Vaasan yliopisto
UNIVERSITY OF VAASA

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THE USABILITY OF COVERED CALLS IN THE EURO STOXX 50 INDEX

Master's degree
programme in Finance

Vaasa 2024

UNIVERSITY OF VAASA
Faculty of Business Studies
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Title of the Thesis:	THE USABILITY OF COVERED CALLS IN THE EURO STOXX 50 INDEX
Degree:	Master of Science in Economics and business Administration
Programme:	Master's Degree Program in Finance
Supervisor:	Anupam Dutta
Year:	2024 **Pages:** 72

ABSTRACT:
Tämän tutkimuksen tarkoituksena on tutkia suojattujen osto-optiostrategioiden (covered call strategies) käyttökelpoisuutta Euro STOXX 50 -indeksissä, erityisesti Euroopan markkinoilla. Suojattuja osto-optioita tarkastellaan eri taloudellisissa olosuhteissa, kuten matalien korkojen ja korkean volatiliteetin aikakausina. Suojatut osto-optiostrategiat, joissa sijoittaja pitää pitkää positiota omaisuuserässä ja myy osto-optioita kyseiseen omaisuuserään, ovat osoittautuneet tehokkaiksi riskin alentamisen keinoiksi samalla, kun ne voivat tarjota lisätuottoa. Suojattujen osto-optioiden ja buy-write-strategioiden kasvava suosio sijoittajien ja rahoituslaitosten keskuudessa toimii tämän tutkimuksen motivaationa. Suojattujen osto-optiostrategioiden tavoitteena on yleensä tuottaa tuloja optiopreemioiden avulla, vaikka tämä edellyttääkin osittaista luopumista osakkeen mahdollisista kurssinousuista. Tässä tutkimuksessa arvioidaan Euro STOXX 50 BuyWrite -indeksin sekä eritasoisten rahallisuusasteiden (moneyness), kuten at-the-money (ATM), out-of-the-money (OTM) ja in-the-money (ITM) strategioiden teoreettista ja toteutunutta suorituskykyä. Tarkastelujakso ulottuu ajalle 16.1.2004–18.10.2023 ja kattaa muun muassa finanssikriisin, Kreikan velkakriisin sekä koronaviruspandemian aiheuttaman pörssiromahduksen.

Tutkimuksessa käytetään Black-Scholes-optiohinnoittelumallia laskettaessa päivittäisiä optioarvoja VSTOXX-indeksin implisiittisen volatiliteetin avulla. CAPM-suorituskykymittauksia hyödynnetään arvioimaan suojattujen osto-optiostrategioiden vuosittaisia tuottoja ja riskiä suhteessa Euro STOXX 50 kokonaistuottoindeksiin. Empiiriset tulokset osoittavat hypoteesin vastaisesti, että Euro STOXX BuyWrite jää tuoton alapuolelle suhteessa Euro STOXX 50 -vertailuindeksiin riskikorjattuna. Kuitenkin teoreettisesti lasketut suojattu osto-optiostrategiat tarjoavat ylivoimaisia riskikorjattuja tuottoja vuosittaisen tuoton perusteella erityisesti laskusuhdanteisina tai matalan volatiliteetin kausina. Tutkimuksessa tarkastellaan myös covered call -strategioiden rahallisuusasteen (moneyness) säätämisen vaikutusta tuottojen parantamiseen. Tulokset viittaavat siihen, että vaikka teoreettiset suojatun osto-option mallit osoittavat ihanteellisissa olosuhteissa johdonmukaisesti ylivoimaista suorituskykyä, käytännön haasteet, kuten transaktiokustannukset ja likviditeettirajoitteet, heikentävät näitä voittoja todellisissa markkinatilanteissa.

KEYWORDS: covered call strategy, buy-write strategy, risk-adjusted performance, Stoxx50, VSTOXX, Black-Scholes model, theoretical option pricing limitations

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1 INTRODUCTION

Global stock markets have faced significant turbulence throughout the 21st century. Events like the market downturn in 2002, the 2008 global financial crisis, the Greek dept crisis in 2011, the COVID-19 pandemic, and the energy crisis, have led to substantial losses for both individual and institutional investors. These occurrences reveal a recurring theme: financial markets are in constant change, with growing signs that volatility will continue to rise in the future. Moreover, these crises emphasize the importance of finding more effective ways to diversify investment portfolios (Lodha, 2008)

Rational investors seek to maximize returns while minimizing risk, aiming for a well-balanced, risk-adjusted portfolio. Today, various financial instruments, such as futures, options, and short selling, are available to protect against downward market movements. However, each tool comes with its own limitations. Short selling, which involves selling shares borrowed from another investor, entails significant costs, interest charges, and the potential for a short squeeze. Futures contracts, which require buying or selling an underlying asset at a predetermined price on a specific date, offer a straightforward hedge against market declines. However, the mark-to-market requirements and uncertain cash flow obligations often make futures more suited for speculation rather than reliable hedging (Hull, 2012). Options, on the other hand, provide flexibility with a known cash outflow, making them a preferred choice for hedging (Fodor et al., 2010). Among the various option-based strategies designed for hedging, this study focuses specifically on the covered call strategy.

1.1 The construction of covered call

Figure 1 illustrates the payout diagram of a covered call strategy. In this strategy, an investor takes a long position in an underlying asset, such as the EURO STOXX 50 index. The initial investment is made when the underlying asset is valued at 100. If the value of the index increases, the investor gains a positive return, while a decrease in the value of the index results in a negative return.

To construct a covered call, the investor writes a call option against the underlying asset position, setting the strike price at 100, and receives a premium of 5. As outlined in Section 2, if the underlying asset price rises above the strike price of 100 at the option's maturity, the written call option is exercised, and the investor's maximum profit is capped at the sum of the premium plus the gain up to the strike price. On the other hand, if the price of the index is below 100 at maturity, the written call option is not exercised, and the investor retains the premium as compensation for the downside risk.

For instance, if the underlying asset value falls to 90 points at maturity, the investor's effective loss is reduced to -5, instead of the -10 they would have incurred without the premium from the covered call. As Figure 1 demonstrates, the potential gains are capped, but the premium earned helps to mitigate potential losses. This strategy allows the investor to generate additional income through the premium received while accepting a limit on the potential upside gains.

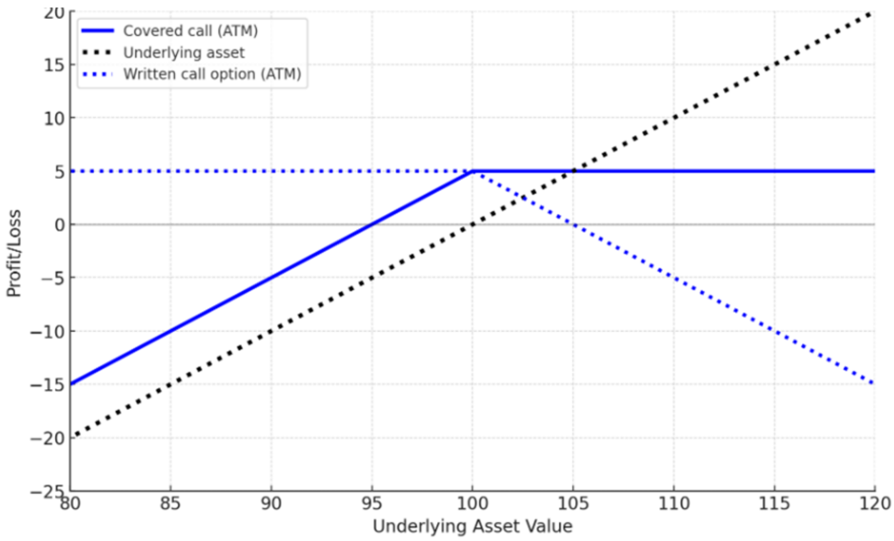

Figure 1: Covered call payout diagram. Data source: Whaley (2002) simulated by using python.

1.1.1 Covered call formula

This study uses the formula developed by Whaley (2002). The limitations of the formula, along with broader analysis and applications, are discussed in upcoming sections. However, the basic fundamentals are covered in this section.

The daily return of the S&P 500 index (Whaley, 2002) is calculated as follows:

$$R_{S,t} = \frac{S_t - S_{t-1} + D_t}{S_{t-1}}, \tag{1}$$

where St represents the closing level of the S&P 500 index on dayt and Dt denotes the cash dividend paid on that day. The formula's numerator captures the income generated over the day, which consists of both price appreciation (St - St-1), and dividend income Dt. The denominator represents the initial investment outlay, which is the index level from the previous day's close (St-1). (Whaley, 2002)

Covered call return (Whaley, 2002):

$$R_{covered\ call,t} = \frac{S_t + D_t - S_{t-1} - (C_t - C_{t-1})}{S_{t-1} - C_{t-1}} \tag{2}$$

The covered call return is computed similarly to the index return, with the addition of the call option's price dynamics. Here, Ct represents the closing price of the call option on day t. The numerator consists of the stock index price increase and dividend income Dt, subtracted by the change in the call option price (Ct - Ct-1). The key aspect of the covered call strategy is that the total income generated exceeds that of the S&P 500 index when the underlying asset's price remains flat or declines slightly, while underperforming when the underlying asset's price increases significantly. The denominator consists of the previous day's index level (St-1) minus the call option's price at the previous close (Ct-1). (Whaley, 2002).

The covered call strategy, therefore, allows investors to generate additional income through the premium received for writing the call, while potentially limiting upside gains. On days when the call option loses value, the overall return of the covered call position can exceed the return from simply holding the underlying index. On the contrary, when the call option gains value, it reduces the return from holding the underlying asset. This strategy aims to enhance returns during periods of relatively low market volatility, when the underlying asset's price does not significantly exceed the strike price.

1.2 Purpose of the study

Strategy indices have become a relatively recent focus in academic research, with Whaley (2002) being the first to publish findings on this topic. Since then, academic interest in strategy indices has grown significantly (see, e.g., (Feldman & Roy, 2005); (Hill et al., 2006); (Kapadia, 2007); (Kapadia N. a., 2011).

Initial studies have largely focused on the U.S. market, particularly examining the S&P 500 index and covered call strategies during times of higher risk-free rates. In addition, various stock exchanges have since developed their own covered call strategy indices for major markets, including STOXX, Deutsche Börse, Dow Jones, the Australian Stock Exchange and the FTE100. Since the launch of the BXM in 2002, the CBOE has introduced multiple additional strategy indices influenced by the findings from earlier research on covered call strategies.

Recent trends suggest that the growing popularity of covered call strategies may be partially attributed to the behavior of implied volatility. Hedge funds that invest in spot implied volatility indices can enhance their risk-adjusted returns, as implied volatility is negatively correlated with market returns (Dash, 2005). This negative correlation helps to provide a innate hedge, making covered call strategies more appealing, particularly during volatile market conditions.

Additionally, maintaining a long position in an implied volatility index can improve the risk-adjusted performance of a portfolio during bear markets. For instance, call options on the implied volatility index of the S&P 500 provide better protection in downturns compared to put options on the S&P 500 (Kapadia N. a., 2011). This protection during bear markets highlights the potential for implied volatility to serve as a crucial component in enhancing covered call strategies. As a result, integrating implied volatility into such strategies can offer investors a more effective way of managing risk.

Thus, the introduction of new covered call strategy indices by major exchanges could be a response to the growing need for innovative investment approaches that leverage implied volatility to achieve better risk-adjusted returns. Covered call strategies not only capitalize on higher option premiums available during periods of increased implied volatility but also help offset the declining effectiveness of traditional international diversification. By generating additional income and offering potential downside protection, they provide investors with better tools suited for today's global markets, where economies are more connected, and markets often move together. (Whaley, 2002) (Hill et al., 2006)

Inspired by prior research on the covered call strategy, as highlighted by works such as Whaley (2002), Feldman & Roy (2005), Hill et al. (2006) and Kapadia N. a (2011) this study builds upon the foundation set by these earlier works. Deviating from previous studies that concentrate on other markets, this research focuses on European markets, specifically during bullish phases characterized by low interest rates and disrupted by sharp volatility spikes, such as during the Greek debt crisis and the COVID-19 pandemic. To the best of the author's knowledge, there has not been a comprehensive study evaluating the risk-adjusted performance of the covered call strategy during low-interest-rate environments using the STOXX 50 index.

While prior studies have indicated superior risk-adjusted performance of the covered call strategy within individual countries, this study investigates whether these benefits hold true across multiple European countries.

Hill et al. (2006) concludes that utilizing a dynamic strike price strategy in covered call writing can yield greater returns with reduced volatility compared to the underlying S&P 500 index. This excess performance might be explained by the adaptive nature of the dynamic strategy, which recalibrates the strike price in response to volatility changes. Furthermore, their research indicates that covered calls with a one-month maturity tend to outperform those with longer maturities.

1.3 Research problems and hypotheses

This study aims to evaluate the risk-adjusted performance of the covered call strategy within the European stock market, focusing on the STOXX 50 index. The research question is: Does a covered call strategy applied to the STOXX 50 index deliver superior risk-adjusted returns compared to holding the index itself? The STOXX 50 index consists of 50 leading blue-chip companies from 19 European countries, reflecting a broad view of Europe's most prominent businesses.

The decision to assess the STOXX 50 index, instead of the more commonly researched S&P 500 index, is motivated by the need to understand the applicability of the covered call strategy within the European context. The European stock market exhibits distinctive characteristics compared to the U.S. market, including varying levels of volatility, market structure, and investor behavior. Additionally, the European market is influenced by a more diverse range of macroeconomic policies across its member countries, leading to potentially different risk-return dynamics for option strategies. As a result, it is crucial to assess whether findings from studies on the S&P 500, such as those by Whaley (2002) are applicable to European markets or if regional differences lead to varied performance outcomes for covered call strategies.

Feldman & Roy (2005) found that covered call strategies provided consistent income and mitigated downside risk, particularly in markets characterized by macroeconomic uncertainty, which is typical in Europe during the 21st century. Hill et al. (2006) further suggests that covered call strategies are well-suited for broad market indices, such as the STOXX 50, that represent blue-chip companies, as they offer liquidity and stability. These are important factors for implementing option-based strategies effectively. The first hypothesis is:

> H1: The benchmark STOXX 50 BuyWrite outperforms the underlying STOXX 50 index in risk-adjusted basis.

Theoretical covered call strategies often yield higher returns compared to actual market performance due to assumptions of idealized conditions. Theoretical models assume perfect liquidity, no transaction costs, and constant volatility, conditions that rarely hold true in real financial markets (Black & Scholes, 1973). In practice, real-world frictions like bid-ask spreads, transaction costs, and taxes all diminish potential returns. Furthermore, implied volatility used in theoretical pricing often overestimates the premium income generated, and unexpected volatility spikes can negatively impact returns (Bollen & Whaley, 2004). Additionally, real-world investors face behavioral biases such as hesitation or overreaction, which lead to suboptimal decision-making, creating a gap between theoretical and realized returns (Barberis & Thaler, 2003).

Moreover, real markets are subject to liquidity constraints and potential market impact from large trades, which are not accounted for in theoretical models. Execution delays and difficulty finding favorable strike prices can lead to not optimal, further widening the performance gap (Stoll, 1978). The combined effect of these real-world factors, including transaction costs and behavioral influences, contributes to lower realized returns in actual financial markets compared to the hypothetical returns suggested by theoretical covered call models (Whaley, 2002). The second hypothesis is:

> H2: Theoretical ATM covered call strategy yields higher excess returns and yields superior risk-adjusted results compared to benchmark STOXX 50 BuyWrite (ATM).

Altering the moneyness levels of a covered call strategy can lead to greater risk-adjusted returns by optimizing the balance between premium income and downside risk. Writing slightly out-of-the-money (OTM) calls allows investors to capture both premium income and potential capital gains up to the strike price, which can enhance the Sharpe ratio compared to at-the-money (ATM) calls that entirely cap the upside (Hill et al., 2006). Additionally, altering moneyness can take advantage of volatility skew. Options with different moneyness levels often have different implied volatilities, making premiums more attractive relative to risk (Bollen & Whaley, 2004).

Furthermore, OTM covered calls result in lower delta exposure, reducing risk during adverse market conditions and decreasing potential drawdowns, thereby improving overall portfolio stability (Black & Scholes, 1973). By dynamically adjusting the moneyness level based on market trends, investors retain greater flexibility and can balance income generation with the opportunity for asset appreciation. This flexibility not only improves return stability but also enhances risk management, making altered moneyness covered calls a effective strategy for achieving higher risk-adjusted returns (Whaley, 2002), (Barberis & Thaler, 2003). Thus, the third hypothesis is:

> H3: Adjusting the moneyness levels of covered call strategies results in higher risk-adjusted returns compared to traditional ATM covered call strategies.

1.4 Structure of the thesis

The structure of this thesis is as follows. The second chapter reviews previous literature on the subject, including several studies on covered calls as an investment strategy across different indexes worldwide. Additionally, the psychology behind the popularity of covered calls is discussed. The third chapter focuses on option pricing theory, with a detailed examination of the Black-Scholes option model and an extensive discussion on the limitations of theoretical option pricing. The fourth chapter presents the performance measures used to capture excess risk-adjusted returns. The fifth chapter introduces the data used in this thesis. The sixth chapter outlines the methodology and assesses the empirical results. Finally, the seventh chapter provides the concluding remarks.

2 LITERATURE REVIEW

This section examines prior research on the benefits of incorporating the covered call strategy within a portfolio, considering its application across different markets and indexes. Firstly, the factors contributing to the effectiveness and overall performance of this strategy are presented. Additionally, it is important to assess whether the success of covered calls extends consistently to other indexes as well.

2.1 Performance of covered call against the S&P 500

Whaley (2002) was the first to empirically analyze the performance of the BXM index in comparison to the S&P 500 index. Using data from June 1988 to December 2001, the study finds that the BXM delivers returns comparable to those of the S&P 500 but with lower standard deviation. Additionally, the BXM outperforms the S&P 500 when evaluating with various portfolio performance metrics. Notably, Whaley (2002) utilized semi-standard deviation rather than standard deviation to better assess risk, due to the limitations of standard deviation in accounting for both positive and negative returns unwanted. (Whaley, 2002)

Supporting Whaley's (2002) findings, Feldman and Roy (2005) also conclude that the BXM provides superior risk-adjusted performance relative to the S&P 500, even when extending the analysis period to March 31, 2004. In addition to Whaley (2002), Feldman and Roy (2005) employ additional performance measures, such as the Stutzer index, Leland's alpha, and the Sortino ratio. These measures consider non-normal return distributions, which is particularly relevant when assessing portfolios that include option securities, as discussed in Section 4.

Similarly, Hill, Balasubramanian, Gregory, and Tierens (2006) report consistent results, highlighting even better performance of the BXM from January 1, 1990, to October 25, 2005. During this period, the BXM achieves an annualized return of 11%, compared to the S&P 500's 10.4%. Moreover, the BXM exhibits lower standard deviation than the S&P

500, at 9.1% versus 14.5%, respectively. Hill et al. (2006) also note that the BXM performed particularly well during stable or bearish market conditions (Hill et al., 2006).

All three studies, Whaley (2002), Feldman and Roy (2005), and Hill et al. (2006), observe excess kurtosis and negative skewness in the return distribution of the BXM. Kurtosis indicates the weight of the tails of a distribution; in this case, the presence of excess kurtosis implies a pronounced peak around the mean compared to a normal distribution (Hull, 2012). Skewness, meanwhile, measures the asymmetry of the distribution: negative skewness implies that the distribution skews to the left, while positive skewness indicates a skew to the right (Bodie et al, 2013). Whaley (2002) emphasize that negative skewness is expected for a covered call strategy, as it caps potential upside gains, thereby limiting the right tail of the distribution. Since neither the BXM nor the S&P 500 follows a normal distribution, Whaley (2002), Feldman and Roy (2005), and Hill et al. (2006) argue for the importance of using performance metrics that account for non-normal return distributions.

Furthermore, Whaley (2002) note that investors tend to pay a premium for portfolios with positive skewness, anticipating larger gains, while requiring compensation to accept negative skewness. Consequently, portfolios with negative skewness tend to outperform on a risk-adjusted basis, whereas those with positive skewness tend to underperform.

Table 1 presents a summary of the findings from Whaley (2002) and Feldman and Roy (2005), comparing the performance of the BXM and the S&P 500. The results consistently demonstrate that the BXM outperforms the S&P 500 on a risk-adjusted basis. However, it is worth noting that when using performance metrics that consider non-normal distributions, the BXM's risk-adjusted performance appears relatively weaker, yet it still outperforms the S&P 500. This is evident when comparing Whaley's (2002) semi-standard deviation results to those using standard deviation, as standard deviation yields relatively more favorable outcomes for the BXM. A similar pattern is observed in Feldman and Roy's (2005) findings, with the Sharpe ratio showing better results for the BXM compared to the Stutzer index.

Table 1. Performance statistics of covered call strategy on S&P 500 index (Whaley, 2002); (Feldman & Roy, 2005)

Panel A: Monthly data	June 1988 to December 2001		June 1988 to March 2004	
	BXM	S&P 500	BXM	S&P 500
Arithmetic Mean %	1.11	1.19	1.02	1.05
Median Return %	1.42	1.48		
Compound Rate of Return %			0.98	0.96
Standard Deviation %	2.66	4.1	2.83	4.22
Semistandard Deviation %	1.89	2.7		
Skewness	-1.437	-0.445	-1.249	-0.456
Excess Kurtosis	4.984	0.718	3.963	0.609
Beta (with standard deviation)	0.558	1.00		
Beta (with semistandard deviation)	0.622	1.00		
Sharpe Ratio (with standard deviation)	0.234	0.172	0.225	0.159
Sharpe Ratio (with semistandard deviation)	0.331	0.261		
Stutzer Index			0.216	0.158
M-squared (with standard deviation) %	1.36	1.19		
M-squared (with semistandard deviation) %	1.29	1.19		
Treynor Ratio (with standard deviation)	0.011	0.007		
Treynor Ratio (with semistandard deviation)	0.01	0.007		
Jensen Alpha (with standard deviation) %	0.23	0.00		
Jensen Alpha (with semistandard deviation) %	0.19	0.00		

Panel B: Annualized data	June 1988 to December 2001		June 1988 to March 2004	
	BXM	S&P 500	BXM	S&P 500
Arithmetic Mean %	13.63	14.07	12.93	13.40
Compound Rate of Return %			12.39	12.20
Standard Deviation %			10.99	16.50
Treynor Ratio %			14.10	8.72
Jensen Alpha %			2.93	0.00
Leland's Alpha %			2.81	0.00
M-squared %			17.20	13.40
Semistandard Deviation %			7.79	10.90
Sortino Ratio			1.56	1.15

Analyzing the performance of a covered call strategy across different market environments is crucial. Table 2 summarizes the findings by Feldman and Roy (2005), focusing on two distinct market phases: bull and bear markets. Panels A and B illustrate two different definitions of market upturns and downturns. Panel A provides an estimation period from June 1988 to March 2004, containing 41 bearish months and 81 bullish months. Here, a bearish month is defined by an S&P 500 return of -2% or lower, whereas a bullish month is defined by an S&P 500 return of 2% or higher. Panel B, on the other hand, highlights the single largest market upswing and downturn, with the largest draw-down occurring from September 2000 to September 2002, and the largest run-up from September 1998 to March 2000.

The results presented in Table 2 align with those reported by Hill et al. (2006). During bearish market conditions, the BXM outperforms the S&P 500 in terms of monthly returns. However, during bullish conditions, the BXM fails to match the S&P 500's monthly returns. Feldman and Roy's (2005) results support these findings: in bullish markets, the BXM losses upside potential above the strike price of the call option it has written. Conversely, during bearish periods, the BXM mitigates potential losses by collecting a premium from writing the call option. These results demonstrate the typical features of the covered call strategy. (Feldman & Roy, 2005).

Table 2. Performance statistics of covered call strategy during bull and bear markets (Feldman & Roy, 2005)

Panel A: Bull and Bear Markets	Bull Market		Bear Market	
	BXM	S&P 500	BXM	S&P 500
Monthly Arithmetic Mean %	2.95	4.77	-2.54	-4.86
Monthly Arithmetic Deviation %	1.69	2.14	3.09	2.75

Panel B: The Largest Bull and Bear Market	Bull Market		Bear Market	
	BXM	S&P 500	BXM	S&P 500
Monthly Compound Rate of Return %	2.25	2.50	-1.40	-2.30

2.2 Performance compared to other indexes and markets

Previous studies consistently indicate that the covered call strategy outperforms the S&P 500 on a risk-adjusted basis. However, it is also important to evaluate the performance of the covered call strategy across different markets to determine whether its superior risk-adjusted returns are consistent. Therefore, the performance of covered calls is compared with that of the Russell 2000, the Australian Stock Exchange, and the Indian market indexes to name few.

2.2.1 Russell 2000

Kapadian and Szado (2011) provide evidence that the covered call strategy has consistently outperformed the Russell 2000 index on a risk-adjusted basis, particularly when employing one-month call options. However, Hill et al. (2006) found that this consistent outperformance did not hold when using options with two-month expirations. The period analyzed by Kapadian and Szado (2011) spans from January 19, 1996, to March 31, 2011, allowing for an assessment under various market conditions and different moneyness levels of the covered call strategy. This study extends their earlier work (Kapadian & Szado, 2006), focusing on a longer period, but the results remain consistent: the covered call strategy continues to outperform the Russell 2000 index even when extending the analysis to the period from November 17, 2006, to March 31, 2011. (Kapadian & Szado, 2011).

The findings of Kapadian and Szado (2011), as reflected in Table 3, align with previous research, showing that covered calls outperform the Russell 2000 in every risk-adjusted measure. Notably, the covered call strategy demonstrates superior performance even under unfavorable market conditions for an options-based strategy, such as when the index experiences prolonged positive returns combined with low volatility. During this challenging period, from February 20, 2003, to November 16, 2006, the covered call strategy generated three-quarters of the market return with only half the volatility, thereby outperforming the Russell 2000 on a risk-adjusted basis.

Table 3. Performance statistics of covered call strategy on Russell 2000 index (Kapadia & Szado, 2011).

	Russell 2000	5 % OTM	2 % OTM	ATM	2 % ITM	5 % ITM
Annualized Return %	8.11	10.21	8.87	7.30	6.94	5.54
Annualized Standard Deviation %	21.06	18.63	16.57	14.66	13.24	10.99
Mean Monthly Return %	0.84	0.94	0.83	0.68	0.64	0.50
Median Monthly Return %	1.68	1.74	1.77	1.62	1.33	0.91
Skewness	-0.56	-1.04	-1.40	-1.76	-2.16	-2.72
Excess Kurtosis	0.81	1.85	3.49	5.45	8.15	12.37
Maximum Monthly Return %	16.51	10.57	9.68	10.16	10.01	8.26
Minimum Monthly Return %	-20.80	-18.86	-18.69	-17.84	-17.69	-16.43
Maximum Drawdown %	-52.90	-46.00	-42.90	-37.70	-34.80	-31.30
Maximum Run Up %	226.2	337.10	264.70	193.00	178.00	130.70
Sharpe Ratio	0.23	0.37	0.33	0.27	0.27	0.20
Jensen's Monthly Alpha %	0.00	0.21	0.15	0.06	0.07	0.06
CAPM Beta	1.00	0.84	0.72	0.60	0.51	0.38
M^2 %	1.03	1.26	1.19	1.09	1.21	1.03
Treynor Ratio	0.05	0.08	0.08	0.07	0.07	0.06
Leland's Monthly Alpha %	0.00	0.20	0.14	0.05	0.06	0.00
Leland's Beta	1.00	0.86	0.74	0.63	0.53	0.40
Stutzer Index	0.21	0.33	0.30	0.24	0.24	0.18

2.2.2 Australian market

It is also essential to analyze the performance of the covered call strategy in smaller or less liquid markets. Mugwagwa, Ramiah, Noughton, and Moosa (2012) investigate the buy-write (covered call) strategy in the Australian Stock Exchange. Their findings were partially in line with previous studies, demonstrating superior risk-adjusted returns for low moneyness levels of out-of-the-money (OTM) options. However, unlike previous research Mugwagwa et al. (2012) found that the covered call strategy did not consistently yield excess returns. The study emphasizes the significance of selecting the appropriate moneyness level. Moreover, their results indicate that monthly options produced lower returns compared to quarterly and yearly intervals. These results differ with Hill et al. (2006), who found that monthly options consistently produced the lowest volatility in the U.S. market, whereas the yearly options portfolios were the least volatile in Australia. A potential explanation for these differing outcomes is that Australian traders primarily utilize quarterly options, while their U.S. counterparts tend to trade monthly options.

(Mugwagwa et al., 2012). These findings highlight the fact that while covered calls can generate excess returns, careful consideration must be given to both the moneyness level and option intervals, depending on the specific market in which the strategy is employed.

2.2.3 Indian market

Aggarwal and Gupta (2013) explored the performance of covered calls in developing markets, specifically on the Indian S&P CNX Nifty index. Their findings are consistent with previous research in that the return distributions from the covered call portfolio were non-normal. Additionally, the covered call strategy outperforms a simple buy-and-hold portfolio on a risk-adjusted basis. Consequently, Aggarwal and Gupta (2013) conclude that incorporating options could enhance portfolio performance. However, they note that the optimal moneyness levels differ from those observed in the S&P 500 market; a 5% in-the-money (ITM) short call exhibits superior performance, whereas a 2% OTM call was optimal for the S&P 500. (Aggarwal & Gupta, 2013)

2.2.4 Reevaluating the performance on the S&P 500 and other markets

More recent and additional studies are discussed below. Highlighting the fact that covered call strategies can provide excess risk-adjusted returns under certain conditions, particularly for risk adverse investors. However, the findings discuss also that the success depends on market conditions, appropriate moneyness levels and how skewness is considered.

Brooks, Chance, and Hemler (2019) examine the alleged superior performance of covered call strategies on the S&P 500 index. Their findings challenge the previously documented excess returns by focusing on the role of skewness, which they argue has been largely overlooked by both researchers and practitioners. The study presents two adjusted estimates of the alpha of covered call strategies that take skewness into account. These adjustments reveal that prior claims of superior performance might have been wrong. The authors also highlight that the timing of the holding period within the expiration cycle could mask the effects of skewness, leading to inaccurate performance conclusions. The results suggest that traditional metrics may overestimate the benefits of covered calls, and properly adjusted alphas show little evidence of excess returns, indicating that selling widely traded options in this manner does not consistently generate alpha. (Brooks et al, 2019)

Stotz (2011) explore the concept of stochastic dominance in the context of covered call and uncovered put strategies. The research focuses on evaluating strike prices conditioned on proxies for expected returns, using unconditional strike prices. In an empirical examination of the Dow Jones EURO STOXX 50 index, it is found that covered call strategies demonstrate second and third-degree stochastic dominance over simple index investments, whereas uncovered put strategies fail to achieve similar results. The findings indicate that conditioning strike prices on expected returns can provide an advantage over unconditional strike prices, thus enhancing the performance of covered call strategies compared to a basic index strategy. (Stotz, 2011).

Foltice (2022) revisits both covered call and protective put strategies, comparing them to a simple buy-and-hold approach. The analysis confirmed that covered call strategies outperform the buy-and-hold strategy in terms of both total and risk-adjusted returns, with consistent excess returns over time, even after factoring in trading costs and tax implications. On the other hand, the protective put strategy significantly underperformed both in terms of return and risk-adjusted measures, increasing the probability of losses in most months. Furthermore, an analysis of investor preferences using the prospect theory utility function indicates that out-of-the-money covered calls provide the highest use for investors with moderate risk aversion, while in-the-money covered calls are preferred by those with greater risk aversion. (Foltice, 2022)

Allen (2015) investigated whether covered call writing was suitable for risk-averse investors, such as retirees seeking stable income with limited risk. The findings support the use of covered call strategies as a method of generating regular income while reducing portfolio volatility. However, the strategy also caps potential gains, making it most appropriate for risk-averse investors willing to sacrifice upside for the benefit of constant income. Allen highlights potential drawbacks, such as fees, expenses, and the volatility risk premium, which could negatively impact returns. The study concludes that the strategy is most suitable for conservative investors in tax-protected accounts with low fees. (Allen, 2015)

Leggio and Lien (2005) address the limitations of traditional performance metrics, such as the Sharpe ratio, when evaluating portfolios that include derivatives. The covered call strategy, while commonly recommended to investors, may not be ideal, as traditional risk measures like the Sharpe ratio fail to account for the non-normal return distributions inherent in derivative-based strategies. The authors use alternative risk-adjusted metrics, including the Sortino ratio and the upside potential ratio, which consider only downside risk. Their findings indicate that a market index portfolio often outperforms a covered call strategy when evaluated with these improved metrics, suggesting that covered call strategies might not be as advantageous as once thought. (Leggio & Lien, 2005)

Israelov and Nielsen (2015) presented a new methodology for assessing the risk and performance attribution of covered call strategies. Their analysis separates covered call strategies into three main components: equity risk, volatility risk, and exposure to an equity reversal strategy. The authors show that equity exposure provides most of the return and risk, while the short volatility exposure, despite achieving a near unit Sharpe ratio, contributes only marginally to overall risk. The equity reversal exposure, on the other hand, accounts for a significant percentage of risk but did not deliver applicable returns. By eliminating the uncompensated equity reversal exposure, they propose a modified covered call strategy that offers a higher Sharpe ratio, lower volatility, and reduced downside beta. (Israelov, 2015)

Figelman (2008) introduce a theoretical framework for understanding the performance of covered call strategies relative to the underlying stock index. The framework allows for a breakdown of the expected return and risk, using semi-standard deviation, of covered call strategies, with an empirical comparison to the underlying index. The author proposes the concept of a call risk premium, representing the difference between the real-world expected value of a call option and its market price. Figelman (2008) found that the implied-realized volatility spread, and the equity risk premium had opposing effects on the performance of covered call strategies, with the spread effect strengthening as the time to expiration decreases. Consequently, the study suggests that short-dated call options provided better outcomes for covered call strategies.

Choi, Jeong, and Park (2018) analyze covered call strategies in conjunction with time series momentum across ten asset classes. The study found that incorporating covered call and momentum strategies as tactical overlays provide enhanced risk-adjusted performance compared to a buy-and-hold investments. These strategies are integrated into established risk-based allocation methods such as maximum diversification and equal risk contribution. The authors propose a framework called Autocorrelation Factor Allocation (ACFA), which used the positive and negative autocorrelation properties of covered calls and momentum to create portfolios that demonstrate superior risk-adjusted returns relative to traditional buy-and-hold approaches. (Choi et al, 2018)

Board, Sutcliffe, and Patrinos (2000) assess the performance of partially and fully covered call strategies compared to a standard equity portfolio. The study uses a variety of criteria and four different utility functions to analyze the risk-return profile of covered call strategies. Although the criteria did not provide definitive evidence favoring one strategy over another, all four utility functions suggest that covered call strategies are preferable during the study period, thereby supporting the use of covered calls as a viable investment approach. (Board et al, 2000)

2.3 Performance with different moneyness levels

Hill et al. (2006) conduct a comparison of multiple covered call strategies, each with different levels of moneyness. The analysis spans the period from January 18, 1990, to November 17, 2005, and include strategies such as at-the-money (ATM), 2% out-of-the-money (OTM), and 5% OTM, as well as the S&P 500 and the BXM. Table 4 presents the findings from Hill et al. (2006), demonstrating that all of the covered call strategies outperformed the S&P 500 in terms of both annualized returns and risk-adjusted performance. Among these, the 2% OTM and ATM strategies provided the highest returns, with the ATM strategy achieving the excess return with the lowest standard deviation. (Hill et al., 2006)

Table 4. S&P500´s annualized performance against different covered call strategies. (Hill et al, 2006)

Strategy	Return %	Return % vs. S&P 500	Standard Deviation %
S&P500	10.92	-	14.15
BXM	11.27	0.35	9.10
ATM	13.25	2.33	8.50
2% OTM	13.42	2.5	10.43
5% OTM	12.22	1.3	12.63

From an investor's perspective, different moneyness levels provide a range of alternatives, each suited to specific market conditions. For instance, at-the-money (ATM) options may offer better protection during market downturns, whereas 2% out-of-the-money (OTM) options can yield better returns during bullish phases. However, Hill et al. (2006) emphasize that as the moneyness level increases, the return distribution starts to resemble that of the S&P 500. Striking the right balance between these moneyness levels is key to optimizing performance. Additionally, Kapadia and Szado (2007) suggest that by actively determining the appropriate moneyness for writing call options, the risk-adjusted performance of a covered call strategy could be further enhanced.

Hill et al. (2006) also investigate whether shorter-term one-month call options are inferior compared to longer-term options. They examine the performance of three-month call options to assess their effect on the risk-adjusted performance of covered call strategies. Their findings reveal that one-month call options outperform three-month options. The only situation in which an investor might prefer a longer-term option is when implied volatility is unusually high and expected returns on the S&P 500 index are negative or moderate. The superior performance of one-month call options can be attributed to three main factors: the frequent resetting of strike prices in rising markets, greater participation in time decay during highly volatile bear markets, and a more favorable spread between implied and realized volatility.

2.4 Reasons behind the popularity of covered call

According to basic finance theory, an optioned portfolio should not outperform in a mean-variance framework under conditions of market efficiency (Fama, 1970). However, options remain highly popular among traders, investors, and speculators.

Early research indicates that behavioral finance may help explain the apparent conflict between the popularity of covered calls and their relative performance (Aggarwal & Gupta, 2013). Notably, most investors are influenced by heuristics and framing effects beyond pure risk-return considerations (Shefrin, 2002). Shefrin & Statman (1993) apply prospect theory (Kahneman & Tversky, 1979) and hedonic framing (Thaler, 1985) to conclude that a prospect theory investor would prefer the relative safety of a covered call strategy. Moreover, investors guided by prospect theory are more likely to favor fully covered calls over partially covered ones and prefer OTM covered calls to in-the-money (ITM) covered calls.

Feldman and Roy (2005) identify a behavioral factor that may contribute to the performance of covered call strategies. Specifically, the relative performance could be partially explained by the tendency of call buyers to systematically overestimate the value of calls. Additionally, Rabin (1998) argue that call option buyers are often overconfident, leading to sustained upward pricing pressure and higher implied volatility. If these assumptions hold, part of the relative performance of the BXM index can be attributed to the overconfidence bias (Rabin, 1998).

3 Option pricing

An option is a financial instrument that provides the holder with the right, but not the obligation, to buy or sell an underlying asset at a predetermined price within a specified period. The price agreed upon for the underlying asset, which the holder must pay if the option is exercised, is known as the exercise price or strike price. The final date by which the option must be exercised is called the expiration date or maturity date. Options come in two forms: American and European. An American option can be exercised at any point up until its expiration, whereas a European option can only be exercised on the expiration date (Black & Scholes, 1973). Given that European options are more straightforward to analyze, this study will focus on European options. (Hull, 2012).

Options are further categorized into two main types: call options and put options. A call option provides the holder with the right to purchase the underlying asset at a predetermined price and date, whereas a put option grants the right to sell the underlying asset. Importantly, an option gives the holder the right but not the obligation to execute the transaction, which distinguishes options from futures and forwards, where the holder is required to fulfill the contract. Conversely, the writer, or seller, of an option has an obligation but no rights; in return for granting these rights, the writer receives a premium paid by the option holder (Hull, 2012)

The following is a simplified example of a call option: An investor purchases a European call option with an exercise price of 100€ to buy 100 shares of a particular stock. The current stock price is 96€, the option expires in one month, and the option premium is 1€, resulting in an initial investment of 100€. Two potential scenarios are considered (1 and 2):

1: At the expiration date, the stock price is 98€. In this scenario, the investor would not exercise the option, as the market price is below the strike price of 100€. Consequently, the investor incurs a loss of the initial investment of 100€.

2: At the expiration date, the stock price is 120€. In this scenario, the investor exercises the option, acquiring 100 shares at 100€ each. If sold immediately at the market price, the investor gains 20€ per share, resulting in a total gain of 200€, excluding transaction costs. After accounting for the initial cost of the option, the net profit is 100€.

From the writer's perspective, the profit outcome is the opposite. In S1, the writer retains the premium, resulting in a profit of 100€. In S2, the writer faces a net loss of 100€.

3.1 The Black-Scholes option pricing model

As discussed in the previous chapter, European options are simpler to analyze compared to American options. Consequently, a vast number of studies utilize European options in their option pricing models. One of the most well-known models for pricing European options on non-dividend-paying stocks was introduced in 1973 by Robert C. Merton, Myron S. Scholes, and Fischer Black. This model, which earned a Nobel Prize in 1997, is now widely known as the Black-Scholes (BSM) model (Jarrow, 1999).

While earlier researchers had made similar assumptions and accurately calculated the expected payoff of European options, the Black-Scholes model introduces a key innovation: its independence from the expected return and risk premium of the underlying stock. Additionally, the model showed that a portfolio could be modified risk-free for short periods by buying and shorting options and the underlying stock. Another important aspect of the Black-Scholes model is its statement that if options are correctly priced, arbitrage opportunities cannot be created by combining long and short positions in options and their underlying stocks (Hull, 2012).

To determine the value of a stock option, six key factors need to be considered: the current stock price, the strike price, time to maturity, volatility, the risk-free interest rate, and any expected dividends during the option's lifetime (Hull, 2012). Black and Scholes (1973) made assumptions regarding these factors to derive their model. Two fundamental assumptions in the Black-Scholes model are that risk-free interest rate and volatility are constant (Jarrow, 1999).

However, these assumptions are simplifications and only hold for short-term options on equities or equity indices (Jarrow, 1999). The Black-Scholes formula is provided below:

$$c = S_0 N(d_1) - K e^{-rT} N(d_2) \tag{3}$$

$$p = K e^{-rT} N(-d_2) - S_0 N(-d_1) \tag{4}$$

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \tag{5}$$

$$d_2 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} \tag{6}$$

where, the variables c and p represent the prices of European call and put options. The symbol S0 represents the share price at time zero, while K stands for the exercise price. The continuously compounded risk-free rate is represented by r, σ represents the volatility of the share price, and T is the time to expiration. Additionally, N(x) is the cumulative distribution function for a standard normal distribution, which indicates the probability that a normally distributed random variable will be less than x. Importantly, the value of the option is independent of the expected return on the underlying share. This is because the expected return reflects the share price itself, which already incorporates the risk and return characteristics of the asset (Hull, 2012, pp. 313-314).

If the assumptions are accurate, understanding the returns of a covered call would be straightforward. However, in practice, returns are affected by transaction costs and the actual value of the options, which tends to be higher than the theoretical value provided by the Black-Scholes model. As a result, implied volatilities are higher than realized volatilities, creating the possibility for covered calls to outperform (Kapadia N. a., 2011).

3.2 Heston option model

The Heston model, introduced by Heston (1993), is a popular alternative to the Black-Scholes model for pricing options. Unlike the Black-Scholes model, which assumes constant volatility, the Heston model allows for stochastic volatility, meaning that the volatility itself is modeled as a random process. This flexibility makes the Heston model particularly useful for capturing real-world features such as volatility clustering and the volatility smile. Moreover, the Heston model is capable of fitting observed market prices more accurately in environments with dynamic volatility patterns (Heston, 1993). Despite these advantages, the Heston model is more complex and requires more inputs compared to the Black-Scholes model. Due to its simplicity, the Black-Scholes model (BSM) remains widely used in practice and will be utilized for this study also (Black & Scholes, 1973; Hull, 2012).

3.3 Theoretical option pricing limitations

This section discusses the limitations of theoretical option pricing in more depth. Theoretical models of option pricing often assume ideal market conditions, such as accurate pricing, constant volatility, and perfect liquidity, all of which rarely exist in actual financial markets (Black & Scholes, 1973; Hull, 2012). These assumptions can result in distorted results compared to practical implementation, where actual financial markets factors, such as market frictions and changing volatility, influence performance and outcomes.

3.3.1 Volatility assumptions

The Black-Scholes model, often used to determine the theoretical value of options, assumes constant volatility over time. Implied volatility represents the market's expectation of future fluctuations, while realized volatility reflects the historical movement of the asset. However, in practice, volatility is stochastic and changes due to different market conditions, which affects the effectiveness of implementing covered call strategies in practice. When implied volatility exceeds realized volatility, as is often observed in actual financial markets, the premiums received from selling call options are inflated. This leads to excess returns in theoretical models, since the volatility risk premium creates higher option prices compared to what actual realized outcomes suggest (Bates, 2008). Actual financial data, show that volatility is neither constant nor symmetrical across strikes or time horizons. This discrepancy led to the development of models incorporating volatility surfaces, allowing for more accurate modeling of implied volatilities in various market scenarios, particularly under skewness and kurtosis (Feunou et al., 2017).

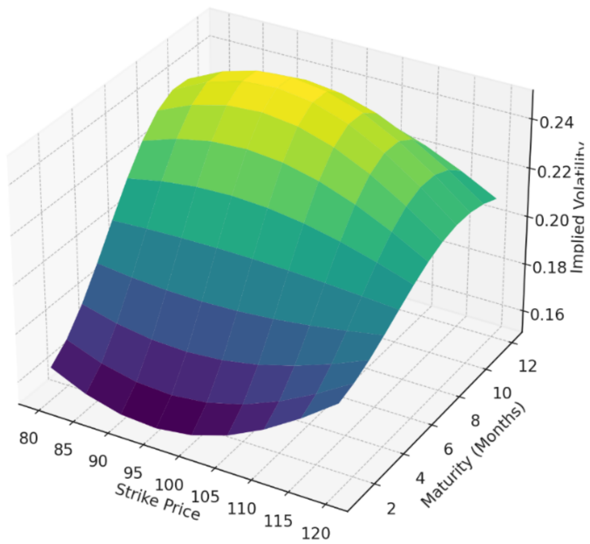

Figure 2: Volatility surface. Source: (Feunou et al., 2017) simulated artificially with pyhton

3.3.2 Volatility smiles and volatility types

In actual financial markets, the implied volatility of options is not constant across different strikes and expirations- The volatility smile is a pattern in which implied volatility is higher for deep in-the-money (ITM) and out-of-the-money (OTM) options compared to at-the-money (ATM) options. This phenomenon highlights the limitations of the Black-Scholes model, which assumes constant volatility. The volatility smile reflects market expectations of extreme price movements, with traders demanding higher premiums for options that offer protection against such risks (Rubinstein, 1994).

To illustrate this concept, the figure 3 below demonstrates the volatility smile pattern, where implied volatility is higher at the extremes of the strike price range compared to at-the-money options. This smile-like curve underscores the market's perception of higher risks associated with significant price moves, influencing option pricing accordingly (Rebonato, 2005). Distinct types of volatility is used in option pricing, each impacting the model differently.

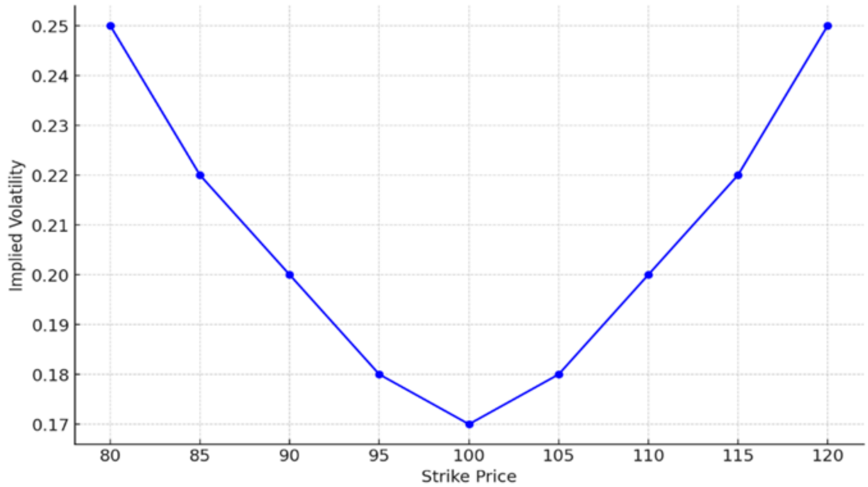

Figure 3: Volatility smile. Source: Rebonato (2005) simulated artificially with pyhton

Local volatility assumes that volatility is a function of both the asset price and time, meaning it can vary along different paths the underlying asset might take. Local volatility models, such as the one developed by Derman and Kani (1996), can better capture the variations in implied volatilities across strike prices, thereby providing more accurate pricing in the presence of a volatility smile (Derman & Kani, 1996).

Stochastic volatility models, like the Heston model, account for volatility that itself evolves over time according to a random process. This type of model is particularly useful in reflecting the dynamic nature of market volatility, capturing volatility clustering, and the changes observed in response to economic events (Heston, 1993).

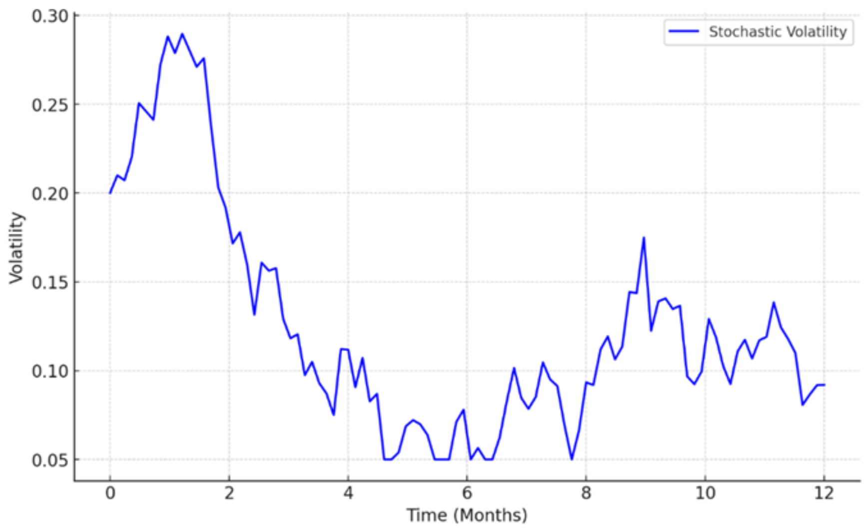

Figure 4: Stochastic volatility Heston model. Source: Heston (1993) simulated artificially with pyhton

Implied volatility is derived from the market prices of options and represents the market's expectations of future volatility. Unlike historical or realized volatility, which measures past price fluctuations, implied volatility is forward-looking and indicates how much the market expects the underlying asset to move during the life of the option. It is a critical component in option pricing models like Black-Scholes, where it plays a key role in determining the option premium.

Implied volatility is influenced by several factors, including market sentiment, the demand for options, and overall uncertainty about future market conditions. For example, during the 2008 financial crisis, implied volatility spiked significantly as investors sought options for protection, reflecting heightened uncertainty and increased demand for hedging instruments (Bollerslev et al, 2009). During periods of increased uncertainty or market stress, investors may seek greater protection, leading to higher demand for options. This increased demand, especially for out-of-the-money options, can drive implied volatility higher. During periods of increased uncertainty or market stress, investors may seek greater protection, leading to higher demand for options. This increased demand, especially for out-of-the-money options, can drive implied volatility higher.

The VSTOXX index is a commonly used measure of implied volatility for the EURO STOXX 50 index, providing a instrument of market expectations regarding future volatility in the Eurozone (Seegopaul & Shuttlewood, 2024). High implied volatility generally indicates greater risk and uncertainty, leading to more expensive options, while low implied volatility suggests a stable market environment with cheaper options.

It is important to note that implied volatility does not indicate the direction of the expected movement, only the magnitude. Traders use it to assess the relative prices of options. Higher implied volatility translates to higher option premiums, which can benefit option sellers but may also indicate heightened market risk (Hull, 2012; Bollen & Whaley, 2004).

The differences between these types of volatility can significantly impact option pricing. Local volatility can produce more realistic prices for specific scenarios, while stochastic volatility better reflects the randomness in volatility movements over time. Implied volatility is often higher due to the market's inherent risk aversion, which tends to lead to overpricing of options, especially in times of uncertainty.

3.3.3 Jump risk and market shocks

In financial markets, the price of the underlying asset is incline to sudden jumps caused by unexpected news or events. These sudden movements, which are commonly referred to as jump risk, can have significant effects on both the value of the asset and the call options written on it. In contrast, theoretical models such as Black-Scholes assume smooth asset price changes and do not account for these sudden jumps. The jump-diffusion model introduced by Kou (2002) highlights that ignoring jump risk can lead to underestimating potential losses from these sudden movements, thereby exaggerating the returns from covered call strategies in theoretical settings (Merton, 1973); (Kou, 2002).

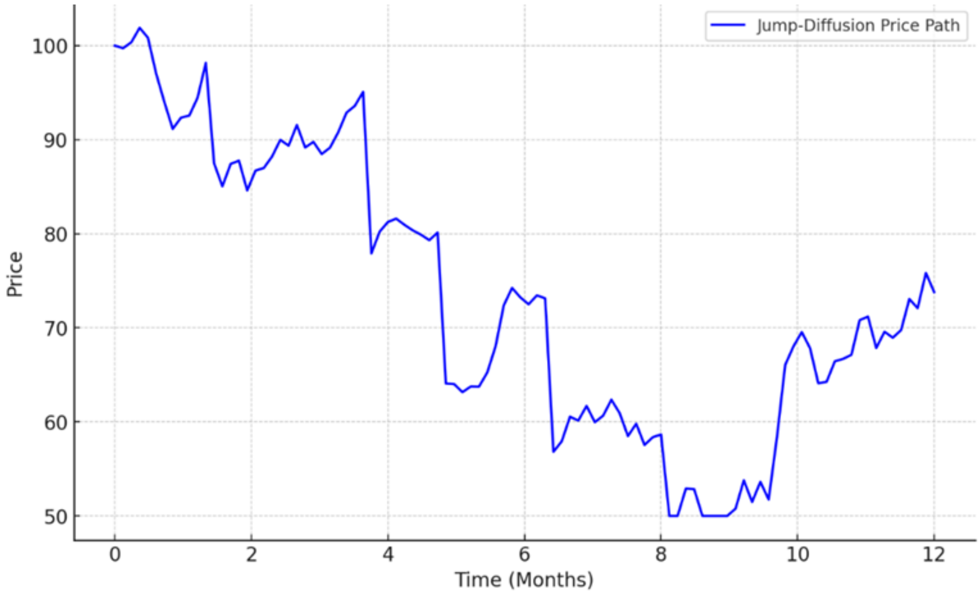

Figure 5: Jump risk. Source: Kou (2002) simulated artificially with python

3.3.4 Market assumptions & Implied versus realized volatility

Theoretical covered call strategies often base assumptions of a frictionless market, meaning that there are no transaction costs, taxes, or bid-ask spreads. In practice, these reduce the net income generated by covered calls. Additionally, continuous hedging, which is assumed to be feasible without incurring costs, is unrealistic in the real market. In reality, transaction costs and liquidity constraints reduce profitability, resulting in lower realized returns compared to theoretical expectations (Merton, 1973). These perfect market assumptions, therefore, lead to overestimated returns in theoretical models since they ignore practical costs associated with the implementation of covered call strategies.

Theoretical returns often rely on implied volatility to price options. Implied volatility, derived from models like VSTOXX, represents the market's expectation of future volatility. However, in practice, implied volatility tends to be higher than realized volatility due to investor demand for protection against downside risks. This leads to inflated premiums for call options and can generate excess returns when using theoretical models. These returns depend heavily on implied volatility not being realized, resulting in an underestimation of the true risk in the theoretical setup (Heynen et al., 1994).

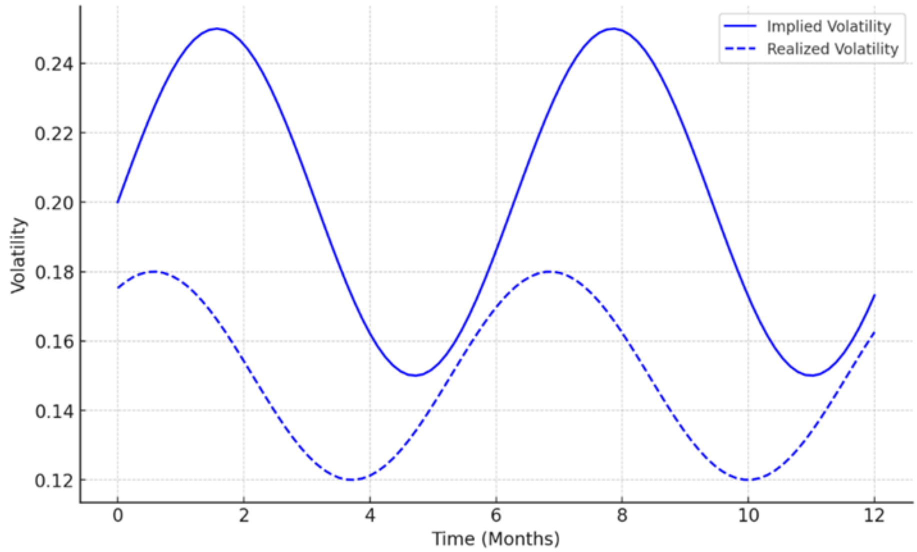

Figure 6: Implied volatility vs realized volatility. Source: Heynen et al., (1994) simulated artificially with python

3.3.5 The Greeks and sensitivity analysis

The Greeks are fundamental for understanding an option's sensitivity to various factors, which helps explain discrepancies between theoretical and actual financial market option pricing. These metrics help in measuring how option prices change in response to different factors, making them essential for managing risk in option strategies.

Delta (Δ) measures the sensitivity of an option's price to changes in the price of the underlying asset. In covered call strategies, delta helps gauge how the position will change with price movements, impacting the strategy's potential payoff. A delta close to 1 for a call option means that the option price moves coherently with the underlying asset, whereas a lower delta indicates less sensitivity. Understanding delta is also important for constructing delta-neutral portfolios, where changes in the underlying asset's price are hedged to maintain a net zero exposure (Lee, 2010). (Ederington, 2003)

A delta-neutral strategy involves constructing a portfolio of options and underlying assets so that the overall delta is zero, meaning price movements of the underlying asset have minimal impact. Traders adjust positions to maintain neutrality, buying or selling the underlying asset as needed. The objective is to profit from factors like time decay (theta) or changes in volatility (vega). Delta-neutral strategies require active management, especially in volatile markets, to capitalize on pricing inefficiencies (Black & Scholes, 1973; Hull, 2012).

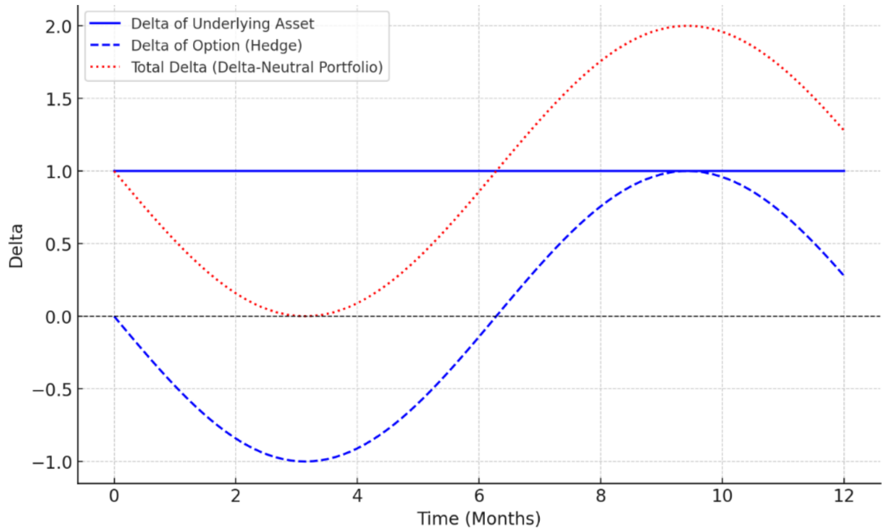

Figure 7: Delta neutral strategy. Source: (Deacon, 2000) simulated artificially with python

Gamma (Γ) measures the rate of change of delta with respect to the underlying asset's price. High gamma values indicate higher sensitivity to changes in the underlying asset's price, implying that the covered call strategy requires frequent adjustments to maintain a neutral exposure. Gamma is highest for at-the-money (ATM) options and decreases as options move deeper in-the-money (ITM) or out-of-the-money (OTM). This characteristic highlights the challenges of managing risk for ATM options close to expiration, where even small movements in the underlying asset can lead to significant changes in delta. (Lee, 2010); (Ederington, 2003)

Theta (Θ) represents the time decay of an option's value. Covered calls benefit from positive theta, as time decay erodes the value of the written call, contributing to the strategy's income. However, sudden changes in the underlying price can diminish this benefit. Theta decay accelerates as the expiration date approaches, especially for ATM options. This makes theta a critical consideration for option sellers, as time decay is a primary source of profitability in such strategies. (Lee, 2010); (Ederington, 2003)

Vega (ν) measures sensitivity to changes in implied volatility. Since covered calls involve selling volatility, an increase in implied volatility can lead to losses, whereas decreasing volatility can enhance returns. The use of implied volatility indices like VSTOXX highlights how changes in market sentiment and perceived risk impact the strategy. Higher vega implies that an option's value is highly sensitive to volatility changes, which is particularly relevant for options with longer maturities, as they are more affected by changes in market expectations of future volatility. (Lee, 2010); (Ederington, 2003)

Rho (ρ) measures sensitivity to changes in interest rates. Changes in interest rates have less direct impact on covered call strategies compared to other Greeks but can still influence the cost of carrying the underlying asset. For call options, an increase in interest rates generally increases the option's price, while for put options, the value decreases. Although rho is often less emphasized compared to other Greeks, it can be significant in environments with rapidly changing interest rates, especially for longer-term options (Lee, 2010); (Ederington, 2003)

The interaction of these Greeks plays a crucial role in understanding and managing options. For instance, a covered call strategy benefits from positive theta but is exposed to gamma risk, particularly as expiration approaches. Similarly, the strategy's performance depends on managing vega risk, as increased volatility can lead to adverse outcomes. Understanding how these Greeks interact allows traders and portfolio managers to construct hedging strategies that mitigate risk while capitalizing on favorable market conditions. Advanced strategies, such as gamma scalping or vega hedging, involve continuous adjustments to maintain an optimal balance between risk and return. (Lee, 2010); (Ederington, 2003)

3.3.6 Investor sentiment and behavioral factors

Market dynamics, such as investor sentiment, play a key role in determining real-world option prices. During periods of heightened market stress, increased demand for hedging instruments, such as put options, can distort implied volatility, which then influences call option premiums. Theoretical models like Black-Scholes do not adequately account for these behavioral aspects, leading to an overestimation of the returns from covered call strategies, particularly in environments where investor sentiment significantly influences pricing (Jarrow, 1999); (Merton, 1973).

4 PORTFOLIO PERFORMANCE EVALUATION

This section focuses on evaluating the performance of a covered call strategy on a risk-adjusted basis. It also considers portfolio performance metrics that account for non-normal returns, as Kapadia and Szado (2007) reported that portfolios including derivative securities often exhibit non-normal return distributions.

The Capital Asset Pricing Model, CAPM, is a fundamental framework used to evaluate the risk and return of a portfolio. CAPM suggests that the expected return of a portfolio is related to its systematic risk, which is measured by beta (β). Beta represents the sensitivity of the portfolio's returns to market movements, with a beta of 1 indicating that the portfolio moves in line with the market. A beta greater than 1 implies higher sensitivity to market changes, while a beta less than 1 indicates lower sensitivity (Sharpe, 1964). In the context of covered call strategies, the beta may vary depending on the underlying asset and the level of market exposure. The use of beta is crucial for understanding how much risk a portfolio carries relative to the overall market. (Lee, 2010); (Bodie et al, 2013).

Another important concept related to CAPM is alpha (α), which represents the abnormal return of a portfolio relative to its expected return, as predicted by CAPM. A positive alpha indicates that the portfolio has outperformed its expected return, given its level of risk, while a negative alpha suggests underperformance (Bodie et al, 2013). Covered call strategies may generate positive or negative alpha depending on the market conditions and the effectiveness of the strategy in capturing premium while managing downside risk. Jensen's alpha, discussed in Section 4.4, is used to quantify this abnormal performance, and assess whether the portfolio has provided value beyond what would be expected based on its systematic risk. (Bodie et al, 2013).

To appropriately assess portfolio performance, it is important to discuss the concept of risk. Typically, standard deviation is used as the most common measure of risk. However, since covered call strategies often lead to non-normal return distributions, standard deviation may yield slightly distorted results. Standard deviation treats all deviations from the expected return as risk, regardless of direction, which can be misleading, especially for covered call strategies that often have asymmetric return profiles due to their limited upside potential and higher probability of small, consistent gains. Whaley (2002) suggests that semi-standard deviation, which considers only those returns falling below a benchmark, such as the risk-free rate or the mean return, may be a better measure in this context. For example, in covered call strategies, semi-standard deviation avoids penalizing the portfolio for large positive returns, which are not considered risky but rather desirable outcomes. Thus, the reference return used in calculating semi-standard deviation should be clearly defined. Various performance measures are discussed in the following subsections.

4.1 Treynor´s measure

The Treynor measure is initially developed to evaluate the return-to-risk trade-off of various funds (Treynor, 1965). As shown in equation 7, Treynor's measure provides the excess return per unit of risk (Bodie et al, 2013).

$$\text{Treynor´s measure} = \frac{\bar{r}_p - \bar{r}_f}{\beta_p} \quad (7)$$

4.2 Sharpe ratio

The Sharpe ratio is a widely used metric for evaluating risk-adjusted performance, built as an extension of Treynor's (1965) earlier work, with the key distinction being that the Sharpe ratio considers total risk rather than just systematic risk (Sharpe, 1966). It is crucial to acknowledge, however, that using this measure with non-normal return distributions may lead to biased outcomes (Feldman & Roy, 2005). Equation 8 represents the trade-off between reward and volatility (Bodie et al, 2013).

$$\text{Sharpe ratio} = \frac{\bar{r}_p - \bar{r}_f}{\sigma_p} \quad (8)$$

4.3 Sortino ratio

Sortino and Price (1994) observes that the Sharpe ratio could produce misleading results when dealing with non-normal return distributions, which is often the case for covered call strategies due to their limited upside and high likelihood of small, consistent gains. To address this, the Sortino ratio modifies the Sharpe ratio by using semi-standard deviation instead of standard deviation, thereby focusing only on negative deviations from the mean. (Sortino & Price, 1994). The Sortino ratio is as follows:

$$\text{Sortino ratio} = \frac{\bar{r}_p - t}{\theta_{rp}(t)} \tag{9}$$

, where rp represents the portfolio return, t denotes the target return, and θ(t) refers to the semi-standard deviation (Pedersen, 2002).

4.4 Jensen´s alpha

A risk-adjusted performance measure, unlike previous comparative studies, evaluates the absolute performance of a portfolio instead of ranking it against others. Therefore, Jensen's alpha provides insight into whether a portfolio's performance meets an absolute benchmark (Jensen, 1968). Equation 10 measures the expected return in comparison to the return predicted by the CAPM (Bodie et al, 2013).

Jensen´s alpha = α_p=r̄_p-[r̄_f+β_p (r̄_m-r̄_f)] (10)

4.5 Leland´s alpha & beta

Most performance measurements utilize the capital asset pricing model (CAPM) to evaluate portfolio returns. These measures often incorrectly assume that all returns are normally distributed, overlooking the effects of skewness and excess kurtosis. Leland (1999), however, introduces a simple adjustment to the CAPM beta to obtain an accurate risk measure for portfolios with non-normal return distributions. This modified CAPM beta or risk factor Bp is the primary difference between Jensen's alpha and Leland's alpha. Notably, Leland's alpha and beta do not require any additional information beyond what is used for the CAPM (Leland, 1991). Furthermore, when Leland's beta yields absolute values less than 1 for portfolios involving short call options, it indicates that the portfolio is less sensitive to market movements (Aggarwal & Gupta, 2013).

$$\text{Leland´s alpha} = A_p = E(r_p) - B_p[E(r_{mkt} - r_f)] - r_f \tag{11}$$

$$\text{Leland´s beta} = B_p = \frac{cov[r_p-(1+r_{mkt})^{-b}]}{cov[r_{mkt}-(1+r_{mkt})^{-b}]} \tag{12}$$

where, E(r_p) indicates the expected return and b represents markets price of risk.

4.6 Stutzer index

The Stutzer Index extends the Sharpe ratio by accounting for skewness and kurtosis, making it a more appropriate metric for assessing portfolios with non-normal return distributions (Stutzer, 2000). This is especially applicable to covered call strategies, which often exhibit skewed return distributions due to their limited upside and increased likelihood of small, steady gains. The Stutzer Index is computed as follows:

$$I_{p=\underset{\theta}{max}}\left[-log(\tfrac{1}{T}\textstyle\sum_{i=1}^{T} e^{\theta r_i})\right] \tag{13}$$

, where the Ip is the maximum value of the formula shown in equation 13, r_i , i=1,2,…,T, is an excess return series of T observations and θ is a metric to be simulated to maximize I_p. The Stutzer index is formed based on the Stutzer statistic above:

$$\text{Stutzer index} = sign(\overline{r})\sqrt{2\, I_p} \tag{14}$$

where, the sign($\overline{\mathrm{r}}$) represents the mean excess return, generally relative to the risk-free rate. Additionally, when the returns ri follow a normal distribution, the Stutzer Index yields the same expected value as the Sharpe ratio.

4.7 M-squared

Similar to the Sharpe ratio, the M-squared (M2) measure evaluates risk by considering total volatility. However, M2 is often more practical because its risk-adjusted performance is easier to interpret compared to the Sharpe ratio. To compute M2, as illustrated in equation 15, the managed portfolio is combined with T-bills (short-term obligations) to align its volatility with that of a market index, such as the S&P 500. The adjusted portfolio, denoted as P*, should have a standard deviation equal to that of the S&P 500 after these adjustments. Once the standard deviations are matched, a direct performance comparison between the adjusted portfolio P and the market index M can be made by simply comparing their respective returns, as shown below (Bierwag et al., 1993):

$$\text{M-squared} = r_{p*} - r_M \tag{15}$$

5 DATA AND METHODOLOGY

For this study, the EURO STOXX 50 Total Return Index is selected due to its sufficient transaction volume, which helps in obtaining relevant results. Additionally, the covered call strategy on the STOXX 50 index offers a different perspective compared to prior studies, as European markets have not been as widely examined during periods of low interest rates (see, e.g., Whaley, 2002; Feldman & Roy, 2005; Hill et al., 2006; Kapadia & Szado, 2007). Due to the unavailability of historical market price data for STOXX 50 index call options, theoretical option prices are used in this study instead of actual market prices. These theoretical prices are calculated using the Black-Scholes model. The STOXX 50 implied volatility 1-month spot index, VSTOXX, is employed as a proxy for implied volatility, which is incorporated into the Black-Scholes model. Furthermore, it is assumed that the Black-Scholes model is applicable and accurately values the options. However, the limitations and practical applications of the Black-Scholes model are thoroughly discussed. Additionally, the risk-adjusted performance of the STOXX 50 BuyWrite index is evaluated in this study.

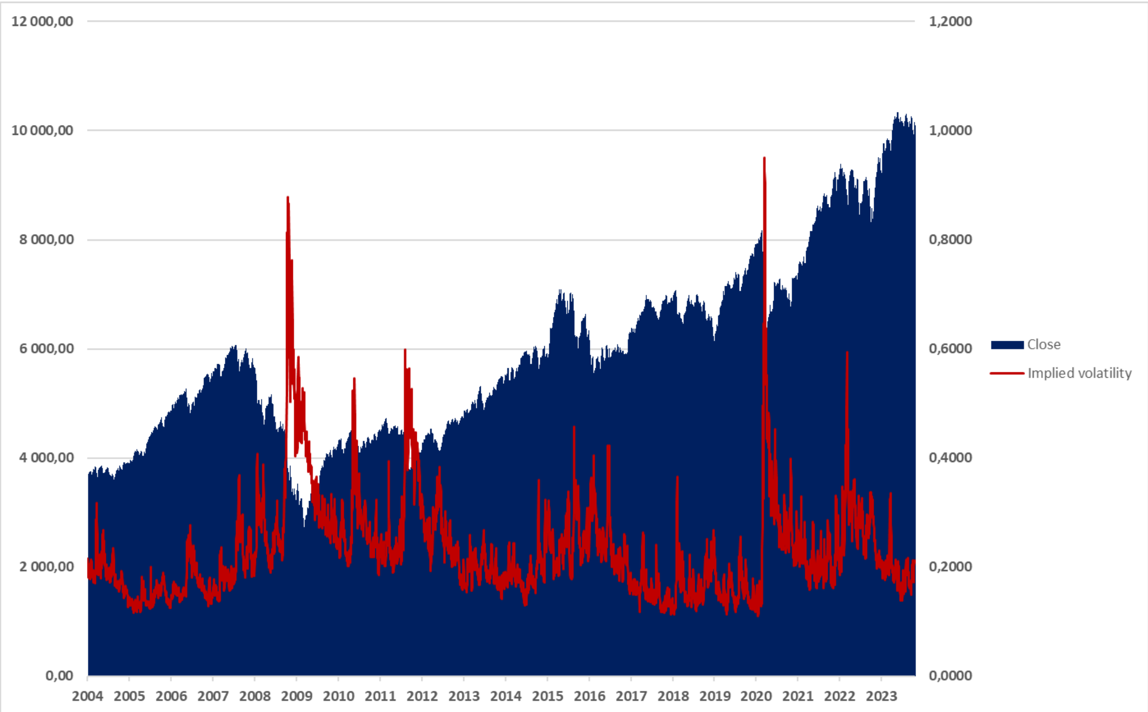

Figure 8: STOXX 50 total return index and VSTOXX (1M) implied volatility 2004-2023

5.1 Data

Data used in this study is collected from the STOXX.com database. This study uses daily closing values from 2 January, 2004 to 19 September, 2023 consisting of 5039 daily observations. The time period is chosen because the STOXX index began calculating the volatility index, VSTOXX, on 1 January, 2004. STOXX50 total return index is chosen as a proxy for the constructed covered call and VSTOXX (1month) as the implied volatility proxy. Furthermore, since STOXX50 published their own covered call strategy its performance is also evaluated against the underlying Stoxx50 total return index.

5.1.1 Data on STOXX50, STOXX50 BuyWrite index, VSTOXX and risk-free rate

STOXX Ltd, established in 1997, now part of the ISS STOXX group, administers both the STOXX and DAX indices in compliance with the European Benchmark Regulation. This family of indices encompasses more than 17,000 transparent indices, including major benchmarks like the EURO STOXX 50, STOXX Europe 600, and DAX. STOXX indices are extensively utilized by organizations worldwide for benchmarking purposes, as well as serving as the underlying assets for a variety of investment products, including ETFs, futures and options. (stoxx.com, 2024)

EURO STOXX50 BuyWrite index represents an ATM buy-write or covered call option strategy. In this strategy, an investor purchases the STOXX 50 total return index and simultaneously sells a call option on the EURO STOXX 50. This index is constructed based on the EURO STOXX 50 price index or total return index in conjunction with a EURO STOXX 50 call option traded on the Eurex Exchange. Appendix 1 demonstrates the formula Stoxx uses to construct the covered call. (stoxx.com, 2024).

STOXX50 total return index, symbol SX5GT, represents the performance of the 50 largest companies within the Eurozone's 20 largest sectors, based on free-float market capitalization. As part of the STOXX blue-chip index family, it captures approximately 60% of the free-float market capitalization of the EURO STOXX Total Market Index (TMI). This index is widely recognized and highly liquid, serving as a benchmark and an underlying for financial products, including options, futures, and ETFs. The largest exposure of the index is to the technology sector and to the French and German markets. Appendix 2 demonstrates the sector, country, and company weights. (stoxx.com, 2024).

VSTOXX index is intended to capture the implied volatility of the EURO STOXX 50 Index over future periods, based on options traded on the Eurex Exchange. The VSTOXX family consists of eight sub-indices, which represent the next 1, 2, 3, 6, 9, 12, 18, and 24-month expirations of EURO STOXX 50 option contracts. Additionally, there are 12 main VSTOXX indices covering time ranges from 30 to 360 days, in increments of 30 days. This study uses the 1month option expiry VSTOXX index. (stoxx.com, 2024).

The VSTOXX methodology uses all available option strikes to derive an accurate estimation of implied volatility, unlike other models that only consider near at-the-money strikes. EURO STOXX 50 options are among the most traded products on Eurex. The VSTOXX indices reflect the skewed or smiling nature of the volatility surface. The VSTOXX methodology is also based on a non-arbitrage approach, which is commonly used in the pricing of variance swaps. (stoxx.com, 2024).

Risk-free rate proxy is collected from the European central bank data base. The European Central Bank recommended on 13 September 2018 that the euro short-term rate (€STR) be adopted as the risk-free rate for the euro area. Thus, €STR is used in this study. (Bank, 2024)

5.2 Methodology

This section provides an overview of the methodology used to construct the theoretical covered call strategy in this study. Additionally, the specific formulas used to calculate the returns are discussed.

5.2.1 Construction of theoretical covered call strategy

The STOXX 50 index dataset consists of 5039 daily observations from the period 2004 to 2023. 36 days were deleted from the dataset because volatility values were not found, indicating that the stock market was closed on those days. The daily theoretical price of the written ATM (at-the-money) STOXX 50 call option is computed by inputting the daily closing prices of the spot VSTOXX, STOXX 50, and the risk-free interest rate into the Black-Scholes-Merton (BSM) model. Time to maturity is calculated using trading days, while the risk-free interest rate is determined using calendar days. It is assumed that a new call option is written immediately after the previous one is exercised.

The expiration date for all written call options is the third Friday of each month. If the exchange is closed on that day, the expiration date is adjusted to the previous trading day to ensure that a call option is written in all time periods. The settlement price is also calculated on the third Friday of the month, or on the previous day if the exchange is closed. Using an expiration date of one month, or every third Friday, produces 236 observation data points.

5.2.2 Return of theoretical covered call strategy

This study calculates the return of covered call and settlement price as in Whaley (2002).

$$R_{covered\ call,t} = \frac{S_t + D_t - S_{t-1} - (C_t - C_{t-1})}{S_{t-1} - C_{t-1}} \tag{16}$$

represents the return of the covered call strategy at time t. The symbol St signifies the spot price of the underlying STOXX 50 index at time t, while Dt represents the dividends received from the underlying index at the same time. Dividends are not subtracted in this study since this study uses a total return index. St-1 stands for the spot price of the STOXX 50 index at the previous time period (t-1). Similarly, Ct and Ct-1 refer to the call option prices at time t and the previous time period (t-1), respectively. This formula calculates the return by considering the change in the spot price of the index and the changes in the call option price. The denominator represents the initial investment value, which is the spot price subtracted by the call premium at the beginning of the period.

$$C_{settle,t} = \max(0, S_{settle,t} - X) \tag{17}$$

represents the settlement price of STOXX 50 call option on settlement day t. $S_{settle,t}$ is the closing value of the STOXX 50 index on settlement day t and X is the exercise price of the STOXX 50 call option. If $S_{settle,t} - X$ Is negative the option expiries worthless. If $S_{settle,t} - X$ Is positive the option holder exercises the option. The settlement price of the STOXX 50 call option is equal to the difference.

$$C_{settle,t} = -\max(0, S_{settle,t} - X) \tag{18}$$

this equation shows that the maximum profit for the call option writer at maturity t is 0 if the option is not exercised. However, if the option is exercised, the writer incurs a loss. Additionally, the total payoff from the written call option position is positive if the settlement price of the call option is lower than the premium initially received. On the other hand, the total payoff for the call option writer becomes negative if the settlement price of the call option exceeds the premium received when the option was written.

6 RESULTS

The performance of STOXX 50, STOXX 50 BuyWrite and theoretical covered call option strategies performance is analyzed in this section. Firstly, a correlation analyzes is conducted following up with in-depth performance metrics analyzes and lastly the limitations of theoretical covered calls is discussed.

Table 5. Key statistics on STOXX 50 index and covered call strategies. Estimation period from January 2004 to October 2023 with 236 monthly observations.

	Stoxx 50	STOXX 50 BuyWrite	ITM -2%	ATM	OTM 2%	OTM 5%	OTM 10%
Observations	236	236	236	236	236	236	236
Mean	172,738	167,400	120,251	226,654	257,871	254,116	210,904
Annualized return	5,827	4,436	0,808	7,329	8,090	7,925	6,887
Lowest return	83,906	92,600	63,578	99,196	98,944	96,832	96,333
Highest return	317,072	254,700	162,370	407,652	470,113	458,830	382,772
Standard deviation	56,242	44,358	23,847	81,567	99,143	96,400	73,552
Kurtosis	-0,383	-1,192	-0,821	-0,913	-0,913	-0,964	-0,826
Skewness	0,646	0,140	-0,477	0,364	0,339	0,317	0,423

The correlation analysis, sensitivity to market movements, in table 6 shows statistically significant positive correlations between most of the strategies and the STOXX 50 index, particularly for the STOXX 50 BuyWrite strategy (ρ = 0.95). The ITM -2% strategy exhibits a lower correlation with the other strategies and the market, suggesting it can provide effective diversification benefits.

Table 6. Correlation analysis. Estimation period from January 2004 to October 2023 with 236 monthly observations. * = p-value <0.1, ** = p-value <0.05 *** =p-value <0.01

	STOXX 50	STOXX 50 BuyWrite	ITM -2%	ATM	OTM 2%	OTM 5%	OTM 10%	VSTOXX
STOXX 50	1.0	0.954***	-0.047	0.935***	0.939***	0.949***	0.975***	-0.258***
STOXX 50 BuyWrite	0.954***	1.0	0.132**	0.947***	0.948***	0.96***	0.972***	-0.322***
ITM -2%	-0.047	0.132**	1.0	0.302***	0.282***	0.252***	0.164**	0.209***
ATM	0.935***	0.947***	0.302***	1.0	0.999***	0.997***	0.987***	-0.131**
OTM 2%	0.939***	0.948***	0.282***	0.999***	1.0	0.998***	0.989***	-0.118*
OTM 5%	0.949***	0.960***	0.252***	0.997***	0.998***	1.0	0.994***	-0.146**
OTM 10%	0.975***	0.972***	0.164**	0.987***	0.989***	0.994***	1.0	-0.198***
VSTOXX	-0.258***	-0.322***	0.209***	-0.131**	-0.118*	-0.146**	-0.198***	1.0

The ITM -2% covered call strategy does not show statistically significant correlation with the STOXX 50 index. However, it has a statistically significant positive correlation with VSTOXX implying that is performs during periods of high volatility. Other strategies have a negative correlation with VSTOXX which aligns with the expectation that increased uncertainty leads to reduced returns.

The Kendall's Tau correlation is a non-parametric statistic that measures the strength and direction of association between two ranked variables. It is particularly useful when the data is not normally distributed or contains outliers, as it is based on ranks rather than the raw values. Unlike Pearson correlation, which measures linear relationships, Kendall's Tau evaluates the ordinal association by comparing the number of concordant and discordant pairs. It is robust to non-linear relationships and less sensitive to outliers, making it suitable for assessing correlations in financial time series data. (Kendall, 1938); (Conover, 1999)

The Kendall's Tau correlation test shows that the STOXX 50 index has a strong positive association with most of the option strategies, such as STOXX 50 BuyWrite, ATM, and OTM 2%. The Tau values for these strategies were all above 0.75, indicating a high degree of correlation with the STOXX 50. The p-values were close to zero, suggesting that these correlations are statistically significant. In contrast, the ITM -2% strategy showed a weak and statistically insignificant correlation with the STOXX 50, with a Tau value close to zero and a high p-value. This suggests that ITM -2% may behave independently of the broader market, potentially providing diversification benefits to a portfolio that includes other strategies highly correlated with the STOXX 50.

Table 7. Kendall's Tau correlation test. Estimation period from January 2004 to October 2023 with 236 monthly observations. * = p-value <0.1, ** = p-value <0.05 *** =p-value <0.01

	Stoxx 50	STOXX 50 BuyWrite	ITM -2%	ATM	OTM 2%	OTM 5%	OTM 10%
Stoxx 50	1	0,861***	-0,037	0,758***	0,768***	0,799***	0,863***

6.1 Performance of Stoxx 50 BuyWrite strategy

The figure 9 demonstrates the indexed performance of STOXX 50, STOXX 50 BuyWrite and VTOXX monthly spots. The STOXX 50 outperform the STOXX 50 BuyWrite during the study period. The STOXX 50 is at index value 304,58 with a return of 205% compared to STOXX 50 BuyWrite at index value 234,82 with 135% return.

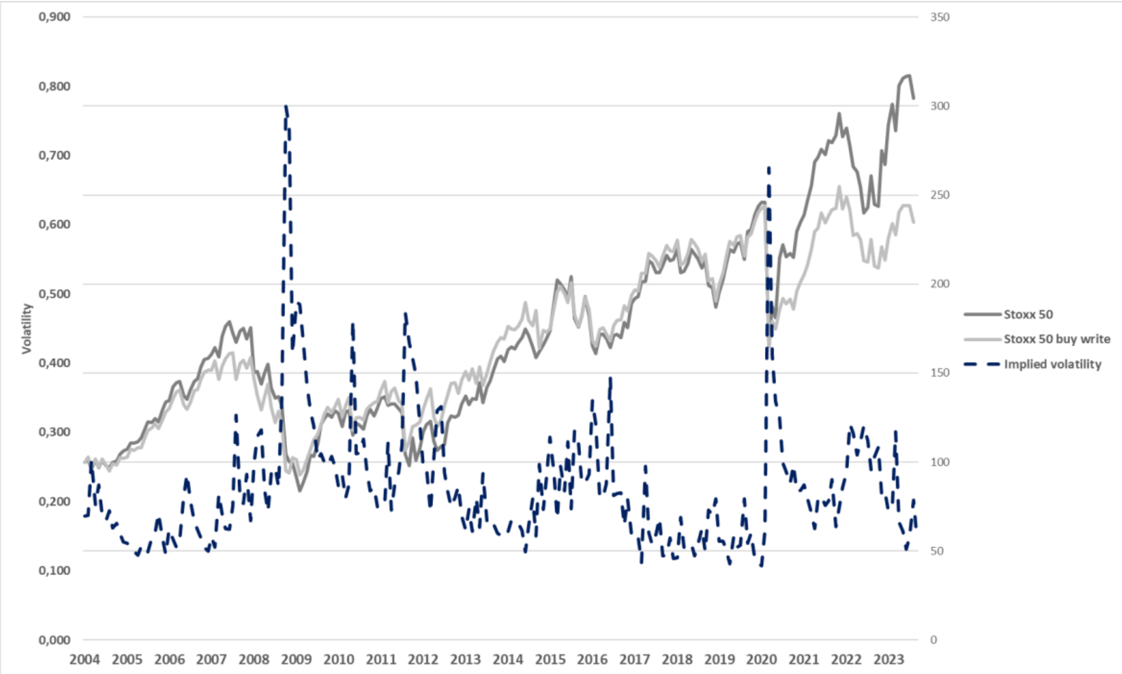

Figure 9: STOXX50 total return index vs STOXX50 BuyWrite index & VSTOXX 2004-2023

When comparing, table 8, the STOXX 50 index to the STOXX 50 BuyWrite strategy, the performance reveals a close to zero trade-off between returns and risk. The STOXX 50 delivers higher annualized returns at 5.83%, compared to 4.44% for the BuyWrite strategy. Even though, the BuyWrite strategy is designed to generate excess returns through covered call writing, in terms of risk-adjusted metrics, the STOXX 50 outperforms the BuyWrite strategy, with higher Sharpe 0.354 vs. 0.291 and Stutzer indices 0.124 vs. 0.084, suggesting better returns for the risks taken. While the BuyWrite strategy offers lower volatility, as indicated by a lower beta 0.81 vs. 1.00 and a less severe maximum drawdown -42.65% compared to -53.12%, it does not outperform the STOXX 50 on a risk-adjusted basis. The BuyWrite strategy's negative Leland's alpha (-0.02%) further suggests underperformance relative to market expectations, indicating that the excess returns from option premiums do not sufficiently compensate for the opportunity cost of covered upside during bull markets.

Table 8. STOXX 50 & STOXX 50 BuyWrite performance measures. Estimation period from January 2004 to October 2023 with 236 monthly observations.

	Annualized Return %	Sharpe Ratio	Maximum Drawdown %	Leland's Monthly Alpha %	Leland's Beta	Stutzer Index
STOXX 50	5,827	0,354	-53,123	0,000	1,000	0,124
STOXX 50 BuyWrite	4,436	0,291	-42,648	-0,020	0,810	0,084

Thus, it can be concluded that the first hypothesis is not supported:

> H1: The benchmark STOXX 50 BuyWrite outperforms the underlying STOXX 50 index in risk-adjusted basis.

The distribution graph in figure 10 highlights differences in tail behavior and skewness and kurtosis between the two strategies. The STOXX 50 BuyWrite strategy has a heavier left tail and is slightly left-skewed, indicating a higher likelihood of moderate negative returns. In contrast, the STOXX 50 shows more balanced returns with a longer right tail, suggesting greater potential for large positive returns. The higher kurtosis of the STOXX

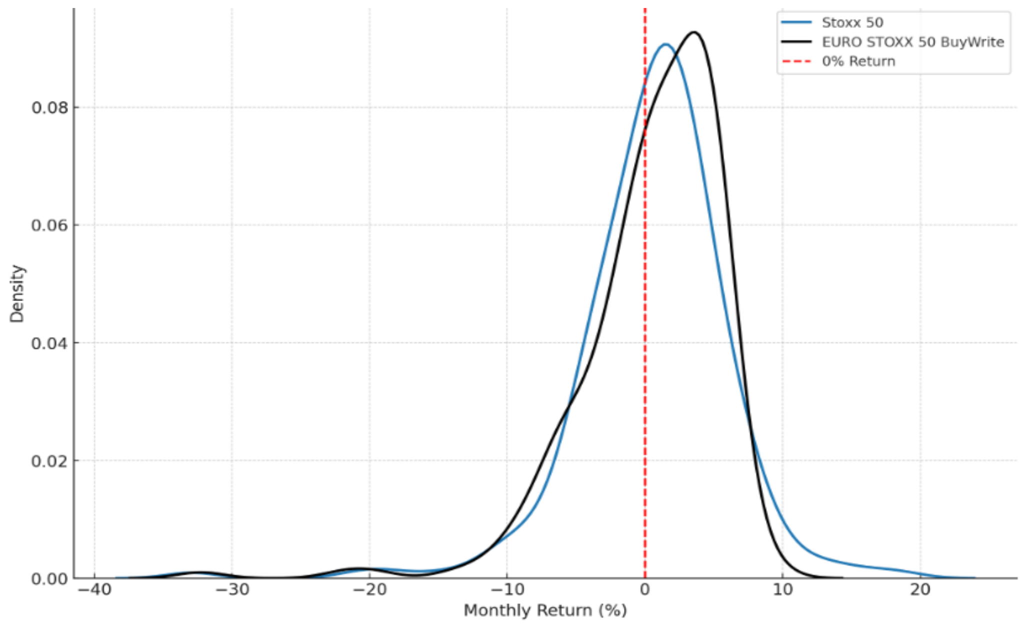

Figure 10: Monthly return distribution of STOXX 50 & STOXX 50 BuyWrite (2004-2023)

50 BuyWrite strategy implies more concentrated returns around the mean, whereas the STOXX 50 exhibits greater dispersion, with a higher probability of extreme outcomes. The graph highlights the varying risk-return profiles of the STOXX 50 index and the STOXX 50 BuyWrite strategy. The STOXX 50 BuyWrite strategy offers a more stable return distribution, with limited chances of extreme outcomes.

6.1.1 Performance during bear market and bull market

The STOXX 50 BuyWrite strategy tends to outperform the STOXX 50 index during periods of market turmoil due to the stabilizing effect of option premiums, shown in table 9. For instance, during the Financial Crisis (2007-2009), the BuyWrite strategy demonstrated a mean monthly return of -0.20%, compared to the STOXX 50's -0.41%, indicating a less severe decline. Similarly, during the Greek Crisis (2011-2012), the BuyWrite strategy yielded a monthly mean return of 0.32%, slightly outperforming the STOXX 50 by 0.28%. The premiums generated from writing covered calls provided a buffer, reducing the overall impact of negative market movements and resulting in smaller negative compound returns relative to the STOXX 50. This dynamic highlight the defensive characteristics of the BuyWrite strategy, particularly in environments marked by prolonged market uncertainty and gradual downturns.

However, during rapid and extreme downturns, such as the Covid-crash in early 2020, the BuyWrite strategy's effectiveness is limited. The monthly mean return for the BuyWrite strategy during this period was -32.26%, only marginally better than the STOXX 50 at -32.91%, illustrating that the income from option premiums was insufficient to mitigate the sharp losses. The BuyWrite strategy, therefore, is particularly advantageous in mitigating losses during sustained periods of market stress, providing risk-averse investors with a relatively smoother return profile. Conversely, during market recoveries, such as the Post-Financial Crisis and Post-Covid periods, the STOXX 50 significantly outperformed due to its uncapped upside potential, which enabled full participation in the bull market.

Table 9. Stoxx 50 & Stoxx 50 BuyWrite performance during bear and bull markets. Estimation period from January 2004 to October 2023 with 236 monthly observations.

Panel A: Bear Markets	Financial Crisis		Greek Crisis		Covid Crash	
	Stoxx50 BuyWrite	Stoxx 50	Stoxx50 BuyWrite	Stoxx 50	Stoxx50 BuyWrite	Stoxx 50
Monthly Arithmetic Mean %	-0,196	-0,411	0,397	0,164	-32,260	-32,912
Monthly Arithmetic Deviation %	6,490	6,492	6,571	7,304		
Monthly Compound Rate of Return %	-0,402	-0,609	0,169	-0,093	-17,696	-18,093

Panel B: Bull Markets	Post-Covid	
	Stoxx50 BuyWrite	Stoxx 50
Monthly Arithmetic Mean %	0,503	0,887
Monthly Arithmetic Deviation %	3,725	4,595
Monthly Compound Rate of Return %	0,422	0,763

6.2 Performance of theoretical covered call strategies

The figure 11 demonstrates the indexed performance of the theoretical covered call strategies and the benchmark indexes STOXX 50 and STOXX 50 BuyWrite. It is inherent that the theoretical strategies outperform the benchmarks during the study period excluding the ITM -2%. The highest indexed value is by the OTM 2% at index value 461,80 with a return of 362% during the study period compered to STOXX 50 BuyWrite at index value 234,82 with a return of 135%.

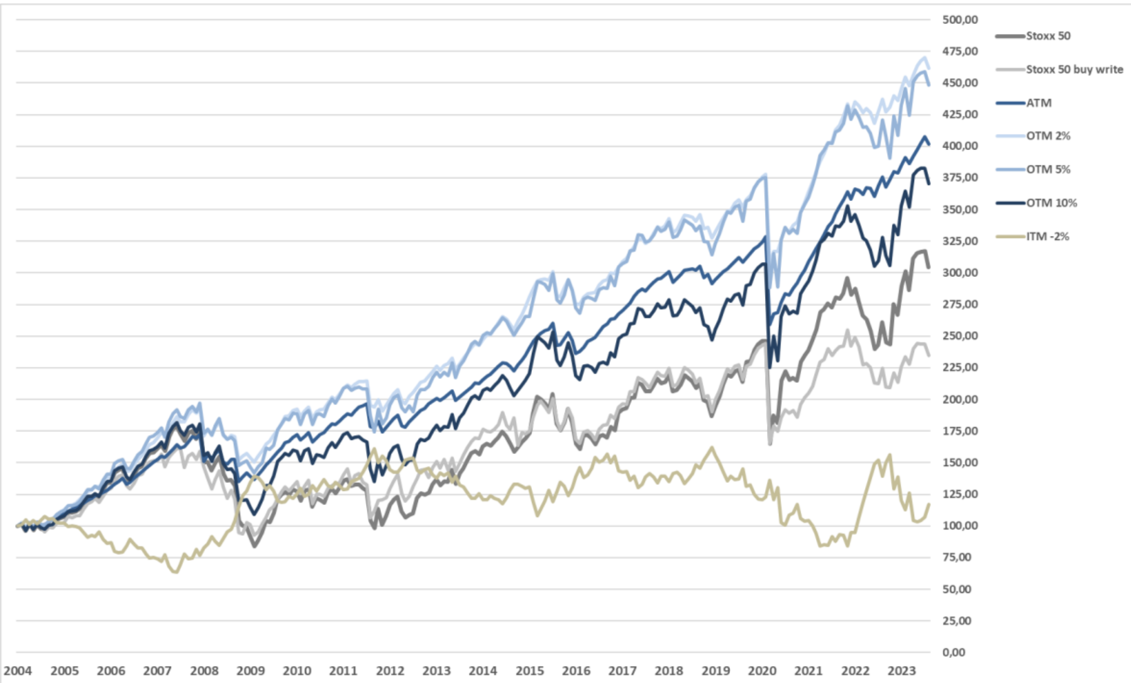

Figure 11: STOXX50 vs STOXX50 BuyWrite, ATM, OTM, ITM 2004-2023

Table 10. STOXX 50 index and covered call strategies performance statistics and risk measures. Estimation period from January 2004 to October 2023 with 236 monthly observations.

	Stoxx 50	STOXX 50 BuyWrite	ITM -2%	ATM	OTM 2%	OTM 5%	OTM 10%
Annualized Return %	5.826	4.436	0.807	7.329	8.090	7.925	6.887
Annualized Standard Deviation %	18.808	17.690	18.506	8.8037	9.0285	13.009	15.158
Semi-Standard Deviation %	16.690	17.190	12.763	13.111	11.002	11.665	13.402
Mean Monthly Return %	0.630	0.504	0.212	0.628	0.688	0.712	0.658
Median Monthly Return %	0.960	1.333	0.387	1.357	1.595	1.115	0.902
Skewness	-1.299	-2.081	-0.466	-4.382	-3.185	-1.353	-1.269
Excess Kurtosis	4.410	5.469	-1.85	24.79	13.28	4.526	4.155
Maximum Monthly Return %	18.449	9.1750	13.095	3.5287	3.5294	12.788	15.105
Minimum Monthly Return %	-32.911	-32.260	-20.919	-21.118	-18.746	-23.151	-26.473
Maximum Drawdown %	-53.123	-42.648	-48.196	-21.626	-22.537	-28.137	-40.053
Maximum Run Up %	277.8	175.0	155.3	310.9	375.1	373.8	297.3
Sharpe Ratio	0.354	0.291	0.088	0.754	0.815	0.588	0.461
Sortino Ratio	0.159	0.125	0.055	0.292	0.334	0.270	0.211
CAPM Beta	1	0.810	-0.798	0.392	0.428	0.666	0.797
M^2 %	1.998	1.656	0.558	4.169	4.504	3.269	2.581
Treynor Ratio	0.555	0.530	-0.17	1.410	1.433	0.957	0.731
Leland's Monthly Alpha %	0	-0.02	0.580	0.335	0.375	0.267	0.140
Leland's Beta	1	0.810	-0.79	0.392	0.428	0.666	0.797
Stutzer Index	0.123	0.083	0.007	0.565	0.662	0.343	0.211

The table 10 demonstrates that OTM 2% and ATM strategies have the highest annualized returns of 8.09% and 7.33%. In comparison, the STOXX 50 index has a return of 5.83%, while the more conservative ITM -2% strategy yields an annualized return of 0.81%. Regarding volatility, the ITM -2% strategy has the highest standard deviation 18.51%, reflecting increased risk. Conversely, the ATM and OTM 2% strategies exhibit lower volatility levels 8.80% and 9.03%, making them appealing for investors seeking a promising risk-return balance.

Risk-adjusted metrics such as the Sharpe, Sortino and Treynor ratios further highlight the advantages of the OTM 2% and ATM strategies. The Sharpe ratios for these strategies are 0.82 and 0.75, respectively, indicating superior risk-adjusted returns compared to other strategies. In contrast, the ITM -2% strategy has a Sharpe ratio of only 0.09, and the

STOXX 50 BuyWrite strategy has a relatively low Sharpe ratio of 0.29. The Treynor ratios for OTM 2% and ATM are 1.43 and 1.41, respectively, while the negative Treynor ratio for ITM -2% indicates suboptimal performance relative to its risk exposure.

Market sensitivity, as measured by CAPM beta, reveals that the ATM and OTM 2% strategies have lower betas of 0.39 and 0.43, respectively, suggesting reduced sensitivity to overall market movements. This lower sensitivity makes these strategies attractive for investors seeking equity exposure without full market risk. The ITM -2% strategy, with a beta of -0.80, demonstrates inverse market sensitivity, positioning it as a potential diversifier during market downturns. Additionally, positive Leland's monthly alpha values for the OTM 2% and ATM strategies, 0.38% and 0.34%, indicate outperformance relative to market expectations. The OTM 2% and ATM strategies perform the best in terms of risk-adjusted returns, with high Sharpe and Treynor ratios, as well as strong return potential. The ATM strategy outperforms the STOXX 50 BuyWrite strategy in terms of return potential, risk-adjusted returns, and market sensitivity. Thus, the second and third hypothesis is supported:

> H2: Theoretical ATM covered call strategy yields higher excess returns and yields superior risk-adjusted results compared to benchmark STOXX 50 BuyWrite (ATM).

> H3: Adjusting the moneyness levels of covered call strategies results in higher risk-adjusted returns compared to traditional ATM covered call strategies.

The figure 12 highlights the varying risk-return distributions of the different option strategies. The STOXX 50 and STOXX 50 BuyWrite strategies exhibit noticeable central peaks, indicating a concentration of returns around specific values, which suggests consistent performance with limited variability. In contrast, the ATM and OTM strategies (2%, 5%, 10%) demonstrate smoother peaks with wider distributions, implying a broader range of potential monthly returns, including both moderate positive and negative outcomes. This reflects a more varied return profile, suitable for investors seeking growth with an acceptance of greater risk.

Tail behavior further highlights the risk-return dynamics of these strategies. The left tails of ITM -2% and STOXX 50 BuyWrite are heavier, indicating a higher probability of significant negative returns, while the lighter left tails of ATM and OTM strategies suggest reduced exposure to severe losses. Conversely, the right tails for ATM and OTM strategies are more pronounced, suggesting a higher potential for occasional large positive returns. This tail behavior implies that while conservative strategies like STOXX 50 BuyWrite offer stability, the ATM and OTM strategies provide greater upside potential at the cost of increased variability. Additionally, the skewness of the distributions indicates that ITM -2%

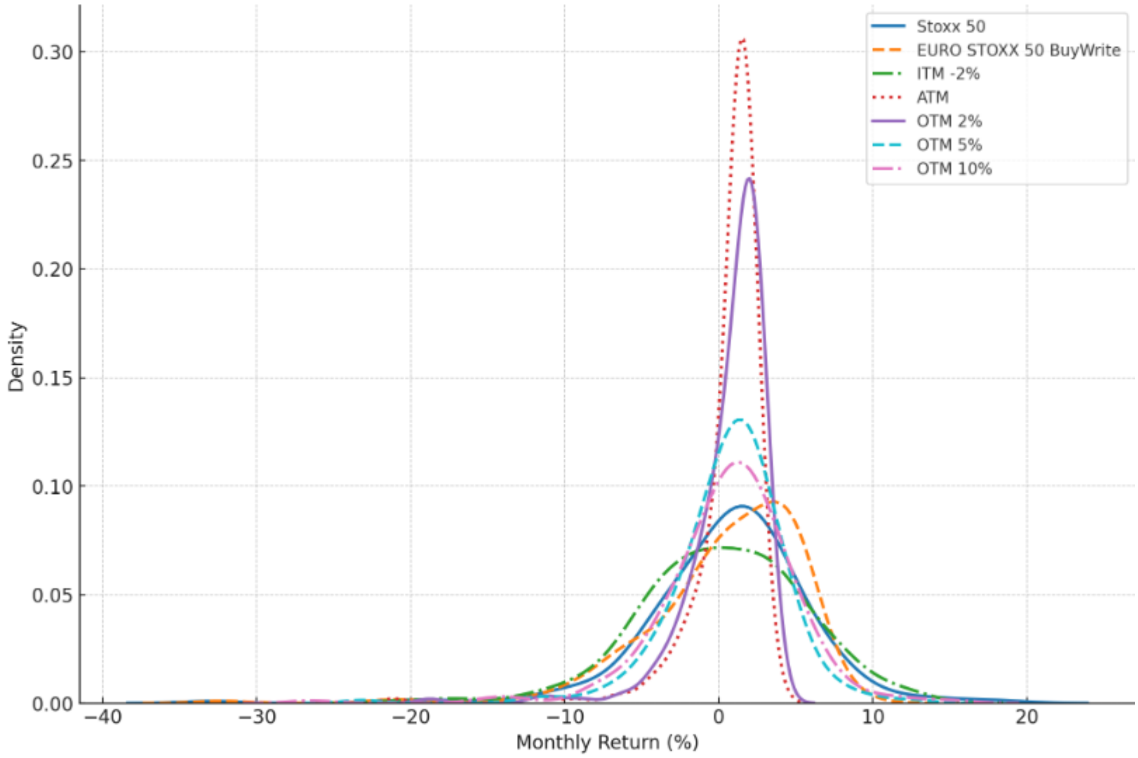

Figure 12: Monthly return distribution STOXX50 & covered call strategies 2004-2023

is slightly left-skewed, implying a greater likelihood of negative returns, whereas ATM and OTM strategies are either balanced or slightly right-skewed, indicating a higher chance of positive returns. The kurtosis of the ATM and OTM 2% strategies, characterized by flatter peaks, suggests higher dispersion and increased probability of extreme outcomes compared to the sharper peaks of STOXX 50 BuyWrite, which indicate more concentrated returns around the mean.

6.2.1 Theoretical covered call limitations and discussion

The comparison between the STOXX 50 BuyWrite strategy and the theoretical ATM covered call strategy reveals the practical limitations inherent in applying model-based strategies in actual financial markets. While the theoretical strategy might suggest superior risk-adjusted returns, the influence of transaction costs, liquidity constraints, execution risks, market timing issues, and volatility changes significantly impacts the actual performance of the strategy. The STOXX 50 BuyWrite strategy, which utilizes actual traded call options, provides a more realistic picture of what investors can expect when implementing covered call strategies in practice, often resulting in lower returns compared to the idealized theoretical outcomes.

Figure 13 demonstrates the 30-day rolling returns of STOXX 50 BuyWrite and ATM Strategy. It indicates that the theoretical ATM covered call outperforms the STOXX 50 BuyWrite strategy during market downturns. This could be explained by market friction and performance drag. Implying that during abrupt market movements it is not possible to write call options at the theoretical level.

Figure 13: Rolling returns for STOXX 50 BuyWrite and ATM strategy (30-Day Rolling)

Option premiums represent the price paid by the buyer to the writer of an option, reflecting the risk and potential value associated with the option's underlying asset. The tehoretical ATM stategy call option premium average is 2.45%, while Feldman and Roy (2005) reported an average monthly option premium of 1.69% for ATM call options, and

Hill et al. (2006) found that the average monthly premium is 2.1%. These variations in option premium levels highlight how premiums can differ significantly depending on market conditions, investor sentiment, and model assumptions. Such differences in premiums can distort option prices compared to actual financial market conditions. For instance, higher premiums may suggest greater market volatility or increased perceived risk, causing the theoretical option price to diverge from what investors are willing to pay in practice.

The VTOXX volatility spread, defined as the difference between implied volatility and realized volatility, provides key understandings into market expectations and risk perception. In figure 14, the volatility spread fluctuates over time, with significant negative spikes during major financial events, such as the 2008 financial crisis. A negative volatility spread implies that realized volatility has exceeded implied volatility, which often occurs during unexpected market turmoil. During these times, market participants underestimate the extent of actual price fluctuations, leading to increased market uncertainty and a rapid adjustment of expectations.

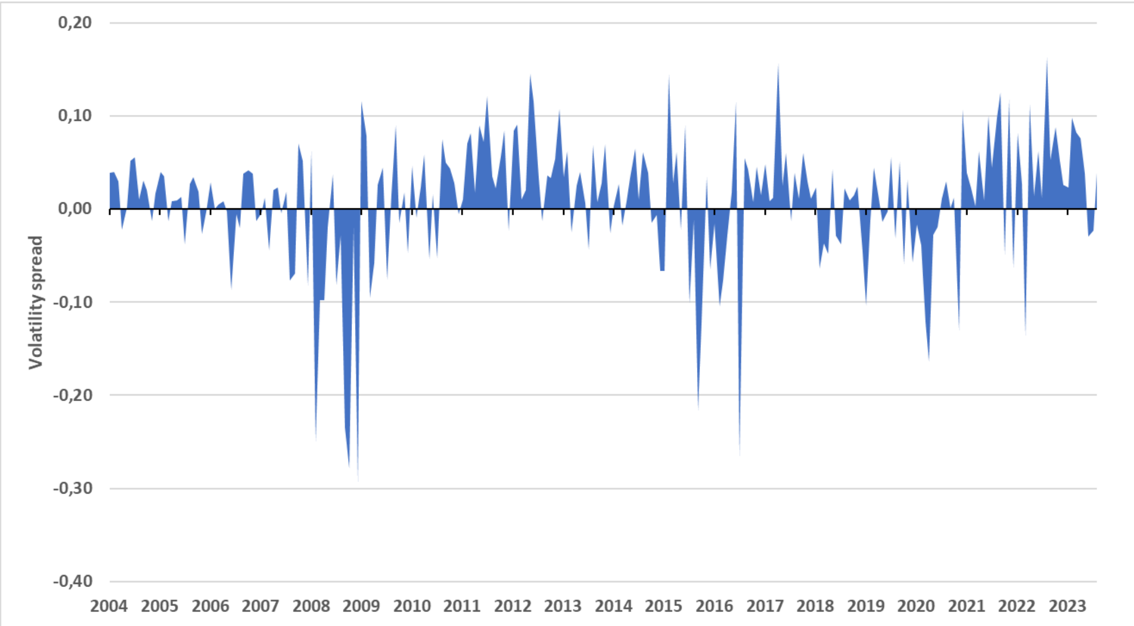

Figure 14: Volatility spread implied volatility vs realized volatility, VSTOXX

Higher implied volatility, figure 15, reflects increased uncertainty and perceived risk within financial markets. The frequent periods of higher implied volatility compared to realized volatility suggest a consistent risk premium demanded by option sellers to compensate for uncertainty. This risk premium can lead to a divergence between theoretical option prices and actual market prices, resulting in mispricing. For instance, options may be priced higher than their theoretical value due to elevated implied volatility, causing discrepancies in the perceived vs. actual cost of hedging.

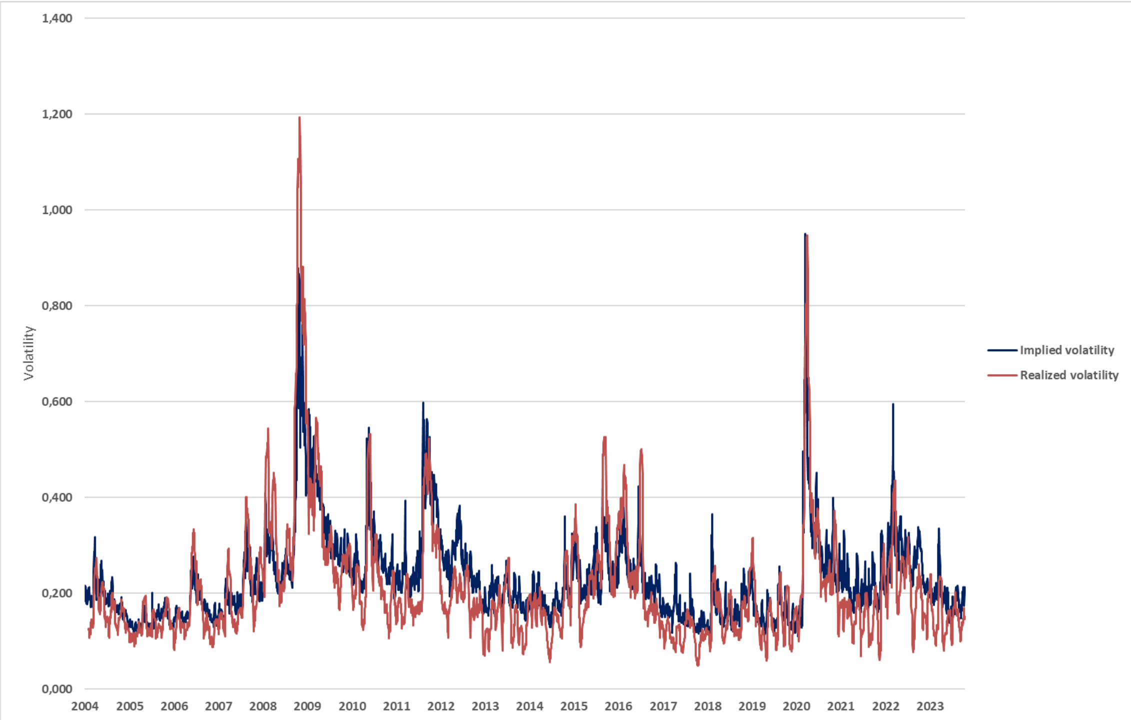

Figure 15: STOXX50 Implied volatility (VSTOXX) vs realized volatility 2004-2023

During market turmoil, such as the 2008 financial crisis and the Covid-19 pandemic, realized volatility tends to spike, as shown in the second graph. This spike in realized volatility implies increased market instability and unexpected price movements. When realized volatility is higher than implied volatility, it signals that the actual market risk is greater than anticipated, often leading to abrupt market corrections and increased stress on financial systems. The gap between implied and realized volatility underscores the challenges in predicting market behavior accurately, particularly during crises. Thus, understanding the dynamics between implied and realized volatility, and the resulting volatility spread, is crucial for assessing market risks, pricing options correctly, and making informed investment decisions. This gap could result into execution delays and difficulty finding favorable strike prices that can lead to not optimal premiums, further widening the performance gap (Stoll, 1978).

A theoretical covered call strategy can produce excess returns compared to real-world implementation due to simplifying assumptions, such as constant volatility, no transaction costs, and continuous price changes. In practical scenarios, factors like jump risk, transaction costs, volatility smiles, and the gap between implied and realized volatility introduce complexities that are not accounted for in traditional models like Black-Scholes. Additionally, the Greeks play an important role in understanding the sensitivity of option prices to various factors, helping to explain why theoretical returns may differ from actual financial market outcomes. In conclusion, while theoretical models provide a useful framework, they often fail to capture the complexities of actual financial markets, leading to discrepancies between expected and realized performance.

For further research, it would be valuable to extend the analysis to consider transaction costs, slippage, and liquidity constraints to provide a more realistic assessment of strategy performance. Additionally, examining the impact of different markets, such as high versus low volatility environments, could help better understand the conditions under which certain covered call strategies outperform. A study incorporating behavioral factors and market sentiment could also be insightful, as these elements play a significant role in option pricing and market dynamics. Moreover, future studies could explore alternative option strategies, such as collars or straddles, to determine whether they provide more effective risk management or return enhancement compared to covered call strategies.

7 CONCLUSIONS

The usability of covered calls within the Euro STOXX 50 Index is analyzed to assess the strategies viability as an investment strategy in the European markets, particularly during periods of low interest rates and market volatility. This study aims to contribute to the academic literature by examining whether covered calls can offer superior risk-adjusted returns, compared to simply holding the underlying STOXX 50 index. The motivation behind this research lies in the observed popularity of covered call strategies in financial markets and their increasing use in diversified investment portfolios. Covered call writing, a strategy involving holding a long position in an asset while simultaneously writing call options on the same asset, is proven to be an effective method to generate excess returns, particularly during times of low market volatility or moderate price appreciation.

The hypotheses proposed in this study focus on whether the previous studies hold true in the European markets during bullish, volatile, and low risk-free market conditions. To test this research question, the STOXX50 BuyWrite index is analyzed against the benchmark STOXX 50 index. Furthermore, theoretical covered call strategies with different moneyness levels are analyzed. The hypothesis used in this study are:

> H1: The benchmark STOXX 50 BuyWrite outperforms the underlying STOXX 50 index in risk-adjusted basis.
>
> H2: Theoretical ATM covered call strategy yields higher excess returns and yields superior risk-adjusted results compared to benchmark STOXX 50 BuyWrite (ATM).
>
> H3: Adjusting the moneyness levels of covered call strategies results in higher risk-adjusted returns compared to traditional ATM covered call strategies.

Results form the empirical part of this study indicate surprisingly that the STOXX 50 Buy-Write benchmark covered call do not show excess or risk-adjusted performance against the STOXX 50. This result is contradictory with previous studies. Even though, STOXX 50 BuyWrite results lower volatility and minor downward protection during market crashes, the return and risk profile do not support the claim that it is a usable investment strategy. Thus, the hypothesis 1 is not supported.

However, the theoretical covered call strategies show superior excess returns excluding the ITM -2% strategy. The ATM strategy outperforms the STOXX 50 BuyWrite strategy in terms of returns, risk-adjusted returns, and market sensitivity. The ATM strategy has a higher annualized return of 7.33% compared to the lower return 4,44% of the BuyWrite strategy. Additionally, the ATM strategy displays lower volatility, standard deviation of 8.80%, and a higher Sharpe ratio 0.75 compared to the BuyWrite strategy's Sharpe ratio of 0.29, indicating superior risk-adjusted performance. With a lower beta of 0.39, the ATM strategy is less sensitive to market movements than the BuyWrite strategy beta of 0.81, making it more appealing for investors seeking equity exposure with reduced market risk. Overall, the ATM strategy provides better returns, lower risk, and a more favorable risk-return profile than the STOXX 50 BuyWrite strategy thus the hypothesis 2 is supported.

The analysis of different moneyness levels showed that out-of-the-money (OTM) covered call strategies generally provided higher returns compared to the at-the-money (ATM) strategy. In particular, the OTM 2% and OTM 5% strategies delivered higher Sharpe ratios compared to the ATM strategy, suggesting better risk-adjusted returns. This is because the OTM strategies allowed for greater participation in market gains while still providing income through option premiums. Therefore, H3 is supported, as adjusting the moneyness levels of covered call strategies improved the risk-adjusted returns compared to the ATM covered call strategy.

Despite these promising findings of the theoretical covered call strategies, there are limitations to consider. The reliance on theoretical pricing models, particularly Black-Scholes, introduces challenges since assumptions like constant volatility and the absence of jump risks do not hold in real markets. The study also assumes perfect liquidity and ignores transaction costs, which would significantly affect the excess returns of these strategies. Furthermore, the empirical scope of the study is limited to European markets, which have distinct characteristics compared to U.S. or emerging markets. This limits the generalizability of the findings to other geographic regions.

In conclusion, theoretical covered call strategies prove to be a useful strategy for investors seeking to enhance income, reduce portfolio volatility, and improve risk-adjusted performance, particularly in stable or bearish market environments. However, the theoretical outperformance highlighted in this study highlights the need for caution when applying these strategies in real-world scenarios, where market conditions often deviate significantly from idealized assumptions. Future research could extend this analysis by including more comprehensive transaction cost models, assessing behavioral factors in option pricing, and considering the impact of varying interest rate environments. Ultimately, covered calls remain an attractive yet complex strategy for generating risk-adjusted returns, provided that investors are mindful of their limitations and the specific market environments in which they are used.

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Appendices

Appendix 1. EURO STOXX 50 BuyWrite. Source: (stoxx.com, Indexguide , 2024)

5.3.1. INDEX FORMULA

Two versions of the indices are available, Total Return and Price.

Total Return

The Total Return version of the index combines the EURO STOXX 50 (Net Return) Index and a EURO STOXX 50 call option. On regular trading days the Total Return version is calculated as follows:

$$\mathrm{BW(TR)}_t = \frac{\left[\frac{\mathrm{ESTX50(NR)}_t}{\mathrm{ESTX50(NR)}_{\mathrm{EXP}}} \cdot \mathrm{ESTX50}(P)_{\mathrm{EXP}}\right] - C_t}{\mathrm{ESTX50}(P)_{\mathrm{EXP}} - C_0} \cdot \mathrm{BW(TR)}_{\mathrm{EXP}}$$

The rolling is carried out monthly on every third Friday, i.e., on the expiry date (EXP).

$$\mathrm{BW(TR)}_{\mathrm{EXP}} = \frac{\left[\frac{\mathrm{ESTX50(NR)}_{\mathrm{EXP}}}{\mathrm{ESTX50(NR)}_{\mathrm{EXP}-1}} \cdot \mathrm{ESTX50}(P)_{\mathrm{EXP}-1}\right] - C'_{\mathrm{EXP}}}{\mathrm{ESTX50}(P)_{\mathrm{EXP}-1} - C'_0} \cdot \mathrm{BW(TR)}_{\mathrm{EXP}-1}$$

Where:

$\mathrm{BW(TR)}_t$	= EURO STOXX 50 BuyWrite index or EURO STOXX 50 BuyWrite (100%) index at time (t)
$\mathrm{BW(TR)}_{\mathrm{EXP}}$	= Settlement value of EURO STOXX 50 BuyWrite index or EURO STOXX 50 BuyWrite (100%) index at the previous expiry date (EXP)
$\mathrm{BW(TR)}_{\mathrm{EXP}-1}$	= Settlement value of EURO STOXX 50 BuyWrite index or EURO STOXX 50 BuyWrite (100%) index at the last expiry date before the previous expiry date(EXP-1)
$\mathrm{ESTX50(NR)}_t$	= Last price of EURO STOXX 50 (Net Return) index at time t
$\mathrm{ESTX50(NR)}_{\mathrm{EXP}}$	= Settlement price of EURO STOXX 50 (Net Return) index at the previous expiry date (EXP)
$\mathrm{ESTX50(NR)}_{\mathrm{EXP}-1}$	= Settlement price of EURO STOXX 50 (Net Return) index at the last expiry date before the previous expiry date (EXP-1)
$\mathrm{ESTX50(P)}_{\mathrm{EXP}}$	= Settlement price of EURO STOXX 50 (Price) index at the previous expiry date (EXP)
$\mathrm{ESTX50(P)}_{\mathrm{EXP}-1}$	= Settlement price of EURO STOXX 50 (Price) index at the last expiry date before the previous expiry date (EXP-1)
C_t	= Last price of the EURO STOXX 50 call option at time t
C_0	= Inclusion price of the EURO STOXX 50 call option, i.e. averages of all best bids quoted on Eurex between 12:15 – 12:45 CET on the last expiry date (EXP)
C'_{EXP}	= Settlement price of old EURO STOXX 50 call option at the last expiry date (EXP)
C'_0	= Inclusion price of the old EURO STOXX 50 call option; i.e. averages of all best bids quoted on Eurex between 12:15 – 12:45 CET on the last expiry date (EXP-1) before the previous expiry date (EXP)

Price

The Price version of the index combines the EURO STOXX 50 (Price) Index and a EURO STOXX 50 call option.

On regular trading days the Price version of the index is calculated as follows:

$$\mathrm{BW}(P)_t = \frac{\mathrm{ESTX50}(P)_t - C_t}{\mathrm{ESTX50}(P)_{\mathrm{EXP}} - C_0} \cdot \mathrm{BW}(P)_{\mathrm{EXP}}$$

The rolling is carried out monthly on every third Friday, i.e. on the expiry date (EXP).

$$\mathrm{BW}(P)_{\mathrm{EXP}} = \frac{\mathrm{ESTX50}(P)_{\mathrm{EXP}} - C'_{\mathrm{EXP}}}{\mathrm{ESTX50}(P)_{\mathrm{EXP\text{-}1}} - C'_0} \cdot \mathrm{BW}(P)_{\mathrm{EXP\text{-}1}}$$

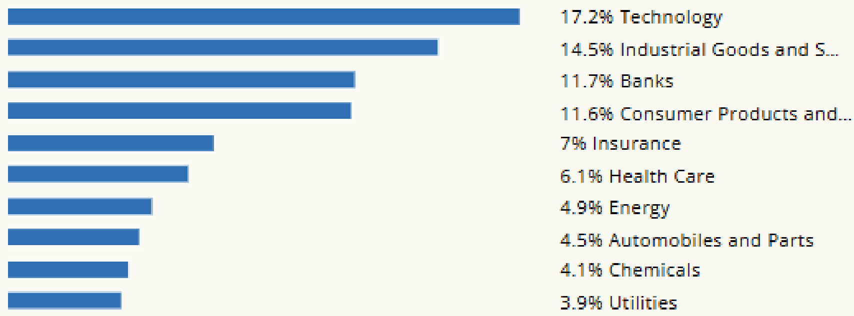
Where:

$\mathrm{BW(P)}_t$	= EURO STOXX 50 BuyWrite (Price) index or EURO STOXX 50 BuyWrite (100%) (Price) index at time (t)
$\mathrm{BW(P)}_{\mathrm{EXP}}$	= Settlement value of EURO STOXX 50 BuyWrite (Price) index or EURO STOXX 50 BuyWrite (100%) (Price) index at the previous expiry date (EXP)

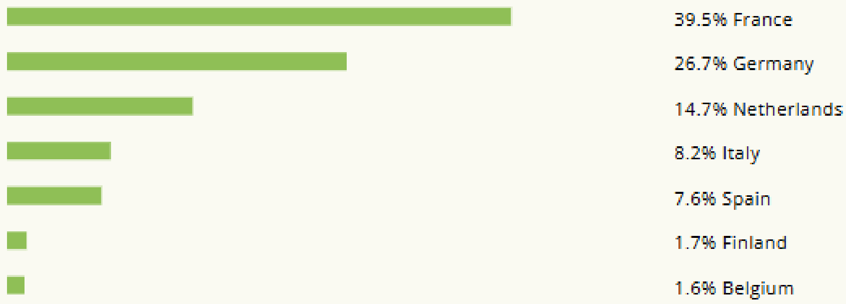
$BW(P)_{EXP-1}$	= Settlement value of EURO STOXX 50 BuyWrite (Price) index or EURO STOXX 50 BuyWrite (100%) (Price) index at the last expiry date before the previous expiry date (EXP-1)
$ESTX50(P)_{EXP}$	= Settlement price of EURO STOXX 50 (Price) index at the previous expiry date (EXP)
$ESTX50(P)_{EXP-1}$	= Settlement price of EURO STOXX 50 (Price) index at the last expiry date before the previous expiry date (EXP-1)
C_t	= Last price of the EURO STOXX 50 call option at time (t)
C_0	= Inclusion price of the EURO STOXX 50 call option; i.e. averages of all best bids quoted on Eurex between 12:15 – 12:45 CET on the last expiry date (EXP)
C'_{EXP}	= Settlement price of old EURO STOXX 50 call option at the last expiry date (EXP)
C'_0	= Inclusion price of the old EURO STOXX 50 call option; i.e. averages of all best bids quoted on Eurex between 12:15 – 12:45 CET on the last expiry date (EXP-1) before the previous expiry date (EXP)

Appendix 2. STOXX 50 index weighting. Source: (stoxx.com, Factsheet, SX5E, 2024)

Supersector weighting (top 10)



Country weighting



Top 10 Components[4]

Company	Supersector	Country	Weight
ASML HLDG	Technology	Netherlands	8.481%
SAP	Technology	Germany	5.938%
LVMH MOET HENNESSY	Consumer Products and Services	France	5.009%
TOTALENERGIES	Energy	France	3.993%
SIEMENS	Industrial Goods and Services	Germany	3.882%
SCHNEIDER ELECTRIC	Industrial Goods and Services	France	3.870%
SANOFI	Health Care	France	3.370%
ALLIANZ	Insurance	Germany	3.289%
AIR LIQUIDE	Chemicals	France	2.851%
L'OREAL	Consumer Products and Services	France	2.765%

[3]Net dividend yield is calculated as net return index return minus price index return
[4]Based on the composition as of September 30, 2024