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Analysis of the Impacts of the COVID-19 Pandemic on Efficient Markets and Retail Trade
Activity


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## ABSTRACT

In this paper, I examine how the COVID-19 pandemic and subsequent lockdowns affected the stock patterns of prominent companies within the hospitality and travel industries. I use multiple statistical tests to determine potential departures from the Efficient Market Hypothesis. I also discuss the trading behavior of retail investors in light of the pandemic's impacts through a review of academic literature as well as examination of a dataset composed from Robinhood users.

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**Chapter 1**

**Introduction**

The past two years have seen a number of tumultuous events largely stemming from the advent of the COVID-19 virus and its subsequent global spread. Global shutdowns quickly followed the disease as it made its way across continents, devastating communities and changing the way societies lived and worked. Capital markets were not immune to this rapid change as a sudden and violent dip in the spring of 2020 was followed by a swift rebound driven especially by sectors in which society found itself newly dependent such as virtual technology, biopharmaceuticals, and e-commerce.

The S&P 500 bottomed out on March 23, 2020 with a negative 34% return from the year's peak which occurred on February 19 of that year (Yahoo Finance). Simultaneously, the Chicago Board of Exchange's Volatility Index, also known as the Fear Index, which provides a gauge of the market's expected volatility by measuring the prices on out of the money options with expirations between one and two months jumped 510% from the beginning of the year to reach a high on March 16. The values reached by the nearly thirty-year-old VIX index have only been surpassed in the fall of 2008 alongside the financial crisis (Yahoo Finance). With capital markets under significant stress from a nearly unprecedented, globe-sweeping event, there existed cause to evaluate the performance of the Efficient Market Hypothesis (EMH) under said conditions.

Alongside of the broad market disruptions, one of the noteworthy changes taking place as a result of pandemic-induced lockdowns was a new, virtual work format. Without the time

commitment of a lengthy commute or the usual activities occupying daily life, individuals turned to all sorts of stay-at-home friendly activities in order to take advantage of this idle period. Noteworthy among newly popular hobbies was active personal investing through trading apps such as Robinhood. These individuals, known as retail investors, operate as their own fund managers through online brokerages—many of which dropped trading commissions in 2019, paving the way for a new era of novice day trading (McCabe, 2021). Previously existing as an inconsequential market force, retail investors became much more pronounced in the spring of 2020 and will likely continue in their larger role within the market in the near future.

In this thesis I begin with a review of recent academic literature on the behaviors of retail investors, especially those utilizing the Robinhood platform. I then discuss the Efficient Market Hypothesis and provide a methodology for testing the behavior of a stock for compliance with the principles of the EMH. The paper discusses the results from those tests and establishes that equities of selected travel and hospitality companies did not behave differently to other publicly traded companies in accordance with the Efficient Market Hypothesis. Having established similar levels of compliance with market efficiency principles among the tested groups in both the period prior to the onset of the pandemic and the period following the onset of the pandemic, I provide a brief overview of Robinhood users' interest in the travel and hospitality segment as measured by changes in relative holding levels throughout the beginning of 2020. I conclude with a discussion of the results ascertained through this paper.

**Chapter 2**

**Literature Review**

Retail traders as a group have been increasing in number for a variety of reasons, among them easier access to markets through advances in financial technology, strong market returns, and a fading memory of the financial crisis. To compound this new situation among individual investors, the recent onset of the COVID-19 pandemic caused a massive disruption of both capital markets and lifestyles. Companies that were directly affected by the lockdowns and travel bans spreading across the globe moved violently in both positive and negative swings. Travel and hospitality bore the brunt of negative price movement, while the technology sector led by companies that filled crucial needs during shutdowns saw massive share gains.

Because of the increasingly large number of retail investors operating in the market within the past two years, research into the decision-making of this group provides important information into overall market behavior. Anecdotally, users of online trading applications such as Robinhood are said to invest primarily in risky, "meme" stocks that gain significant attention on various online communities. However, current research points to Robinhood investors holding a balanced portfolio that can best be described as containing stocks with above average trading volume over the past year. This is in opposition to the narrative that the primary user of Robinhood holds a collection of highly visible, speculative companies. However, there were instances of small-cap firms experiencing high interest among Robinhood investors especially in market segments appealing to younger demographics. Evidence of this is the popularity of Aurora Cannabis which was the most widely held stock on the platform for a short period in early 2019. In addition, other stocks in highly visible categories likewise experienced elevated trading volume (Welch, 2020). I find in this thesis support that during the COVID-19 pandemic,

Robinhood users substantially increased holdings in the highly impacted travel and hospitality sector relative to high-volume and dividend paying stocks.

While the crowd consensus portfolio constructed by Welch was found to be relatively stable and balanced, other research points to instances of various technical strategies employed by Robinhood users. Robinhood users were found to implement momentum trading strategies as a primary strategy when choosing which stocks to buy. This was found to be the case by analyzing the percent change in the holdings by Robinhood users of a stock that experienced positive overnight returns. Further, many Robinhood users were identified as utilizing a contrarian trading strategy whereby users would increase their holdings of or purchase a stock after it experienced negative overnight returns. While Welch's artificially constructed portfolio was associated with a positive alpha, momentum strategies by Robinhood users are associated with next day losses on average. Contrarian strategies, fare slightly better in the dataset as overnight losses leading to next day purchases are followed by a positive return on average (Pagano, 2021).

Similarly, Robinhood users were disproportionately invested in high-attention stocks, oftentimes to their detriment as measured by a twenty-day return period following purchase. When evaluating episodes of mass purchases as identified by being within the top 0.5% of stocks by volume on the Robinhood platform, users of the app experience a negative 4.7% return over the subsequent month. In instances with more significant positive volume changes, the negative returns increase significantly, meaning that those looking to trade with a heavy momentum strategy oftentimes miss out on the initial gains and only receive the downward adjustment. This effect is found primarily in small-cap stocks, companies with less than one billion in market capitalization, whereas the effect was not found in stocks with market caps above that threshold.

This gives further credence to the picture of a Robinhood user chasing a higher risk investment strategy by choosing a portfolio of volatile, small-cap stocks that are not significantly visible to the general public (Barber, Huang, Odean, Schwarz, 2021).

As Robinhood users increased in number over the recent years, their effect on the overall market has correspondingly increased as well. Studies into the impact that Robinhood investors had on the liquidity of the overall market suggest that during times of significant strain, retail investors as a class acted as a liquidity provider, helping to stabilize a turbulent marketplace. Researchers found that retail investors contributed liquidity to the market with inverse proportion to a mobility index measuring the amount that individuals were leaving their home environment. During the initial months of lockdown, retail investors had a positive impact on lowering the bid-ask spread of market equities, while this effect was found to have lessened when states began to open back up and individuals became more mobile. This study showcases the growing role of individual investors in the broader stock market and the changing approach that regulators and other market participants have towards this class of individuals. The authors of the study argue that less intervention by the Federal Reserve was necessary as a result of the stabilizing actions of Robinhood users and retail investors more generally (Ozik, Sadka, Shen, 2021).

The time period surrounding the onset of the COVID-19 pandemic was associated with not only major movements in investor participation, but also with a unique government-established direct stimulus program. Beginning in April of 2020, the IRS sent out economic impact payments of 1,200 dollars to individual tax filers making less than 75,000 dollars and 2,400 dollars to joint tax filers making less than a combined 150,000 dollars. These direct stimulus payments distributed as part of the CARES Act passed by Congress in March of 2020 represent an unexpected wealth shock to a broad swath of American consumers (Questions). This

type of unplanned positive cash flow for such a large number of individuals is somewhat of a rare incidence and has occurred during the two previous recessions of the twenty-first century—first in 2001 following the fallout of the dot-com bubble and then again in 2008 after the housing crisis (Parker, Souleles, Johnson, McClelland, 2013). Both of these periods predate the rise of commission-free trading and popular investing applications such as Robinhood, causing research into consumer uses of the respective stimulus funds to be less applicable in the more recent distribution. The dispersion of the first economic impact payments provide partial motivation for the evaluation of Efficient Market Hypothesis compliance among selected stocks within the travel and hospitality sector that occurs in this paper.

The first fiscal stimulus legislation passed to bolster the economy in the face of the COVID-19 pandemic occurred throughout March of 2020 with the most significant portion occurring on March 27. This act, known as the Coronavirus Aid, Relief, and Economic Security Act, gave all Americans earning less than $75,000 individually a direct economic impact payment in the amount of $1,200 plus $500 for each dependent child. Beginning the week of April 13, these payments were sent out to millions of Americans and continued throughout the following months (Questions).

This situation is comparable to tax rebates issued in 2008 in the midst of the Great Recession known as economic stimulus payments. The magnitude of the payments differed as direct stimulus payments administered as part of the CARES act offered approximately twice the per person amount. Research into the effect of the 2008 stimulus payments showed that on average between 12% and 30% of the rebates were spent on "nondurable consumption goods" within three months. When accounting for other types of purchases by including durable goods, most notably motor vehicles, between 50% and 90% of the rebates were consumed within that

three-month timeframe. This research lines up with the findings of a previous study looking into

the effects of the same policy, but during the 2001 recession which estimated direct stimulus

payments to be 20% to 40% consumed on nondurable goods. Due to the increased size of the

economic impact payment distributed in 2008 relative to the payment sent out in 2001, it is

believed that purchases skew more towards the purchase of durable goods rather than lower cost,

nondurable goods (Parker, Souleles, Johnson, McClelland, 2013). Similarly, the costs associated

with investing in a portfolio of stocks generally aligns closer to the cost of purchase of durable

goods and as a result the economic impact payments distributed in the spring of 2020 might also

skew more heavily towards the purchase of higher cost goods/assets.

Because of advancements in financial technology made since 2008 and the wider

availability of low-cost investment vehicles, consumers have a far greater range of opportunities

for spending their direct stimulus funds. One particular asset that is noteworthy for both retail

and institutional investors is Bitcoin. The cryptocurrency (created in 2009 – after the distribution

of the last round of recession-induced stimulus) has gained significant attention in recent years

due both to the usefulness of its underpinning blockchain technology as well as its meteoric price

increases. Due to its popularity among retail investors, researchers sought to measure the effect

that 2020 stimulus payments had on the price of Bitcoin as well as its trading volume in the

weeks after U.S. residents began receiving their stimulus. This research studied the impact of

trading in Bitcoin by retail investors following the distribution of the first economic impact

payments and lasting until the end of the period of delivery. They found that trading in Bitcoin

during the three-week period of interest beginning April 9, 2020 and ending later that month was

associated with an overall volume increase of 3.8% and a price increase of 0.7% from retail

investors alone. This study attempted to identify and isolate trades in Bitcoin that stemmed from

the arrival of the direct stimulus funds by measuring first the time period of purchase, but then also the dollar amount of the purchase in an attempt to exclude pre-planned trades by those unaffected by the wealth shock. The authors of the study posit that those who did not experience adverse effects (unemployment/lost wages) from the pandemic were in a position to use the money in other avenues that could potentially generate future wealth. Conducted by researchers at the Federal Reserve Bank in Cleveland, this study sought to provide empirical evidence that government funds were not being used in economically unproductive manners by a large number of recipients. Noteworthy within the research is their prediction that the same effect of higher trading volume and increased price in Bitcoin can be found in other, similar asset classes such as other cryptocurrencies or equities (Divakaruni, Zimmerman, 2021). It is likely this effect can be seen in equal or greater magnitude in the Robinhood data due to the similarities between the two asset types and overlapping investor demographics.

## Chapter 3

## Tests of the Efficient Market Hypothesis

**Data Collection**

As the spread of a new, viral disease was the impetus for global lockdowns that significantly reduced or even eliminated both domestic and international travel, companies with significant frontage to this travel market were especially hard hit. These companies belonged to sizable industries such as airlines, hospitality, and cruise lines as significant uncertainty loomed over the prospect of a return to pre-pandemic levels of travel. Within weeks of the first documented U.S. domestic case of COVID-19, billions of dollars of market value were wiped out of airlines, hotels, and other travel-based industries.

This massive spike of volatility in the market is a cause for investigation into the behavior of equity prices following the onset of the pandemic. Specifically, the stock prices of companies in the travel sector will be investigated for potential violations of the Efficient Market Hypothesis. In order to differentiate the impact that the pandemic lockdowns had on travel related stocks, a comparison set of securities composed of companies without exposure to the travel industry will be used. Historical closing prices from the period 3/19/2020 lasting until 12/31/2021 will be used in the statistical evaluation of both stocks with high exposure to travel and hospitality as well as those that were relatively unaffected by the lockdowns. February 3, 2020 is used as the break date in evaluating the before and after of pandemic-induced returns. This date corresponds to the United States' issuance of a public health emergency declaration which followed a World Health Organization announcement of a global health emergency three days beforehand (AJMC).

**Efficient Market Hypothesis**

The Efficient Market Hypothesis, a transformational theory largely attributed to University of Chicago Professor Eugene Fama, posits that the price of assets in the marketplace "fully reflects" the information relevant to the formation of that value. This concept rejects the notion that active evaluation by professionals can lead to the identification of under- or overvalued companies as new information is quickly processed into the price – eliminating potential arbitrage opportunities. Instead, the Efficient Market Hypothesis suggests that return is a function of risk and the varying classification of risk by investors can lead to diverging estimates on the equilibrium value (1970).

One implication of that concept is that stocks follow what is deemed a random walk with one-period returns moving independently and with identical distributions. The theory of the random walk therefore implies that it is impossible that returns could be correlated with previous returns, otherwise there would be an element of predictability able to be exploited by investors. This theory explains that new information not previously included in the evaluation of the stock is the only item that could change the price of the security and as a result, returns over any time period could not be correlated as news itself is not correlated.

The Efficient Market Hypothesis has multiple forms with strong, semi-strong, and weak versions of the theory differentiating themselves by the amount of information that is believed to be included in the stock price. The weak form of the EMH states that the only consideration of the present stock price is the past stock price and accompanying metrics such as volume. Semi-strong and strong both go further and posit that all public information is incorporated in the price of a stock, while the strong form of the EMH suggests that even private information is also included in the trading price of a company's shares (Fama, 1970).

**Stationarity and Augmented Dickey-Fuller Test**

Stationarity is an important concept relating to time series in considering the efficacy of the Efficient Market Hypothesis and the augmented dickey-fuller test is a popular method used to evaluate whether a time series is stationary or not. A stationary time series denotes that the mean and variance of the data are constant over time and that the data does not exhibit seasonality. Stationary time series change only in a constant manner and as a result this type of time series cannot be compatible with the Efficient Market Hypothesis. A stochastic process presents itself as a counterpart to stationarity as it is defined by a random set of variables without a constant mean or variance. As a result, a time series that is following a random walk as required by the Efficient Market Hypothesis will be characterized as a stochastic process and cannot exhibit stationarity – a violation of the EMH.

The concept behind the augmented dickey-fuller test is to evaluate time series data to determine if it is stationary or not. In testing this time series for potential violations of the Efficient Market Hypothesis, the results of the augmented dickey fuller test will have to show that there is a unit root present and that the data is not stationary. A unit root indicates that a time series is indeed compliant with the Efficient Market Hypothesis. The equation for the augmented dickey-fuller test is given below.

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

Subtracting $X_{t-1}$ from both sides returns the following equation.

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

The augmented dickey-fuller test returns a result of failing to reject the null hypothesis of a unit root if the coefficient $\beta$ is equal to or approximately equal to one as written in the second equation (Moyer, 2020). In this scenario, the test suggests that the data is compliant with the confines of the Efficient Market Hypothesis and follows a random walk.

In employing this test, I am attempting to see whether there was a change in the price movement of certain stocks before and after the onset of the COVID-19 pandemic. Companies with high exposure to the travel industry such as hotels, airlines, and cruise lines were uniquely affected by the onset of the pandemic. It is my expectation that in utilizing the augmented dickey-fuller test, the time period before the arrival of the pandemic will show the presence of a unit root implying compliance with the Efficient Market Hypothesis, while the period following the onset of the pandemic will fail to show a unit root, implying that stocks did not follow a random walk.

**Variance Ratio Test**

The variance ratio test is another test that can be used to evaluate a stock's behavior in regard to its relation to the Efficient Market Hypothesis. This test is being used to analyze whether the returns on certain stocks are consistent with a martingale process rather than following a pattern of serial correlation. A martingale process states that the conditional expected value of a variable is simply equal to the current value of the variable. In the context of stock

trading, if an individual security was being sold at price *X* today, but with an expectation that the price of the stock would go to *X+10* tomorrow, the current price would naturally be bid up to match that of the expected price of the next day. Operating under the assumption that stocks incorporate all previous information, the most reasonable expectation for tomorrow's stock price is simply today's price. A stock following such a pattern would be said to be a martingale given that its current trading price reflected the expected value of the next day's trading price (Aspnes, 2012). A series that is identified as a martingale is compliant with the Efficient Market Hypothesis.

The variance ratio test represents one avenue in which the returns of a stock can be evaluated as a martingale in compliance with the Efficient Market Hypothesis. This test was originally utilized by researchers Lo and MacKinlay in a paper evaluating the random walk of weekly stock returns over the period 1962-85. The statistical test involves evaluating the variance of an asset's return over multiple periods against the single period variance of the asset multiplied by the length of the period. The variance of the sum of returns should be equal to the sum of the variance of the same returns if the two returns are independent (1988). Therefore, the ratio of the variance of the sums to the sum of the variances should approach one if the stocks are following a random walk and have daily returns that are independent.

# Chapter 4

## Results of the Efficient Market Hypothesis Tests

## Augmented Dickey-Fuller Test

*Stocks with significant exposure to international and domestic travel prior to the onset of*

*COVID-19 induced lockdowns: March 19, 2018 to January 31, 2020.*

I conducted augmented dickey-fuller tests for the share prices of six companies that had

significant exposure to international and domestic travel in the period lasting from March 19,

2018 to January 31, 2020. This period represents the normal functioning of travel markets prior

to any restrictions imposed due to the worldwide spread of the COVID-19 virus. In determining

whether the augmented dickey-fuller test is statistically significant, the results will be compared

to a p-value of 0.05. If the p-value of the test is less than 0.05, I reject the null hypothesis that

there is a unit root present in the time-series which would imply that the data is stationary and is

thus a potential violation of the random walk component of the Efficient Market Hypothesis. The

p-values for the six stocks are listed in Table 1.

| Company | P-Value | Consistent with EMH? |
|---|---|---|
| Carnival (CCL) | 0.3620 | Yes |
| Delta Air Lines (DAL) | 0.1490 | Yes |
| Hilton (HLT) | 0.9056 | Yes |
| Marriott (MAR) | 0.3676 | Yes |
| Southwest Airlines (LUV) | 0.0473 | No |

| Royal Caribbean (RCL) | 0.1169 | Yes |

**Table 1 - Augmented Dickey-Fuller Test Travel and Hospitality Pre-Pandemic**

For all of the above listed companies, their share prices behaved in accordance with what the Efficient Market Hypothesis would predict save for the exception of Southwest Airlines. Interestingly, the stock price of Southwest Airlines exhibited stationarity at a statistically significant level during the nearly two-year period preceding the pandemic and associated lockdowns.

*Stocks outside of the hospitality and travel industries prior to the onset of the COVID-19 induced lockdowns: March 19, 2018 to January 31, 2020.*

In order to evaluate the results of the travel and hospitality sensitive stocks, a collection of random stocks drawn from the Fortune 500 are tested. While these companies likely experienced various impacts from the COVID-19 lockdowns, their main lines of business are outside of the travel and hospitality sectors.

| Company | P-Value | Consistent with EMH? |
|---|---|---|
| American International Group (AIG) | 0.5306 | Yes |
| Assurant (AIZ) | 0.8755 | Yes |
| CommScope (COMM) | 0.2944 | Yes |
| General Mills (GIS) | 0.7394 | Yes |
| Textron (TXT) | 0.7052 | Yes |
| United States Steel (X) | 0.6336 | Yes |

**Table 2 - Augmented Dickey-Fuller Test Comparison Firms Pre-Pandemic**

*Stocks with significant exposure to international and domestic travel prior to the onset of*

*COVID-19 induced lockdowns: February 3, 2020 to December 31, 2021.*

For the same companies that have a significant portion of their revenue concentrated in the travel sector, the augmented dickey-fuller test is conducted during the time period February 3, 2020 to December 31, 2021. The start date in this time period represents the date in which the United States issued a public health emergency declaration following the spread of COVID-19 to countries across the globe. In order to be compliant with the random walk component of the Efficient Market Hypothesis, the share price of a firm cannot behave as a stationary time series as represented by a p-value of 0.05 or lower for this test of the presence of a unit root. The p-values for the six stocks are listed in Table 3.

| Company | P-Value | Consistent with the EMH? |
|---|---|---|
| Carnival (CCL) | 0.0161 | No |
| Delta Air Lines (DAL) | 0.1612 | Yes |
| Hilton (HLT) | 0.9200 | Yes |
| Marriott (MAR) | 0.7339 | Yes |
| Southwest Airlines (LUV) | 0.4912 | Yes |
| Royal Caribbean (RCL) | 0.0889 | Yes |

**Table 3 - Augmented Dickey-Fuller Test Travel and Hospitality Pandemic Period**

All of the above listed stocks exhibited behavior consistent with the Efficient Market Hypothesis except for Carnival Cruise Lines stock which demonstrated evidence of stationarity and thus not following a random walk as proscribed by the EMH.

*Stocks without significant exposure to travel prior to the onset of the COVID-19 induced*

*lockdowns: February 3, 2020 to December 31, 2021.*

| Company | P-Value | Consistent with EMH? |
|---|---|---|
| American International Group (AIG) | 0.8444 | Yes |
| Assurant (AIZ) | 0.7378 | Yes |
| CommScope (COMM) | 0.6241 | Yes |
| General Mills (GIS) | 0.2671 | Yes |
| Textron (TXT) | 0.9416 | Yes |
| United States Steel (X) | 0.7357 | Yes |

**Table 4 - Augmented Dickey-Fuller Test Comparison Firms Pandemic Period**

## Variance Ratio Test

For the period March 19, 2018 to January 31, 2020 and February 3, 2020 to December 31, 2021, I conducted variance ratio tests on the share prices of the six aforementioned companies that had significant exposure to the domestic and international travel industry. In order to be considered a martingale where the conditional expectation of the variable is equal to the current value of the same variable, the outcome of the variance ratio test would approximately equal one. A variable ratio test that returns a value less than one shows evidence of mean reversion as the then current share price moves in an opposite direction to the price movement from the previous day. A variable ratio test that exceeds one shows evidence of momentum whereby a stock price moves in the same direction as the previous day's price movement. Both evidence of mean reversion and momentum would be violations of the Efficient Market Hypothesis.

*Stocks with significant exposure to international and domestic travel prior to the onset of*

*COVID-19 induced lockdowns: March 19, 2018 to January 31, 2020.*

| Company | Consistent with the EMH? |
|---|---|
| Carnival (CCL) | Partially<br><br>Fail to reject null hypothesis at K=2, 16 with 90% confidence interval<br><br>Reject null hypothesis at K=4, 8 with 90% confidence interval |
| Delta Air Lines (DAL) | Yes |
| Hilton (HLT) | Yes |
| Marriott (MAR) | Yes |
| Southwest Airlines (LUV) | Yes |
| Royal Caribbean (RCL) | Yes |

**Table 5 - Variance Ratio Test Travel and Hospitality Pre-Pandemic**

For the period March 19, 2018 lasting until January 31, 2020, the variance ratio test only found one violation among the tested stocks in the travel and hospitality sectors – Carnival Cruise Lines. The null hypothesis of CCL being a martingale is rejected at the 90% confidence interval for K=4, 8. With a variance ratio in excess of one, there is evidence of momentum for Carnival Cruise Lines during this period. The variance ratio test failed to reject the null hypothesis of the other stocks behaving as martingales at all confidence levels.

*Stocks without significant exposure to travel prior to the onset of the COVID-19 induced*

*lockdowns: March 19, 2018 to January 31, 2020.*

| Company | Consistent with the EMH? |
|---------|--------------------------|
| American International Group (AIG) | Yes |
| Assurant (AIZ) | Yes |
| CommScope (COMM) | Yes |
| General Mills (GIS) | Yes |
| Textron (TXT) | Partially<br><br>Fail to reject null hypothesis at K=2, 4 with 90% confidence interval<br><br>Reject null hypothesis at K=8, 16 with 90% confidence interval |
| United States Steel (X) | Partially<br><br>Fail to reject null hypothesis at K=4, 8, 16 with 90% confidence interval<br><br>Reject null hypothesis at K=2 with 90% confidence interval |

**Table 6 - Variance Ratio Test Comparison Firms Pre-Pandemic**

For the period lasting March 19, 2018 to January 31, 2020, the variance ratio test found two stocks among the group of companies outside of the travel and hospitality that violated EMH principles – Textron and United States Steel. The null hypothesis of the time series being a martingale is rejected at K=8, 16 for Textron and K=2 for United States Steel. Shares of Textron were found to engage in a pattern of momentum while those of United States Steel were found to engage in mean reversion. All other stocks failed to reject the null hypothesis of a martingale at all confidence intervals.

*Stocks with significant exposure to international and domestic travel prior to the onset of COVID-19 induced lockdowns: February 3, 2020 to December 31, 2021.*

| Company | Consistent with the EMH? |
|---------|--------------------------|
| Carnival (CCL) | Yes |
| Delta Air Lines (DAL) | Yes |
| Hilton (HLT) | Yes |
| Marriott (MAR) | Yes |
| Southwest Airlines (LUV) | Yes |
| Royal Caribbean (RCL) | Partially<br><br>Fail to reject null hypothesis at K=2, 4<br><br>Reject null hypothesis at K=8, 16 with 90% and 95% confidence interval respectively |

**Table 7 - Variance Ratio Test Travel and Hospitality Pandemic Period**

For the period lasting February 3, 2020 to December 31, 2021 the variance ratio test found one company not in compliance with the principles of the Efficient Market Hypothesis, returning a result of rejecting the null hypothesis. The test determined that shares of Royal Caribbean were not a martingale at the 90% and 95% confidence levels for K=8 and K=16 respectively. The test returned values in excess of one, suggesting that returns followed a pattern consistent with a momentum trading strategy.

*Stocks without significant exposure to travel prior to the onset of the COVID-19 induced lockdowns: February 3, 2020 to December 31, 2021.*

| Company | Consistent with EMH? |
|---------|----------------------|
| American International Group (AIG) | Yes |
| Assurant (AIZ) | Yes |
| CommScope (COMM) | Yes |
| General Mills (GIS) | Yes |
| Textron (TXT) | Yes |
| United States Steel (X) | Yes |

**Table 8 - Variance Ratio Test Comparison Firms Pandemic Period**

For the period February 3, 2020 to December 31, 2021, the variance ratio test found no violations among the tested stocks outside of the travel and hospitality sector. The variance ratio test failed to reject the null hypothesis of all stocks behaving as martingales at all confidence levels.

**Chapter 5**

**Examination of the Holdings of Retail Investors**

In evaluating the price movement of these stocks, I am also considering the response by individual, retail investors. Retail investors flooded into the marketplace during the spring of 2020 for a variety of reasons including increased free time and fewer expenses as a result of pandemic-induced lockdowns. While there is not data on the industry wide volume of trades made by retail investors, one stock trading platform aimed at young, novice investors – Robinhood – does have publicly available data for all trades made between May 2018 and August 2020. During this period, a private website – Robintrack – pulled real time data on the amount of a stock held by Robinhood users in aggregate. The specific manner in which the data was collected allowed holding levels to be calculated approximately on an hour basis. While the Robinhood platform is significant in the recent growth of its user base, its total assets under management are significantly less than other retail brokerage firms such as Charles Schwab or Fidelity that also cater to individual investors. Further, the average age of all Robinhood users is 31 and as such have risk profiles and investment horizons that differ from the broader retail investment community (Moise and Singh, 2021). For these reasons, any data on the holding levels of Robinhood users cannot necessarily be ascribed to follow a pattern of behavior also practiced by other individual investors.

It could be expected that during potential periods of deviation from market efficiency in certain stocks, the volume data from Robintrack would show changes in the holding levels of the respective stocks. Individual investors attempting to engage in a momentum trading strategy would seek to enter into a stock after it has seen successive price increases over a period of time. In such a case that the stock price data would exhibit momentum, the variance ratio test would

return a number in excess of one. That is, the returns would be serially correlated and have a positive covariance leading to the variance of the sum of returns exceeding the sum of the variance of the returns.

Similarly, another type of trading strategy that Robinhood users could be potentially employing is termed mean reversion. The underlying theory behind mean reversion is that assets have a tendency to return to long-run equilibrium, or mean, levels. Using the variance ratio test, a value of less than one suggests that the variance of the sum of the returns has a negative covariance, causing the numerator term to be less than the variance of the returns added together. In practice, this type of trading strategy can be seen when investors pile into a stock that has recently decreased in price below its long-run average or when investors pull out of a stock after a rise in price that brings it above its mean. Both instances represent trading strategies that are not compatible with the Efficient Market Hypothesis and its assertion that the current price of the stock represents all information relevant to its evaluation.

The Robintrack data shows that there was a trend of elevated investor interest among Robinhood users in stocks with significant exposure to the travel industry as the pandemic spread to the United States. To evaluate user interest in the hospitality and travel sector, I compiled total aggregate holding volume among Robinhood users for the six previously tested stocks – Carnival Cruise Lines, Delta Air Lines Hilton Worldwide, Marriott International, Royal Caribbean Group, and Southwest Airlines. I then compiled total aggregate holding volume for two additional groups to serve as comparison. The first additional group consisted of the six most popular NASDAQ listed stocks as measured by web searches and is labeled 'web views' on Figure 1. The second additional group consisted of the ten largest holdings from the Dow Jones U.S. Select Dividend Index and is labeled 'dividend index' on Figure 1. These groups are used to

differentiate trading strategies – one with a concentration on growth-oriented stocks and one with

a concentration on dividend paying stocks. For all three groups of stocks I aggregate total

holdings and index it to holding levels on January 1, 2020 to ensure a comparison is made in

relative as opposed to absolute terms.

Figure 1 displays the number of Robinhood users holding a stock relative to the number

of users holding that stock on January 1, 2020. Displayed on the graph are the three selected

groups. Hospitality and travel outpaced the other groups with a 2,870% increase in the number of

holding users followed by the dividend index with growth of 122.2% and web views increasing

by 49.8%. During this time, Robinhood users demonstrated a clear interest in the especially hard-

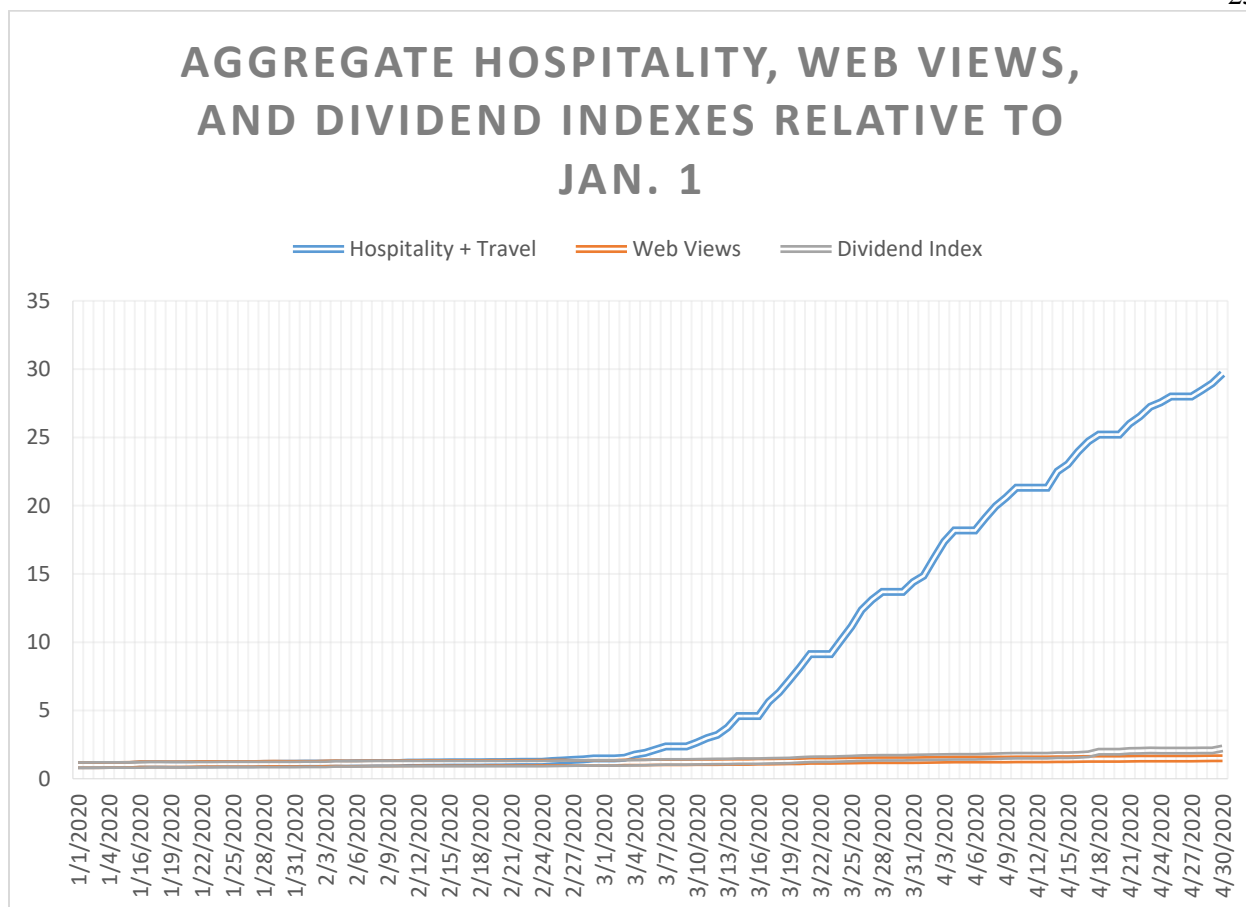hit segment that included leisure and business travel.

**Figure 1 – Robinhood Aggregate Volume Data**

With a clear increase in total aggregate holdings across the hospitality and travel segment, Figure 2 illustrates the breakdown among the six tested stocks. The cruise operators of Royal Caribbean and Carnival Cruise Lines experienced the most significant increase in holding levels, rising 17,090% and 11,900% respectively. The other tested stocks experienced significant increases as well sparked by the spread of COVID-19 into the United States.
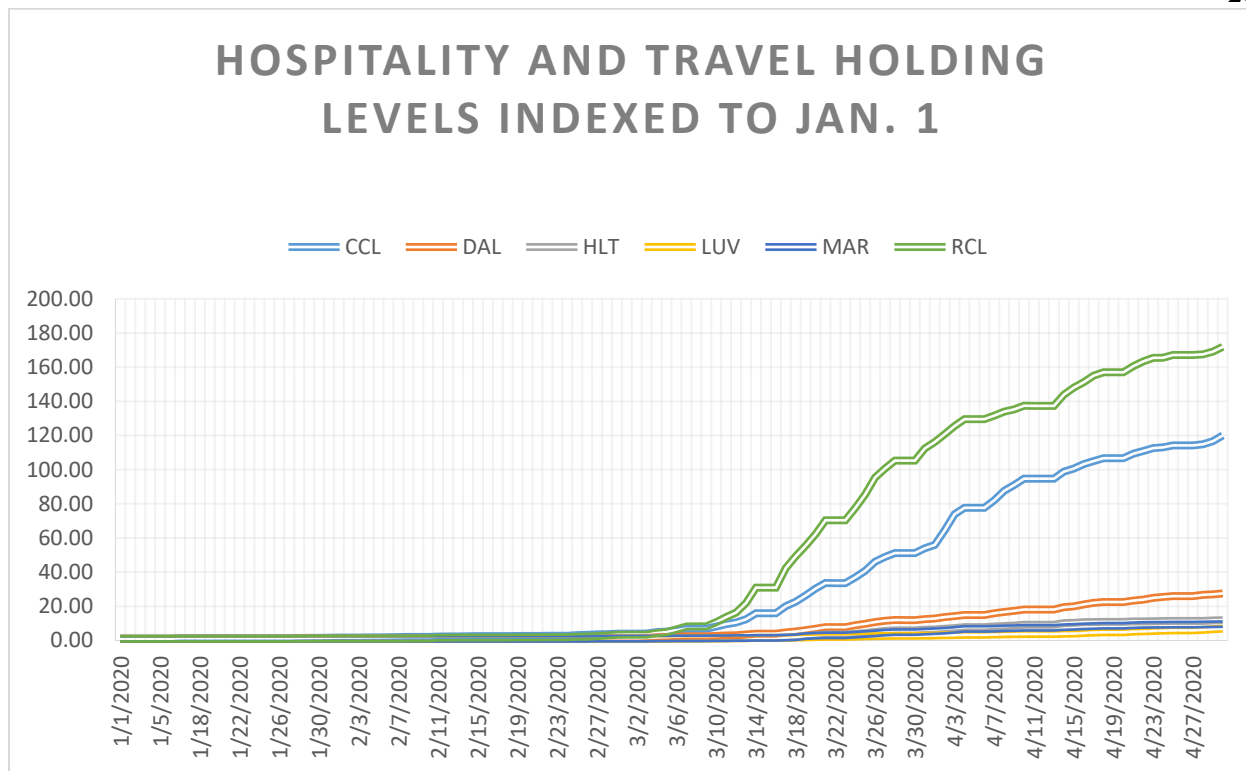
**Figure 2 – Robinhood Individual Stock Volume Data**

**Chapter 6**

**Discussion**

Through this paper, the share prices of several companies were examined to determine their compliance with the Efficient Market Hypothesis. In order to establish any instances of potential violations, two statistical tests – the augmented dickey-fuller test and variance ratio test – were implemented on the adjusted closing prices of twelve companies over a period stretching from March 19, 2018 to December 31, 2021. These tests showed that there were several instances over the course of the period in which the stock prices of multiple companies exhibited serial correlation. These instances, however, were rare and happened with similar frequency in both periods of study – before the onset of the pandemic-induced lockdowns and afterwards. While there was a possibility to exploit price movements in certain travel and hospitality stocks in some periods, these episodes constituted an insignificant minority within the overall market.

Retail traders during this period were also discussed in relation to a database that collected the level of stock holdings for Robinhood users in individual stocks. This group of investors greatly expanded during the period in which lockdowns were introduced across the globe and consequently took a special interest in stocks hit especially hard by COVID-19. To measure the level of interest specifically in travel and hospitality as compared to other companies that were traded using the Robinhood platform, the travel and hospitality stocks were evaluated against a selection of popular stocks listed on the NASDAQ index as well as stocks listed on the Dow Jones U.S. Select Dividend Index. Holding changes in travel and hospitality far exceeded that of the other two groups, indicating that there was an abnormal interest among Robinhood users to purchase shares of companies that had recently been adversely impacted by the COVID-19 pandemic.

Among the stocks that were examined within the travel and hospitality collection, cruise lines saw an especially large influx of investors as measured by the relative change since January 1, 2020. The inflow of new investors occurred primarily beginning in early March as the pandemic spread to the United States and began to visibly alter U.S. society through work shutdowns and stay at home orders.

# Chapter 7

## Conclusion

The impacts of COVID-19 extended beyond the clear health implications of the virus. Capital markets experienced significant turmoil as the virus achieved a global reach and spread quickly throughout the United States. Despite the tumult, capital markets appeared to maintain similar levels of efficiency to the period directly before the onset of the pandemic.

Robinhood users saw the pandemic induced downturn as an opportunity and significantly increased holdings of stocks connected to the travel and hospitality sector. Throughout this period, retail investors have been emboldened by past successes and are more willing to challenge conventional Wall Street thinking moving forward.

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# ACADEMIC VITA

## Education
Pennsylvania State University, University Park, PA                                                    May 2022
Schreyer Honors College
Bachelor of Science in Economics
Bachelor of Science in Finance

## Professional Experience
***Corporate Finance Intern*** *– Johnson & Johnson*                                 May 2021 – August 2021
- Supported key legal finance projects including the allocation of 2022 internal expenditures to over 50 operating companies with a total charge-out of approximately 200 million dollars
- Enhanced financial model to automate once manual process involving the categorization of headcount by various attributes
- Helped to organize accruals belonging to multiple finance groups in the close of the second quarter
- Competed in finance case competition with a team of interns to evaluate and provide verbal recommendations for a hypothetical acquisition scenario

***Financial Planning and Analysis Co-op*** *– The Hershey Company*          June 2020 – December 2020
- Contributed to key finance projects within the SG&A group by updating the use of certain models to keep track of approximately 20 million dollars of IT expenditures for the 2021 fiscal year
- Created a thorough process documentation to explain the steps needed to complete the aforementioned project from end to end
- Learned and utilized the data transformation software Alteryx as well as the data visualization tool Power BI in order to create and distribute a monthly sales report to a global team
- Presented summary of key project components to multiple affected stakeholders and served as first contact in answering questions

## Leadership Experience
***Vice President of Education***, *Penn State University Economics Association*          August 2021 – Present
- Oversees and coordinates five individual committees that make up the education department that is responsible for informing club members of new economic developments in print and visual media
- Previously served as Print Education Coordinator and was the editor of "The Optimal Bundle," a monthly, economic-themed publication that is distributed throughout the organization in an online format from August 2020 – May 2021

***Student Grader***, *Penn State University Department of Economics*      August 2019 – May 2020, August 2021 – Present
- Part of a team responsible for the grading of programming assignments and exams of 160 students in introductory econometrics course
- Assisted the instructor of intermediate macroeconomics in the grading of four homework assignments and three exams throughout the semester with a class size of 150 students
- Evaluates student understanding of class material and assigns grades in a uniform manner