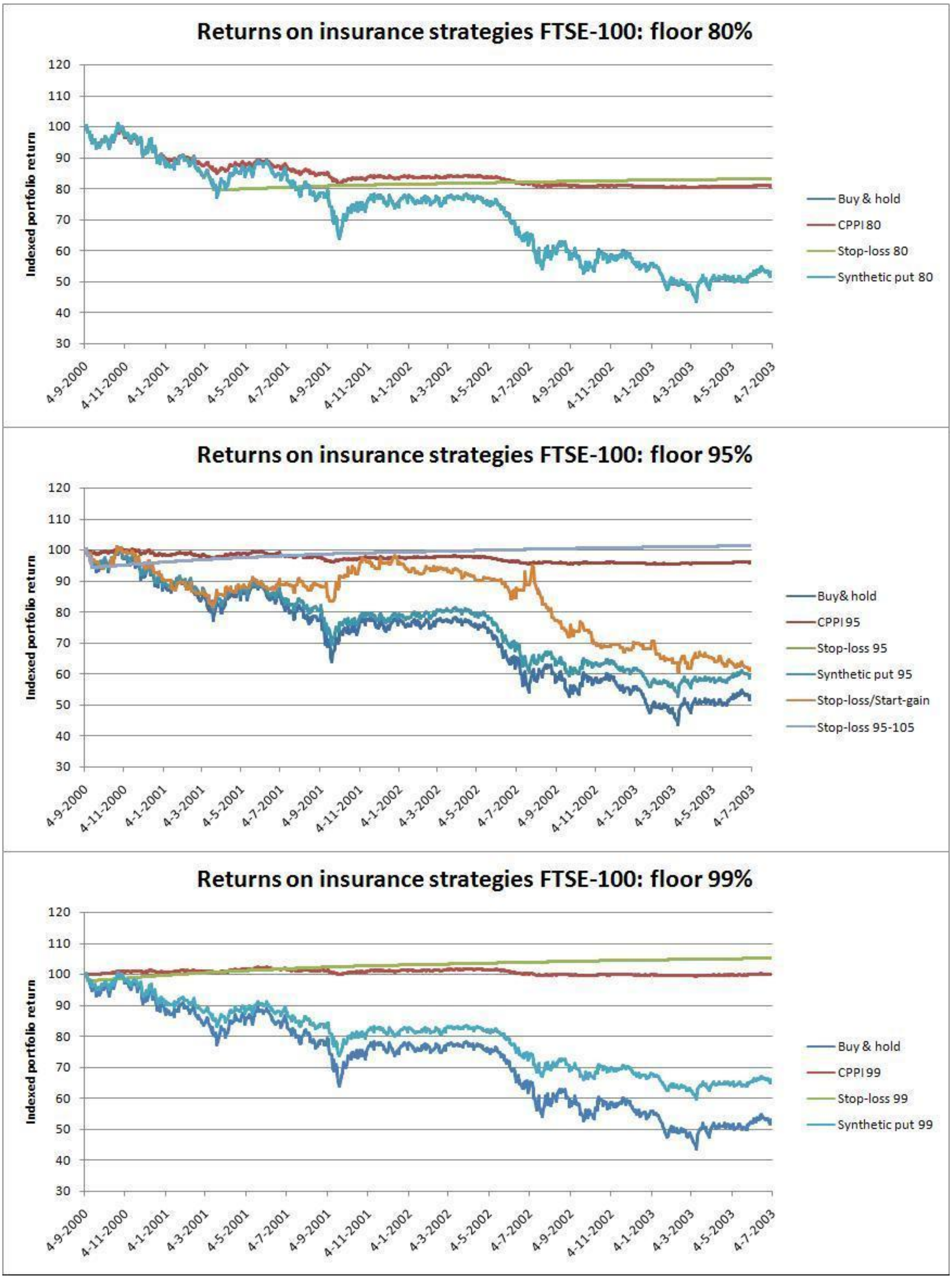

Figure 7: Returns on insured portfolios containing the FTSE-100 index as risky asset: period 2

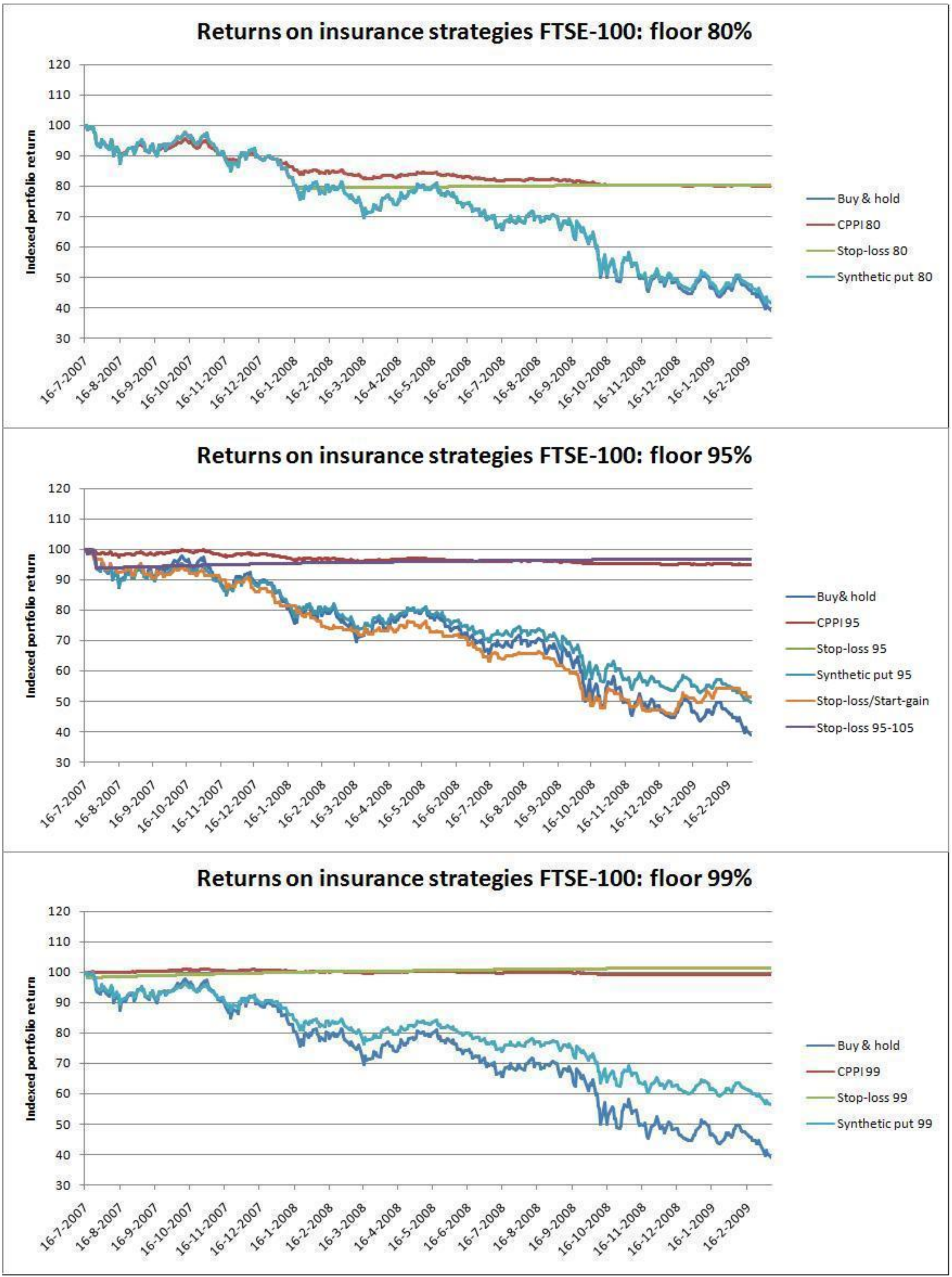

Figure 8: Returns on insured portfolios containing the NASDAQ index as risky asset: period 1

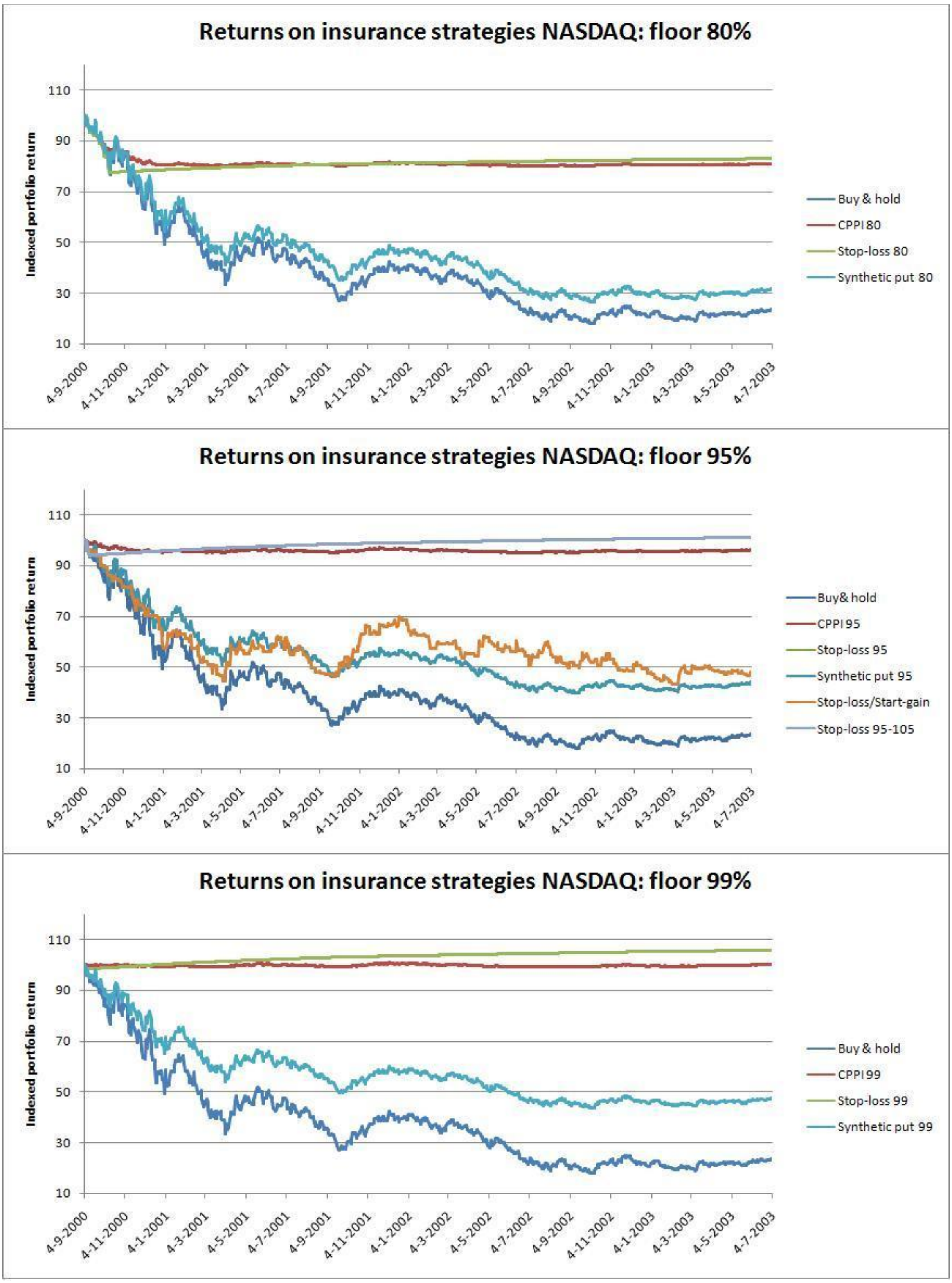

Figure 9: Returns on insured portfolios containing the NASDAQ index as risky asset: period 2

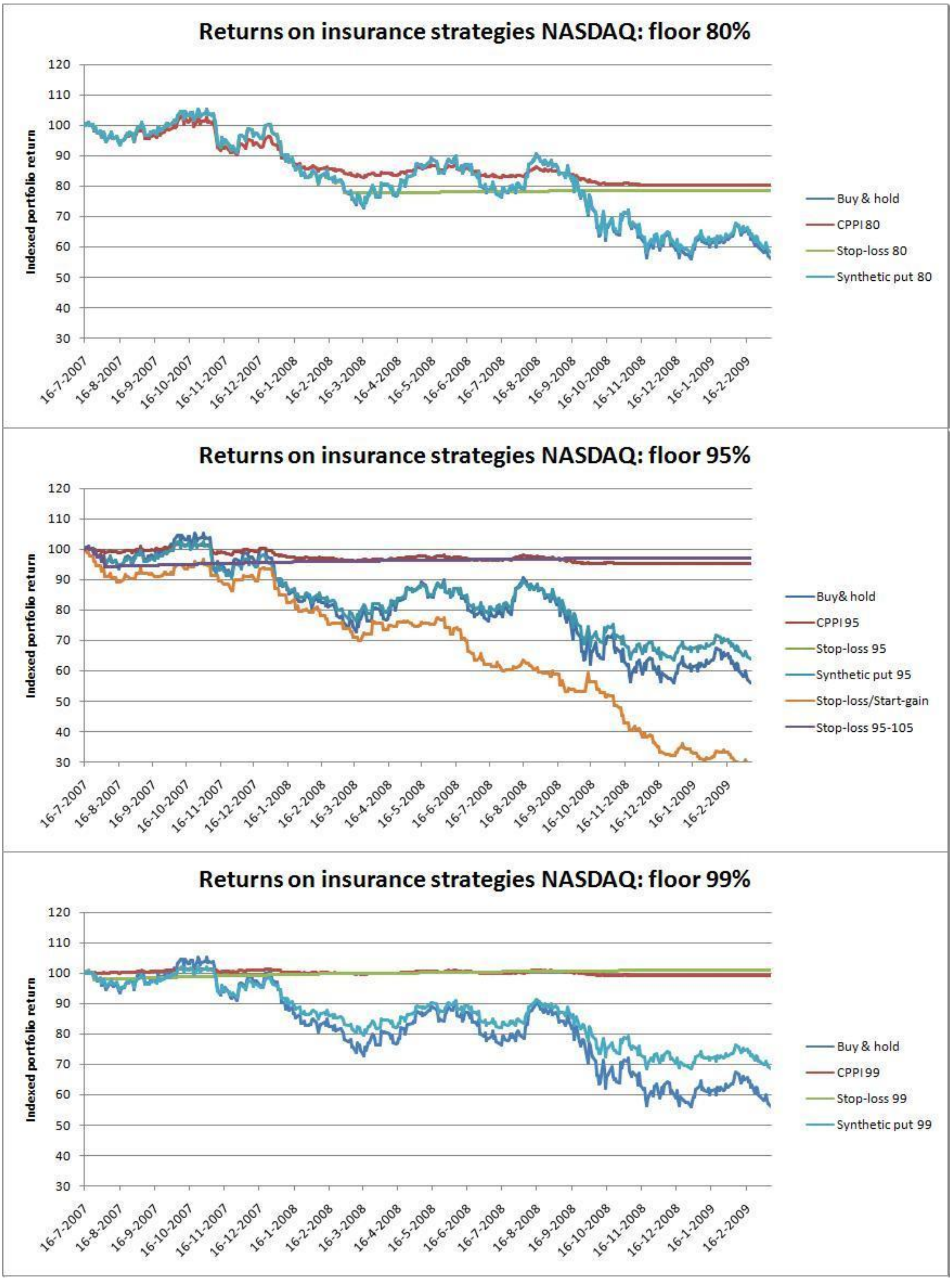

Figure 10: Returns on insured portfolios containing the Nikkei-225 index as risky asset: period 1

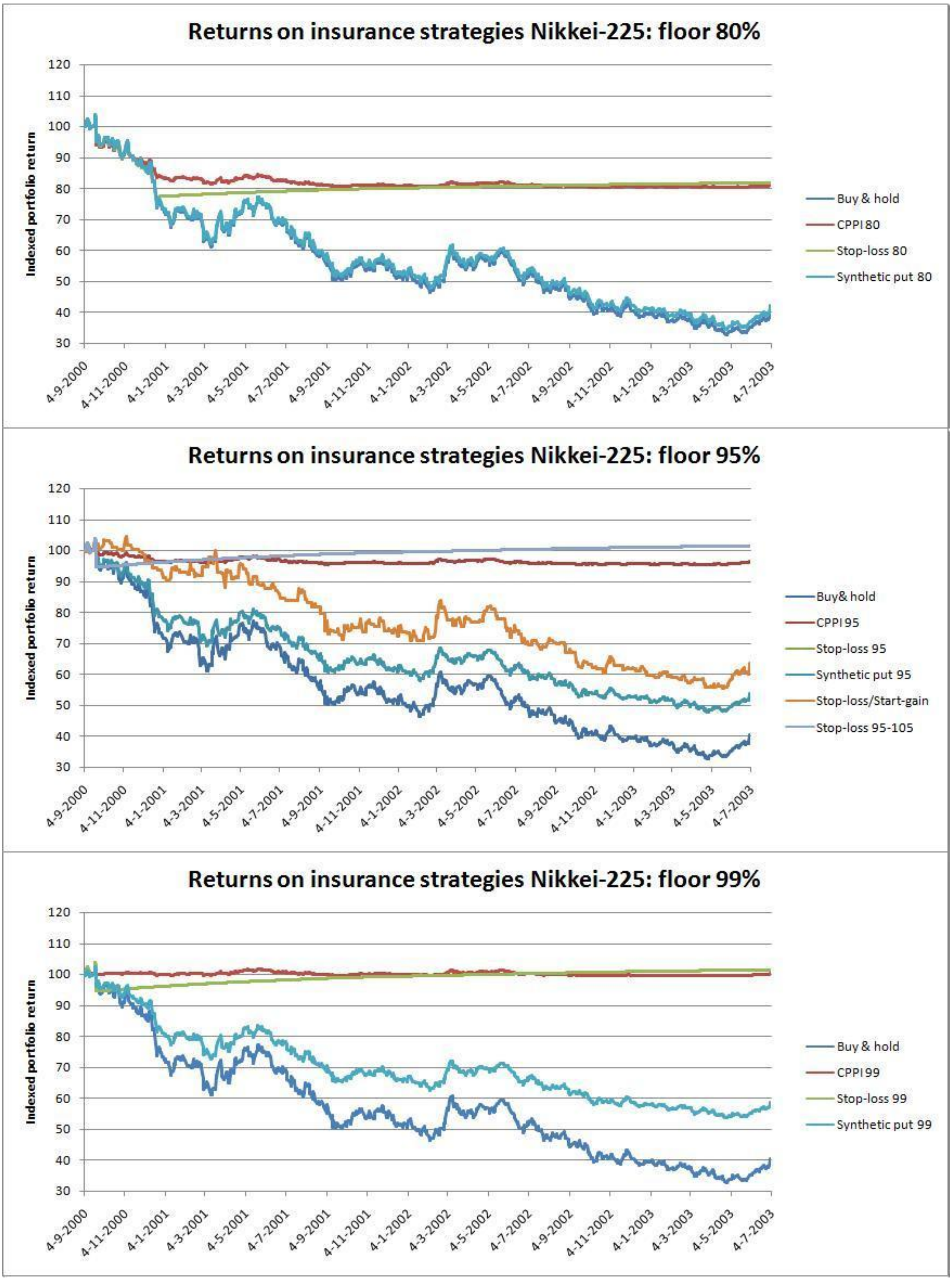

Figure 11: Returns on insured portfolios containing the Nikkei-225 index as risky asset: period 2

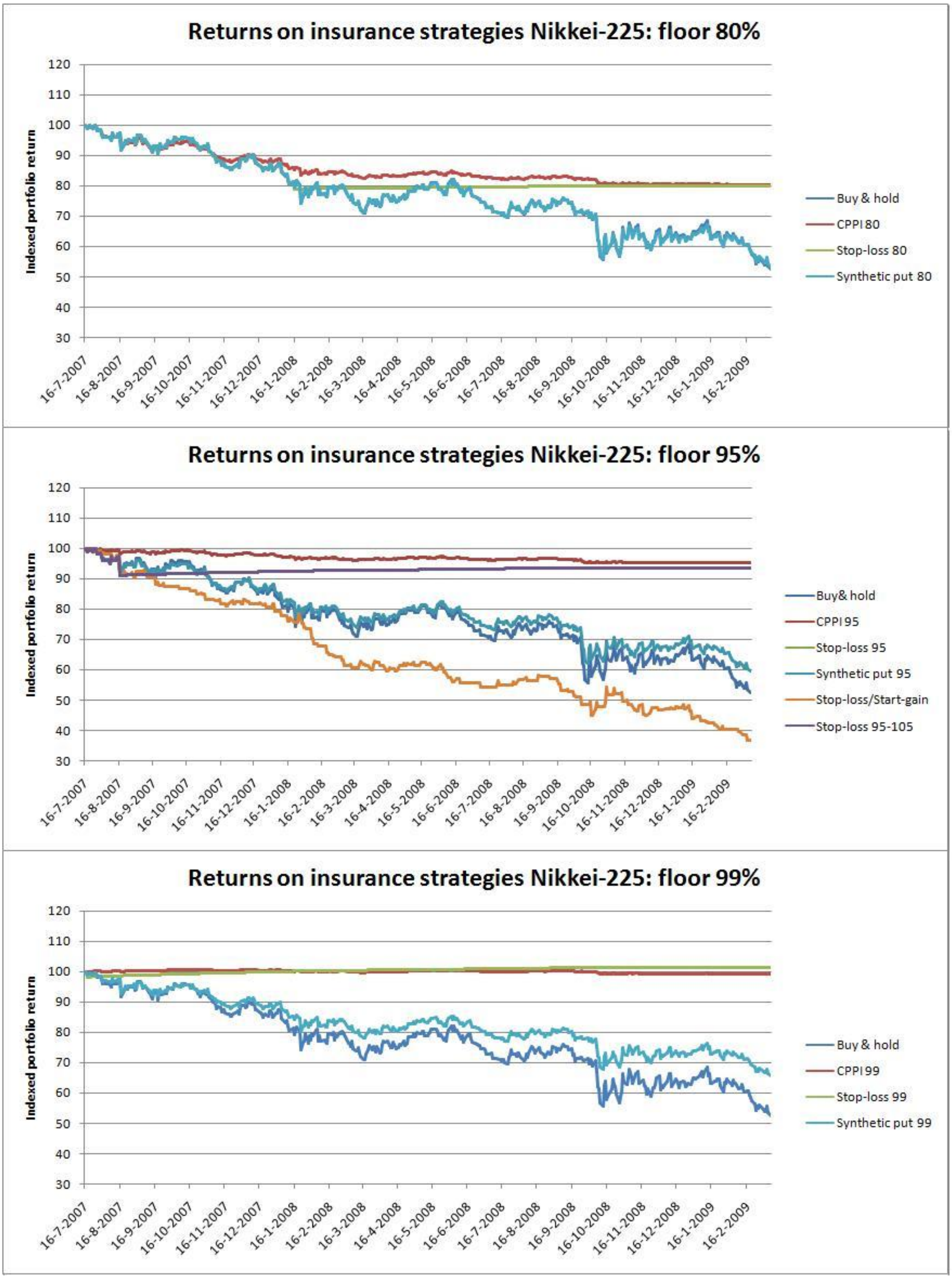

Figure 12: Returns on insured portfolios containing the FTSE-100 index as risky asset: period 3

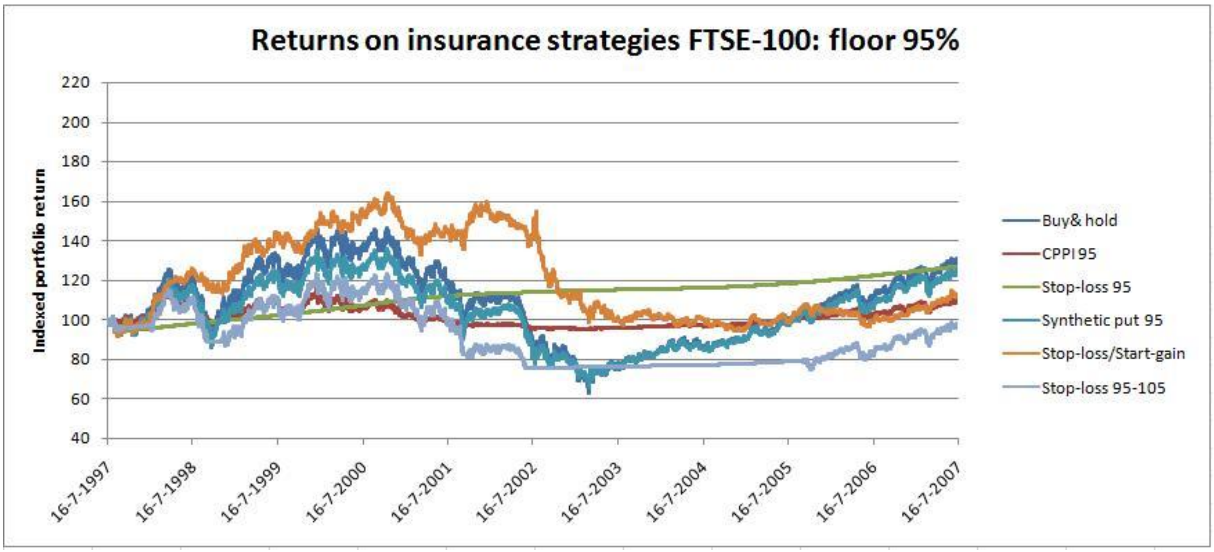

Figure 13: Returns on insured portfolios containing the NASDAQ index as risky asset: period 3

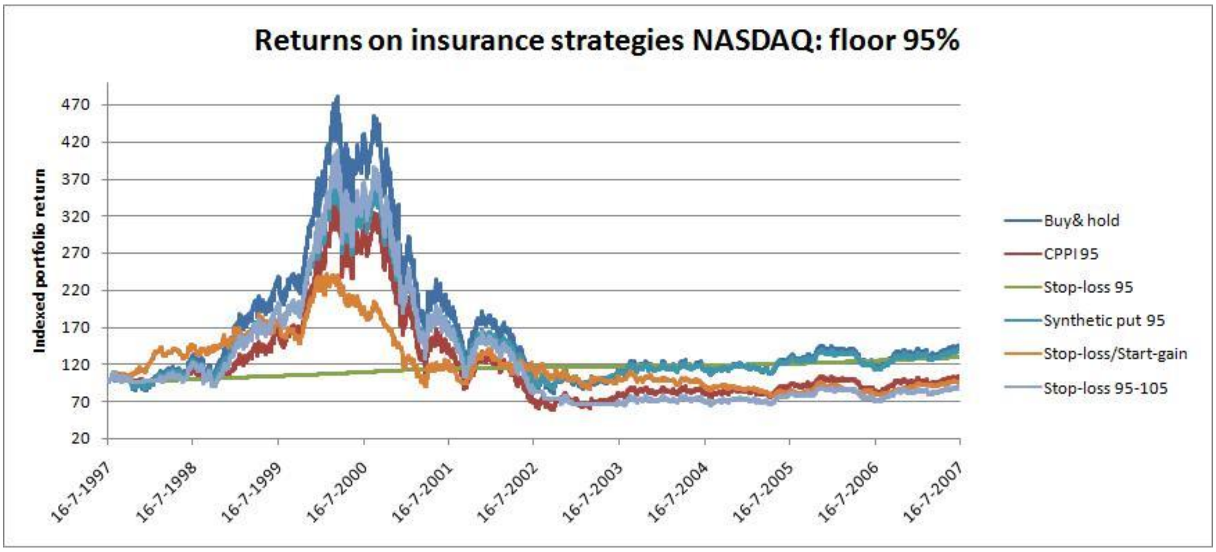

Figure 14: Returns on insured portfolios containing the Nikkei-225 index as risky asset: period 3