UNIVERSITY OF TURKU
Turku School of Economics

Short Straddle Strategy's Profitability and Implied Volatility After 2019 Trading Fee Removal

Study on U.S Large Cap Stocks

Department of Accounting and Finance

Bachelor's thesis

Author:
Aku Kavka

Supervisor:
Habeeb Yahya

23.11.2024
Turku

The originality of this thesis has been checked in accordance with the University of Turku quality assurance system using the Turnitin Originality Check service.

Bachelor's thesis

Subject: Accounting and Finance
Author: Aku Kavka
Title: Short Straddle Strategy's Profitability and Implied Volatility After 2019 Trading Fee Removal
Supervisor: Habeeb Yahya
Number of pages: 27 pages + appendices 2 pages
Date: 23.11.2024

This thesis investigates the impact of trading fee removal on implied volatility (IV) and the profitability of the short straddle strategy. The removal of trading fees by major U.S. brokers in October 2019 significantly increased retail participation and trading volumes, particularly in short-term options. Using data from Apple (AAPL), Amazon (AMZN), and Tesla (TSLA), this study employs Interrupted Time Series Analysis (ITSA) to examine changes in IV, historical volatility (HV), and the IV/HV ratio. Additionally, the Mann-Whitney U-test evaluates the profitability of the short straddle strategy before and after the fee removal.

The findings reveal that trading fee removal led to immediate spikes in IV for speculative stocks like Tesla, followed by stabilization over time. However, the IV/HV ratio remained largely unchanged, indicating stability in the relationship between expected and realized volatility. The profitability analysis of the short straddle strategy shows no significant improvement post-fee removal, with both median and mean returns slightly lower in the post-intervention period. Despite this, greater variability in returns was observed, suggesting that individual trade timing could enhance profitability.

This study contributes to the literature by linking policy changes to market dynamics and strategy performance, offering insights for investors, policymakers, and researchers. Future research could develop indicators to optimize strategy timing and expand the analysis to include diverse stocks and market conditions.

Key words: Trading Fee Removal, Options Trading, Short Straddle Strategy, Implied Volatility

Kandidaatintutkielma

Oppiaine: Laskentatoimi ja rahoitus
Tekijä: Aku Kavka
Otsikko: Short Straddle-strategian kannattavuus ja implisiittinen volatiliteetti vuoden 2019 kaupankäyntikulujen poistamisen jälkeen
Ohjaaja: Habeeb Yahya
Sivumäärä: 27 sivua + liitteet 2 sivua
Päivämäärä: 23.11.2024

Tässä opinnäytetyössä tutkitaan kaupankäyntimaksujen poistamisen vaikutusta implisiittiseen volatiliteettiin (IV) ja lyhyen straddle-strategian kannattavuuteen. Suurimpien yhdysvaltalaisten välittäjien lokakuussa 2019 toteuttama kaupankäyntimaksujen poistaminen lisäsi merkittävästi vähittäiskaupan osallistumista ja kaupankäyntivolyymia erityisesti lyhytaikaisissa optioissa. Tässä tutkimuksessa käytetään Applen (AAPL), Amazonin (AMZN) ja Teslan (TSLA) tietoja, ja käytetään keskeytettyä aikasarja-analyysiä (ITSA) IV:n, historiallisen volatiliteetin (HV) ja IV/HV-suhteen muutosten tutkimiseen. Lisäksi Mann-Whitneyn U-testillä arvioidaan lyhyen straddle-strategian kannattavuutta ennen ja jälkeen kaupankäyntikulujen poistamisen.

Tulokset osoittavat, että kaupankäyntimaksujen poistaminen johti Teslan kaltaisten spekulatiivisten osakkeiden IV:n välittömiin piikkeihin, joita seurasi vakautuminen ajan myötä. IV/HV-suhde pysyi kuitenkin suurelta osin muuttumattomana, mikä viittaa odotetun ja toteutuneen volatiliteetin välisen suhteen vakauteen. Lyhyen straddle-strategian kannattavuusanalyysi ei osoita merkittävää parannusta maksujen poistamisen jälkeen, sillä sekä mediaani- että keskituotto olivat hieman alhaisemmat intervention jälkeisenä aikana. Tästä huolimatta tuotoissa havaittiin suurempaa vaihtelua, mikä viittaa siihen, että yksittäisten kauppojen ajoitus voisi parantaa kannattavuutta.

Tämä tutkimus täydentää kirjallisuutta yhdistämällä politiikkamuutokset markkinoiden dynamiikkaan ja strategian suorituskykyyn ja tarjoaa näkemyksiä sijoittajille, poliittisille päättäjille ja tutkijoille. Tulevaisuudessa tutkimuksessa voitaisiin kehittää indikaattoreita strategian ajoituksen optimoimiseksi ja laajentaa analyysia kattamaan erilaisia osakkeita ja markkinaolosuhteita.

Avainsanat: Kaupankäyntipalkkioiden poistaminen, optiokauppa, Short Straddle -strategia, implisiittinen volatiliteetti.

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1.1 Introduction to the Topic

Options trading is an investment approach that offers unique opportunities and flexibility compared to traditional stock investing. Unlike stocks, options allow investors to create strategies that may not be possible through direct stock ownership. These strategies can generate returns even if the price of the underlying stock does not change, making them adaptable to different market conditions. This flexibility helps investors manage risk and pursue rewards in ways that traditional stock investing often cannot achieve.

One strategy designed for stable markets and small price movements is the short straddle. This strategy involves selling both a put option and a call option on the same underlying asset, with the same expiration date. The short straddle works best in low-volatility markets, as both options may expire worthless, allowing the investor to keep the premiums received. However, the strategy carries high risks. Large price movements can cause significant losses because the potential downside is unlimited. This makes the short straddle a speculative strategy that requires careful market analysis and strong risk management to be used effectively. (Shamkuwar, 2023)

Options trading became much more accessible in October 2019 when major platforms like Charles Schwab, TD Ameritrade, E*Trade, and Fidelity removed their trading fees. A study by Barclays found that this change allowed more retail investors, especially those with smaller portfolios, to enter the options market. Without commissions, trading became cheaper, leading to a significant increase in trading volume, particularly for short-term options. This rise in activity, driven by many new and speculative investors, caused noticeable changes in market behavior and likely affected implied volatility. (Deshpande, 2020)

Although Barclays' study offers useful insights into how trading volume changed after the removal of fees, it does not explain the specific methods used or how this change affected the profitability and risk of different trading strategies. This gap in the research is the main motivation for this thesis. The goal is to explore the impact of trading fee removal on implied volatility and the performance of the short straddle strategy, providing a clearer understanding of these market changes.

This thesis investigates how eliminating trading fees has affected the returns of the short straddle strategy and the implied volatility of options on major U.S. companies and whether the 2019 changes made the short straddle strategy more appealing to investors and whether they caused significant shifts in implied volatility.

1.2 Aim and Scope of the Thesis

The primary objective of this thesis is to assess how the elimination of trading fees in 2019 has affected the short straddle strategy and implied volatility in large U.S. firms. Two key research questions are addressed:

1. How has the removal of trading fees impacted implied volatility?
2. Has the short straddle strategy become more profitable since the elimination of trading fees?

By answering these questions, this thesis seeks to evaluate the implications of trading fee removal on option trading strategies and broader market behavior.

1.3 The Outline of the Thesis

This study is divided into two primary sections, offering a detailed examination of the impact of trading fee removal on market dynamics, implied volatility, and the profitability of the short straddle strategy.

The first section presents a comprehensive review of the relevant literature, establishing the theoretical framework for the research. It begins with an overview of options trading and pricing mechanisms, emphasizing the foundational principles of the Black-Scholes model. This part explores the key factors influencing option prices, such as implied and historical volatility, and examines their significance in market behavior. The review also delves into the relationship between implied and realized volatility, discussing their implications for investment strategies. Furthermore, it evaluates prior studies on the connection between trading volume, market volatility, and structural changes, providing essential context for analyzing the removal of trading fees.

The second section comprises an empirical analysis of the effects of trading fee removal on implied volatility and the short straddle strategy. The analysis focuses on data from major U.S. stocks, including Apple (AAPL), Amazon (AMZN), and Tesla (TSLA), assessing changes in implied and historical volatility before and after the intervention. The study employs Interrupted Time Series Analysis (ITSA) to identify both immediate and long-term shifts in volatility and the implied-to-historical volatility ratio (IV/HV). Additionally, the profitability of the short straddle strategy are examined using the Mann-Whitney U-test to determine whether trading fee removal had a significant impact on returns. The analysis is supported by visual tools such as histograms and box plots, which highlight changes in profitability and variability over time.

By integrating theoretical perspectives with empirical findings, this study seeks to provide a robust understanding of how the elimination of trading fees has shaped market behavior, influenced investment strategies, and impacted financial dynamics. The results contribute to the broader literature on financial markets and offer actionable insights for policymakers, investors, and scholars.

2 Literature review

2.1 What Are Options and How Are They Priced?

Options are financial derivatives that grant the holder the right, but not the obligation, to buy or sell a specified underlying asset at a predetermined price on or before a specified date. Options are classified into two main types based on their exercise characteristics. European options can only be exercised at the end of their lifespan, on the specified expiration date. In contrast, American options offer greater flexibility, allowing the holder to exercise the option at any point during its validity, up to and including the expiration date. This thesis examines European call and put options. (Black & Scholes, 1973)

2.1.1 Black-Scholes Model and the Role of Volatility in Option Pricing

The Black-Scholes model, introduced by Fisher Black and Myron Scholes in 1973, is one of the most renowned frameworks for option pricing. It was the first mathematical model designed to determine the fair value of options, significantly transforming the landscape of options trading and pricing. The model utilizes a mathematical equation that incorporates key variables, including the current price of the underlying asset, the strike price of the option, the time to expiration, the risk-free interest rate, and the implied volatility of the underlying asset. These variables work together to provide a systematic and quantitative approach to pricing options. (Black and Scholes, 1973)

The Black-Scholes model makes several assumptions that influence its results. It assumes that the price of the underlying stock follows a random process, meaning price changes are independent and not influenced by past movements. The model also assumes that volatility remains constant, even though in real markets, volatility often fluctuates. Similarly, the risk-free interest rate is assumed to stay the same, which is not always true, especially during uncertain market conditions. The model expects no dividends to be paid during the life of the option and assumes that returns follow a lognormal distribution. However, in practice, the distribution of returns has "fat tails," meaning extreme price movements, both up and down, occur more often than the model predicts, which can affect its accuracy. (Procházka, 2011)

To understand how implied volatility influences option pricing, it is important to examine how the Black-Scholes model calculates the price of an option mathematically. The mathematical formula for the Black-Scholes model is as follows:

$$For\ Call\ Options: C = S_0N(d_1) - Ke^{-rt}N(d_2)$$
$$For\ Put\ Options: P = Ke^{-rt}N(-d_2) - S_0N(-d_1)$$

Where:

$$S_0 = Current\ price\ of\ the\ underlying\ asset$$
$$K = Strike\ Price$$
$$r = Risk\ Free\ Rate$$
$$t = Time\ to\ Expiration$$
$$N = Cumulative\ Normal\ Distribution\ Function$$

(Hull & Rotman, 2018)

Volatility is a crucial factor in the Black-Scholes model and can be measured in two ways: historical volatility (HV) and implied volatility (IV). Historical volatility looks at past price movements to determine how much an asset's price has fluctuated over time. High historical volatility indicates that the asset's price has experienced significant changes in the past, suggesting higher risk. Implied volatility, on the other hand, is derived from the market price of the option and represents traders' expectations of future price movements. To calculate implied volatility, traders reverse-engineer the Black-Scholes model by inputting the known option price and solving for volatility. (Liu & Song, 2024)

Implied volatility has certain advantages over historical volatility. While historical volatility assumes that past patterns will continue, it may not capture sudden changes or shifts in market behavior. Implied volatility, being forward-looking, reflects the market's current expectations, making it more accurate for predicting option prices under existing conditions. As a result, implied volatility is often considered a more effective tool for forecasting option prices. These two types of volatility serve different purposes and are both important for understanding and pricing options effectively. (Liu & Song, 2024)

2.1.2 Relationship Between Implied and Realized Volatility

A study by Christensen and Prabhala (1998) examines how well implied volatility can predict realised volatility. Implied volatility refers to market expectations of future price movements and is derived from option prices. Realised volatility, on the other hand, is the actual price movements that have occurred over a given period. The study found that while implied volatility is often a good prediction, it is not always an accurate reflection of realised volatility. Implied volatility can therefore provide valuable information about market expectations, but it is affected by various practical factors and market disturbances that can cause prediction errors. This means that while implied volatility is useful, it cannot always be fully relied upon to predict accurate future volatility. (Christensen & Prabhala, 1998)

Scott Mixon's article explores the relationship between implied volatility and realized volatility, highlighting that implied volatility is generally higher than realized volatility, creating what is known as a volatility gap. This gap is attributed to the volatility risk premium, where investors require higher returns for taking on greater risk. However, the volatility gap has narrowed over time due to several market developments. The concentration of options trading on organized exchanges and the resulting transparency have reduced the need for a high volatility risk premium. Additionally, advancements in modern option pricing methods have improved market efficiency, further minimizing the difference between implied and realized volatility. These changes have contributed to a more streamlined and predictable options market. (Mixon, 2009)

The predictive accuracy of implied volatility in forecasting future price movements directly impacts the disparity between implied volatility and realized volatility. When this gap is substantial, with implied volatility consistently exceeding realized volatility, it may present opportunities for investors to capitalize on this discrepancy by anticipating lower actual volatility. Understanding of these volatility measures is essential for evaluating strategies such as the short straddle, which relies on stable volatility conditions to achieve profitability.

2.2 Short Straddle

When an investor sells an option, their maximum profit is the premium they receive for the sale. This profit can decrease if the option price changes and results in a loss. If the option expires worthless, the investor keeps the full premium without incurring any loss. The return, in this case, is simply the premium earned minus any losses from price changes. However, selling options carries significant risk. While the profit is capped at the premium received, the potential loss is theoretically unlimited, as the option’s value could rise dramatically before expiry. When selling a call option, the investor assumes the underlying asset's price will not go up. Similarly, when selling a put option, the investor expects the price will not go down. (Pilbeam, 2018)

The short straddle strategy reflects the view that the price of the underlying asset will remain stable, with no significant movement in either direction. If the price moves up or down beyond the total premiums collected, the investor incurs a loss. The ideal outcome is when the price of the underlying asset stays the same, causing both the call and put options to expire worthless. In this case, the investor's profit equals the combined premiums received from selling both options.

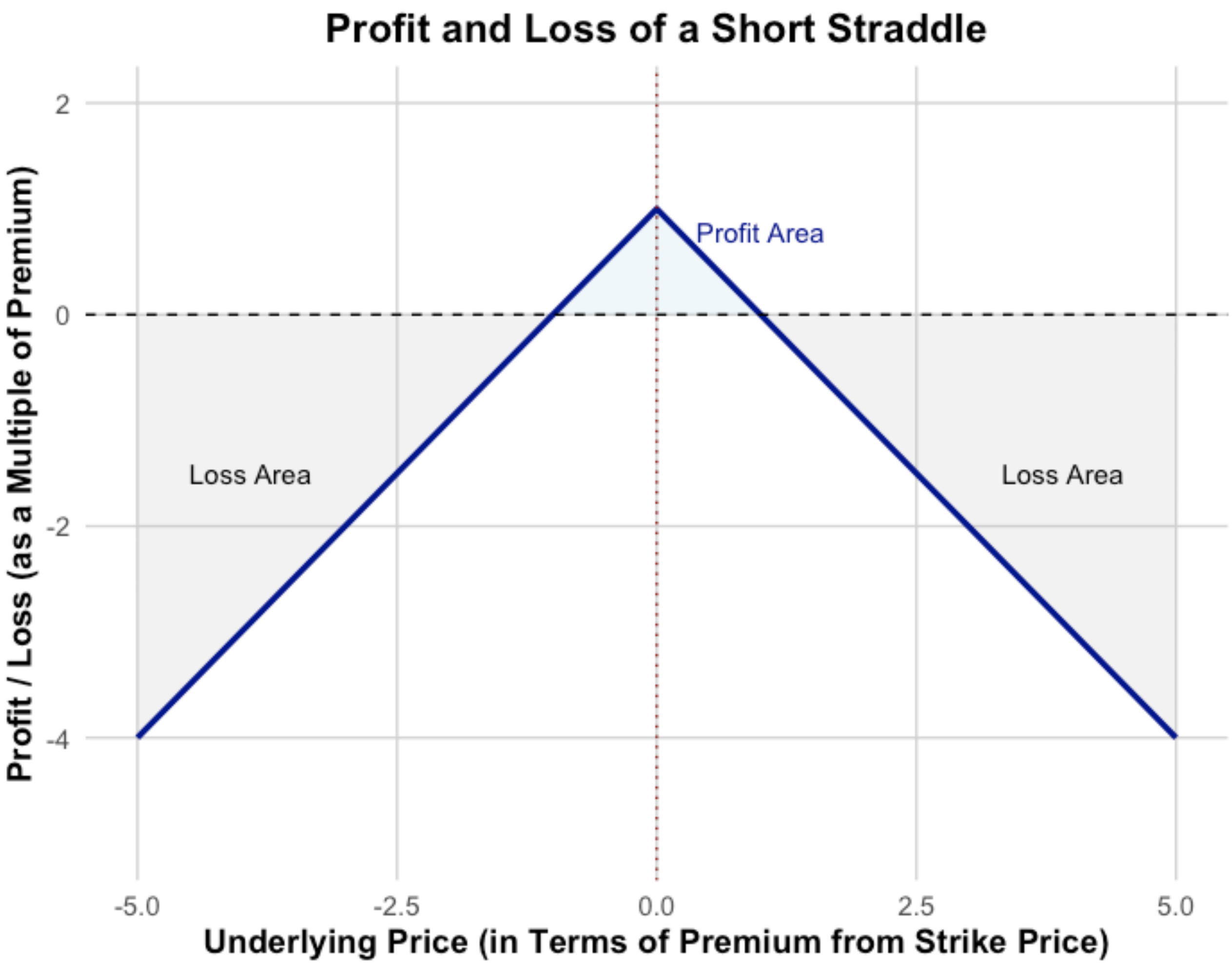


Figure 1. Short Straddle Profit and Loss

The short straddle strategy is useful for investors during stable market conditions, as it allows them to earn returns by collecting premiums from selling both call and put options. Studies, such as the one conducted on the WIG20 index from 2005 to 2015, have shown that the short straddle performs better than the long straddle in periods of low volatility. This research, which included phases of market growth, decline, and stability, highlighted that the short straddle consistently provided positive returns when volatility was low. Since potential losses are unlimited, large price movements in either direction can result in substantial losses. Consequently, the strategy requires a margin deposit to manage possible losses, adding complexity to its execution. As a result, the short straddle is better suited for experienced investors who can handle its high risk and complexity. (Flotyński, 2017)

Since option pricing depends on volatility, and higher implied volatility increases option prices, the short straddle strategy can be particularly effective when options are perceived as overvalued. In situations where implied volatility exceeds historical volatility, the strategy benefits from the inflated premiums associated with these conditions. This makes the short straddle a viable approach in markets where options are priced higher due to elevated implied volatility.

2.3 Trading Fee Removal in 2019

In October 2019, major U.S. online options brokers, including Charles Schwab, TD Ameritrade, E*Trade, and Fidelity, removed trading fees entirely, as reported by Barclays. This change made options trading more appealing and accessible to smaller investors, particularly for short options, and led to a significant increase in trading volumes. (Deshpande, 2020)

The removal of trading fees had two significant impacts. First, it eliminated the direct costs associated with trading, which had been a substantial burden for many investors, particularly retail traders and frequent market participants. Without these fees, investors could retain a greater portion of their returns, enhancing overall profitability. This change was especially advantageous for strategies with narrow profit margins, where even slight cost reductions could yield notable improvements.

Second, the elimination of fees led to a sharp increase in trading volumes. Between July 2019 and July 2020, Tesla's options trading volume surged by $1327.83 billion, Amazon's by $843.62 billion, and Apple’s by $366.52 billion. Additionally, the removal of fees altered trading patterns. Smaller trades involving 1–10 contracts grew to account for 45% of call option volume, while the share of larger institutional trades decreased to 25%. (Deshpande, 2020)

Changes in trading volume significantly influence the relationship between trading activity and implied volatility, with a strong positive correlation observed. Behavioral biases, such as availability, conservatism, and extrapolation, drive this relationship as investors rely on recent experiences and adjust expectations gradually to new information. These effects are most pronounced during periods of heightened market volatility, where larger trading volumes amplify their impact on implied volatility. (Cheuathonghua & Padungsaksawasdi, 2024)

2.4 Delta Neutral Position

Delta is a key metric in options trading that measures how the price of an option changes in relation to changes in the price of its underlying asset. For European call options, delta can be calculated mathematically as $\Delta(\text{call}) = N(d_1)$, where $N(d_1)$ represents the cumulative probability of d_1 under a standard normal distribution. For European put options, delta is calculated as $\Delta(\text{put}) = N(d_1) - 1$. (Hull & White, 2017)

A delta-neutral position is a strategy employed by market makers to manage risk by balancing the delta of their options portfolio, ensuring that it is unaffected by small price movements in the underlying asset. This is achieved through delta hedging, where market makers dynamically buy or sell the underlying stock to offset changes in the portfolio's delta. The hedging activity can create price pressures in the stock market, with upward or downward movements depending on whether market makers are buying or selling to adjust their positions. Retail investors, particularly those trading short-term options, contribute significantly to inventory imbalances for market makers, compelling frequent hedging adjustments. (Flynn, 2024)

If implied volatility increases, market makers may hedge their sold options by purchasing the underlying stock, particularly when a significant number of investors buy call options. This activity may contribute to higher realized volatility and amplify market movements. As the stock price rises due to these hedging actions, call options may appear increasingly attractive to investors, potentially driving further demand. This, in turn, may prompt additional hedging by market makers, creating a feedback loop. Such a cycle may result in escalating price movements and volatility, illustrating how the interplay between options trading and underlying assets can influence market dynamics.

These findings form the foundation for the empirical part of this study, which investigates the impact of trading fee removal on implied volatility and the profitability of the short straddle strategy. By examining the relationship between trading costs, trading volume, and behavioural patterns, this research extends the existing literature on options trading. It incorporates insights from option pricing models, the role of implied and realized volatility, and delta-neutral strategies to provide a more comprehensive understanding of how market interventions influence investor behaviour.

3 Empirical Analysis

3.1 Implied Volatility and Volatility Before and After Fee Removal

3.1.1 Data for Implied Volatility Analysis

This section examines how Implied Volatility (IV), Historical Volatility (HV), and their ratio (IV/HV) evolved following the changes in trading fees introduced in October 2019. The dataset, retrieved from the LSEG Refinitiv database, spans the period from January 1, 2016, to November 8, 2024. The analysis focuses on the three stocks with the largest increases in option exercise volume during the period: Apple Inc., Amazon Inc., and Tesla Inc. In this study implied volatility is measured at weekly intervals, based on the 30-day at-the-money option implied volatility for each of the selected stocks. (Deshpande, 2020)

Historical volatility is calculated using the closing price of each stock for all available trading days within the observation period. Logarithmic returns are calculated by dividing each day's closing price by the previous day's closing price and taking the natural logarithm of the result. Volatility is then computed as the standard deviation of the previous 30 days' returns, annualized to reflect 252 trading days. The IV/HV ratio is determined by dividing the implied volatility by the historical volatility on days for which both data points are available.

3.1.2 Interrupted Time Series Analysis

Interrupted Time Series Analysis (ITS) is employed to measure changes in both short- and long-term trends resulting from the intervention. The ITS method defines a pre-intervention period to establish an expected trend that serves as a baseline for comparison with the post-intervention period. Hypotheses are developed regarding how the intervention is anticipated to impact the data, allowing for the detection of immediate level changes and longer-term trends. For this thesis, the ITS analysis assesses the effect of the October 2019 trading fee changes, using the pre-intervention period as a benchmark. (Bernal et al., 2017)

ITS analysis models the outcome variable (Y) using three explanatory variables: Time (t), a binary Intervention variable (0 for pre-intervention, 1 for post-intervention), and the interaction term between Time and Intervention. The model is mathematically represented as follows:

$$Y_t = \beta_0 + \beta_1 \cdot Time_t + \beta_2 \cdot Intervention + \beta_3 \cdot (Time_t \cdot Intervention_t)$$

Where:

$$\beta_0: The\ baseline\ level\ of\ the\ outcome\ \ before\ the\ intervention\ starts$$

$$\beta_1: The\ change\ in\ the\ outcome\ associated\ with\ each\ unit\ increase\ in\ time$$

$$\beta_2: The\ change\ in\ the\ level\ of\ the\ outcome\ following\ the\ intervention$$

$$\beta_3: The\ change\ in\ the\ slope\ of\ the\ outcome\ trend\ following\ the\ intervention$$

(Bernal et al., 2017)

The use of ITS analysis to examine the IV, HV and IV/HV ratio of the data has been implemented with the intervention set to October 1, 2019, before which the intervention is set to binary 0 and after which it is set to binary 1. The aim is to analyze the changes in β_2 and β_3 and their level of significance. In this model, β_2 observes the immediate effect of the removal of trading costs on the variables. β_3 illustrates the long-term trend, which we use to analyse whether the event had a longer-term effect on implied volatility, historical volatility and the relationship between them. The overall 95% level of significance is used as the significance level. This means that the probability that the result is caused by random causes is at most 5%.

3.1.3 ITSA Results for Implied Volatility

The removal of trading fees had significant effects on the implied volatility (IV) of AAPL, AMZN, and TSLA, as shown by the results of the Interrupted Time Series Analysis (ITSA).

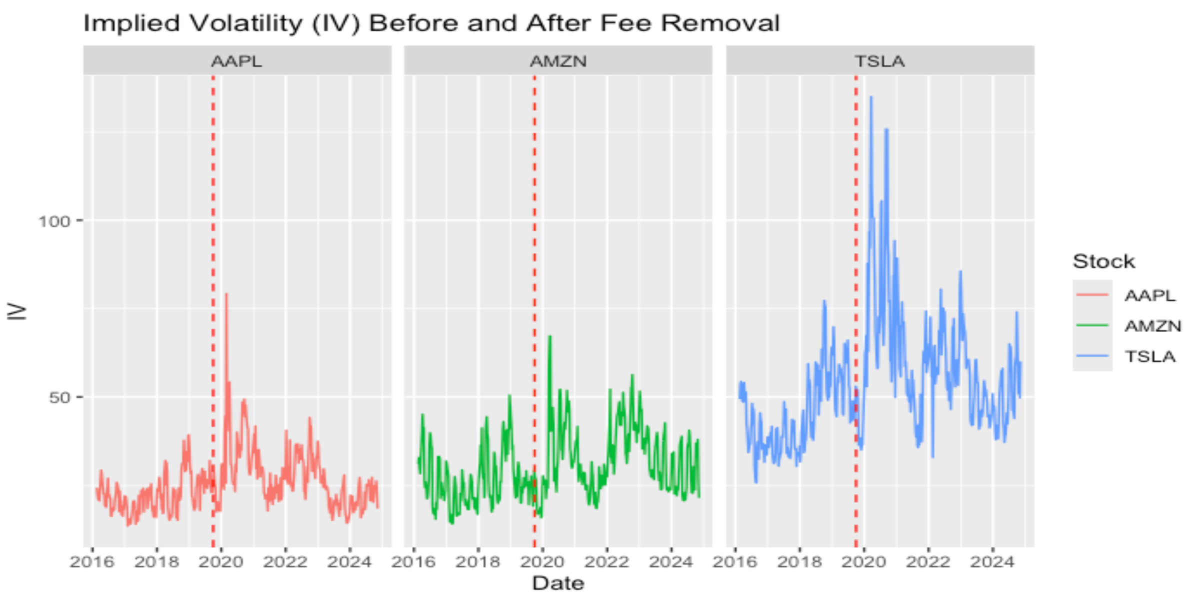


Figure 2. Implied Volatility Before and After Trading Fee Removal

Table 1. Summary of ITSA Model for Implied Volatility

Summary of ITSA Model for Implied Volatility (IV)

Stock	term	estimate	std.error	statistic	p.value
AAPL	(Intercept)	19.0118	0.9683	19.6346	0.0000
AAPL	Time	0.0052	0.0013	4.0749	0.0001
AAPL	Post_Intervention	24.7934	2.0209	12.2683	0.0000
AAPL	I(Time * Post_Intervention)	-0.0125	0.0015	-8.3958	0.0000
AMZN	(Intercept)	25.0267	1.3137	19.0504	0.0000
AMZN	Time	0.0024	0.0017	1.3656	0.1728
AMZN	Post_Intervention	8.3707	2.7440	3.0506	0.0024
AMZN	I(Time * Post_Intervention)	-0.0027	0.0020	-1.3162	0.1888
TSLA	(Intercept)	34.9617	1.9730	17.7205	0.0000
TSLA	Time	0.0154	0.0026	5.9395	0.0000
TSLA	Post_Intervention	52.4633	4.1128	12.7560	0.0000
TSLA	I(Time * Post_Intervention)	-0.0278	0.0030	-9.1952	0.0000

For AAPL, implied volatility displayed a clear upward trend before the removal of trading fees, with the time trend showing a positive and significant slope. This indicates that IV was already increasing prior to the intervention. After the removal of fees, there was a sharp and statistically significant spike in IV, highlighting an immediate reaction likely driven by increased market activity or speculative trading. However, over time, this trend began to slow, as evidenced by a significant negative interaction term. This suggests that while the initial impact of the fee removal was substantial, the market gradually stabilized as investor behavior adjusted.

AMZN, on the other hand, showed a more stable response to the fee removal. There was no significant trend in IV before the intervention, indicating that volatility remained steady leading up to the policy change. Post-intervention, IV experienced a moderate and statistically significant increase, reflecting a smaller but measurable reaction to the removal of fees. Unlike AAPL, there were no significant long-term adjustments to the IV trend, suggesting that AMZN's market was less affected by the policy change and remained relatively stable over time.

TSLA exhibited the most dramatic response among the three stocks. Before the intervention, TSLA's IV was already increasing at a steep and statistically significant rate, reflecting its speculative and high-risk nature. The removal of trading fees caused a substantial and immediate spike in IV, highlighting the stock's sensitivity to market changes and increased speculative trading. However, similar to AAPL, TSLA's IV trend began to slow over time, as indicated by a significant negative interaction term. This suggests that while the initial impact was pronounced, the volatility trend eventually stabilized as market conditions normalized.

In summary, the removal of trading fees had distinct impacts on the implied volatility of AAPL, AMZN, and TSLA. AAPL and TSLA experienced significant short-term spikes in IV, followed by a gradual stabilization in the long term. AMZN, however, exhibited a more moderate response, with minimal long-term effects. These findings demonstrate how different stock characteristics and market dynamics influence the way implied volatility reacts to major policy changes. Stocks with speculative profiles, like TSLA, tend to show sharper and more immediate responses, while more stable stocks, like AMZN, exhibit more measured changes. This analysis underscores the importance of considering stock-specific factors when evaluating the broader implications of trading fee removal on market behavior.

Building on the earlier analysis of implied volatility (IV), it is also important to examine how the removal of trading fees influenced the relationship between implied and historical volatility, as captured by the IV/HV ratio. While IV reflects market expectations of future price movements, the IV/HV ratio provides a broader perspective by comparing these expectations with actual price fluctuations. This analysis helps determine whether the removal of fees disrupted this balance, offering additional insights into the longer-term stability of market dynamics across AAPL, AMZN, and TSLA.

Table 2. Summary of ITSA Model for IV/HV Ratio

Summary of ITSA Model for IV/HV Ratio

Stock	term	estimate	std.error	statistic	p.value
AAPL	(Intercept)	1.1896	0.0449	26.5141	0.0000
AAPL	Time	-0.0002	0.0001	-2.6270	0.0089
AAPL	Post_Intervention	-0.0120	0.0936	-0.1284	0.8979
AAPL	I(Time * Post_Intervention)	0.0001	0.0001	1.3455	0.1792
AMZN	(Intercept)	1.3281	0.0569	23.3509	0.0000
AMZN	Time	-0.0002	0.0001	-2.8057	0.0052
AMZN	Post_Intervention	-0.1613	0.1188	-1.3574	0.1754
AMZN	I(Time * Post_Intervention)	0.0002	0.0001	1.8785	0.0610
TSLA	(Intercept)	1.1603	0.0378	30.6629	0.0000
TSLA	Time	-0.0001	0.0000	-1.9421	0.0528
TSLA	Post_Intervention	0.0359	0.0789	0.4545	0.6497
TSLA	I(Time * Post_Intervention)	0.0000	0.0001	0.4950	0.6208

The ITSA analysis of the IV/HV ratio shows minimal impact from the trading fee removal across AAPL, AMZN, and TSLA. AAPL exhibited a slight downward trend in the IV/HV ratio before the intervention, with no significant immediate or long-term changes post-intervention. AMZN also had a small pre-intervention downward trend, with a borderline trend reversal after the fee removal, though the changes were not statistically conclusive. TSLA displayed high variability in the IV/HV ratio, but the intervention had no significant effect on either the level or trend. Overall, the fee removal did not meaningfully alter the relationship between implied and historical volatility for these stocks.

The analysis supports the literature on delta-neutral strategies and the impact of hedging on implied volatility (IV). While the removal of trading fees increased market activity and caused occasional IV spikes, it did not significantly alter the IV/HV ratio, aligning with findings on the stability of this metric despite market interventions (Flynn, 2024).

3.2 Profitability Before and After Fee Removal

Now that we have examined changes in implied volatility and the IV/HV ratio, we turn our attention to the short straddle strategy to determine whether its profitability has been affected. This section analyses the impact of trading fee removal on returns, providing a detailed evaluation of its influence on the performance of the strategy.

3.2.1 Data of Mann-Whitney U-Test

Data for this analysis has been obtained from the LSEG Refinitiv database, covering the period from January 1, 2016, to November 8, 2024. The dataset includes the closing prices of shares, the implied volatility (IV) of at-the-money (ATM) options, and the risk-free interest rate. For the risk-free rate, the U.S. 3-month government bond yield has been utilized. The closing prices of shares have been used to calculate theoretical call and put option prices and to evaluate short straddle returns on the options' expiration dates. In this analysis, the exercise price of the option is set equal to the stock price at the time of option purchase, ensuring the option is at-the-money. All options included in the dataset have a one-month time to expiration, focusing the analysis on short-term option performance.

The data includes observations from three major stocks: Apple, Amazon, and Tesla. These stocks are treated as a single portfolio with equal representation, consisting of ten randomly selected trading days before and ten randomly selected trading days after the removal of trading fees. This method ensures an equal number of observations for each stock, providing a balanced and consistent dataset for comparison.

A significant limitation in this study was the unavailability of detailed historical options data. To address this, the Black-Scholes model was employed to estimate theoretical option prices. While this approach provided a robust framework for analysis, it required assumptions that may not fully align with real-world market conditions.

The hypothesis being tested is that profits have increased after the removal of trading fees. Specifically, the analysis aims to determine whether the removal of these fees has led to a statistically significant rise in returns during the post-intervention period compared to the pre-intervention period. The test is one-sided, focusing on whether the profits have increased rather than remained the same or decreased.

3.2.2 Mann-Whitney U-test Methods

The Mann-Whitney U-test is a non-parametric statistical method used to compare two independent groups. It is particularly useful when data do not meet the assumptions of normality required for parametric tests. The U-test ranks all values from both groups combined, assigning average ranks to tied values. The ranks for each group are summed, and the U-values are calculated using the following formulas:

$$U_1 = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - R_2$$

Where:

$$R_1 = The\ Sum\ of\ the\ Ranks\ for\ Group\ 1$$
$$R_2 = The\ Sum\ of\ the\ Ranks\ for\ Group\ 2$$
$$n_1 = Number\ of\ Observations\ in\ Group\ 1$$
$$n_2 = Number\ of\ Observations\ in\ Group\ 2$$

(Wall Emerson, 2023)

The smaller of the two U-values is used to test the null hypothesis (H_0), which states there has been a significant increase in returns. This is compared to a critical U-value to determine statistical significance (LaMorte, 2017). Hypotheses are interpreted with significance levels typically set at 95% *($\alpha = 0.05$)*. The Mann-Whitney U-test has been used in financial research. For instance Azhar, used this method to analyze the profitability of electricity companies, demonstrating its relevance for studying financial outcomes. (Azhar, 2017)

The hypothesis for this analysis focuses on evaluating the impact of removing trading fees on profits. Specifically, the study aims to determine whether the intervention led to a measurable increase in returns. The following hypotheses were formulated to guide the analysis:

- **Null Hypothesis ($\boldsymbol{H_0}$)**: The removal of trading fees has not led to an increase in profits (median and mean returns in the post period are equal to those in the pre period).
- **Alternative Hypothesis ($\boldsymbol{H_1}$)**: The removal of trading fees has led to an increase in profits (median and mean returns in the post period are greater than those in the pre period).

3.2.3 Results from Mann Whitney U-test

The results of the Mann-Whitney U-test (appendix 1) shows no significant increase in post-period returns following the removal of trading costs. On the contrary, both the median and mean profits are lower in the post period compared to the pre period. The calculated $(p = 0{,}66)$ far exceeds the significance threshold of $(\alpha = 0.05)$, leading us to fail to reject the null hypothesis that the removal of trading fees has not increased profitability. These findings imply that, rather than enhancing returns, the policy change may have had a neutral or slightly negative effect on profitability.

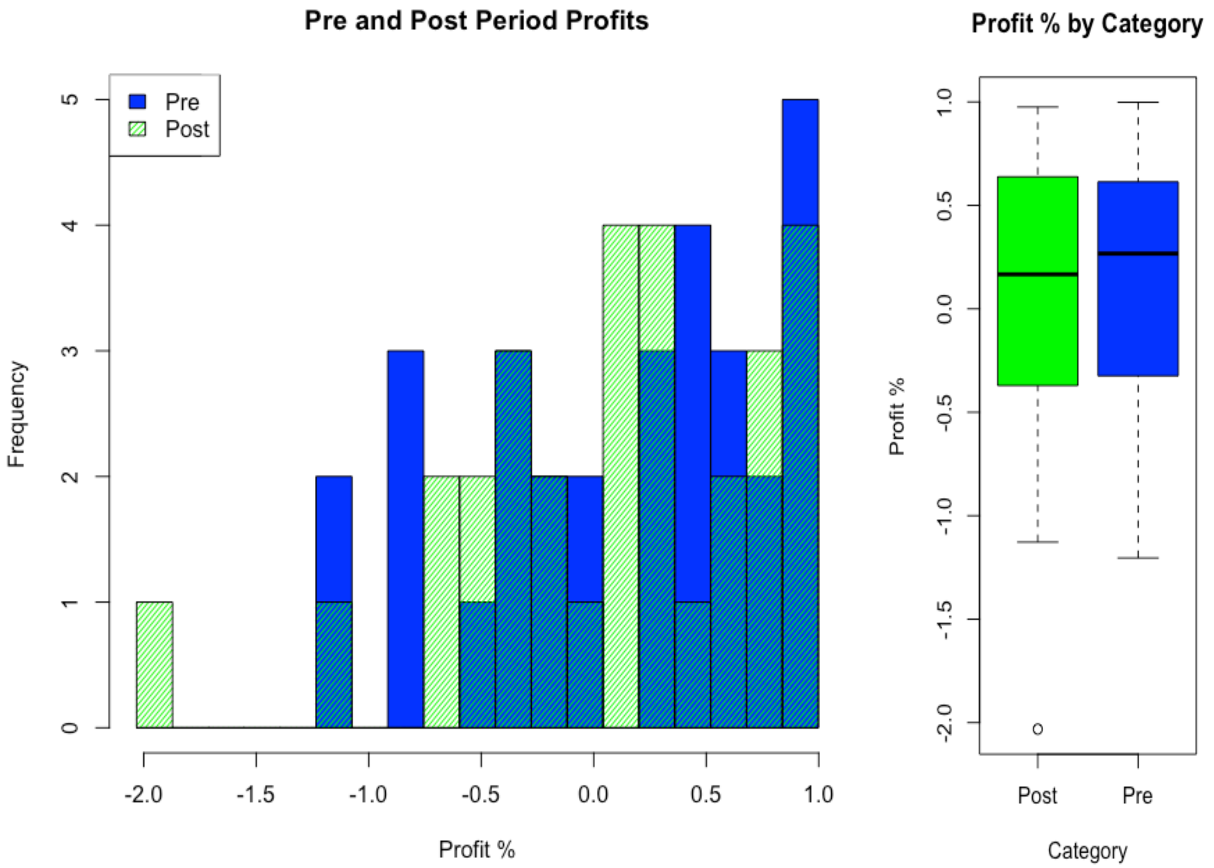


Figure 3. Mann-Whitney U-Test Results

Although the U-test did not indicate that the profitability of the short straddle strategy improved on randomly selected days, the results reveal significant variability in returns, particularly following the removal of trading fees. The histogram comparing profit percentages between the "Pre" and "Post" periods further illustrates this variability. Both periods are centred around 0%, with profit percentages ranging from -2.0% to +1.0%. However, the "Pre" period shows a more concentrated distribution, especially near the higher range of 0.5% to 1.0%, while the "Post" period exhibits a broader and more evenly spread range. Despite significant overlap in the central range (0% to 0.5%), the wider spread in the "Post" period suggests greater variability in profits.

This variability indicates that, while the strategy did not show overall improvement, changes in the trading environment may offer better opportunities for individual trades. Thus, if an investor can successfully time their trades, the short straddle strategy could remain a highly profitable approach, emphasizing the importance of timing in leveraging these opportunities.

4 Conclusion

The removal of trading fees in October 2019 was a major change in financial markets, making options trading more accessible, especially for small retail investors. This policy led to a significant increase in trading volumes, particularly in short-term options, and affected key aspects such as implied volatility (IV), but it did not increase the profits of the short straddle strategy.

This study examined the impact of fee removal on implied volatility and the short straddle strategy using data from three major stocks: AAPL, AMZN, and TSLA. The findings show that implied volatility reacted immediately after the fee removal, with the largest changes observed in speculative stocks. However, the ratio of implied to historical volatility (IV/HV) stayed mostly stable, indicating that the relationship between expected and realized volatility was not disrupted. For the short straddle strategy, results show no increase in profitability after the removal of fees. Instead, both median and mean returns were lower in the post-fee-removal period, and no significant improvement in returns was observed.

The findings of this study reveal that the expected relationship between volatility and the profitability of the short straddle strategy did not materialize, which may deviate from the assumptions outlined in the introduction. While implied volatility showed a short-term reaction to the removal of trading fees, the ratio of implied to historical volatility remained largely stable, and no significant improvement in the strategy's profitability was observed. This suggests that the changes in market dynamics may be more complex than initially anticipated.

Future research could build upon this study in several meaningful directions. Firstly, the development of specific indicators to determine optimal conditions for executing the short straddle strategy could offer significant value to investors. Such indicators might focus on identifying periods when implied volatility surpasses historical volatility or when market conditions stabilize following volatility spikes, thereby enhancing profitability while mitigating associated risks. Secondly, extending the analysis to encompass a broader range of stocks and sectors would facilitate the examination of whether these strategies and observed patterns are consistent across various market environments. This expanded scope would contribute to a more comprehensive understanding of the interplay between volatility dynamics and options trading strategies under diverse market conditions.

By focusing on these areas, future research could offer practical insights for investors and traders, showing how volatility differences can be used effectively and how these findings apply to different areas of the financial market.

References

Azhar, S. (2017). A Comparative Study of Working Capital Management, Solvency and Profitability of Private and State Owned Power Distribution Utilities Using Mann Whitney U Test. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3087867

Bernal, J. L., Cummins, S., & Gasparrini, A. (2017). Interrupted time series regression for the evaluation of public health interventions: A tutorial. *International Journal of Epidemiology*, *46*(1), 348–355. https://doi.org/10.1093/ije/dyw098

Black, F., & Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *Journal of Political Economy*, *81*(3), 637–654.

Cheuathonghua, M., & Padungsaksawasdi, C. (2024). The volume-implied volatility relation in financial markets: A behavioral explanation. *The North American Journal of Economics and Finance*, *71*, 102098. https://doi.org/10.1016/j.najef.2024.102098

Christensen, B. J., & Prabhala, N. R. (1998). The relation between implied and realized volatility1. *Journal of Financial Economics*, *50*(2), 125–150. https://doi.org/10.1016/S0304-405X(98)00034-8

Deshpande, M. S. (2020). U.S. Equity Derivatives Strategy: Impact of Retail Options Trading. *Barclays U.S. Equity Derivatives Strategy*. https://amarketplaceofideas.com/wp-content/uploads/2021/08/Barclays_US_Equity_Derivatives_Strategy_Impact_of_Retail_Options_Trading.pdf

Flotyński, M. J. (2017). Comparison of the results of long and short straddle option strategies on the WIG20 during 2005–2015. *Poznań University of Economics and Business*.

Flynn, M. (2024). Charming! Retail Option Volume and Delta Hedging Effects on Stock Pricing. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4733077

Hull, J., & Rotman, J. L. (2018). *Solutions manual options, futures, and other derivatives* (9th edition, global edition). Pearson Education Limited.

Hull, J., & White, A. (2017). Optimal delta hedging for options. *Journal of Banking & Finance*, *82*, 180–190. https://doi.org/10.1016/j.jbankfin.2017.05.006

LaMorte, W. W. (2017). *Mann Whitney U Test (Wilcoxon Rank Sum Test)*. https://sphweb.bumc.bu.edu/otlt/mph-modules/bs/bs704_nonparametric/bs704_nonparametric4.html

Liu, Y., & Song, H. (2024). A Prediction of Option Price via Two Volatility Computations with Application to a 50ETF Option. *Applied Science and Innovative Research*, *8*(1), p185. https://doi.org/10.22158/asir.v8n1p185

Mixon, S. (2009). Option markets and implied volatility: Past versus present☆. *Journal of Financial Economics*, *94*(2), 171–191. https://doi.org/10.1016/j.jfineco.2008.09.010

Pilbeam, K. (2018). *Finance and Financial Markets* (4th ed). Macmillan Education UK.

Procházka, I. D. (2011). *The Collection of Papers 2011 is published under financial support of the Internal Science Foundation of the University of Economics, Prague (registration number of the project F1/11/2011).*

Shamkuwar, M. A. (2023). Analytical Study of Short Straddle and Short Strangle. *International Journal of Research Publication and Reviews*, *Vol 4*(no 4), pp 864-868.

Wall Emerson, R. (2023). Mann-Whitney U test and t-test. *Journal of Visual Impairment & Blindness*, *117*(1), 99–100. https://doi.org/10.1177/0145482X221150592

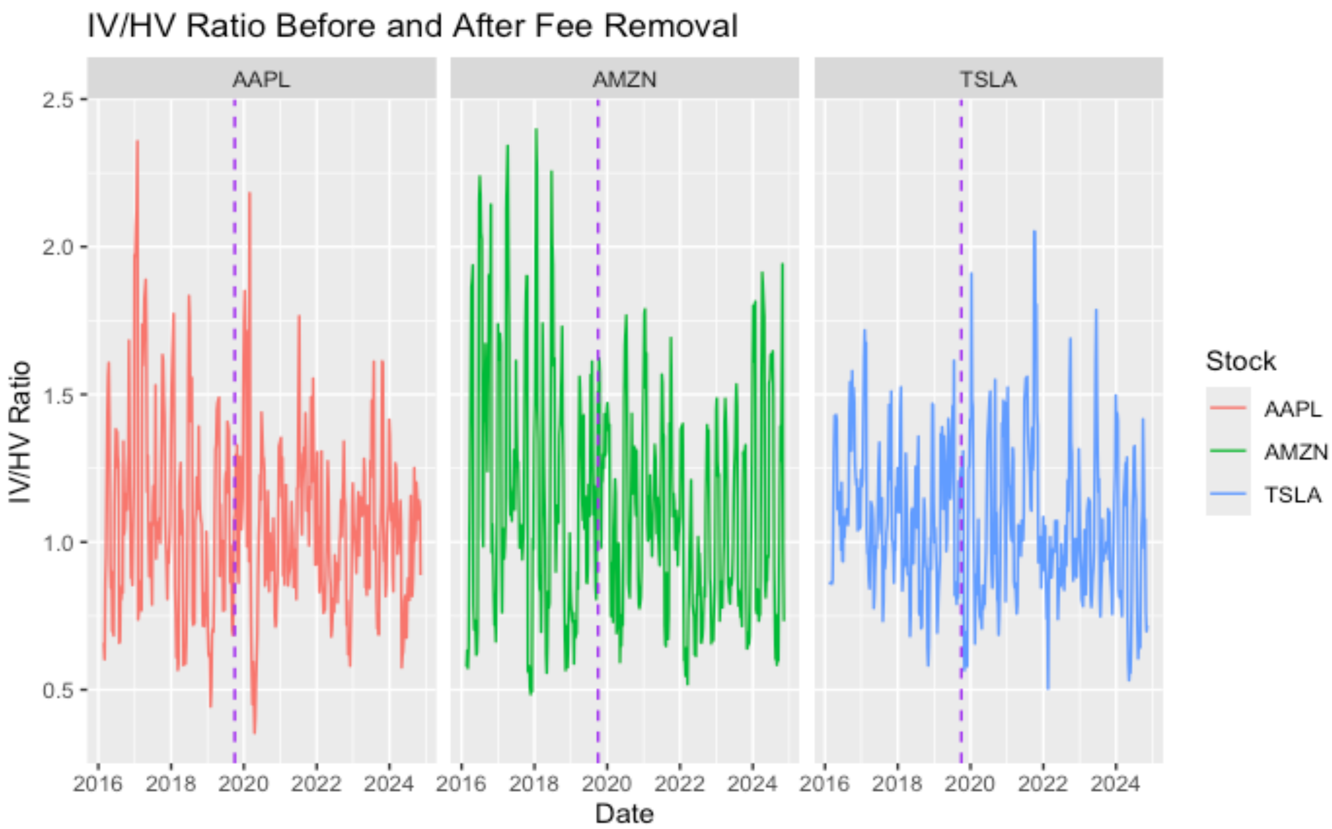
Appendices

Appendix 1 Mann-Whitney U Test Results

Mann-Whitney U Test Results

	Statistic	Value
1	U1	477
2	U2	423
3	P-value	0.657840781290377
4	Pre Median	0.266721769
5	Post Median	0.166716663
6	Pre Mean	0.118624135933333
7	Post Mean	0.0738320461666666
8	Pre SD	0.662647861993531
9	Post SD	0.685942109331189

Appendix 2 Chart of IV/HV Ratio Before and After Fee Removal



Appendix 3 Use of Artificial Intelligence

In this study, AI tools (ChatGPT-4), have been utilized to enhance the quality and clarity of written language and to assist in constructing R code for data analysis. These tools were employed to improve the efficiency of the research process by providing suggestions for text refinement and generating initial code structures for statistical analyses.

All text and code generated by AI have been reviewed and validated to ensure their accuracy and relevance to the research objectives. Final responsibility for the correctness and reliability of the content rests entirely with the author. This ensures that while AI has been a supportive tool in the research process, the interpretations, conclusions, and overall integrity of the study remain under the author's control.