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Peter T. Paul School of Business and Economics Undergraduate Thesis

How Efficient is Market Pricing: Can Investors Beat the Market? Further, are Prices Always Right as Stated in the Efficient Market Hypothesis?

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ABSTRACT

The Efficient Market Hypothesis is a widely accepted economic theory developed by economist Eugene Fama. The theory states that at any given time, an asset's price reflects all available public information and will always trade at fair value. The motivation for this research is derived from the content taught in undergraduate finance courses. In undergraduate academia finance students are introduced to the idea of market efficiency, as it is a building block for future theory and application. However, this theory is rarely questioned in the world of undergraduate academia, rather just taken as fact by students.

The underlying research in this paper attempts to answer a key question in the investment world of "are asset prices always right as stated in the EMH?". If asset prices are always trading at fair value, individuals cannot achieve a return on investment that is higher than the market average, rendering active management useless.

This research has concluded that there are times where assets are not priced to fair value. This is not to say that the EMH is wrong, but rather 'not right' 100% of the time. Market inefficiency is driven by three main factors that will be mentioned in this paper: (1) Investor cognitive error (2) Market disruptions and illiquidity (3) Investor emotions (fear & greed). Throughout the paper there will be examples of both extremely efficient & inefficient market pricing.

This paper will prove useful for any finance student or recreational investor who has never challenged the EMH and is attempting to form their own opinion on market efficiency.

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INTRODUCTION

The research in this paper discusses market efficiency and whether or not assets are always priced correctly. This topic is particularly interesting due to the differing opinions of many people in the industry. Many believe in the idea of perfect efficiency at all times, while others support inefficiency and the opportunity to exploit those inefficiencies. Some believe generating excess returns is about luck, which would mean that active managers are essentially taking shots in the dark to pick stocks that will outperform. Others believe the generation of excess returns is about skill and being able to see the market from a different, more non-conventional way.

This paper is going to relate instances where markets show efficiency, as well as instances where the Efficient Markets Hypothesis (EMH) is challenged. The EMH states that asset prices reflect all current information and that assets always trade at their fair value, making Alpha generation impossible. The data focuses on many aspects of the market as a whole; the following points are analyzed:

- Efficient Market Pricing
- Fixed Income Arbitrage
- Homo Economicus
- Inefficient Market Pricing
- Technology in Markets
- Berkshire Hathaway & Warren Buffet

The findings explained in this paper should provide useful to any investor who is trying to form their own opinion on market efficiency. It is crucial that all investors understand market efficiency before making investment decisions, as their beliefs could be contradicted by their strategies. Further, this paper is useful for finance students who have not yet formed their own opinion about market efficiency, but just believe what they have been taught in basic academia.

BACKGROUND AND PRIOR LITERATURE

Early examples of financial markets can be dated back to Europe in the 1100s with the trading of agricultural debt. The idea of a “stock market”, however, was not introduced until the 1500s. According to *Economics Discussion*, a market refers to “an arrangement whereby buyers and sellers come in contact with each other, directly or indirectly, to sell and buy goods” (2020). A stock market is a platform that gives investors the ability to buy, sell, and negotiate prices of many assets. The assets mentioned in this paper will be referring to stocks and bonds. A stock is a small share of a company that can be bought on the public market. Stocks are known as riskier investments because the holder is only entitled to the residual cashflow the company provides after paying all other claimants. A bond on the other hand is recognized as a fixed-income instrument. Bonds are typically safer investments and can more or less ensure monetary gain depending on the credibility of the borrower and structure of the bond. A bond is essentially a loan made by one party to another where the borrower will pay interest payments to the lender with principal repayment at the stated maturity date.

This section gives background information necessary to understand the research findings laid out later in the paper. It offers many differing opinions on the topic and displays insights from several of the world’s most respected investors and economists.

EMH: Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) is one of the most widely accepted theories in the world of finance. The EMH was created by Eugene Fama during his Ph.D dissertation. This theory sets the foundation for nearly all entry-level finance courses. It is the base for the Capital Asset Pricing Model (CAPM) which shows how risk is correlated with return in the financial markets.

The EMH states that share prices reflect all current information and that stocks always trade at their fair value. According to the EMH, asset prices are never over or undervalued, which means the generation of excess returns relative to a benchmark is impossible. In simple terms, this means that assets are never ‘on-sale’, rather always the retail price. This theory does not believe in active management, as there is no Alpha (excess return) to be discovered. Further, the only way to achieve high returns, according to EMH, is to increase the riskiness of the asset.

CAPM is a formula is derived from the EMH and is able to estimate the return of a specific asset assuming markets are perfectly efficient.

Figure 1
CAPM: Capital Asset Pricing Model
 (CFA Institute, 2020)

$$ER_i = R_f + \beta_i(ER_m - R_f)$$

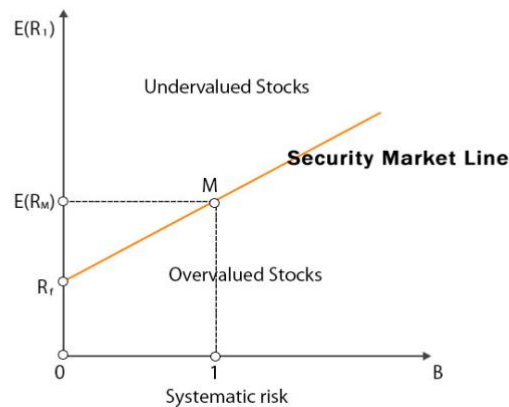
ER_i: Expected Security Return

R_f: Risk-Free Rate

B_i: Beta - Correlation of an individual securities volatility to the market as a whole

ER_m: Expected Market Return

Figure 2
Security Market Line
 (Investopedia, 2020)



In finance there are two types of risk; systematic and unsystematic. Systematic risk is defined as market risk, which cannot be diversified away in a portfolio. This risk cannot be controlled such as interest rates, macroeconomic events, etc. Unsystematic risk is firm-specific risk, which can be decreased through diversification of assets in a portfolio. According to the CFA Institute (2020), CAPM defines the relationship between systematic risk (a risk that cannot be decreased through diversification, aka market risk) and expected return. Assuming that markets are efficient, which CAPM does, as beta (risk) increases, so does the expected return. On the SML we see that as the x-axis (beta) is increased, the y-axis (return) is also increased. Undervalued stocks are to be located above the SML and overvalued stocks are to be located below the SML.

Adaptive Market Hypothesis:

The Adaptive Market Hypothesis (AMH) is a theory proposed by Andrew Lo (2004). Lo is a professor at MIT and has produced many studies about different areas of finance throughout his career. Along with the Adaptive Markets Hypothesis Lo has released many books including, *The Econometrics of Financial Markets*, *A Non-Random Walk Down Wall Street*, *Hedge Funds: An Analytic Perspective*, and *The Evolution of Technical Analysis*.

The Adaptive Market Hypothesis takes beliefs about the EMH and combines them with behavioral finance and human evolution. The hypothesis states that humans and markets are constantly working towards greater efficiency, just as species are always adapting to better fit the world around them (Lo). To support this, Lo not only uses examples in the industry of finance, but also enforces his hypothesis with biological principles. Lo believes that people are fairly rational beings, however, when faced with fear, greed, and other natural feelings, humans make

decisions that are not in their best economic interest. This theory challenges the idea of Homo Economicus, which states that humans are always perfectly rational economic beings (Lo).

The AMH believes in arbitrage, contrary to the EMH which renders arbitrage impossible. The idea is that more efficient and advanced investment decisions or strategies (i.e. strategies used by hedge funds) are able to act on the inefficiency of others to extract excess returns.

Efficiently Inefficient:

Efficiently Inefficient was written and released by Financial Economist Lasse Heje Pedersen in 2015. The text argues that markets are neither completely efficient, nor inefficient. Pedersen states:

“prices are pushed away from their fundamental values because of a variety of demand pressures and institutional frictions, and, although prices are kept in check by intense competition among money managers, this process leads the market to become inefficient to an efficient extent: just inefficient enough that active investors and their money managers can be compensated for their costs and risks through superior performance and just efficient enough that the rewards to money management after all costs do not encourage entry of new managers or additional investor capital,” (2015, p.4).

Throughout the book, Pedersen focuses on key hedge fund strategies. He combines modern research with interviews from experienced and well-known money managers to generate an interesting perspective on market efficiency.

Capital Ideas Evolving:

Capital Ideas Evolving was written by Peter Bernstein, who was the founder of his own investment consultant firm. *Capital Ideas Evolving* is an updated version of his prior “*Capital Ideas*” which was written in 1992. This text covers many new aspects of investing such as

hedging, hyperactive trading, quantitative trading, and the search for excess returns. Further, the book centers around five key theories in finance:

“Capital Ideas refers to Harry Markowitz’s work on portfolio selection, Franco Modigliani’s and Merton Miller’s revolutionary view about corporate finance and the behavior of markets, the Sharpe-Treynor-Mossin-Litner Capital Asset Pricing Model, Eugene Fama’s explication of the Efficient Market Hypothesis, and the options pricing model of Fischer Black, Myron Scholes, and Robert C. Merton” (Bernstein, 2009).

These 5 topics in finance have completely revolutionized the way people invest. This book was crucial in gaining a better understanding on how portfolio theory has changed over the years.

Buffett the Making of an American Capitalist:

Written by Roger Lowenstein, *Buffett the Making of an American Capitalist* is essentially a biography on Warren Buffett's life. Although this book was not necessarily a crucial read for this research, it most certainly was beneficial in indirect ways. The book gave insight into Buffett’s thought process when making investment decisions and building his company, Berkshire Hathaway.

Buffett is famous for value investing, which is investing in companies believed to be trading well below their book value (Lowenstein). The EMH argues that value investing is impossible because assets are never over or undervalued.

Contrary to some modern-day investors, Buffett's favorite assets are those he never sells. He is more concerned about the long-term trajectory and potential of the company rather than the short-term profit that can be made trading assets.

A section of this paper will discuss in further detail Buffett and Berkshire Hathaway's success. The data used will challenge the EMH, as Buffett has been able to outperform the market by a drastic margin over the course of his investment career.

OBJECTIVES OF RESEARCH

After researching existing theories hypothesized by the greats in the industry, it is important that this research not only ties the concepts together and brings them to life, but also challenges them. The purpose of this paper is to investigate how efficient market pricing actually is. The efficient market hypothesis (EMH) states that share prices reflect all the information available, and therefore makes alpha generation impossible. Believers in EMH claim the only way to obtain higher returns is to take on riskier investments (i.e. increasing beta). However, in rare cases, we have seen active investors able to generate alpha while keeping risk near that of the index (Bernstein, 2009). In the *Research Findings* section of this report the following questions are attempted to be answered using conclusive data:

- Are assets always priced correctly?
 - Does EMH always hold true?
- What causes market mispricing?
- What role does technology play in market efficiency?
- Is it possible to exploit market efficiency through trading strategies?
- Does active management outperform passive management?

RESEARCH FINDINGS

The research findings looked at in connection with this paper both support and challenge the EMH. Examples displaying extreme efficiency will be used to illustrate how efficient the market can be. Examples will also be incorporated showing how inefficient markets can be. As

previously mentioned, these inefficiencies are driven by investor emotions, cognitive error, and market disruptions such as illiquidity.

The remainder of this paper will be divided into two parts, market efficiency & inefficiency. Examples supporting EMH will be given first which will then be challenged with examples of market inefficiency.

Market Efficiency: Morton Thiokol

Figure 3
Intraday Stock Prices Following the Challenger Explosion on 01/28/1996
(Lo, 2019)

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M.T. Maloney, J.H. Mulherin / Journal of Corporate Finance 9 (2003) 453–479

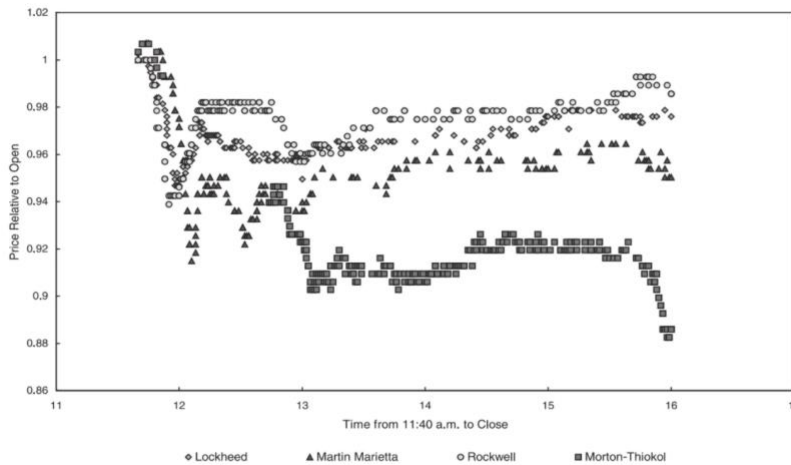


Fig. 1. Intraday stock price movements following the challenger disaster.

The first example of market efficiency relates to the extremely quick and efficient repricing of a specific asset. We have seen examples of extremely efficient repricing over a very short period of time, which reinforces the EMH.

On January 28, 1986 the NASA Challenger tragically exploded. There were four main vendors who together built the ship. The stock market, however, primarily punished only one

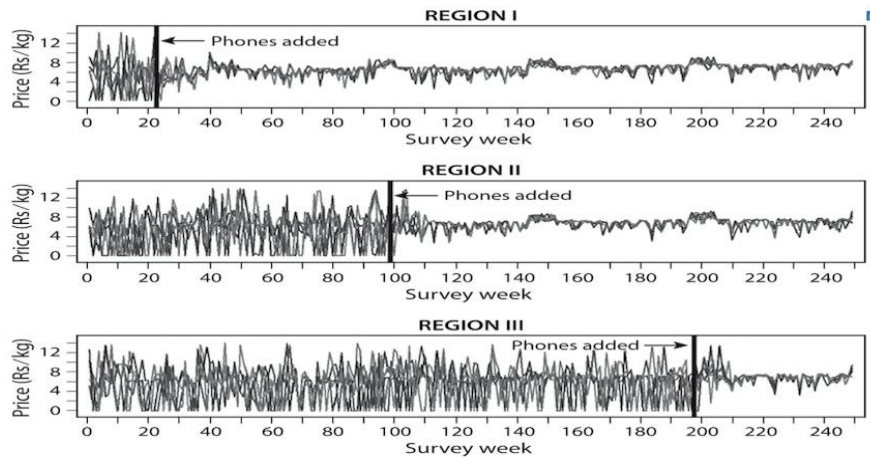
vendor, Morton Thiokol. Morton Thiokol's stock sell-off began immediately after the accident, and by the end of the day the company ticked down 12%, which equaled a decline in market capitalization of around \$209 mm. This re-pricing represents the market rapidly discounting the value of future cash flows and essentially assigning fault for the crash well before any investigation was even started. What is interesting here is that when the Rogers Commission concluded their investigation of the crash (5 months later), they established that the cost of all of the settlements, damages, and loss of future cash flows for Morton Thiokol equaled \$200 mm. The market was able to price in all of this information in just a few hours, whereas it took the Rogers Commission 5 months (Lo). EMH supporters would argue that the market took all available information and was then able to accurately re-access the intrinsic value of the company in a matter of hours.

The market was able to re-price very quickly due to the ability to access information on the spot. However, before technology this efficient re-pricing may have not been able to take place given the market as a whole would not have known about the incident.

The next example shows how big an impact technology has on the markets and how it leads to greater efficiency when implemented, as described in the fish markets in Western India.

Market Efficiency: Technology Changing Markets

Figure 4
Price Volatility of Fish Across 3 Regions in India; Before & After Mobile Phones
(Lo, 2019)



This example of market efficiency is crucial in displaying the ever more important role that technology plays in markets. In 1997 Harvard Economist Robert Jensen conducted a study that tracked the prices of sardines across different fish markets in Kerala, India. The timing of this study was important, as mobile phones were just being added to the region. Figure 4, above, displays the price volatility of fish before and after the implementation of cell phones. It can be concluded from the data that prior to mobile phones, there were massive swings in the price of fish. Efficient market believers would argue that these prices were always efficient, as they reflected all available information at the time. However, it is clear that once mobile phones were added to each region the price swings decreased immensely. By analyzing the graphs, it can be concluded that mobile phones drastically increased the efficiency of this specific market.

It is important to relate this concept back to the previous figure of Morton Thiokol. Due to the market as a whole having access to the same information because of a given technology, it was able to effectively re-price the company. Had the proper technology not been in place, it is possible that the market would not have been able to re-price Morton Thiokol so efficiently.

Non-believers in the EMH would argue that these devices helped bring prices closer to fair value, rendering prices before phones “inefficient”. Neither side of the aisle is necessarily

right or wrong here. Yes, technology dramatically increased the efficiency of this market which may have once shown some inefficiency, however, prior to phones, fisherman were pricing their fish based on all available public information, which supports the EMH.

Although the above example is not directly related to financial markets, the same holds true in equity and bond markets. Technology is transforming the way people invest. Computers have the ability to quickly exploit inefficient market pricing, therefore rapidly increasing market efficiency. These trades can take place in a fraction of a second with extremely low transaction costs. Before computers and high-frequency trading, it was not possible to exploit such mispricing. David Shaw, CEO of well-respected hedge fund D.E. Shaw & Co. mentions:

“Effects tended to disappear over time...Anomalies that had previously generated significant profits stopped making money, and you had to discover other, more complex effects that people hadn’t found. The market is never completely efficient, but it certainly has a tendency to become more efficient over” (Lo, 2015, p.239)

Technology is, and will continue to be, a massive driver of market efficiency, constantly pushing prices closer to fair value.

Homo Economicus: The Perfectly Rational Economic Being

When addressing the question “are markets efficient?” it is important to also consider the question “are the forces that drive the market efficient?” Homo Economicus is a term behavioral economist use to describe a perfectly rational economic being. This idea suggests that humans always act in the most rational way to maximize profit. Although trading is becoming more automated and computer-based, humans are still a driving force in the markets. If humans are perfectly efficient, prices will always reflect fair value as investors will never commit a cognitive error and will always make efficient trades. However, if humans are not perfectly rational beings,

how can it be concluded that markets are perfectly efficient?

It is a widely accepted idea among economists that humans are not perfectly rational individuals. However, economists such as Eugene Fama argues that investor's individual inefficiencies occur at the same frequency, and as a result, these inefficiencies offset each other, which keeps the market as a whole efficient. Many studies have been conducted around the idea of Homo Economicus, and the findings tend to disprove the theory. A study conducted by Daniel Kahneman and Amos Tversky revolves around how human "attitudes towards risk concerning gains may be quite different from their attitudes toward risk concerning losses." (San Jose State University Economics Department, n.d.). When people were given a choice between receiving a guaranteed \$1000 or a 50% chance of receiving \$2500 many chose the guaranteed \$1000. Now although this is the risk-averse option, it is not mathematically the most profitable. The perfectly rational economic choice would be to take the 50% chance of \$2500 as the monetary gain averages \$1250, opposed to \$1000 for the risk-averse option.

Their studies show that "people's attitudes toward risks concerning gains differ from their attitudes toward risks concerning losses." (San Jose State University Economics Department, n.d.). The same is true in financial markets. Buyers and sellers may act much differently when confronted with the same risk probability depending on what side of the trade they are on. To illustrate this idea, Behavioral Economist and Professor Richard Thaler conducted a study with his students at the University of Chicago. The students "were told to assume they had just won \$30 and were offered a coin-flip upon which they would win or lose \$9. Seventy percent of the students opted for the coin-flip. When other students were offered \$30 for certain versus a coin-flip in which they got either \$21 or \$39 a much smaller proportion, 43%, opted for the coin-flip." Although the monetary gain and probabilities of success were the exact same, when offered with

certain monetary gain students chose the risk-averse option as opposed to the risk-seeking option. (San Jose State University Economics Department, n.d.)

Market Inefficiency: Buffett & Berkshire Hathaway

Throughout history there have been clear examples of achieving excess returns, however, with added risk. Warren Buffett is the most well-known investor who has achieved this feat over a number of years.

“Berkshire Hathaway has realized a Sharpe ratio of 0.76, higher than any other stock or mutual fund with a history of more than 30 years, and Berkshire has a significant alpha to traditional risk factors. However, we find that the alpha becomes insignificant when controlling for exposures to Betting-Against-Beta and Quality-Minus-Junk factors.

Further, we estimate that Buffett’s leverage is about 1.6-to-1 on average” (Frazzini, Kabiller, & Pedersen, 2013, P.105).

When analyzing Berkshire Hathaway's returns, it is important to look at standard deviation in comparison to that of the DOW and S&P 500. Standard deviation is used by investors to measure the risk of a particular stock or portfolio. The standard deviation can then be compared to other stocks/portfolios to determine which one is riskier. Typically, it can be assumed that a higher standard deviation leads to more return, due to the fact that there is more risk associated with the assets.

- Berkshire Hathaway Standard Deviation: 1.76
- VOO (S&P 500 ETF) Standard Deviation: 1.37

Based on the data it is clear that Berkshire Hathaway does assume more risk than the S&P 500 since it has a higher standard deviation. That being said, Berkshire Hathaway has consistently produced returns far more impressive than the S&P:

- Compounded Annual Gain from 1965-2017
 - Per share BV: 19.1%
 - Per share MV: 20.9%
 - S&P 500: 9.9%
- Overall Gain from 1964-2017
 - Per share BV: 1,088,029%
 - Per share MV: 2,404,748%
 - S&P 500: 15,508%
- In 2015 a \$1 investment in 1964 was worth...
 - Berkshire Hathaway: \$15,893
 - S&P 500: \$113

Figure 5
Berkshire Hathaway v. S&P500 Price Comparison 1980-2017
 (Fidelity Investments)



From 1965 to 2017 Berkshire Hathaway outperformed the S&P by a compounded average of 11% per year. Not only were they producing higher yearly returns, their overall growth since 1964 was 115 times that of the S&P 500. (“BRK/B | Stock Snapshot - Fidelity”)

Although Berkshire Hathaway has been able to outperform an index over a long period of time, there is extensive evidence showing that active management very rarely outperforms an

index. *Capital Ideas Evolving* mentions that the market is the average result of what all other investors are doing. Because of this, some will be performing well, and some will perform poorly. It is important to note that this short-term outperformance is not the same thing as outperforming after adjustment for risk (Bernstein, 2009).

From 1977 to 1990 Fidelity's Magellan Fund rose more than 2700%, resulting in an annual compounded return of 29%. The fund was managed by the famous investor Peter Lynch who said that his only stock-picking criteria was his "common sense". Although there was clearly more going on than common sense, this quote appears to acknowledge that he recognizes he may have just gotten lucky. (Bernstein, 2009)

Burton Malkiel's book *A Random Walk Down Wall Street* studied all of the 139 mutual funds that have survived since 1970. His analysis revealed that 76 funds underperformed by more than 100bps and only 4 outperformed by more than 200bps per year. Furthering this point, Malkiel mentions that "more than 80% of actively managed large-capitalization funds covered in Lipper Analytical Services failed to match the returns of the S&P 500 over periods longer than 10 years," (Malkiel, 2012). While this mostly supports the EMH, it does challenge it in a sense that 4 funds were in fact able to outperform the market. If the EMH held true at all times, this would "technically" be impossible. However, as previously mentioned, we have seen investors such as Buffett and Lynch greatly outperform, which 'should' be impossible assuming 100% efficiency at all times. This leads to the next section of the paper which challenges the EMH that markets are constantly efficient.

Market Inefficiency: NYSE: CUBA

Figure 6
NYSE: CUBA Price to NAV from May 2014–March 2016
(Bloomberg, 2020)



Figure 7
NYSE: CUBA Top 10 Holdings
 (Fidelity Investments, 2020)

Top 10 Holdings		
Ticker:	Company Name:	Holding %:
MTZ	MasTec Inc	15.59%
RCL	Royal Caribbean Cruises Ltd	7.24%
BPOP	Popular Inc	6.39%
NCLH	Norwegian Cruise Line Holdings Ltd	6.31%
FBP	First BanCorp	5.65%
CPA	Copa Holdings SA Class A	5.13%
LEN	Lennar Corp	4.84%
VAC	Marriott Vacations Worldwide Corp	3.71%
FDP	Fresh Del Monte Produce Inc	3.09%
NEE	NextEra Energy Inc	2.99%

Although many examples of market efficiency have been discussed above, it is crucial to analyze moments of inefficiency in the markets due to the cognitive error of investors. On December 18, 2014, President Obama announced he was going to lighten restrictions against Cuba. Following this information, the mutual fund “CUBA” which historically traded at 10-15% discount to NAV, was suddenly trading at a 70% premium to NAV. In simple terms, on

December 18th one could purchase \$100 of assets for \$90, however, on December 19th it cost \$170 to purchase \$100 worth of assets. What is extremely interesting about this price increase is that the fund had no investment interest in the country of Cuba. In 2014 the fund was made up of 69% US Equities, and 31% in foreign stocks, confirming no correlation to any Cuban companies. This market inefficiency was caused by the cognitive error of investors. Due to the fund's name, people made assumptions it had investment interest in the country itself, when really it did not. Many would attribute this to investors getting ahead of their cognitive analysis. This phenomenon would be described by non-believers in the EMH as a bubble. A bubble is defined as "asset prices unwarranted by the fundamentals of the asset and driven by exuberant market behavior," (Kenton, 2020). The data shows that it wasn't until September of 2015 that the price aligned with NAV. This example greatly challenges the EMH as this fund went through a period of 9 months where its price did not reflect all available information, rather it reflected the cognitive mistakes of investors.

Market Inefficiency: Fixed Income Arbitrage (Buy 10 5/8 August 2015 Sell 4 1/4 August 2015)

Figure 8

Chart Displaying a Yield Spread between two U.S. Treasury Notes (01/01/2008-04/30/2019)
(Bloomberg, 2020)

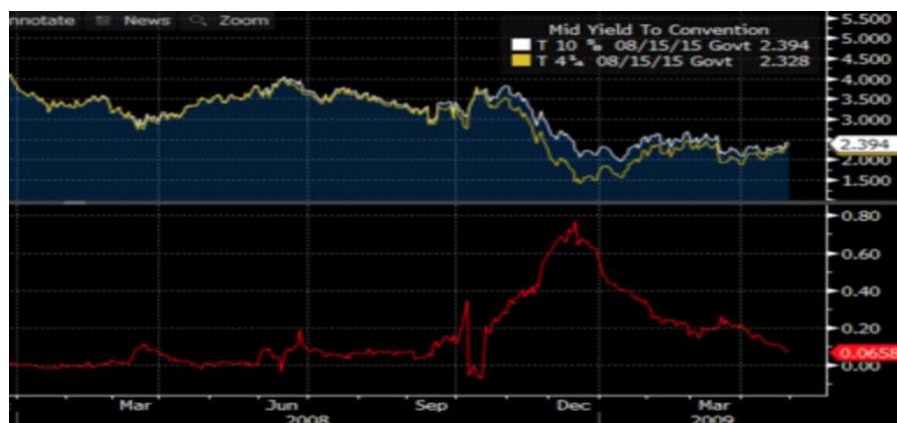


Figure 8 challenges the ‘Law of One Price’, which according to the Corporate Finance Institute is an “economic theory that states that the price of identical goods in different markets must be the same.” (CFI, 2019). This specific example regards two different US Treasury Notes. The white line is a 30-year note originally issued in 1985 and the yellow line is a 10-year note originally issued in 2005. Although these two notes were issued on different dates, they mature on the same day, meaning they have the same TTM (time to maturity). These bonds should now be effectively fungible and therefore should have the same yield. However, due to illiquidity in the markets, a yield spread began to form. A yield spread is defined as the difference in yield between two differing debt instruments (Chen, 2020).

To exploit this inefficiency and generate short term alpha, bond arbitrageurs would perform a trade selling the rich security and buying the cheap security. When this trade is executed, the arbitrageurs take the narrowing of the spread as profit. As shown in the graph above, the yields on these two securities formed during the financial crisis in 2008.

This example reflects how market disruptions can lead to inefficient pricing. The impaired liquidity is not a result of investor error, rather technical events that affect trading efficiency in the markets. If markets were always priced efficiently, two U.S. treasury notes maturing on the same date should always have the same yield.

CONCLUSION

Utilizing both primary and secondary research, it can be concluded that there are times where markets show inefficiency. These inefficiencies are a result of investor emotions and cognitive error, as well as market disruptions and illiquidity. The idea of Homo Economicus has been called into question by numerous studies further enforcing the idea that humans commit

cognitive errors when making investment decisions. This supports the conclusion that markets cannot remain perfectly efficient at all times due to human error.

However, this is not to say that markets are not efficient the majority of the time. With high-frequency and AI trading becoming more prevalent, markets are constantly adapting, bringing asset prices closer to fair value. The EMH remains true the majority of the time, but there is enough data suggesting that markets do show inefficiencies, and it is possible to discover, and exploit market inefficiencies generating excess returns.

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