ETF Volatility around the New York Stock Exchange Close

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In this study we extend the work of Chang, Jain and Locke (1995) who study the Standard and Poor's 500 (S&P 500) Index futures contract volatility around NYSE close by examining three ETFs, the Spider, the Diamonds and the Cubes price volatilities after market close. Similar to the S&P 500 Index futures contract ETFs continue trading until 16:15, which is 15 minutes after their underlying indexes are reported. This is the first study to the best of our knowledge to examine the volatility of ETFs around the NYSE close. We document that similar to the findings of Chang, Jain and Locke (1995) the Spider volatility has the pronounced U-shaped pattern however, the Diamonds and the Cubes volatilities consistently drop in the 15 minutes after NYSE close.

INTRODUCTION

In this study we extend the work of Chang, Jain and Locke (1995) by examining the volatility of the SPDR S&P 500 ("SPDR®" is a registered trademark of Standard & Poor's Financial Services LLC ("S&P") and has been licensed for use by State Street Corporation) Exchange Traded Fund (ETF), also known as the Spider, around the close of the New York Stock Exchange (NYSE). In addition, we also examine the volatility of two other prominent ETFs, the SPDR Dow Jones Industrial Average ETF, also known as Diamonds, and the PowerShares NASDAQ 100 Trust Series I ETF (The NASDAQ 100 Trust Series I ETF is a trademark registered by Invesco Powershares Capital Management LLC), also known as Cubes around the close of NYSE. Chang, Jain and Locke (1995) study the Standard and Poor's 500 (S&P 500) Index futures contract volatility around the NYSE close. Chang, Jain and Locke (1995) find that the volatility of the futures contract drops at 16:00, the time of NYSE close but increases towards the end of the futures contract trading close at 16:15. They find that the volatility pattern is U-shaped in this timeframe.

Similar to the S&P 500 Index futures contract the Spider continues trading until 16:15, which is 15 minutes after the NYSE close. Similar to the conclusion of Chang, Jain and Locke (1995) the Spider's volatility consistently drops in the 15 minutes after the NYSE close and increase in the end of this 15 minute window, also exhibiting U-shaped pattern. However, this finding applies only to the Spider, because the Diamonds and the Cubes do not exhibit this pattern and have the volatility consistently decrease in this window. This is the first study to the best of our knowledge to examine the volatility of ETFs around the NYSE close.

MOTIVATION AND LITERATURE REVIEW

The reason this is an important issue is due to the fact that the major financial indexes, such as the S&P 500, the Dow Jones Industrial Average (DJIA) and the NASDAQ 100 (NDX) indexes, are reported at 16:00 Eastern Time when the NYSE closes. The component stocks of the indexes stop trading at 16:00 as well and therefore there are no ETF Net Asset Value (NAV) changes. Nguyen (2005) points out that the authorized participants who arbitrage any deviations of the ETF price from the ETF NAV via the ETF unit creation and redemption process have until 16:00 to notify the trust of any creation or redemption of units. Thus, arbitrage in the 16:00-16:15 window is virtually non-existent; however, the ETF continues trading regardless of the lack of NAV change. We document significant price changes in this event window and we endow this to liquidity traders' activity.

Most of the studies examining intradaily behavior of stock prices focus on the trading day time period between stock markets open at 9:30 and stock market close at 16:00. These studies document a U-shaped trading pattern of stocks. Admati and Pfleiderer (1988) examine why trading is concentrated in the beginning and the end of the trading day. They suggest that the concentration might be due to the behavior of liquidity and informed traders. Liquidity traders participate in the stock market for reasons not related to the future payoffs of the securities whereas informed traders trade on the proprietary information about the security future payoffs that they posses. Admati and Pfleiderer develop a theoretical model explaining the U-shaped intradaily trading pattern. Foster and Viswanathan (1990) also develop a theoretical model explaining daily stock prices even though not on intradaily basis. In their study they suggest that the informed traders posses more proprietary information on Monday than on Tuesday and show that indeed price volatility is highest on Mondays.

UNIVARIATE ANALYSIS

In this study we examine the behavior of Spider, Diamonds and Cubes prices after NYSE close. Table 1 provides information on the three ETFs used in this study. In aggregate, at the end of 2010 these three ETFs held approximately 12% of the assets in the industry. These three ETFs are the oldest in the industry and all three are structured as unit investment trusts. The differences among these ETFs are the different indexes that they track and the fact that the Diamonds pays dividends monthly whereas the Spider and the Cubes pay dividends quarterly.

TABLE 1
ETF DESCRIPTION

	Spider	Diamonds	Cubes
Type	Unit Investment Trust	Unit Investment Trust	Unit Investment Trust
Design	1/10 of S&P 500	1/100 of DJIA	1/40 of NDX
Dividends	Quarterly	Monthly	Quarterly
Inception Date	January 30, 1993	January 20, 1998	April 13, 1999
Ticker	SPY	DIA	QQQQ
Exchange	AMEX	NYSE	NASDAQ
Assets (Millions, December 2010)	$89,872	$8,721	$22,062
Percentage of Assets in Industry	8.90%	0.86%	2.19%

We use intradaily data from the NYSE Trade and Quote (TAQ) Daily Trades file and from pitrading.com for the three ETFs. TAQ does not provide data on the underlying indexes, pitrading.com provides intradaily data on the underlying indexes and there are no data on the indexes after 16:00. The data are available in seconds intervals in the period January 01, 2004 until May 28, 2010. Similar to Chang, Jain and Locke (1995) we use the Parkinson (1980) Extreme Value Method for Estimating

Variance. This method uses the natural log of the ratio of highest to lowest price in the interval as a better estimator of volatility than the traditional volatility measure, the standard deviation. We estimate volatility in the period after NYSE closes at 16:00 until ETF trading closes at 16:15.

TABLE 2
VOLATILITY RESULTS USING PARKINSON (1980) EXTREME VALUE METHOD FOR ESTIMATING VARIANCE BETWEEN 15:45 AND 16:15

Spider		Average Volatility in Basis Points				
Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 15:45-16:00	55.76	60.33	57.19	66.85	53.28	58.75
2) 16:00-16:15	86.23	93.07	97.94	96.09	83.47	91.52
3) difference	30.48	32.74	40.76	29.24	30.19	32.77
4) t-statistic	6.02***	5.18***	6.00***	5.20***	7.48***	12.86***
N	300	329	332	325	317	1603
Diamonds		Average Volatility in Basis Points				
Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 15:45-16:00	31.77	29.95	35.75	34.63	34.89	33.42
2) 16:00-16:15	31.56	31.91	34.19	35.74	34.38	33.58
3) difference	-0.20	1.96	-1.56	1.11	-0.51	0.16
4) t-statistic	-0.06	0.67	-0.58	0.49	-0.18	0.13
N	300	329	332	324	316	1601
Cubes		Average Volatility in Basis Points				
Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 15:45-16:00	53.40	51.65	49.93	48.84	57.55	52.22
2) 16:00-16:15	67.66	74.95	78.37	83.70	78.59	76.79
3) difference	14.26	23.30	28.44	34.87	21.04	24.57
4) t-statistic	2.42**	3.95***	6.18***	7.23***	5.64***	10.89***
N	296	327	330	322	316	1591

Note: Statistical significance at the 1%, 5% and 10% level is denoted with ***, ** and *, respectively.

Following Chang, Jain and Locke (1995) methodology Table 2 reports the volatility between 15:45 and 16:15. We compare the volatility based on the Parkinson (1980) Extreme Value Method for Estimating Variance in the 15 minute interval before 16:00 and the 15 minute interval after 16:00. The matched sample t-tests reject equality between the volatilities in those intervals. The statistically significant positive coefficients for the Spider and Cubes indicate that the volatility after 16:00 is higher. The Diamonds ETF is the exception with statistically insignificant differences in these two adjacent 15 minute intervals.

Again, following Chang, Jain and Locke (1995) methodology we compute minute-by-minute volatility in the 15 minutes interval after the NYSE closes. The minute-by-minute volatility results for the three ETFs are reported in Table 3 Panels 1-3. The table shows that the Spider and the Cubes have much larger volatilities than the Diamonds every day of the week. The Spider has an average volatility for all

days of the week of 20.67 which is the largest among the three ETFs, followed by the Cubes with volatility of 14.15 and the Diamonds with average volatility of 6.98. However, the after market close volatility of the Diamonds appears not to be statistically different from the before market close volatility. The after market close volatility of the Spider and the Cubes are statistically different from the before market close volatilities. These univariate results indicate that an extended multivariate analysis is required to capture additional relations among the volatilities.

Foster and Viswanathan (1990) find that daily stock price volatility is higher on Mondays than it is on Tuesdays. We find that this is true only at the ETF trading close at 16:15. Prior to this time Monday stock prices are less volatile than the Tuesday prices for the three ETFs every day of the week. Wednesday appears to be the day in which the Spider has the highest average volatility after market close. Thursday is the day with highest after market volatility for Diamonds and Cubes.

Chang, Jain and Locke (1995) find that volatility of the S&P 500 futures contract exhibits a U-shaped pattern. The pattern for the Spiders is U-shaped, as shown on Figure 1. The figure is based on the minute-by-minute volatility estimates provided in Table 3 for all days aggregated together. The volatility pattern indicates that the Spider volatility consistently drops in 12 minutes after the NYSE close but abruptly increases in the last three minutes of trading.

TABLE 3
MINUTE-BY-MINUTE VOLATILITY RESULTS USING PARKINSON (1980) EXTREME VALUE METHOD FOR ESTIMATING VARIANCE

PANEL A: SPIDER

Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 16:00-16:01	20.74	19.64	30.68	27.35	21.97	24.16
2) 16:01-16:02	28.20	19.82	20.21	24.36	23.12	23.04
3) 16:02-16:03	21.70	20.09	23.07	21.93	21.58	21.68
4) 16:03-16:04	21.19	20.77	18.43	21.12	20.20	20.32
5) 16:04-16:05	16.46	18.95	18.88	21.77	18.03	18.85
6) 16:05-16:06	20.07	25.53	19.16	18.74	18.12	20.35
7) 16:06-16:07	14.01	18.97	16.60	20.65	17.45	17.60
8) 16:07-16:08	22.09	20.62	18.58	19.44	17.85	19.69
9) 16:08-16:09	15.81	20.41	21.11	22.54	16.51	19.36
10) 16:09-16:10	15.16	18.87	20.26	20.00	16.69	18.27
11) 16:10-16:11	14.00	18.18	15.30	19.55	17.79	17.00
12) 16:11-16:12	17.65	14.74	12.49	19.09	16.15	15.98
13) 16:12-16:13	27.75	26.39	26.69	31.46	28.76	28.21
14) 16:13-16:14	24.32	24.30	22.04	26.69	23.59	24.18
15) 16:14-16:15	23.22	18.92	23.48	22.06	18.81	21.29
average	20.16	20.41	20.47	22.45	19.77	20.67
median	20.74	19.82	20.21	21.77	18.12	20.32
stdev	4.60	2.98	4.46	3.60	3.46	3.22
min	14.00	14.74	12.49	18.74	16.15	15.98
max	28.20	26.39	30.68	31.46	28.76	28.21
Difference from the day before		0.26	0.05	1.98	-2.68	

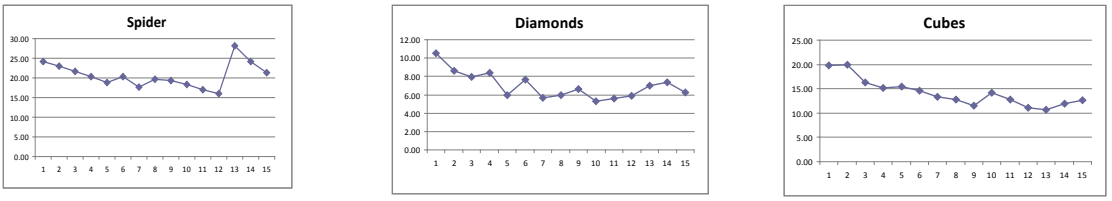
PANEL B: DIAMONDS

Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 16:00-16:01	8.98	9.17	10.41	13.84	10.06	10.51
2) 16:01-16:02	6.07	7.24	8.82	12.7	7.85	8.6
3) 16:02-16:03	8.88	6.26	6.90	12.14	5.66	7.94
4) 16:03-16:04	8.09	7.31	8.83	9.26	8.50	8.4
5) 16:04-16:05	5.45	6.02	4.88	8.15	5.50	5.99
6) 16:05-16:06	5.29	9.74	9.25	6.04	7.56	7.62
7) 16:06-16:07	5.27	5.29	5.70	5.98	6.22	5.7
8) 16:07-16:08	4.23	4.12	9.06	6.75	5.59	5.96
9) 16:08-16:09	6.71	7.29	6.65	4.69	7.76	6.6
10) 16:09-16:10	4.59	5.07	6.73	5.24	4.84	5.33
11) 16:10-16:11	5.38	6.19	5.37	5.74	5.18	5.57
12) 16:11-16:12	6.53	5.75	4.71	6.65	6.05	5.87
13) 16:12-16:13	11.13	5.68	7.92	4.72	6.11	6.99
14) 16:13-16:14	10.94	7.16	6.37	5.29	7.56	7.37
15) 16:14-16:15	6.72	5.90	6.14	6.11	6.29	6.23
average	6.95	6.55	7.18	7.55	6.72	6.98
median	6.53	6.19	6.73	6.11	6.22	6.60
stdev	2.19	1.49	1.76	3.03	1.44	1.44
min	4.23	4.12	4.71	4.69	4.84	5.33
max	11.13	9.74	10.41	13.84	10.06	10.51
Difference from the day before		-0.40	0.64	0.37	-0.84	

PANEL C: CUBES

Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 16:00-16:01	16.42	18.80	21.23	23.48	19.05	19.86
2) 16:01-16:02	12.31	17.55	16.99	24.06	28.60	19.95
3) 16:02-16:03	14.97	18.41	13.94	18.40	15.34	16.23
4) 16:03-16:04	12.53	12.08	13.98	20.80	16.15	15.14
5) 16:04-16:05	12.7	16.71	16.63	16.98	14.02	15.47
6) 16:05-16:06	13.49	16.89	11.48	16.64	14.30	14.59
7) 16:06-16:07	12.03	13.66	16.33	12.75	11.46	13.28
8) 16:07-16:08	9.04	13.86	14.72	13.76	12.15	12.80
9) 16:08-16:09	9.39	11.08	12.32	14.09	10.37	11.51
10) 16:09-16:10	12.66	14.34	13.95	18.56	11.10	14.18
11) 16:10-16:11	12.41	15.25	13.47	12.55	10.01	12.79
12) 16:11-16:12	10.61	9.78	11.44	13.61	10.15	11.16
13) 16:12-16:13	11.74	11.07	7.85	12.04	10.77	10.67
14) 16:13-16:14	11.6	13.58	11.14	12.2	11.22	11.96
15) 16:14-16:15	13.33	12.87	11.85	13.9	11.62	12.71
average	12.35	14.40	13.82	16.25	13.75	14.15
median	12.41	13.86	13.94	14.09	11.62	13.28
stdev	1.88	2.81	3.16	4.04	4.86	2.84
min	9.04	9.78	7.85	12.04	10.01	10.67
max	16.42	18.80	21.23	24.06	28.60	19.95
Difference from the day before		2.05	-0.57	2.43	-2.50	

FIGURE 1
MINUTE-BY-MINUTE VOLATILITY OF SPIDER, DIAMONDS AND CUBES
(ALL DAYS)

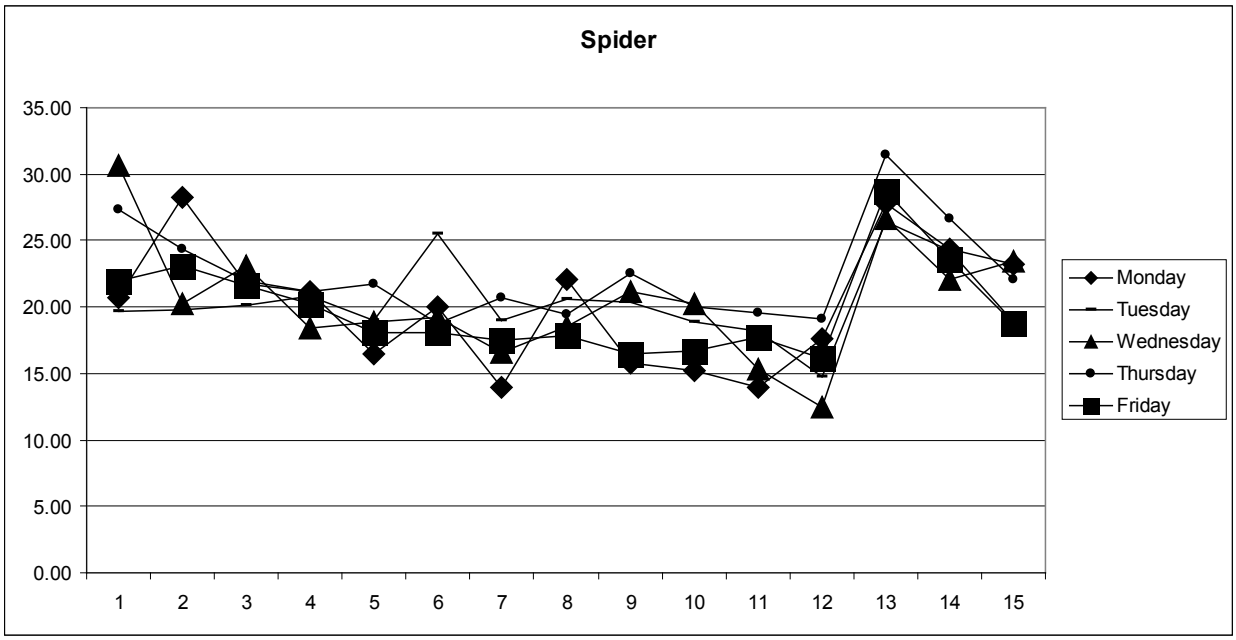


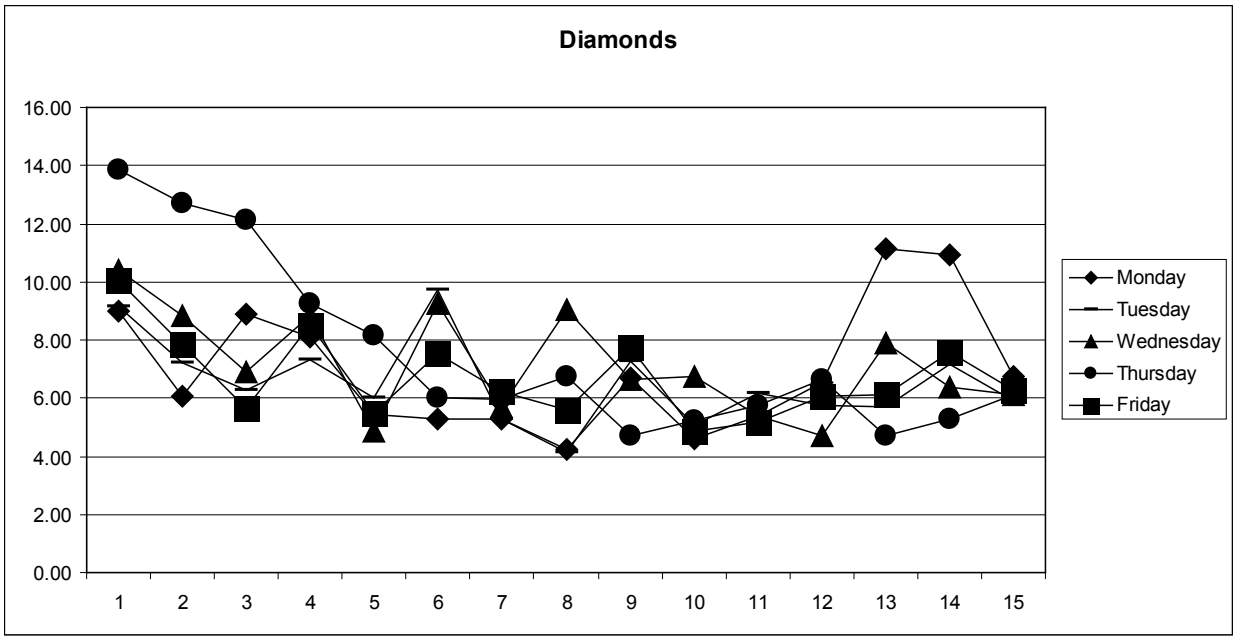
The volatility patterns for the Diamonds and the Cubes in the 15 minutes after NYSE close are downwards sloping and not U-shaped. There appears to by a slight increase of volatility three minutes before the market close but it is not as pronounced as to indicate a reversal of the downwards trend as it is for the Spider. The aggregate day pattern in the figure resembles the Friday volatility pattern in Chang, Jain and Locke (1995) study. The volatility patterns by day are provided and discussed next.

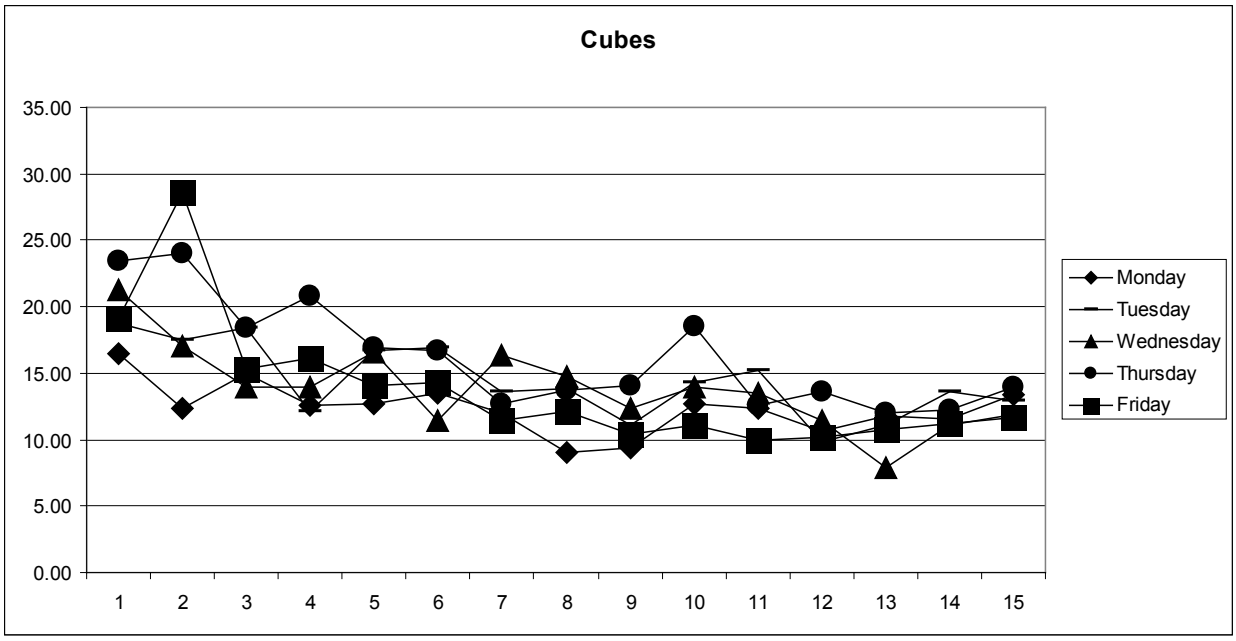
When we examine the behavior of the minute-by-minute volatility by day of the week the Spider volatility increases three minutes prior to the ETF close again for every business day of the week whereas Chang, Jain and Locke (1995) find a decreasing pattern of the S&P 500 futures contract on Friday. We find that the Friday volatility pattern of the Spider is U-shaped just as it is for the rest of the business days. These results are presented in Figure 2.

The Diamonds volatility also increases three minutes prior to the ETF close but only on Monday. The Diamonds Thursday after market volatility three minutes after the market close at 16:00 appears to be abnormally high relative to the rest of the business days. The rest of the business days exhibit the consistent decrease in volatility in the 15 minute interval after market close. The Cubes volatility consistently decreases in this interval every day of the business week.

FIGURE 2
MINUTE-BY-MINUTE VOLATILITY OF SPIDER, DIAMONDS AND CUBES
(DAY OF WEEK)







MULTIVARIATE ANALYSIS

Next, we employ regression analysis to examine the behavior of the after market close volatility across days of the week and ETFs. The models that we employ are specified as follows:

$$Volatility_i = \alpha_0 + \beta_1(Monday) + \beta_2(Tuesday) + \beta_3(Wednesday) + \beta_3(Thursday) + \beta_3(Spider) + \beta_3(Cubes) + \varepsilon_i \quad (1)$$

,

$$Volatility_i = \alpha_0 + \beta_1(Monday) + \beta_2(Tuesday) + \beta_3(Wednesday) + \beta_3(Thursday) + \beta_3(Spider) + \beta_3(Diamonds) + \varepsilon_i \quad (2)$$

,

$$Volatility_i = \alpha_0 + \beta_1(Monday) + \beta_2(Tuesday) + \beta_3(Wednesday) + \beta_3(Thursday) + \beta_3(Cubes) + \beta_3(Diamonds) + \varepsilon_i \quad (3)$$

where Volatility is the estimated minute volatility per ETF, Monday, Tuesday, Wednesday and Thursday are dummy variables for the day of the week and Spider, Diamonds and Cubes are dummies for the respective ETFs.

The multivariate analysis results are presented in Table 4. The results indicate that Thursday consistently has the higher statistically significant volatility when compared to the rest of the week days. Monday or Tuesday do not seem to play a significant role as factors affecting volatility after NYSE close. Also, the Spider and Cubes consistently have higher volatilities whereas the Diamonds have consistently decreasing volatility.

TABLE 4
REGRESSION RESULTS

	(1)		(2)		(3)	
Variable	Estimate	t - statistic	Estimate	t - statistic	Estimate	t - statistic
Intercept	6.49	11.42***	13.61	23.97***	20.15	35.48***
mon	-0.26	-0.39	-0.26	-0.39	-0.26	-0.39
tue	0.37	0.55	0.37	0.55	0.37	0.55
wed	0.41	0.60	0.41	0.60	0.41	0.60
th	2.00	2.95***	2.00	2.95***	2.00	2.95***
Spider	13.66	25.98***	6.54	12.43***		
Diamonds			-7.13	-13.55***	-13.66	-25.98***
Cubes	7.13	13.55***			-6.54	-12.43***
R-sq		0.75		0.75		0.75
N		225		225		225

Note: Statistical significance at the 1%, 5% and 10% level is denoted with ***, ** and *, respectively.

Considering that there are only two types of investors, liquidity and informed traders, as discussed in Admati and Pfleiderer (1988) and that the ETFs derive their value from the behavior of the underlying index that they track, it is fair to assume who of the two investors plays a role in the ETF volatility formation after market close. The indexes do not change after market close, because the component stocks stop trading at the market close.

The information flow, however, does not stop after market close, it is well documented that most major corporate announcements actually occur after market close. Therefore, informed traders have information to trade around the clock. What the informed traders do not have is the opportunity to trade based on this information because the market is closed. ETFs derive their value from the underlying stocks. Therefore, the fact that there is significant volatility in the 15 minute window after market close can be due only to the activity of the liquidity traders.

This idea requires further investigation. If the average number of trades in the 15 minute intervals prior and after market close are examined some interesting results transpire. Table 5 shows the results for the average number of trades in these intervals. It becomes immediately clear that the average number of trades drops about five times after the market closes indicating the withdrawal from the market of large number of traders. As per the earlier discussion it is reasonable to posit that the traders who are most likely to exit the market after close are the informed traders.

TABLE 5
AVERAGE NUMBER OF TRADES

Spider		Average Number of Trades				
Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 15:45-16:00	18363.30	19359.62	19656.75	20978.67	20683.71	19824.79
2) 16:00-16:15	4188.19	4209.71	4262.65	4592.97	4982.70	4447.21
3) difference	-14175.10	-15149.90	-15394.10	-16385.69	-15701.01	-15377.58
4) t-statistic	-13.45***	-13.9***	-14.05***	-12.90***	-13.61***	-30.25***
N	300	329	332	325	317	1603
Diamonds		Average Number of Trades				
Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 15:45-16:00	1911.32	2047.72	2100.46	2246.40	2216.09	2106.54
2) 16:00-16:15	225.80	245.44	237.54	238.43	273.96	244.33
3) difference	-1685.52	-1802.27	-1862.92	-2007.96	-1942.12	-1862.20
4) t-statistic	-13.96***	-14.75***	-14.66***	-13.04***	-13.47***	-30.98***
N	300	329	332	324	316	1601
Cubes		Average Number of Trades				
Interval	Monday (1)	Tuesday (2)	Wednesday (3)	Thursday (4)	Friday (5)	All Days (6)
1) 15:45-16:00	6995.42	7311.28	7444.40	7731.66	7466.30	7395.99
2) 16:00-16:15	1751.26	1965.56	2001.09	2330.24	1881.35	1990.14
3) difference	-5244.16	-5345.72	-5443.30	-5401.41	-5584.94	-5405.85
4) t-statistic	-20.00***	-20.40***	-20.61***	-18.7***	-20.81***	-44.88***
N	296	327	330	322	316	1591

Note: Statistical significance at the 1%, 5% and 10% level is denoted with ***, ** and *, respectively.

CONCLUSION

In this study we examine the three oldest ETFs, the Spider, the Diamonds and the Cubes and extend the work of Chang, Jain and Locke (1995) who study the Standard and Poor's 500 (S&P 500) Index futures contract volatility around NYSE close. Similar to the S&P 500 Index futures contract ETFs continue trading until 16:15, which is 15 minutes after the S&P 500 index is reported.

This is the first study to the best of our knowledge to examine the volatility of ETFs around the NYSE close. We document that similar to the findings of Chang, Jain and Locke (1995) the Spider volatility has the pronounced U-shaped pattern however, the Diamonds and the Cubes volatilities consistently drop in the 15 minutes after NYSE close. A possible explanation is the fact that the component stocks of the indexes stop trading at 16:00 causing the ETF NAV not change in this timeframe either. The trading price is determined based on supply and demand and is kept close to NAV by the authorized participants' arbitrage activities. However, as Nguyen (2005) points out the ETF arbitrage in the 16:00-16:15 window is virtually non-existent, thus making the price change in this time frame most likely due to supply and demand imbalances. Supply and demand imbalances occur regardless of availability of information and thus similar to the study by Admati and Pfleiderer (1988) might be endowed to liquidity traders.

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