THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF ECONOMICS

TRUMPING MARKET EFFICIENCY: EVALUATING THE EFFICIENT MARKET HYPOTHESIS AND MARKET VOLATILITY IN RESPONSE TO DONALD TRUMP'S TWITTER

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SPRING 2020

A thesis
submitted in partial fulfillment of the requirements
for baccalaureate degrees
in Economics & Finance with honors in Economics

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ABSTRACT

In this paper, I discuss the growing importance of social media on the financial markets. Specifically, I look to how Donald Trump's use of Twitter has impacted the financial press, and as a result the financial markets as well. This paper looks for potential profitable opportunities by understanding if/how Donald Trump's tweets are violating important financial models. Statistical and econometric tests are performed to better understand the impact of President Trump's Twitter on the stock market.

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AKNOWLEDGEMENTS

I would like the thank the Department of Economics for their continued support during my undergraduate career. Through scholarships, teaching assistant positions, research assistant positions, and rigorous coursework I have learned more than I could have ever imagined.

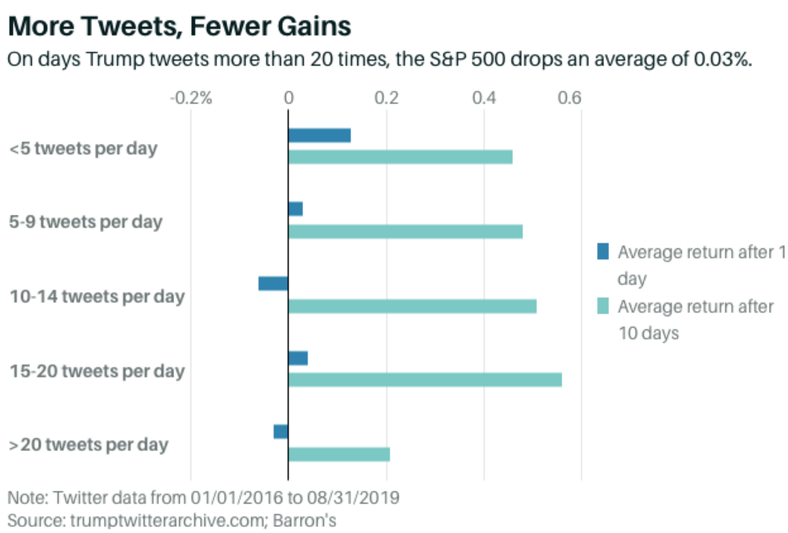
I would also like to specifically thank Professor Chuderewicz for his guidance throughout my entire education at Penn State and through this thesis process.

Finally, I would like to thank my family and friends for their endless support. They have challenged me both in and out of the classroom. I would not have been able to complete this task without their love and support.

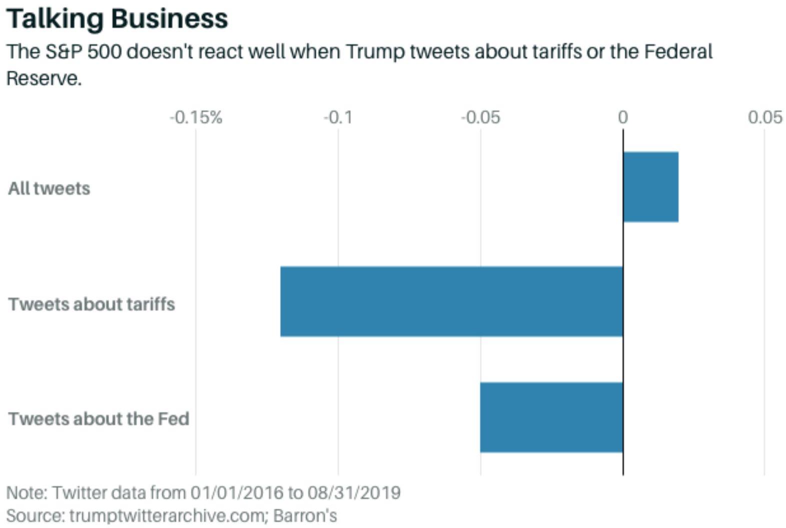
Chapter 1

Introduction

Since May 2009, Donald Trump has used his Twitter account to voice opinions on reality television, celebrities, businesses, past administrations, public policies, social change, and trade relations. His 46,000+ tweets of 280 word blurbs have generated attention from more than 66.9 million followers ("realDonaldTrump," 2019). In fact, the Daily Show with Trevor Noah held a pop-up museum in cities like Washington D.C., Los Angeles, Miami, and New York City to showcase/mock Donald Trump's Twitter Library (Noah, 2019). In more recent times, popular news outlets have studied the correlation between Donald Trump's Twitter account and the movement of the stock market. Bloomberg created an interactive index of the Dow Jones Industrial Average that links open and close values of the Dow to Donald Trump's tweets (Petri & Houston, 2017). Barron's distinguished that the S&P 500 drops on average by 0.03% when the president tweets more than 20 times in a day[1]



(Liu, 2017). In addition, Barron's determined that the S&P 500 reacts worse to Donald Trump's tweets about tariffs and the Federal Reserve than all of his tweets[2]



(Liu, 2017). Finally, JPMorgan analysts created their own index to follow Trump's Twitter, and to analyze price dynamics (Stewart, 2019). Evidently, Donald Trump's Twitter account is influential in the financial markets and must be explored further considering two fundamental theories in finance: the Efficient Market Hypothesis and the Capital Asset Pricing Model.

The Efficient Market Hypothesis (EMH) is highly regarded in the finance/economic academic community. Nobel Prize winning economist, Eugene Fama, developed this theory in the 1960's, and it is still the basis of most asset pricing models. In short, the theory states that assets' prices reflect *all* available information. In essence, there should be no arbitrage opportunities when a market is efficient. The EMH is significant to all investors in a market, as new information should be automatically reflected in an asset's price, creating equal opportunity. In short, one investor will not have more information over others, therefore they cannot gain unusual profits. Investors should care if Trump's tweets violate the EMH because then there are arbitrage opportunities for certain investors to make a profit.

In addition to the EMH, the Capital Asset Pricing Model (CAPM), is a respected theory in the finance/economic academia. Developed by William Sharpe, a financial economist, CAPM describes the relationship between systematic risk and the expected return for assets such as stocks. The formula for calculating the expected return of an asset is: $ER_i = R_f + B_i(ER_m - R_f)$, where

ER_i = Expected return of the asset

R_f = risk free rate (usually treasuries)

B_i = beta of the investment; a measure of how much risk the investment will add to the portfolio

$(ER_m - R_f)$ = market risk premium; return expected from the market above the risk free rate.

Investors should care if Trump's "Tweeting Regime" has violated the EMH, as there might be scope for profitable arbitrage on the basis of his tweets. They also should care about the impending volatility of the stocks through the CAPM.

In the first section of this paper, I will identify and review the literature on the Efficient Market Hypothesis and the Capital Asset Pricing Model. Next, I will provide explanations for the two statistical models used in the paper with regards to the Efficient Market Hypothesis. Then, I will provide the results from the data using the augmented dickey-fuller test and the martingale process. Next, I will provide the methodologies used to test the CAPM. Then, I will provide the data from the methodologies relevant to the CAPM. After, I will dive deeper into the data and relate it to the use of social media. In this section, I will also talk about how investors can use my findings. Finally, I will conclude and reiterate all findings, and mention future research.

Chapter 2

Review of the Literature

The Efficient Market Hypothesis and the Capital Asset Pricing Model are two popular theories, and the basis of many other models. In 2013, Eugene Fama won the Nobel Prize in Economic Sciences for his research on the Efficient Market Hypothesis ("The University of Chicago Booth School of Business"). In his piece, "Efficient Capital Markets: A Review of Theory and Empirical Work," Fama reviews the past literature on the EMH theory, as well as enlists his own empirical work to emphasize that the theory holds in real time.

The Efficient Market Hypothesis

The EMH was originally derived from another theory known as the *random walk hypothesis*. During the 1860's, a French broker named Jules Regnault wrote the foundations of the random walk hypothesis in his book "Chance Calculus and the Philosophy of the Stock Exchange" (Preda, 2004, p. 351-352). Since the 1860's, several economists have contributed to the literature around the random walk hypothesis, and based other theories such as the EMH on their findings. Although Eugene Fama did not originally come up with the random walk hypothesis, he utilized the theory to help explain stock price changes in an article called, "Random Walks in Stock Market Prices." Essentially, the random walk hypothesis states that price movements are random and cannot be predicted. Thus, technical and fundamental analysis cannot predict the movement of stock prices (Fama, 1995, p. 75). Technical analysis is a trading technique where historical values are utilized to predict future values (Azzopardi, 2010, p.13). Fundamental analysis operates under the assumption that all assets have an intrinsic value based on the earning value of the asset. Believers of fundamental analysis think that understanding securities' intrinsic values would help to predict future values (Fama, 1995, p.75). The Efficient Market Hypothesis adds to the random walk hypothesis with regards to available information.

According to Fama, "A market in which prices always "fully reflect" available information is called "efficient"" (Fama, 1970, p. 383). Investors should care that a market is efficient so that no individual investor in the market has an advantage over others with regards to information, and potential earnings. If the Efficient Market Hypothesis holds, when new information is shared it is available to *all* investors, then the price of the security should remain unchanged. The information is thus already incorporated into the price.

Fama goes on to explain three different levels of efficiency. The first form of market efficiency is called *weak-form efficiency*. Weak-form efficiency states that the price of an asset includes historical prices. In essence, past information cannot be used to predict future prices, and excess returns will not be gained from trading based on historical information. Securities follow a random walk, and technical analysis would not render abnormal returns/results (Fama, 1970, p. 383-390). The rejection of technical analysis arises from the random walk component of the weak-form efficiency.

The next form of market efficiency is called *semi-strong efficiency*. Under semi-strong efficiency, not only are past prices reflected in the asset's price, but *all* public information (historic and current) is as well (Fama, 1970, p. 383). With semi-strong efficiency, both technical and fundamental analysis are ineffective in gaining abnormal returns.

Finally, *strong-form efficiency* is the last variation of efficiency that Fama described. Strong-form efficiency incorporates weak form, semi-strong form, and additionally states that prices incorporate private information as well (Fama, 1970, p. 383). Thus, inside traders or specialists in the industry cannot gain a consistent competitive advantage over the average investor.

There are several essential conditions to uphold market efficiency. Fama lists the conditions as (1) zero transaction costs, (2) all information is freely available, (3) everyone agrees on the meaning of the information regarding the current price and future prices (Fama, 1970, p. 387). Fama notes in "Efficient Capital Markets: A Review of Theory and Empirical Work" that finding a frictionless market as described above is not practical with current market conditions. However, his empirical research finds that all three conditions exist to some extent in the market place, which allows for efficiency (Fama, 1970, p. 388).

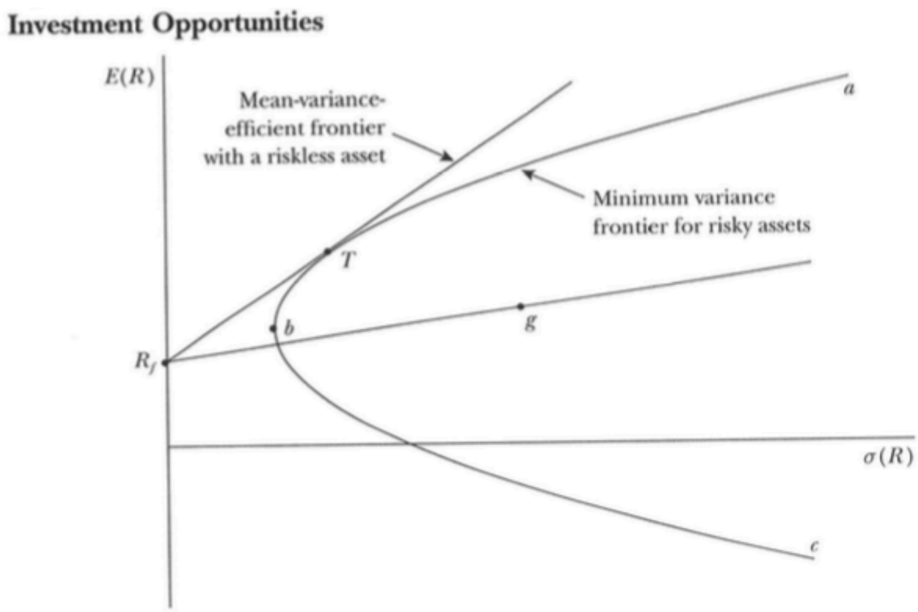
The findings from Fama's work are momentous in the investing community. Throughout his work, Fama found that there is no evidence *against* the weak and semi-strong form, and very little evidence *against* the strong form of efficiency (Fama, 1970, p. 388). Fama's studies on public announcements are important to the empirical research that is to follow in this paper. Public announcements in the form of Donald Trump's tweets will be utilized later to test market efficiency. Fama reviewed the work conducted by Myron Scholes, and found that prices adjust efficiently to public information, thus supporting the semi-strong form of the EMH (Fama, 1970, p. 409). Scholes' research on secondary issues of stock shows that the strong form does not always hold. Scholes believes that mutual funds may have access to extra information, and the price changes with secondary issues involving mutual funds are not always reflective of efficiency (Fama, 1970, p. 413). Nonetheless, the subsequent research to follow will test that the semi-strong form is upheld with Donald Trump's tweets.

Capital Asset Pricing Model

The next key theory to be tested throughout this paper is the Capital Asset Pricing Model. William Sharpe and John Lintner contributed significantly to the research on this theory, ultimately earning Sharpe the Nobel Prize in 1990 (Fama & French, 2004, p. 25). Essentially, the CAPM depicts the relationship between risk and expected return for securities. Just as the EMH is built upon another theory, the random walk hypothesis, the CAPM is built upon the model of portfolio choice by Harry Markowitz.

The model of portfolio choice assumes that all investors are risk averse, meaning they try to minimize risk. In addition, when picking a portfolio they care about the variance and the mean of their investments (Fama & French, 2004, p. 26). Mean-variance efficient portfolios are the only logical choice for investors. A mean-variance efficient portfolio 1) maximizes expected return given the variance, and 2) minimizes the variance given the expected return. The Capital Asset Pricing Model expands on the idea of a mean-variance efficient portfolio to predict expected returns by measures of risk (Fama & French, 2004, p.26).

Figure 3 below helps to understand the relationship between a mean-variance efficient portfolio and the Capital Asset Pricing Model[3]. The vertical axis is a measure of expected return, where the horizontal axis is a measure of the given portfolio's risk. The risk is measured as the standard deviation. The figure *abc* is a combination of expected returns and risks from portfolios that seek to minimize variance at different levels of expected returns. This curve is known as the *minimum variance frontier*. When looking at *a*, higher expected return requires higher risk. Meanwhile, *b*, lower risk yields a lower expected return. There is a clear tradeoff between risk and return (Fama & French, 2004, p.26-27).



With the risk-free rate added, all investors have an opportunity set that involves either borrowing/lending in the risk-free asset, and a single risky portfolio that is the tangency point between the risk-free asset and the efficient frontier, *T*. CAPM is important due to the risk-free asset. In this model, all investors invest in some proportion of *T*, the risky portfolio of assets. According to Fama and French,

> "it must be the value-weight market portfolio of risky assets. Specifically, each risky asset's weight in the tangency portfolio, which we now call *M* (for the "market"), must be the total market value of all outstanding units of the asset divided by the total market value of all risky assets. In addition, the risk-free rate must be set (along with the prices of risky assets) to clear the market for risk-free borrowing and lending. In short, the CAPM assumptions imply that the market portfolio *M* must be on the minimum variance frontier if the asset market is to clear." (Fama & French, 2004, p.28).

This logic derives the equation mentioned earlier for calculating the expected return of an asset is:

$ER_i = R_f + B_i(ER_m - R_f)$,

where

ER_i = Expected return of the asset

R_f = risk free rate (usually treasuries)

B_i = beta of the investment; a measure of how much risk the investment will add to the portfolio

(ER_m - R_f) = market risk premium; return expected from the market above the risk free rate.

With some theories, there are unrealistic assumptions made in the model. With the Capital Asset Pricing Model, the idea of *unrestricted* risk-free borrowing and lending is not ideal. In 1972, Fisher Black found that CAPM still holds in a world with *restricted* risk-free borrowing and lending when short sales of risky assets are instead unrestricted (Fama & French, 2004, p. 29).

The Capital Asset Pricing Model will be utilized in the remainder of this paper to test the B_i, *beta of the investment; a measure of how much risk the investment will add to the portfolio,* for both trade-related stocks and domestic stocks both before and after Donald Trump's "Tweeting Regime."

Chapter 3

Methodologies for Testing the Efficient Market Hypothesis

Data Collection

To better understand the impact of Donald Trump's tweets, historical prices of trade-related and domestic stocks is taken from Yahoo! Finance (Yahoo Finance, 2019). Daily closing price data from February 29, 2016 to December 3, 2019 for over 50 stocks is collected. I chose the time range given that on February 27, 2018 a federal judge upheld the legality and constitutionality of Trump's plans to build a wall across the Mexican border. This date had been a turning point in the Trump administration as well as in Donald Trump's use of Twitter. The following day, February 28, 2018, he tweeted eight times. On this same day, Trump sent out the first of his several tariff tweets.

February 28, 2018 is the break date used in the following statistical methodologies to distinguish a "Tweeting Regime," a period where Donald Trump continuously tweets about the ongoing trade war. The period from February 29, 2016 to February 28, 2018 is compared to the period February 28, 2018 to December 3, 2019, where it is expected that his tweets may have a larger/different impact on the trade-related stocks relative to the domestic stocks.

Selection of Stocks

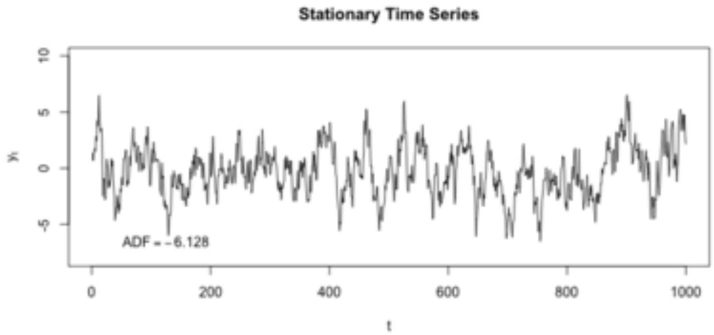
The Street, a popular online investment publication, provides a list of 50 stocks traded on the S&P 500 with high revenue exposure to China (Sozzi, 2019). Their total revenue exposure to China can range from 11% to 60% of total revenue. In short, these stocks are trade-related stocks, and are utilized to test market efficiency before and after the break date. On the other hand, Goldman Sachs recommends a list of domestic stocks that have little to no exposure to China (Li, 2019). Their measurement of no exposure to China is by choosing stocks that have 100% of their sales in the United States. The selection of trade-related and domestic stocks is significant in distinguishing how Trump's trade related tweets may be affecting the stock market.

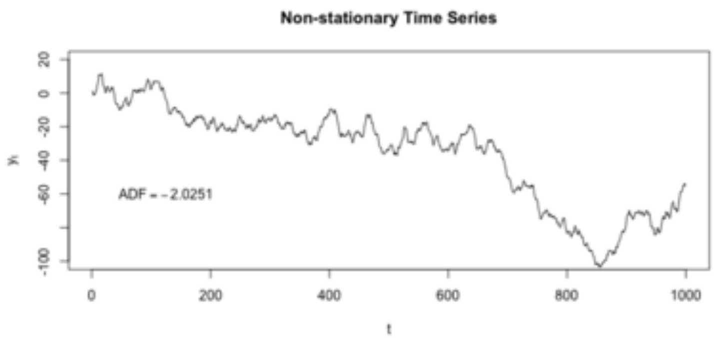
The five trade-related stocks selected are Qualcomm Incorporated (QCOM), Qorvo, Inc. (QRVO), Broadcom, Inc. (AVGO), Micron Technology, Inc. (MU), and Texas Instruments Incorporated (TXN). Their respective revenue exposure to China is as follows: 63.3%, 60.0%, 51.9%, 49.5%, and 42.9% (Sozzi, 2019). The five trade-related stocks were selected by having the highest revenue exposure to China.

The five domestic stocks selected are the Allstate Corporation (ALL), CVS Health Corporation (CVS), Dollar General Corporation (DG), J.B. Hunt Transport Services, Inc. (JBHT), and Ross Stores, Inc. (ROST). All five stocks have 100% of their sales in the United States (Li, 2019). The five domestic stocks were selected at random.

Augmented Dickey-Fuller Unit Root Test

To test that the selected stocks follow a random walk, consistent with the Efficient Market Hypothesis, I will employ augmented dickey-fuller unit root tests. The augmented dickey-fuller unit root test tests for stationarity. Time series data is stationary when characteristics such as the mean, variance, and covariance stay constant over time (Palachy, 2019). If a dataset is stationary, it does not follow a random walk. The figures below help to distinguish the difference between stationary and nonstationary time series data (Palachy, 2019).





When running the augmented dickey-fuller test, I test if there is a unit root in the series. If there is a unit root, then the data is nonstationary and is consistent with the EMH. In the equation below, $\beta = 1$ signifies that the time series X has a unit root. As I am looking to see that the data is consistent with the EMH, the augmented dickey-fuller test must fail to reject the null hypothesis of a unit root. The augmented dickey-fuller equation is below:

$$X_t = \alpha + \beta X_{t-1} + \varepsilon_t$$

I then can subtract X_{t-1} from both sides of the equation to get:

$$\Delta X = \alpha + (\beta-1)X_{t-1} + \varepsilon_t$$

The augmented part is adding lagged dependent variables on the righthand side to deal with possible serial correlation in the errors:

$$\Delta X = \alpha + (\beta\text{-}1)X_{t\text{-}1} + \Delta X_{t\text{-}I} + \varepsilon_t$$

If the $(\beta - 1)$ coefficient in the equation above is insignificantly different from zero (implying $\beta = 1$), I fail to reject the null hypothesis of a unit root. So, if $\beta = 1$, I can conclude that there is a unit root, and that the data is consistent with following a random walk and also consistent with the EMH. However, if $(\beta - 1)$ in the equation above is significantly different from zero, there are opportunities for investors to beat the market, thus violating the EMH. Understanding momentum and mean reversion trading strategies, in addition to the violation, allows for profitable arbitrage opportunities.

During the time frame of February 29, 2016 through February 28, 2018, I would expect the data to have a unit root and to follow a random walk, given the EMH. I am also testing to see if during the time frame of February 28, 2018 through December 3, 2019, when Donald Trump's Tweets about trade was in constant force, that there is no unit root, that the data does not follow a random walk, and that the EMH is violated. Naturally, I am investigating whether or not there are any differences in the times series properties among trade-related stocks vs. domestic stocks for both time periods.

The augmented dickey-fuller test is only one way to investigate whether the data is consistent EMH. Variance ratio tests are another way to test market efficiency.

Martingale Processes and Variance Ratio Tests

Variance ratio tests are used in conjunction with the dickey-fuller tests to determine if the time series are consistent with the EMH. Before variance ratio tests can be conducted, the stochastic process in probability theory must be understood. First, a stochastic process is a group of random variables indexed by time (Gabbiani & Cox, 2010, p.251). A martingale process is when the group of random variables' (the stochastic process) conditional expectation of the next value is equal to the present value at that particular time (Aspnes, 2020). Yale Professor of Computer Science, James Aspnes, relates the martingale process to casino gambling to understand the concept by saying,

> "We can think of this process as describing the state of our finances after we've been playing in a casino for a while. If the casino is perfectly fair (unlike what happens in real life), then each bet we place should have an expected return of 0. In other words, if we want to estimate based on what we know at time t how much money we will have at time t+1, our best guess would be X_t" (Apnes, 2020).

The variance ratio test examines the predictability of time series data by comparing variances of an asset's returns, $y_t - y_{t-k}$, calculated over various time intervals. If the variance of the sum of returns during a specified interval is equivalent to the sum of the variance of the individual returns during that same interval then the time series data are consistent with the martingale process and the EMH. For example, the sum of the variances of each of the one-day periods making up for an eight-day interval should be equivalent to the variance of an eight-day period.

The covariance of X,Y (X = returns at time t, Y=returns at time t+1) should be equal to zero when the returns are independent. The variance of the sum of two variables is given by equation below:

$$Var(X+Y) = Var(X) + Var(Y) + 2(\sigma X)(\sigma Y)(\rho X,Y)$$

If returns are uncorrelated, the COV(X,Y), which is $[2(\sigma X)(\sigma Y)(\rho X,Y)]$, should be equal to zero. Therefore, the equation becomes:

$$\text{Var}(X+Y) = \text{Var}(X) + \text{Var}(Y).$$

The sum of the variance of individual period returns should equate to the variance of the sum of independent returns.

If the time series follows a random walk, the ratio of Var(X+Y) divided by Var(X) + Var(Y) should converge to unity. The variance of the q-period difference should be q times the variance of the one-period difference making the variance ratio equivalent to 1, if the returns are independent of one another. The variance of its qth differences will grow linearly with q if the data set follows a random walk. The variance ratio of the q-period return is defined as:

$$V(q) = \frac{\text{var}(x_t + x_{t-1} + \ldots + x_{t-q+1})/q}{\text{var}(x_t)} = \frac{\text{var}(y - y_{t-q})/q}{\text{var}(y_t - y_{t-1})} = 1 + 2\sum_{i=1}^{q-1}\frac{(q-i)}{q}\rho_i$$

where ρ_i is the ith lag autocorrelation coefficient of x_t (Johnson, 2014). Doug Johnson, a former Schreyer scholar, also employed variance ratio tests in his thesis, which is where this explanation comes from.

The ultimate goal of the variance ratio test is that if returns are uncorrelated over time, then $\text{var}(x_t + x_{t-1} + \ldots + x_{t-q+1}) = q\ \text{var}(x_t)$. The null hypothesis can be thought of as H_0: $\rho_1 = \rho_2 = \ldots = \rho_q = 0$, which is essentially indicating that the variance ratio ($V(q)$) = 1, and that returns are serially uncorrelated. With regard to the equation above, the final term on the righthand goes to zero when $\rho = 0$ and the variance ratio = 1.

With regards to this paper, I am testing if the returns are serially uncorrelated. The null hypothesis of the test is that if the returns are serially uncorrelated, they follow a martingale process, consistent with the EMH. The variance ratio tests would equal 1 because $\rho_i = 0$. If the series does not follow a martingale process, the variance ratio tests would not equal 1 (I would reject the null hypothesis. There is thus indication that the returns either exhibit momentum (moving in the same direction, positive serial correlation) or mean reversion (returns change direction and revert back to the mean), both of which violate the EMH. Understanding if the data exhibits momentum (there will be a positive serial correlation with $\rho_i > 0$ resulting in the variance ratio being significantly greater than 1) or mean reversion (there will be negative serial correlation with $\rho_i < 0$, and the variance ratio will be significantly less than 1) is important as there are specific trading strategies to benefit off of. That is, you could consistently beat the market, clearly violating the EMH. Both the augmented dickey fuller tests and variance ratio tests will be conducted using EViews software, and the output is within the data section of this paper.

Chapter 4

Results for Testing Efficient Market Hypothesis

Augmented Dickey-Fuller Tests

Trade-Related Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

For the time period February 29, 2016 through February 28, 2018, augmented dickey fuller tests were conducted for all five trade-related stocks. The output of all the unit root tests are provided in the data section. I look to the p-value of the test to determine if the data is consistent with the EMH. For a p-value of 0.05 or lower, I can reject the null hypothesis of a unit root at the 95% confidence level. In short, if the p-value is 0.05 or lower, the data exhibits stationarity, does not follow a random walk, and is not consistent with the EMH. The p-values of the stocks are as follows: QCOM has a p-value of 0.2017, QRVO has a p-value of 0.3081, AVGO has a p-value of 0.4141, MU has a p-value of 0.9519, and finally TXN has a p-value of 0.7910. I fail to reject the null hypothesis for all five stocks. This implies that the trade-related stocks do follow a random walk, the data is nonstationary, and that they are consistent with the EMH.

Domestic Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

For the domestic stocks during the same time frame, the augmented dickey-fuller test fails to reject the null hypothesis that there is a unit root. The p-values of the stocks are as follows: ALL has a p-value of 0.7235, CVS has a p-value of 0.7020, DG has a p-value of 0.5890, JBHT has a p-value of 0.8736, and ROST has a p-value of 0.7798. In all, the five domestic stocks from this time period follow a random walk, are nonstationary, and that they are consistent with the EMH.

Trade-Related Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

The same procedure was repeated for the trade-related stocks during the time frame of February 28, 2018 to December 3, 2019. The p-values of the stocks are as follows: QCOM has a p-value of 0.4118, QRVO has a p-value of 0.8079, AVGO has a p-value of 0.4788, MU has a p-value of 0.3472, and TXN has a p-value of 0.3740. I fail to reject the null hypothesis for all five stocks. This implies that the trade-related stocks do follow a random walk, the data is nonstationary, and that they are consistent with the EMH.

Domestic Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

The same procedure was repeated for the domestic stocks during the time frame of February 28, 2018 to December 3, 2019. The augmented dickey-fuller test fails to reject the null hypothesis that there is a unit root for all five domestic stocks. The insufficient p-values of the stocks are as follows: ALL has a p-value of 0.6594, CVS has a p-value of 0.6193, DG has a p-value 0.8893, JBHT has a p-value 0.4286, and ROST has a p-value of 0.6886. In all, the five domestic stocks from this time period follow a random walk, are nonstationary, and that they are consistent with the EMH.

Variance Ratio Tests

Trade-Related Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

For the time period February 29, 2016 through February 28, 2018, variance ratio tests were conducted for all five trade-related stocks. The output of all the tests are in the data section. I fail to reject that QCOM, QRVO, AVGO, and MU are martingales. When looking at TXN, for K=4, the variance ratio test is significantly less than 1 at the 10% level. This indicates mean reversion. During the 4 day period, an investor in TXN would be able to beat the market by understanding the returns follow the pattern of mean reversion. Nonetheless, for K=2,8,16, for the same TXN stock, there is no evidence of mean reversion. In all, during the first sample period where Donald Trump was less active on Twitter, the empirical results regarding the five trade-related stocks are consistent with the EMH.

Domestic Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

For the time period February 29, 2016 through February 28, 2018, variance ratio tests were conducted for all five domestic stocks. I fail to reject that ALL, CVS, DG, JBHT, and ROST are martingales. Similar to the trade-related stocks during this period, the five domestic stocks are consistent with the Efficient Market Hypothesis. There is no evidence of momentum or mean reversion for both the trade-related and domestic stocks during this time frame, except for the TXN K=4 results.

Trade-Related Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

For the time period February 28, 2018 through December 3, 2019, variance ratio tests were conducted for all five trade-related stocks. For QCOM, at K=8,16, I reject the null hypothesis that it is a martingale at a 95% confidence level. The variance ratio is significantly greater than one, showing evidence of momentum. For QRVO, AVGO, and MU, at all K values, I fail to reject the null hypothesis that they are martingales. Finally, for TXN, at all K values, I reject the null hypothesis at a 95% confidence level. Each variance ratio is significantly less than one, indicating evidence of mean reversion. I reject the null hypothesis that QCOM and TXN are martingales. There is evidence of momentum and mean reversion for stocks QCOM and TXN respectively, and the Efficient Market Hypothesis is violated.

Domestic Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

For the time period February 28, 2018 through December 3, 2019, variance ratio tests were conducted for all five domestic stocks. For ALL, at K=4, I reject the null hypothesis at a 90% confidence level. For ALL, at K=8, I reject the null hypothesis at a 95% confidence level. Both variance ratios are significantly less than one indicating mean reversion and violation of the EMH. For CVS, at K = 2, 8, I reject the null hypothesis at a 90% confidence level. For CVS, at K = 4, I reject the null hypothesis at a 95% confidence level. The variance ratios are greater than one, implying momentum and violation of the EMH. For DG, JBHT, and ROST I fail to reject the null hypothesis. The data for all three of these stocks during the “Tweeting Regime” are consistent with the EMH.

Chapter 5

Methodologies for Testing the Capital Asset Pricing Model

Capital Asset Pricing Model

In addition to testing the Efficient Market Hypothesis, the Capital Asset Pricing Model is employed to test whether the stocks are more volatile during the "Tweeting Regime." The Capital Asset Pricing Model formula is:

$$ER_i - R_f, = R_f + B_i(ER_m - R_f),$$

where

ER_i = excess return; return expected from the asset above the risk free rate.

R_f = risk free rate (usually treasuries)

B_i = beta of the investment; a measure of how much risk the investment will add to the portfolio

$(ER_m - R_f)$ = excess return; return expected from the market above the risk free rate.

I will be looking at the B_i of the same ten stocks before the tweeting regime and during the tweeting regime to truly test volatility. The beta is a measurement for risk, i.e. the higher the beta, then the higher the risk. I would expect the B_i of the trade-related stocks to be higher during the "Tweeting Regime" when compared to the timeframe before the "Tweeting Regime." Also, the betas of the five trade-related stocks will be compared to that of the five domestic stocks, and I predict they will be higher than that of the domestic stocks.

Data Collection

To calculate the individual betas of each stock I will utilize the same historical prices of trade-related and domestic stocks from Yahoo! Finance (Yahoo Finance, 2019). In addition, I will employ U.S. market return data from Kenneth French's research (French, 2019). French's research gives daily values of the risk free rate (R_f) and the excess return from the market premium $(ER_m - R_f)$ for the time frame being examined.

Understanding B_i

B_i is a measure to distinguish how volatile a stock is relative to the market. The stock market has a B_i = to one. If a stock has a B_i = to one, then the stock moves with the market. If a stock has a B_i greater than one, this suggests the stock is more volatile than the market. The stock moves more than the market. Stocks with a large beta have higher systematic risk, but with higher risk comes expected higher return. If a stock has a B_i less than one, then the stock is less volatile than the market. The stock moves less than the market. B_i is a measure of short term risk (Grant & McClure, 2020).

Risk Preferences

Understanding a stock's expected risk is important as investors have different risk preferences. A *risk averse* investor is hesitant to take a risk despite the potential gain. The investor will choose an investment which has a lower predictable payoff rather than an unknown possibly larger and riskier return ("Risk averse definition," 2020). A *risk neutral* individual does not focus on risk at all, but rather focuses on the potential gains of an investment. Since they do not look at the downside risk, their preferences would aim more towards a stock with a higher beta due to the nature of the potential higher gains (Scott, 2020). Finally, a *risk seeker* will choose an investment with higher risk, despite knowing an investment with the same expected returns and lower risk ("What is risk seeking," 2020). This individual also would prefer stocks with large betas.

Calculating B_i

To calculate the individual betas of each stock, I first have to calculate the daily return of each stock. To calculate the percentage return of an individual stock on a given day t:

$$Daily\ Return_{(t)} = (100)(P_t - P_{t-1})/(P_{t-1})$$

where

P_t *is the stock price today*

and

P_{t-1} *is the stock price the previous day*.

The daily percentage return for all ten stocks is calculated from February 28, 2016 through December 3, 2019.

Next, the excess return of the individual stock is calculated by utilizing the daily risk free rates from French's research ($R_{f(t)}$). The excess return for a stock on given day t is:

$$Excess\ Return: Daily\ Return_{(t)} - R_{f(t)}$$

where

$$Daily\ Return_{(t)} = (100)(P_t - P_{t-1})/(P_{t-1})$$

and

$R_{f(t)}$ *is the daily risk free rate from Kenneth French's three factor research*

Daily excess returns for all ten stocks are calculated from February 28, 2016 through December 3, 2019.

Finally, using excel, I am able utilize OLS regressions to calculate the beta (B_i) of each stock during the two-time frames (before tweeting regime vs. during tweeting regime). Then, I can compare the betas of each individual stock from the time frame before Trump's Twitter use and during.

Chapter 6

Results for Testing the Capital Asset Pricing Model

Capital Asset Pricing Model

Trade-Related Stocks

As expected, the trade-related stocks all have a beta significantly greater than one during the first timeframe. The betas range from 1.18 to 1.92. The average beta of all trade-related stocks during the first time period is 1.45. During the second timeframe, where Donald Trump tweeted continuously about the trade war, the betas are still significantly greater than one. I am looking to see if the betas have increased significantly from period one to two as a result of the volatile tweets. However, the betas of the trade related stocks during the second period differ from the betas during the first period very minimally. The average beta during the second period is 1.42, which is not significantly different than the average beta of all trade-related stocks during the first period.

Domestic Stocks

On the other hand, the domestic stocks all have a beta less than one during the first timeframe. This indicates that the domestic stocks move less than the market, and that they have less risk/return than the trade-related stocks. The betas range from 0.64 to 0.98. The average beta of all domestic stocks during the first timeframe is 0.77. During period two, the "Tweeting Regime," the domestic stocks continue to have betas less than one. The betas range from 0.70 to 0.94, and the average beta of all domestic stocks is 0.82.

Investor Preferences

Although the trade-related stocks did not become more volatile during the second period, there are still interesting findings for investors to take away. If an investor is risk-averse, they should look to the domestic stocks over the trade-related stocks. The domestic stocks in both periods are less risky than the trade-related stocks. Since *risk-averse* investors prefer safe investments over riskier investments, they should stick to the domestic stocks. In addition, they should consider looking further into the stock JBHT. JBHT has a beta that is closest to the market beta of 1 during both periods. If an investor is *risk neutral*, they would benefit from looking at the trade-related stocks, especially MU, which has the highest beta during both periods. As a risk neutral investor cares for large gains over risk, MU is a stock with higher expected returns due to the higher risk feature.

Chapter 7

Discussion

Efficient Market Hypothesis

When testing the EMH, I paid particular attention to see if the trade-related stocks failed to satisfy the EMH. I utilized augmented dickey-fuller tests as well as variance ratio tests to see if the EMH is violated. With such high revenue exposures to China, I expected that some of the trade-related stocks would fail the uphold the EMH, and create arbitrage opportunities for investors. Understanding their price movements through the variance ratio tests would allow investors to make profits. In using augmented dickey-fuller tests, I can conclude that both the domestic and trade-related stocks are nonstationary, and do not violate the EMH during both time periods through this statistical test. Nonetheless, the findings under the variance ratio test are significant. During the "Tweeting Regime" period, two trade-related stocks, QCOM and TXN, exhibit evidence of momentum and mean reversion respectively. At the same time, two domestic stocks, ALL and CVS, exhibit mean reversion and momentum. If the data exhibits momentum (there will be a positive serial correlation within the returns with $\rho_i > 0$, resulting in the variance ratio being significantly greater than 1, or mean reversion (there will be negative serial correlation with $\rho_i < 0$, and the variance ratio will be significantly less than 1) you can consistently beat the market. For the stocks with momentum, buy on upticks and sell on downticks. For stocks with mean reversion, sell on upticks and buy on downticks.

Capital Asset Pricing Model

When looking to the Capital Asset Pricing Model, I was particularly interested to see if trade-related stocks are more volatile than domestics stocks, and that the trade-related stocks are more volatile in the second period than the first. Although the average betas of the second period did not differ greatly, as compared to the first period, I did find evidence that the trade-related stocks are riskier than domestic stocks. Investors can use this information in conjunction with their own risk preferences when choosing to invest in any of the ten stocks.

Possible Drawbacks

The domestic stock selection was chosen at random using a random number generator. Given a list of 15 stocks that all have 100% of their sales in the United States, five were selected at random. The stocks not only differ in prices, but also in industries. When choosing the trade-related stocks, five stocks out of forty-six were chosen given they had the highest revenue exposure to China, not at random. This selection method was chosen to see the importance of Chinese revenue exposure. All five of the trade-related stocks are semi-conductor/technology companies. Given that all five stocks are in the same industry, their price movements could have been contributed to other factors outside of the "Tweeting Regime." An improvement to this research would be to also test trade-related stocks in other industries, such as 'blue collar' stocks. In addition, in the future a larger sample size could be tested.

Chapter 8

Conclusion

With over 48 million Twitter users, the social media platform is growing as a source of information (Twitter, 2020). Significant figures, such as the President of the United States, are employing Twitter to spread both news and their opinions. In the coming years, there will likely be an even greater use of Twitter in the political sphere, especially with an upcoming election.

The research does not conclude here, but actually opens the door for more research to follow. Other public figures' use of Twitter and the correlation with the stock market can be researched, other trade-related stocks can be studied, and individual industries can be looked at more closely. The main takeaway from this research is that the growing use of technology and social media is having an impact on the financial world. Investors should consider the damages it can cause to their profits, but also the opportunity social media can create to make profits.

Data

Augmented Dickey-Fuller Tests

Trade-Related Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

Stock	**p-value**	**Consistent with EMH**
QCOM	0.2017	Yes
QRVO	0.3081	Yes
AVGO	0.4141	Yes
MU	0.9519	Yes
TXN	0.7910	Yes

Domestic Stocks - BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

Stock	**p-value**	**Consistent with EMH**
ALL	0.7235	Yes
CVS	0.6193	Yes
DG	0.5890	Yes
JBHT	0.8736	Yes
ROST	0.7798	Yes

Trade-Related Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

Stock	**p-value**	**Consistent with EMH**
QCOM	0.4118	Yes
QRVO	0.8079	Yes
AVGO	0.4788	Yes
MU	0.3472	Yes
TXN	0.3740	Yes

Domestic Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

Stock	**p-value**	**Consistent with EMH**

ALL	0.6594	Yes
CVS	0.6193	Yes
DG	0.8893	Yes
JBHT	0.4286	Yes
ROST	0.6886	Yes

Data

Variance Ratio Test

Trade-Related Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

Stock	Null Hypothesis	Consistent with EMH
QCOM	Fail to reject	Yes
QRVO	Fail to reject	Yes
AVGO	Fail to reject	Yes
MU	Fail to reject	Yes
TXN	Fail to reject at K = 2, 8, 16 Reject null at K = 4 (90% confidence level)	Yes No; Evidence of mean reversion

Domestic Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

Stock	Null Hypothesis	Consistent with EMH
ALL	Fail to reject	Yes
CVS	Fail to reject	Yes
DG	Fail to reject	Yes
JBHT	Fail to reject	Yes
ROST	Fail to reject	Yes

Trade-Related Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

Stock	Null Hypothesis	Consistent with EMH
QCOM	Fail to reject at K = 2, 4 Reject null at K = 8, 16 (95% confidence level)	Yes No; Evidence of momentum
QRVO	Fail to reject	Yes
AVGO	Fail to reject	Yes
MU	Fail to reject	Yes

TXN	Reject null at K = 2, 4, 8, 16 (95% confidence level)	No; Evidence of mean reversion

Domestic Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

Stock	**Null Hypothesis**	**Consistent with EMH**
ALL	Fail to reject at K = 2, 16 Reject null at K = 4, 8 (90%, 95% confidence level)	Yes No; Evidence of mean reversion
CVS	Fail to reject at K = 16 Reject null at K = 2, 4, 8 (90%, 95%, 90% confidence level)	Yes No; Evidence of momentum
DG	Fail to reject	Yes
JBHT	Fail to reject	Yes
ROST	Fail to reject	Yes

Data

Capital Asset Pricing Model

Trade-Related Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

Stock	**Beta (B_i)**
QCOM	1.18983165
QRVO	1.56849104
AVGO	1.34953113
MU	1.92925316
TXN	1.22505526

Domestic Stocks – BEFORE THE TWEETING REGIME: February 29, 2016 through February 28, 2018

Stock	**Beta (B_i)**
ALL	0.7132608
CVS	0.64763961
DG	0.74033727
JBHT	0.98537393
ROST	0.75664052

Trade-Related Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

Stock	**Beta (B_i)**
QCOM	1.13337187

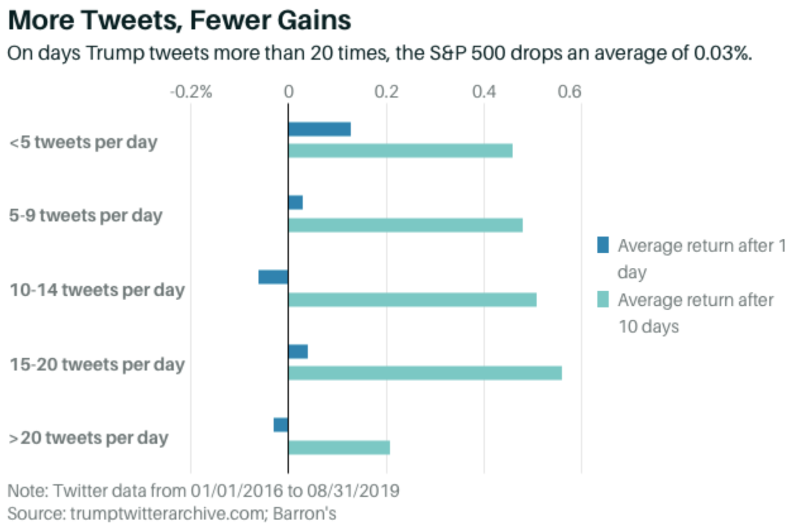
QRVO	1.50715734
AVGO	1.21244217
MU	1.92531241
TXN	1.31088355

Domestic Stocks – DURING THE TWEETING REGIME: February 28, 2018 – December 3, 2019

Stock	**Beta (B_i)**
ALL	0.70075659
CVS	0.81787084
DG	0.71796059
JBHT	0.93228173
ROST	0.94975581

List of Figures

1.



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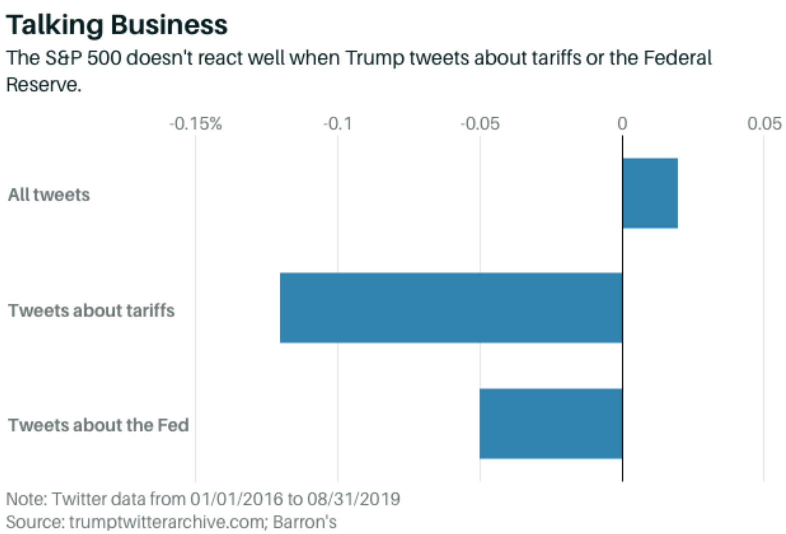

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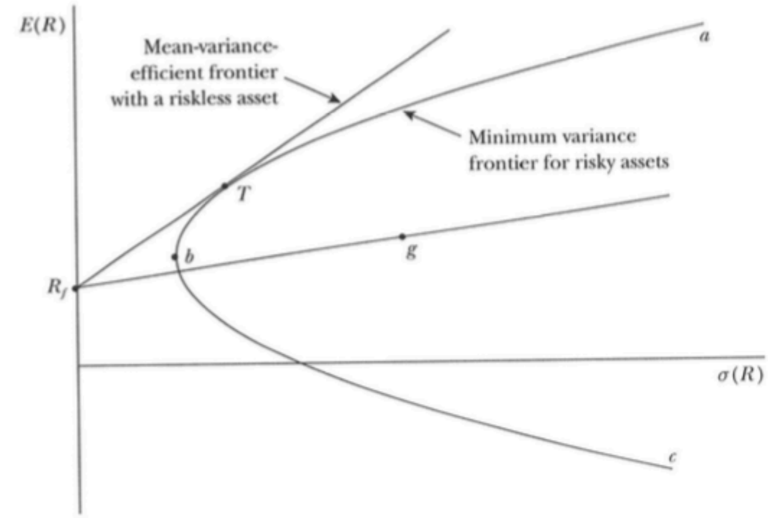
Investment Opportunities



References

Aspnes, J. (n.d.). *Martingales*. Retrieved January 28, 2020, from http://www.cs.yale.edu/homes/aspnes/pinewiki/Martingales.html

Azzopardi, P. V. (2010). *Behavioural technical analysis : An introduction to behavioural finance and its role in technical analysis*. Retrieved from https://ebookcentral.proquest.com

Fama, E. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance, 25*(2), 383-417. doi:10.2307/2325486

Fama, E. (1995). Random Walks in Stock Market Prices. *Financial Analysts Journal, 51*(1), 75-80. Retrieved from www.jstor.org/stable/4479810

Fama, E. F., & French, K. R. (2004). The capital asset pricing model: Theory and evidence. *The Journal of Economic Perspectives, 18*(3), 25-46. Retrieved from http://ezaccess.libraries.psu.edu/login?url=https://search-proquest com.ezaccess.libraries.psu.edu/docview/212090442?accountid=13158

Gabbiani, F., & Cox, S. J. (2010). *Mathematics for neuroscientists* (1. ed.f). Elsevier, Acad. Press.

Grant, M., & McClure, B. (n.d.). *What beta means when considering a stock's risk*. Investopedia. Retrieved February 24, 2020, from https://www.investopedia.com/investing/beta-know-risk/

Li, Y. (2019, August 6). *Investors can hide out in domestic stocks from the China trade war*. CNBC. https://www.cnbc.com/2019/08/06/investors-can-hide-out-in-domestic-stocks-from-the-china-trade-war.html

Liu, E. (2019, September). Yes, Trump's Tweets Move the Stock Market. But Not for Long. In *Barron's*. Retrieved from https://www.barrons.com/articles/donald-trump-twitter-stock-market-51567803655

Noah, T. (n.d.). In *The Daily Show with Trevor Noah*. Retrieved from http://www.cc.com/shows/the-daily-show-with-trevor-noah/trump-twitter-library

Palachy, S. (2019, September 22). *Stationarity in time series analysis*. Medium. https://towardsdatascience.com/stationarity-in-time-series-analysis-90c94f27322

Petri, J., & Houston, T. (2017, January 20). In *Bloomberg*. Retrieved from https://www.bloomberg.com/features/trump-tweets-market/

Preda, A. (2004). Informative Prices, Rational Investors: The Emergence of the Random Walk Hypothesis and the Nineteenth-Century "Science of Financial Investments." *History of Political Economy*, *36*(2), 351–386. https://doi org.ezaccess.libraries.psu.edu/10.1215/00182702-36-2-351

realDonaldTrump. (2019). [Tweet] https://twitter.com/realDonaldTrump

Risk averse definition—Favoring lower returns over lower volatility. (n.d.). Corporate Finance Institute. Retrieved February 24, 2020, from https://corporatefinanceinstitute.com/resources/knowledge/finance/risk-averse-definition/

Scott, G. (n.d.). *Risk neutral definition*. Investopedia. Retrieved February 24, 2020, from https://www.investopedia.com/terms/r/riskneutral.asp

Sozzi, B. (n.d.). *50 stocks that could be shredded in the u. S. Trade war with china*. TheStreet. Retrieved January 28, 2020, from https://www.thestreet.com/opinion/fifty-stocks-that could-be-shredded-if-a-us-trade-war-with-china-ignites-1451570

Stewart, E. (2019, September). In *The Volfefe Index, Wall Street's new way to measure the effects of Trump tweets, explained*. Retrieved from https://www.vox.com/policy-and politics/2019/9/9/20857451/trump-stock-market-tweet-volfefe-jpmorgan-twitter

The University of Chicago Booth School of Business, www.chicagobooth.edu/faculty/directory/f/eugene-f-fama.

What is risk-seeking? Definition and meaning. (n.d.). *Market Business News*. Retrieved February 24, 2020, from https://marketbusinessnews.com/financial-glossary/risk-seeking-definition-meaning/

Yahoo finance—Stock market live, quotes, business & finance news. (n.d.). Retrieved January 28, 2020, from https://finance.yahoo.com/

ACADEMIC VITA

PROFESSIONAL EXPERIENCE

JPMorgan Chase & Co. **Washington D.C.**
Middle Market Banking and Specialized Industries Summer Analyst *June 2019 – Aug 2019*
- Supported a team of commercial bankers, underwriters, treasury management officers, and analysts with on-going daily projects and tasks
- Developed pitch books and presentations, prepared credit approval packages and transaction approval memos, completed financial modeling, and researched industries and prospective clients
- Met with current and prospective clients to discuss changes in their business and offer advice through various banking products

Verizon **Basking Ridge, NJ**
Finance Leadership Development Program Intern *Jun 2018 – Aug 2018*
- Developed professional, technical, and leadership skills through a series of hands-on trainings, networking events and project requests
- Evaluated all Wireless HQ Finance and Market Finance Dashboards, while also documenting key performance indicators contained in each, active user base, and other relevant information on Tableau Software
- Provided recommendation to CFO on how to augment its digital finance presence in order to support internal teams

The Pennsylvania State University Department of Economics **University Park, PA**
Undergraduate Teaching Assistant *Aug 2017 – Present*
- Selected to improve the instruction for over 300 students taking Intermediate Macroeconomics Analysis
- Dedicated 5 hours each week to grade assignments and exams which covered principle topics and the financial crisis

Undergraduate Research Assistant *Jan 2018 – May 2018*
- Completed 125 hours of statistical economic research using data from Alibaba Group, funded by Bates White LLC
- Created spreadsheets, ran regressions, and analyzed quantitative output on STATA software to test consumer demand

Wall Street Boot Camp **University Park, PA**
Graduate *Aug 2017 – Dec 2017*
- Accepted into a highly competitive training program that prepares students for careers in the financial field
- Attended weekly lectures by Wall Street alumni on investment banking, sales and trading, equity research, private wealth management, and asset management careers

LEADERSHIP & ACTIVITIES

Schreyer Honors College Freshman Orientation **University Park, PA**
Academic Team Leader | Mentor *Jan 2017 – Present*
- Selected to coordinate with the Schreyer Honors College faculty to plan educational events and guest speakers for the benefit of first year students
- Trained incoming mentors on the values of the Schreyer Honors College and on their leadership capabilities
- Engaged with a cohort of 8 incoming first year business students by offering insight on scheduling advice, research experiences, college study tips, time management strategies, Penn State cultural norms, and extracurricular opportunities to facilitate the college transition

Phi Chi Theta Co-Ed Professional Business Fraternity **University Park, PA**
Director of Corporate Relations *Nov 2017 – May 2018*
- Improved professionalism within the brotherhood by executing and presenting at weekly chapter meetings
- Facilitated and supervised professional events with various corporate partners, companies, and organizations

Corporate Relations Chair *Apr 2017 – Nov 2017*
- Implemented events to help brothers improve case competition work, resume, LinkedIn, and interview skills