

VIX to S&P 500 Correlation Over the Weekend: Are Market Makers Using S&P 500 Weekend Returns to Price VIX on Monday Morning?

Wan Jia Lin¹

¹ the CFO of AI Technology Inc., He earned his PhD degree from Walden University, United States

Correspondence: Wan Jia Lin, PhD, CPA, the CFO of AI Technology Inc., United States.

Received: December 13, 2022

Accepted: January 14, 2023

Available online: January 19, 2023

doi:10.11114/aef.v10i1.5819

URL: <https://doi.org/10.11114/aef.v10i1.5819>

Abstract

This paper studied the correlation between the S&P 500 ETF (SPY) weekend returns and the VIX changes. Two distinct patterns are found: (1) VIX is dropping intraday and rising overnight; (2) a negative SPY weekend return correlates with VIX weekend change. We found the negative correlation is statistically significant ($P=0.000$). This proves that option market makers are using SPY Friday overnight returns to adjust the implied volatility the next morning. This may lead to a profitable options model that sells high IV options closing on Friday and buys them back next Monday, especially before the earnings announcement.

Keywords: volatility seasonality, VIX, S&P 500 overnight returns

1. Introduction

The “VIX” (which tells us the level of the expected volatility of the S&P 500 Index for the next 30 days) is observed to express a particular pattern over the year and has been proven to be negatively correlated with the intraday return of the S&P 500 (Bauer, 2022). Bauer’s study is on the intraday of S&P 500 index data.

2. Literature Review

Previous studies on the Day-of-the-Week seasonality of volatility of the S&P 500 is focused on the intraday when the stock market is open during day time. Berument & Kiyamaz (2001) reported high Wednesday and low Monday return, and low Wednesday volatility and high Monday volatilities in both US stock market and Istanbul Stock Market. Yalcin & Yucel (2006) confirmed the same results on S&P 500 and VIX. Farooq, Nouaddi & Ahmed (2013) found the same effect in emerging markets (Saudi Stock Exchange), but volatility is higher on Wednesday, the last trading day of a week in Saudi Stock Exchange.

Ozenbas & Zamanian (2011) found the same effect in the US and European stock markets. Volatility is high on Monday morning and Friday afternoons. Orhan & Emikonel (2021) also found day of the week effect on Bitcoins with higher Monday returns and higher Saturday volatility. A study on the seasonality of VIX (Hirsch, 2022) focused on monthly seasons from January to December each year, which confirmed that VIX spikes in October and bottoms in July of a year.

However, there is little research investigating the overnight VIX, its correlation with intraday S&P 500 returns and its impact on option pricing. Zhang & Zhao (2021) studied the Nasdaq index volatility, and found that 40% of the volatility of the S&P 500 and Nasdaq index is overnight volatility, the rest 60% contributes to the intraday movements.

Knuteson (2019) claimed that Wall Street big firms and some market makers are manipulating the market by marking the opening prices high or lower and profiting from the gap up and gap downs of most US stocks. However, Knuteson did not found sufficient evidence and any strong correlations of the gaps with any other financial factors.

We approach this VIX phenomenon from a Day-of-Week Seasonal perspective and found that options implied volatility (VIX) is substantially higher over the weekend (from Friday close to next Monday open).

We discovered a unique pattern in the VIX pricing: VIX is higher when the market is opening (9:30 to 10:30 Eastern Standard Time) and lower when the market is near closing (3:00 pm to 4:00pm EST).

However, our study on the overnight and intraday effect of the volatility index (VIX) shows VIX is always positive overnight and negative intraday for the entire 32-year period from Jan 2, 1990 to Dec 2, 2022. Option market makers can control implied volatility (IV) to increase profit and minimize risk of selling options, thus options market

participants can benefit from this phenomenon by selling high IV option spreads in the afternoon of Friday and buying them back next week in the afternoon of Monday.

In search of clues to the underlying causes of the superior surge of the VIX overnight, we examined the behavior of VIX overnight and intraday patterns. We found strong overnight effect in the VIX index and proposed an option trading strategy to capture potential return variance of this effect.

3. Methodology and Data

The data consist of daily observations of the opening and closing prices of the VIX index, and the price data of the S&P 500 index ETF (Symbol: SPY) from 1993 to 2022 (29 years since the inception of SPY).

The total daily close-to-close return is calculated as $CC_t = (C_t - C_{t-1})$ where C_t is the closing price on day t . The closing price is a cum dividend price of the SPY. The daytime return (open to close return) is $CO_t = C_t - O_t$ where O_t is the opening price on day t . The overnight return (previous close to open return) is the difference between O_t and C_{t-1} , $OC_t = O_t - C_{t-1}$.

Data	Sampling Period	Number of Datasets	Sample Size
SPY	1993 to 2022	1	7,506
VIX	1990 to 2022	1	8,300
Total		2	15,806

In data analysis outliers may have impact on the results. The conventional Bollerslev (1986) GARCH model and other models have been used to assess the volatility in VIX. However, the models' predictability can not cover the extremes.

When we look at the historical IV of 84.83 on March 17, 2020 and the intraday and overnight IVs, we can see the overnight IV is not so volatile. But the pattern is still there: Friday overnight VIX is still higher than other days of the week. From March 20, 2020 (Friday) to March 23, 2020 (Monday), VIX was up 8.04, 4 times higher than the average of other days in the same week. Comparison of the intraday and overnight VIX changes in March 2020 is shown in Chart 1.

Chart 1. VIX intraday and overnight changes in March 2020.



From Chart 1 we can see even in extreme S&P 500 index volatility, overnight VIX change is not so high.

Although VIX is not the same as the actual volatility of the S&P 500 index, VIX is only the expectation of S&P 500 volatility in the next 30 days. Vodenska & Chambers (2013) discovered that VIX and S&P 500 are not always in pace. In a bull market, VIX overestimates the S&P 500 index volatility in financial stable periods, and underestimates the S&P 500 index volatility throughout high volatility periods. VIX has the implied volatility and option market maker's expectation embedded.

4. Results and Discussion

A. The Intraday and Overnight Patterns of VIX

Table 1. Statistics Summary of Intraday and Overnight patterns of VIX for the period classified by Day of the Week

	<u>Mon</u>	<u>Tue</u>	<u>Wed</u>	<u>Thu</u>	<u>Fri</u>	<u>p value</u>
<u>Panel A. VIX Intraday Return Computed from Opening Price to Closing Price</u>						
Mean Return	-0.133	-0.103	-0.051	-0.014	-0.121	0.0803
Sample Size	1,560	1,701	1,700	1,671	1,658	
<u>Panel B. VIX Overnight Return Computed from Closing Price to Next Opening Price</u>						
Mean Return	-0.063	-0.029	0.027	-0.042	0.518	0.0001
Sample Size	1,560	1,701	1,700	1,671	1,658	

Two interesting patterns are discovered: (1) Intraday VIX is negative (dropping from open to close) on all days of a week, especially on Mondays; (2) Friday overnight VIX is extremely higher than all other days of a week. The p value = 0.0001.

This means options market makers are raising implied volatility between the closing of Friday to the Opening of next Monday (over the weekend) to minimize their risks of selling options over the weekend.

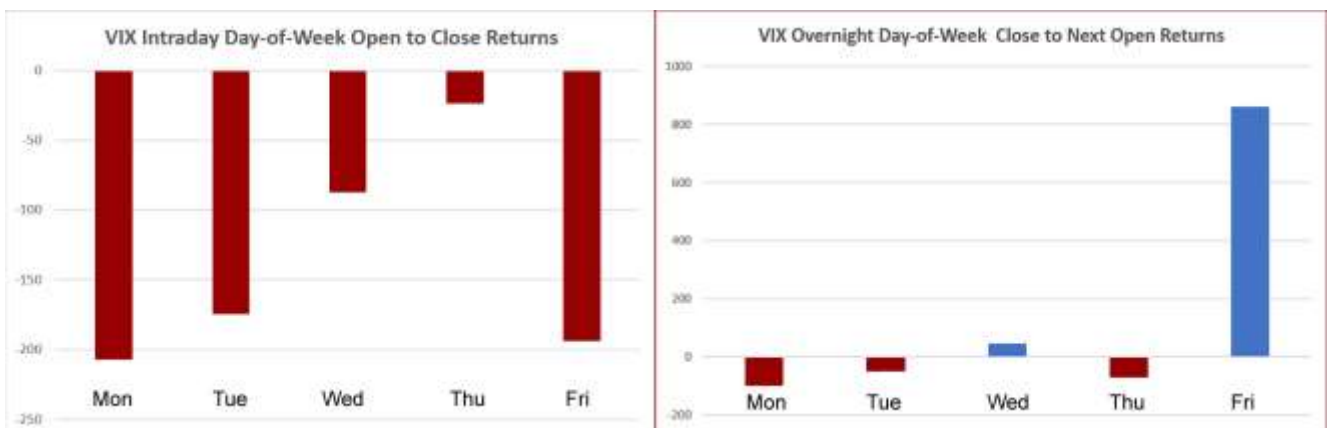


Figure 1. VIX Day-of-the-Week Effect

B. Day-of-Week Patterns of SPY Overnight Returns

Results from the day-of-week analysis of the SPY overnight returns are presented in Table 2. The $p < 0.05$.

Table 2. Summary of Overnight Returns of SPY for the Entire Sample Period Classified by Day of the Week

	<u>Mon</u>	<u>Tue</u>	<u>Wed</u>	<u>Thu</u>	<u>Fri</u>	<u>p value</u>
<u>SPY Overnight Return Computed from Closing to Next Opening Price</u>						
S&P 500 Futures ETF (SPY)						
Mean Return	0.131	0.071	-0.014	0.027	0.033	0.0439
Sample Size	1,409	1,502	1,502	1,502	1,502	

C. Two Statistically Significant Patterns

(1) During intraday trading hours, VIX is higher at the opening hour from 9:30am to 10:30 am EST, and lower before

the close of a trading day from 3:30pm to 4:00 pm EST;

- (2) VIX (volatility index) recorded an average of gain of 0.518% over the weekend, meaning 75% of the upward movement of VIX occurred over the weekend when the market is closed.

5. The Option Strategy

The purpose of this study is not to explain the reason of the overnight effect of SPY and its correlation with the VIX change over the weekend. Instead, we are repressing evidence that option market makers may be using overnight SPY return as a parameter to adjust the implied volatility in pricing options in the morning of Monday; and trying to build a robust options strategy to capture this seasonal effect of VIX.

Joe Corona (2005) reported in an interview with John Lothian News that large firms on Wall Street are taking advantage of the opening high IV of options by selling what he called Power Condor, short near the money calls and long out of the money calls in larger numbers in the morning.

From the strong upward movement of VIX over the weekend, we built an option IV arbitrage strategy which buys an iron condo or a calendar spread before the closing of Friday afternoon EST and close the position in the afternoon of next Monday. This strategy can also be used to capture IV spikes before earnings release of a company with options that is going to release earnings after Friday closing or on next Monday or Tuesday.

5.1 The Weekend Strategy

This model is to buy an iron condo or a calendar spread in the afternoon of Friday when IV is low, and sell it in the morning of next Monday (or next trading day), when IV spikes. This strategy works in September and October when historical VIX is high.

We can also use this strategy on options on VIX by selling options on VIX in the morning of Monday and closing the position before the closing in the afternoon of Friday.

5.2 Post-Earnings IV Crush Strategy

The post-earnings IV crush is a well-understood fact, but the opportunities to profit from it aren't as straightforward as they might seem. When a company is going to release earnings next Monday, the close month IV will spike in the afternoon of Friday. This strategy is to sell the front month option spreads and buy the next expiration spread with the same strike price at the same time. The position will be closed after earnings release next Monday or Tuesday.

5.3 Robustness Check

We compared the percentages of positive overnight returns and positive returns over means to the total sample size of Friday VIX data, the positive return percentage is 76.62% (meaning over 76% of the VIX upward changes happened from Friday close to next Monday open) and the positive return over means is 51.05%.

Assets	Monday Positive	Total Sample	% Positive	% Over Means
VIX	1,659		76.62%	51.05%

For each day (overnight) of the week, the number of positive and negative returns is computed. A z-statistic is computed to test the null hypothesis that positive and negative returns are equally likely events.

Mendenhall (2004) discussed the risk in selling options after earnings announcement. For our proposed Post-Earnings IV Crush Strategy, it only works when front month IV is two times higher than the IV next month. If the front month IV is not 200% higher, this strategy may not work. Bid-ask spread is also an issue. We need to choose stock options with narrow bid-ask spread.

5.4 VIX-SPY Friday Overnight Correlation Analysis

We found statistically significant negative correlation between S&P 500 ETF (SPY) Friday overnight performance and VIX Friday overnight (to next Monday) levels. When the SPY Friday overnight return is high (Next Monday opens higher), VIX Friday overnight is low (VIX next Monday will be low); when next Monday opens lower, VIX will go up next Monday morning. This is the basic foundation for option market makers to adjust the implied volatility. Market makers also need to consider option buyers' demand for options.

Market makers are relying on the overnight returns of SPY to set the implied volatility level next Monday. Market makers also need to consider other factors such as US 10-year bond yield (Connolly, Stivers & Sun 2005) and 2-year yield. A strong correlation between US bond yields and VIX also exists. (Rankin & Idil, 2014).

Here are the correlation analysis results:

Equation: $Y = -0.898 * X + 0.5931$, $p < 0.0001$. $F = 714.3$ $DFn, DFd = 1,998$. Slope = -1.114.

Overnight	VIX Fri	SPY Mon	SPY Tue	SPY Wed	SPY Thu	SPY Fri
VIX Fri	1					
SPY Mon	-0.0279991	1				
SPY Tue	0.01091811	-0.0068737	1			
SPY Wed	0.02800712	0.11942953	0.04926988	1		
SPY Thu	-0.0067302	-0.1179419	-0.0373661	0.02695251	1	
SPY Fri	-0.4445287	0.01922412	-0.0716421	-0.0261962	-0.0048192	1

Here are the t-test results (p=0.000):

	VIX Friday	SPY Friday
Mean	0.530612517	0.032689747
Variance	1.152245061	2.679587697
Observations	1502	1502
Pearson Correlation	-0.444528662	
Hypothesized Mean Difference	0	
df	1501	
t Stat	8.308836804	
P(T<=t) one-tail	0.0000000	
t Critical one-tail	1.645869427	
P(T<=t) two-tail	0.0000000	
t Critical two-tail	1.961545699	

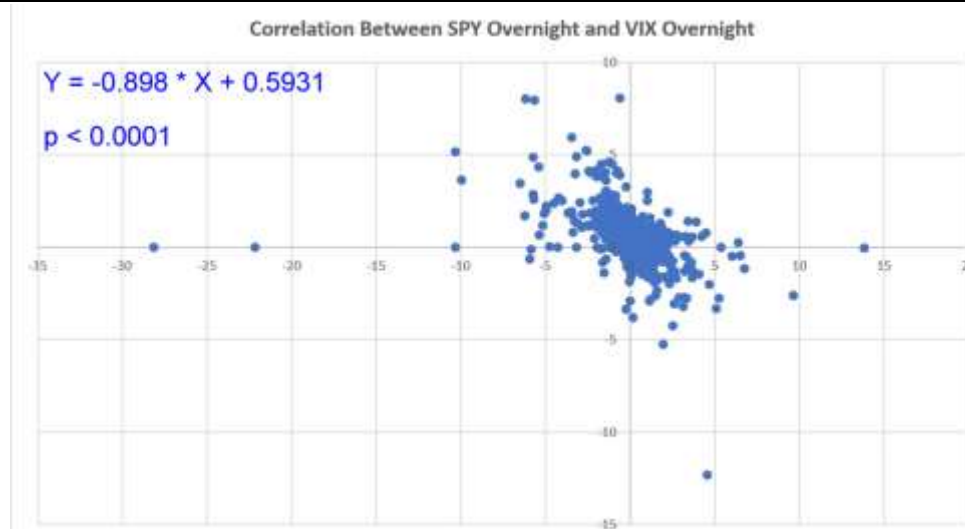


Figure 2. Correlation Chart

Since IV is the only factor in the option pricing model that is not known (other 4 factors are known), and the 0.45 negative correlation coefficient means option market makers may be relying heavily on the S&P 500 Friday overnight return to price the IV of next Monday morning.

6. Conclusions

The results of this study provide a comprehensive investigation of the correlation between the Friday overnight return and the VIX Monday overnight change. Evidence is present that, during the sampling period, two distinct and significant seasonal patterns are present in volatility index. The results are significant in two respects. First it shows that intraday VIX is high in the morning, and low in the afternoon. Second, VIX overnight has strong day of the week seasonality when VIX is exceptionally high over the weekend.

Previous studies on the seasonality of VIX focused on monthly seasonals from January to December each year, which proved that VIX tops in October and bottoms in July. Our results concerning VIX are focused on the days of the week, with VIX spikes over the weekend. Since the correlation is negative, we have reason to believe that market makers may be using the SPY overnight return from Friday night to Monday morning or next trading day to price the options next Monday morning (using past weekend's SPY overnight return to determine the opening implied volatility level on Monday) because implied volatility is the only variable in the option pricing model that can be changed by market makers.

This study reveals that the observed day-of-the-week pattern in VIX and its negative correlation with SPY overnight return are both statistically significant. For the VIX phenomenon, options traders can sell options at the close of Friday when IV is high, and avoid buying options in the morning opening hours of a trading day.

Knuteson has been claiming that market makers in Wall Street are manipulating the market by adjust the opening price of US stocks to profit from the gap ups and gap downs. But Knuteson did not provide sufficient evidence. In our study, evidence is obvious that the level of VIX in the morning of Monday is negatively correlated with the weekend S&P 500 returns. This suggests that market makers can price the options in the morning of Monday based heavily on the S&P 500 weekend returns.

In order to protect investors, we suggest that financial policy makers can set a limit on the level of implied volatility similar to a circuit breaker in the futures market.

References

- Bauer, S. (2022). Inside volatility trading: breaking down the VIX index and its correlation to the S&P 500 index. *Study Report*, CBOE.
- Berument, H., & Kiymaz, H. (2001). The day of the week effect on stock market volatility. *Journal of Economics and Finance*, 25(2), 181. <https://doi.org/10.1007/BF02744521>
- Connolly, R., Stivers, C., & Sun, L. (2005). Stock market uncertainty and the stock-bond return relation. *Journal of Financial and Quantitative Analysis*, 40(1), 161-194. <https://doi.org/10.1017/S0022109000001782>
- Farooq, O., Bouaddi, M., & Ahmed, N. (2013). Day of the week and its effect on stock market volatility: evidence from an emerging market. *The Journal of Applied Business Research*, 29(6). <https://doi.org/10.19030/jabr.v29i6.8210>
- Gonzalez, M. T., & Guerrero, D. E. (2013). Day-of-the-week effect on the VIX. *The North America Journal of Economics and Finance*, 25, 243-260. <https://doi.org/10.1016/j.najef.2012.06.003>
- Hirsch, J. (2022). VIX and volatility have historically increased August through October. *Traders' Almanac*.
- Knuteson, B. (2020). *Celebrating three decades of worldwide stock market manipulation*. Capital Markets: Market Efficiency eJournal. <https://doi.org/10.2139/ssrn.3490879>
- Liu, J. (2015). Day of the week effect in returns and volatility of the S&P 500 sector indices. *Working Paper, University of Jerusalem*.
- Mendenhall, R. (2004). Arbitrage risk and post-earnings-announcement drift. *The Journal of Business*, 77(4), 875-894. <https://doi.org/10.1086/422627>
- Orhan, A., Emikonel, M., & Emikonel, M. (2021). Volatility and the day of the week effect on Bitcoin returns. *Journal of Emerging Economics and Policy*, 6(2), 51-58.
- Ozenbas, D., & Zamanian, Z. (2011). Day of the week effects in intra-day volatility patterns of equity markets: a study of US and European stock markets. *International Business & Economics Research Journal*, 5(6). <https://doi.org/10.19030/iber.v5i6.3485>
- Vodenska, I., & Chambers, Q. J. (2013). Understanding the relationship between VIX and the S&P 500 index volatility. *26th Australian Finance and Banking Conference*. <https://doi.org/10.2139/ssrn.2311964>
- Wang, T., Cheng, S., Yin, F., & Yu, M. (2022). Overnight volatility, realized volatility and option pricing. *Journal of Futures Market*. <https://doi.org/10.1002/fut.22330>
- Yalcin, Y., & Yucel, E. M. (2006). The day-of-the-week effect on stock-market volatility and return: evidence from emerging markets. *Czech. Journal of Economics and Finance*, 56.
- Zhang, Z., & Zhao, R. (2021). Is overnight volatility overlooked? *Working Paper, Claremont Graduate University*. <https://doi.org/10.2139/ssrn.3574323>

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the [Creative Commons Attribution license](#) which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.