UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER THESIS

DIVERGENCE BETWEEN REAL ECONOMY AND STOCK MARKETS IN CORRELATION WITH AN ASSET BUBBLE FORMATION

Zurich, August 2023 NIKA DROBNIČ

AUTHORSHIP STATEMENT

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LIST OF ABBREVIATIONS

AAII – American Association of Individuals
ABS – Asset Backed Security
ADF – Augmented Dickey-Fuller Test
BSADF – Backward sup ADF
CAPE – Cyclically Adjusted Price to Earnings Ratio
CDO – Collateral Debt Obligation
CMC – Coin Market Cap
CPI – Consumer Price Index
D/E – Debt to Equity Ratio
DDM – Dividend Discount Model
DJIA – Dow Jones Industrial Index
EBITDA – Earnings Before Interest, Tax, Depreciation and Amortisation
ECB – European Central Bank
EMH – Efficient Market Hypothesis
EPS – Earnings per Share
EV – Electric Vehicle
FCFE – Free Cash to Equity
FED – Federal Reserve's Bank
FRED – Federal Reserve Economic Data
G7 – The International Group of Seven
GDP – Gross Domestic Product
GNP – Gross National Product
IMF – International Monetary Fund
IPO – Initial Public Offering

IT – Information Technology
LPPL – Log-periodic Power Law
M1 – Money Supply that is Composed of Currency, Demand Deposits and other Liquid Deposits
MBS – Mortgage-Backed Securities
MP – Member of Parliament
NYSE – New York Stock Exchange
OECD – Organisation for Economic Co-operation and Development
OTC – Over the Counter
P/FCF – Price to Free Cash Flow
PCR – Put-to-Call Ratio
PE – Price to Earnings
PSY model – Augmented Dickey-Fuller Model Proposed by Phillips, Shi and Yu
Q – Quarter
QoQ – Quarter on Quarter
RH – Research Hypothesis
ROE – Return on Equity
RQ – Research Question
S&P 500 – Standard and Poor's 500 Index
SEC – U.S. Securities and Exchange Commission
SSC – South Sea Company
TARF – Troubled Assets Relief Program
UK – United Kingdom
US – United States
VC – Venture Capital
VIX – Volatility Index
VW – Volkswagen
WHO – World Health Organisation
WILL5000PR – Willshire 5000 Price Index
YTD – Year to Date

INTRODUCTION

In the recent past (the year 2020), the economy went through an interesting shock, which differentiated from the previous financial crisis. This time the source of the shock did not originate from financial markets (like for example the 2008 financial crisis) but from an external factor - an unknown virus. Therefore the future of real as well as financial markets in 2020 was even more uncertain than ever. Economic activities were frozen and there was a high uncertainty about when or if consumption (especially in service sectors) would return back to normal. One might expect that the real economy as well as financial markets would need time to recover. On the contrary, financial markets (the focus in the thesis is on the US (United States) stock markets) finished the year 2020 higher than they started. DJIA (Dow Jones Industrial Index) increased by 7.3%, S&P 500 (Standard and Poor's 500 Index) by 16.3% and Nasdaq by 43.6%. This is despite an average fall in companies' earnings by 15% instead of the initially predicted 10% increase (Tappe, 2020). Furthermore, according to Graham's theory (Graham, Zweig & Buffet, 2006), the PE (Price to Earnings) ratio in efficient markets should not be over 20. Observing Shiller's PE ratio for S&P 500, it can be seen that it reached almost 35 at the end of 2020, the highest since the DotCom bubble. Combined with other unusual events in financial markets such as Tesla's stock reaching PE of 200, the CMC (Coin Market Cap) 200 Crypto Index reaching nearly 400% return, short attacks etc., we could observe that financial markets might not have been accurately reflecting the performance of the real economy and that share of irrational behaviour among investors was increasing. There were multiple articles stating, that "this time is different" and in contrast to my expectation, not many articles were pointing out concern about a market bubble and/or irrationality in financial markets (those articles only started appearing once so called "Everything Bubble" already popped in mid-2022). This motivated me to further dive into the topic of market bubbles and try to determine whether there was a market bubble present in the US stock market between 2018 and 2022.

Considering, that the topic of market bubbles only became more popular in the 1990s, there is little consensus on a definition of the phenomena, furthermore, there is also a lack of precise calculations for the indication and timing of bubbles. Currently, the most accurate model to measure market bubbles is the model by Phillips, Shu and Yu (2015), which uses dividend yield as an input. Other more known indicators, such as CAPE Ratio (Cyclically Adjusted Price to Earnings Ratio), Buffet's Indicator etc., serve more as a rule of thumb and have multiple constraints. In my words, I would define a market bubble as a phenomenon in financial markets, when a performance of financial market diverge from performance of real economy due to an increased irrationality of investors. Therefore the purpose of this thesis is to research newly proposed indicators for market bubbles, which are aligned with my definition of a market bubble. Part of indicators is going to be focusing on a divergence between performance of real and financial markets and the other part is going to be focusing on irrational behaviour of investors. Furthermore, considering that market bubbles are usually analysed only after their burst, there is little research material on the stock market

bubble in 2021. Hereby the second part of the thesis is focused, to determine whether there was a market bubble present on the US stock market between 2018 and 2022.

As mentioned by my proposed definition of a market bubble, I believe that whenever we observe a divergence between performance of financial markets and real economy, we should trigger an alarm and start analysing further with indicators of whether we could be in a bubble territory. Thus, I am first going to test RH (Research Hypothesis) 1: "Divergence between real and financial markets is correlated with bubble formation". Despite a common practice to compare performance of financial markets in time=t and performance of real markets in time=t, as one is a leading and another one lagging indicator, I am going to compare lagged performance of financial markets with a performance of real markets. Secondly, I am going to focus on indicators, firstly focusing again on divergence between financial markets and real economy: Market Cap to GDP (Gross Domestic Product) Ratio. Although the ratio proposed by Buffet in 2001 is well known, I am going to adjust it to offset some of the current constraints of the ratio and hereby test RH2: "Adjusted Buffet's indicator performs significantly better than non-adjusted indicator". Moving on, I am going to address irrationality of investors by proposing two new indicators: Put/Call ratio and Insider Trading ratio and hereby test RH3: "Share of stock ownership by insiders is significantly different during market bubble than during other time periods" and RH4: "Put/Call Ratio is significantly different during market bubble than during other time periods". Last but not least, considering, that it was visible in 2021, that financial markets were diverging from real markets and that there was high irrationality among investors, I am going to use existing models and rule-of-thumb ratios as well as newly proposed ratios which prove to be effective and test for RH5: "During years 2018 and 2022 there was a market bubble".

The thesis is built from three parts: the first one focuses on theory, the second one on proposed indicators and the last one on the potential market bubbles between 2018 and 2022. In the first chapter, I address interconnectedness between real economy and financial markets and serves as an introduction to the topic of market bubbles as well as the basis for the discussion in the third part of the thesis. The first part is based on secondary data and provides an explanation of how financial markets and real economy are connected, how they influence each other and what are the indicators that they are starting to diverge. The literature overview continues in the second part as I explore past market bubbles and provide an overview of already established indicators and models. Furthermore, I propose and test a new set of indicators, and test them based on data obtained mostly from Bloomberg and FRED (Federal Reserve Economic Data) and further processed in Excel and R Studio. In the last part, I am going to again start the chapter with secondary data as I am going to introduce the current market trends and relevant events which happened in the past two years. Later in the last chapter, quantitative methods are going to be used in order to test for the market bubbles in US markets between the years 2018 and 2022.

The overall thesis is relevant for three main groups: investors, regulators as well as researchers. Findings from RH1 could be useful mostly for regulators. If confirmed, regulators could then put more focus on observing the relationship between real markets and financial markets (adjusted for a 2-quarter lag) and use it as an additional indicator when deciding on fiscal and/ or monetary policies. RH2 (Adjusted Buffet's indicator), RH3 (Insiders activity) and RH4 (Put/Call Ratio) hypotheses could be useful for investors, especially for value and contrarian investors. As value investors are buying when prices of stocks are relatively cheap and contrarians are buying when everyone is selling, the three newly proposed indicators could help them out with their strategy. As mentioned, there is no single indicator to time market bubbles, therefore proposing new and improved indicators might help them to more accurately time market and adjust their investing strategies accordingly. Lastly, RH2, RH3, RH4 and RH5 hypotheses add value to the research community. For RH2 – RH4 I haven't found any papers which would test those new/adjusted indicators. Therefore my research does add a few pieces to the overall market bubble puzzle, testing and proposing indicators, which haven't yet been researched. The same holds true for the RH5. Having searched materials regarding the PSY model (which is supposed to be the best model so far for stamping market bubbles), the latest study using the PSY model for the US stock market only covers data until 2018. This means, that this paper would also be the first one to employ PSY model on US stock data including the time period when COVID-19 as well as the start of the Ukraine – Russia impacted stock markets. Moreover, due to data/time limitations, not all analyses were done as initially planned, the thesis also opens a cue for further research based on a more exact dataset and further research later in time, covering a time frame beyond the year 2022. Further details regarding the limitations of analysis are going to be discussed further in the thesis.

1 CONNECTION BETWEEN THE REAL ECONOMY AND FINANCIAL MARKETS

To better explain stock markets and their connection to the real economy, I am first overviewing financial systems as a whole.

1.1 Financial Systems and their Role

A financial system could be defined as a network of financial institutions and markets, dealing with a variety of financial instruments, which are engaged in money transmission activities and provision of loan and credit facilities (CFI, 2022b). Financial institutions transfer funds from net savers to net borrowers. Other institutional units, such as households, corporations, governments and central banks also play an important role in the financial system (IMF, 2006). On the net borrower side, we usually find corporations and governments, while on the net saver side, we usually find households, corporations and financial institutions. However, the needs of net savers and net borrowers differ as net savers tend to invest smaller amounts for shorter periods, seeking low risk and high liquidity, while

net borrowers require larger amounts for longer periods to fund new projects, making withdrawals complicated and returns risky. Hence financial institutions play an important role as they provide both parties with maturity, size, liquidity and risk transformation, supporting the growth of the economy (Ö. Dursun-de Neef, personal communication, October 22, 2018).

Besides above mentioned participants within a financial system, we can also observe financial markets, which are places, where securities can be traded and where savers and borrowers can be linked directly without a financial intermediary. There are many different categories of markets regarding the characteristics of securities traded and the structure of markets themselves. Firstly we can break down markets regarding the maturity of securities. Within (1) money markets one can trade short-term securities, meaning the maturity of the security is shorter than a year. When the security's duration is longer, they are traded on (2) capital markets. The most known representatives of capital markets are the stock and bonds (corporate and government) markets. Further, there are also different financial markets for newly issued securities, called (3) primary market and for existing securities called (4) secondary market. Within primary markets, a financial institution issues security on behalf of a client determines the price of the security and sells it to larger investors. On the other hand, secondary markets are inclusive, meaning that both institutional investors and smaller, retail investors can take part. Parties are buying and selling securities, however as they are trading with other investors the underlying company does not directly profit from the price increase (Cecchetti & Schoenholtz, 2014). The secondary market is further divided, depending on the market structure. Securities can be traded either on organized and regulated stock exchanges, referred to as (5) exchanges, or on (6) OTC (Over the Counter) markets which describe over-the-counter markets, decentralized markets, where unlisted securities can be bought and where price for securities can be further negotiated. Lastly, we divide financial markets regarding the type of financial assets being traded. Most commonly known are stock (or equity) market, bond market, money market, and commodities market where natural resources or commodities like metals, oil, and grains can be bought and sold and finally the derivatives market, where more complex financial products are traded, which are usually used for hedging positions in other markets or speculative intentions (CFI, n.d.).

1.2 Stock Markets and their Role

The focus of the paper will mostly be on secondary capital markets, more specifically on secondary stock markets. While on primary markets securities are created, on secondary markets previously issued securities are traded among investors, without any interference from the issuing company. This means that the company which issued those securities does not receive any new funds. From this perspective, one might assume, that importance of primary markets might be higher for a company issuing securities. Furthermore, we could also assume that the price change of already issued securities on secondary markets would

not hold that much importance to the issuing company. Nevertheless, the secondary stock market is the most widely followed financial market by investors and by listed companies.

We can attribute stock markets many roles, however, we can summarize all of them into three roles which together all contribute to accelerated economic growth. The first role is promoting investment via relatively high returns and liquidity. Without stock markets, it would be also difficult to decide which company or industry will use the given capital to the maximum use and would therefore deserve a higher share of capital allocated to them. Hence the second role, very important for corporations as net borrowers, is the efficient allocation of scarce capital resources. Secondary markets do not directly allocate capital resources, but they do provide a signal based on which capital is efficiently allocated in the primary markets. One characteristic of stock markets is also the high dissemination of information. This means that based on publicly available data, market participants form their expectations on the price of shares. Whenever new information arises, it is almost immediately incorporated into expectations. In the case of an efficient market, based on demand and supply for shares of companies, stock markets should reflect a proper valuation of securities. After an initial public offering, price of those shares is changing. Although it does not directly affect the number of assets the company is holding, it affects a future capability of a company to secure larger amounts of additional funding. Furthermore, volatility of share price, especially downward deviation can also attract a takeover. Lastly, we can also attribute capital markets' provision of trading mechanisms. They facilitate communication and later agreements between demand and supply. After an agreement, they also provide clearing and settlement to execute agreements.

Stock prices are changing constantly. As mentioned before, even when insignificant information appears, investors immediately react to it, trying to reap profits, before everyone else reacts to the information, therefore lags between information release and price correction are usually negligible (Lo, 2007). This is explained by the EMH (Efficient Market Hypothesis) developed by Samuelson and Fama in the 1960s. According to this theory, stock (as other assets) prices are always reflecting a true value of a company by incorporating in price all available information. There are 3 versions of EMH, depending on the information included in the price. At its purest, strong form, stock prices include all information, both publicly available and private information. Within the semi-strong version, prices have incorporated all publicly available information as well as historical prices. Within the weak form, stocks are priced only based on historical prices and returns. The weak form also leads to the random walk theory, which states that future prices are unpredictable and are fluctuating randomly. Current prices are reflecting all current information, nevertheless, future prices will fully reflect future information, which is currently unknown and can be completely random. Therefore, an investor shall not be able to earn superior risk-adjusted profit, using only analysis of past prices, volumes and returns (Dupernex, 2007).

To summarize, markets are efficient when prices fully reflect available information. However, even Fama pointed out, that there are potential sources of inefficiency such as transaction costs, disagreement among investors about implications of new information and the fact, that not all information is freely available (Fama, 1970). Another source of inefficiency could be the fact that EMH relies on the hypothesis that investors are behaving rationally. Therefore, mostly behavioural economists contradict this theory, claiming that investors often behave irrationally, exhibiting predictable behaviour. Experimental economists have documented numerous behaviour biases like overconfidence, overreaction, loss aversion, risk aversion, herding, etc. (Kumar, 2017). Similarly, there are multiple arguments against Random Walk Theory, which is connected to a weak form of EMH. One of the arguments is that stock prices can gain momentum in short run, as investors see that prices are moving in the same direction for a longer time. Schiller (2000) for example uses this argument to explain the Dot Com bubble. Supporters of EMH do acknowledge presence of behavioural biases, however, the market forces (for example rational arbitrageurs) should neutralise those biases and bring prices back to rational levels. Therefore, the impact of behavioural biases should be negligible and irrelevant (Lo, 2007).

Overall, there is still no general conclusion on whether the EMH hypothesis is indeed accurate and relevant in practice or not. According to the EMH theory, markets are behaving rationally. Therefore, one should not expect speculative bubbles and market crashes. Aliber and Kindleberger (2015) thus argue, that behavioural biases are not immediately neutralised by market forces, but may persist on the market for multiple months if not years. Therefore, for the paper, I will use the conclusion of Grossman and Stiglitz, who are saying that EMH presents an idealized image of financial markets and can be used as a benchmark for measuring relative efficiency (Lo, 2007). In both cases, in an efficient and inefficient market, there are multiple factors causing stock prices to change. In an efficient market, factors driving price change are mainly fundamental factors, while in an inefficient we can find also other factors, which might be based on emotions. Overall, these factors can be sorted into three categories: fundamental factors, technical factors and market sentiment.

1.2.1 Fundamental Factors

According to the EMH, the intrinsic price of an asset should be the same as its market price. In case the two are different, this should present an arbitrage opportunity for market participants, therefore the market value would soon be corrected to the intrinsic price (Fama, 1970). Analysis using mainly fundamental factors is called fundamental analysis and is one of the two basic methodologies investors use to determine whether to buy or sell stocks. With this analysis, an analyst would like to measure a security's intrinsic or "true" value and use it then as a benchmark when comparing it with a market price. The main assumption of fundamental analysis is that although stocks are mispriced in short run, in long run, stocks are going to move to their intrinsic value ("correct price") (Segal, 2023).

Fundamental factors, which are contributing to company's underlying value can be either qualitative or quantitative. Under quantitative factors, we check company's financials and most frequently ratios such as D/E (Debt to Equity Ratio), EPS (Earnings per Share), PE, etc. Qualitative factors on the other hand are business model, competitive advantage, corporate policy, management and similar. Doing a fundamental analysis, one does an analysis of not only a company but also its environment including industry and overall economy.

Although performance of certain companies does not depend on the performance of the overall economy, the economy's performance usually presents a systematic risk for companies, having an impact on their growth and cost of capital. To analyse the well-being of the economy, researchers usually use multiple indicators, trying to pinpoint the current stage of the business cycle (expansion, peak, contraction, depression, recovery). The most important and most observed indicator is GDP as it presents the sum of all final goods and services produced in a country (in a certain period). It could be referred to as the value of the total size of an economy. Originating from the aggregate expenditure equation:

$$GDP = C + I + G + (X - M), \quad (1)$$

GDP is taking into account data about personal consumption (C), gross private domestic investment (I) and net export (X-I). Analysing changes in GDP and its components help explain at which point of the business cycle we currently are and help us predict where on the cycle economy might be moving. GDP reporting is quarterly, which means, that the indicator could not be used to predict short-term market performance, but rather help us identify long-term trends. Therefore, GDP can be categorised as one of the lagging indicators, as the change of the indicator usually happens only after the whole economy has already changed (Yamarone, 2004). The second important lagging indicator is CPI (Consumer Price Index), which reflects an increase in consumer prices, or inflation. Increased CPI might indicate, that demand for goods and services is increasing and the economy is growing, nevertheless, too high inflation could also erode a household's income and savings. On the other hand, deflation indicates, that demand has decreased, which might lead to lower corporate profits and higher unemployment. Consequently, we could also analyse the unemployment rate, which signals if consumers have more or less money to spend and corporate profits, which is usually correlated with GDP and results in job growth (Yamarone, 2004). In contrast to above mentioned lagging indicators, indicators which usually change before the economy changes as a whole and therefore can predict economic changes in a short time, are labelled as leading indicators. For predicting the performance of the US economy in short term, The Conference Board is using Leading Economic Indicators Index, which is an index incorporating 10 leading indicators (average weekly hours in manufacturing, average weekly initial jobless claims for unemployment insurance, money supply, interest rate spread and others (Yamarone, 2004)).

After getting a sense of the overall market performance, one can move to analyse microeconomic factors, focusing on industry analysis and company analysis. Using fundamental analysis, we not only get a signal if a company might be performing well or not, but we can calculate or estimate the company's "true" value. When the intrinsic value is higher than the market price, a company might be overpriced and vice versa. We can use two types of valuations to estimate if the market price of a chosen stock is correctly priced. Firstly, one can use intrinsic valuation, using mostly factors derived from the income statement, balance sheet and cash flow statement of the company. Secondly, one can use relative valuation, comparing the company's financial ratio with the ratios of other competitors. When markets are relatively efficient, the "true" value of a company using both multiples should be very similar. Absolut valuation models value a company based on its ability to generate cash flows in the future by incorporating the probability of those cash flows. For calculating the absolute value of chosen company we have different models such as the dividend discount model, discounted cash flow model, residual income model etc. The main inputs for these models as well as for multiples are "fundamentals" – financials of a company, sourced from cash flows statement, income statement and balance sheet as well as expected growth and requested return on capital, both highly dependent on the economy's performance (NYU Stern School of Business, n.a.).

When a rational investor purchases a share, they should be prepared to pay exactly the present value of what they will receive if they keep the stock to infinity. Most likely they will each year receive a dividend, which means that the share value should be the same as the present value of all dividends, the company will pay out in future years. Based on these assumptions, we can calculate the stock's internal value using Dividend Discount Model. The basic formula for this model is:

$$P(t = 0) = (div\ (t = 0)\ x\ (1 + g))\ /\ (r - g), \qquad (2)$$

where div is a dividend, r estimation of the cost of equity and g constant growth rate for dividends. Although it is a widely used model, it has many shortcomings. First of all, young companies usually do not pay out dividends yet, therefore they cannot be valued using this model. Furthermore also for mature companies, it is not necessary, that their dividends will be growing constantly at the same growth rate. The problem also occurs, when the growth rate of dividends is greater than the company's cost of equity.

The dividend pay-out ratio does not always necessarily resembles a company's performance as companies might borrow money and continue with stable dividend pay-outs even when their performance deteriorate. Therefore, another model was created, taking into account free cash flow, the cash flow company has left after paying operations expenses and capital expenditures. Using free cash flow models, we can either calculate using free cash flow to equity or free cash flow to firm. Free cash flow to firm represents cash available for both

equity and debt when FCFE (Free Cash to Equity) already takes into account interest payment. Thus FCFE is also addressed as levered cash flow. The formula is:

$$FCFE = Cash\ from\ operations - Capex + Net\ debt\ issued, \quad (3)$$

with an additional formula:

$$V\ (t = 0) = FCFE\ /\ ((r - g)), \quad (4)$$

we come to the final intrinsic value of a company. When divided by a number of shares, it gives us intrinsic value of a share (Pinto, Robinson & Stowe, 2018).

While valuing a company using intrinsic or absolute valuation is rather complex, using relative valuation is relatively quicker, nevertheless might be less exact. Relative valuations use financial multiples, averages and ratios like PE ratio, ROE (Return on Equity), operating margin, P/FCF (Price to Free Cash Flow) etc. When evaluating the intrinsic value of a company, firstly we have to find a set of similar companies, usual competitors within chosen industry, whose average of the ratios is going to present the benchmark. Secondly, we convert market values into standardised values, which creates multiples, as we can not compare absolute values. Finally, we also have to take into account any differences between comparable companies, which might cause differences within multiples. In case chosen company has a higher / lower multiple than the benchmark which can not be explained by qualitative factors, this might be a signal that the market is mispricing the stock. As this valuation is rather simple, it is also much more popular among investors. According to a survey of equity valuation practitioners conducted by Pinto Robinson and Stowe (2018) almost 93% of surveyed individuals use market multiples to evaluate a company's true value, while discount value approaches (absolute valuations) were used in 79% (they are using more methods for valuation). We can categorise multiples into four categories, Earnings multiples, Book Value multiples, Revenues multiples and Industry Specific multiples (Damodaran, n.a.). Returning to the survey from Pinto, Robinson and Stowe (2018), the most commonly used multiple is the PE ratio, which is used by 88% of respondents. This ratio measures the current share price to its EPS. Investors use this ratio to either compare a company with similar companies or with changes in ratio for the same company over time. A high PE might indicate, that the share price is overvalued. Therefore some economists are writing about a possible market bubble once the PE ratio disproportionally increases. Higher PE is also common for higher growth firms, firms with lower reinvestment needs and firms with a lower risk (leverage). For this specific ratio most severe limitation is, that can not be used for relatively young companies, where earnings are still negative or close to zero (Groves, 2023).

1.2.2 Sentiment and Behavioural Finance

The second main school of thought when it comes to approaching markets is technical analysis. The assumption for technical analysis is similar for the EMH – that price already includes all available information, which means that all fundamental factors are already discounted in the price. Nevertheless, they do not believe in random walk theory and believe that based on analysis of statistical trends, like price movement and volumes, the future price can be predicted. Hereby the purpose of this analysis is to identify price change trends preceding price trends based on the fundamental analysis, which is more focused on current price than on future movements. This comes from another hypothesis, claiming that price moves always follow a certain trend, which can be observed both in the short and long term. With analysis of trends, they try to capture and predict the market sentiment of price trends or said differently, the human element behind trade decisions. This is based on another hypothesis, that market psychology – the prevailing emotion of investors in time, either optimism (greed) or pessimism (fear) is to some degree predictable (Mawson, 2022).

Market sentiment describes how investors feel currently about the asset market and prices. They can either be optimistic, which means that the market is bullish or pessimistic with a bearish market. Based on sentiment, some investors place their investment strategies either to act with market sentiment or in a contrarian view, against the market view. Technical analysis does capture to a certain point a market sentiment, by checking on what is the current market trend, nevertheless, they take into account purely the price and volumes of an asset, chart patterns, trends and oscillators (Schiller, 2015). Market sentiment can be besides technical analysis, evaluated also based on sentiment indicators such as put/call ratio, consumer sentiment indicator, volatility index, high/low indicator etc. Although some sentiment indicators coincide with technical indicators and vice versa, technical indicators and technical analysis overall put more focus on pure data, than on explanation or prediction of current beliefs and emotions on the market (CFA, n.d.).

In an efficient market, we would be able to price a stock with fundamental analysis, however, the price tomorrow cannot be evaluated, as there might be unexpected news which might change fundamentals. In an efficient market also technical analysis would be useless as prices would move randomly, depending on the news, therefore not moving in any observable trends. Furthermore, there would also be no specific market sentiment, or it would have no impact on investors' investment decisions. However, the main reason why technical analysis is used and why we cannot rely only on fundamental analysis is the involvement of emotions when investing, or saying it differently, irrational investing (Jensen, 1978). Irrational investors are influenced by cognitive, emotional and social forces. Due to this they make sub-optimal investment decissions which do not lead to utility maximization. The subfield of economics researching how emotions and psychological factors influence investment decisions is called behavioural finance and has become more popular relatively late, only in the second half of the 20th century. The human brain is

designed that in general looks for patterns, and shortcuts, every person has a different hormonal balance affecting our decisions and also other external and internal factors are influencing our everyday behaviour and although one might wish we cannot turn this off during investing. Therefore, there are many phenomena observed in markets, which partially explain why the observed market price differs from the fundamental price (CFA, n.d.).

One of the phenomena is herding behaviour, which is an innate human behaviour. People tend to follow the actions of the herd assuming, that if others are buying or selling stocks, they must know something. This behaviour has caused market bubbles and crashes in the past, nonetheless, the behaviour is still observed in modern markets. Further behaviour which might lead to a market bubble is a positive feedback loop. When prices start rising acceleratingly, this attracts more investors and media attention, creating even higher demand, and pushing demand further. This phenomenon is driven by social psychology factors such as extrapolation and the greater fool theory, where investors buy overvalued assets based on the belief that they can sell to another investor for an even higher price in future. Investors do not necessarily buy assets based on underlying fundamentals, but solely on the expectation of selling to a "greater fool" (Bogan, 2021). Hayes (2022) also argues, that financial markets overall are driven by emotions, especially greed and fear. Investors are tempted to invest when markets are bullish and there are success stories of overnight millionaires, while they panic and start selling to minimize losses when prices drop. Anchoring bias also plays a role, as investors may hold onto a specific asset even when it has lost value due to subconsciously giving disproportionate weight to a specific benchmark, such as the initial purchase price.

There are many other biases or heuristics, which cause investors subconsciously assign higher or lower weight to certain information. For example, due to recency bias, investors tend to overweight the importance of new information regardless of its importance or probability. Thus during bubbles and before market crashes, many investors say to comfort themselves that “this time is different”, as they already forgot the previous market crash. People also tend to put more weight on information, which confirms their existing beliefs due to confirmation bias. Therefore due to numerous biases and human nature, I strongly believe that humans can not behave as rational market participants, which may lead to irrational moves in financial markets. (CFA, n.d.).

1.2.3 Real Economy and Financial Markets

A real economy includes all non-financial aspects of an economy, such as the production of goods and services. GDP is used to measure the total monetary value of finished goods and services produced in a country within a given period. Further, the real economy’s performance is measured by indicators such as unemployment rates, inflation, interest rates, and company profits. Leading indicators, such as the consumer confidence index, corporate capital expenditures, and jobless claims, can give us a prediction of future economic

performance, while lagging indicators, such as GDP growth, can provide information about past performance. The stock market reflects the sentiment in the economy and can provide an immediate picture of how things are going, while GDP is a more reliable indicator measured quarterly. Studies have shown that when the stock market performs well, the real economy should also see favourable growth with a lag of one quarter, but there is no relationship in the other direction Krchniva (2016).

The stock market does indicate the real economy's performance because it is the real economy which influences stock markets. As per DDM (Dividend Discount Model) and FCFE model, drivers of stock price are primarily dividends or free cash flow to equity and required return on equity. Both factors depend on the real economy's performance. As mentioned above in the real economy we have a demand and supply of goods and services, which are changing over time due to various reasons. When private consumption is high, demand for goods and services increases and if input prices remain the same, corporate profits increase due to price increases or increases in sold quantities. Consequently, the company also has higher FCFE and the possibility to increase dividends, which leads to a higher fundamental value of stock price. Similarly, if private investment increases, this usually leads to higher productivity which again leads to higher corporate profits. Also, government spending promotes lower unemployment, which leads to higher consumption. Therefore whenever the real economy is growing, this is reflected in the stock market, as the growth influences corporate profits, which are the main anchor for making decisions on the stock price. Nevertheless, as real economy performance is measured with a lag and also any news on real economy improvement takes time to reflect in the real economy. The second main driver of stock prices, which is derived from the real economy is the required return on equity, which strongly depends on interest rates. Interest rate is supposed to be risk-free, but for riskier assets like equities, the required return is higher due to the possibility of losses. The required return on equity can be calculated using the formula:

$$r(e) = r(f) + \beta\, x\, ((E\,(r(m)) - r(f)), \tag{5}$$

where r(f) is the risk-free rate, β is the beta of a specific company measuring its sensitivity to the market, and E (r(m)) is the expected market return. Changes in interest rates, therefore, do lead to changes in stock prices.

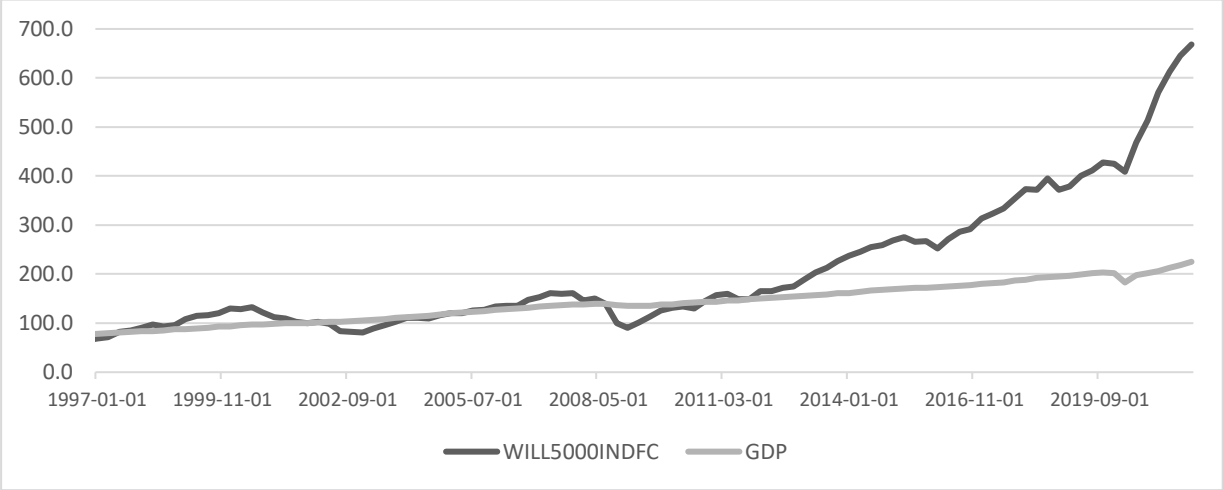
One of the open questions among economists is on the other hand how financial markets (if at all) impact the real economy. Financial markets in developed countries attract a lot of attention and resources, however, certain economists argue, that financial markets are only a "sideshow" and do not have an actual impact on the economy. Primary financial markets impact real economy, as they facilitate capital transfer. New capital then leads to increased productivity, increased income, lowered unemployment and increased consumption. All that in the end leads to economic growth. Nevertheless, there is little consensus on how secondary markets affect the real economy. Binswanger (1999) shows, that since the 1980s

results on the stock market did not affect real economic activity. In contrast, Fama (1990) showed, that increases in the stock market lead to increases in the real economy. This can be supported by an argument, that when stock prices increase, investors have felt that their wealth increases, thus they change their consumption behaviour, boosting the real economy. Bond, Edmans and Goldstein (2011) also argue, that the secondary stock market acts as an information aggregator, which then helps managers, capital providers and regulators to make a decision. Every individual participant in the secondary market has their information and to secure profit, they trade based on their information. Therefore aggregated, the stock market should reflect all information on the market or market consensus about the company's future performance and opportunities. This is supported also by many pieces of research, which shows that company managers indeed use the company's stock price as a source of information when making decisions.

1.2.4 The Disconnection between Financial Markets and Real Economy

Having mentioned above, stock prices depend on fundamentals such as the required rate of return and corporate profits, which depend on monetary policy and the performance of the real economy. However, in imperfect markets, we also have the effect of irrationality and emotions, which might add to stock price changes. Especially recently there is a popular topic discussing the disconnect between financial markets and the real economy or in other words, the increasing impact of emotions while trading instead of relying on the fundamentals of stocks. The interest in this topic was caused by the COVID-19 outburst, which caused firstly a sharp drop in major indices in February and March 2020, however, they then quickly rebounded to past values, although economic indicators deteriorated. In April 2020 Krugman wrote that the expected GDP fall in the US was almost 5% in a year with a forecasted unemployment rate of 16% until the end of 2021. Nevertheless, stock prices returned to their previous levels, although there was news that consumption is going to decrease, consequently decreasing corporate profits. Below in Figure 1, we can see Wilshire 5000 Index, which seeks to capture all US investible markets and US GDP. Both time series are represented as an index, which is 100 at time Q (quarter) 4 2001 (approximate end of Dot Com bubble crisis). What is visible from the graph is, that US investible market was tracking GDP, however, it exceeded GDP growth between 1998 and 2002 (Dot Com bubble), 2006 and 2008 (housing crisis) and after 2010 Wilshire 5000 started accelerating growth, completely detaching itself from GDP growth. The question there thus is, why the stock market is detaching from real markets and might be this sign of a stock market bubble?

Figure 1: Wilshire 5000 Total Market Full Cap Index vs GDP



Source: FRED Economic data (2022a), FRED Economic data (2022b)

Already in 2001, Warren Buffet opened a topic on the divergence between the real economy's performance and the performance of financial markets. He presented an example of two 17-year periods:

Table 1: Buffet's example of decoupling of Real Economy and Financial markets

Year	DIJA index on 31.12	DIJA growth (in %)	GDP growth (in %)	Interest rate (in %)
1964	874.12	0.1	373	4.2
1981	875.0			13.65
1981	875.0	949.3	177	13.65
1998	9181.43			5.09

Source: Buffet & Loomis (2011)

Although the stock market should be a leading indicator of how the real economy is going to perform, and although stock market prices should rely on stock's fundamentals – corporate earnings, which are a function of consumer spending, corporate investment and also import and export, very similar than GDP, differences are notable. During the first 17 years period, GDP grew three times, when stocks merely increased, while in the second period, stocks increased more than nine times, when GDP increased only 1.7 times. Buffet here explains, that the extreme difference between growth in both markets comes from three factors. One of them being interest rates. Based on interest rates we can assume, that while interest rates increased from 1964 to 1981, stocks were not that interesting investment anymore, as there were also other substitutes with similar or even higher yields and lower risk (time deposits, bonds etc.). Furthermore, also the value of an asset (the price of the stock) changes dramatically with a change in interest rate, as the interest rate is used as a denominator in cash flow valuation models. Thus it comes as no surprise, that when interest rates decreased, also valuations of stocks increased. The second factor impacting stock prices is corporate profits or expected profits, which increased around 2000 due to technological advancements. The third factor is the behavioural factor or irrationality of investors due to

fear, greed, herding behaviour and other behavioural biases. Buffet (Buffet & Loomis, 2001) point out, that it is not just individual investors who are behaving irrationally, but also institutional investors. Here he proposed an example of fund and pension managers, who were supposed to be rational and have long-term profits in mind. They were increasing their stock positions in 1972 when stocks were reaching their heights, but offloading them when they were relatively cheap in 1987. He adds, that also in 1975 it was interesting to observe portfolios of pension funds, as they included multiple stocks of which expected cumulative returns should yield around 7%, when one could easily get long-term government bonds, yielding 10.4%, not to mention that the risk was lower.

2 MARKET BUBBLES

Economic cycles are inevitable occurrences, which can be described as alternating periods between the expansion and contraction of an economy. Those fluctuations are reflected in financial markets through the prices of assets. It is expected that during expansion consumer spending is higher, and unemployment lower, which results in higher corporate profits and the opposite during contraction. Nevertheless, in history, we record multiple accelerated rises and contractions in financial markets, which do not necessarily mirror the cycle of the real economy, especially when it comes to the tempo of a rise. Furthermore, accelerated growth in financial markets is usually isolated within an individual asset type or industry. The rapid expansion, followed by a contraction in various business sectors some economists call “a market bubble” (Girdzijauskas, Štreimikiene, Čepinskis, Moskaliova, Jurkonyte and others, 2009). However, there is limited agreement on the definition of a market bubble, and some economists also dispute its existence. Before 1990 there was not much research being done on market bubbles, as US stock markets seemed to be rather efficient. Although we could count 1929 as a period of a market bubble, some argue that for example, the PE indicator was “only” at 20 (compared to the 1990s when S&P 500 PE was above 30), thus there was no real asset bubble. Nevertheless in the 1990s, there were multiple internet stocks with practically no or little earnings, being evaluated instead of earnings, on the number of views or clicks. Prices of internet stocks surged, completely dispatching from fundamentals, and attracting economists to research the phenomena (Veneroso & Pascali, 2021). Furthermore, the interest between economists increased even further after the housing bubble in 2008, as this time the burst of the bubble had a significant negative effect on the US economy and worldwide (Evanoff et. al, 2012).

The second reason for little research on market bubbles was also the wide acceptance and recognition of the efficient market hypothesis in the second half of the twentieth century. According to Jensen (1987), it was “the best established empirical fact in economics”. Schiller (2013) argues, that if EMH holds, then the price of a stock should be steady, as it is the present value of future dividends, which do not oscillate on an hourly basis. Critics then answered, that amount of dividends might change and historical dividend growth might change as investors are constantly evaluating new information and how could it impact

future dividends. Schiller is then answering, that what are they evaluating is the possibility of black swan events, which rarely happened in history. Furthermore, in history, all the information which according to EMH causes price changes, rarely actually impacted the number of dividends or their probability. Thus Schiller argues, that based on only dividends and their growth, the price of the asset should be smooth with little volatility. Therefore it might be something else causing the oscillations in prices, such as "animal spirits", which were already observed by Keynes. He observed that critical decisions of market participants were not always made based on calculations, but also based on impulses (gut feelings). Schiller then adds, that according to EMH, these irrational trades would then be offset by arbitrageurs, nevertheless also arbitrageurs or as he called them "smart money" investors, who also have to be careful on markets, as they can create losses due to unpredictable trades made by irrational investors.

Personally, I strongly agree with Schiller. As previously mentioned, the stock price is representing the present value of future cash flows. Under the assumption that we hold stock until infinity, the price then depends on dividends and the required rate of return (or expected cost of equity). Considering, that companies are paying dividends usually annually or bi-annually and considering that companies' dividends are usually steadily increasing through the years, without excessive volatility, the same should hold for stock prices. However, the reason for stock price volatility might be day-to-day changes in expectations regarding the expected cost of equity. Nevertheless, expectations itself incorporate human factor, which is strongly led by emotions. People are the ones setting assumptions on which models for the expected cost of equity, thus it is difficult to calculate the price solely based on rational assumptions. Furthermore, due to past examples of over-optimism and then over-pessimism of investors, it is hard to conclude, that markets are efficient. Furthermore, we have an enormous amount of retail investors, who do not have access to sophisticated datasets and models for market analysis or have sufficient time and knowledge for the required analysis. There are also transaction costs, which sometimes offset the opportunity of an investor to take advantage of mispriced stock prices and put prices back to equilibrium as per EMH. Therefore I strongly believe that financial markets are not efficient and that market bubbles indeed exist and can be used as a primary exhibit against the EMH.

Moving on, the next debate in a circle of economists is on the definition of the bubble. Below I have listed a limited number of definitions:

- Santoni (1987)

"Positive serial correlation in returns delinking price and fundamentals as bubble forms."

- Martin & Ventura (2011)

"Large swings in asset prices movements relative to economic activity."

- Stiglitz (1990)

"If the reason that the price is high today is because investors believe that selling price will be high tomorrow – when fundamental factors do not seem to justify such price, then bubble exists."

- Schiller (2013)

"A situation in which news of price increases spurs investor enthusiasm which spreads by psychological contagion from person to person, in the process amplifying stories that might justify the price increase and bringing in a larger and larger class of investors, who, despite doubts about the real value of the investment, are drawn to it partly through envy of others' successes and partly through a gambler's excitement.«

Summarising all the definitions I could say that a bubble occurs, whenever the prices of assets are delinked and visibly higher than the asset's intrinsic/fundamental value for a longer period. During this period, we also observe high trading volumes, the price being delinked from the general economic activity and irrational behaviour from market participants. There are multiple definitions, nevertheless, they are all relatively vague and leave researchers to further set their assumptions. Firstly majority of economists use fundamental or intrinsic value to describe asset bubbles, there is no consensus on what exactly fundamentals are and how we should measure and which are critical values indicating delinking of asset prices from their intrinsic value. Furthermore, a frequently included indicator is also irrational behaviour which yet again is hard to quantify and is usually a qualitative variable, meaning that it depends on the author's assumptions and biases. As so far there is no perfect definition, which would define market bubbles without leaving space for further personal interpretation by a researcher, I am taking in this thesis into consideration Garber's (2000) definition: "Fundamentals are a collection of variables that we believe should drive asset prices. In the context of a particular model of asset price determination, if we have a seriously missed forecast of asset prices we might then say that there is a bubble. This is no more than saying that something is happening that we can't explain". Although the definition is not impeccable, I have chosen it due to the last sentence, describing market bubble as moves of financial markets, which can not be explained by qualitative analysis, meaning that there is an additional strong determinant of stock price which is qualitative, such as irrationality of investors.

Even before introducing the theory of irrational behaviour of market participants, EMH challenged the theory of rational market bubbles. The first model of rational bubbles (Blanchard & Watson, 1982) assumes, that all investors have rational expectations and share the same information. One of the examples of these rational bubbles is fiat money, as the actual fundamental value of a 50$ bill is practically zero, nonetheless, it holds a value of 50$. Those kinds of bubbles are generated by extraneous events (not fundamental factors) and form merely due to self-fulfilling expectations regarding the future asset price. The price of the asset is, therefore, the following:

$$P(t) = P(t, f) + B(t), \tag{6}$$

where P(t,f) represents the fundamental value of the asset in time and B(t) the bubble component, which is the difference between the actual price and its intrinsic value

determined by its fundamentals. The bubble component in the following time period denoted as B(t+1) is:

$$B(t+1) = \frac{(1+r)\ x\ B(t)}{r\ x\ \pi}, \tag{7}$$

where r is the growth rate of a bubble, which grows with a probability π. Thus market participants purchase an asset solely in anticipation, that they are going to resell It for a higher price. This however is possible only when the transversality condition does not hold, giving an infinite number of solutions for P(t) – market price. However if

$$Lim(t\rightarrow\infty)\ \frac{(r)\wedge(1+t)}{(1+r)}\ x\ \pi = 0, \tag{8}$$

meaning that the transversality condition holds, then the $B(t) = 0$ and $P(t) = P(t, f)$. Therefore one held theoretical explanation for rational speculative bubbles is that they violate the transversality condition. There have been a couple of critics of this theory. For example, Diba and Grossman (1988) comment, that if this theory holds, then the bubble has to start already on day one of the trading and cannot start only at t+1 or any subsequent period.

The second model of rational bubbles by Froot & Obsfeld (1991) has the same assumption of rational expectations, nevertheless, they assume that information is asymmetrical. The prerequisite of this model is also that assets' fundamental value is calculated based on dividends in a linear non-deterministic approach. Based on this theory, price changes due to information on the fundamental factors – dividends and the bubble exists as investors react differently based on the news regarding dividends. Here the market price is determined similarly as before the fundamental price times bubble component, however, the bubble component changes, as it is determined by dividend changes:

$$B\big(D(t)\big) = c\ x\ D(t)^{\lambda}, \tag{9}$$

where D(t) represents dividends, and c and λ are parameters where c>0 and $\lambda > 1$. The bubble component therefore here depends on dividends, however, if there is no news which might distort the dividend growth, the bubble component remains constant.

Nevertheless, many economists challenged the fact that all investors behave purely rationally and that there are no additional constraints. According to the first theory on irrational bubbles, we have rational and irrational investors in the market. However, due to certain limitations, arbitrage for rational investors is limited, thus mispricing cannot be corrected right away. Thaler and Barberis (2003) say that arbitrage could be limited due to the fundamental risk. In case there is no perfect substitute for the specific asset which would be used as hedging or any other hedging possibility, rational investors have a risk that he is wrong about the arbitrage opportunity and suffers loss. It might also happen, that rational

investors would enter a short position on an asset, believing it is overpriced. Nevertheless, it might happen that fundamentals then change and the overpriced price becomes a rational price. De Long (1990) continues, that arbitrage could be limited due to noise trade risk. De Long explains that rational investors are usually interested in short-term results. For example, we could count find and portfolio managers as rational investors and their performance is usually evaluated based on short-term results and not on long-term results. However, noise traders might keep the price and even increase the mispricing for a longer period of time. Thus if fund managers enter a short position in overpriced assets and noise traders push the price even further, due to short-term losses fund manager experience fund outflows and has to unwind their positions. Abreu and Brunnermeier (2003) add, that there is also a synchronisation risk. As one rational trader usually is not able to correct mispricing, they depend on other rational investors and their timing. Rational investors share different views on when should they start with arbitrage. Rational investors, therefore, know that there is a bubble and that it is going to burst, however, they do not know when. In case they enter short positions too early, they might suffer losses as other rational investors have not yet decided to do the same. Thus according to Abreu and Burnnermeier (2003), individual rational investors prefer to ride the bubble rather than correct mispricing. Aliber and Kindleberger (2015) also present examples from history, when rational investors were riding the bubble. In 1719 it was the Hoares Bank riding the South Sea Bubble and later in 1999 hedge funds were heavily invested in technology stocks, although they were overpriced.

The second theory on irrational bubbles states, that irrational bubbles emerge not only due to arbitrage constraints but also due to heterogenous beliefs between rational investors. Even when investors have all the same data, they agree to disagree about fundamental value of an asset. Usually, heterogeneous belief bubbles are also accompanied by price volatility and high volume in trading (Brunnermeier, 2008). Smith, Suchanek, and Williams (1988) tested this by conducting an experimental study to investigate bubbles in lab-created markets for finite-lived dividend-paying assets. They found that assets were often traded at prices above their fundamental values, a result later confirmed by several other studies. Experiments also showed, as discussed by different authors above, that constraints such as short-sales and trader experience were important factors contributing to asset bubbles.

2.1 Examples of the Bubbles from the History

As mentioned above, also in artificial settings (lab), where assumptions about financial markets such as no transaction cost, the same information for all market participants etc. are fulfilled, scientists observed stocks above their fundamental values. Including transaction fees, information asymmetry and other constraints we face in the real world, one could assume that this phenomenon is going to be observed also on real financial markets. Throughout history, there have been numerous instances of market bubbles with some of them having more significant impacts on economies and individual investors than others. Although these market bubbles serve as cautionary tales of the dangers of speculation and

the importance of careful investment strategies, they have been repeating also in the 21st century.

2.1.1 Tulipomania

The first recorded market bubble occurred in the Netherlands in the 1630s. With the end of the war with Spain, the Netherlands was able to redirect its wealth for economic recovery during the "Dutch Golden Age." The increase in wealth increased investments, especially in art and flowers. Tulips, which arrived in Europe from the Ottoman Empire in the 1500s, became a status symbol and a new investment opportunity. (Garber, 2000). Due to the nature of flowers' reproductive cycle, supply was not able to follow the demand which caused an increase in prices. The demand for tulips exceeded the supply, causing an increase in prices. However, as bulbs were only able to be traded during specific months, they solve this by trading futures. The buyer usually had to pay 10% upfront, which enabled investors to buy on a margin. The purpose of buying contracts was not to receive tulips, but merely to sell them for a higher price (Garber, 2000). More people became attracted to trading, causing prices to rise dramatically, peaking at around 450k USD in 1636. The bubble burst in 1637 due to a lack of demand during a routine auction, causing panic and a drop in prices to 10% of the peak price. The decline in prices affected many households who lost money, but as the bulb trading represented only a fraction of the Netherlands' economy it had limited consequences on the overall economy (Aliber & Kindleberger, 2015).

2.1.2 South Sea Bubble

The South Sea Bubble was a market bubble arising in the UK (United Kingdom) in the 18th century. The UK was at war with Spain and had accumulated a large amount of public debt, which led the government to establish the SSC (South Sea Company) to manage its debt. The idea was for SSC to take over some of the debt from private individuals in exchange for shares and to offer lower interest rates to the government. The government also gave SSC a monopoly over trading with South America, which was meant to make the deal appealing to debtholders. As shares of another publicly traded company East India, which actively traded with countries in the East, were performing great, people were excited about an opportunity to get SSC shares. However, the downside was that SSC had limited trading right with South America as the ports were owned by Spain, which only allowed SSC to trade slaves and send one ship per year to each port, compared to the many ships the East India Company was sending each month (Vogel, 2018).

The directors of SSC continued to advertise successful trade with South America (Vogel, 2018). Shares were in high demand, also because there were not many other securities to invest in. Soon also MPs (Members of Parliament) and other officials started buying SSC shares. As there was a lot of publicity around SSC, especially about trading success, yielding high profits to shareholders and high dividends, there was a lot of hype around the company.

The share price increased from 330 £ in March 1720 to 550 £ in May. Later it was enabled to purchase new shares with only 20 % of the down payment with payment of the remaining amount in the future. Shares reached a peak in July when shares were trading above 1000 £. The number of investors in SSC involved was at that time equal to 2/3 of London's inhabitants and the value of the company was approximated to be around 300 million £ with 60 million £ of debt. Needless to say, the directors were aware of the bubble and were therefore selling their stocks in August, when new stocks were sold for 1000 £. Also, MPs, who presented 14 % of subscribers during initial offerings, presented only 5 % of subscribers during the last offering, indicating, that they were informed better than other investors. Bursts of other market bubbles in Amsterdam and Paris added to the liquidity struggle. The breaking point for SSC was the announcement of unrealistic dividends equal to ¼ of the UK's GDP. This destroyed the company's reputation and caused an extreme drop in share price to 175 £ in September. Later on, there was an investigation exposing corruption, bribery and accounting fraud, however, the company kept operating until 19 century (Quinn & Turner, 2020). The SSC stock crash, due to widespread public involvement, was thought to have a broader impact on the economy, but no exact YoY GDP numbers exist to confirm this. Available import/export data shows a slight decrease in exports, but there's no evidence of a major economic disruption caused by the South Sea Bubble (Hoppit, 2002).

2.1.3 Railway Mania

The repeal of the Bubble Act in 1825 (imposed after the SSC stock crash) allowed for public participation in the stock market and led to an increase in advertising of "riskless" investments.

The UK's industrial revolution led to innovations in steam-powered locomotives and iron tracks, but initially, trains were not seen as suitable for passenger transportation. The first modern railway built in 1830 from Manchester to Liverpool shifted perceptions due to the demand for passenger transport and increased interest in investing in railways. With a growing middle class and low-interest rates, there was an increasing number of investors looking for good investment opportunities (Vogel, 2018). Investing in railway companies became extremely popular due to high dividends, high expected returns, and the practice of buying on margin with partially paid shares that were traded on secondary markets. This made stocks accessible to a larger pool of investors, who were attracted by advertisements of railway stocks as wealth-generating machines. At its peak, railway investments accounted for 7% of GDP or half of all investments in the economy. (Odlyzko, 2011). Railway shares reached their peak in the summer of 1845. After that prices started falling due to multiple reasons. Firstly, many companies called capital around 1.5 years after they received approval for a route. As investors did not have available cash to pay the rest of the share's nominal value, they started selling positions in other railway companies. Some companies also faced an issue, that multiple investors were not able to pay in capital and therefore they were not able to finance projects. Secondly, the Bank of England increased interest rates (Odlyzko, 2010). Lastly, many railway companies turned out to be unprofitable or less profitable than

expected due to increased prices for materials, equipment and services and also due to higher operating costs than predicted. Thus many investors started selling railway stocks and once the price started declining, also other investors got anxious. By April 1850, when prices reached the bottom, they decreased by 66 % compared to their peak (Odlyzko, 2011).

In October 1847 the UK faced a financial crisis. Bank of England increased rates four times until then and limited lending capabilities. Therefore in mid-October, the UK had a "Week of Terror" as even prominent banks were seeking the help of BoE to help them facilitate liquidity needs. Although Railway Mania did not cause a financial crisis in the UK, it still contributed to the increased pressure on money markets, as investors had to withdraw money to meet capital calls (Quinn & Turner, 2020).

2.1.4 Roaring 20s and the Great Depression

In the 1920s, the US democratized financial markets, as they wanted to sell as many Liberty bonds as possible to finance their involvement in World War I. After the war, the US experienced a period of economic prosperity also due to higher productivity attributable to electrification. Furthermore, FED (Federal Reserve's Bank) decreased interest rates, incentivising lending activities. Aggregate demand increased resulting from increased consumer credits, overall market optimism, and increased productivity which resulted also in salary growth. As liquidity was abundant in markets, retail investors started to search for investment possibilities (Quinn & Turner, 2020).

Although Liberty bonds were extremely popular, in 1928, US investors moved their capital into domestic stocks. DIJA index increased from August 1921 to January 1928 by 218 %. The economy in general recorded stable growth, however, the main reason for the growth was the increased profitability of companies (mainly due to increased productivity), which enabled paying out higher dividends. Receiving high dividends, attracted other investors to enter the stock market with the belief that anyone can get rich on Wall Street. To "get rich on Wall Street" even faster, brokers offered investors margin trading. It is estimated that roughly 40 % of retail investors back then had a margin account (Rapp, 2014). Due to the high demand for stocks and their high prices, more companies decided to issue new stocks. The amount of newly issued stocks in USD, therefore, increased from 839 million USD in 1926 to 4.8 billion USD in 1929. Stock prices were increasing acceleratingly. DJIA almost quadrupled from 1920 (90.40 USD) to September 1929 (362.35 USD), which despite high GDP growth (on average 4.7 % per year), was not explainable by fundamentals.

In August 1929, the economy reached its peak and after that, consumer spending and investments slowly dropped, causing companies to lower production and increase unemployment. Despite this, stock prices continued to grow. Furthermore, FED also raised interest rates back to 6 % and in London, the stock market already started collapsing on the 20th of September (Vogel, 2018). On the 23rd of October 1929, panic took over also Wall

Street, leading to a sell-off spiral triggered by margin calls and pushing the economy to depression, which lasted around 10 years. Even if previous market bubbles only impacted individuals and overall did not have a major impact on the economy, this bubble burst resulted in the worst economic downturn in the history of the industrialized world with nationwide loss of confidence, reduced consumer spending, lower production, and high unemployment due to multiple credit defaults. In June 1932 DJIA's value dropped to 46.85 USD, while the economy reached a bottom year later, with 15 million unemployed and around 50% of banks being bankrupt. In 1933 when nominal GDP already fell by 45 %, the government decided, to get off the gold standard and intervene (Quinn & Turner, 2020).

2.1.5 Dot Com Bubble

The next major market bubble in the US began in the 1990s, when the US economy boomed, driven by advances in personal computing and communication technology, leading to increased productivity and expanded internet usage, growing from 14 million users in 1993 to 663 million users in 2002. In the 1990s, US companies focused on software business with barriers to entry due to intellectual property protection, therefore promising high future profits (Rapp, 2014). Soon there were multiple new companies offering e-commerce, online advertising, online social networks, infrastructure for online companies etc., most of them wishing to become the next Microsoft in terms of success. Start-ups were easily granted financing by VC (Venture Capital), but they started raising money also through IPOs (Initial Public Offerings). The number of IPOs increased from below 100 per year during the 1984-1991 period to 274 in 1996, with a value of $98 billion. The number rose to 371 IPOs worth $450 billion in 1999, reaching a record of over $500 billion in 2000 (Quinn & Turner, 2020).

The stock started increasing also for already established companies in the IT (Information Technology) industry. Although valuations were extremely high, analysts were justifying that “this time is different” and that old valuation techniques do not apply in this “new world”. In addition, multiple IT companies had unprofitable business models, however, economists argued, that earnings are no longer relevant for valuing stocks. Low saving rates and easy online trading drove more and more retail investors to the stock market, with technology stocks having a spillover effect on other sectors. The S&P 500 index rose 115% from 1990-1996, 30% in 1997, 26% in 1998, and 20% in 1999. From 1982-1999, US stock prices multiplied by 13, the largest increase in 200 years. The market capitalization of the USA went from 60% of the GDP in 1982 to 300% in 1999 (Aliber & Kindleberger, 2015). At its peak in March 2000, the CAPE ratio was 45, compared to its long-term average of 15 and 33 before the 1929 market crash (Quinn & Turner, 2020).

At the end of 1996, Fed chairman Alan Greenspan commented that the stock market was in "irrational exuberance" due to high prices. NASDAQ and DJIA reached record-high levels, but the main problem with new internet companies was that they were not profitable and short on cash (Aliber & Kindleberger, 2015). Already 1 month before NASDAQ’s peak in

March, insiders sold 23x more shares than they bought. In March 2000, FED increased interest rates, causing Wall Street analysts to change their outlook on tech stocks and causing prices to decrease further and investors to face margin calls (Quinn & Turner, 2020). By the end of the year, NASDAQ lost half its value from its peak. Both NASDAQ and S&P 500 continued to fall in 2001 and were impacted by the 9/11 attacks. NASDAQ reached a bottom point in October 2002 before recovering and reaching its peak again in March 2015. Despite a significant drop in the stock market, economic activity remained unchanged, with consumer spending not decreasing dramatically, and banks not being exposed to tech sectors avoiding severe losses and still being able to provide credit. The US entered a recession in 2001, but GDP growth eventually picked up (NBER, 2001).

2.1.6 United States Housing Bubble

The Dot com bubble led to an increase in real estate prices, as people's wealth increased from high stock valuations. During the years 1997 to 2001, prices increased by 47 %. After the Dot com bubble burst Fed lowered interest rates, from an initial 5% to 1%. This made refinancing mortgages easier for individuals, and new mortgages more affordable. After most eligible individuals already had a mortgage, new applications started slowing down. To increase the banks relaxed regulations, tapping into the low-income market segment (Rapp, 2014). Hereby banks started approving applications also to individuals with no appropriate stable income, no long-term employment and no assets, leading to the speculative buying of properties for quick profits. These buyers believed that they would be able to sell houses a couple of years after with high profits, remediating the fact that they were not able to service loan payments in the long term (Rapp, 2014). Banks de-risked their subprime mortgage portfolio by securitising (mostly subprime) mortgages into CDOs (Collateral Debt Obligation) and selling them to investors, removing the obligations from their balance sheets (Mansharamani, 2019). As they did not carry the risk anymore, the incentive to do a proper background check on mortgage applicants decreased, leading to improper documentation on lenders (Rapp 2014). Housing prices continue to rise. 90% of people surveyed in 2003 expected them to triple in the next decade (Quinn & Turner, 2020). Aggregated, between January 2000 and the summer of 2006, US real estate prices rose by more than 80%, although they rose by only 25% in the last 100 years. The fast growth was not in sync with 2 fundamental factors, which drive price growth of real estate, growth of population and growth of building costs. Although the population is constantly growing, the growth, was linear and not exponential as in the case of home prices.

FED started increasing interest rates from 1% in 2004 to 5% in 2006, causing higher mortgage payments for those with floating interest rates. Many mortgage owners were unable to make payments and defaulted, as their payments were already barely manageable when interest rates were lower. Real estate prices decreased drastically in popular cities, due to defaults and unattractive mortgage conditions. In June 2008, a record 1 million homes ended in foreclosure (Rapp, 2014). As defaults accumulated, also CDOs practically lost their

value, leading to capital losses for banks, who were the main buyers. Banks had to write off $1 trillion globally, with $600 billion in the USA, pushing some banks into distress (Rapp, 2014). As the leverage ratio of banks increased, they were not able to borrow more until they deleverage. Thus they started selling their assets, leading to a fire sale and even larger losses. Due to the interconnectedness of financial systems, one bank in distress does not endanger only itself, but also other banks. Banks also were not sure, which other banks held toxic ABSs (asset backed securities), thus they completely stopped interbank lending. As banks were not able to provide new loans at the same pace, investments decreased as did consumer spending. In addition, consumers in the past used profits from real estate sales, second mortgages etc. to spend more, which was not possible anymore. Therefore consumer spending decreased even further, leading to low corporate profits and higher unemployment (Mansharamani, 2019).

The US economy was already facing a downturn of economic activity in the first half of 2008, nevertheless, with ceased spending from households and companies, a mild downturn turned into a deep recession. US GDP fell deeply, leading to a 5.5 million job loss and a $650 billion loss of income (Swagel, 2009). The government passed several acts and decreased interest rates, but the economy recovered slowly, ending the recession in June 2009 and reaching pre-recession levels in Q3 2011. Household net worth recovered in Q3 2012 and unemployment fell below 5% in May 2016 (FRED Economic data, 2023c).

2.1.7 Drivers of Market Bubbles

Based on Kindleberger and Minsky's model, a typical bubble has 5 phases. A bubble starts with (1) displacement. Usually, there is a new technological breakthrough or some other major change in the economy, which causes excitement in the public and usually expectation for increased growth of the economy either through higher productivity or through something else. During the displacement phase, a rational investor notices that asset prices in certain markets/industries are expected to increase, thus they increase their investments there. In the second, (2) boom stage, the asset bubble becomes self-reinforcing. Due to past gains and convincible explanations (for example new technological paradigm) to extrapolate the current asset growth and also to the future, investors are drawn to participate in a bubble. Following the boom we have (3) euphoria, which as the name itself explains draws the attention of most individuals, also individuals who were not participating in asset markets before. There are a lot of stories going around about overnight success stories of people, who got rich participating in the asset market. Although these investors were early investors, to follow the success story, people start speculating and investing larger amounts of money, as they believe the price is going to increase further, securing them high gains. The price grows exponentially until speculators start cashing out their gains. Firstly it is usually insiders who start selling and then price fall triggers also other speculators to sell. The initial euphoria is then replaced by panic selling ((4) crisis) as investors would like to transfer their assets to cash as soon as possible to avoid even further price falls. As the bubble deflates and many

investors realised losses, public opinion turns into (5) revulsion, accusing other investors, who left the bubble in time, of fraud and immoral practices (Aliber & Kindleberger, 2015).

Similarly, Quinn and Turner (2020) describe pre-dispositions for a market bubble. They refer to the triangle overall as a fire, as it is tangible, destructive, self-perpetuating and hard to control after it starts. They continue with a metaphor, describing that for a fire we need oxygen, fuel and heat. Once the three components are present, a spark can start a fire, which can be put down if we for example remove one of the components. They compare oxygen in nature to marketability in asset markets. Assets are more attractive if firstly they are even allowed to be traded can be bought for a relatively small amount of cash, are easy to find seller and buyer and can be transported. For the second component, they compare fuel with money and credit, as a bubble can only start forming when there is enough capital to invest in it. When interest rates are low and lending policies lose, a lot of times borrowed money is invested into a bubble, driving prices higher. Secondly, also low-interest rate on their own promotes funds to flow into riskier assets, as traditional, safe assets such as government bonds and deposit offer very low returns. Finally, they compare heat with speculation, which in this case means buying assets solely to sell them for a higher price later in time. Quinn and Turner (2020) point out, that there are always speculators in markets, however during the time of bubble formation, the number of them increases. Early investors/speculators make gains, attracting other speculators to aim for profit. As new speculators enter markets, prices increase making early investors even more money. Thus the bubble becomes self-perpetuating, attracting more and more speculators, also ones who have no experience in trading/ investing. Finally, we have a spark which is used to light a fire or to start a market bubble. Similarly, as Kindleberger and Minsky, Quinn and Turner argue, the spark or in markets an exogenous element starting a bubble, comes either from technological advancement or breakthrough or due to a drastic change in government policy. On one hand, a technological breakthrough can improve productivity and thus the profitability of companies. Due to this expectation, market price rises, attracting speculators. Furthermore, as the technology itself is new, it is difficult to predict with certainty how much it will improve profitability, thus investors might agree to disagree on the asset's new fundamental value. In addition, due to this breakthrough, there is usually also a lot of media attention, increasing the attractiveness of stocks. Regarding government policy they argue, that sometimes governments intentionally change policies to increase asset prices, as they aim to consequently increase their popularity among voters.

As from the above summarised past market bubbles, we can see that market bubbles all went through similar phases, which are summarised in theories from Kindleberger and Minsky and are overlapping also with the theory presented by Quinn and Turner (2020). If we start with displacement or a “spark”, we can see that after the introduction of new technologies such as powered locomotives (railway mania), electricity (roaring 20s) and the internet (Dot com bubble), there was always a bubble forming afterwards. Similarly, before past bubbles, there were multiple significant changes in the economy or policies. For example, the war

ended before the start of tulipomania and the Roaring ’20s, causing the redirection of government funds from financing war to financing the development of the economy and better prosperity of people. There were also multiple changes in important policies before the start of bubbles such as a repeal of the Bubble Act before railway mania, the democratisation of financial markets before the Roaring 20s and the relaxation of policies regarding subprime mortgages before the US housing bubble. Quinn and Turner (2020) also mention liquidity or “fuel” being one of the main constituents of a bubble. We can detect increased liquidity before the start of mentioned bubbles. Wealth-increased interest rates were decreased before railway mania, the roaring 20s and the real estate market bubble. During the boom stage, we observed all assets where bubbles appeared to increase in values as mentioned in summaries, which led to euphoria or as Quinn and Turner (2020) would call it, “heat” or speculation. This was visible for example during tulipomania, as trading of tulips started going through futures, meaning that investors did not buy the actual flower to serve its purpose as a piece of ornament, but purely for speculative purposes. Furthermore, another piece of evidence of speculation is buying assets on margin, introduced during the tulipomania and then being used during every consecutive bubble. In addition, the euphoria was fostered by strong marketing campaigns before the Roaring 20s and later on during market bubbles at the beginning of the 21st century. During many bubbles, like the SSC bubble, and dot com bubble, we have seen, that insider investors or people with more knowledge on the matter, exited positions rather early. Along with this, there were moments, which moved investors' sentiment from overly optimistic to overly pessimistic. During tulipomania, it was the auction where no one wanted to purchase the tulip for a requested price, for railway mania it was the year when the capital was called in and for 21st-century bubbles, it was the increase of interest rates.

2.2 Indicators and Models for Timing Market Bubbles

Referring to definitions of market bubbles stated above, all are describing a bubble as accelerated growth in market prices. However, not every fast growth of market prices is a market bubble. Prices might rise due to a justified change in fundamentals or prices just might be more expensive for a short-term period of time, however, this does not mean that a price crash or market bubble deflation is following. When reading materials on market bubbles and how to detect them, one can see, that it is rather difficult to predict when we are in a bubble and even harder to predict at which stage of a bubble we are or when a bubble is going to deflate. Therefore below I am presenting a brief overview of models and rule-of-thumb indicators, which were previously used to detect (usually ex-post) the presence of market bubbles. I am putting more focus on the market cap to GDP ratio, PE ratio and model by Phillips, Shu and Yu (2015), as they are going to be used during my quantitative research. Other indicators and models, which are not the focus of this paper are going to be mentioned briefly.

2.2.1 Market Cap to GDP Ratio

In many articles, addressed to the general public we can find mentioned "Buffet indicator" or "Market capitalisation to GDP ratio". It was proposed in 2001 by Warren Buffet as "probably the best single measure of where valuations stand at any given moment". The indicator measures the price of the aggregate stock market at a certain time compared to underlying GDP, which (GDP) is supposed to represent the fundamental/true value of the economy. The formula for measuring the Buffet indicator for the US market can be seen as:

$$Indicator = ((Wilshire\ 5000\ market\ capitalisation)) \ / \ (US\ GDP)\ x\ 100. \qquad (10)$$

The model is based on supply-side models, which explain stock market returns based on the macroeconomic performance of the economy (GDP). The argument behind these models is, that positive stock market returns happen due to an increase in corporate profits (EPS) which happen due to increased productivity. Therefore long-term growth of the stock market should not be different to the long-term growth of the economy (GDP growth). Although the Buffet indicator is often mentioned in different articles, it was not that frequently used in scientific research. Chang and Pak (2017) use the indicator to analyse which country out of 34 is attractive for investments – has the highest expected equity return, Pysarenko, Alexeev & Taupin (2019) also employ this indicator to structure a portfolio based on Markowitz Mean-Variance Optimisation Model.

The model is most likely used less frequently, as it serves more as a rule of thumb and has multiple shortcomings. Bonaparte (2021) writes a paper arguing, that the Buffet Indicator is biased, therefore incorrect. Firstly, GDP is measuring the performance of the whole chosen economy, which means that both private as well as public companies are included as well as government spending. Nevertheless, major indices only measure the performance of public companies. Therefore we must assume that we can extrapolate the performance of public companies also to private ones. Nevertheless, the risk remains that in the case of one company with a high weight in the index going private, the ratio would drastically change, and the same could happen if a larger private company would go public. Although it might seem that there is a low risk of a larger company like Apple going private, as it would be a rather complex and costly transaction, this did for example happen when Twitter was taken private in 2022 and therefore was removed from S&P 500. Furthermore, it also might seem that there is a small risk of a larger company going public, as a majority of large companies seem to already be public. Nonetheless, for example, private company Cargill with more than USD 100 billion in revenues in 2022 might significantly impact the returns of S&P 500 due to the size it would be given a high weight. For comparison, Visa Inc. with a 1% weight in S&P 500 had approximately USD 30 billion in revenues in 2022. Secondly, multiple public companies, have subsidiaries abroad for tax optimisation, therefore their profit growth is fully captured in a stock price change, but not in GDP growth. This could be easily mitigated by replacing GDP growth with GNP (Gross National Product), as it measures all output by a country's companies regardless of where around the world they have

subsidiaries. Thirdly, an important constraint to the indicator is also interest rates, as they are not included. As interest rates are one of the components of the cost of equity, which means they are one of the determinants of market price movements, they should not be disregarded. Especially if we are extending the index to long time series we can see, that interest rates have been lowering from approximately 8% at the beginning of 1990 to 5% in 2006 and almost zero after the housing bubble up until 2015 with another almost zero interest rate period after COVID-19 and before March 2022. To sum up, interest rates have been slowly decreasing with longer periods of almost zero interest rates and with interest hikes, which resulted in much lower interest rates (for example approximately 2% in 2017) compared to the relatively high-interest rate in the past which during certain periods almost even reached 10%. Due to all constraints Tanner (2021) for example commented, that it should not serve as a single indicator of overvalued and market and perhaps market bubble, but it should be used also with other market bubble indicators. Last but not least, researches show, that there is a strong correlation between GDP growth and corporate profit growth. This makes sense, as corporate profits are indirectly included. However, the same study by MSCI Barra Research (2010) then shows that GDP growth has only a poor annual correlation with equity returns. The reason for the poor correlation is the following overlooked fact. GDP is a lagging indicator of economic performance, while stock markets are leading indicators. GDP is reflecting past performance, however, stock markets are always forward-looking. In case investors receive news at time X, that in time X+n certain company is most likely going to outperform, their price will not change only in time X+n, but in time X the expectations regarding company's performance at X+n are already reflected. Therefore comparing GDP and stock returns in the same period X would then mean that we are comparing the performance of the economy with one indicator (GDP) reflecting an actual performance from X and another indicator (stock market returns) reflecting an expected performance in X+n, which is incorrect. Stock and Watson (2003) found that stock markets are usually by 2-3 quarters ahead of the real economy, the same conclusions were made by Avouyi and Matheron (2005).

2.2.2 Schiller's PE Ratio or Cyclically Adjusted PE Ratio

One of the thumb rules when comparing the stock price of one company with a comparable company is the PE ratio, comparing the price of a selected stock with its EPS. In the previous indicator, the fundamental value of the whole economy was GDP. Going to one layer beneath, to stocks, the fundamental value being a true value of a stock, is strongly impacted by revenues which could also be therefore labelled as a fundamental indicator. For the identification of market bubbles where whole markets are observed based on their time trend, PE is cyclically adjusted to avoid false indications of market bubbles merely due to changes in a natural market cycle. The PE ratio instead of current earnings uses the moving average of earnings for the past 5 or 10 years, adjusted for inflation. Therefore any excessive short-term earnings are smoothened out using an average. The ratio was introduced by Robert Shiller, thus is it also known as "Schiller's PE Ratio". The ratio itself was not primarily

developed for the identification of market bubbles, but more to identify whether markets are over or under-valuated in a specific time period. The higher the index, the higher the probability that the market is overvalued. Schiller's PE ratio can be found in research papers more frequently than Buffet's indicator. Klement (2012) uses this indicator to predict the future performance of a selected stock market. As Buffet's indicator, also Schiller's PE ratio is criticised for not including the interest rate. Therefore there have been suggestions to further divide the ratio also with a yield of 10-year Treasury notes.

To this critique, I may add another thought. Although EPS is taken as an average of multiple years, it could be manipulated. For example, a company might be intentionally showing a lower profit or for example, doing share buybacks to synthetically increase EPS. Furthermore, the ratio also depends on the company's capital structure, resulting in a lower PE ratio for higher-leveraged companies. Although EPS shows earnings per share which is important information for investors, EBITDA (Earnings Before Interest, Tax, Depreciation and Amortisation) might be a better measure of profitability, especially for comparison of multiple companies or companies across different industries. EBITDA shows earnings before interests, tax, depreciation and amortisation, including only the company's revenue and less operating expenses. Therefore we can make a better comparison of companies, considering that we compare them purely on the profitability of their operations. Therefore we are excluding any income/expense from non-operating activities such as investing, we exclude variables of different capital structures, different accounting standards and different taxation policies. As a counterweight, one could say, that firstly if a company wants to manipulate ratios by adjusting non-operating expenses and outstanding shares, they can not continue doing it long term. Secondly, although net income includes non-operating expenses, therefore is not the best comparison of companies' profitability, as they may decide on different financing and other external factors, these factors indeed also impact at the end of the day how much money can be distributed to shareholders. One company might be less profitable from an operational perspective, however, if they manage long term to optimise taxes and receive income also from non-operating income, this is going to enable them to pay out a higher dividend to shareholders. Hereby, although I could suggest changing EPS with EBITDA, considering that perhaps EBITDA might be better to compare companies with each other, the PE ratio also suffices our need to compare a set of the same companies within a time frame.

2.2.3 Model by Phillips, Shi and Yu

As mentioned above, Blanchard and Watson (1982) defined stock market price as in formula (6). When B(t) is not equal to 0, then a bubble is present and we can observe explosive behaviour. Diba and Grossman already (1988) tested for explosive behaviour in ΔP with a Dickey-Fuller test on S&P 500 data, testing for nonstationary data. However, Evans (1991) then criticized, that their model cannot distinguish between stationary processes and periodically collapsing bubbles. Phillips, Wu ad Yu (2009) improved the model using the

ADF (Augmented Dickey-Fuller Test) test with structural breaks to distinguish between stationary data and periodically collapsing bubbles in 2011 successfully then indicated the beginning and end of the dot com bubble. Based on their model, the bubble started forming in 1995 and then started deflating in September 2000 – March 2001. Also, Homm and Breitung (2012) commented, that the model is extremely effective for real-time bubble detection. Nevertheless, one issue persisted. The model can predict and timestamp a market bubble, however when data series are longer and there are multiple bubbles present in time series, the model only timestamps the first bubble, but it is not successful in identifying and timestamping others. To remove this constraint, they proposed an improved model, Backward sup augmented Dickey-Fuller test or BSADF. The previous model proposed by Phillips, Wu and Yu recursively calculated right-side unit root test statistics based on expanding the window of observations up to the current data point, while the PSY model (Augmented Dickey-Fuller Model Proposed by Phillips, Shi and Yu) used moving window recursion of sup statistics based on a sequence of right-sided unit root test calculated over flex windows of varying length taken up to the current data point.

In general Dickey-Fuller test is used to test if time series is stationary or not and belongs to unit root tests. Time series can be defined as:

$$y(t) = D(t) + Z(t) + \varepsilon(t), \tag{11}$$

where ε (t) is considered an error (noise) with normal distribution, D (t) a deterministic component or a constant and Z (t) a stochastic component, which might consist of a unit root or not. To test for a unit root one might use multiple models such as Phillips Perron, KPSS, Durbin Watson, Dickey-Fuller test etc. If we then choose the Dickey-Fuller test and have an autoregressive model:

$$y(t) = \rho \; x \; y(t-1) + \varepsilon(t). \tag{12}$$

We then test the null hypothesis:

$$H(0): \rho = 1 \; (model \; is \; not \; stationary, we \; have \; a \; random \; walk) \tag{13}$$

$$H(1): \rho < 1 \; (model \; is \; stationary) \tag{14}$$

If we subtract then y $(t-1)$ on both sides, we get the following equation:

$$\Delta \, y \, (t) = (\rho - 1) \, y \, (t-1) + \varepsilon(t) \tag{15}$$

and we can then mark $(\rho - 1) = \delta$ and get:

$$\Delta \, y \, (t) = \delta \; x \; y \, (t-1) + \varepsilon(t). \tag{16}$$

Then we test for the null hypothesis:

$$H(0): \delta = 0 \ (model\ is\ stationary) \tag{17}$$

$$H(1): \delta < 0 \ (model\ is\ not\ stationary) \tag{18}$$

We then compute t statistics as in the usual regression model as:

$$t(\hat{\delta}) = \frac{\hat{\delta}}{SE(\hat{\delta})}. \tag{19}$$

However as y $(t-1)$ under the null hypothesis is not stationary, we can not compare $t(\hat{\delta})$ to normal t distribution, but we have to compare it to the Dickey-Fuller distribution. To further remove autocorrelation from the series, Phillips, Shi and Yu (2015) use ADF. The equation then changes to:

$$\Delta y\,(t) = \alpha + \beta(t) + \delta\ x\ y\,(t-1) + \omega\,(1)\,\Delta y\,(t-1) + \cdots + \omega\,(p-1)\,\Delta y\,(t-p+1) + \varepsilon(t). \tag{20}$$

We test a hypothesis similarly to before, however for the ω we can compare t statistics to t distribution, the null hypothesis is, that Δ y is stationary. When

$$t(\hat{\delta}) < DF\ (critical\ value), \tag{21}$$

then we reject the null hypothesis that the model is stationary. In the opposite case when

$$t(\hat{\delta}) < \mathrm{DF}\ (\text{critical value}), \tag{22}$$

we do not reject the null hypothesis and it means that we have a random walk model. In stationary models, any shocks eventually die out, while the non-stationary effect of a shock is supposed to be permanent. When using a left-tailed ADF we test if the model is efficient market hypothesis holds (random walk). However, to test for bubbles, we use right-tailed ADF as we test for explosiveness in time series:

$$\mathrm{H}(1): \delta > 0\ (\text{explosive behaviour}). \tag{23}$$

Furthermore, as mentioned before, ADF is sufficient when we have a shorter period of time series where only one bubble occurs. Therefore Phillips, Shi and Yu (2015) suggested Backwards sup ADF (BSADF). This means, that the PSY procedure calculates ADF statistics recursively from backwards expanding sample sequences. The endpoint of all samples is fixed on the point of observation interest and it allows the starting point to vary. Wherever the PSY statistics first exceed the critical value and subsequently fall, we can mark a bubble. An additional improvement which was added in 2015 was the introduction of a new bootstrap procedure, eliminating heteroskedasticity and multiplicity issues.

2.2.4 Other Indicators and Models

Schiller's and Buffet's indicators are widely popularly used for indication of market overheating, however as summarised above, one can observe other patterns, which are repeating during multiple bubbles and might serve as a bubble indicator. Firstly we observe exogen disruptive events in the economy and sometimes we also observe the democratisation of financial markets. The second factor, which was present during the majority of bubbles was increased money supply, usually as a consequence of low interest rates. Alessi and Detken (2009) list 89 different potential indicators, which are related to the real economy and also financial variables and then test which of these parameters would be the best for indication of market bubbles in 18 OECD (Organisation for Economic Co-operation and Development) countries (looking as an aggregate, not an individual country) between 1970 and 2008. Their results show, that the best indicator for the euro area is the global private credit gap and the global M1 (Money Supply that is Composed of Currency, Demand Deposits and other Liquid Deposits) gap. The credit gap is defined as the difference between the amount of credit that is needed to support sustainable economic growth and the amount of credit which is actually in the global financial system. The study found that by using the optimal 70% percentile across countries, a signal was able to predict 95% of high-cost booms, with a correct signal rate of 82% and a false alarm rate of 32%. The first warning signal typically occurred 5.5 quarters before a high-cost boom. The M1 gap is defined as the difference between the growth rate of money supply (including currency and overnight deposits) in the economy and the growth rate of nominal GDP and compared to the credit gap even at the 90% threshold, it did not provide signals between 2005 and 2008.

Besides quantitative indicators, many researchers tried to examine indicators, which would capture behavioural components. Liao, Peng and Zhu (2022) investigate the relationship between market bubbles and trading volume in financial markets and conclude that trading volume is positively correlated with the degree of extrapolative expectations – a belief that past trends will continue, which can lead to the formation of speculative bubbles. Considering, that during market bubbles, there is high trading volume, one could also assume, that the VIX (Volatility Index) index, measuring the volatility of markets, would be a good indicator. Research done by Sornette, Cauwels and Smlyanov (2018) shows, that VIX is not a reliable indicator. In addition to individual indicators, there are also statistical models, which can be used to indicate market bubbles such as LPPL (Log-periodic Power Law) Model. This model is based on the assumption that market bubbles are characterized by a rapid increase in asset prices, followed by a sudden collapse. The LPPL model uses mathematical equations to identify the presence of a bubble and predict the timing of its collapse. Most papers using this model focus rather on market crashes, such as the paper from Gonçalves, Borda, Vieiera, and Matos (2022) analysing the Portuguese market and a study by Koistinen (2020) analysing the Finnish market. Therefore in this paper, I will not further use this model.

2.3 Proposed Indicators

As mentioned, there is no perfect indicator, which could be used individually and would be fully reliable. Established indicators are more or less a rule of thumb indicators and should be analysed holistically with an overview of the situation of the economy and together with other indicators. Therefore in the thesis I am exploring new indicators, some are just a modification of already established ones and some indicators have not yet been addressed in research papers. Considering that during past market bubbles as well as during the pandemic it was noticeable, that financial markets are going in the opposite direction of the real economy, my main hypothesis is, that divergence between the real economy and financial markets is one of the indicators, which can signal that financial markets are in a bubble. As the per definition of market bubbles used for this thesis, fundamentals should be driving price of a stock. Whenever market price is severely different from fundamentals, something is happening that we cannot explain - B(t) in formula (6). If we apply this from one stock to a full economy, we could say that performance of financial market is driven by fundamental factors (one of them being GDP) and when they (adjusted for lag) start to diverge significantly, there is a B(t) component present, which I would interpret as component based on irrational behaviours of investors. Therefore, I first try to find a way how to quantify this divergence between the real economy and financial markets and then test if their divergence correlates with past market bubbles. Furthermore, there is already one indicator measuring divergence between GDP and financial markets, however, it is criticised due to certain constraints. Therefore in the second step, I tried to take the existing rule of thumb indicator (Buffets indicator) and adjust it and partially try to remove its constraints. Lastly, I wanted to find a new, not yet tested indicator, which would be able to measure B(t) and detect when B(t) is large enough to mark developments in financial markets as a market bubble. Thus, I have chosen two indicators, which are measuring developments in financial markets from a behavioural point of view and would be able to capture when behaviour irrationality of investors is large enough. I saw both indicators already mentioned in new outlets for retail investors, however, I have not come across a paper by a researcher or any other paper where the reliability of the indicator would be used.

2.3.1 Correlation between Financial Markets and Real Economy (RH1)

My first research question and the main topic of this thesis is, that the Divergence of real markets from financial markets is somehow connected with market bubble formation. My perception from reading materials on past market bubbles is, that whenever we can observe extreme optimism in stock markets (or any other markets), which are not aligned with the real economy and expectations about the future performance of the real economy, we might observe market bubbles. Therefore my RH1 states that “Divergence between real and financial markets is correlated with bubble formation”. To check this, I did the following. From the database from the Federal Reserve Bank of St. Louis, I have taken data for Willshire 5000 Price Index (FRED Economic data, 2023b) as well as for gross GDP for the

USA quarterly (FRED Economic data, 2023a). As mentioned before, financial markets reflect the expected performance of the real economy. This means, that the index for Q1 2022 and GDP for Q1 2022 cannot be comparable, as they both reflect different states. An index reflects expectations for the future, based on information we have in Q1 2022 and GDP reflects the actual performance of the economy in Q1. Therefore to make them more comparable, I could use lags for Willshire 5000 to compare the expectations it had for time X in time X-1 with economic performance in X. As mentioned before, GDP is lagging approximately 2-3 quarters. Therefore I am going to use a lag of 2 time periods in my quantitative research. This means, that I am going to compare GDP in time X with Willshire 5000 Index in time X-2 quarters. An observed period is from Q1 1971 to Q2 2022. I split the observed period into 4 parts: the time period between Q1 1971 to Q4 2017 and the time period between Q4 2017 and Q2 2022. Until the year 2018, there were a couple of market bubbles, which PSY detected. However, as mentioned in the text, this is not a 100% reliable model, therefore it is important that I can confirm these detected periods also with other articles and research on the specific market bubbles. Therefore, when I address a certain time period as a market bubble, I can be more certain that indeed it was a market bubble. Nevertheless, after 2018 I cannot maintain the same certainty, considering that there are not yet many articles and research on any further market bubble (I expect that there will be more papers on this topic in the following years). Therefore, in the time period 1971-2018, I am testing RH1 to confirm if this is indeed a good indicator and then on the later data I am testing RH5, based on which I am trying to determine whether there was a market bubble present during 2018 and 2022. Both periods I then split into time periods when the market was experiencing market bubbles – "bubble" and when there were no bubbles – "no bubble". Then I took QoQ (Quarter on Quarter) growth rates for GDP and lagged Willshire 5000 and calculated the Pearson correlation coefficient between growth rates for the "non-bubble" time period and "bubble" time period. Afterwards, I am testing for the significance of the Pearson correlation coefficient using a two-tailed t-test. Based on my RH1, the Pearson correlation coefficient for the "bubble" sample should not be significantly different than 0 (real market and financial market returns are not correlated) and for the "no bubble" sample I should be able to reject the null hypothesis stating that the Pearson correlation coefficient is different than zero (real market and financial market returns should be correlated).

2.3.2 Adjusted Buffet's Indicator (RH1 & RH2)

Another indicator uses both real economy indicator (GDP) and financial market indicator (index) to detect market bubbles in Buffet's indicator or Market cap to GDP ratio. Although Warren Buffet called this indicator the single best indicator for market bubbles, multiple researchers criticise this indicator due to multiple shortcomings. Therefore I will try to address at least some of those shortcomings and test RH2: "Adjusted Buffet indicator is a significantly better indicator than non-adjusted indicator". In addition, the test if Buffets indicator is different in times of bubble and in times of not indicated bubble, will serve as an additional test for RH1. Firstly, as discussed under the previous indicator, to make the real

economy and financial markets comparable, I am going to use 2Q lag for Willshire 5000 index. The time frame as well as the source of data is the same as for the previous indicator. Another shortcoming of using GDP in the formula is, that many of Willshire 5000 companies use offshore subsidiaries for tax optimisation. Therefore their revenues are not captured by GDP. Shaxon (2019) estimates that Fortune 500 companies in 2017 held approximately USD 2.6 trillion offshore in a so-called "tax haven". Thus instead of GDP, I will use for the analysis GNP (FRED Economic data, 2023d), for the same time period as GDP for the previous indicator. In addition, a shortcoming of the index is that it does not incorporate interest rates. Recently solely based on the index, due to record high values, one could say that it is a clear signal, that the US capital market is in a bubble, nevertheless one can find explanations, that due to record low interest rates, prices are not that inflated. Consequently, I would like to adjust the index for interest rates. I have taken the Federal funds effective rate (FRED Economic data, 2023e). Then I set starting point as 2% and created an adjustment factor for all periods to remove the impact of different interest rates and have Willshire 5000 values for all periods with an interest rate of 2%. I am then going to split the indicator as before into 4 time periods, before Q4 2017 and after Q4 2017, to the "bubble" time period and "no bubble" period. I am going to take the mean of the "bubble" period and "non-bubble" period and use a two-tailed t-test to check if the adjusted Buffet's indicator is statistically different during the "bubble" vs the "non-bubble" period indicated by the PSY model. I am going to repeat the same process for non-adjusted Buffet's indicator and then use a two-tailed t-test, this time to check if the results I got with adjusted indicators are indeed statistically different than the initial indicator.

2.3.3 Insider Trading Activity (RH3)

As mentioned in the "Market Sentiment" chapter, whenever financial markets are not in line with real markets, the difference many time is due to human sentiment or irrationality of investors, which is hard to measure/indicate. When there is a market bubble, we observe many trends such as high media involvement, an increase in retail investors, greater fool theory etc.
Therefore, my next proposed indicators are not going to be related to real markets, but they are intended to capture "qualitative trends", measuring market sentiment. Between newly proposed indicators, which are supposed to track market sentiment are insider trading (legal) activity and the ratio of long and put option positions, which both have been associated with market bubbles by Morch, Vishny and Shleifer (1990) and Battalio and Schultz (2006).

Insider trading can be either legal or illegal depending on when a person, who has access to non-public information of public company purchases or sells shares of this company. Usually, this includes top officers, executives and larger shareholders (>10% shareholders). SEC (2021) defined illegal insider trading as: "The buying or selling of a security, in breach of a fiduciary duty or other relationship of trust and confidence, based on material, non-public information about the security". Putting it differently, whenever a person has access

to material information, which was not yet made public and based on this information performs a trade, it puts other investors in an unfair position therefore can make unfair profits. For illegal purchases, SEC (U.S. Securities and Exchange Commission) usually fines the offender, however, also jail time is possible. On the other hand, there is also legal insider trading activity, when people close to the company and its information trade its shares. These trades have to all be submitted to SEC and be disclosed on the company's website.

Insider activity (legal) is not observed only by SEC, but also by investors. Overall around 50% of public companies have at least one transaction made by an insider trader per year and on average their trading volume represents approximately 0.6% of the company's market capitalisation. Already in 2001, Lakonishok and Lee summarised why is it important to track insider trades "Company executives and directors know their business more intimately than any Wall Street analyst would. They know when a new product is flying out the door when inventories are piling up, whether profit margins are expanding or whether production costs are rising… You always hear about smart money. Generally, that is the smart money". To add to this sentence, also company's executives buy or receive the company's stocks as part of their compensation, meaning that the goal is to sell them when profit is the highest for them. Although they are prohibited to trade based on information, which is not yet made public, there is also another type of information, which is more intangible and will never really be public, like how workforce spirit looks like (it can predict further staffing issues or lower productivity), relationships with clients and suppliers and also other intangible information, but also tangible information, as not all numbers are shared with investors. Lahkonishok and Lee (2001) observed that insider trades are informative, so being able to predict how this company's stock might perform in the future. They found 6 studies performed before 2000, which show that insiders do earn abnormal returns. They also found one study, observing insider trades in the Oslo Stock Exchange, where a researcher was not able to confirm this. They also found different studies (also completed before 2000), which observe that other market participants react relatively slowly to managerial signals. In this specific study, there was no focus on insider trading per se, but on stock repurchases, which also signals that the management board is confident that the current price is undervalued. They also observe a couple of studies studying if imitation of insider investors could yield an individual investor abnormal returns, however, there was no conclusion, as some studies found abnormal returns, other studies poorer results and third studies conclude, that abnormal results are offset by additional monitoring costs. In another study, Lahkonishok and Lee (2001) would like to find out if insiders (what we can see from their transactions) can time the market. They confirm, that insiders do have the ability to time the market. On average when they are purchasing new stocks, markets continue to grow and vice versa with an annual spread in returns of more than 10%. Also Seyhun (1998, p. 137-151) observes that before the market crash in 1987, there was an increased amount of insider activity, namely a higher volume of sale orders. Already during the South Sea bubble insider investors sold shares in August for around 1000, while other investors started massively selling shares a month later for only 175. Similarly during the Dot com bubble 1

month before the NASDAQ peak insiders sold 23 times more shares than they have bought during the same time frame. In 2008, right after the real estate crisis, Marin and Oliver (2008) also observed, that volume of insider stock sales increased multiple months before the crash of stock markets.

As researchers have been finding for multiple years, insiders indeed can time the market and they usually leave the market months before the stock market bubble pops, I want to test if a change in share of ownership by insider traders (legal trades observed) is somehow correlated with market bubbles. The aim of RH3: "Share of stock ownership by insiders is significantly different during market bubble than during other time periods", is to confirm that based on this insider trading indicator, one would be able to see when there is a market bubble. The assumption is, that with market bubble reaching a peak, insiders would slowly start to exit positions and prepare for a market downturn. The idea on how to test this index is the following. I am going to choose an index covering the USA market. Then for each constituent, I am going to obtain years' share of stocks held by insiders. Then I am going to multiply the weight of the specific stock within the index with their share of stocks held by insider investors. Summing up all stocks would then give me a share of stocks held by insider traders at a specific time for the whole index. Based on this, I am going to be able to check if the trend in the share of stocks held by insiders is correlated with market bubbles detected with the PSY model. For this purpose, I have extracted data from Bloomberg Terminal (2022a). Considering I would need data for multiple periods times the number of index constituents, I would require an immense data set to be extracted from Bloomberg. Therefore, due to data download restrictions, instead of choosing Willshire 5000 or S&P 500, I have chosen an index with a lower number of constituents, the DJIA index. As Bloomberg did not have data on insider trading activity for DJIA Index on a monthly basis before 2010, I was only able to analyse for a time period between March 2010 and September 2022. Again due to data restrictions, I have fixated the index with weights for constituents as of September 2022.

2.3.4 Put Call Volume Ratio (RH4)

The second proposed indicator is the Put Call Ratio, which is comparing the volume of sold put vs call options in a chosen time period. Although options are usually used either for hedging or for speculating, many use them also as a short-term predictability indicator, as it sorts of measure investors' sentiment. Oyster (1997) even calls it "one of the most effective ways we can gauge investor sentiment". Put options enable a buyer to sell the underlying asset for a predetermined price. This means that when there is an increase in sold put options (the ratio is high), investors might expect the price to drop, thus they want to secure themselves a right to sell an asset at prices which are still relatively high. On the other hand, call options enable an investor to buy an underlying asset for a predetermined price in future. When the ratio drops, usually the mean volume of sold call options increases, investors expect that the market will grow in the future, thus they want to enable themselves a

possibility to buy this asset in future at relatively low prices. When investing, momentum traders may use this to go with the market, while contrarian investors might use this to go against the market. This means that whenever the indicator is extremely high and would mean that current market sentiment would be bearish, contrarian investors would employ strategy to buy assets and vice versa. One downside of this ratio is mentioned in CFI (2022a), as overall there is an increased number of sold put options, as asset managers used them to hedge. Nevertheless, as this factor increased the amount of sold put options throughout the whole year (is constant), it should not significantly impact results. The only aspect is, that the thresholds for "bearish"/ "neutral" and "bullish" markets are a bit different than one would imagine. The threshold for neutral markets is therefore around 0.7, increasing to 1 would already mean that market sentiment might be bearish and when decreasing to 0.5 the markets might be weighted more towards a bullish market. Already in 1988 Billingsley and Chance (1988) researched the effectiveness of market timing based on put-call ratios. Although they were using only data for less than 3 years, they found that using the PCR (Put-to-Call Ratio) as a short-term market sentiment indicator, if you use it as a momentum trader. Whenever the PCR was signalling a bullish market they bought an asset and whenever it turned bearish they liquidated it. The strategy in the end provided them with excessive returns, which were then neutralised by high transaction costs. Bandyopadhyay and Jones (2008) also summarise that based on past research, rising PCR should signal a drop in markets. Also in their research, they were using a dataset for approximately 2 years. They compared the PCR indicator with VIX Indicator and concluded, that PCR is indeed a better indicator that measures investor sentiment than VIX. Although these researchers were using the VIX indicator only on short data series and were using a momentum strategy, Forbes (2021) provides a different view. They say that option buyers are in most cases wrong and losing money, thus whenever we have a certain trend it means that the reversed trend is coming. In this article, they point out the current extremely low ratio of around 0.4, which is similar to the ratio (0.39) before the dot com bubble burst. As the indicator is frequently used in many articles from news outlets, yet I haven't found any formal research linking indicators to market bubbles, I will do a test to check if there is a correlation between market bubbles and put / call ratio. If my null hypothesis: "RH(0)4: Put/Call Ratio remains the same during the bubble and non-bubble times" can be dismissed, this indicator will also be used in the third chapter as one indicator helping to indicate if there was a market bubble between 2018 and 2022. For the analysis, I am using all exchanges Put/Call data (OPCVTPCR Index) exported from Bloomberg Terminal (2022b) from the years 1990 to 2018. Similarly, as for other indicators, I split them into two categories: Put/Call ratio during the times when the PSY model detected market bubbles and Put/Call ratio when no bubbles were detected. Doing the two sample t-test assuming unequal variances, I have tested a hypothesis RH(0): μ (no bubble time period) = μ (bubble times).

2.4 Indicators and Historical Market Bubbles Between 1970 and 2018

In this chapter, I will take indicators proposed in the previous chapter and analyse their validity on data between 1970 to 2018. I am going to use PSY model results as a benchmark based on which I am going to test other indicators if they indicate market bubbles approximately at the same time as the benchmark and could be therefore used also on their own, more like a rule of thumb before employing more complex PSY model. Indicators, which will yield positive results, are then also going to be used also in the second part, when I am going to test for market bubbles in the recent time frame, 2018 to 2022. Due to data being available for insider trading only after 2010, I will only analyse the proposed indicator in the second part, based on conclusions made by other indicators regarding the presence of a market bubble.

2.4.1 Time Stamping past Market Bubbles with PSY

Although timing market bubbles is still extremely difficult and yields inaccurate results, the PSY model is currently the best possible model for timing bubbles. Therefore my assumption for this thesis is, that bubbles indicated with the PSY model, are the correctly timed beginnings and ends of market bubbles from history. For the dataset, I took S&P 500 Index dividend yields extracted from Nasdaq Data Link (2023a) and processed data in R Studio. Having entered inversed monthly dividend yield for S&P 500 for a time period between January 1970 and December 2017, the PSY model detected 6 explosive time periods. Firstly the model records inverted an explosive time period in December 1974, when the market crash happened after the collapse of the Bretton Woods system and led to the 1973-1975 recession. Although this thesis is not analysing recessions and market crashes, these time periods are going to be used in further analysis. As I am going to use "bubble periods" and "non-bubble" periods from this model for further analysis of indices, I am also going to take into account the market crashes the model indicated. Namely, I am going to exclude them from my sample, as they could distort the final results. When a market crash was not indicated by the model, I make an assumption that the price decline was not explosive enough to be captured by the model, therefore also is not going to distort the sample significantly. The second detected bubble was between February 1987 and October 1987. During this time period, there was no particular market bubble on stock exchanges in the USA, which would be mentioned in the papers. After the 1980s recession, the US economy firstly recovered rather fast and then later, end of 1985 entered into more stable growth with lower inflation levels. DJIA Index for example raised from August 1982 to August 1987 from 776 to 2.722. However, as indicated by the model, the bubble ended beginning of October 1987 (due to monthly dataset dates can not be more accurate). This coincides with a market crash which happened on the USA stock exchanges on the 17th of October when "Black Monday" occurred.

Figure 2: S&P 500 Price to Dividend Ratio & Indicated Bubbles

Source: Nasdaq Data Link (2023a)

The third explosive period indicated by the model was one of the most famous bubbles in US history: the Dot Com bubble, which started roughly around 1995 and started deflating in 2000, with a faster tempo after September 2001 due to the 9/11 attack. The model detects a bubble between December 1995 and the beginning of July 1996, as in July 1996 S&P 500 value slightly dropped. Then it detects the bubble again from November 1996 to the beginning of March 2001, when the index drops. As S&P 500 temporarily again regain value, there was another bubble detected between April 2001 and the beginning of August 2001, when the stock market decreases significantly. Lastly, the model detected another stock crash between October 2008 and the beginning of April 2009, when the financial crisis of 2008 started after the collapse of Lehman Brothers in September 2008. Detected periods can be seen in the output by RStudio presented in Figure 2.

2.4.2 Correlation between Financial Markets and Real Economy between 1970 and 2018 (RH1)

Multiple times there was a statement, that we are in a market bubble, as financial markets are decoupling from real markets. Therefore within RH 1, I am trying to confirm that "Divergence between real and financial markets is correlated with bubble formation". As described in detail in Chapter 2.3.1, a plan was to calculate the Pearson correlation coefficient for 2 separate samples. One where PSY detected bubbles and one where PSY did not detect bubbles (market crashes detected by PSY were excluded). The hypothesis, therefore, is the following:

$$H(0\ I\ no\ bubble)\rho = 0 \tag{24}$$

$$H(1\ I\ no\ bubble)\rho \neq 0 \tag{25}$$

$$H(0\ I\ bubble)\rho = 0 \tag{26}$$

$$H(1\ I\ bubble)\rho \neq 0 \quad (27)$$

Firstly I have analysed all 4 samples: GDP growth and Willshire 5000 growth (FRED Economic data, 2023a&b) bubble periods and non-bubble periods, for linearity, normality, homoskedasticity and outliers. After removing outliers, one sample was smaller than 30. Thus, I have used Spearman Rank Correlation (and two-tailed t-test), which is a non-parametric test, therefore often considered more appropriate than the Pearson correlation coefficient for small sample sizes or when the data is not normally distributed.

Spearman Rank Correlation Coefficient for data for the time period without identification of bubble is positive, 0.16 with a t=2.00 and p=0.05. Therefore, I can reject RH(0), that Pearson coefficient equals zero, which would mean, that there is no correlation between financial markets growth and growth of the real economy when there is no market bubble at α=5%. On the other hand, Spearman Rank Correlation Coefficient for data during the identified market bubbles is positive, 0.31 with t=1.61 and p=0.12 (Appendix Table 1). Therefore, I cannot reject the hypothesis that the correlation between the growth of financial markets and the real economy is different from zero. As I was able to reject the null hypothesis for time series during no-bubble times and not for time series during bubble times, I can conclude, that we observe a disconnect between financial markets and real markets when bubbles are forming in financial markets.

This analysis, as well as other consecutive analyses in this paper, have multiple limitations. Firstly they are all based on the PSY model. The output from the model is the main factor, based on which I split one sample into two samples: bubble and non-bubble time period. Therefore if there is an anomaly in the model, also further analyses are not accurate. Secondly, due to data constraints, the PSY model is using S&P 500 data, while all other analysis is done on Willshire 5000 data. Although Willshire 5000 includes constituents of the S&P 500, the comparison could be more accurate using Willshire 5000 data also in the PSY model. In addition, as GDP is reported quarterly, wherever analysis is based on GDP data, data are reported quarterly, while when PSY model gives output on a monthly basis. Ideally, all data would be reported in the same format, preferably on a daily or weekly frequency, however, due to data constraints this was not possible. Analysis based on GDP has another constraint. To make GDP growth compared with stock market growth, I have used lags for stock market returns. I have used 2Q lags, however, there is no exact guidance on how many quarters or months the real economy is lagging behind stock markets. Lastly, all samples are split into “non-bubble” and “bubble” time period samples. Considering, that there is more frequently a “non-bubble” time period than a “bubble” time period, sample sizes are rather different, with the “bubble” time period sample being smaller than 30 and the “no bubble” time period being higher than 140. I was also able to get data only from 1970 on, thus capturing only 2 larger market bubbles. Again ideally, both samples would have a comparable number of observations.

2.4.3 PE Ratio

The PE ratio is one of the commonly used rule-of-thumb ratios to evaluate whether there might be a market bubble. Although as well as other indicators PE also has its disadvantages, adjusting the PE ratio any further is not the topic of this thesis. Therefore I am going to use the widely used PE ratio, having in mind its constraints. One of the disadvantages is, that we can not compare the PE ratios of companies that are start-ups or in distress, as in this case, the PE ratio is negative. Furthermore also when comparing the PE ratios of individual companies, we have to be mindful of differences in ratios across industries. Nevertheless, as we are not comparing company-specific PE ratios, these disadvantages are not that important. A relevant disadvantage of the ratio is its sensitivity to non-operational factors such as a change in interest rates, economic conditions, political events etc., which might change the company's stock price, even when performance remains unchanged. In addition, the indicator also fails to include additional financial metrics of companies such as indebtedness, cash flow and also prediction of future performance.

To test whether could be used as an indicator, I have tried taking the Shiller PE Ratio based on S&P 500 index, directly from Nasdaq Data Link (2023b) for a time period between 1970 and 2018. Considering that both samples of "bubble" as well as "non-bubble" periods were not normally distributed, but had a sample higher than 60, I have used Welch's t-test to test if mean PE during the "bubble" time period is statistically different than during "non-bubble" period. Using a t-test with a P value below 0.01 (Appendix Table 2), I can reject the null hypothesis, that the PE means of "non-bubble" periods are equal to the PE mean of "bubble" periods. The Mean of the "non-bubble" period equals 18.06, while when meaning in the bubble period equals 33.27. Further, I have used mean PE=33.27 as a cut of value, marking periods above this critical value as "bubble". Then I compared it to the PSY model output. If I take PSY model output as a benchmark, with the cut of value we were able to indicate 52% of periods during the market bubble. 32% of periods market as a bubble by the PE ratio were falsely indicated. I am going to use this cut of value in the second part when analysing recent market data. Nevertheless, as this indicator is not the focus of the thesis, further research should be conducted to make any remarks regarding its effectiveness.

2.4.4 Adjusted Buffet's Indicator

One of the rather famous "rule of thumb" indicators for market bubbles is Buffets Indicator or Market Cap to GDP Ratio. As per Warren Buffet, whenever the indicator increases to a range of 90% to 115%, the market is vastly overpriced. However, I have used a bit different approach than the scale proposed by Buffet. Firstly I adjusted it to improve certain constraints. As outlined above, I used 2Q lag for Willshire 5000 index (FRED Economic data, 2023b), replaced GDP with GNP (FRED Economic data, 2023d) and adjusted the indicator for interest rates (FRED Economic data, 2023e). Firstly I tested if the adjusted indicator is indeed statistically different from the no adjusted indicator. Using Welche's t-

test for indicators during "bubble" and "no bubble" time, I received the same results for both periods. As the p-value is larger than 0.15, I cannot reject the null hypothesis, that the adjusted Buffets indicator is statistically different from the non-adjusted indicator (Appendix Table 3). Having used a cut of the value of the mean during bubble times for both the adjusted and non-adjusted index, I receive better results with the adjusted index. With the adjusted index I was able to indicate almost 60% of bubbles indicated by PSY (52% with non-adjusted) and the error (% of wrongly indicated bubbles) was 54% (66% non-adjusted). Therefore, I am still going to use in the future the adjusted, however, more research would be needed to further pinpoint how the indicator would react if only one constraint would be changed and not three at the time. Secondly, I have tested if the mean of Buffet's indicator is statistically different during the "bubble" time period versus the "non-bubble" time period. With alpha lower than 5%, I can reject the null hypothesis, that means are the same (Appendix Table 4). The mean for the "bubble" time period was 97% (107% non-adjusted), which is in line with Buffet's guidance. During the "non-bubble" time period, the mean is 71% (74% non-adjusted). The buffet indicator is therefore going to be one of the indicators used in the second part of an analysis of data between 2018-2022.

Despite making numerous adjustments to the index, constraints persist. Firstly, although I am going to be using the Willshire 5000 index, this is not eliminating all shortcomings. Willshire 5000 as well as S&P 500 both have a high weight of Information Technology at around 27-28%, which means that whenever the Information Technology sector over/underperforms, this has a relatively higher impact on the index compared to over/underperformance of other sectors. The top 10 companies (top 2% companies for S&P 500 and top 0.3% for Willshire 5000) represent around 25% of the index. Therefore in the case of one top 10 companies going private, the index would have falsely distorted numbers. Furthermore, adjustments such as lag in Willshire 5000 and interest rates are both made with numbers set as an assumption, therefore results might differ when one takes a different lag or different target interest rate. Lastly, the whole analysis is based on the assumption, that the PSY model correctly indicated market bubbles. Therefore, there is a risk that if there are anomalies in the PSY model, the whole analysis is incorrect.

2.4.5 Put / Call Ratio

For the Put/Call ratio, I have exported Put/Call data from the years 1990 to 2018 (Bloomberg Terminal, 2022b) and split them into two categories: Put/Call ratio during the times when the PSY model detected market bubbles and Put/Call ratio when no bubbles were detected. After excluding outliers, and testing for normal distribution and equal variances I decided to use Welch's test or t-test as samples are normally distributed, but have different variances. Doing Welch's, I have tested hypothesis

$$H(0): mean\ (no\ bubble\ time\ period)\ =\ mean\ (bubble\ times). \qquad (28)$$

The mean for Put/Cal Ratio during bubble times is 0.56 meaning that there are approximately 1.77 call options bought per 1 put option. On the other hand, during the non-bumble times, the mean was 0.80 (per the theory above it should be 0.7) which means that there were approximately 1.25 call options bought per one-put call. This shows a relative balance between call and put options during non-bubble times and extreme optimism on markets during bubble times. To sum up, as this newly proposed indicator applied to past data was statistically different between a bubble and no bubble time (Appendix Table 5), therefore I will use it as an indicator during the second part. To do this, I am going to apply a 0.564 put/call ratio as a threshold for the market bubble.

As well with other indicators, also this indicator has the main constraint, that it relies on the PSY model. Meaning, that in case of anomalies in the PSY model, the indicator test is not reliable. Furthermore, also the put-call ratio is taken for all exchange put / call ratios, which might deviate from the S&P 500 Put/Call Ratio. Therefore in further research, it might be better to take the Willshire 5000 data as a base in the PSY model.

2.5 Discussion on Results

In the first part of the analysis, I used data from 1970 to 2018. Firstly I created a benchmark with the PSY model, to get information on which periods we had market bubbles. Based on the PSY model we had 2 main periods where market bubbles were detected between 1972 and 2018. One bubble was detected end of 1985 until 1987, when the US economy was recovering at high speed after the 80's recession, with (over) positivity being reflected also on financial markets. The bubble ended with a market crash, known as "Black Monday" on the 17th of October in 1987. The second indicated bubble was the well-known dot com bubble, which PSY detected already in 1995.

After setting the benchmark, I started testing indicators against a benchmark, trying to pick favourable indicators, which I could also use in the second part of the analysis, trying to answer if there was a market bubble from 2 years 018 until 2022. I started with the RH1, asking how is a divergence between real markets and financial markets connected with the formation of market bubbles. For this purpose, I have checked firstly the correlation between GDP and Willshire 5000 (with 2Q lag). Doing the analysis, I received almost favourable results. During the market bubble correlation coefficient was positive, however with a p-value above 0.05, I was not able to reject a hypothesis, that it is different than 0. When testing the same hypothesis for a non-market time period, the correlation was positive and I was able to reject the null hypothesis, that correlation is different than zero. Therefore based on this analysis I can reject main RH01, which says that Divergence between real and financial markets is not correlated with bubble formation. As per the analysis we see, that during a market bubble, real and financial markets are not correlated anymore, therefore in divergence, while during a non-bubble time, the correlation returns.

Secondly, I focused on finding which set of established indicators is suitable for bubble formation. Firstly I tested the PE ratio. With Welche's t-test, I have come to the conclusion, that the PE ratio during a market bubble is significantly different than during non-market bubble times. I will therefore use the mean which I got for a bubble time period as a cut of value for the second part.

The main hypothesis of the thesis was, that market bubbles happen when stock market performance start diverging from fundamentals. On a single stock level this means, that stock price starts increasing, although its fundamentals, core financials from an income statement, cash flow statement and balance sheet, based on which we can get stuck "true value", remain the same. Aggregating this on a whole stock market, we are looking then if the whole stock market is moving disproportionally to moves in the real economy. The performance of the real economy is mainly measured by GDP, which is linked back to the company's performance (and other factors, which impact the company's performance). The second established indicator is the Buffets indicator. As it has multiple constraints, I tried adjusting it for inflation, changing GDP with GNP and S&P500 with Willshire 5000 and further also using 2Q lag as GDP/GNP are lagging behind stock exchange values. Having tested for mean differences, I can not reject a RH2 null hypothesis, that the adjusted Buffet's indicator has a statistically different mean than a non-adjusted indicator. Nevertheless, as an adjusted indicator has a lower error rate and indicates a higher percentage of bubbles indicated by PSY, I am using this indicator also in the second part.

Lastly, I wanted to test a new indicator, Put/Call volume ratio. Using a similar method as before, I was able to reject RH 3 stating, that Put/Call Ratio is significantly different during a market bubble than during other periods. Therefore, I am also going to use Put/Call ratio means during bubble time as a cut of value to detect potential market bubbles on data after the year 2018.

As discussed more in detail under every part of the analysis, there are multiple constraints one needs to have in mind when interpreting results. Firstly the whole analysis depends on the reliability of the PSY test. In case the PSY test is not reliable or there are some anomalies, the whole analysis based on this would be questionable. Furthermore, data used for the PSY test is based on a different index than the following analysis and in addition the frequencies of index data reporting are different (monthly vs quarterly), therefore there is a possibility for slight deviations due to this constraint. Not to mention, that even Willshire 5000 does not capture the whole market, therefore I need to make assumptions for the whole US stock market based on a sample of companies included in the index. Furthermore, PSY only captured 2 market bubbles, leaving me with a rather small sample of bubble data, exposing me to an increased risk of Type I error. Lastly, considering that GDP and GNP are only measured quarterly and all other data is on a monthly basis, it might be possible, that data does not fully overlap. Therefore, there is an opportunity for further research with a focus on the singular indicator and their constraints mentioned in the first part.

One indicator which would be interesting to observe is the number of investors as during past bubble periods trading was firstly an activity only for professionals, but it then got more and more popular also among non-professionals during market bubbles. On one hand, it could be consistent with the finding from Liao, Peng and Zhu, as more market participants also cause higher trading volume. On the contrary, one could also argue, that an increased number of participants would improve market efficiency as more participants can see the rational picture and take the arbitrage opportunity to correct mispricing. One could also argue, that considering that the increased number of traders is usually due to retail traders, who do not operate with high-value trades, this can not have a significant impact on the market. Nevertheless, we did have short attacks in the past like GameStop stocks, where only retail traders managed to cause a market bubble for one specific stock. Regarding this indicator I have not found any reliable data, however, it could be a good starting point for someone to look further for its reliability. Furthermore, it would be also interesting to analyse other sentiment indicators such as the AAII (American Association of Individuals) Survey, which is measuring market sentiment weekly based on surveys and sentiment analysis of news, using natural language processing and machine learning techniques to analyse news articles and social media posts for the sentiment. However, these potential indications are just an idea for further research and they are not going to be further researched within this paper.

3 CURRENT GAP BETWEEN THE MARKETS: ARE WE IN A BUBBLE?

Before deep diving into the second part of the analysis based on data between 2018 and 2022, I am going to briefly touch upon the stock market and economy's development during this timeline to provide a background for further interpretation of quantitative results.

3.1 Stock Markets after the Great Financial Crisis

In 2009 global recession hit, causing the world's GDP to shrink by 1.7%. The US experienced its strongest economic slowdown in 30 years, thus FED as well as central banks worldwide attempted to provide liquidity to the economy and lower interest rates. Although US Treasury pursued stabilising the economy with TARF (Troubled Assets Relief Program), increasing liquidity and purchasing MBS (Mortgage-Backed Securities), S&P 500 still experienced the maximum loss in history as it fell by almost 20%. The US managed to end the deepest recession since 1930 in Q3 2009 (Brank, 2010). Afterwards, the USA entered the longest bull market in history, lasting 132 months, from March 2009 until March 2020. Gains were steady, but slow, with the S&P 500 average annual return of 15%. Therefore, although being the longest bull in history, it was only the fourth-best decade since 1930, with the best decade being the 1950s with an average annualised return of 19.21%. Furthermore, also Schiller's PE ratio, which reached a value of 44 before the Dot com bubble

crash, reached only a value of around 30 (Heath, 2019). Drivers for the longest bull markets were multiple. Firstly, the base prices of stocks in 2009 were relatively depressed, due to the crisis in 2008. Secondly, there was an aggressive monetary and fiscal policy employed worldwide. Quantitative easing and record-low interest rates provided liquidity in markets. Despite interest rates being gradually increased in 2015, they never reached the pre-crisis level of 5.25%. Consequently, due to low returns on a fixed income, investors' money moved to equities. Due to low-interest rates, companies also refinanced their debts, increasing profitability (Divine, 2019).

Although the bull market lasted until March 2020, even before that multiple articles were warning, that US equities are in a market bubble. There was high marketability of US equities, especially due to online broker platforms. Furthermore, there was excessive liquidity due to low-interest rates and quantitative easing. Nevertheless, it is hard to measure if there was speculation and also there was no significant displacement, which could serve as a »spark« for a market bubble. In 2013 Robert Schiller first started highlighting his concerns regarding a sharp increase in US stock prices, despite the economy still being relatively weak. Similarly, some investment strategists raised concerns about what might happen when FED decides to stop monetary stimulus (Clinch, 2013). In 2015 there were even more articles. Schiller this time specifically said that US equities are in a bubble, especially as the investor sentiment looked similar to in 2000. Also, the valuations confidence index showed, that investors think prices are as overvalued as in the 2000s. Further, Donald Trump 2015 emphasised the concern of a market bubble together with hedge fund manager Carl Iahn (Egan, 2015). In 2016 Financial Times (Mallaby, 2016) again warned, that stock prices increased sharply, although earnings growth expectations were mostly downward revised. In addition, he also pointed out that housing market prices are again reaching levels from 2007. In 2018 there was another article, warning that the S&P 500 almost tripled since March 2009 and that »cheap money« is creating the largest asset bubbles of all time (Amaro, 2018).

3.2 Influence of Covid-19

The S&P 500 ended 2018 down 6%, marking its largest correction since the Great Financial Crisis. This was a result of fears of a global economic slowdown due to geopolitical events such as the US-China trade war and Brexit. In August, an inverted yield curve appeared, triggering FED to decrease interest rates three times in 2019 to a final band of 1.5% to 1.75%. The good performance of indexes was also driven by the stock price boom in the technology sector, particularly the performance of Apple and Microsoft stocks. Due to these factors, indexes had a great year, with the S&P 500 up 29% and NASDAQ up 35%, both reaching their best performance since 2013 (Isbitts, 2019).

In 2020, optimism continued until the outbreak of COVID-19 in China (S&P500 chart with main events can be seen in Appendix Figure 1). It caused fear and uncertainty, especially

when the first cases started emerging outside China. Companies started reporting supply chain issues and consequently decreasing expected sales forecasts (Štimac, 2020). During the last week of February S&P 500 lost -12.59% (-6.37% YTD (Year to Date)), recording the worst weekly performance since the Great Depression in 2008 (Bombač, 2020). On the 11th of March WHO (World Health Organisation) officially announced a pandemic, pushing indexes even lower. In the week between 13th and 20th March indexes declined with S&P 500 declining by -11.65% or -24.55% YTD. The severity of insecurity was visible from observing VIX Index, as it reached the highest value in history. Financial analytics in the majority agreed, that economy cannot escape a recession, the only question is the severity and length of it. To at least partially prevent a longer recession, all countries started preparing stimulus programs for their economy. The US announced USD 700 billion in quantitative easing with a further decrease in interest rates (Jelenc, 2020). In April IMF (International Monetary Fund) shared that they expect the largest GDP downturn since 1993 (excluding war times). Despite G7 (The International Group of Seven) countries releasing to their economies 5 times more money as they did in 2009 to battle the Great Recession, new unemployment claims continue rising. In 4 weeks the US, therefore, lost all newly created jobs after the 2008 crisis. End of April companies starts reporting Q1 results. It was expected that profits would fall by 13%, however, S&P 500 companies reported on average even higher fall, of 22% (Perossa, 2020).

In May S&P 500 started growing, despite negative news such as the US unemployment rate reaching the highest rate in the last 80 years. In July number of cases again started increasing, realizing the fear of the second wave. Furthermore, Q2 GDP numbers were announced, with GDP recording a worse fall than in 2008. Nevertheless, it started to look like economies were recovering faster than expected as the US unemployment rate started decreasing in July. Thus also indexes started to increase, recording the best quarter for stocks in the last 20 years (Granda, 2020). In September investors started questioning stock prices, being afraid that the prices are too high. Besides this, the number of COVID-19 cases started increasing. IMF also announced, that they expect global GDP to decrease by 4.4% in 2020, which is a higher decrease than in 2009. The recovery speed of the US economy slowed in December with the unemployment rate higher than expected, Furthermore, S&P 500 companies reported on average a 6.42% drop in profit in Q3. On the other hand, FDA-approved Pfizer and Biontech vaccines are to be used in the USA. Therefore overall markets finished 2020 quite optimistically with S&P 500 ending the year 8.8% above the start value (Keber, 2020).

2021 continued with the positive trend with Joe Biden being elected president of the USA, which increased the probability of new financial stimulus for households and corporates. Companies started announcing 4Q profits and approximately 81% (past average 74%) exceeded profits expectations. On the other hand, new job creation was only half compared to expected. In February also the Rescue Plan was approved, however, it triggered many warnings that the package is not needed in such an amount and that due to excessive

liquidity, this will put pressure on inflation. FED responded to fears saying, that the higher inflation will only be temporary and that they are only going to increase interest rates when the US economy fully recovers. S&P 500 first time went over 4000, recording 11.56% growth YTD. With April's inflation at 4.2%, FED announced, that an interest rate hike might happen earlier than initially expected. Fear of interest rate hikes faded end of June, resulting in S&P growing by 17.56% YTD (Perossa, 2021). End of July there was again a hike in new COVID-19 cases, despite the high vaccination rate, causing increased volatility in markets. Therefore FED signalled that probability to keep an expansive monetary policy longer time, increased. This news positively impacted capital markets, which caused the S&P 500 to gain 23.87 YTD in the first week of August. Furthermore, after a majority of S&P 500 companies reported Q2 results, it was visible, that economy is recovering extremely fast. Nevertheless, in mid-August consumer sentiment decreased to the lowest level since 2011, as there was an increased fear of the delta variant. In August new job creation was 500k below expectations, thus investors got scared that besides high inflation also economic growth is going to slow down. Furthermore, also analytics on Bloomberg started warning, that equities might be overvalued considering the macroeconomic picture (Jelenc, 2021).

Negative sentiment continued in October with additional reports on supply chain issues and new job creation lower than expected. Moreover, IMF decreased expected global GDP growth to 5.9% from 6%. In November Q3 GDP results showed a slowing down in the US economy. From Q2, when growth was 6.7%, growth decreased to 2%. The number of COVID-19 cases again started increasing, however, indexes continue a positive growth trend. Mid-November markets again got a bit surprised due to high inflation of +6.2% for October, YoY, which is the highest growth since November 1990. However, investors agreed that inflation is most likely at its highest and can from now on only decrease. Therefore S&P 500 only continued with growth, finishing 2021 38.2% higher than it started the year (Vrčkovnik, 2021).

3.3 Post-Covid Markets

Although 2022 COVID-19 did not disappear, the world experienced different shocks, which led people to stop focusing on the pandemic. Despite different expectations, on February 24th Russian army started military operations in Ukraine. Multiple countries responded with various sanctions and an embargo on the import of energy from Russia, which put Europe in an energy crisis. The US was less severely impacted, considering it doesn't rely on Russia for gas and oil. Although many expected the war to end relatively quickly due to Russia's military superiority, it is still ongoing. Increased money supply from COVID-19 support packages combined with a restart of the tourism & service sector after lockdowns, and higher energy and food prices due to the war led to high inflation in 2022. This triggered a response by the FED, which increased interest rates seven times in 2022, with rates ending the year at 4.25%-4.5% compared to the 0%-0.25% band at the beginning of the year. S&P 500

consequently lost -13.0% in 2022, mainly due to a decline in technology stock prices (Zakotnik, 2023).

3.3.1 Individual Stock Bubbles

One of the factors, present during all market bubbles, was irrationality. Although in the past, it was a bit difficult or complex to define when market participants were behaving irrationally, or was this visible only in a long term, beginning of the 2021 was a bit different. Brick-and-mortar game store Game Stop had its last positive profit in 2017 and was struggling due to competition from online retailers. The struggle increased especially during COVID-19, as there was a decrease in-store visits. Therefore multiple professional investors and hedge funds, expecting a continuous drop in the price, entered into a short position in this stock. At the beginning of 2021 therefore almost 140% of the public float was sold short. Nevertheless, there was soon a drastic price rise, triggered by multiple participants of the subreddit WallStreetBets. Despite the source of irrationality usually being greed, this time the main driver was anger against Wall Street hedge funds and eagerness to prove them wrong. The aim was to gather retail investors, which usually individually hold relatively little power in markets, and use their joint "power" to "overtake" institutional investors. Due to high media coverage, especially social media, more and more retail investors joined the movement. In January 2021 therefore stock increased by more than 1500%, making January 28 temporarily the highest-valued company in Russel 2000 Index. First and Second of February, the stock lost almost 80% of its peak value, however, on February 24th the price again rose times two in only 90 minutes. Although there was no particular change in fundamentals, which would back the sudden price rise and although the price after the increase also decreased, subreddit participants, promoted holding on to the stocks. Although the price has decreased from the peak in January, when prices were above 80 USD, it still trades above 15 USD, compared to 2 USD before the short squeeze. Although the event was mainly limited to Game Stop and a couple of other stocks, the reach was so extensive, that on the 27th of January trading volume of several shares was higher than during the peak of the Great Financial Crisis in October 2008. Furthermore, some brokers like Robinhood even had to disable the "buy" option for the stock, as they were not able to post sufficient collateral at the clearing house to execute buy orders (Foroohar, 2021).

The second stock which attracted a lot of attention and caused multiple debates about whether the stock is overvalued or not is Tesla stock. Already in November 2020 market capitalisation of the company reached 500 Billion USD (550% growth YTD), ending 2020 with a 670 Billion USD market cap. This means that Tesla's market capitalisation was higher than the market capitalisation of the top 5 car manufacturers combined (Toyota: 215B, VW (Volkswagen) 100B, Daimler 76B, Ford 35B and Honda 49B), although Tesla's market share (market share of car manufacturers, not EV (electric vehicle) manufacturers) was not even at 1%. It is true, that they have been fast growing with market price growth in 2020 of more than 500%, profit growth of more than 50% and vehicle delivery of more than 35%,

however, the question is still if this is sustainable growth and whether the growth is not too slow considering the price hike. Morningstar (2020) also warned, that even when demand continues rising and even though Musk estimated a production volume of 20 million in 2030, there is a problem with production capacity, as they do not see their production sites being able to expand and open up so fast. Furthermore, they also question if global mass adoption of EV vehicles is already that close in years. One of the ratios, which might be alarming is the price-to-earnings ratio, which is for the automotive sector approximately 20, which was for Tesla in 2020 over 1000. Tesla had the benefit of being the first one to introduce EVs. Nevertheless, it looks like the market believed that competition can not keep up, although Volkswagen's EV production was growing 6x as fast as Tesla's. Furthermore, another strong competition is rising in Asia countries with companies like Xpeng and Nio. The second one for example developed a model, very similar to Tesla's X model for a 50% lower price. Morningstar's warnings were more than valid, which is also visible from the stock price decline beginning of 2022, when Tesla stocks decreased more than 11% in a day due to a delay in vehicle production and due to bad news that they are not working yet on a model, which should cost only 25k USD (Kolodny, 2022). End of 2022 stock decreased even further due to Musk selling a higher share of Tesla stocks than initially signalled and due to missed revenue targets especially, as competitors are catching up (Pratley, 2023).

2.3.2 Cryptocurrencies

Market bubbles usually appear in different asset classes like stocks, real estate, commodities etc., however in 2021 multiple articles pointed out a bubble also in cryptocurrency markets. Cryptocurrencies evolved in 2008 as a response to the Great Financial Crisis and consequent distrust in a bank and other financial institutions. The idea was, to create an asset, which would be independent of government and therefore could not be manipulated. The first currency, Bitcoin was presented by Satoshi Nakamoto in the paper "Bitcoin: A peer-to-peer Electronic cash system". Cryptocurrencies are a digital and encrypted decentralised medium of exchange. Transactions are being verified via mathematical problems, which are being resolved by users, paying their share of cryptocurrencies when resolving the problem (verifying transaction) and adding this block of information to the centralised ledger (Hooson, 2022). Cryptocurrencies should facilitate transactions and asset transfers on a decentralised and secure network, enable confidentiality of transfers, lower transaction costs and offer secure transactions based on an unbreakable encryption system. Cryptocurrencies should ideally be able to replace existing fiat currencies, nevertheless, they still have multiple setbacks. There is a risk of hacking, high volatility, irreversibility of transactions and due to the high energy insensitivity of mining also a highly negative environmental impact. Furthermore, it is hard to say that cryptocurrencies perform the main roles of money. It is not proven that they would store value. Even cryptocurrencies, which are tied to a fiat currency, do not always track the fiat currency. Even the most popular and known cryptocurrency is not recognised as a universal payment method and also liquidity and

traceability could not always be assured. Therefore it is difficult to conclude, that cryptocurrencies are any time soon going to replace existing fiat currencies (Amundi, 2022).

Secondly, cryptocurrencies, especially Bitcoin, should also serve as some sort of "digital gold", shielding investors from inflation caused by central banks by massive quantitative easing. If this was not important reason enough after the Great Financial Crisis, it became an important reason after the COVID-19 outbreak, as countries introduced high government stimulus, rushing liquidity to markets. Nevertheless, as mentioned before, due to high volatility, despite rising prices, it would be wrong to label cryptocurrencies as "haven" during inflation, as daily growth can easily double digits. A more strong argument, than merely hedging against inflation is, that investors are simply looking for high returns. Bitcoin reaching three-digit growth in a year, compared to the long-term average low double-digit growth of the S&P 500, presents a tempting opportunity to increase investors' wealth. With yields being extremely low and excessive liquidity, investors started looking for riskier investments (Greifeld & Hajric, 2022). Although many coins do not have intrinsic value, demand for cryptocurrencies comes in most cases solely due to anticipation of capital gains. ECB (European Central Bank) member of the Executive Board, Fabio Panetta, 2022 added, that cryptocurrency mania in 2021 was similar to the gold rush 170 years ago. Especially due to social media, success stories are more known and advertised, there is an increase in people advising on cryptocurrency trading, which creates conditions for fear of missing out. Buying assets solely due to the expectation of their price rise, increased amount of investors, and high liquidity on markets are all factors, we have observed also during previous market bubbles. Therefore although there is no good model to test for a bubble in cryptocurrencies, as it is hard to evaluate their fundamental value, from a behavioural perspective, we could say that in 2020 and 2021, cryptocurrencies were in a bubble.

3.4 Testing for Bubble

The second part of RQ (Research Question) and RH5 are focused on market developments between 2018 and 2022 and if there was a time period, which we could count as a market bubble. That being said, there is no perfect model, which would be able to accurately predict when we are in a bubble. In the first part, I used PSY as a benchmark, however considering that detected market bubbles are already documented in multiple articles, I was able to do a "sanity check" whether PSY results match with market bubbles, which were already documented and researched in the past.

Economists advise interpreting signals given by these indicators carefully and that they should not be interpreted on their own, but together with other indicators. (Alessi & Detken, 2009), however in this case is this even more important, considering that there are few papers and articles being written about a market bubble between 2018 and 2022. Thus I will not only apply the PSY model to market data from January 2018 to January 2023 but also then add indicators, which proved to be quite accurate for past market bubbles: PE Ratio, adjusted Buffet's Indicator, and Put/Call Ratio. Swinkels and Umlauft (2022) also test which

indicator – Buffet's or Schiller's might be most accurate. They conclude, that for an individual country, Buffet's indicator is substantially more accurate and has higher t-values than Shiller's PE ratio. Nevertheless, for the United States, the difference is negligible, therefore I will use both indicators in my research. As for insider trading, I was only able to get data from 2010 I will firstly use the above indicators to conclude a potential market bubble during 2018-2022 and then also test if insider trading might be something which could indicate market bubbles.

3.4.1 Applying PSY Model on 2018 - 2022 Data

Same as under 2.3 Using indicators on historical bubbles, I have employed PSY model in RStudio as per Phillips & Shi (2017), using S&P 500, however for a longer time period. Additionally was included the time period between 2018 and 2022 was in order to confirm whether there was a market bubble present during this time period.

Table 2: Bubble and Crisis Periods in the Wilshire 5000 between 2018 and 2022

Number of market bubbles	Start of the market bubble	End of the market bubble
1	31.3.2020	31.5.2020
2	01.07.2020	01.07.2020

Source: Nasdaq Data Link, 2023a

As visible in Table 2, for the time period between 2018 and 2022, the PSY model did not recognize any market bubbles. It did, however, catch 2 time periods, when markets dropped significantly: March to May 2020, when COVID-19 started and again in July 2020, reflecting worse performance in June 2020 when FED published its outlook for the year's GDP and policy strategy. Nevertheless, besides the two market drops, it did not capture any market hikes which might be reflecting a market bubble. Solely based on the PSY model, we can therefore conclude, that during 2018 and 2022, there was no market bubble. Nevertheless, as written before, the model has its downsides, therefore before fully disproving the RH5 that there was a bubble period between 2018 and 2022 in the stock market in the USA, I will employ also more rule-of-thumb bubble indicators, which were already employed in the past to test for market bubbles, as a market cap to GDP ratio and Cyclically adjusted PE Ratio. In addition at the end, I will then add also the indicators newly proposed in this paper, which had favourable results when applying them against the 1975-2018 market bubbles.

3.4.3 Applying Indicators to Test for Bubble

In previous chapters, I tested if the adjusted Buffet's indicator is statistically different from a non-adjusted indicator. Although I have received a result that they are not statistically different, I am going to be using the adjusted index to analyse if there was a market bubble between 2018 and 2022. I am going to be using a mean of adjusted indicator for a bubble

time period as a critical value. Therefore, whenever the adjusted indicator is going to be above 107%, I will mark the time period as a "bubble" time period according to the adjusted Buffet's indicator.

From 2018 Q1 to 2022 Q2, adjusted Buffet's indicator varied between 133% to 195%, higher than during any of the previously detected bubble time periods (Appendix Table 6). Therefore, as per adjusted Buffet's indicator, I would conclude, that there was a bubble during 2018 Q4 and 2022 Q2. As discussed in the previous chapters, more than 50% time when the adjusted indicator indicated a bubble, it was a false indication. Nevertheless, considering that all (except Q2 2018) quarter time periods between Q1 2018 and Q2 2022 exceed not only the selected critical value, but critical value +1 standard deviation and during Q2 2020 and Q4 2021 even critical value + 2 standard deviations, I would conclude, that probability of falsely indicated market bubble is low, but not zero.

The second rule of thumb indicator is Schiller's Cyclically Adjusted Price to Earnings Ratio. A high ratio means that the price is relatively high compared to the underlying company's earnings, however, there is no specific rule, at which price assets should be overvalued and should indicate a market bubble. For the US stock market, the historical average is around 15-16, reaching higher levels before Black Monday – 23 and during the Dot Com Bubble. The average ratio during the Dot Com Bubble, which was time-stamped by the PSY model was 33.26, starting at 15.82 and reaching as high a ratio as 43.22. Taking the mean level of 30.26, as a critical value, I observe one bubble time period in January 2018, followed by a longer bubble period between December 2020 and April 2022. The CAPE ratio was varying from 33.31 to 38.58 (Appendix Figure 7). Although those were the highest CAPE values in history, they did not reach mean +1 standard deviation as in the case of Buffet's indicator. CAPE ratio has a lower share of falsely indicated market bubbles at around 30%.

Based on findings in Chapter 2.4.5. I am going to be comparing the means of time periods between 2018 and 2022 with a critical value, which I set at 0.56, which was the mean for the put/call ratio during the bubble time period analysed in Chapter 2.4.5. In 2018 and 2019 means were very similar, moving from 0.83 to 0.90. This means, that on average there was approximately a balance between put and call options, similar to during the no-bubble periods, where the average was 0.80. In February, March and April 2020 values breached 1.0, which coincide with market panic when the pandemic started. In June 2020 the ratio started decreasing, breaching critical value in May, June 2021, and October 2021. The end of January ratio started increasing, again coinciding with the start of the Russia-Ukraine war (Appendix Table 8).

Another proposed indicator was insider trading, however, due to data availability, I was only able to analyse for years from 2010 on. For this purpose, I have selected the DJIA index, which consists of 30 blue-chip companies trading on the NYSE (New York Stock Exchange) & Nasdaq. For every stock, I have exported a share of stocks being held by insiders in a

particular month. Finally, I have added shares of every stock multiplied by its weight. The result was a share of stocks owned by insiders for the whole DJIA index for a particular month. The hypothesis was, that based on this insider trading indicator, one would be able to see when there is a market bubble. The assumption was, that with the market bubble reaching a peak, insiders would slowly start to exit positions and prepare for a market downturn. Based on PSY there was no market bubble during 2018-2022, however, other indicators did catch a possibility of a market bubble. Nevertheless, the only observed trend with the Insider Trading indicator was, that the share of stocks held by insiders was constantly decreasing from 2018 to 2022 (Appendix Figure 2), without any additional observable jumps or drops, which would correlate with observations based on other indicators. Therefore I conclude, that this indicator might not be appropriate for indication of market bubbles.

Although the idea is relatively good, the main limitation of this test is the data. For other tests I am using the S&P 500 or Willshire 5000, which include as many public companies as possible, to try to extrapolate findings based on indexes to the whole financial market of the US. Nevertheless, DJIA Index only consists of 30 blue-chip companies trading on NYSE & Nasdaq. This means, that it includes only part of the US financial market and is less accurate to make assumptions for the whole financial market based on results. Furthermore, an index is not adjusted for periodic changes in constituents and their weights, which additionally decreases accuracy. Lastly, all other indicators were tested on past data, during which PSY detected market bubbles, which also coincided with market bubbles which have been discussed in different papers and literature. However, the test for insider trading activity is only completed on a data set, when PSY has not indicated any market bubbles and there are also not many papers which would state that there was a market bubble present during this time period. Although there are some papers already mentioning that there was a market bubble during 2020 and 2021, there is not enough data yet to strictly pinpoint the start and end of this bubble. Therefore it is extremely difficult to conclude the correlation of the dataset with market bubbles, considering that there was no market bubble during the time. Nevertheless, this analysis does bring a starting point for further analysis, where the focus could be solely on this indicator and where the researcher would remove the constraints with the better dataset, ideally Willshire 5000 for the same time period as I had for other indicators.

3.5 Discussion

Considering, that there were multiple signals, which could message to an observer, that we were indeed seeing a market bubble or that we has all conditions as per Quinn and Turner already fulfilled, one would have expected that we have learned from the past and would prevent additional bubbles. In the economy between 2018 and 2022, we had a great predisposition for a market bubble. “Oxygen” was in place with high marketability of the majority of assets, especially stocks. We had multiple apps where one can simply click a few

times and make a trade compared to the past, where the whole process of buying a stock was rather complex. Furthermore, with fraction trading, anyone can start investing in companies with already a dollar. In addition, there are multiple discount brokers, which offer low or even no fees per trade, again making it extremely easy and affordable to trade. Also, the second required building block "fuel" or liquidity was fulfilled. With continued quantitative easing after the 2008 crisis, record low-interest rates (up until March 2022) and monetary assistance companies and individuals received during the COVID-19 crisis, M1 in the US increased from approximately US 1 trillion in 2000 to more than US 20 trillion in March 2022. When it comes to "heat" or speculation, I tend to agree with Quinn and Turner (2020) saying, that there are always speculators on market, however during the bubble their number just increases. Especially with accessibility to information and social media, people can very quickly get information about "the next breakthrough" in which they have to invest which could lead to an increased number of speculators on market. Also, marketing strategies are getting more and more sophisticated, meaning that it is easier to start successfully targeting people, who are going to turn into speculators. Alongside, Charles Kindleberger (2015) also nicely explains why the number of speculators tends to increase exponentially »There is nothing so disturbing to one's well-being and judgment as to see a friend get rich«. I would also add that with restrictions due to the COVID-19 virus, many people were not able to live their lives fully, being forced to stay at home and not socialise. Therefore this presented a perfect opportunity for some people to use their (then substantial) spare time to speculate on financial markets, especially as liquidity was higher than usual. To sum up, considering that market bubbles re-appeared also in the 21st century, we have not yet learned how to prevent them. In addition, the advancements in technology have enabled the best marketability of stocks as ever seen in history. Following excessive liquidity in the US market and easily triggered euphoria and speculation through social media, the conditions for the creation of a market bubble were probably one of if not the best in history. Adding possible sparks in a form of breakthroughs such as the development of artificial intelligence and blockchain, combined with major shifts in an economy such as the outburst of COVID-19, gives multiple opportunities for a star of a market bubble.

From the theory perspective, we, therefore, see that conditions as well as spark for the market bubble between 2018 and 2022 were present. The second question then is, if the financial market's performance was in line with the performance of the real economy. After the start of COVID-19, corporate profits, which are the main driver of stock prices, dropped by 22% in Q1 2020, compared to expected positive growth. Analysts expected the largest GDP drop since 1993 and also in Q3 company profits continued to be negative, this time approximately -6%. One could argue, that stock prices are forward-looking, thus they already predicted a rebound in profits. Nevertheless, let us take a look at an example. Imagine that COVID-19 never happened. In January 2020 analysts were expecting very moderate growth of US stocks, between 3-7.5% for the year 2020. Now we add the COVID-19 outburst and the fact, that companies will have losses, meaning that they might have to pause dividend distribution for a year or two in the best scenario (finding an effective vaccine). Nevertheless, in March

2020 worse scenario was still possible, the scenario being a change in world and our status quo. This would impact corporate profits even more, as certain businesses, especially service companies would be forced to close. Nevertheless, end of 2020 S&P 500 ended approximately 9% up, higher than expected market return without the pandemic. Did markets expect, that best case scenario will happen and that after the end of the pandemic, corporate profits will be doubled, making up for all losses they created in 2020? Personally, I doubt it. In addition, end of 2020 it was still very unclear what the future will look like and if we are going to be able to start living the life we had before. Thus any betting on fast recovery would be as mentioned, betting or speculating. One could argue, that prices are reasonable due to an increase in monetary supply, however, I strongly believe that there was a higher than usual presence of irrationality among investors. Besides visible disconnect between real market performance and performance of stock markets, there were also additional events proving irrationality, such as the Game Stop short squeeze, Tesla exceeding the market cap of the 5 largest car makers, Bitcoin reaching three-digit growth etc. The above summarised observations were however only qualitative observations of irrationality. Therefore it was important to also check what were results based on indicators.

Based only on the PSY model, for which I made an assumption, that it is currently the best model for detecting bubbles, therefore should be the most correct, there were no market bubbles detected on the US stock market during 2018-2022. On the other hand rule of thumb indicators and the newly proposed Put/Call Ratio were all signalling that there was a market bubble. According to Buffet's indicator, the bubble started in Q2 2020 and ended end with Q1 2022. Similarly, according to the CAPE ratio the bubble started a bit later, in December 2020, and end of April 2022. Checking for bubbles also via Put/Call Ratio, with the ratio breaching critical value in May, June and October 2021, it is also visible, that there could be a market bubble in 2021. Therefore my conclusion is, that there was a market bubble in 2021. Based on the indicators above and based on qualitative observations, I would conclude, that there was a market bubble present in US stock markets starting at approximately beginning and ending at approximately end of the 2021.

I would like to emphasise, that considering that used indicators give different start dates, there are limitations to this research. As the bubble was not picked up by the PSY model, I was not able to provide with more accurate evaluation. Nevertheless, it might happen that after the bubble will deflate and there might be a minor crisis in 2023, with longer data from 2018-2024, the PSY model might pick up also 2021 period as a market bubble. Furthermore, also this evaluation has similar limitations as in the first part. One of the limitations is inconsistency when it comes to data frequency, as different indicators are reported differently, furthermore, we also use different indexes such as Willshire 5000, S&P 500 and DJIA (ideally only one would be used). In addition, indicators rely on critical values, which I determined in the first part. Considering, that I had data sets with only a limited number of identified market bubbles, the sample of "bubble period" observations based on which I set

critical value, was for some indicators below 30. Hereby, there is an opportunity for further analysis with better data sets, which could give more accurate results.

CONCLUSION

Ever since the Dot Com Bubble and later on the Great financial crisis, the concept of market bubbles started gaining attention from researchers and media. Especially during the years 2017 and 2018, as markets have been recording the longest "bull run". Despite my general interest in market bubbles, my motivation for research picked up during 2020 and 2021, as despite the uncertain future performance of the economy due to the pandemic, markets were behaving extremely optimistically. As per my definition, a market bubble is present, when lagged performance of stock markets (or price of a stock) is no longer correlated with performance of real economy (or a fundamental value of a stock). At this moment value of stock market equals to value of stock market based on fundamentals, which could be mainly narrowed to corporate profits, which are correlated with GDP growth plus a bubble component, which increases with irrationality of investors. Therefore I think that whenever we sense based on stock market's performance, economy performance and news articles, that real economy and financial markets are diverging, we should start looking at quantitative indicators to see if a market bubble is present.

My main goal with the thesis was to dig deeper into my definition of a market bubble, mainly the part that real market and financial market are correlated. Thus the first hypothesis I tested was RH1: Divergence between real and financial markets is correlated with bubble formation. As mentioned, after we noticed, that the two might not be correlated anymore (under the assumption, that we adjusted performance of financial markets with an appropriate lag), it would be good to start checking quantitative indicators. As there are multiple indicators for testing a market bubble, and none of them is perfect, I decided to propose new indicators, some that are based on a divergence between real economy and financial markets and some which are based on irrationality of investors. Thus later on I test the following hypothesis: RH2: Adjusted Buffet's indicator performs significantly better than the non-adjusted indicator, RH3: Share of stock ownership by insiders is significantly different during market bubble than during other time periods, and RH4: Put/Call Ratio is significantly different during market bubble than during other time periods. As I said, part of the motivation for the thesis came also from a visible disconnect between real economy and financial markets between 2020 and 2022. Hereby in the last part of my thesis, I have used existing indicators as well as newly proposed indicators to test hypothesis RH5: During the years 2018 and 2022, there was a market bubble.

Having analysed Wilshire 5000 returns and US GDP growth, adjusted Buffet's indicator and Put Call ratio between 1973 and 2018 and taking into account market bubbles indicated by the PSY model, I received following results. During time periods, when market bubbles were identified, a correlation between performance of stock market (Wilshire 5000, adjusted for

a 2-quarter lag for stock market) and real market (US GDP), was not significantly different than 0. On the contrary, when market bubbles were not identified, a correlation was positive at 0.16 and significantly different from 0. Herby, I can confirm RH1: Divergence between real and financial markets is correlated with bubble formation. Continuing with the Buffet indicator, I got results, that the Buffet indicator as well as adjusted Buffet indicator were significantly different during identified bubble period vs non-bubble period, nevertheless, I was not able to confirm RH2: Adjusted Buffet's indicator performs significantly better than non-adjusted indicator. Although adjusted and non-adjusted indicators were not significantly different, I have used adjusted indicator when testing for RH 5, as it has a higher accuracy rate compared to non-adjusted (although, not statistically significant). Due to data limitation, I have tested RH 3 based on data from 2010 on and based on DJIA indicator, however as the share of stocks owned by insiders only decreased since then, there was no pattern, based on which I could further confirm RH3. Therefore I did not use any statistical tests to test RH 3: Share of stock ownership by insiders is significantly different during market bubble than during other time periods, as already from visual inspection of data there was no link visible between share of stock ownership by insiders and market bubbles. On the contrary, Put/Call ratio proved to be a good indicator, as I was able to confirm RH4: Put/Call Ratio is significantly different during a market bubble than during other time periods. Lastly, I used the PSY model, PE ratio, adjusted Buffets indicator and Put/Call ratio to test RH5. Although the PSY model did not detect a bubble, all other indicators as well as based on visible irrationality in markets, I decided to confirm the RH5: During the years 2018 and 2022, there was a market bubble. I have received different results from indicators in terms of timing, thus I have then used a personal opinion to set a timeline for market bubble from the beginning to the end of 2021.

The main constraint of results is, that findings strongly rely on results from the PSY model. According to the literature, this is currently the most accurate model, nevertheless, based on all the market bubbles it indicated, not all were as relevant as to be mentioned in the literature (for example the bubble indicated before Black Monday). Furthermore, as the growth of the economy is only available on quarterly data and market bubbles were indicated on a monthly basis, this is another factor, which might make results less accurate. In addition, Insider trading indicator was also tested only on data set from 2010 on when the PSY model did not detect any market bubbles, therefore it is hard to make any precise conclusions about this indicator.

As mentioned at the beginning, the answer to this research question does not aim to provide investment advice or guidance for regulators, however, it purely analyses market data from a market bubble perspective. Based on the results I conclude, that the thesis had added some parts to the universe of market bubble research starting with positive results proving that there is a correlation between real and financial markets during non-bubble times, but there is no correlation during bubble times (RH1). Confirming, that there is a different correlation between the time period when there are market bubbles and periods without them, opens an

opportunity for further researchers to mould this finding into a new market bubble indicator, using a correlation between financial and real market growth to indicate a market bubble. In addition, it also adds a positive argument for the initial non-adjusted Buffet indicator. Many economists have been criticising it strongly, however, based on analysis even when adjusting it partially, there is no significant difference between adjusted and non-adjusted indicator (RH2). Although I was not able to get any useful results with RH3, due to various constraints such as data variability only for a short time period, considering that the indicator has not yet been further researched, it still opens a possibility of further research whenever a researcher has access to more suitable data. Furthermore, data were also retrieved for the DJIA index, with less than 50 constituents, however, the results most likely would be much more reliable when working on larger indices like S&P 500. Although the Put/Call ratio indicator (RH4) has been mentioned online multiple times, I have not come across scientific research confirming the reliability of the indicator. Therefore, this thesis might serve as partial scientific confirmation of the indicator's reliability. Lastly, as there is not much research literature on the topic of market bubble in 2021, the thesis provides a good starting point for further research for this specific time period, especially when the bubble is going to deflate and PSY might detect it.

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APPENDICES

Appendix 1: Povzetek (Summary in Slovene language)

Koncept finančnih mehurčkov je začel pridobivati popularnost med mediji in raziskovalci že od Dot Com finančnega mehurčka ter kasneje po globalni finančni krizi v letih 2007 in 2008. Še posebno v letih 2017 in 2018 smo lahko opazili veliko število člankov, saj so trgi beležili najdaljše obdobje »bikovskega trga«. Čeprav sem že dlje časa zainteresirana za to temo, sem dodatno motivacijo za raziskovanje pridobila med letoma 2020 in 2021. Po eni strani smo zaradi pandemije živeli v veliki negotovosti glede prihodnosti, po drugi strani pa so bili finančni trgi izredno pozitivno naravnani. Sama bi definirala finančne mehurčke kot obdobje, ko uspešnost delniškega trga (ali cena posamezne delnice) ne korelira več z uspešnostjo realnega trga (ali pa fundamentov določene delnice, kar lahko zožimo na korporativni dobiček, ki je povezan z bruto domačim proizvodom). V tem trenutku je vrednost delniškega trga enaka fundamentalni vrednosti vseh delnic, dodana pa je komponenta finančnega mehurčka, ki je odvisna od prisotnosti iracionalnosti investitorjev na trgu. Na podlagi te definicije menim, da bi bilo vsakič, ko opazimo, da se realna ekonomija in delniški trg začneta oddaljevati drug od drugega na podlagi opazovanja delniškega trga, realnega trga ter finančnih novic, primerno uporabiti kazalnike za preverjanje prisotnosti finančnega mehurčka.

Glavni cilj naloge je, da se poglobim v mojo definicijo finančnega mehurčka s poudarkom na korelaciji realne ekonomije in delniškega trga. Zato je prva raziskovalna hipoteza, ki jo testiram, naslednja: RH1: Divergenca med realno ekonomijo in finančnimi trgi je povezana s pojavom finančnih mehurčkov. Ko opazimo, da oba trga nista več korelirana (pod predpostavko, da smo ustrezno uporabili zamik uspešnosti finančnih trgov), bi bilo priporočljivo začeti uporabljati kvantitativne kazalnike. Ker obstaja veliko kazalnikov, vendar noben ni popoln, sem se odločila predlagati tudi dodatne kazalnike, ki so povezani bodisi z divergenco med realnimi trgi in finančnimi trgi ali z iracionalnostjo investitorjev. Hipoteze, ki se nanašajo na nove kazalnike, so naslednje: RH2: Prilagojen Buffetov kazalnik deluje bolje kot neprilagojen Buffetov kazalnik; RH3: Delež delnic v lasti tako imenovanih »insiderjev« je drugačen v času finančnih mehurčkov kot v času, ko ni finančnih mehurčkov; RH4: Razmerje »Put/Call« je drugačno v času finančnega mehurčka kot sicer. Na koncu sem uporabila tako obstoječe kazalnike kot tudi nove kazalnike ter preverila še RH5: Med letoma 2018 in 2022 smo opazili finančni mehurček.

Analiza je temeljila na indeksu Wilshire 5000, bruto domačem proizvodu Združenih držav Amerike, prilagojenem Buffetovem kazalniku ter razmerju Put/Call med letoma 1973 in 2018. Izhodišče za analizo so bili rezultati PSY modela, na podlagi katerih sem določila, kdaj so bili prisotni finančni mehurčki med letoma 1973 in 2018. V času finančnih mehurčkov korelacija med delniškim trgom (indeks Wilshire 5000, zamaknjen za dve četrtletji) in realnim trgom (bruto domači proizvod Združenih držav Amerike) ni bila statistično različna od nič. Nasprotno pa je bila korelacija v času, ko nismo zaznali finančnih mehurčkov, pozitivna in statistično različna od nič. Na podlagi tega lahko potrdim RH1, ki pravi, da divergenca med realno ekonomijo in finančnimi trgi korelira s pojavom finančnih

mehurčkov. Ko sem nadaljevala z Buffetovim kazalnikom, sem dobila rezultate, ki kažejo, da sta tako prilagojeni kot neprilagojeni Buffetov kazalnik različna v času finančnih mehurčkov v primerjavi s časom, ko finančnih mehurčkov ni bilo. Vendar pa prilagojeni in neprilagojeni Buffetov kazalnik med seboj nista statistično različna, zato RH2 nisem mogla potrditi. Sicer je prilagojen kazalnik zaznal več finančnih mehurčkov kot neprilagojen (vendar to ni statistično značilno), zato bom v zadnjem delu (RH5) vseeno uporabila prilagojeni kazalnik. Zaradi omejitev pri podatkih sem RH3 lahko testirala le na podlagi podatkov po letu 2010 in na podlagi DJIA indeksa. Edini vzorec, ki sem ga opazila, je bil, da je delež delnic v lasti »insiderjev« od leta 2010 padal. Zato RH3, ki pravi, da je delež delnic v lasti »insiderjev« različen v času finančnih mehurčkov v primerjavi z obdobjem brez mehurčkov, nisem morala potrditi. Za zadnji predlagani kazalnik sem dobila dobre rezultate, saj sem uspela potrditi, da je razmerje »Put/Call« drugačno v času finančnega mehurčka kot v času, ko ni zaznanih finančnih mehurčkov. Nazadnje sem uporabila PSY model, PE razmerje, prilagojen Buffetov kazalnik in razmerje »Put/Call«, da sem testirala RH5. Čeprav PSY model ni zaznal finančnega mehurčka, so ga zaznali vsi ostali kazalniki. Prav tako sem ob hitrem pregledu dogodkov na finančnih trgih opazila, da je bila prisotna višja iracionalnost investitorjev kot običajno. Zato sem se na podlagi vseh kazalnikov in dogajanja na trgu odločila potrditi RH5, ki trdi, da je bil prisoten finančni mehurček med letom 2018 in 2022. Ker so vsi kazalniki predlagali različne časovne okvire za mehurček, sem po lastni presoji sklenila, da se je finančni mehurček najverjetneje začel v začetku in končal konec leta 2021.

Vredno je opozoriti, da so rezultati izjemno odvisni od rezultatov PSY modela, ki je trenutno glede na literaturo, najbolj zanesljiv model za identificiranje finančnih mehurčkov. Poleg tega imam podatke za bruto domači proizvod na četrtletni ravni, vse ostale pa na mesečni ravni, zato so lahko končni rezultati rahlo manj zanesljivi. Prav tako sem za RH3 imela na voljo le podatke po letu 2010, ko PSY ni zaznal finančnega mehurčka, zato je težko priti do kakršnihkoli zaključkov glede te raziskovalne hipoteze

Kot omenjeno v uvodu, namen te magistrske naloge ni zagotavljanje smernic za investiranje ali za regulatorje. Glavni cilj je dodati nove koščke v celostno sliko finančnih mehurčkov, ki je še vedno nepopolna. Z dokazom, da obstaja korelacija med realno ekonomijo in finančnim trgom v času, ko ni finančnih mehurčkov, ter da te korelacije ni, ko so mehurčki prisotni, odpiram novo poglavje, ki ga lahko raziskovalci podrobneje preučijo in morda predlagajo nove kazalnike. Številni ekonomisti so doslej ostro kritizirali Buffetov kazalnik. Z dokazom, da prilagojeni kazalnik ni statistično drugačen od neprilagojenega, sem priskrbela dodaten pozitiven argument glede tega kazalnika. Tudi če ga prilagodim za kritike, ostaja statistično podoben trenutno manj sofisticiranemu kazalniku. Čeprav mi ni uspelo potrditi RH3 glede »Insider« kazalnika, predvsem zaradi omejitev pri podatkih, sem odprla možnost drugim raziskovalcem, da lahko v primeru boljše dostopnosti do podatkov uporabijo enak pristop in pridobijo bolj natančne zaključke. Čeprav je bilo razmerje »Put/Call« večkrat omenjeno v spletnih člankih, nisem našla znanstvenega članka, ki bi

raziskoval ta kazalnik. Zato lahko ta naloga služi kot potrditev zanesljivosti tega kazalnika. Nazadnje, naloga služi tudi za testiranje obdobja med letoma 2018 in 2022 za finančne mehurčke ter potrditev njihove prisotnosti v letu 2021. Ker trenutno še ni veliko člankov na to temo, lahko naloga služi tudi kot izhodišče za ponovno analizo tržnih mehurčkov po nekaj letih, ko bodo na voljo podatki za daljše časovno obdobje in ko bi jih morda zaznal tudi PSY model.

Appendix Table 1: Spearman Rank Correlation and two tailed z-test for testing RH1 on data 1970 - 2018

BUBBLE	
Spearman Rank Correlation	0.31
t	1.61
n	26
p	0.12

No BUBBLE	
Spearman Rank Correlation	0.16
t	2.00
n	149
p	0.05

Source: (FRED Economic data, 2023a&b)

Appendix Table 2: CAPE mean and t-test on data 1970 - 2018 (no hypothesis testing)

	BUBBLE	NO BUBBLE
Mean	33.2665753	18.0553535
Variance	70.5282895	44.4839877
Observations	73	495
Hypothesized Mean Difference	0	
df	86	
t Stat	14.8023469	
P(T<=t) one-tail	1.133E-25	
t Critical one-tail	1.66276545	
P(T<=t) two-tail	2.2659E-25	
t Critical two-tail	1.98793421	

Source: Nasdaq Data Link (2023b)

Appendix Table 3: T-test on means of adjusted and unadjusted Market Cap to GDP Ratio (RH2) on data from 1970 - 2018

	BUBBLE I NO AJD.	BUBBLE I ADJ.
Mean	97%	107%
Variance	0.077104707	0.069148591
Observations	27	27
Hypothesized Mean Difference	0	
df	52	
t Stat	-1.379708648	
P(T<=t) one-tail	0.086790293	
t Critical one-tail	1.674689154	
P(T<=t) two-tail	0.173580586	
t Critical two-tail	2.006646805	

	NO BUBBLE I ADJ.	NO BUBBLE I NO ADJ.
Mean	71%	74%
Variance	0.067590869	0.063335178
Observations	158	158
Hypothesized Mean Difference	0	
df	314	
t Stat	-1.162246814	
P(T<=t) one-tail	0.123008918	
t Critical one-tail	1.649720831	
P(T<=t) two-tail	0.246017837	
t Critical two-tail	1.967547698	

Source: FRED Economic data, (2023a,b,d,e)

Appendix Table 4: T-test on means of Market Cap to GDP Ratio during market bubble and no-bubble on data from 1970 - 2018

	BUBBLE I NO AJD.	NO BUBBLE I ADJ.
Mean	97%	71%
Variance	0.077104707	0.067590869
Observations	27	158
Hypothesized Mean Difference	0	
df	34	
t Stat	4.58827962	
P(T<=t) one-tail	2.91687E-05	
t Critical one-tail	1.690924255	
P(T<=t) two-tail	5.83374E-05	
t Critical two-tail	2.032244509	

	BUBBLE I ADJ.	NO BUBBLE I NO ADJ.
Mean	107%	74%
Variance	0.069148591	0.063335178
Observations	27	158
Hypothesized Mean Difference	0	
df	35	
t Stat	6.082043065	
P(T<=t) one-tail	3.01062E-07	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	6.02124E-07	
t Critical two-tail	2.030107928	

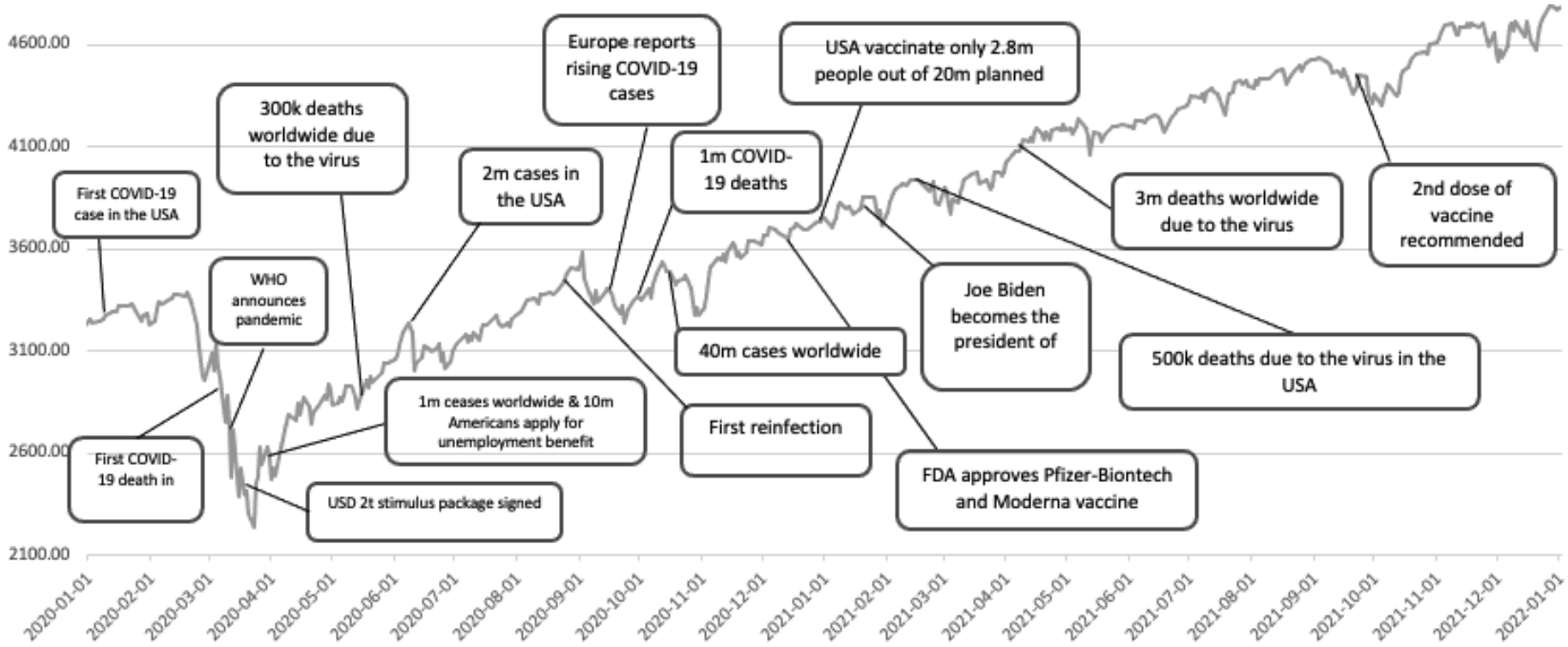
Source: FRED Economic data, (2023a,b,d,e)

Appendix Table 5: Put/Call Ratio t-test to test RH4 on data from 1970 - 2018

	BUBBLE	NO BUBBLE
Mean	56%	80%
Variance	0.010453624	0.03095947
Observations	70	250
Hypothesized Mean Difference	0	
df	187	
t Stat	-14.53840975	
P(T<=t) one-tail	7.77833E-33	
t Critical one-tail	1.653042889	
P(T<=t) two-tail	1.55567E-32	
t Critical two-tail	1.972731033	

Source: Bloomberg Terminal (2022b)

Appendix Figure 1: S&P 500 and events between 2020 and 2022



Source: FRED Economic data, (2023f) and NLB Funds (2022 and 2023)

Appendix Table 6: Testing RH 5 based on Adjusted Market Cap to GDP Ratio on data from 2018 - 2022

DATE	ADJ. TRESHOLD	ADJ. INDICATOR	BUBBLE AS PER INDICATOR

2017 - Q4	107%	137%	yes
2018 - Q1	107%	143%	yes
2018 - Q2	107%	133%	yes
2018 - Q3	107%	134%	yes
2018 - Q4	107%	141%	yes
2019 - Q1	107%	143%	yes
2019 - Q2	107%	146%	yes
2019 - Q3	107%	143%	yes
2019 - Q4	107%	135%	yes
2020 - Q1	107%	154%	yes
2020 - Q2	107%	182%	yes
2020 - Q3	107%	184%	yes
2020 - Q4	107%	196%	yes
2021 - Q1	107%	200%	yes
2021 - Q2	107%	201%	yes
2021 - Q3	107%	189%	yes
2021 - Q4	107%	167%	yes
2022 - Q1	107%	159%	yes
2022 - Q2	107%	152%	yes

Source: FRED Economic data, (2023a,b,d,e)

Appendix Table 7: Testing RH 5 based on CAPE Ratio on data from 2018 - 2022

DATE	TRESHOLD	INDICATOR	BUBBLE AS PER INDICATOR	DATE	TRESHOLD	INDICATOR	BUBBLE AS PER INDICATOR
01/01/2018	33.27	33.31	yes	01/11/2020	33.27	32.47	
01/02/2018	33.27	32.04		01/12/2020	33.27	33.77	yes
01/03/2018	33.27	31.81		01/01/2021	33.27	34.51	yes
01/04/2018	33.27	30.97		01/02/2021	33.27	35.1	yes

01/05/2018	33.27	31.24		01/03/2021	33.27	35.04	yes
01/06/2018	33.27	31.63		01/04/2021	33.27	36.72	yes
01/07/2018	33.27	31.89		01/05/2021	33.27	36.55	yes
01/08/2018	33.27	32.39		01/06/2021	33.27	36.7	yes
01/09/2018	33.27	32.62		01/07/2021	33.27	37.44	yes
01/10/2018	33.27	31.04		01/08/2021	33.27	37.97	yes
01/11/2018	33.27	30.2		01/09/2021	33.27	37.62	yes
01/12/2018	33.27	28.29		01/10/2021	33.27	37.25	yes
01/01/2019	33.27	28.38		01/11/2021	33.27	38.58	yes
01/02/2019	33.27	29.54		01/12/2021	33.27	38.31	yes
01/03/2019	33.27	29.58		01/01/2022	33.27	36.94	yes
01/04/2019	33.27	30.13		01/02/2022	33.27	35.29	yes
01/05/2019	33.27	29.24		01/03/2022	33.27	34.27	yes
01/06/2019	33.27	29.28		01/04/2022	33.27	33.89	yes
01/07/2019	33.27	29.99		01/05/2022	33.27	30.8	
01/08/2019	33.27	28.71		01/06/2022	33.27	29.29	
01/09/2019	33.27	29.23		01/07/2022	33.27	29.35	
01/10/2019	33.27	28.84		01/08/2022	33.27	31.17	
01/11/2019	33.27	29.84		01/09/2022	33.27	29.53	
01/12/2019	33.27	30.33		30/09/2022	33.27	26.84	
01/01/2020	33.27	30.99		01/10/2022	33.27	27.08	
01/02/2020	33.27	30.73		31/10/2022	33.27	28.53	
01/03/2020	33.27	24.82		01/11/2022	33.27	28.46	
01/04/2020	33.27	25.93		30/11/2022	33.27	29.9	
01/05/2020	33.27	27.33		01/12/2022	33.27	28.46	

01/06/2020	33.27	28.84	01/01/2023	33.27	28.65
01/07/2020	33.27	29.6	31/01/2023	33.27	29.61
01/08/2020	33.27	31.16	01/02/2023	33.27	29.92
01/09/2020	33.27	30.84	28/02/2023	33.27	28.84
01/10/2020	33.27	31.28	01/03/2023	33.27	28.7

Source: Nasdaq Data Link (2023b)

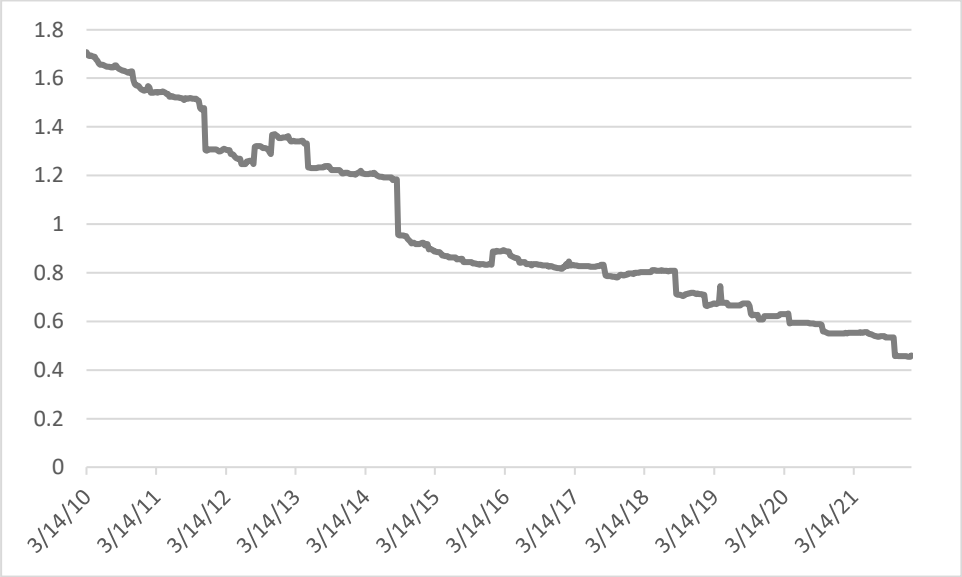
Appendix Table 8: Testing RH 5 based on Put/Call Ratio on data from 2018 - 2022

DATE	THRESHOLD	INDICATOR	BUBBLE AS PER INDICATOR	DATE	THRESHOLD	INDICATOR	BUBBLE AS PER INDICATOR
31/01/2018	0.59	0.818		29/05/2020	0.59	0.838	
28/02/2018	0.59	0.968		30/06/2020	0.59	0.716	
30/03/2018	0.59	0.92		31/07/2020	0.59	0.73	
30/04/2018	0.59	0.851		31/08/2020	0.59	0.573	
31/05/2018	0.59	0.911		30/09/2020	0.59	0.694	
29/06/2018	0.59	0.943		30/10/2020	0.59	0.93	
31/07/2018	0.59	0.852		30/11/2020	0.59	0.566	
31/08/2018	0.59	0.854		31/12/2020	0.59	0.65	
28/09/2018	0.59	0.894		29/01/2021	0.59	0.665	
31/10/2018	0.59	1.006		26/02/2021	0.59	0.684	
30/11/2018	0.59	0.821		31/03/2021	0.59	0.583	

31/12/2018	0.59	0.922	30/04/2021	0.59	0.711	
31/01/2019	0.59	0.802	31/05/2021	0.59	0.548	yes
28/02/2019	0.59	0.961	30/06/2021	0.59	0.521	yes
29/03/2019	0.59	0.811	30/07/2021	0.59	0.728	
30/04/2019	0.59	0.928	31/08/2021	0.59	0.587	
31/05/2019	0.59	1.197	30/09/2021	0.59	0.775	
28/06/2019	0.59	0.803	29/10/2021	0.59	0.557	yes
31/07/2019	0.59	0.925	30/11/2021	0.59	0.698	
30/08/2019	0.59	1.086	31/12/2021	0.59	0.662	
30/09/2019	0.59	1.004	31/01/2022	0.59	0.831	
31/10/2019	0.59	0.825	28/02/2022	0.59	0.836	
29/11/2019	0.59	0.767	31/03/2022	0.59	0.782	
31/12/2019	0.59	0.696	29/04/2022	0.59	1.026	
31/01/2020	0.59	1.063	31/05/2022	0.59	0.812	
28/02/2020	0.59	1.274	30/06/2022	0.59	0.954	
31/03/2020	0.59	1.101	29/07/2022	0.59	0.792	
30/04/2020	0.59	0.856				

Source: Bloomberg Terminal (2022b)

Appendix Figure 2: Cumulative Percentage of Insider Shares Outstanding for DJIA Index between 2010 and 2022



Source: Bloomberg Terminal (2022a)