Vaasan yliopisto
UNIVERSITY OF VAASA

Tommi Lehtonen

The impact of uncertainty on the pricing of derivatives

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UNIVERSITY OF VAASA
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Author: Tommi Lehtonen
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ABSTRACT:
The objective of this thesis is to examine the effects of uncertainty on the pricing of different derivatives. More specifically, the thesis examines the pricing of volatility in short-term and long-term, continuing with the influence of external uncertainty on derivative prices. Lastly, the thesis discusses the role of behavioral biases in derivative pricing.

The ambiguous nature of economic, political and geopolitic uncertainties conjectures that these factors contribute significantly to the use of derivatives. Since derivatives are highly relevant in risk-management and speculation, markets should incorporate uncertainty into prices, taking into account both the source and the magnitude of the uncertainty. Thus, external uncertainty should influence derivative pricing according to its specific type and nature.

Financial literature carries an assumption that volatility specifically stays constant, and only certain components affect the valuation of derivatives. However, previous studies provide strong evidence against the accuracy of rational pricing models. The studies give varying results on the pricing of volatility in derivatives, which depend on the maturity or the underlying asset of the derivative. Finally, behavioral finance and decision-making theories suggest that the ambiguity of uncertain prospects and risk-averse characteristics of market participants have a clear impact on rational asset pricing.

KEYWORDS: Derivatives, Uncertainty, Volatility, Pricing, Behavioral finance

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TIIVISTELMÄ:
Tämän tutkielman tavoitteena on tutkia epävarmuuden vaikutuksia eri johdannaisten hinnoitteluun. Tutkielma keskittyy tarkemmin ottaen volatiliteetin hinnoitteluun lyhyellä ja pitkällä aikavälillä, sekä tarkastelee ulkoisen epävarmuuden vaikutusta johdannaisten hintoihin. Lopuksi tutkielma käsittelee behavioristisen taloustieteen ja käyttäytymisharhojen roolia johdannaisten hinnanmuodostuksessa.

Taloudellisen, poliittisen ja geopoliittisen epävarmuuden monitulkintainen luonne antaa olettaa, että nämä tekijät vaikuttavat merkittävästi johdannaisten käyttöön. Koska johdannaiset ovat varsin oleellisia riskienhallinnassa ja spekuloinnissa, markkinoiden tulisi sisällyttää epävarmuus johdannaisten hintoihin ottaen huomioon sekä epävarmuuden lähde että voimakkuus. Näin ollen ulkoisen epävarmuuden tulisi vaikuttaa johdannaisten hinnoitteluun sen erityisen tyypin ja laadun mukaan.

Taloustieteellinen kirjallisuus olettaa hintojen volatiliteetin olevan vakio, sekä vain tiettyjen tekijöiden vaikuttavan johdannaisten hinnoitteluun. Viimeaikaiset tutkimukset tarjoavat kuitenkin vahvaa näyttöä rationaalisten hinnoittelumallien täsmällisyyttä vastaan. Tutkimukset antavat johdannaisten volatiliteetin hinnoittelusta eriäviä tuloksia, jotka vaihtelevat maturiteetin johdannaisen maturiteetin tai kohde-etuuden mukaan. Lisäksi behavioristiset rahoitus- ja päätöksentekoteoriat viittaavat siihen, että epävarmojen näkymien monitulkintaisuus sekä markkinaosapuolten halukkuus välttää riskejä vaikuttaa selvästi rationaaliseen hinnoitteluun.

AVAINSANAT: Johdannaiset, Epävarmuus, Volatiliteetti, Hinnoittelu, Behavioristinen taloustiede

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1 Introduction

Derivatives portray a crucial role in modern financial markets, serving various purposes for market participants. Different applications of derivatives in risk management, speculation, arbitrage and information gathering are widely recognized among firms, banks, institutions and other market participants. However, pricing such an instrument with theoretical accuracy can be complicated.

When geopolitical and macroeconomical uncertainty prevails, volatility tends to increase in the financial markets (Lin et al., 2024, p. 16). The fluctuation of asset returns and future uncertainty have an ambiguous impact on derivative pricing, which has sparked an extensive discussion in financial literature, and challenged the suitability of existing pricing models (Huang & Yao, 2021, p. 3278).

The Black-Scholes model holds as one of the most famous and commonly used models for pricing derivatives, especially options. The price of a derivative is directly shaped by several factors including volatility, whose estimation is particularly challenging. The BSM-model assumes constant volatility and risk-free rate in its pricing, and leaves indirect factors out of the equation (Black & Scholes, 1973, p. 640). However, fluctuations in volatility, along with macroeconomical and geopolitical uncertainty, can lead to potential mispricings and inefficiencies in the markets. An explanation for the lack of efficiency could lie in behavioral finance, which highlights investors being irrational and risk-averse from time to time.

Robert Merton (1980), along with many conventional asset pricing theories, suggests that there exists a risk-return tradeoff in the markets, implying that riskier investments tend to offer greater returns. On the contrary, there has been ongoing debate throughout history about the link between the two variables, which appears to be weak (Campbell & Hentschel, 1992). This has challenged the idea of a complete tradeoff.

This thesis examines how previously mentioned volatility and uncertainty affect the prices of derivatives based on mostly returns, risk premiums and implied volatility. Furthermore, the thesis addresses what drives the impact of indirect factors on derivative pricing.

1.1 Purpose of the study

The purpose of the thesis is to investigate how volatility and uncertainty affect derivative prices, and whether a stance about mispricing can be established. If implied volatility appears to be inflated compared to realized volatility, the study will then explore potential causes behind this. Firstly, it is theoretically expected that short-term derivatives are conceived as more reliable than derivatives with maturities of longer term. Hence, market participants may demand heavy premiums due to this perceived reliability. The pricing should then vary between derivatives with different maturities, leading to the first hypothesis:

H_1 = Implied volatility exceeds realized volatility in short-term

According to the Efficient Market Hypothesis (EMH), rational arbitraguers should prevent persistent mispricing by exploiting arbitrage opportunities, whereas pricing errors made by irrational participants should largely cancel each other out. However, if the prices seem to remain inflated, this may indicate behavioral biases related to risk-aversion and psychological pressure of bearing uncertainty. Furthermore, the role of external uncertainty, such as geopolitical risks, may not be presented in traditional pricing models, which might contribute to the pricing as well. Building on the first one, the second hypothesis goes:

H_2 = Uncertainty creates discrepancies in derivative pricing

The hypotheses are grounded in extensive literature on option pricing, return volatility, market efficiency and behavioral finance, leading to the two presumptions of the thesis.

1.2 Structure of the study

The structure of the thesis is as follows: The introduction chapter presents the key motivations and hypotheses of the study. Chapter Two establishes the foundations of derivatives and their valuation processes. Chapter Three explores market volatility and uncertainty to provide a solid understanding of the key variables under investigation. Chapter Four investigates behavioral dimensions that contribute to uncertainty and exemplifies it. Chapter Five reviews the relevant literature, and finally, Chapter Six concludes the thesis by summarizing the main findings.

2 Derivatives

The effect of external uncertainty and volatility in derivatives becomes easier to comprehend after securing an understanding of the basic principles regarding derivatives. Hence, derivatives will first be broken down to shed light on their fundamentals, leading to a more in-depth overview of the various types of derivatives. For the purposes of this thesis and the literature review, the discussion below features mostly futures, forwards and options, although swaps are considered briefly.

2.1 Derivative markets

Derivatives are mainly utilized in hedging, speculation and arbitrage (Hull, 2022, p. 41). In simplicity, a derivative works as a contract between two different parties involved in a predetermined agreement about a future transaction. It depends on the derivative's specific type, whether the contract is exercised optionally or automatically. There exists different markets where derivative trades occur, where market participants, liquidity and governance varies between the markets. Exchange-traded markets are regulated by institutional rules, price discovery and standardized contracts, where individuals and companies trade among each other (Dodd, n.d.). Whereas Over-The-Counter (OTC) markets are categorized by Hull (2022, Chapter 1.2) as less formal and largely unregulated, persuading mostly large financial institutions, corporations and banks.

As previously told, derivative's price derives from an underlying asset. The scale of different underlyings is enormous, with the more commonly used assets being commodities, energy, equities, stock indexes, treasuries, bonds, currencies and interest rates (CME Group, 2025). Due to the OTC market's less regulated nature, derivatives traded in this market can be constructed to meet the participant's specific needs, further expanding the scale of possible derivatives. The sole reason to use OTC derivatives instead of exchange-traded ones is to establish a perfect hedge, which fulfills hedging needs as well as other requirements, that are related to delivery for example (Heckinger et al., 2014, p. 27). The more unique and unusual derivatives traded in OTC markets are nicknamed as exotic derivatives, due to their complicated nature and payoff structures.

2.2 Different derivatives

As mentioned, derivatives are evolving continuously and the variety of different underlying assets keeps increasing. Next are some of the most fundamental and popularized instruments traded in the world of derivatives.

2.2.1 Futures, forwards and swaps

One of the most simple derivatives in the markets are futures and forwards, which have a similar function. A forward is an agreement about an exchange with a certain price, taking place at a certain date (Heckinger & Mengle, 2013, p. 3). The two parties take different sides of the contract, as one agrees to buy the underlying asset and the other one agrees to sell. In other words, the parties will take long and short positions respectively. As mentioned earlier, futures and forwards are alike, except futures are exchange-traded whereas forwards are traded in the OTC market (Hull, 2022, p. 30). Forwards can also be interpreted to have more counterparty risk because of the less regulatory environment of the OTC markets, as can be swaps.

Swaps are among the most essential instruments in the debt capital markets, involving set of two or more building blocks (Choudhry, 2010, p. 131). Swap contract is an OTC traded instrument between two parties agreeing to exchange cash flows typically in multiple future dates. Thus a swap contract can be viewed as a series of multiple forward contracts. A common swap of interest rates involves one party paying fixed rate and the other one floating rate on a stream of cash flows. Same principle can be applied to currency exchange rates and other variables such as volatility or variance (Hull, 2022, p. 195). A variance swap is a cash-settled forward contract involving one party to pay fixed delivery price to the other one, which is usually the amount of the market-implied variance at inception (ECB, 2007, p. 89). The buyer profits if the realized variance exceeds the initial market-implied variance.

Due to the obligatory nature of forwards and futures, the payoff from either contract can be calculated straight from the delivery price and the asset's price for immediate delivery, also known as the spot price. Unlike the forecoming options, forwards and futures don't require any premium in order to enter the contract (Hull, 2022, p. 31). This yields that the long position's total gain from a forward or future contract is the asset's spot price subtracted by the contracts delivery price. Conversely for the short position, the opposite holds true. Hull (2022, p. 30) also states that the prices of futures and forwards are ultimately set by supply and demand. This implies that an increase in demand for long positions drives the prices up, whereas increased desire to go short puts downward pressure on the prices.

2.2.2 Options

Options are among the most popular derivatives used for variety of purposes. An option displays a right but no obligation to buy or sell an underlying asset with a certain strike price and maturity (Hull, 2022, p. 31). Call options give the right to acquire the asset and put options give the right to sell the assets. The price to pay is ultimately determined by the market participants. In addition, "American" options give the right to exercise the contract at any given time up to its maturity, whereas "European" options can be exercised only on the expiration date (Black & Scholes, 1973, p. 637).

Options display asymmetrical balance of rights and obligations, due to the the seller having an obligation to sell (buy), if the buyer decides to exercise the call (put) option (Heckinger & Mengle, 2013, p. 4). Moreover, the seller usually requires a premium from the buyer. This premium can be viewed as an insurance premium paid by the buyer in exchange for the right, but not the obligation, to exercise the contract if needed, which provides a form of protection (Choudhry, 2010, p. 157). The premium further distinguishes options from other derivatives, as their payoff structures vary between the buyer and the seller.

The participant selling (shorting) a call or put option, receives a maximum payoff equal to the premium collected, assuming that the option buyer acts rationally and exercises the contract only when it's beneficial. If exercising the option would be against the buyer's best interests, the option expires worthless and results in a loss that is limited to the premium that was paid to the seller. If an option is profitable, it is said to be In-The-Money (ITM), which means that the strike price is below the spot price, in the case of a call option. On the contrary, put options are considered to be in-the-money when the strike price is higher the spot price. Options are At-the-money (ATM), when the spot price and strike price are equal.

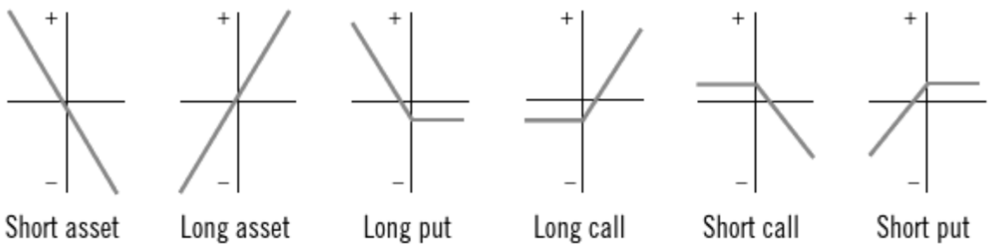

Figure 1. Payoff structures of options (Choudhry, 2010, p. 160).

2.3 The pricing of derivatives

Fundamental pricing methods and underlying assumptions used in derivative valuation are briefly introduced below, leading to a more in-depth investigation of option pricing and the Black-Scholes-Merton model. The role of volatility and indirect components in the pricing processes are also addressed.

2.3.1 Underlying assumptions

There are several assumptions that justify the pricing formulas and establish the basis for their applicability. To make sense of the underying foundations, Hull (2022, p. 39) assumes that there are neither arbitrage opportunities nor transaction costs regarding futures and forwards. Moreover, depositing and lending are presumed to occur at the same risk-free rate, and based on Merton's (1973, p. 178) findings, discounting and compounding can also be conducted using a risk-free rate in the pricing processes. In addition to futures and forwards, the same assumptions are applied in the pricing of options in the BSM-model (Black & Scholes, 1973, p. 640). Lastly, common calculations of swap prices are typically based on the future value of an interest rate, currency exchange rate or some other underlying variable (Hull, 2022, p. 172).

2.3.2 Pricing and valuation

Prices of futures and forwards can be derived from specific variables, such as time to maturity, today's price of an underlying asset and a risk-free interest rate expressed with continuous compounding (Hull, 2022, p. 126). In the case of options, strike price and volatility factors come also into the equation (Choudhry & Eales, 2003, p. 190). The pricing of volatility makes the calculation of a theoretically correct derivative price more complicated, as opposed to forwards and futures.

Forwards and futures' theoretical prices are formed similarly by compounding an underlying asset's price at the time of the pricing with a risk-free interest rate until the contract's maturity (Hull, 2022, p. 130). The pricing does not include a volatility variable. However, as previously mentioned, future and forward prices move accordingly to the laws of supply and demand, indicating that increase in either variable should move the prices respectively. In addition, Keynes (1930) has argued that speculators demand a premium for the exposure of volatility and insurance provided to the hedgers, resulting in discount on the future prices (Chang, 1985, p. 193). On the contrary, option prices are directly affected by volatility, which enables complex pricing models for options (Hull, 2022, p. 247).

Before expiration, option's price is said to simply consist of intrinsic value and time value (CME Group, 2025). Long call option's intrinsic value is marked by the difference between the underlying asset's market value and the contract's strike price. For long put options the opposite holds true. In the case of going short on either one, intrinsic value is the opposite of going long (Hull, 2022, p. 231). Thus the difference between option's overall value and its intrinsic value is considered the time value. Furthermore, Black and Scholes (1973, p. 638) cover that options tend to usually decrease in value if the time to expiration decreases. The volatility factor is also closely linked to time value, as longer time to maturity increases the probability of price fluctuations (Hull, 2022, p. 249).

2.3.3 BSM-model

One of the most profound and famous option pricing models is the Black-Scholes-Merton model, or simply Black-Scholes model, which presents a pricing mechanism for Europen options (Black & Scholes, 1973, p. 640). In their model, Black and Scholes (1973,

p. 640) assume that the stock pays no dividends, there are no transaction costs, short selling is allowed without any penalties and borrowing with risk-free rate is possible. Based on the assumptions, the only inputs affecting the value of an option in the BSM-model are the current stock price, time to maturity and variables taken as constants: stock price volatility and the risk-free interest rate (Black & Scholes, 1973, p. 641). The formulas for call and put options are the following:

$$c = S_0N(d_1) - Ke^{-rt}N(d_2) \text{ and} \qquad (1)$$
$$p = Ke^{-rT}N(-d_2) - S_0N(-d_1), \qquad (2)$$

where the *c* and *p* variables are the prices of a European call and a put option, *S* marks the current stock price, *K* is the strike price, *r* is the risk-free rate compounded continuously and *T* stands for time to maturity. The different variations of *N(d)* are the functions of cumulative probability distribution for a variable with a standard normal distribution (Hull, 2022, p. 353). In addition, volatility appears in these formulas of cumulative probability distribution functions as its own variable.

Assumption of the constants in the BSM-model has faced criticism about their applicability. Regarding the constance of the risk-free interest rate, Choudhry (2010, p. 180) points out rates being dynamic, which makes the assumption unrealistic. Moreover, an interest rate swap generally serves the sole purpose of eliminating the uncertainty caused by fluctuating interest rates. Continuing with volatility, the model's premise is that the share price follows geometric Brownian motion, which depicts volatility as constant (Choudhry, 2003, p. 191). However, Andersen et al. (2001, p. 44) underscore a widely known fact among finance academics, that volatility varies over time. In particular, the BSM-model assumes smooth and continuous price paths, which is partially overturned by the existence of jumps and discontinuities in stock prices (Bollerslev & Todorov, 2023). This idea gets backed by Choudhry's (2010, p. 180) notion that in reality the movements of stock prices, especially relatively high or low, are not deterministic. The constant variance or volatility assumption has been labeled as dubious, and is further illustrated by the BSM-model's remarkably worse pricing accuracy of foreign currency options than regular stock options (Heston, 1993, p. 328). Thus, the insufficient pricing of variance has led to the development of models with stochastic volatility and jump risks. Hull and White (1987, p. 299) note that under the assumption that a stock option's volatility is uncorrelated with its price, the BSM-model overprices options when the strike and spot prices are equal (at-the-money), and underprices options deep in-the-money or out-of-the-money.

2.3.4 Variance and jump-risk premiums

Volatility in the financial markets can be translated to measure price fluctuations and uncertainty about returns (Hull, 2022, p. 342). Simultaneously option prices are established to carry a premium, which represents the expected profits gained from the contract (Choudhry, 2010, p. 166). A required premium is essentially the extra return an investor demands for bearing risk, which results in a discount on the asset's price. One of the most generally known premiums is the equity risk premium, which serves as a compensation for the deviation of the asset returns (Fama & McBeth, 1973). Since the underlying asset's price determines whether an option will be exercised, its price plays a crucial role in the assesment of the option's demanded premium. The more radical price behaviour the underlying asset, the greater its influence on option pricing (Choudhry, 2010, p. 168). Hull (2022, p. 248) completes the notion by stating volatility to always increase an option's price, regardless if the option is a put or a call option.

In addition to equity risk premiums, financial literature establishes a risk for the fluctuation of variances themselves, called variance risk, which demands a premium for the randomness of future variance (Todorov, 2010, p. 345). There exists different variations for calculating the premium, as unique models for expected and implied volatility are utilized. Carr and Wu (2016, p. 3) define this premium as the difference between option implied volatility and the option expected realized volatility. The Bank of Canada (2017) on the other hand, explains the concept of variance premiums as the difference between option implied volatility and the actual realized volatility, both of which are examined later on. However, the classic capital asset pricing models account for only continuous risks, thus leaving sudden price jumps out of the equations (Arouri et al., 2019, p. 1). The indication is that returns should behave smoothly through gradual movements.

However, evidence of discontinuous price movements proves that there exists continuous price changes as well as discontinuous price jumps (Bollerslev & Todorov, 2023, p. 1). In theory, asset prices should instantly jump and adjust to reflect new information as it becomes available, or so does the efficient market hypothesis state (Christensen et al., 2025, p. 1). Research literature strongly suggests that jump risks as well as risks of extreme events explain the variance risk premiums in asset pricing, and constitute an important determinant to the pricing of options too (Alexiou & Rompolis, 2024). What's more, Eraker et al. (2004, p. 1293) conclude that pricing models without jumps in volatility are inevitably misspecified and insufficient, as conditional return volatility is left out. There is also evidence from the behaviour of equity prices following earnings announcements suggesting that markets engage in rapid price discovery, which can get overvalued or underestimated from time to time (Christen et al., 2025, p. 23). Nevertheless, derivatives incorporate risk premiums such as equity, variance and jump-risks in response to future uncertainty. This leads wide range of external factors to influence the pricing of derivatives indirectly.

3 Uncertainty in the derivative markets

Financial uncertainty can be depicted in various ways and quantified through different measures. In financial markets, uncertainty may arise from realized stock market volatility, and additionally from higher levels of implied volatility. At the aggregate level, uncertainty surrounding economic policy, trade wars, geopolitical risks and future macroeconomic health of the economy all contribute to the unpredictability of equity prices.

3.1 Realized and implied stock volatility

Volatility marks as a traditional estimate of risk, playing a central role in risk management and asset pricing (Andersen et al., 2001, p. 44). Stock volatility reflects the distribution of an asset's returns over a period of time, and therefore presents a risk factor. This is due to the increasing probability of financial loss as volatility in the markets increases (De Silva et al., 2017, Chapter 14). Furthermore, volatility can be divided into realized volatility and implied volatility. Realized volatility measures the variability of returns over specific time period, which can be calculated empirically from data (Andersen et al., 2003). It gives an unbiased estimate of return volatility, and under suitable conditions, it forecasts future risk highly efficiently (Andersen et al., 2003, p. 581). Although, Andersen et al. (2001, p. 45) point out that realized volatility is a noisy indicator of volatility, meaning it contains a lot of randomness. Additionally, realized volatility has the dynamics of both continuous price processes and jumps, which weakens the forecasting power of the simpler models of realized volatility (Andersen et al., 2007).

However, many studies have found option-implied volatility to be superior as a volatility estimator compared to realized volatility, due to its forward-looking nature (Jeon et al., 2020, p. 1109). As per Hull (2022, p. 358), implied volatility is the volatility that is implied by the option prices, depicting the market's opinion about the volatility of a particular asset. One of the most well-known benchmarks for implied volatility and market uncertainty is the VIX index, which is essentially calculated from the bid and ask quotes of the S&P 500 index options. VIX index solves the value for volatility from the option prices and provides insight into the market's expectation of future volatility for the next 30 days (CBOE, 2025). In addition, the VIX index itself can be an underlying asset for a derivative, allowing market participants to speculate and hedge purely on implied volatility.

Furthermore, the SKEW index aims to provide greater clarity on the market's opinion about disaster-risks and financial downturn compared to regular the VIX index. The SKEW index gets derived from the S&P 500 index options the same way the VIX is, but instead of using broad range of options with different strike prices, SKEW index includes only options that are out-of-the-money. Thus, the SKEW index captures more accurately the pricing of extreme market movements (Mora-Valencia, 2021).

To quantify uncertainty related to stocks, different measures can range from realized and implied volatility to even volatility of implied volatility (VoV). Specifically, volatility of option-implied volatility reflects the uncertainty about future uncertainty. It's being praised for advantages such as forward-looking nature, ease of calculation and the fact that it's derived directly from the market transactions (Jeon et al., 2020, p. 1110). Nevertheless, Andersen et al. (2001, p. 44) state that the validity of volatility measures such as stochastic volatility models, depend on specific distributional assumptions. In addition, the validity of implied volatilities depends upon further assumptions about the market price of volatility risk (Andersen et al., 2001, p. 44).

So far, none of the previously introduced measures address the cause of the realized or implied volatility in question, regardless of which measure is chosen. Thus, potential sources of volatility and uncertainty are examined next.

3.2 External drivers of uncertainty

Fluctuations in economic policy, geopolitical landscape and general macroeconomical uncertainty are known to create concerns among market participants and trigger additional market volatility. These indirect factors have the potential to contribute to the pricing of derivatives.

3.2.1 Economic policy

Economic policy uncertainty plays a vital role in shaping future volatility, as economic policies and disputes affect the decision-making of economic agents (Laubsch et al., 2024, p. 1). Governments are in the central of shaping the environment where the private sector operates, contributing via taxes, subsidies, law enforcement and environmental policy regulation (Pastor & Veronesi, 2012, p. 1219). In addition, numerous studies have recognized the impact of economic policy uncertainty on assets such as stocks, bonds and commodities (Cheng et al., 2024, p. 50). This gets backed by Goodell and Vähämaa's (2013, p. 1109) study, where they find evidence of political uncertainty inflating the option prices around the US presidential elections. The study underscores uncertainty about future politicial outcomes to affect investors' decision-making and consequently the pricing of options, due to the potential impact of future political effects.

The political stance of a country can significantly shape its future economy through trade policy, which stands out as one of the most substantial political decisions. Indeed, trade policy contributes directly to the level of economic uncertainty (Laubsch et al., 2024, p. 2). By determining trade relations and tariffs, trade policy affects the imports and can spread uncertainty to other markets, influencing sales and production plans of firms (Crowley, 2018, p. 96). Thus, derivative markets are directly influenced by trade policies, since derivatives are immensely utilized in hedging and speculation in the middle of turbulent international markets.

Lastly, it is found that economic policy uncertainty (EPU) and forecasted short-term excess stock returns are positively correlated, with equities more sensitive to EPU tending to underperform those that are more resilient (Brogaard & Detzel, 2015, p. 3). Additionally, the uncertainty has been recorded to induce unemployment and suppress investment activity, which is why it commands a risk premium among market participants (Kelly et al., 2016, p. 2418).

3.2.2 Geopolitical risks

Strenuous literature highlights geopolitical risks to pose a threat to the stability of the world's financial system, and presents geopolitical uncertainty as one of the explanatory reasons for market phenomenons such as risk premiums, disaster risks and market volatility (Bouri et al., 2025). Moreover, geopolitical risks are shown to foreshadow lower levels of investment and employment, due to an increased probability of disaster and long-term risks (Caldara & Iacoviello, 2022). Geopolitical risks could disrupt global supply chains and potentially influence the flow of capital and trade, highlighting the similarities between economic and geopolitical uncertainty (Caldara & Iacoviello, 2022).

Acharya et al. (2013, p. 461) find that when speculators are capitally constrained and commodity producers have an increased desire to hedge, commodity futures prices are pressed down from their regular prices. This is more or less due to the increased supply of futures triggered by hedging commodity producers, and the lack of demand from speculators and arbitraguers. Another previous example of financial effects disseminating from geopolitical risks is the Russia's war of aggression against Ukraine. As a result of sanctions placed against Russian banks and changes to the currency system, systemic risk transmitted from the ruble to other markets and triggered a spillover of volatility across numerous assets (Lin et al., 2024, p. 13).

Interestingly, both economic policy and geopolitical risk uncertainty are positively correlated with return volatility, at least in the commodity markets (Laubsch et al., 2024, p. 2). Although uncertainty stemming from economic policy and geopolitical risks share similar characteristics, there seems to be one key difference between them. Apparently, economic policy uncertainty tends to push commodity prices down due to potential supply disruption, but geopolitical uncertainty doesn’t. (Laubsch et al., 2024, p. 2). Smales (2021, p. 359) adds that geopolitical risks have a greater effect on energy price volatility than stock volatility, which is primarily due to the previously mentioned supply-side factors.

3.2.3 Aggregate macroeconomic uncertainty

Whether uncertainty originates from economic policy or geopolitical risks, the macroeconomic health of an economy stands out as a key determinant in the valuation of different assets. As noted by Schwert (1989, p. 1116), a shift in uncertainty about future aggregate level of economy clearly influences prices, through the discount of expected future cash flows. In the case of actively traded treasuries and government bonds, the cash-flows are fixed, which yields that the discount rates are actually the only relevant quantities in the pricing of bonds (Beber & Brandt, 2006, p. 1998). The effects of macroeconomic shifts are further addressed by Shiller (1981, p. 434), as he notes that the fluctuations of future dividends have a direct influence on the volatility of stock returns.

Current macroeconomic volatility measured by inflation, industrial production growth and monetary growth, all predict weakly the volatility of stocks and bonds (Schwert, 1989, p. 1145). Conversely, Schwert (1989) finds the correlation between the two to be stronger when financial asset volatility predicts macroeconomic volatility. This is explained by the tendency of speculative assets to react quickly on information about future economic events, and in general, market fluctuations are perceived negatively. However, volatility does not always signal a negative growth within economic conditions.

Economic uncertainty seems to be diverse and categorized as either good or bad, depending on the underlying innovations. Segal et al. (2015, p. 369) state that bad uncertainty refers to volatility, which is associated with negative effects on macroeconomic variables, such as consumption and earnings, while good uncertainty is linked to positive innovations to investment and rising asset prices. In essence, market fluctuations under good or bad uncertainty arise from expectations of the future, which in turn generates volatility (Segal et al., 2015, p. 369). Segal (2015) adds the volatility to be triggered from the fact that, even if the market's trajectory seems clear, the scale and magnitude of it remains unknown.

3.2.4 Monetary policy

Monetary policy aims to achieve various economic goals such as targeted inflation and growth rates, primarily by controlling money supply and interest rates. That is why the announcements by the most influential central banks can significantly impact the exchange rates, due to the significant link between the leveraged currency markets and monetary policy (Mueller et al., 2017, p. 1213). This linkage enables monetary movements to potentially disrupt the prices of especially currency derivatives. Moreover monetary policy contributes to the aggregate health of economy, as discounting is directly affected by changes in real interest rates and risk-free interest rates.

Traditional portfolio allocation models forecast increasing interest rates and tight monetary policy to reduce risk-seeking. This is due to higher interest rates on safe assets tending to appeal to risk-return preferences of investors (Dellariccia et al., 2017, p. 614).

Conversely, the relationship between monetary policy and stock market volatility constantly shows, that loose monetary policy tends to feed risk seeking in the short-term future. This gets exemplified by Bekaert et al. (2013, p. 722), as they show positive correlation between VIX and the past real interest rates, indicating that risk seeking increased as real interest rates decreased.

In periods of low interest rates, a herding behaviour among investment managers tends to amplify the overall riskiness in the markets. Apparently, the managers seek to avoid underperformance by adopting similar riskier investment strategies (Bekaert et al., 2013, p. 787). Park and Sabourian (2011, p. 974) note that the same applies to times of great economic uncertainty, where price fluctuations occur partially due to behavioral shifts within investors, yielding market participants to follow the crowd. Whether driven by high risk appetite or market uncertainty, the absence of clear direction can lead to irrational behavior and trigger emotionally driven unfounded actions such as herding. This goes on to highlight the relevance of behavioral finance and decision-making theories in the valuation of derivatives.

4 Behavioral dynamics of derivative pricing

The notion of perfect rationality in economics, which includes rational derivative pricing, has been widely challenged throughout the years. Kahneman (2003, p. 1449) goes as far as to argue that rational models are not only improbable, but also psychologically unrealistic. The substantial evidence on volatility smiles and pronounced pricing associated with hedging, demonstrate the role of the human factor in derivative markets.

Recalling the volatility variable in the Black-Scholes-Merton option pricing model, it is empirically evident, that derivative markets contradict the assumption of a constant volatility. Derivatives often exhibit a curvature known as the volatility smile, which reflects a pattern where implied volatility increases as the options move increasinly to either in-the-money or out-of-the-money (Buraschi & Jackwerth, 2001, p. 495). Moreover, if the maturity and strike price of an option remain unchanged, the volatility smile is identical for calls and puts, due to arbitrage-free markets. Regarding equity options, Hull (2022) underlines the volatility smile to resemble a skew rather than a smile, due to the negative correlation between volatility and stock prices. For the same reason an implied probability distribution for stock options expresses heavier pricing of volatility in options with low strike price, relative to ones with higher strike price (Hull, 2022, p. 457). Given the assumption of constant volatility in the BSM model, the implied volatility curve should appear flat across all the strike prices, though it does not. Buraschi and Jackwerth (2001, p. 496) aknowledge that the violations of theoretical models are of such nature that market imperfections alone do not provide a sufficient explanation.

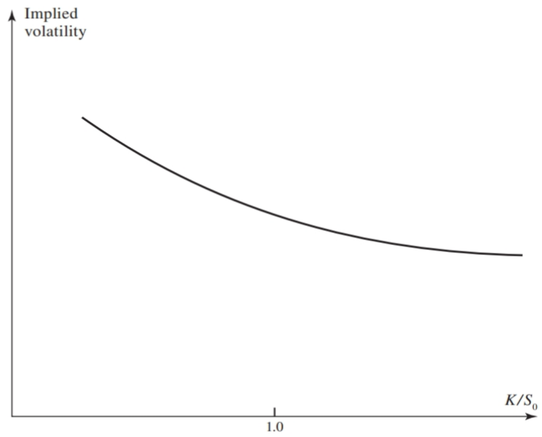

Figure 2. Volatility skew for stock options (Hull, 2022, p. 456)

After establishing the negative correlation between equity prices and volatility, Hull (2022, p. 457) identifies financial leverage as one of the explanatory reasons for the volatility, along with higher required premiums triggered by external factors. Still, the cause for these external factors remain unanswered. The famous psychological theory of prospects by Kahneman and Tversky (1979) provides a plausible reason for the relatively high implied volatilities through the concept of risk aversion. The prospect theory notes that people tend to avoid sure losses, and are characteristically more sensitive to losses than to gains of the same size (Kahneman, 2003, p. 1456). Kahneman and Tversky (1979, p. 264) illustrate risk aversion as the preference for a certain outcome over a risky one, that has an expected value equivalent to the value in the certain prospect. The prospect theory provides two separate phenomenons that cover the overweighing of certain prospects: certainty effect and reflection effect.

Kahneman and Tversky (1979) note through the concept of certainty effect that people tend to overweight certain outcomes relative to merely probable ones. Even if the alternative prospect offeres a slightly higher expected value, people seem to overwhelmingly choose the guaranteed gains (Kahneman & Tversky, 1979, p. 265). The reflection effect portrays a different version of the desire for certainty, when the gains are replaced by losses. Given a choice between a certain loss and a risky prospect with small chance of avoiding the loss but lower expected value, well majority of the people tend to choose the latter option (Kahneman & Tversky, 1979, p. 268). Both of the effects highlight the power of certain outcomes over rational decision-making. However, when the probabilities are unknown, the expected value of a prospect cannot be calculated, and the concept of risk aversion gets expanded.

Fox and Tversky (1995, p. 585) highlight this fundamental issue in decision-making, where the probability of an outcome is unmeasurable. As a result, individuals are left with ambiguity, which shifts decision-making towards the valuation of unclear prospects. Fox and Tversky (1995, p. 586) suggest, that an ambiguous prospect commands a greater risk premium than a measurable risk, as their numerous experiments show a preference for well-defined bets over ambiguous ones. However, Kahneman (2003, p. 1454) implies that ambiguity gets suppressed when decision-making is based on intuitive judgement, as it typically is among experienced decision makers. This is compatible with Fox and Tversky's (1995) finding where ambiguity aversion increases when decision-maker acts on inferior knowledge and decreases when decision-maker feels competent.

Nonetheless, the aversion of risk and ambiguity highlight a tendency among people to overweight certain outcomes in decision-making, while being reluctant to act on decisions with ambiguous outcomes. Hence, the prospect theory and aversion of ambiguity would suggest that during the times of market fluctuation and unclarity, instruments of certainty attract investors regardless of pronounced valuation.

5 The contribution of uncertainty in derivative pricing

The pricing of derivatives has attracted significant attention from academics and researchers throughout their development. Derivatives have fundamentally shaped the valuation of uncertainty and volatility. More importantly, perceptions of price fluctuations have dominantly been found negative, which goes on to question how risk-averse the market participants actually are. It could be conjectured that the prospect of losing, accompanied by external uncertainty create discrepancies in derivative markets. This could potentially explain the time-varying pricing of volatility. This chapter examines implications drawn from the relevant research and academic studies, and critically discusses implications made for and against the hypotheses of the thesis.

5.1 The price of short-term volatility

Hedging volatility through any derivative eliminates uncertainty related to prices completely, while options provide insurance against fluctuations. This utility is expected to be more accurate in short-term than long-term, providing more reliability to the buyer. Carr and Wu (2016, p. 2) confirm that investors have much more confidence on movements of implied volatilities in near-term than in the long run. Hence, it should be logical for derivatives with short maturities to command a premium for their convenience, which would result in higher prices.

Giglio et al. (2017) cover this subject through risk premiums on variance swap contracts and variance forwards on S&P 500 with several maturities. Variance swaps reward the investor for taking on direct exposure of the future variance. The contract earns surplus for the buyer if realized variance is greater than expected. Thus, variance swaps serve as a pure hedge against future variance, and gives insight into the pricing of volatility. Giglio et al. (2017, p. 233) state, that with the strategy of buying a variance forward and selling it 30 days later, forwards with maturities of one or two months earned heavily negative risk premiums. On the other hand, maturities of three months or more earned zero or even positive risk premiums. Eraker and Wu (2017, p. 73) obtain similar results regarding the pricing of short-term volatility derivatives, as they record large negative annualized returns on VIX futures. Giglio et al. (2017, p. 235) suggest that the large demanded premiums serve as a compensation for the hedge against realized volatility. The authors actually found forwards with maturities over one month being purely exposed to news about future volatility, not to realized volatility. More precisely, movements in VIX future prices are largely driven by the expectations of the first two weeks of the contract, after which the pricing is much more gradual (Giglio et al., 2017). So, it appears uncertainty didn't exhibit heavy pricing as the risk premiums weren't negative, or even turned out to be positive. This could challenge many theoretical models of asset pricing and the commanded premiums on futures as proposed by Keynes (1930).

However, it must be noted, that the previous studies are restricted to volatility that is related to companies listed on the S&P500 only, which yields at least two shortcomings: Even though the S&P500 and U.S. stocks are among the most globally traded assets, the studies lack geographical validity, as they exclude markets such as European and Chinese stocks. Furthermore, the volatility considered in these studies completely ignores the fluctuations in all the other asset classes beyond equities, revealing only the pricing of financial volatility. To get a deeper insight into the behavior of uncertainty and volatility, a study using larger scale of underlyings from several different markets gets reviewed next.

The study of Dew-Becker et al. (2021) examines how both uncertainty and realized volatility are perceived by investors, whether they are priced differently, and how shocks to implied volatility affect derivative returns. The study's conclusions are built up on risk premiums and returns gathered from a wide scale of different option contracts from 19 different option markets. In their study, the hedging of future uncertainty is executed through option contracts with commodity, VIX and other index futures as the underlying assets. The results reveal the risk premiums on hedging implied volatility to be positive in the majority of the cases, whereas hedging realized volatility brought overall negative returns. This aligns with the previous findings of Giglio et al. (2017) on the pricing of future uncertainty. For nonfinancial underlyings, the returns from hedging uncertainty are significantly positive, whilst financial underlyings didn’t carry negative nor positive risk premium on average. However, the hedging of realized volatility in both financial and real sectors of the economy consistently earned negative returns (Dew-Becker et al., 2021, p. 25). Moreover, the premiums on OTM options are twice as large relative to the premiums on ITM options, which could imply that investors are more averse to large fluctuations in the markets rather than small movements. Paired up with the fact that hedging future uncertainty didn’t command significant premiums, the role of behavioral finance and psychological factors are seemingly brought into the discussion. Nevertheless, large premiums on derivatives that hedge short-term volatility lack a thorough justification, even though potential implications can be drawn.

Eraker and Wu (2017, p. 91) suggest that the large risk premiums can be explained by level of risk aversion, volatility jumps and volatility persistence. The component of risk aversion determines the sensitivity of the rate of returns to volatility, and thus would enhance the correlation between negative returns and volatility. Moreover, the volatility jump component helps to explain the larger volatility premiums. Eraker and Wu (2017) find that the implied volatility makes a slower reverse to its long-run mean after a jump in volatility, compared to the realized volatility itself. Moreover, the attitudes of investors regarding volatility jumps and risk aversion are suggested to be time varying. Todorov (2010) finds jumps in market prices to have a central role in explaining the variance risk premiums, by noting jumps in market prices to be typically accompanied with spikes in implied volatility. Todorov (2010, p. 347) finds also that rather than having a quick mean reversion and limited effects on the future market dynamics, variance risk premiums have a much slower return to their long-run mean than realized volatility.

The previous list of risks gets expanded by Fournier et al. (2024), through the addition of illiquidity and intermediary risks. Apparently, the role of ample liquidity is shown to be taken for granted in the traditional pricing models as well as the demand and supply shocks on option pricing (Fournier et al., 2024, p. 2290). In their conducted study using data on index option returns from over two decades, Fournier et al. (2024, p. 2292) find S&P 500 puts to be much more sensitive to variance risk than call options, highlighting the differing pricing between puts and calls. Still, the intermediary capital factor and the tail factor in the pricing model of the authors are able to explain option returns only to a minimal degree. The explanatory power of those factors get ultimately dominated by variance and market risk factors (Fournier et al., 2024, p. 2291). The authors also note variance premium to spike during crises, which aligns with the previous studies on variance risk and volatility smiles.

When combined together, the results of Fournier et al. (2024) and Dew-Becker et al. (2021) indicate clearly the heavy pricing of out-of-the-money derivatives. The contribution of variance risk premiums are approximately twice the amount of market risk premiums on deep OTM option prices. The two risk premiums explain about equally the prices of OTM options, but market risk premiums explain the majority of ATM option prices (Fournier et al., 2024). The results align with the finding of negative risk premiums on short-term OTM options being nearly twice the size of the premiums in ITM options (Dew-Becker et al., 2021). This underscores the influence of large market downturns on the psychological driver of derivative pricing, where risk aversion, herding behaviour and intermediary risks lead to elevated pricing of derivatives.

However, compelling evidence suggests that when markets are uncertain about future volatility, the option implied volatility predicts future volatility more accurately. In other words, the markets tend to price the future volatility without inflated premiums, when the markets are unsure. Jeon et al. (2020, p. 1110) find that when volatility of option implied volatility (VoV) is high, the option implied volatility tends to become more informative about future volatility compared to periods of low VoV. It is recognized by

Jeon et al. (2020) that directional traders tend to move away from the markets during high uncertainty, whereas volatility-informed traders enter the market. The latter types of traders exploit the asymmetry of information, and this way the randomness of the implied volatility gets reduced (Jeon et al., 2020, p. 1110). Conversely, this finding implies that there needs to be a relatively similar view of the future uncertainty shared between market participants in order for implied volatility to exceed realized volatility.

Lastly to criticize the role of behavioral biases, the demand for derivatives that may overshoot realized volatility cannot be explained by behavioral factors alone. The majority of the studies above focus on negative returns from a certain holding period, which speaks only to the profitability of that exact time period. However, derivatives serve as a key hedging tool in risk management for large corporations, banks, financial institutions, and firms in non-financial industries. These kind of market participants most probably have a need to to eliminate future uncertainty away, which in turn could make them indifferent to the price of hedging. These kind of actions could simply be driven by regulatory compliance such as the Basel accords, industry norms, field-specific practices, capital requirements or expectations of intermediaries.

5.2 The price of external uncertainy

Thus far, the similarities and differences between economic uncertainty and geopolitic risk uncertainty have been briefly discussed. The links between economic uncertainty, geopolitic risks and uncertainty in the markets are examined next.

As a reminder, the SKEW index stands as a typical measure of expected larger market movements through the implied volatility levels of OTM options. It provides insight into the risk preferences of investors. To start off, the SKEW index and VIX index are found to be negatively correlated, as well as the SKEW index and economic policy uncertainty (Bevilacqua & Tunaru, 2021). The authors additionally note, that geopolitical risk uncertainty has a positive relation with the SKEW index and negative correlation with the VIX index. Bevilacqua and Tunaru (2021, p. 12) note that financial events do not appear to influence measures of geopolitical uncertainty nor the SKEW index the same way they affect VIX index and the measures of economic policy uncertainty.

The previous results would suggest that the uncertainty of geopolitical risks is the one driving the market's pricing of volatility jumps and larger market fluctuations. Simultaneously, Bevilacqua and Tunaru (2021) find that SKEW index predicts well the future levels of VIX index with a negative relation. This could imply that geopolitical events ignite the OTM option premiums as the fear of larger economic downturn introduces itself, which would then be followed by the actual economic outcomes resulting from geopolitical instances. This fits in with the general finding of geopolitical risks presenting a possibility of disaster risk, explaining stock market volatility and various phenomenoms related to financial markets (Bouri et al., 2025). More in detail, it is found that global geopolitical risks drive financial risks up to six months, and country-specific indeces predict financial risks for even longer period of time (Bouri et al., 2025, p. 18). Lastly, Ludvigson et al. (2021) conclude that macroeconomic uncertainty is the consequence of fluctuations in the real economy, which in turn is initially caused by financially-related uncertainty. With commodities being closely related to geopolitics, the discussion will shift to their price behaviour.

In a study conducted by Acharaya et al. (2013, p. 442), the authors find firm-specific uncertainty to press commodity future prices down, resulting in considerable excess returns in short-term futures. By utilizing historical data and FAS disclosures, the authors find increased measures of aggregate default risk of commodity producers to forecast greater excess returns on short-term futures on the respective commodities. Moreover, the desire to hedge is found to be correlated with commodity producer's default risk, implying that commodity firms are the ones hedging, which would explain the increasing supply of commodities and excess returns (Acharaya et al., 2013). In addition, the authors note the effects of this correlation to be enhanced with short-term volatility of the commodity prices. The study also recognizes the capital constraints of speculators to limit the exploitation of low prices of futures, which inflates the price of hedging even more due to the lack of buyers (Acharaya et al., 2013, p. 462).

Combining commodity derivatives with external uncertainty, a study by Laubsch et al. (2024) will be reviewed next. Laubsch et al. (2024, p. 6) record commodity returns to be positively correlated with geopolitical risks but negatively with economic uncertainty. Still, both types of uncertainty tend to increase volatility in the commodity markets, due to the short-term hedging desires of market participants (Laubsch et al., 2024, p. 2). The average returns of commodity futures increase significantly during periods of elevated geopolitical risks and economic uncertainty. These results are similar to those of Acharaya et al. (2013), where the effect of rising default-risks of producer firms are linked to positive returns on commodity futures. Laubsch et al. (2024) suggest that geopolitical risks tend to threaten supply chains and thus boost commodity prices, which results in higher returns. Furthermore, they find economic policy uncertainty to have negative price effect, which ultimately leads to worse commodity future returns during times of high economic stress.

More or less, the both cases exhibit hedging as more costly when demand in futures decreases, with volatility enhancing the effect. Laubsch et al. (2024, p. 6) record economic uncertainty to suppress demand from firms and households resulting in lower commodity prices, leading to lower future returns. However, the authors note that economic uncertainty has positive price effect during recessions, which gets backed by Acharaya et al. (2013). They find commodity future risk premiums to rise when speculative activity gets reduced, as it generally does during recessions. In addition, during uncertain times, speculators and arbitrageurs may likely face margin and capital constraints and not be able to correct potential mispricing (Acharaya et al., 2013). Hedging through futures thus seems to be more suitable during high economic uncertainty, whilst geopolitical risk uncertainty and recessions supports going long on futures.

As outlined in the theory section, future monetary policy presents another source of uncertainty. Through globalization of financial markets, the role of monetary policy and actions of central banks have become increasingly vital when stabilizing macroeconomic fluctuations. However, the magnitude of the effects on the real economy depends not only on the actions of central banks, but also on the expectations of market participants. Lastauskas and Ngueyn (2023) explores the global impact of an increase in the U.S. monetary policy uncertainty through variables such as volatility of inflation, output growth and interest rates in the U.S. and 32 other countries. The study results indicate an unexpected shift in the U.S. monetary policy uncertainty to be accompanied with recessionary and disinflatory effects, as well as rapid changes in output and inflation volatilities (Lastauskas & Nguyen, 2023, p. 19). In addition, the authors find rest of the world outside the U.S. to behave in a strong synchronous manner, highlighting the spillover effect of specifically the U.S. monetary policy uncertainty on global scale. More particularly, the authors find that a sudden increase in U.S. monetary policy uncertainty suppresses U.S. stocks as well as European and Asian equities, underlining the impact of not only monetary decisions but also market expectations.

Another study supporting the significance of monetary policy uncertainty is conducted by Mueller et al. (2017). The authors examine the impact of Federal Open Market Committee’s announcement days on currency exchange rates. On the announcement days, vital news about the U.S. monetary policy get released to the markets, which can potentially cause significant economic effects in the currency markets, due to their highly leveraged nature. Mueller et al. (2017) find that an increase in the US monetary policy uncertainty forecasts higher excess returns for other currencies. The magnitude of the announcement days gets enhanced by the differential of an interest rate and the U.S. dollar. The same effect occurs when the policy adopted on the announcement day is monetary easing, also then other currency returns tend to thrive (Mueller et al., 2017, p. 1214). The authors record the excess returns to be a consequence of currency risk premia, that derives from the grown uncertainty about monetary policy. Thus, the actual announcement of interest rates constitute a secondary factor that influences exchange rates, after the uncertainty and expectations are already priced in by the markets. Additionally, future monetary policy decisions convey a significant impact on the pricing of currency derivatives due to their dual exposure to both interest rates and exchange rates.

Finally, an array of suggested trading strategies for excess profits and efficient hedging are found through multiple previously mentioned studies, that support the second hypothesis of the thesis, proposing uncertainty to be the key explanatory factor behind variations in derivative pricing. Firstly, Dew-Becker et al. (2021, p. 39) find the strategy of going long on implied volatility and short on realized volatility to attain better returns, relative to simply going long on either one. They find the greatest risk-adjusted returns from a portfolio that combines both implied and realized volatility, indicating that shorting derivatives that hedge realized volatility and longing derivatives that hedge imlied volatility yields internal hedging. With currencies, Mueller et al. (2017, p. 1215) find the strategy of shorting U.S. dollar and going long on other currencies to yield excess returns on announcement days on U.S. monetary policy compared to any other day. Interestingly, the authors note that the returns are not accompanied by equally large increase in risk. Regarding commodities, Acharaya et al. (2013, p. 461) suggest producer firms to hedge less through short-selling of futures and instead decrease their inventory holdings in response to increasing costs of hedging.

Overall, the specific nature of external uncertainty appears to play a significant role in the pricing of derivatives, as numerous studies differ between the effects of geopolitical and economic uncertainty on derivatives returns. In addition to external uncertainty, the roles of behavioral biases, expectations and intermediary risks appear to be vital in asset valuation. This implies, that it is not only the external uncertainty stemming from various different sources that affects the pricing of derivatives, but also investor-specific behavioral uncertainty.

5.3 The role of behavioral uncertainty

The discussion above highlight inflated pricing of volatility to be at least partially due to shared risk-averion between market participants and short-term volatility, rather than rational valuation of future risks. Going back to Kahneman and Tversky (1979), they underline people tending to overweight certainty in decision-making and in outcomes that are deemed secure. This aligns with the results of heavily priced hedging, which reflects the willingness of invetors to pay for certainty. Similarly, futures actively used for hedging purposes often carry significant risk premiums and thus compensate those who bear volatility risk for others. A similar pattern was already recognized by Keynes (1930) in his theory, where the speculator taking the long side of a futures contract demands a premium for bearing uncertainty, resulting in expected excess returns. In addition, the confidence of short-term forecasting seems to appeal to market participants regardless of heavy pricing. The increased prices of short-term derivatives don't seem to shut down market participants' desire to hedge, thus giving recognition to Kahneman and Tversky's (1979) prospect theory.

Furthermore, the results of Jeon et al. (2020) seem to be compatible with Fox and Tversky's (1995) study on aversion of ambiguity. This type of behaviour suggests decision-making to rely on clear outcomes over vague and ambiguous ones. As a result, the fluctuative implied volatility is viewed as unattractive due to its randomness, which makes the decision-making ambiguous. This would support the notion of Jeon et al. (2020), where everyone but the volatility-informed traders would leave the markets during changing expectations of volatility. Coinciding with the previous suggestion, Fox and Tversky (1995) note ambiguity to get defied when decision-maker is acting on superior knowledge. Kahneman (2003) adds, that the intuitive judgement of experienced decision-makers dampen the effect of ambiguity on decision-making. This finding fits the idea of volatility-informed traders being the only ones left when implied volatility fluctuates.

6 Conclusions

This thesis examines the influence of uncertainty on derivative pricing through versatile measures of market uncertainty, derivative returns and risk premiums. More specifically, the study aims to establish a comprehensive view of the differences between the pricing of short-term and long-term volatility. Subsequently, the contribution of uncertainty to the pricing of derivatives is examined through various sources of external uncertainty and additionally viewed through the lense of behavioral finance. The thesis includes a section covering theoretical background in derivatives and introduces relevant literature on derivative pricing as well as measures of volatility and uncertainty. The research hypotheses are embedded in vast literature of derivative pricing, and related studies are utilized in the development of the results.

Numerous previous studies highlight volatility to be perceived negatively and heavily priced in short-term derivatives, while longer term volatility seems to be fairly valued or even underestimated. More specifically, hedging realized volatility attains radically negative returns, while the fluctuations of implied and long-term volatility brought non-negative returns in most cases. Ultimately, the first hypothesis gets strong support from recent studies. Implied volatility exceeding realized volatility is explained via premiums carried by equity risk, variance risk, jump-risk and intermediary risks. However, these premiums appear to be inflated in derivatives that hedge short-term volatility, when comparing to realized volatility. Whereas derivatives hedging implied volatility and future uncertainty did not carry hefty premiums and yielded excess returns in most studies.

Additionally, it appears that behavioral uncertainty and risk-averse characteristics are predominantly contributing to the inflated premiums. Jumps in volatilities and market prices, accompanied by psychological frameworks and evidence on OTM options suggest, that the fears of larger market movements primarily drive the pricing of derivatives. The specific source of the uncertainty gains also relevance, as the effects on intermediary risks seem to vary between geopolitical and economic policy uncertainty. Even though market uncertainties tend to possess an increasive effect on price volatility, the signs and impact of these variations seems to depent on the source of the uncertainty and investor specific characteristics.

As a final note, the realm of derivatives covers an enormous number of potential patterns for profits and losses, that depend more or less on the prevailing market conditions. This may affect the results of the studies in the thesis and lead to different implications. Researchers may also be biased or emphasize different causes for their findings due to country-specific factors or the time period where the studies were conducted. Therefore, the potential causes and their varying consequences should be taken as suggestions and interpretations rather than factual information. Future empirical research should be conducted on global uncertainty to shed more light on the effects of global events that bear uncertainty, such as volatile trade policies and heightened geopolitical tensions arising from wars and conflicts.

References

Acharya, V., Lochstoer, L. & Ramadorai, T. (2013). Limits to arbitrage and hedging: Evidence from commodity markets. *Journal of Financial Economics,* 109(2), 441-465. Retrieved 2025-4-14 from https://doi.org/10.1016/j.jfineco.2013.03.003

Alexiou, L. & Rompolis, L. (2024). Jump tail risk exposure and the cross-section of stock returns. *Journal of Empirical Finance,* 79, 1-29. Retrieved 2025-6-9 from https://doi.org/10.1016/j.jempfin.2024.101565

Andersen, T. G., Bollerslev, T., Diebold, F. X., & Ebens, H. (2001). The distribution of realized stock return volatility. *Journal of Financial Economics,* 61(1), 43–76. Retrieved 2025-8-9 from https://doi.org/10.1016/S0304-405X(01)00055-1

Andersen, T. G., Bollerslev, T., Diebold, F. X., & Labys, P. (2003). Modeling and Forecasting Realized Volatility. *Econometrica*, 71(2), 579–625. Retrieved 2025-8-9 from https://www.jstor.org/stable/3082068

Andersen, T. G., Bollerslev, T., & Diebold, F. X. (2007). Roughing It up: Including Jump Components in the Measurement, Modeling, and Forecasting of Return Volatility. *The Review of Economics and Statistics*, 89(4), 701–720. Retrieved 2025-8-9 from http://www.jstor.org/stable/40043095

Arouri, M., M'saddek, O. & Pukthuangthong, K. (2019). Jump risk premia across major international equity markets. *Journal of Empirical Finance* 52, 1-21. Retrieved 2025-6-9 from https://doi.org/10.1016/j.jempfin.2019.02.004

Bank of Canada. (2017). *Variance Premium, Downside Risk and Expected Stock Returns*, 1-45. Retrieved 2025-6-16 from https://www.bankofcanada.ca/wp-content/uploads/2017/12/swp2017-58.pdf

Bekaert, G., Hoerova, M. & Lo Duca, M. (2013). Risk, uncertainty and monetary policy. *Journal of Monetary Economics*, 60(7), 771-788. Retrieved 2025-5-24 from https://doi.org/10.1016/j.jmoneco.2013.06.003

Bevilacqua, M. & Tunaru, R. (2021). The SKEW index: Extracting what has been left. *Journal of Financial Stability,* 53, 1-16. Retrieved 2025-6-30 from https://doi.org/10.1016/j.jfs.2020.100816

Black, F. & Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *Journal of Political Economy*, 81(3), 637-654. Retrieved 2025-4-13 from https://www.jstor.org/stable/1831029

Bollerslev, T. & Todorov, V. (2023). The jump leverage risk premium. *Journal of Financial Economics,* 150(3), 2-20. Retrieved 2025-6-9 from https://doi.org/10.1016/j.jfineco.2023.103723

Bouri, E., Foglia, M., Gupta, R. & Plakandaras, V. (2025). Rare disasters and multilayer spillovers between volatility and skewness in international stock markets over a century of data: The role of geopolitical risk. *International Review of Economic and Finance, 101,* 1-24. Retrieved 2025-6-8 from https://doi.org/10.1016/j.iref.2025.104183

Brogaard, J. & Detzel, A. (2015). The Asset-Pricing Implications of Government Economic Policy Uncertainty. *Management Science,* 61(1), 3-18. Retrieved 2025-5-13 from https://doi.org/10.1287/mnsc.2014.2044

Buraschi, A., & Jackwerth, J. (2001). The Price of a Smile: Hedging and Spanning in Option Markets. *The Review of Financial Studies*, 14(2), 495–527. http://www.jstor.org/stable/2696749

Caldara, D., & Iacoviello, M. (2022). Measuring Geopolitical Risk. *The American Economic Review*, 112(4), 1194–1225. Retrieved 2025-5-13 from https://www.jstor.org/stable/27121936

Campbell, J. & Hentschel, L. (1992). No news is good news: An asymmetric model of changing volatility in stock returns. *Journal of Financial Economics,* 31(3), 281-318. Retrieved 2025-4-11 from https://doi.org/10.1016/0304-405X(92)90037-X

Carr, P. & Wu, L. (2016). Analyzing volatility risk and risk premium in option contracts: A new theory. *Journal of Financial Economics,* 120*(1)*, 1-20. Retrieved 2025-6-9 from https://doi.org/10.1016/j.jfineco.2016.01.004

CBOE. (2025). *CBOE VIX FAQ*. Retrieved 2025-5-10 from https://www.cboe.com/tradable_products/vix/faqs/

Chang, E. C. (1985). Returns to Speculators and the Theory of Normal Backwardation. *The Journal of Finance*, 40(1), 193–208. Retrieved 2025-6-24 https://doi.org/10.2307/2328055

Cheng, F., Fang, Z., Li, T., Sensoy, A. & Wang, C. (2024). Economic Policy Uncertainty and Options Markets Participation: Hedge or Speculation? *Borsa Istanbul Review,* 24(1), 50-59. Retrieved 2025-5-10 from https://doi.org/10.1016/j.bir.2024.04.006

Choudhdry, M. (2010). *Fixed-income securities and derivatives handbook.* John Wiley & Sons inc. 2010. Retrieved 2025-4-13 from https://ebookcentral-proquest-com.proxy.uwasa.fi/lib/tritonia-ebooks/detail.action?docID=540087

Choudhry, M. & Eales, B. (2003). *Derivative instruments: A guide to theory, valuation, analysis and practice.* Elsevier Science & Technology. Retrieved 2025-4-13 from https://ebookcentral-proquest-com.proxy.uwasa.fi/lib/tritonia-ebooks/detail.action?docID=299022.

Christensen, K., Timmerman, A. & Veliyev, B. (2025). Warp speed price moves: Jumps after earnings announcements. *Journal of Financial Economics,* 167*,* 1-25. Retrieved 2025-6-16 from https://doi.org/10.1016/j.jfineco.2025.104010

CME Group (2025). *CME Group All Products – Codes and Slate.* Retrieved 2025-4-11 from https://www.cmegroup.com/markets/products.html#sortAsc

CME Group (2025). *Calculating Options Moneyness & Intrinsic Value*. Retrieved 2025-4-13 from https://www.cmegroup.com/education/courses/introduction-to-options/calculating-options-moneyness-and-intrinsic-value.html

Crowley, M., Meng, N. & Song, H. (2018). Tariff scares: Trade Policy Uncertainty and Foreign Market Entry by Chinese Firms. *Journal of International Economics,* 114, 96-115. Retrieved 2025-5-17 from https://doi.org/10.1016/j.jinteco.2018.05.003

Dew-Becker, I., Giglio, S. & Kelly, B. (2021). Hedging macroeconomic and financial uncertainty and volatility. *Journal of Financial Economics,* 142(1)*,* 23-45. Retrieved 2025-7-7 from https://doi.org/10.1016/j.jfineco.2021.05.053

Dodd, R. (n.d.) *Financial markets: Exchange Or Over the Counter.* International Monetary Fund. Retrieved 2025-4-11 from https://www.imf.org/en/Publications/fandd/issues/Series/Back-to-Basics/Financial-Markets

Eraker, B., Johannes, M., & Polson, N. (2003). The Impact of Jumps in Volatility and Returns. *The Journal of Finance*, 58(3), 1269–1300. Retrieved 2025-6-16 from http://www.jstor.org/stable/3094580

European Central Bank (2007 June). *Variance Swaps*, 88-90. Retrieved 2025-4-11 from https://www.ecb.europa.eu/press/financial-stability-publications/fsr/focus/2007/pdf/ecb~a209f48731.fsrbox200706_11.pdf

Fama, E. F., & MacBeth, J. D. (1973). Risk, Return, and Equilibrium: Empirical Tests. *Journal of Political Economy*, 81(3), 607–636. http://www.jstor.org/stable/1831028

Fournier, M., Jacobs, K. & Orlowski, P. (2024). Modeling Conditional Factor Risk Premia Implied by Index Option Returns. *The Journal of Finance,* 79(3), 2289-2338. Retrieved 2025-6-28 from https://doi-org.proxy.uwasa.fi/10.1111/jofi.13324

Fox, C. R., & Tversky, A. (1995). Ambiguity Aversion and Comparative Ignorance. *The Quarterly Journal of Economics*, 110(3), 585–603. Retrieved 2025-6-8 from https://doi.org/10.2307/2946693

Goodell, J. & Vähämaa, S. (2013). US presidential elections and implied volatility: The role of political uncertainty, *Journal of Banking & Finance*, 37(3), 1108-1117. Retrieved 2025-4-14 from https://doi.org/10.1016/j.jbankfin.2012.12.001

Heston, S. L. (1993). A Closed-Form Solution for Options with Stochastic Volatility with Applications to Bond and Currency Options. *The Review of Financial Studies*, 6(2), 327–343. Retrieved 2025-5-5 from http://www.jstor.org/stable/2962057

Heckinger, R., Ruffini, I. & Wells, K. (2014). *Understanding derivatives: Markets and Infrastructure, Chapter 3.* Federal Reserve Bank of Chicago, 27-38. Retrieved 2025-4-11 from https://www.chicagofed.org/publications/understanding-derivatives/index

Heckinger, R. & Mengle, D. (2013). *Understanding derivatives: Markets and Infrastructure, Chapter 1.* Federal Reserve Bank of Chicago, 1-11. Retrieved 2025-

4-11 from https://www.chicagofed.org/publications/understanding-derivatives/index

Huang, W. & Yao, X. (2021). Financial Derivatives and Their Application in Enterprises. *Advances in Economics, Business and Management Research*, 203, 3277-3282. Retrieved 2025-4-11 from https://doi.org/10.2991/assehr.k.211209.535

Hull, J. (2022). *Options, Futures, and Other Derivatives 11th edition.* Pearson Education. Retrieved 2025-4-11 from https://bookshelf.vitalsource.com/books/9781292410623

Hull, J. & White, A. (1987). The Pricing of Options on Assets with Stochastic Volatilities. *The Journal of Finance*, 42(2), 281–300. Retrieved 2025-5-5 from https://doi.org/10.2307/2328253

Jeon, B., Seo, S. & Kim, J. (2020). Uncertainty and the volatility forecasting power of option-implied volatility. *The Journal of Futures Markets,* 40(7), 1109-1126. Retrieved 2025-5-10 from https://doi.org/10.1002/fut.22116

Kahneman, D. (2003). Maps of Bounded Rationality: Psychology for Behavioral Economics. *The American Economic Review*, 93(5), 1449–1475. Retrieved 2025-5-24 from http://www.jstor.org/stable/3132137

Kahneman, D. & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, 47(2), 263–291. Retrieved 2025-5-26 from https://doi.org/10.2307/1914185

Kelly, B., Pastor, L., & Veronesi, P. (2016). The Price of Political Uncertainty: Theory and Evidence from the Option Market. *The Journal of Finance*, 71(5), 2417–2480. http://www.jstor.org/stable/44155394

Laubsch, J., Smales, L. & Vo, D. (2024 December). The Influence of Uncertainty on Commodity Futures Returns and Trading Behaviour. *Quarterly Review of Economics and Finance,* 98, 1-16. Retrieved 2025-5-10 from https://doi.org/10.1016/j.qref.2024.101915

Lastauskas, P. & Nguyen, A. (2023). Global impacts of US monetary policy uncertainty shocks. *Journal of International Economics,* 145, 2-23. Retrieved 2025-7-2 from https://doi.org/10.1016/j.jinteco.2023.103830

Lin, Y., Sio-Chung U, T. & Wang, Y. (2024 May). The impact of the Russia-Ukraine war on volatility spillovers. *International Review of Financial Analysis*, 90, Retrieved 2025-4-11 from https://doi.org/10.1016/j.irfa.2024.103194

Ludvigson, S., Ma, S. & Ng, S. (2021). Uncertainty and Business Cycles: Exogenous impulse or Endogenous Response? *American Economic Journal: Macroeconomics,* 13(4), 369-410. Retrieved 2025-7-2 from https://www.aeaweb.org/articles?id=10.1257/mac.20190171

Merton, R. C. (1980). On estimating the expected return on the market: An exploratory investigation*. Journal of Financial Economics*, 8(4), 323-361. Retrieved 2025-4-11 from https://doi.org/10.1016/0304-405X(80)90007-0

Merton, R. C. (1973). Theory of Rational Option Pricing*. The Bell Journal of Economics and Management Science,* 4(1), 141-183. Retrieved 2025-4-13 from https://doi.org/10.2307/3003143

Mora-Valencia, A., Rodriguez-Raga, S. & Vanegas, E. (2021). Skew index: Descriptive analysis, predictive power, and short-term forecast. *The North American Journal of Economics and Finance,* 56*,* 1-21. Retrieved 2025-6-19 from https://doi.org/10.1016/j.najef.2020.101356

Mueller, P., Tahbaz-Salehi, A., & Vedolin, A. (2017). Exchange Rates and Monetary Policy Uncertainty. *The Journal of Finance*, *72*(3), 1213–1251. http://www.jstor.org/stable/26652728

OpenAI. (2023). *ChatGPT-4o* (2024, 13. May) [Large language model]. Retrieved 2025-8-11 from https://chatgpt.com/

Park, A., & Sabourian, H. (2011). Herding and Contrarian Behaviour in Financial Markets. *Econometrica*, *79*(4), 973–1026. http://www.jstor.org/stable/41237854

Pastor, L. & Veronesi, P. (2012). Uncertainty about Government Policy and Stock Prices. *The Journal of Finance*, 67(4), 1219–1264. http://www.jstor.org/stable/23261358

Schwert, G. W. (1989). Why Does Stock Market Volatility Change Over Time? *The Journal of Finance*, 44(5), 1115–1153. Retrieved 2025-4-14 from https://doi.org/10.2307/2328636

Segal, G., Shaliastovich, I. & Yaron, A. (2015). Good and Bad Uncertainty: Macroeconomic and Financial Market Implications. *Journal of Financial Economics,* 117(2), 369-397. Retrieved 2025-5-20 from https://doi.org/10.1016/j.jfineco.2015.05.004

Shiller, R. J. (1981). Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends? *The American Economic Review*, *71*(3), 421–436. Retrieved 2025-5-19 from http://www.jstor.org/stable/1802789

Smales, L. (2021). Geopolitical Risk and Volatility Spillovers in Oil and Stock Markets. *The Quarterly Review of Economics and Finance,* 80, 358-366. Retrieved 2025-5-17 from https://doi.org/10.1016/j.qref.2021.03.008

Todorov, V. (2010). Variance Risk-Premium Dynamics: The Role of Jumps. *The Review of Financial Studies*, *23*(1), 345–383. Retrieved 2025-6-14 from http://www.jstor.org/stable/40468311

Appendices

Appendix 1. The use of artificial intelligence

Artificial intelligence was used as a tool to help construct the text in English and to translate sentences from Finnish to English more fluently. The language model used for this was ChatGPT-4o developed by OpenAI. However, the author finalized the thesis to ensure the validity and accuracy of the text.