STOCK MARKET CIRCUIT BREAKERS AND MARKET VOLATILITY

An Undergraduate Research Scholars Thesis

by

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RESEARCH COMPLIANCE CERTIFICATION

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This project did not require approval from the Texas A&M University Research Compliance & Biosafety office.

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ABSTRACT

Stock Market Circuit Breakers and Market Volatility

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The Securities and Exchange Commission (SEC) sets S&P 500 index circuit breakers, which halt trading due to sudden market declines, at specific price drops, such as a 7 percent price change (Level 1) from the previous trading day's closing price. Also, trading halts due to circuit breakers occur at a 13 percent (Level 2) and 20 percent (Level 3) price change from the previous close. Regardless of the level of the triggered breaker, trading across all stock market platforms halts for a minimum of 15 minutes. However, longer trading halts may occur depending on the price percentage change and when the breaker is triggered during trading hours. These circuit breakers are meant to allow traders additional time to think about changes in the market and their investment positions during trading halts. However, whether this additional time calms the market or increases its volatility is still a matter of debate. Thus far, the literature has addressed this issue theoretically or empirically for other countries. Given that circuit

breakers went off four times in March, we can study the effect of the breakers on market returns and volatility for the U.S. empirically. This thesis will analyze high-frequency, 15-minute interval S&P 500 returns, S&P 500-based realized volatility, and Chicago Board Options Exchange (CBOE) Option-Implied Volatility data from March 2020 to determine the average impact of a circuit breaker's triggering on market volatility measures and market returns.

The markets, in general, were unstable in March 2020, and this volatility can be associated with the spread of COVID-19 and the instituted non-pharmaceutical interventions (NPI) due to state-mandated social distancing restrictions. In addition, uncertainty over future economic outcomes, upcoming quarterly corporate earnings, and the Saudi-Arabia oil price war, in which Saudi-Arabia heavily discounted the price of oil following the collapse of their extraction deal with Russia. The goal of this thesis is not to identify what triggered a circuit breaker, but instead, understand the impact of a circuit breaker on the market in an environment in which these possible changes occur. To do so, we control for some of the events discussed above in this study.

Overall, I find that stock market circuit breakers do not destabilize financial markets despite an increase in S&P 500 volatility. Instead, they can either improve market dynamics or have zero effect on the market.

DEDICATION

To my friends, family, and faculty advisors who encouraged and guided me throughout the research process.

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The data analyzed/used for *Stock Market Circuit Breakers and Market Volatility* were obtained from the Bloomberg Terminal. The analyses depicted in *Stock Market Circuit Breakers and Market Volatility* were conducted in part by Dr. Tatevik Sekhposyan and I and were published in 2020.

All other work conducted for the thesis was completed by the student independently.

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NOMENCLATURE

S&P 500	Standard & Poor's 500 Index
DJIA	Dow Jones Industrial Average
VIX	Chicago Board Options Exchange Volatility Index
SEC	Securities and Exchange Commission
WTI	West Texas Intermediate Index
NYSE	New York Stock Exchange

1. INTRODUCTION

Financial market fluctuations are a natural occurrence over the course of a day's trading hours. These fluctuations may be impacted by current events, company turmoil, overall market speculation, mergers and acquisitions activity, and many other factors. Depending on the direction and severity of the factors mentioned, stock prices may rise or fall by significant amounts. According to the efficient market hypothesis, no matter the circumstances surrounding the market, all stocks are priced correctly across all asset classes, with every investor and trader holding the same up-to-date information (Van Bergen, 2011). While it is only a theory, stock market circuit breakers attempt to uphold the efficient market hypothesis. Instead of letting stocks and indexes suffer heavy losses during market downturns, circuit breakers attempt to cap losses to protect the pricing of stocks.

As a result of the 1987 "Black Monday" stock market crash, the Securities and Exchange Commission (SEC) implemented market-wide stock index circuit breakers for all major U.S. financial indices in order to stabilize large price drops. Similar to an electrical circuit breaker, stock index circuit breakers shut down financial markets to protect their longevity. As outlined by Funakoshi and Hartman (2020), there are three levels at which a circuit breaker can be set off. First, at Level 1, the S&P 500 must decline by 7 percent from the previous day's close price in order to be triggered. Second, at Level 2, the S&P 500 must fall by 13 percent from the previous close price. Third, at Level 3, the S&P must drop by 20 percent for trading to be halted for the remainder of the day. In regards to Levels 1 and 2, the duration of the trading halt lasts for 15 minutes if triggered before 3:25 PM EST. If triggered after this time at these particular levels, all trades are stopped until the next trading day. Even though these circuit breakers are associated with the S&P 500, they will stop trading market-wide when breached.

1.1 Question of Interest

The motivation behind this research is due to the rarity of the events which took place throughout March 2020. As will be discussed below, the last time a circuit breaker was used to halt trading in financial markets was in 1997. Despite major stock market movements since the Dow Jones Industrial Average (DJIA) crash on October 27, 1997, such as the Great Recession (2007-2009) and Flash Crash (2010), market losses were not significant enough to trigger a circuit breaker and halt in trading activity. However, the confusion, threat, and spread of the coronavirus, among other factors, caused the stock market’s massive losses to trigger Standard & Poor’s 500 (S&P 500) Level 1 circuit breakers four times within nine days during March of the previous year. This nine-day period begins on March 9, 2020, and ends on March 18, 2020.

Most of the work on circuit breakers has either been theoretical or has been conducted for other countries. In contrast, this paper adds to the growing body of empirical research on circuit breakers by analyzing the returns and volatility of the S&P 500 index. Also, it provides some insight into how the stock market processes the news on COVID-19 and its implied economic implications at the onset of the pandemic. By analyzing real-time market data, such as S&P 500 returns and its realized and implied volatility over a 15-minute interval, we can test the predictions of the theoretical setups such as circuit breakers’ immediate influence on S&P returns; instead of calming the markets, these circuit breakers might have the perverse effect and could increase price variability and exacerbate price movements.

1.2 Stock Market Circuit Breaker Background

In regards to a significant fall, the stock market experienced its first major crash since the 1960s on October 19, 1987, also known as “Black Monday.” As computer-automated trading was still new at the time, computer networks were not big or strong enough to withstand major sell-offs. Couple this with a widening trade deficit, a new House bill eradicating future government-funded corporate takeovers, and a declining power of the U.S. dollar, the U.S. market was primed for a crash. As investors began to panic, portfolio insurance, which automatically sold investors’ holdings at loss targets to limit portfolio risk in the market, exacerbated the issue at hand. These factors drove the Dow Jones Industrial Average (DJIA) to drop 509 points, or 22.6 percent, on the day (O’Connell, 2018). Due to this extreme crash, the SEC implemented market-wide circuit breakers to prevent any further severe market crashes.

Since the institution of stock market circuit breakers in 1987, they had only been used once during the stock market crash of 1997 before being triggered four times in March 2020. Because of sell-offs in the Asian and European financial markets, investors were wary of U.S. market stability. Due to this uncertainty, the DJIA fell 554.26 points, or 7.18 percent on the day (Zang, 1997). Trading was eventually halted for the remainder of the day after market prices continued to drop from the first circuit breaker trigger an hour earlier.

More recently, circuit breakers were called upon again during the market downfall of March 2020. As a result, S&P 500 circuit breakers were set off on four separate occasions. These four dates include March 9, 12, 16, and 18, which all occurred at the onset of the spread of a new, highly infectious disease. This thesis discusses the basic functionality of stock market circuit breakers and the current events from March 2020 that affected S&P 500 prices and its corresponding Chicago Board Options Exchange Volatility Index (VIX).

1.3 March 2020 S&P 500 Circuit Breakers

In the unprecedented year of 2020, there were many firsts to occur due to a worldwide pandemic brought about by the coronavirus. People across the globe were forced to lockdown inside their homes, wear masks in public, gather in groups of ten or less, and work from home for an extended period. While it was not the first time, the stock market encountered its second index circuit breaker trigger in March in financial market history. However, it was a first when S&P 500 circuit breakers halted trading an additional three times that month. The first trading halt occurred the morning of March 9, followed by further stoppages on March 12, 16, and 18. All four of these stoppages resulted from a Level 1 trigger or 7 percent price drop from the previous day's close price. Below, Table 1.1 details the exact times circuit breakers stopped market activity, the previous day's S&P 500 closing price, the price at the time of the stoppage, and price change calculation:

Table 1.1: Circuit Breaker Overview; Source: Reuters and Bloomberg

Day	Time of Trading Halt	Previous S&P 500 Close Price	Price at Halt	Price Calculation
March 9	9:35-9:50	2972.37	2764.21	7.53%
March 12	9:36-9:50	2741.38	2549.05	7.55%
March 16	9:31-9:45	2711.02	2490.47	8.86%
March 18	12:57-1:11	2529.19	2351.9	7.54%

The change in price calculation above is simply confirming that a 7 percent drop in the S&P 500's price from the previous day's close price occurred to trigger a Level 1 circuit breaker.

1.3.1 Influential Factors Affecting Volatility

The cause of four separate Level 1 triggers may have been a multitude of factors. The first influential factor was the rapid spread of COVID-19 across the globe. Initially, the virus ravaged the Chinese mainland, particularly Wuhan, since the beginning of January. However, it quickly spread to the United States less than a month later and infected 21 cruise ship passengers just two weeks before the first market decline. To further exacerbate market turmoil, the World Health Organization declared the virus a global pandemic and significant concern on March 11. Two days later, the Trump Administration signaled a national emergency and closed U.S. borders to all European citizens (AJMC.com, 2021). Second, the Saudi-Russia oil extraction deal collapsed on March 8. As Saudi Arabia began to discount the price of oil, major oil index prices fell drastically. For example, the West Texas Intermediate Index (WTI), the leading index for crude oil in the United States, plummeted 20 percent (Calhoun, 2020). The price of gasoline in the United States fell, causing the oil and gas industry to suffer heavy losses. This certainly contributed to the market downfall, since oil and gas is a major industry in the U.S. economy. The last factor, which is directly linked to COVID-19, is corporate earnings. With coronavirus spreading rapidly and a national emergency being called, investors were skeptical of the potential impact of quarterly earnings being released in early April (Pisani, 2020). This growing uncertainty continued to negatively impact financial markets, driving prices lower.

1.4 Literature Review

In theory, these trading halts caused by the triggering of a circuit breaker at any level are meant to calm markets, traders, and investors, allowing them more time to analyze trends in the market and make informed decisions on their holdings. However, these trading halts have divided opinions among some economists and analysts. While advocates believe in the overall functionality and purpose of index circuit breakers, others hold the opinion that the 15-minute stoppages significantly increase the current volatility in the market due to frantic sell-offs (Subrahmanyam, 2013). Furthermore, with the increase of high-frequency trading and day traders in today’s market, these hesitant economists have become increasingly worried about higher levels of market volatility due to large volumes of trades occurring in short timespans. With day traders, these individuals may not fully understand the potential effectiveness of trading halts from circuit breakers. This has become increasingly common as commission-free trading apps, such as Robinhood, allow easy access to equity markets for individuals not affiliated with investment banks or investment firms. Individuals who trade on Robinhood can easily make instant market order submissions to buy or sell assets. Nervous investors may quickly sell large volumes of equity when hearing a circuit breaker has been triggered, causing share prices to fall more than usual. Subrahmanyam (2013) highlights this by detailing how high-frequency trades cause market instability through quick market order submissions and cancellations.

Subrahmanyam (1994) furthers his research above by analyzing the empirical effects of the first stock market circuit breakers in the New York Stock Exchange (NYSE) on market volatility. By creating two separate trading periods, or markets, Subrahmanyam calculates, through functions, if an informed trader will continue trading across markets or solely period 1 when a circuit breaker is triggered. Also, he installs a lower and upper-bound variable to account for the necessary price falling out of range, which would halt trading upon a circuit breaker trigger. When the price approaches the created lower-bound price range, the author concludes that the informed trader executes all trades at a single time within period 1 instead of distributing trades across time and markets. If this idea is expanded, then statistically all informed traders will use the same trading strategy. This means that the triggering of circuit breakers increases the probability of fluctuating prices. More importantly, this is the opposite effect that the SEC intended when implementing circuit breakers.

Ackert, Hao, and Hunter (1997) studied the effect of circuit breaker rule changes on market volatility and price limits using the S&P 500 futures index. By using this futures index, the authors were able to analyze expected volatility rates over a specified period of time. To create data samples, they split price limit and volatility data into two separate one-year periods between 1991-1993. The authors failed to discover any significant changes in volatility rates due to rule changes. Further, they argue that circuit breakers may be irrelevant due to not positively affecting market volatility when price limits are altered.

1.5 Hypothesis

To test the arguments of advocates and the opposition, null and alternative hypotheses are presented. The null hypothesis suggests that the triggering of an S&P 500 stock market circuit breaker does not increase volatility or affect S&P 500 returns. The alternative hypothesis instead suggests that the circuit breaker triggers affect market volatility and S&P 500 returns. In addition, we investigate the effect of the news in regards to COVID infection rates, initial unemployment claims, and WTI returns.

2. EMPIRICAL FRAMEWORK

This analysis will use high-frequency daily market data compiled from the Bloomberg Terminal. More specifically, all S&P 500 index and implied volatility (VIX) data spanning all of March 2020 were downloaded from the Line Pricing Charts, which allows for the data to easily be analyzed. This is due to the downloaded price and volatility level data being separated by approximately one minute. From there, data were grouped into 15-minute intervals to best match the time of a circuit breaker trading halt. The 15-minute interval grouping allows us to calculate a realized volatility measure for the market. For example, these intervals spanned from 9:30-9:45, 9:45-10:00, 10:00-10:15, etc. To obtain an initial observation on the collected data, the four days the circuit breakers were triggered were isolated. First, using the 15-minute S&P interval groups, the average price of the S&P 500 was calculated across the entire trading day, which is 9:30 am to 4:00 pm EST. This data and average price across each 15-minute interval is displayed below in Figure 2.1 Panels A-D. This is helpful to visualize how the index price fluctuated throughout the day, both before and after the circuit breaker. Second, the average Chicago Board Options Exchange Volatility Index (VIX) and S&P 500 standard deviation were calculated using their respective 15-minute interval data groups. This data is shown below in Figure 2.2 A-D. Similar to Panels A-D in Figure 2.1, VIX data across all 15-minute intervals throughout the trading day were averaged. To obtain an initial approximation of how volatility affected the S&P 500, the S&P standard deviation was calculated and placed on the same graph. In this case, the S&P 500 standard deviation represents the change in the index's price across a particular 15-minute interval. For additional clarification, the higher the standard deviation across an interval, the greater the change in the index's price.

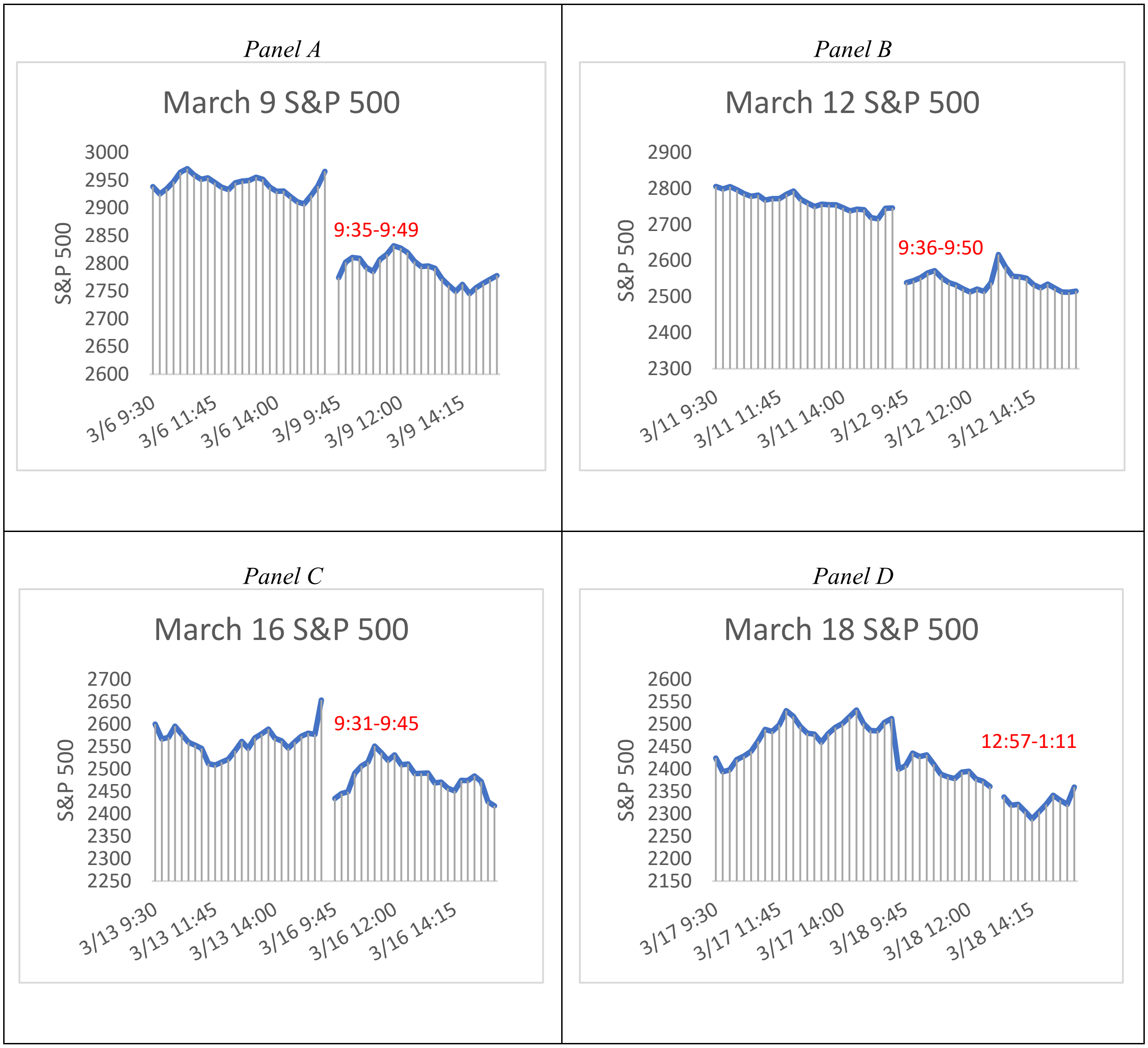

Figure 2.1 Panels A-D: S&P 500 Average Prices; Displays average S&P 500 index throughout each day listed below in 15-minute intervals and the time circuit breakers were triggered (Panel A) March 9 (Panel B) March 12 (Panel C) March 16 (Panel D) March 18

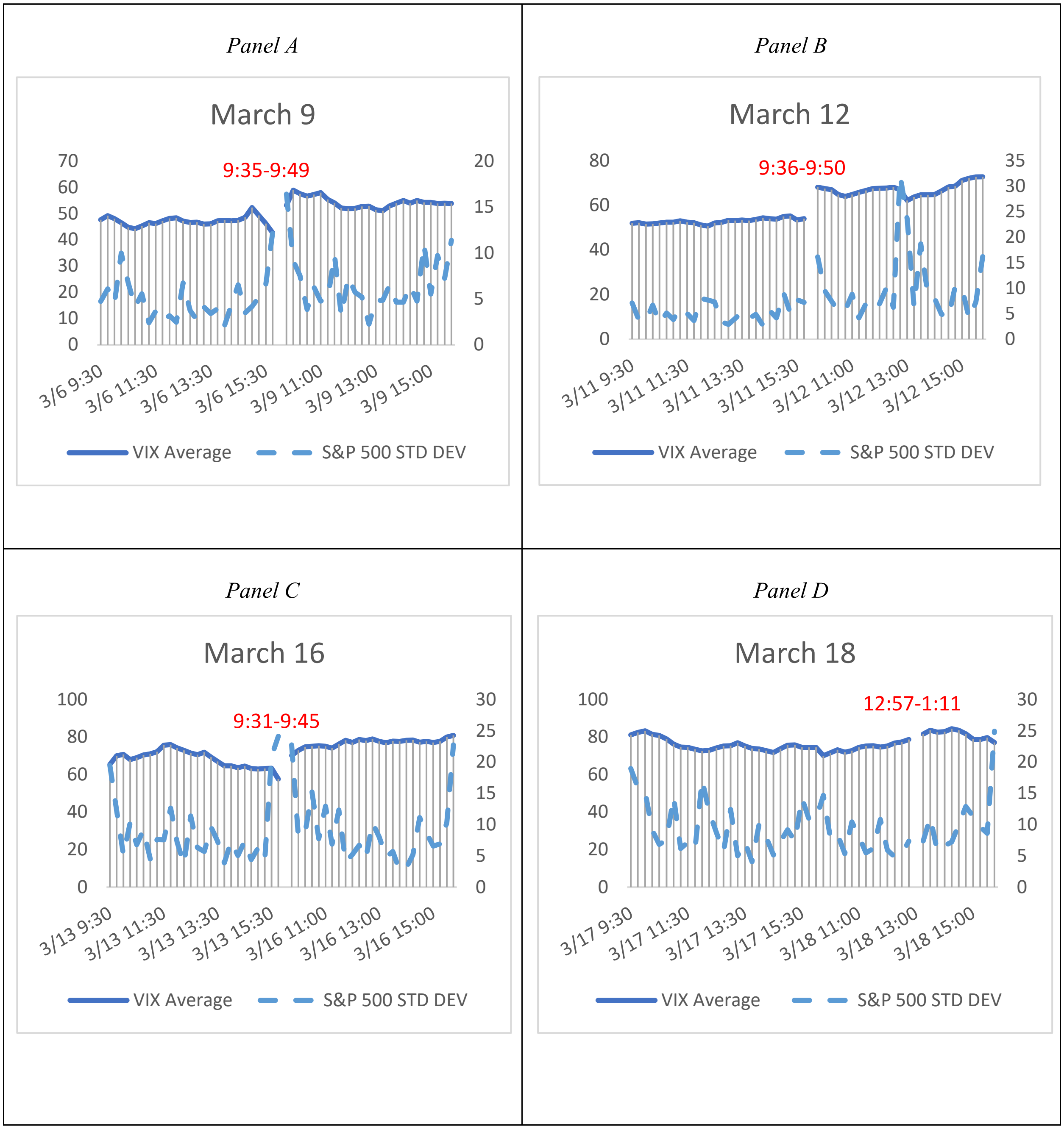

Figure 2.2 Panels A-D: Volatility (VIX) Average and S&P 500 Standard Deviation; Displays standard deviation and average volatility throughout each day listed below in 15-minute intervals and the time circuit breakers were triggered (Panel A) March 9 (Panel B) March 12 (Panel C) March 16 (Panel D) March 18

2.1 Econometric Model

2.1.1 Circuit Breaker Initial Regressions

After compiling and analyzing the initial data results above, we run three separate regressions to further determine stock market circuit breaker effects on S&P 500 returns, VIX, and S&P 500 standard deviation. Unlike the data used in the initial graphs, each regression used the entire month of March 2020 to observe the full effect of a circuit breaker on S&P 500 returns, VIX, and S&P 500 standard deviation. These three variables will be considered dependent (Y) variables in their respective linear regression. While the VIX and S&P 500 standard deviation used were the same as outlined above, the S&P 500 return data was calculated using the 15-minute S&P pricing intervals. In order to determine the S&P 500 returns, a simple percentage change formula was used. This equation was derived as follows in Equation 2.1:

$$(\text{New price-Old price})/\text{Old price} * 100 \qquad (2.1)$$

By using S&P 500 returns in place of its price, it allows for an easier and more practical analysis of this specific regression, as the returns are determined in percentages.

In regards to the control (X) variables, two dummy variables and one lag variable were constructed to control for a trading halt, or circuit breaker triggering. The first X variable dummy, or Trig, isolates the four circuit breaker triggers during March 2020. This isolation was achieved by placing a 1 closest to a 15-minute interval in which a circuit breaker was triggered. In all other intervals without a trigger, a 0 was placed in said intervals. For example, on March 9^{th} the S&P 500 circuit breaker halted trading during the 9:30-9:45 15-minute interval. Because this breaker was in effect, a 1 was placed during this time interval.

The second control dummy, or RemDay, isolates the after-effects of a trigger on each Y variable. In this case, a 1 was placed throughout the remainder of the trading day after a 15-

minute interval in which a trading halt caused by a circuit breaker occurred. Returning to the previous March 9th example, a value of 0 was placed during the 9:30-9:45 circuit breaker trading halt. Then, to account for the after-effects, a 1 was placed for the rest of the 15-minute intervals on this particular day. This control aims to distinguish whether the trigger of a circuit breaker has a lasting effect throughout the day.

Finally, in order to capture persistence in market dynamics, a lag variable is included in the controls. The S&P 500 returns regression uses 15-minute lagged average S&P 500 returns, while the VIX regression uses 15-minute lagged values of the VIX.

2.1.2 COVID Measurements Regressions

To control for the global spread of COVID-19, the three regressions described above were executed again using the same indicator and respective lag variables. In addition, another indicator variable, COVID restrictions, and three other controls are implemented to understand stock market dynamics. To control for COVID restrictions, a dummy variable was created to capture state restrictions (USAToday.com, 2021). When a new state imposed a stay-at-home order, a 1 was placed for that variable throughout the entire day in which the state-mandated order began, while a 0 was placed for any days not containing a new order. In terms of the remaining three control variables, the daily change in mobility rates and percent change in daily COVID cases and deaths were analyzed (all lagged by a day). Because mobility and COVID cases and deaths are released the following day, data released on March 2 is used for March 1, etc. Similar to the S&P returns formula, the percent change in cases and deaths data from the New York Times was calculated to determine the change between days. These two COVID variables aim to capture the effect of COVID announcements and proxy the severity of a pandemic. Using the U.S. National Scaled Mobility and Engagement Index data obtained from the Federal Reserve Bank of Dallas, a simple change in mobility was calculated by subtracting one day's mobility from the previous day. This variable is designed to capture a real-time indicator of the U.S. economic contraction.

2.1.3 WTI Prices and Initial Claims Regressions

In the final set of regressions, which include COVID variables, the three initial regressions are run a third time including other potential economic factors. These factors, or new X variables, are lag WTI, Saudi-Russia oil price war news, and U.S. initial unemployment claims. In order to determine the lag WTI, the same steps as calculating S&P 500 returns were taken. Obtained from FirstRate Data, WTI daily 1-minute interval prices were compiled into the average price across each 15-minute interval throughout each trading day in March 2020. From there, the same percent change formula was used to calculate the returns between intervals. Further, the WTI lag variable operates in the same fashion as each of the considered dependent variables. Finally, two new indicator variables are introduced to our model. The first variable, Saudi-Russia oil price war news, accounts for events that directly caused the price of oil to decline. Because Saudi Arabia discounted the price of their oil on March 8 and 10, a 1 was placed throughout the entirety of both days, while a 0 populated the remaining days in March 2020 (Calhoun, 2020). However, since March 8, 2020, was a Sunday, the 1's placed during this day were incorporated into March 9. U.S. initial unemployment claims, which is the second indicator, details the effect of each Thursday at 8:30 am EST of reported totals in United States unemployment filings (Federal Reserve Bank of New York, 2021). Again, because our data begins at the opening of the market, a 1 was placed every Thursday in March 2020 during the 9:30-9:45 am interval with a 0 during all other time intervals.

2.2 Regression Equation

$$Y_i = \alpha + \beta_1 Trig + \beta_2 RemDay + \beta_3 Y_{i-1} + \varepsilon_i \qquad (2.2)$$

Equation 2.2 is a basic regression equation to fit the three initial regressions, in which the Y variable and its corresponding lag variable are different between each regression trial. Each subscript i denotes S&P returns, VIX, or S&P standard deviation. α is the regression intercept that helps capture the mean dynamics of the dependent variables, while β captures the marginal effects of each covariate. The first indicator variable in the regression, Trig, explains the immediate effect of a circuit breaker trigger on the particular Y variable. Second, the indicator variable RemDay explains the effects on each Y variable throughout the remainder of the trading day after a circuit breaker is triggered. Third, the lag variable $\beta_3 y_{i-1}$ serves as a predictor for each Y variable in future 15-minute intervals. As explained before, the lag captures persistence in market dynamics. Lastly, the error term ε_i accounts for uncertainty in our constructed model.

3. RESULTS

In this section, each regression specification is analyzed, as they discuss different results. 'Circuit Breaker Initial' captures circuit breaker effects, 'COVID Measurements' capture the influence of the global pandemic, and 'Other Economic Indicators' capture the influence of the WTI and initial unemployment claims.

3.1 Discussion of Circuit Breakers and S&P 500 Returns Results

Table 3.1: S&P 500 Returns Regression Statistics

	Circuit Breaker Initial	COVID Measurements	Other Economic Indicators
Trig	-5.1477* (0.3692)	-5.1545* (0.3723)	-4.934* (0.3834)
RemDay	-0.0453 (0.0866)	-0.0588 (0.0989)	-0.0681 (0.0996)
S&P Returns Lag	0.0739* (0.0367)	0.0701* (0.0368)	0.0461 (0.0504)
COVID Restrictions		0.0459 (0.0727)	0.0590 (0.0745)
Mobility		0.0027 (0.0029)	0.0028 (0.0030)
COVID Cases		0.0002 (0.0011)	0.0002 (0.0011)
COVID Deaths		-0.0006 (0.0015)	-0.0004 (0.0016)
Lag WTI			0.0197 (0.0332)
Price War News			0.0548 (0.1196)
Initial Claims			-0.8857* (0.3795)

Note: Each regression includes 570 observations. The appropriate adjusted R^2 values are listed as follows from the columns left to right: 0.25, 0.25, 0.26, respectively. The variable coefficients and standard errors (in parentheses) are included. If a variable's coefficient contains a star, then it's statistically significant at a 5% level.

3.1.1 S&P Returns Circuit Breaker Initial

When looking at the regression results in Table 3.1, it is important to analyze the statistical significance first to decide on whether the considered variables are relevant to the determination of the left-hand-side variable. Statistical significance can be determined by taking the absolute value of the t-statistic at 5% significance for each coefficient. If the absolute value is greater than 1.96, then the variable is statistically significant. When variables are not statistically significant, there is no reason to believe that their impact on returns is different from zero. After analyzing each variable's t-statistic, it can be determined that the indicator variable Trig and lag S&P returns are statistically significant. This is denoted by the star next to their respective coefficient value. As noted through the coefficient values, it can be interpreted that the immediate effect of a circuit breaker, or Trig, caused a 5.15 percentage point decline in S&P 500 returns. Next, if S&P 500 returns are positive and change by one percentage point in the 11:00-11:15 interval, for example, it is predicted that returns will, on average, increase by 0.07 percentage points between 11:15-11:30. Because Trig is statistically significant, a circuit breaker immediately affects S&P 500 returns by its coefficient value or -5.15 percentage points. This means that circuit breakers seem to perform their specified function by stabilizing S&P returns after a Level 1 (7%) price drop is reached. Thus, circuit breakers proxy the immediate impact of a trigger. Because RemDay is not statistically significant, circuit breakers are either beneficial or do not affect the market.

3.1.2 S&P Returns COVID Measurements

Using the same method above, it is determined in Table 3.1 that only the indicator variable Trig is statistically significant. Because no COVID variables were statistically significant, it can be inferred that the effect of circuit breakers on S&P returns does not change in this specification relative to the one before. Also, it is determined that COVID-related news has no importance.

3.1.3 S&P Returns Other Economic Indicators

Examining the other economic variables column in Table 3.1, it is concluded that Trig and initial claims are statistically significant. Due to no initial or COVID variables being significant, the effect of circuit breakers on S&P returns does not change relative to the results in 3.1.1 and 3.1.2. In addition, COVID-related and oil price war news has no significance on returns. However, because initial unemployment claims are significant, the release of new claims data throughout the month decreased returns by approximately 0.89 percentage points. Through this analysis, it can be understood that circuit breakers, again, do not destabilize the market overall. In contrast, the release of unemployment claims data in the United States does decrease S&P returns. Nonetheless, this is presumably a normal occurrence during market downturns. As workers lose their jobs due to companies struggling, investor confidence is sure to decline as returns fall.

3.2 Discussion of Circuit Breakers and Market Volatility Results

Table 3.2: VIX Regression Statistics

	Circuit Breaker Initial	COVID Measurements	Other Economic Indicators
Trig	6.4569* (1.5172)	6.5104* (1.5315)	4.9675* (1.4686)
RemDay	0.7283* (0.3556)	0.8032* (0.4071)	0.6398 (0.3823)
VIX Lag	0.1398* (0.0415)	0.1366* (0.0416)	0.0627 (0.0395)
COVID Restrictions		-0.0689 (0.2985)	-0.0794 (0.2850)
Mobility		-0.0076 (0.0120)	-0.0055 (0.0113)

Table 3.2: Continued

	Circuit Breaker Initial	COVID Measurements	Other Economic Indicators
COVID Cases		-0.0048 (0.0043)	-0.0053 (0.0040)
COVID Deaths		0.0049 (0.0062)	0.0050 (0.0060)
Lag WTI			-0.7753* (0.0947)
Price War News			-0.0925 (0.4574)
Initial Claims			7.3985* (1.4519)

Note: Each regression includes 570 observations. The appropriate adjusted R^2 values are listed as follows from the columns left to right: 0.05, 0.05, 0.18, respectively. The variable coefficients and standard errors (in parentheses) are included. If a variable's coefficient contains a star, then it's statistically significant at a 5% level.

3.2.1 *VIX Circuit Breaker Initial*

When analyzing Trig in Table 3.2, it is concluded that a circuit breaker trigger caused a 6.46-unit increase in volatility in the 15-minute interval in which it is triggered. Also, as stated in RemDay in Table 3.2, there was a 0.73-unit increase in volatility during all periods following a circuit breaker trading halt. Lastly, the VIX lag predicts that if volatility increases in a particular 15-minute interval, then volatility in the next interval is expected to increase by 0.14-units. This regression analysis now allows for an added explanation to a circuit breaker's economic significance. It was determined in the S&P 500 returns regression that circuit breakers stabilize S&P returns in time intervals throughout remaining trading hours after a trading halt. Despite this stabilization, the VIX regression results suggest that the immediate effect of a circuit breaker and effect during remaining trading hours increases market volatility. This leads to potentially preferring one outcome compared to another. Traders and investors must choose between circuit breakers stabilizing returns, but increasing volatility across the market or removing circuit breakers to ride out market swings.

3.2.2 VIX COVID Measurements

When adding additional controls to test for COVID measurements in March 2020, only the initial X and lag variables were statistically significant. While these additional measurements did not have any direct effect on VIX due to their statistical insignificance, they did cause a slight increase in VIX in Trig and RemDay. Although each specific COVID control measurement did not have any direct effect on VIX, they did, however, seem to cause a small increase in VIX on the day of a breaker trigger. This conclusion would infer circuit breakers, because of a global health crisis, increased volatility in the S&P 500 on the day of the trigger. Because the four triggers in March 2020 were within 9 days between March 9-18, this could be cause for concern. The short time in between breaker triggers could make markets too risky as volatility continues to increase, not allowing major indexes ample time to recover from one crash to the next.

3.2.3 VIX Other Economic Indicators

Concerning the final column in Table 3.2, Trig, WTI lag, and initial claims variables were statistically significant. Akin to the same regression for S&P returns, these other economic indicators continue to have a smaller effect on our Y variables. The effect of a trigger immediately is lower compared to regressions 3.2.1 and 3.2.2, while the change in VIX throughout the same day is zero. Despite decreasing prices in oil during March, breakers remained strong, and market volatility decreased due to lag WTI. Again, in any economic slump, workers losing their jobs would be expected depending on the severity of the downturn. Due to the rapid rise in the unemployment rate as a result of increased initial claims, volatility increased as companies were forced to lay off employees to minimize negative cash flow streams.

3.3 Discussion of Circuit Breakers and S&P 500 Standard Deviation Results

Table 3.3: S&P 500 Standard Deviation Regression Statistics

	Circuit Breaker Initial	COVID Measurements	Other Economic Indicators
Trig	0.0024 (1.7603)	-0.1163 (1.7674)	-0.4819 (1.7949)
RemDay	1.5049* (0.4130)	1.2949* (0.4674)	1.2582* (0.4678)
S&P STD DEV Lag	0.4732* (0.0369)	0.4548* (0.0375)	0.4378* (0.0376)
COVID Restrictions		-0.1987 (0.3435)	-0.3023 (0.3490)
Mobility		0.0215 (0.0139)	0.0204 (0.0139)
COVID Cases		0.0103* (0.0050)	0.0109* (0.0050)
COVID Deaths		-0.0070 (0.0071)	-0.0103 (0.0074)
Lag WTI			-0.4008* (0.1134)
Price War News			-0.7393 (0.5602)
Initial Claims			3.2001 (1.7961)

Note: Each regression includes 570 observations. The appropriate adjusted R^2 values are listed as follows from the columns left to right: 0.26, 0.26, 0.28, respectively. The variable coefficients and standard errors (in parentheses) are included. If a variable's coefficient contains a star, then it's statistically significant at a 5% level.

3.3.1 S&P Standard Deviation Circuit Breaker Initial

In the final initial regression, it can be concluded that the indicator variable RemDay and S&P 500 standard deviation lag variable are statistically significant. This means that both variables reject the null hypothesis in favor of the alternative. In trading intervals spanning the rest of the day after a trigger, there is a 1.50-unit increase in the standard deviation caused by RemDay. Finally, the S&P standard deviation lag variable states that if the standard deviation increases in a particular interval, then the standard deviation is expected to increase in the next interval as well. Concerning economic significance, the S&P 500 standard deviation regression results suggest S&P volatility increases in intervals after a circuit breaker is triggered but does not change during the interval in which a breaker halts trading. Because RemDay is statistically significant, we can conclude that circuit breakers destabilize S&P volatility. Despite this volatility, it does not affect the remaining day's S&P returns, as stated in 3.1.

3.3.2 S&P Standard Deviation COVID Measurements

After accounting for the four COVID variables in Table 3.3, RemDay, along with the standard deviation lag and COVID cases variables, are statistically significant. In terms of economic significance, COVID measurements have little to no effect on the S&P standard deviation. However, the additional factors in this regression increase the change in S&P returns in RemDay trading and result in a higher prediction for the next interval's standard deviation. Similar to the initial regression in 3.3.1, circuit breakers destabilize S&P volatility during the remaining trading hours on the day a trigger occurs. However, RemDay in regression 3.1.2 has an effect of zero on S&P 500 returns. This infers that circuit breakers continue to not destabilize the market, instead, having a beneficial effect to no effect at all.

3.3.3 S&P Standard Deviation Other Economic Factors

In the final regression, the variables RemDay, S&P standard deviation lag, COVID cases, and WTI lag are statistically significant. These new factors influenced S&P standard deviation to the same degree as our COVID variables. While the change in S&P returns between 15-minute intervals slightly increased, the predicted standard deviation is approximately the same as in the COVID regression. Further, RemDay S&P volatility continued to decline as more events are controlled in the model. Although S&P volatility is significant, circuit breakers continue to have no destabilizing effect on the market. This can be interpreted because RemDay in regressions

3.1.3 and 3.2.3 is not statistically significant. Breakers remain either valuable or contain no effect on financial markets.

4. CONCLUSION

My results show that circuit breakers perform their intended purpose by stabilizing prices following a Level 1 trigger. Through the regressions, it was expected that no further declines in returns would occur throughout the remainder of the trading day in which a breaker is triggered. However, I also expected volatility to increase during a trading halt. Despite an increase in volatility causing a decline in S&P returns during the interval of a circuit breaker trigger, the effect on returns throughout the remainder of the trading day is zero. Further, VIX in markets after a trigger slightly increases, but not enough to negatively affect S&P returns. With the S&P 500 standard deviation, the change in S&P returns increases after trading resumed following a circuit breaker trigger. However, this change in returns between 15-minute intervals may be positive or have no effect depending on the direction of market swings. This is the SEC's intention for installing circuit breakers in financial markets. It is known that losses will be incurred in the short run, which is the interval in which a breaker is triggered. However, once trading resumes, returns and volatility will rebound to moderate and safe levels. With this verdict, we can prove our hypothesis is supported by the regression analysis in favor of the alternative.

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