MSc Applied Economics and Finance

Master Thesis

Disclosing green bubble indications in the U.S. renewable energy industry

Authors;
Michelle Jørgensen: 124595
Helle Øye Dyhrfjeld: 102950

Supervisor: Thomas Einfeldt
Submitted: 15-05-2020

Number of pages: 119
Characters incl. spaces: 269,861

CBS COPENHAGEN BUSINESS SCHOOL
HANDELSHØJSKOLEN

ABSTRACT

This thesis seeks to investigate if indications of a run-up to a green bubble can be found in the U.S. renewable energy industry, based on observed market tendencies. A time-series analysis is performed investigating the explanatory effects of contagion proxies and fundamental proxies on stock returns. The analysis was performed on three samples grouped based on the degree of involvement in renewable energy. A green sample with a sole focus on renewables, a grey sample in transition to renewables from fossil fuels and a black sample with a sole focus on fossil fuels. Neither the green nor the black sample exhibited indications of a run-up to a bubble. However, through a cointegration test, the grey sample discloses an indication of a bubble run-up.

In line with previous research, the indicated bubble run-up may be a cause of a positive green reward deriving from the grey sample transitioning to renewables (Görgen et al., 2019). The empirical analysis conveys how fully renewable companies have a significant risk attached to the possibility of not received government support, in addition to dependency on innovation. These risk factors are possible reasons for why the green sample is not benefitting from the deduced green reward like they more diversified grey sample possibly do. If these risks decrease it may allow fully renewable companies to benefit fully from the possible indicated green reward which may foster for a green bubble to grow in the future.

Keywords: green bubble; renewable energy; asset price dynamics; time series; carbon risk; green reward

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The first chapter of this master thesis will introduce the green finance tendencies observed in the financial market and describe how these lay the foundation for the research question of this thesis. It will elaborate on the motivation and the applicableness of researching a possible green bubble within renewable energy. This will be followed by description of the delimitations taken in researching the field, and this will be followed by an elaboration on the research approach. Lastly, an overview of the further structure of the thesis will be depicted.

1.1 INTRODUCING THE SCENE

The globe is facing an inevitable climate crisis, caused by humans' actions. The increased global temperature and its consequences has been followed by an increased awareness of the climate change. The stock markets develop together with economic and global trends. Hence, trailing the increasing awareness of the climate crisis, the term green finance has appeared in the financial markets. Green finance or green investing integrates environmental considerations into the investment process and there are numerous of investors looking for green investment opportunities. The two climate activists, Greta Thunberg and George Monbiot further pushed the topic green finance on to the public in describing how green funding is one of the ways people can help fight climate change (Conservation international, 2019). Investors mindset have changed, and investors want to "do more with their money than invest it for a return and that will continue" says James Sym of London-based Schrodes (The Irish Times, 2020). This change of focus is shown in the stock market as green stocks the most recent years has experienced a surge. For example, U.S. investment funds characterized with a sustainable focus, received a record of 21 billion dollars of investments in 2019, which was nearly four times the rate of inflow in 2018 (Financial Times, 2020). This trend has been the most evident in the energy sector, specifically within renewable stocks. Transitioning to a low carbon economy by using renewable energy instead of fossil fuels can keep global warming under the healthy target level of 1.5 ºC. This transition requires investments of an average of three trillion dollars a year, the next three decades (IPCC, 2018). The large required investment need has been heard by investors and is reflected by the surge in renewable stocks in the last and first quarter of 2019 and 2020, respectively. Some analysts have expressed concerns about this development. The head of global ESG research of Credit Suisse, Eugene Klerk, voiced, in regard to the renewables stocks, that "there appears to be a growing disconnection between operational performance and stock price returns. There is a growing awareness or nervousness around this particular topic" (Financial Times, 2020). A disconnection between operational performance, which is an important feature impacting a firms' fundamental value, and the stock price return, may imply that the asset is mispriced. If an asset has an overly high price which its fundamentals cannot justify, the asset may be mispriced in the form of having a bubble component to its pricing. Brunnermeier and Oehmke (2013) describes how the formation of a bubble is often incepted and started from a type of innovation or event. Climate change can be seen as an event that has changed investors priorities and expectations about the future. Overall, climate change has also had an impact on the financial markets bringing in the term green finance, where specifically renewable energy stocks has received great attention and funding the past years. The general pricing of these assets is high and may seem disjointed from their intrinsic value. Consequently, this thesis seeks to investigate whether green renewables stocks has experienced a run-up to a bubble in the past decade.

1.2 RESEARCH QUESTION

The research question is inspired from the increasing green focus observed in the financial market. The great attention and the funding that the field of green finance has received, lays the foundation for the suspicion of whether the market has experienced a run-up to a green financial bubble. The run-up to bubble prices is suspected since the increasing awareness for green stocks has brought in large sums of investment and high valuations for some green companies. This motivates the question of whether the high valuations and prices of the green stocks, reflect their intrinsic fundamental value. If the prices do not reflect its intrinsic value, there may be a bubble component to the green stocks pricing (Porras, 2016). The bubble run-up phase is characterized with growing awareness amongst investors for the specific asset and is where bubbles and imbalances form (Brunnermeier and Oehmke, 2013). Further, the particularly great attention the renewables stocks has received narrows down the research field, into looking at a green bubble development within renewables stocks in the United States (U.S.). The research question is stated below.

Can a run-up to a financial green bubble be indicated in the U.S. renewable energy industry?

- To which degree can stock prices be explained by proxies for fundamental value and proxies for a bubble component?
- Dependent on the degree of involvement in renewable green energy, do the significance of the key proxies differ? Specifically, are the bubble proxies more evident within stocks involved with renewable energy?

The main research question of whether a run-up to a financial green bubble within renewables can be indicated will be examined by analyzing energy companies' stock returns and the explanatory effect of fundamental proxies and bubble proxies. If fundamental proxies have significant explanatory effect on stock returns, the stocks prices are likely to reflect its fundamental value. On the other hand, if bubble proxies, namely contagion proxies, can explain stock returns, a bubble can be indicated. Further, the three samples that are grouped on the basis of degree of involvement in renewable energy will be investigated, to see whether the significance of the fundamental and bubble proxies differ. If contagion proxies are significant for companies involved with either fully, or partially, green renewable energy, and not for companies involved with non-green fossil fuel, it may be indicative of a green bubble. If fundamental proxies are significant for companies involved with fossil fuels, and not for companies involved with renewable energy it may indicate that the fossil fuel companies have a value closer to its fundamental value. Comparison between fossil fuel and renewable companies are also made to distinguish whether the bubble is present in the overall energy industry, or whether it is, as suspected, present in only the green renewable companies.

The question is formulated in past-tense as the analysis will investigate whether there has been a run-up of a green bubble in the time period of 2009 - 2019, since this is the time period where the area of green finance has received great attention. Hence, the research question does not address the new 2020 market conditions that the market currently is facing in relation to the coronavirus pandemic and the current recession. The thesis will examine the implications of the new market situation on the possible indication of a green bubble in the discussion, after the findings has been presented. Overall, it is important to mark that the main empirical analysis conducted in this thesis is based on data and circumstances before the economic recession in which will not be taken into consideration before the discussion.

1.3 Delimitations

A clear delimitation of this thesis is that it does not seek to establish for certain that a run-up to a green bubble has existed. Also, even if an indication of a bubble is present, it is not the equivalent of stating that there has been a bubble, since the indication of a bubble can be present without a bubble being present in the reality (Porras, 2017). Furthermore, Fama (2014) describes how previous predictions made about bubbles only were stated as correct when the bubble had burst. The burst of the bubble is the "basis for the inference that the original bubble prediction was correct" (Fama, 2014:1476). Hence, if the analysis gives an indication of a run-up to a green bubble, whether that prediction will be stated as correct, depends on whether that bubble at some point will burst. Consequently, this thesis limits itself from stating that there has been a run-up to a green bubble, as that task is challenging since history have shown that it can only be established after the burst of the bubble. Hence, the thesis will seek for indications for run-up to a green bubble. The indications and findings are also bound to the chosen statistical method applied, as there are a range of methods that can be used to indicate a bubble. Hence, the findings are limited to the method applied, as other methods could have given other indications and findings.

As the research question states, it looks for indications of a green bubble within renewable energy stocks. Hence, for the purpose of further analysis, the term green bubble will refer to a green bubble within renewable energy stocks. However, although the research analysis is narrowed down to these stocks, the introductory analysis describing the green finance area will uncover similar tendencies for the general group of green stocks. Since the area of general green stocks is outside of the scope of this thesis, additional research is needed to uncover whether the general group of green stocks can be associated with bubble tendencies. Further specification is made by only analyzing companies registered at the two large U.S. stock exchanges NYSE and Nasdaq. Hence, the data sample only includes established public companies, with a large part of their business in the United States.

1.4 Relevance

The study of and aim to identify a potential green bubble can contribute with case specific knowledge research field of bubbles. By conveying specific characteristics of the possible run-up to a green bubble can provide additional case-specific knowledge, which together with other studies of bubbles, collectively can broaden the field of knowledge and understanding of the mechanisms involved in bubbles. Case specific research can be seen as extra important within the field of bubbles, since bubbles will find new ways to form and burst, and thus studying specific bubble cases can provide a better perception of the concept of bubbles. Porras (2017) describes how "achieving a better understanding of the formation of bubbles and the impact of contagion will no doubt determine the stability of future economies" (Porras, 2017:ix). Bubbles are important to understand since they can negatively affect the economy. Long-lasting bubbles affect the real allocation of resources in the economy in addition to draining resources from the system (Porras, 2016:6). Hence, if a run-up to a green bubble can be indicated, this can in the interest of the government, portfolio managers and investors. The U.S. government may find it valuable in the way that some politicians, like Federal Reserve Board Vice Chairman Stanley Fisher, find it important to identify and prevent bubbles, in order to stabilize the economy (Forbes, 2014). Portfolio managers and investors may find it interesting since an indication of a run-up to a green bubble may signal that investments into green renewable stocks should be evaluated critically in order to avoid paying a too high price, for investing in a bubble. For example, James Sym of London-based Schrodes cautioned that "it's important for managers to respect ESG but they should be "very careful" that they don't put investors' money into bubbles" (The Irish Times, 2020). However, as will be debated in the discussion, the current economic environment characterized by a recession, will not allow for a bubble to grow. If a run-up to a green bubble can be indicated as present from 2009 – 2019, it may however, increase the risk of a green bubble forming again when the economy is back in an expansion phase. Further indicating a run-up to a green bubble within renewables, maybe indicate a similar tendency to the general group of green stocks, which may encourage further research on this area. Consequently, uncovering a run-up to a green bubble may be in the interest of researchers, the government, portfolio managers and investors.

1.5 RESEARCH APPROACH

According to Thornhill, Saunders and Lewis (2009) the research approach or research design is a general plan on how to answer the research question. Consequently, all research decisions should be related to the research question. In general, the first decision to make is whether the research question is to be answered with a deductive or inductive approach. A deductive approach builds upon a theory and hypotheses, and a research strategy is set up to test these hypotheses. Furthermore, a deductive approach is testing theory. In order to do so, a set of hypotheses are set up to test the specific theory, where the results of the hypothesis test can be modified in the light of the theory (Thornhill et al., 2009).

1.5.1 Deductive approach applied

This thesis presents a research question that will be answered using a deductive approach. The question does not seek to develop a new theory on the basis of the results, thus, an inductive approach is counterintuitive. The question rather seeks to test whether green stocks can be described as being priced with bubble prices, according to existing theory on bubbles. The deductive approach is implemented using an econometric analysis and framework. The econometric deductive approach implemented in this analysis has three main approaches. Firstly, the method aims to search for relationships between variables. Secondly, the data needs to be measured quantitatively and a set of controls is needed to test the validity of the hypotheses. The controls implemented should test whether the chosen variables are the best ones to the hypothesis. Lastly, it is necessary to collect data on a sufficient number of entities in order to being able to generalize statistically (Thornhill et al., 2009).

The research question posed in this thesis aims to investigate whether renewable energy stocks can be described with bubble prices. A bubble price can be defined as when the price of the asset is over its fundamental value, namely there is a bubble component to the pricing of the asset (Porras, 2016). In order to answer this question, stock price returns are analyzed in relation to its correlation with variables that are presented in financial bubble and asset price theory. According to financial and bubble theory, stock prices and its returns can be explained by the general economic environment, its fundamental variables and bubble components (Porras, 2016:24). By using an econometric time-series approach, the data is analyzed to investigate the relationship between green stock returns and changes in explanatory variables deducted from Porras (2017) financial bubble framework. Hence, if the bubble proxies can explain the development in stock returns within the renewable energy sector over time, this may indicate a bubble within green energy stocks. To test these relationships, data on company financials, stock prices and other trading data is collected on public American energy companies.

The econometric method is chosen as it lays a numerical and founded basis for making inferences on whether a green bubble can be indicated. The phenomenon of bubbles is characterized of abnormally high prices which develops within a period of time. Consequently, by using an econometric time-series approach which analyzes stock price data over time, the possible bubble component may be identified. Further, as opposed to using a few specific case studies, the sampling of numerous American energy companies enables to draw a more general inference on the identified economic phenomenon. However, the drawback with using a time series econometric approach is that faulty relationships that does not represent the truth, may occur.

1.5.2 Collecting empirical theory and literature

Empirical theory and literature have been reviewed from primary sources, such as founding research articles, and secondary sources, such as Porras (2016), which review original fieldwork. Tertiary sources, in the form of the financial databases, like Capital IQ and Federal Reserve Economic Data (FRED), has been used to collect data on stock prices, trading data, financial statement information and macroeconomic data. Theory on bubbles, corporate finance, firm valuation, asset price dynamics and econometrics and time series will be applied. Information on the energy industry, economic environment, institutions and organizations, and news articles will further support the analysis. Further, conversations with the researcher and the author of the main literature and method applied, PhD Eva Porras, have further given insight into the field of bubbles and method applied. Additional mail correspondence with employees at Maj Invest have given insight into a general framework of looking at P/E ratios and expected growth rates.

1.6 Structure

The thesis consists of eight descriptive chapters. The first chapter, as read, introduced the scene, research question, delimitation, relevance and method of the thesis. The second chapter, namely literature review, will introduce the area of green finance and tendencies observed, the energy market, theory on financial bubbles and principles on asset price dynamics. This chapter will lay the foundation for the method and delimitations taken in the research approach and analysis. The third chapter, data sample, will show the market conditions present for the data samples time period, describe field specification, and characteristics of the data samples, and lastly describe variables and how the dataset has been transformed. The fourth chapter will introduce the time series methodology which is the toolbox that will be applied in the fifth chapter, statistical analysis, which analyses the data using an econometric time series analysis. The sixth chapter will describe the findings, its implications and give a review of the applied research approach. The seventh chapter, discussion, will uncover the implications that the new economic environment will have on the findings and research question. The last descriptive chapter, the conclusion, will integrate the findings from before and after the economic recession.

2. LITERATURE REVIEW

For the reader to get a better understanding of the underlying theories and concepts behind the research questions, various literature on relevant topics are presented in this chapter. This part of the thesis will lay the basis for further research and analysis. The first section will present development on the green transition both in the financial markets and the overall economy. The second section describes the energy industry which is important to understand the data samples that later in the thesis will be analyzed. The third section presents theory on financial bubbles and circumstance that is needed for them to grow. The last and fourth section, elaborates on asset price dynamics. This section explains how fundamental variables and contagion proxies can be used to indicate the existence of a bubble. Hence, this section explains the relevance of the variables chosen in the econometric analysis applied later in chapter five.

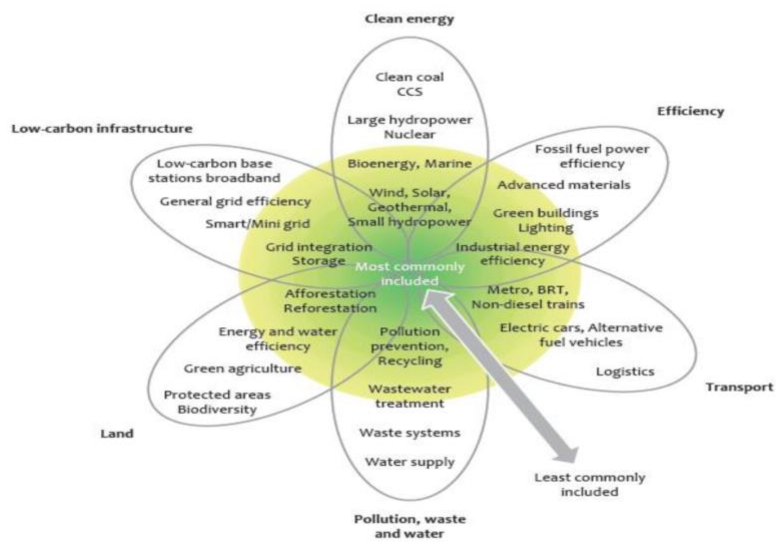
2.1 THE GREEN TRANSITION

2.1.1 SUSTAINABLE FINANCE AND GREEN FINANCE

The stocks markets develop together with events and trends in the general economy and world. In line with the world facing a serious climate crisis, the term sustainable finance has appeared in the stock markets. Investors look for investment opportunities in which their money can contribute to working towards a more sustainable economy. University of California, Berkley (2017) describes sustainable finance as “the practice of creating economic and social value through financial models, products and markets that are sustainable over time.” European commission (collected 24.04.2020) further defines sustainable finance as “to the process of taking due account of environmental and social considerations when making investment decisions, leading to increased investment in longer-term and sustainable activities.” The Environmental, Social and Governance (ESG) score, measures the sustainability and societal impact of an investment in a company or business, and is a fairly widely accepted and used term amongst investors (AXA Investment Managers and AQ Research, 2008). Thus, the concept of sustainable finance, can refer to several related terms such as green finance, carbon finance and ethical finance, which all aim to finance sustainable development.

For the scope of this thesis, green finance is the term that will be investigated, as it is the area where a bubble formation is suspected. Green finance and the approach of green investing integrates environmental considerations into the investment process. It applies a set of criteria to collect environmentally friendly assets active in different areas. Such areas can be renewable energies, alternative fuels, clean technologies and pollution reduction (Lesser, Lobe and Walkshaüsl, 2014). The figure below conveys which terms that are related to green finance and what is least and most commonly included. For example, in the branch "Clean Energy" the terms "Wind, Solar, Geothermal, Small Hydropower" is the most commonly included and the terms "Clean coal" and "Carbon Capture and Storage (CCS)" is least the commonly included in the term green finance.

FIGURE 2.1 COMPONENTS OF GREEN FINANCE DEFINITIONS



Source; United Nations Environment Program (UN Environment), 2017

2.1.2 CLIMATE CHANGE

The climate crisis the globe currently is facing is undeniable. The Intergovernmental Panel on Climate Change (collected 23.04.2020) has stated that, "scientific evidence for warming of the climate system is unequivocal." The evidence for rapid climate change can be seen in a global temperature rise, warmer oceans, shrinking ice sheets, glacial retreat, decreased snow cover, sea level rice, declining arctic sea rise, extreme events and ocean acidification (NASA, collected 23.04.2020). The list is long and conveys the seriousness of the challenge humans are facing.

Individuals and institutions are aware that the globe is under a time pressure in terms of fighting the climate change. Green investments are one of many possible ways individuals and institutions can support the green change towards a more sustainable economy. Although transitioning to a low carbon economy may be capital intensive at first, New Climate Economy (2018) has estimated that the net economic gain from transitioning to a low carbon economy is 26 trillion dollars[1] through to 2030, compared with business-as-usual. A green economy, or a low carbon economy, is an economy that is low carbon and resource efficient (UNEP, collected 23.04.2020). Thus, the term green transition refers to the transition to a green and low carbon economy. Further, transitioning to a low carbon economy represents a large growth potential for green environmentally friendly industries such as renewable energies, alternative fuels, clean technologies (New Climate Economy, 2018). Thus, green investing is attractive for two main causes, it finances a good cause in addition to expected positive returns represented by the expected net economic gain and expected growth in green industries. James Sym of London-based Schrodes describes how investors and clients has changed their mindset in regard to investing. Sym stated to the Irish Times that "clients want money managers to do more with their money than invest it for a return and that will continue" (The Irish Times, 2020). Further António Guterres, secretary general of United Nations, states that "financing is critical for achieving the sustainable development goals and fulfilling the aims of the Paris Agreement on climate change" (United Nations, 2018).

2.1.3 Green initiatives

There are several initiatives that are set out in order to deter the climate changes' negative development. Three main sustainable initiatives are the Paris Agreement and the Sustainable Development Goals (SDG), and United Nations Environment Programme Finance Initiative (UNEP FI) organized by the United Nations. As a part of the Paris Agreement (2016) all parties agreed to «holding the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change» (United nations, 2015). In all there were 175 countries which signed this agreement, including the U.S. (United Nations, 2016). United Nations describes the 17 Sustainable Development Goals as «the blueprint to achieve a better and more sustainable future for all» (United Nations, collected

[1] Dollars in this thesis refers to U.S. dollars (USD)

23.04.2020a). These 17 goals are an agreement between the 193 United Nations member states, and five of these goals is directly related to fighting climate change (United Nations, collected 23.04.2020b). Further, United Nations has an Environment Programme Finance Initiative (UNEP FI) which is a global partnership established between financial institutions and the United Nations Environment Programme (UNEP FI, collected 24.04.2020). UNEP FI aim to "help create a financial sector that serves people and planet while delivering positive impacts" (UNEP FI, collected 24.04.2020). The many initiatives set out, both in general sustainability and specifically directed to green financing, shows the importance and attention this topic of green finance has received.

The 193 United Nations members represent countries from all over the world. These countries face different challenges in financing their sustainable development in line with the SDG goals. The field of green finance is still under development and there are no concrete guidelines on how the "green aspect" are integrated into traditional financial mechanisms (Ziolo and Sergi, 2019). Some of the frameworks that are developed to signal companies' sustainability are the ESG-score and companies' own statement of which SDG-goals they are working towards. Signaling these goals and information may make sustainable investments more transparent in addition to attracting investors that care about the same goals (United Nations, 2019). Although ESG-scores and firms stated SDG goals are present, it still may be hard for investors to grasp how sustainable and environmentally friendly a company in reality is. Companies are aware that many investors are looking to make green investments, and that may induce the companies to green wash themselves. That is, to signal themselves as more environmentally friendly, than what they really are (Bowen, 2014).

2.1.4 GREEN EQUITIES

Within traditional financial products as debt and equity, there is green finance products such as green bonds and green funds (Ministry of Economic Affairs and Employment of Finland, 2017). This section will focus on the green equity side, investigating development in green stocks.

Several studies have found that in later years green equites performs better compared to black equities. Green firms and funds are entities that promotes a green economy, and black firms and funds does the opposite and obstruct for a green economy. Ibikunle and Steffen (2017) investigated the financial performance of green, black and conventional mutual funds over the 1991 - 2014 period. The authors found that over the full sample period the green funds underperformed compared to the conventional mutual funds but found no performance difference between green and black mutual funds. However, the authors evidence suggested that the green mutual funds were beginning to significantly outperform the black mutual funds, especially in the 2012-2014 time period (Ibikunle and Steffen, 2017). Further, Görgen et al. (2019) found that green firms on average outperform black firms. In line with the findings of Ibikunle and Steffen (2017), Görgen et al. (2019) also found that the outperformance of green firms compared to black firms, was particularly evident in the recent years of 2010 - 2016. Görgen et al. (2019) relates the performance to the term carbon risk, which is the financial risk to companies associated with the transition to a low-carbon economy. The authors explain the performance gap, with that green firms are more likely to invest in innovation and clean technology, and less in "dirty" black technologies. Although, the firm would be exposed to carbon today, their investments in green projects would signal future less carbon emissions, and a lower carbon risk (Görgen et al., 2019). The term carbon risk has come as a result from the past years' introduction of carbon pricing in some countries and less willingness from institutional investors to invest in business that rely on the burning of fossil fuels. Hence, black firms will increasingly be exposed to higher capital costs, lower growth, and reduced returns on their investments (Görgen et al., 2019).

In the most recent years, the sustainable and green stocks have experienced a surge. In 2019 a record of 21 billion dollars were invested in U.S. investment funds with a sustainable focus, nearly four times the rate of inflows in 2018 (Financial Times, 2020). The surge of interest was also shown for firms with top ESG rankings in February 2020. Savita Subramanian, head of US equity strategy at Bank of America, describes how companies with strong ESG rankings traded at a 30% premium compared to the poorest performers as measured by their forward price-to-earnings ratios (Financial Times, 2020). This trend has been the most evident in the energy sector. The fossil fuel firms are facing big headwinds given their carbon emissions, whereas the renewable energy stocks had a surge between the last and first quarters of 2019 and 2020 respectively. Eugene Klerk, Credit Suisse's head of global ESG research, expressed, in regard to the renewable energy stocks, that "there appears to be a growing disconnect between operational performance and stock price returns. There is a growing awareness or nervousness around this particular topic" (Financial Times, 2020). Operational performance is often deemed as one of the features that represent a firms' fundamental value. Hence, if there is a disconnection between a proxy for fundamental value and the stock price returns, that may raise the question of whether the stock prices reflect their intrinsic fundamental value. If stock prices are not equal to their fundamental value, there may be a bubble component to their pricing. This is in line with Porras (2016) which defines a bubble as “asset prices that are not justified by the assets ‘fundamentals’ or intrinsic value” (Porras, 2016:5).

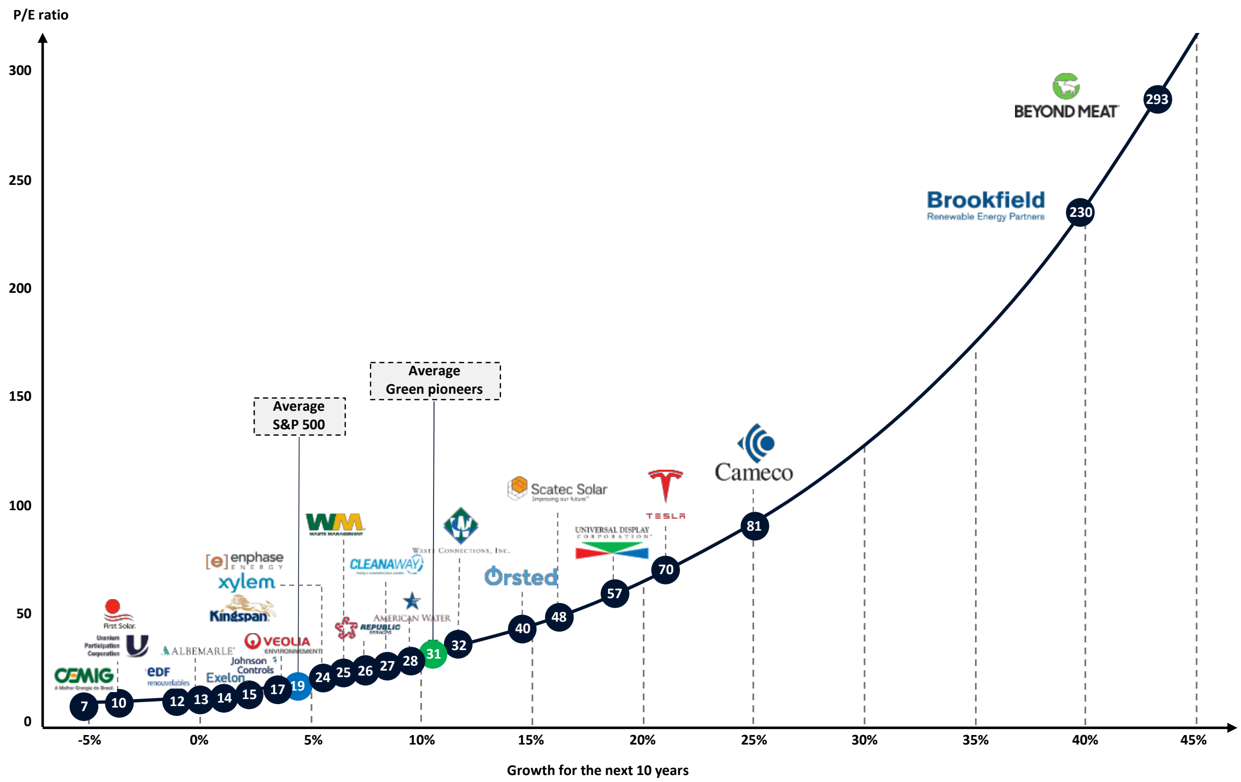
2.1.5 Indications of a green bubble?

The formation of a bubble is often incepted and started from a type of innovation or event (Brunnermeier and Oehmke, 2013). The climate change can be seen as an eye-opening event that has changed investors priorities and expectations about the future. For many, transitioning to a green economy is the only way the globe can be sustained, and this may lead to investors forming a “this time it is different” mindset. This mindset may convince investors that abnormally high stock prices are fairly priced, given the new expectations for the future (Brunnermeier and Oehmke, 2013).

To investigate the indication of a bubble further, price-to-earnings (P/E) ratios and their implicit growth expectations can be examined. The P/E ratio is a ratio for valuing a firm and measures the value of equity to the firm’s earnings. The forward P/E ratio, calculated with the estimated next twelve months EPS is applied in the graph under, and it shows what the market is willing to pay based on the company’s next year’s estimated earnings (Berk and DeMarzo, 2017).

A P/E ratio can implicitly convey expected growth rates for a company, in the way that investors pay a very high price for, often, little expected earnings the next year, in order to hold the stock when it is expected to grow immensely in future years. Thus, by looking at P/E ratios and their related growth expectations a bubble price can be implied. The graph under is a general framework, projected at a presentation made by Maj Invest (2020), which conveys different P/E ratios implicit expected growth rate for the next ten years. It is meant for illustrative purposes to show a general tendency. Thus, it should not be understood as a relationship that always holds true as it is simplified relationship using specific assumptions together with a two-period dividend model (Mail correspondence Maj Invest, 2020). Hence, other assumptions and methods of finding implicit expected growth rates for P/E ratios may find other relationships. See appendix A for calculations of the formation of the graph for the general framework. The framework is used to represent P/E ratios for companies that were named as green pioneers by Saxo Bank Group (2020). Hence, the graph outlined under, shows P/E ratios for selected green pioneers, the green pioneers weighted average P/E ratio and the P/E ratio for S&P500. All numbers are from the date of 31.12.2019.

FIGURE 2.2: P/E RATIOS AND INDICATED FUTURE GROWTH



Source: Maj Invest; Authors

The graph indicates that Beyond Meat and Brookfield renewable energy partners, with the P/E ratios 293 and 230 respectively can be characterized with bubble prices. The former P/E ratio represent an expected growth, every year, the next ten years of nearly 45%, and the latter represent an expected growth, every year, the next ten years of nearly 40%. It is fair to describe these large growth expectations as unrealistic and even naive. The growth expectation induced from companies with a P/E ratio in the range of 70-81 can also be seen as unlikely. According to Maj Invest (2020) stocks with a P/E ratio in the range of 25-50 had indicated a growth at reasonable prices. Further, stocks with P/E ratios in the range of 10-25 are described as value stocks. A key point which is conveyed by the graph is the difference in P/E ratio for S&P500 and the total green pioneers. The average P/E ratio for the green pioneers is higher than the S&P500 with a difference of 12,42. This difference again shows how green stocks has above average high values, compared to the general stock market.

As previously discussed, the stocks that significantly experienced a surge the last and first quarters of 2019 and 2020, were the renewable energy stocks. The price and valuation in some of these stocks have grown immensely the past year. For example, the solar company Enphase energy, was in February 2019 trading at 7 dollars, and in February 2020 it traded at 58 dollars, indicative of a forward P/E ratio of 57 (Financial Times, 2020). Another point worth mentioning is that a large part of the green stocks on the market are involved in the energy industry. For example, energy companies account for 40% of the Saxo Bank Group (2020) list of green pioneers.

As shown, there is a large demand for investing in green stocks. The increasing and large demand for green equities, paired with a limited supply of these stocks, may drive the prices over fundamental value. If prices are above the fundamental value some investors may pay a premium, possibly explained by the green aspect of the stock. On the other side, the stock may have a fair price reasoning the great growth potential for the green industry driven by the large pressure on transitioning to a green economy. The large surge of interest in green stocks, specifically in renewable energy stocks, motivates this thesis' green bubble indicative analysis on stocks in the energy industry.

The next section will elaborate on the energy industry's development, characteristics and structure. Elaboration on this field lays the foundation for understanding the method and logic behind the sampling process of the data. It provides information on the samples different characteristics which is important for understanding the samples different underlying drivers.

2.2 ENERGY INDUSTRY

The energy industry is one of the main industries that is pivotal in keeping global warming in check. United Nations branch for assessment of climate change science, The Intergovernmental Panel on Climate Change (IPCC), found that a transition to renewable energy from fossil fuels can keep global warming under 1.5 ºC. This requires investments of an average of three trillion dollars a year, the next three decades. Transforming the energy supply systems does not require new funds created, but a redirection of investments in fossil fuels into efficiency and renewable energy. This transition has already started, but investments would need to be increased significantly to meet the 1.5°C target (IPCC, 2018). The fact that transitioning to renewable energy alone, can have an immense impact on the global warming, in addition its large required investment need, may act as a large motivation for investors to finance renewable energy.

The required renewable investments and possible related return are dependent on the main characteristics of the energy industry. The following sections will describe the development in the energy industry, segmentation of the types of energy and give an overview of the structure. Knowledge on this field provides understanding of the data samples presented later, its main characteristics and underlying drivers.

2.2.1 Energy defined

The U.S. Energy Information Administration (EIA) defines energy as the ability to do work and describes how energy comes in different forms (EIA, 2019a). Westley (2017) describes energy as "the work and heat available from all energy carriers, from the point of supply to consumption." The consumption of energy can be divided into the different forms such as the primary and secondary form. The primary form is the form without any transformation, such as fossil fuels. The secondary form is where primary energy sources like fossil fuels, coal, natural gas, nuclear energy, solar energy and wind energy is transformed into a secondary form such as electrical power (EIA, 2019a) (EIA, 2020a).

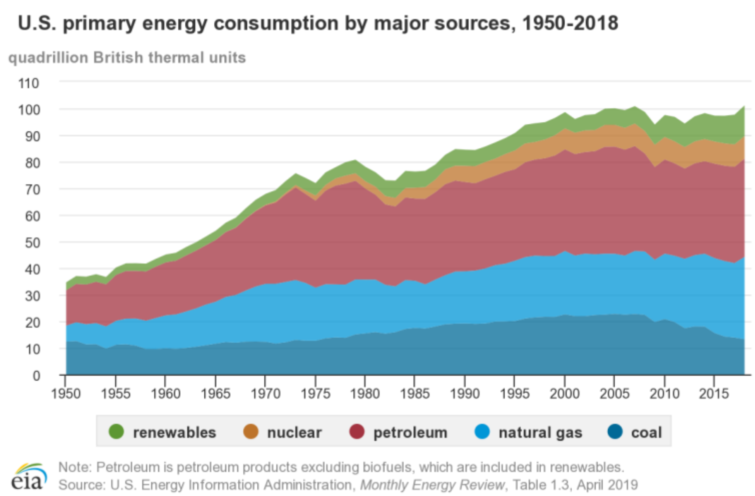
The energy industry can be further grouped into non-renewable energy carriers such as fossil fuels, coal and nuclear fuels and into renewable sources such as wind, solar radiation, hydropower, biomass and geothermal. Energy sources such as fossil fuels, nuclear fuels and biomass can, in its direct form, be stored and transformed into work when needed. Energy sources such as wind and solar radiation need to be transformed, into the secondary form of electricity, the moment where it appears (EIA, 2019a).

The above elaboration on the industry illustrates how the energy industry is complex and includes numerous different energy carriers and several forms and procedures prior to the energy being consumed. Thus, giving a full and detailed overview that can be applied to energy in all of its forms is challenging. Hence, the subsequent sections will give a simplified overview of the players involved and the value chain in order to explain the industry in its broad form and for the reader to understand the analysis grouping of companies that are green, grey and black, and players that although not directly involved in producing energy, still will be considered as a green energy company.

2.2.2 Development

The U.S. Energy Information Administration (EIA) has illustrated the U.S. primary energy consumption by major sources from 1950 – 2018, shown below. In order to compare different types of energy, British thermal units (Btu) is used as a measure of heat energy (EIA, 2019b). As displayed in the graph, the consumption of energy has increased substantially, between the years of 1950 – 2018, going from consuming quadrillion 34,61 Btu to quadrillion 101,12 Btu. Today, the energy consumed consists of 36% petroleum, 31% natural gas, 13% coal, 8% nuclear electric power and 11% renewable energy. Looking at the past decade the graph outlined under conveys a small decrease in the consumption of non-renewable energy and an increase in consumption of renewable energy. Non-renewable energy sources had a negative CAGR of -0,21% in the years of 2008 – 2018, mainly driven by phasing out coal as a primary energy source. Renewable energy has had a positive CAGR of 4,85% in the years of 2008 – 2018. The development of the energy consumption is primarily influenced by technological advancements, consumer behavior and politics. These topics will be elaborated on below.

Figure 2.3: Energy consumption



Source: (EIA, 2019b).

2.2.2.1 Technological advancements

In recent years it has become cheaper to produce renewable energy. The International Renewable Energy Agency (IRENA) (2019) describes how the general cost of the renewable energy technologies improved in 2018 and reached a new low. Furthermore, solar and wind energy has experienced reduced costs deriving from reductions in the cost of battery storage which has decreased 85% since 2010 (Deloitte, 2019). Overall, the reduce in costs is enabled by technological advancements, such new industrial-scale solar farms now producing electricity at cost levels making it competitive within solar energy, some without subsidies (Saxo Bank Group, 2020). The cheaper production of renewable energy sources makes this energy more competitive and accessible and provides incentives for companies and consumers to choose renewable energy. The oil industry has also experienced technological advancements. For example, shale oil extraction, fracking, benefits from innovative drilling techniques, which since 2014 created a boom in U.S. domestic crude oil production. This fracking technique causes ecological damage to the environment and enhances oil's competitiveness (Amadeo, 2020).

2.2.2.2 Governmental policies

The U.S. government, and its sub-branch the U.S. Department of Energy, creates and maintains policies, legislative initiatives and budget requests regarding the U.S. energy industry (U.S. Department of Energy, collected 13.04.2020). In other words, the U.S. government has a great influence on the energy industry, especially in regard to prioritizing non-renewable or renewable energy. In recent years the U.S. has made significant progress on renewable energy expansion and closures of coal-fired power plants. However, the current sitting president Donald J. Trump is scaling back this progress as he announced in 2017 a withdrawal from the Paris Agreement, in addition to his promise to stop a "war" on fossil fuels, specifically coal-fired power plants (Climate transparency, 2019) (Dlouhy, 2019). For example, the 2019 Affordable Clean Energy implemented by Trump, repealing Obama's Clean Power Plan, opens for companies to build new coal plants in addition to not including specific emissions-reduction targets in the power sector for states (Dlouhy, 2019). Furtherly, the Climate Transparency (2019) rates the environmental friendliness of U.S. policies as low for both "Renewable energy in power sector" and "Coal phase-out in power sector."

However, looking at the pro-environment side, despite support from the federal government, the coal industry is in decline. In the years of 2015 – 2018, several coal companies declared bankruptcy, including four industry leaders. This decline is driven by lower costs in renewable energy, and abundant natural gas and renewable energy, in addition to pro-environment regulations aimed at reducing emissions and protect public health. Examples of such regulations and incentives are, federal clean energy tax credits, grants and loans, state-level support policies and requirements to install pollution controls (Climate Transparency, 2019) (Belfer Center, 2017). Further, some U.S. states has incorporated feed-in-tariffs where specific rates on how much of the energy purchased should come from renewables (EIA, collected 09.05.2020).

In 2011 there was a change in the political landscape in regard to renewable subsidies, as a consequence of recovering from the financial crisis in 2008. This brought a large uncertainty to whether the renewable companies would continue receiving governmental support, adding a governmental risk factor to renewable companies. In the years of 2004 - 2009 the annual growth rate in renewable investments was in the range of 32% – 85%, largely driven by governmental subsidies (Johansson, Patwardhan, Nakićenović and Gomez-Echeverri, 2012). However, as a result of the government deficits resulting from the financial crisis, countries implemented austerity policies which led to cuts in renewable support, and cuts in renewable investments (Mahalingam and Reiner, 2016) (REN21, 2018). Renewable companies were especially at this point very reliant on subsidies and the risk of not receiving governmental support was suddenly very evident for the renewable companies. This change led for example to that several solar panel manufacturers in the US and globally reduced their workforce by 20% and that the industry experienced several bankruptcies in the time period 2011 – 2012. Only the large firms seemed to survive the downturn in the industry (Jordan, 2013).

In a global basis, the International Energy Agency (IEA) showed that 70% of the worlds' clean energy investments are directly or indirectly government driven (Birol, 2020). Direct investments include direct government finance, and indirect investments include business and consumer responses to policies such as subsidies or taxes. However, the government does not only subsidize renewable energy, as IEA found that fossil fuels subsidies totaled of approximately 400 billion dollars each year (Birol, 2020).

2.2.2.3 States autonomy

Although the current U.S. governments' policies is not favorable in terms of promoting renewable energy, there is however, considerable climate action happening on a sub-national level and by non-state actors (Climate Transparency, 2019). Climate Transparency (2019) evaluates how public finance institutions are willing to restrict the financing of coal and coal-fired power. In the U.S. the National development agencies and banks, domestic export credit agencies and export credit restriction in OECD are all willing to restrict financing coal activities.

Furthermore, there are several states that are using their autonomy and going against the current president's climate and energy policy. For example, after President Trump withdrew from the Paris agreement, there were 23 governors that individually signed the Paris agreement on behalf of their states. In addition to this, states like California, Hawaii, Maine, Nevada, Virginia, New Mexico, New York and Washington have introduced laws that aims at making the states solely run on renewable fuels within 2050 (Mortensen, 2020). Generally, many Americans wants a green climate change which is represented by the many American green pro-climate organizations and funds supporting this (Leiserowitz, 2006).

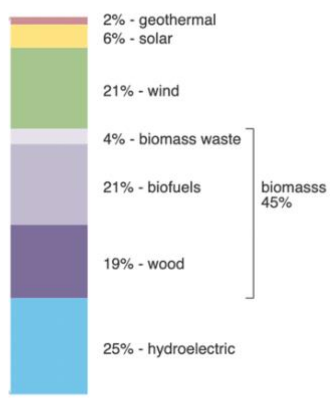
2.2.3 Segmentation

The energy industry can be segmented into companies that operate with renewable energy sources or non-renewable energy sources. Renewable energy comes from sources such as wind, solar radiation, hydropower, biomass and geothermal whereas non-renewable energy comes from sources such as fossil fuels and nuclear energy. The following section will elaborate on these sources of energy. Furthermore, there are four main users of energy in the U.S. and they are the industrial sector, the transportation sector, the residential sector and the commercial sector. Looking at the energy consumption in Btu in 2018, the largest consumer of energy was the industrial sector consuming 32%, the second largest the transportation sector consuming 28%, the second smallest the residential sector consuming 21% and the smallest was the commercial sector consuming 18% of the total energy consumed (EIA, 2019c). These sectors typically consume energy from different sources.

2.2.3.1 Renewable energy sources

Renewable energy comes from sources that are naturally replenishing, like sun, wind and water movements. Thus, renewable energy refers to energy from wind, solar radiation, hydropower, biomass and geothermal sources. The graph below shows the U.S. renewable energy consumption divided by its renewable energy sources.

FIGURE 2.4: U.S. RENEWABLE ENERGY CONSUMPTION BY ENERGY SOURCE, 2018



Source: (EIA, 2019a)

As depicted in the figure above, it shows that in the U.S. the overall biomass fuels is the largest consumed renewable energy source, accounting for 45% of the consumption of renewables. The second and third largest renewable energy sources is hydroelectric and wind with 25% and 21% of renewable energy consumption, respectively.

The renewable energy sources are flow-limited in the amount of energy that is available per unit of time (Frewin, collected 12.04.2020). In most cases the energy needs to be transformed into the secondary form, electricity, in which after transformed can be consumed instantly (EIA, 2019e). If transformed into electricity, the electricity can be stored in batteries or be directly transported out to the consumers. There are new battery storage technologies under development, that will enable electricity to be stored in larger amounts, which is important for the convenience of using renewable energy (Leblanc, 2019). Most commonly, electricity is directly transported through an electricity grid out to the consumers. An electricity grid refers to the complex network which consists of "electricity substations, transformers, and power lines that connect electricity producers and consumers" (EIA, 2019f). The company generating the electricity, may distribute and sell the power independently, or sell it to second party utilities company for the electricity to be distributed and sold to consumers (EIA, 2019f). Some energy companies are involved with both the power generation and distribution, thus involved in both the energy and utility sector.

The process of transforming the renewable energy into electricity is different dependent on the source, but the renewable energy industry generally has a high capital-intensity, and higher capital-intensiveness than non-renewable sources. Renewable energy requires a high upfront cost and a longer investment horizon, in addition to being subject to a higher risk as the green transition is dependent on governmental support and future technology innovation (Volz et al., 2015). Hence, the renewable energy sector requires more investments into R&D as green innovation are needed to increase the applicableness and cost-efficiency for the renewables (Feng and Chen, 2018). Best (2017) found that the transition to renewable energy depends on countries stock of financial capital, where a high financial capital supports transition the more capital-intensive renewable energy (Best, 2017). Further, a positive change in capital expenditures (capex) has happened in later years, decreasing capex which made renewables less capital intensive (Goswami and Kreith, 2015).

Renewable energy plays an important role in reducing greenhouse gas emissions. Using renewable energy can reduce the use of fossil fuels, which emits about 93% of total U.S. anthropogenic carbon dioxide emissions (EIA, 2019d). The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) made in 2012 a comprehensive study that showed that the US can generate most of its electricity from renewable sources by 2050 (NREL, 2012). Thus, the growth potential for the renewable energy industry is large.

2.2.3.2 Non-renewable energy

Non-renewable energy sources are sources that drain fossil reserves deposited over centuries, and when these energy reserves are depleted, they cannot be restored (or not for millions of years) (Conserve Energy Future, collected 13.04.2020) (Sciences learning hub, 2008). Non-renewable energy resources include fossil fuels and nuclear power. The non-renewable energy is not recognized as environmentally friendly.

2.2.3.2 a) Fossil fuel

Fossil fuel include energy from sources like coal, oil and natural gas. These energy sources are dug or pumped out of the ground which is a capital-intensive process (however, less capital-intensive than the renewable energy industry) (Best, 2017). They act as a direct source of energy and can therefore be stored until needed to be used. Companies within this field acquires, explores for, develops, transport and produces natural gas, natural gas liquids, coal and oil in the United States and some worldwide. Burning fossil fuels produce the greenhouse gas, carbon dioxide. Burning coal produces both carbon dioxide and sulfur, which when being let into the air increases the air pollution (Sciences learning hub, 2008). Thus, the environmental impact of using these energy sources is great, and they are a major source of U.S. carbon dioxide emissions (EIA, 2019d).

2.2.3.2 b) Nuclear

According to general definition and classification, nuclear energy is not renewable energy (EIA, collected 13.04.2020). It produces radioactive nuclear waste which is harmful for humans for thousands of years. The waste therefore needs to be safely stored in protecting radiation dry storage containers. An uncontrolled nuclear reaction could result in pollution of air and water. However, there are environmental benefits to using nuclear energy as it does not directly produce carbon dioxide or air pollution (EIA, 2020b). The fact that nuclear companies are listed on Saxo Banks list of green pioneers, highlights nuclear energy recognition as environmentally friendly. Consequently, whether nuclear energy should be part of the futures sustainable energy solution is argued (Rhodes, 2019). Since it is debatable whether nuclear energy is environmentally friendly or not, nuclear companies will not be included in this thesis' analysis. Hence, the industries that will be further focused on, are the fossil fuels and the renewable energy.

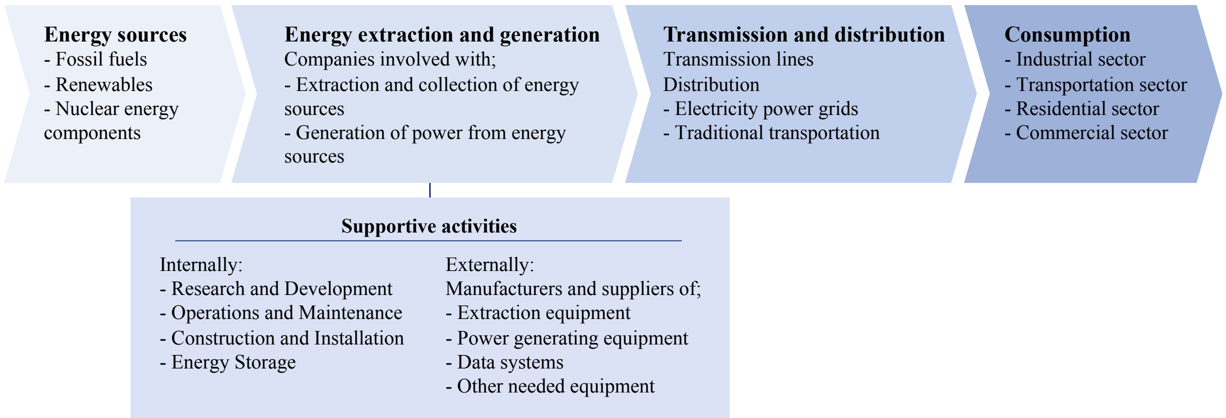
2.2.3.3 Hybrid energy companies

There are energy companies that originally was involved with solely fossil fuel energy sources. However, in recent years fossil fuel companies has transitioned to including renewable energy sources in their business operations. Many companies have started seeing the value of green renewable energy and the need to shift focus, as it is predicted that the fossil fuel energy at some point will be replenished (Sciences learning hub, 2008). Delivering renewable energy is also a way for companies to diversify themselves in a competitive climate where price is usually the only differentiation (Marketline, 2019). Thus, for the purpose of this analysis the data is divided into three samples, green with fully renewable energy, grey with partial renewable (hybrid) and black with non-renewable energy companies.

2.2.4. INDUSTRY STRUCTURE

In order to provide an overview of the activities and actors involved in the general energy industry, this thesis will present a simplified energy industry value chain. As previously highlighted, the energy industry has a complex structure, with many different energy sources, transformation processes, distribution channels and customers. Thus, finding and presenting an overall value chain of the energy that is detailed and applicable for all types of energy sources is challenging. Consequently, this thesis will present a simplified overview of the energy industry's value chain, which presents the main activities and actors involved. By looking at different value chains presented on the energy industry from Bamber, Guinn, Gereffi, Muhimpundu and Norbu (2014), Ugarte et al. (2014), E&M Combustion (2018), and Deloitte (2018), the energy industry's main activities has been identified. Based on these studies, a general energy industry value chain has been crated and is shown below.

FIGURE 2.5: THE ENERGY VALUE CHAIN



Source: Authors

The above outlined activities are meant to give the reader an overview of the energy industry and is therefore a simplified illustration. Thus, exceptions for some energy sources may occur. The figure depicts three main energy sources, namely fossil fuels, renewables and nuclear energy. In exploiting these energy sources there are three main activities, energy extraction and generation, transmission and distribution and, lastly, consumption. For the first activity, energy extraction and generation, the supportive activities are also described. A small elaboration on the activities is given in the illustration. The activities will not be elaborated on furtherly, as deeper insight into this field, is not needed in order to understand this thesis' method and reasoning for sampling companies. However, what is important to add, is firstly, that many of the companies operating in the energy industry is involved in several of the activities in the value chain. This way, the companies can gain larger control and benefit from scale economies. Thus, the data sample will include companies compressed with several activities in the value chain. Secondly, as mentioned previously, many energy companies are involved with several sources of energy, typically operating with both fossil fuels and renewables. Hence, the grey data sample will include companies, previously called hybrid companies, that are involved with both renewable energy and non-renewable energy.

The energy industry is dominated by a few and large firms. Some firms are conglomerates that operates in several industries, and others have a sole focus on energy. The energy industry has become increasingly consolidated in recent years with vertical integration of generation, supply and network activities. This has reduced the incentives to trade and for new companies to enter the industry. Additional barriers to entry are requirements for expertise, investment required in technology, raw materials and plants, finding suitable locations for power plants and the cost of regulatory compliance (Marketline, 2019). This may limit the number of renewable energy companies, and thus the supply of renewable energy stocks which is possible for investors to invest in.

Overall the U.S. energy industry has experienced an increase in production and consumption of renewable energy but faces a few challenges in the transition towards a green economy. Based on companies' degree of involvement in renewables, the data samples will in chapter three be divided into three samples, namely green (fully renewable), grey (hybrid-renewable) and black (non-renewable). This section also describes the renewable energy stocks high capital intensity, risks and limited number of players. As previously described the growing awareness and demand for green renewable stocks, together with limited supply may lay a foundation for a bubble formation for these stocks.

The next section will introduce theory on financial bubbles, the mechanisms involved and which circumstances that is needed to be present for a bubble to form. It will lay the foundation for understanding the last section of this chapter, asset price dynamics which presents the variables applied in this thesis' econometric analysis.

2.3 Financial bubble theory

The following section will introduce theory on financial asset bubbles. It will define financial bubbles, elaborate on bubbles life cycles, describe how human factors affect bubbles growth, state which market conditions that are needed for a bubble to cultivate, and lastly describe the consequences of bubbles.

2.3.1 Introducing bubbles

Brunnermeier and Oehmke (2013) refers to the term bubble as a mispricing of a financial or a real asset. However, not every temporary mispricing can be called a bubble, since a bubble has a "long period of sustained significant mispricing and higher-than-average volatility in the financial markets" (Porras, 2016:6). Porras (2016) defines a bubble as "asset prices that are not justified by the assets 'fundamentals' or intrinsic value" (Porras, 2016:5). The author further elaborates on asset bubbles, "an asset bubble occurs when a financial asset is traded in the market at a price higher than the level its economic fundamentals can sustain, such as when the price of the share grows in the exchange markets for a sustained period of time at a rate much greater than its earnings" (Porras, 2016:5). The long-lasting bubbles can have a negative impact on the economy as it can affect the real allocation of the resources in the economy and drain resources from the system, reasoning why it is important to investigate and understand bubbles (Porras, 2016:6).

2.3.2 Bubble appearance in financial markets

Financial markets can be defined as a place where financial assets are traded. Hence, suppliers and users meet to exchange capital. The financial markets transfer resources across time and between agents and countries. Some agents participating in the financial markets are firms, individuals and the government (Munk, 2015). Historically asset bubbles have occurred in stock, bonds, commodities and housing markets. However, the most significant financial bubbles have been the bubbles occurring in the stock market and housing markets (Porras, 2016). There are several historical examples of financial bubbles. A frequently mentioned bubble is the Dutch tulip mania, where immense expectations and demand for tulips caused the price of a tulip to rise largely over its fundamental value. Further, the Japanese asset price bubble collapse in 1991 had significant impact on the Japanese economy and caused the "lost decade". In recent years, there has been the stock market crash on the Shanghai stock exchange, as well as the 2008 housing bubble collapse in the US, which were followed by a global financial crisis (Porras, 2016). As seen, bubbles occur in a broad specter of geographic areas and markets. Common for all bubbles in financial markets are their significant impact on the economy, both locally and its contamination effect across markets.

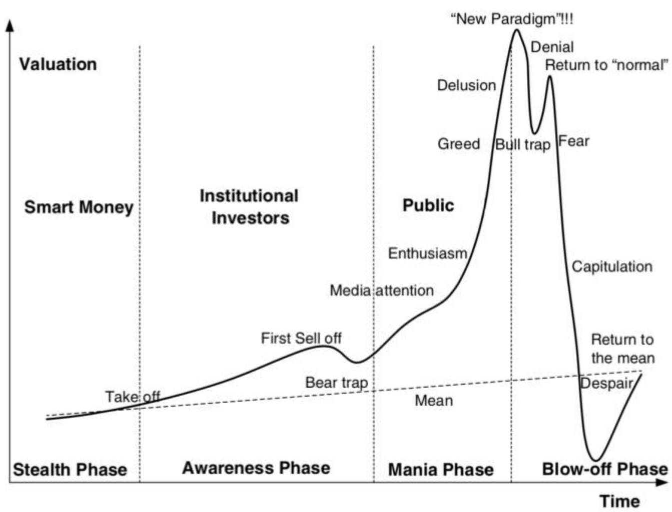
Bubbles can occur at both market level and at sector levels, but most often bubbles occur within a specific sector. As seen by the dot-com bubble in 2000, the pricing of internet stocks had an extensive growth and when the bubbles collapsed, 8 trillion dollars of shareholders wealth was destroyed (Porras, 2016:1). Further, the housing market bubble in 2008 caused a global financial crisis with contamination effects far outside of the housing market. Hence, sector specific bubbles have the possibility to affect a whole market. Previous historic bubbles have been subject to specific events leading to their resurrection. Although subject to individual and particular circumstances, there are many common elements in the bubbles life cycle and the market conditions needed to be present for the bubble to form (Porras, 2016:23). This knowledge can help in the difficult task of detecting a bubble and possibly bubble prevention, if even possible.

The following theory will first elaborate on a bubble's life cycle, secondly the human factors that support the growth of the bubble will be discussed, and lastly the market conditions that are needed for a bubble to cultivate will be identified.

2.3.3 Phases of a bubble's life cycle

The growth of a bubble is characterized with different phases. Brunnermeier and Oehmke (2013) divides a bubbles' life into two phases. A run-up phase, where bubbles and imbalances form followed by the crisis phase, where after the gradual buildup of a bubble and the related imbalances an event triggers the burst of the bubble. Porras further divides a bubbles life into four phases, namely stealth, awareness, mania and the blow-off. The phases have different characteristics, and there are different mechanisms involved. The figure below gives an overview of bubbles' phases showing how the valuation of assets grows with time, and how it lastly falls and the bubble bursts. The figure also shows where the different types of investors typically get involved in the bubble. As the bubble depicts the mania phase is the phase where exponential growth starts. Elaboration on the bubble life cycle follows in the coming sections.

FIGURE 2.6: THE BUBBLE LIFE CYCLE



Source; Rodrigue (2009); Porras (2016:24)

2.3.3.1 Stealth

In the stealth phase the opportunity of wealth creation is discovered by informed investors, also known as "sophisticated" investors. The sophisticated investors are often sector experts who get into the market and purchases larger stakes of the business as prices gradually increases. The assumption of future growth is still an assumption and there is thus risk attached to the opportunity (Porras, 2016:25). Often the expectations of increased profits and economic growth is ignited or rationalized, by the recent availability of a new innovation, new technology, happening or financial innovation (Brunnermeier and Oehmke, 2013:1222). The innovation may create a shift in the economy, which can make it hard for investors to separate whether the high stock prices are because of the new expected growth as a consequence of the innovation, or whether the pricing is high because a bubble has formed. Innovation in form of new financial products may also appear during bubbles, as seen by the collateralized debt obligations in the housing bubble in the U.S. in 2008.

2.3.3.2 Awareness

The awareness phase is characterized as experiencing further asset price increase, as investors are realizing the momentum and adding further capital. Some investors may collect initial returns as buying the asset and selling it relatively higher, in the price increase phase yields profit. The smart money investors benefits from increased awareness, which is also helped by the media making uninformed or “unsophisticated traders” enter the market. Prices start exceeding the fundamental value (Porras, 2016:25). Further, the awareness phase is the opening phase to the mania phase.

2.3.3.3 Mania

In the mania phase, prices are furtherly pushed up, mainly due to unsophisticated investors that believe that previous price increases is an assurance of future price increase, also called a retro-feedback mechanism. The business opportunity is generally known, and unsophisticated trader´s friends and family also get into the market. Money keeps pouring in, further supporting the exponential growth and the understanding of the assets fundamental value is gone. Unsophisticated investors push prices further up in the bubble by accessing additional capital through leverage and loans, rationalized by the appearance of further wealth creation. Meanwhile, sophisticated traders start collecting their returns, de-scaling their investments. The bubble starts halting when there for some reason, information or other mechanics, makes investors realize that the assets fundamentals cannot sustain additional growth. The price level has reached its plateau and the bubble starts collapsing, while credit becomes unavailable (Porras, 2016:25).

2.3.3.4 Blow-off

The last phase is the blow-off phase. The high expectations have changed due to a general market realization. Some investors exit the market promptly, while others hesitate and stay due to problems with determining if the price fall is a temporary setback, or a permanent price collapse, trapping the hesitant investors to stay holding depreciated assets. At this point of time the smart money investors are gone, and the general public is left with the bubble priced assets in which the price drops at increasing rates. Now, every investor is ready to exit the market and cash-in, supported by liquidity needs forcing to fire sell (Brunnermeier and Oehmke, 2013:1222). The retro-feedback mechanism seen during the price appreciation phase now works in the opposite way, now believing that previous price depreciation is evidence for future price depreciation, further supporting the price plunge, pushing the price to a historically low level. Smart investors realize that the significantly low price is under its fundamental value and thus makes a bargain sale on the asset, which at later times can be sold to a higher value (Porras, 2016:25).

2.3.4 HUMAN FACTORS

To understand how a bubble can develop and the associated contagion mechanisms, it is necessary to understand the human aspect and the market behavior that are in play.

2.3.4.1 Bounded rationality

There are four groups of behavioral models and explanations that describe the development of bubbles and contagion. In behavioral models, bubbles may begin to form when agents may over- or underreact to signals regarding the fundamentals (Porras, 2016:19-21).

2.3.4.1 a) Heterogenous beliefs

There are so-called optimistic and pessimistic investors with differences in personality traits, opinions, actions and sale constraints. The optimistic investors neglect the fact that the pessimistic investors integrate their pessimistic views into prices giving a gap in the price assessment, and hence adding a bubble component (Porras, 2016:19).

2.3.4.1 b) Feedback trading

The feedback trading behavior is related to the trading strategy based on recent price movements and similar to the retro-feedback mechanism. When the asset price increases the feedback-trader believes that it indicates further future appreciation, and thus buys the asset, pushing price further upwards. The additional price increase attracts extra attention from other feedback-traders giving the price an additional positive boost. This mechanism pushes the price of the asset to a level where it is above its fundamental value (Porras, 2016:20).

2.3.4.1 c) Biased self-attribution

The bias of self-attribution refers to the case when a person mainly recognizes the signals that confirm his or her prior beliefs, while disregarding the information that opposes the existing opinion and belief. In the case of a bubble, an investor may from a private signal generate a high initial valuation. Later on, when this belief is challenged by contradicting public signals the investor may disregard this information and become overconfident in the initial valuation and not adjust the price according to all information i.e. confirmative and contradicting information (Porras, 2016:20).

2.3.4.1 d) Representativeness heuristic and conservatism bias

The representativeness heuristic works in the opposite way of the conservatism bias, in the way that investors affected by the representativeness heuristic overreact to salient news by putting too much emphasis on such signals compared to their base probabilities. On the opposite side, investors affected by the conservatism bias underreact to salient news signals and thus assign this too low probability weights. The representativeness heuristic and conservatism bias deviates from the assumptions in optimal Bayesian information processing models. The Bayesian models is based on probability and is used to represent and manipulate uncertain information – giving the scientists a tool to define rationality (Porras, 2016:20). The model of Bayesian information processing is dependent on which assumptions that are put into the model, and problems arise when people depart from Bayesian rationality.

2.3.4.2 Market behavior

Market behavior like herding, speculative trading and settings of asymmetric markets may induce investors to act in a way which supports and ignites bubble formation. The following sections will elaborate on this aspect.

2.3.4.2 a) Herding

Herd behavior is important to examine as a transmission mechanism in the way that it can spread word and behavior in regard to the perceived value of the asset. It can induce people to assimilate its behavior in masses, creating exponential growth and devaluation when the bubble bursts, thus an important mechanism in the bubble's life cycle. The are several possible explanations to why herding behavior can make sense for the investor. Firstly, some agents may rather decide to follow and imitate the actions of others, disregarding their own information and perception. In this scenario few individuals may have a disproportionate effect on the whole system. Secondly, there may be costs associated with collecting information. If the cost exceeds the benefit of sampling the information, it may be reasonable for the agent to imitate the behavior of other agents that are assumed to be better informed. This may result in information asymmetry and transmission of crises through global portfolios. Lastly, the relationship between private and public information may induce some agents to copy other agents behavior that are assumed to have superior (i.e. private) information. An additional mechanism that may amplify the herd effect, is the positive feedback reaction, where the more people that join the crowd, more people are induced to follow.

More and more people following the crowd may be assessed as additional evidence of that following the herd is sensible. The positive feedback reaction may explain the excess volatility in asset markets and unpredictable changes in fads (fashions). Overall, herd behavior can make price shocks magnified and explain some of the incremental stock market variability (Porras, 1999:235) (Scharfstein and Stein, 1990). In reference to this thesis' methodology, the herding behavior is what this analysis bubble proxies, namely the contagion proxies, seeks to capture.

2.3.4.2 b) Speculative trading

Theory distinguishes between investors that buy an asset for its perceived fundamental value and speculators that buy an asset for its resale value. The U.S. Commodity Futures Trading Commission (CFTC) defines a speculator as "a trader who does not hedge, but who trades with the objective of achieving profits through the successful anticipation of price movements" (Frankel and Lee, 1996) (Porras, 2016:67). The speculator trades the asset with the goal of benefitting from short- or medium-term anticipated price movements. Hence, the trader does not focus on the fundamental value of the asset, deriving from dividends and interest, but focus rather on following the assets price movements and the market expectations. Thus, speculators may contribute to the growth of a bubble, in the way that although they have an understanding of the fair fundamental value of the asset and the asset may be classified as overpriced, it may be rational to purchase that asset when another (uninformed) investor is willing to purchase the same asset at a higher price (Porras, 2016:237) (Galbraith, 1955). Speculators can be both beneficial and harmful to the financial market. They can be beneficial as they provide liquidity by trading, absorbs risk other agents are not willing to take on, and helps improve overall market efficiency. However, excessive speculating can also be harmful for the proper functioning of the futures markets. Prices can become distorted if a large number of speculators participate and the real underlying demand and supply becomes small compared to trading volume. Additional drawbacks are the short-term volatility influenced by speculators and the speculators effect on financial bubbles (Porras, 2016:67).

2.3.4.2 c) Asymmetric information and incentives

In financial markets, there is several participants holding different information. When these participants, such as funds, banks, rating agencies and financial analysts, are engaging, private information problems may arise. During the housing bubble in 2008, there were several parties involved such as mortgage sellers, intermediaries, mortgage holders, investments funds and homeowners. The different parties were sitting on different information and the mortgages were first sold to homeowners, and again resold to financial intermediaries which again sold the same mortgages to investment funds. These linkages caused problems due lack of transparency and private incentives (Porras, 2016:57). Too much information may also confuse investors and distract them from focusing on the key facts and instead focusing only on certain aspects or announcements. Further, analysts may have incentives to give recommendation that affects stock prices which again affects their own earnings. Then it becomes a private benefit for the analyst, and they may work towards maximizing their own wealth (Porras, 2016:57).

2.3.5 Market conditions enabling bubble formation

There are three general conditions that need to be present for a bubble to cultivate. Firstly, the economic environment has to be a scene where the "right mood" can be fostered. This is typically seen in market expansions, which will be elaborated on under business cycles. Secondly, there must be sufficient credit availability. The monetary and fiscal policy affects the credit availability and will be further discussed in the second sub-section. The third condition that needs to be present is asymmetric information which is a condition in inefficient markets which will be elaborated on in the third sub-section.

2.3.5.1 Business cycles: Economic environment where the right can mood fostered

Porras (2016) explains that a "general condition prior to the bubble development is the existence of an economic environment where the "right mood" can be gauged" (Porras, 2016:24). The upward swing in the economy and the general positive outlook allows investors to believe in potential large wealth creation beyond other current available alternatives. This can drive speculative bubbles where expectations of future earnings are valued more than current realizations (Porras, 2016:24). Thus, the economic environment sets the scene for whether bubbles can cultivate. The macroeconomic environment can be explained by several factors, where economic indicators are one of them. Business cycles is one economic indicator and are defined as up-swings and down-swings in an economy. Up-swings in the economy are typically referred to as market expansion, characterized by upturn in business activity. Down-swings in the economy are known as a recession, characterized by high unemployment and a slowdown in business activity. The different phases of the business cycles go in shift. The highest point of the expansion is called a peak, which is then followed by a decline in the expansion, which at one point will turn into to a recession. The level between a recession and an expansion, is referred to as the recovery phase (Frumkin, 2015).

The causes of business cycles are a research field where new theories and perspectives continuously are developed. Some of the factors reflected by business cycles are production, inflation, prices, profits and employment (Frumkin, 2015). Business cycles can reflect the whole market, but they may also just be present in certain sectors. Further, although business cycles may be present in the whole market, some sectors may not be affected, as they, sometimes reasoned by negative correlation, work in another direction than the market.

2.3.5.2 Monetary and fiscal policy: Credit availability

The second condition that needs to be met for a bubble to form is sufficient credit availability. Helped by the strong upswing in the economy, credit expands, and money is accessed easily. Sufficient credit capacity is necessary in order to reach the market overall, as it is "the aggregate speculative capacity of the market that drives the bubble" (Porras, 2016:24). In detail, the expanded credit is used to purchase bubble priced assets, which causes prices to rise to new heights. This attracts additional investors, with expectations of additional price increases and easy profits, into the process (Porras, 2016:24). Continued process of price inflation expands the bubble, with the help of easily accessible credit.

Monetary and fiscal policies affect the interest rates and credit availability and is thus pivotal in bubble formation (Porras, 2016:24). Porras (2016:31) describes monetary policies as the connection between interest rates and total money supply which are set by the monetary authorities in the given economies. The monetary authorities can through monetary policies control the amount of assets, such as currency in circulation and demand deposit in commercial banks, to achieve a specific goal. The monetary policies vary among economies and their individual objectives. The optimal monetary and fiscal policy for a given economy varies and depends on its economic situation. Fiscal policies in combination with monetary policies are used by the government to achieve economic stability. Fiscal policy instruments are for example taxation and government spending (Porras, 2016).

Common for all monetary policies is that the central banks, also known as monetary authorities, have a set of instruments and target variables that are used to achieve their goals. Interest rates are one of the instruments that the monetary authorities can use. Low interest rates foster credit availability and is thus often present when a financial bubble form. When credit is easily available, investors will prefer to borrow from banks and invest their leveraged capital in financial assets instead of saving (Porras, 2016:33). This can, as previously explained, give rise to and alter bubble prices. Major changes in regulatory environment may also give rise to financial asset bubbles. There may occur difficulties to adjust to the new regulatory environment and asset prices are highly sensitive in these periods (Porras, 2016). Hence, uncertainty of federal policies may gauge for greater volatility in the market and may create difficulties assessing an assets value (Hartley, 2015).

2.3.5.3 Inefficient markets: Information asymmetry

Many of the premises that a bubble grows under is founded in characteristics and mechanisms uncovered in an inefficient market. The definition of efficient markets is derived from Fama (1970) which proposes the efficient market hypothesis (EMH) which posits that a market is efficient if market prices instantly and «fully reflect all available information" (Fama, 1970:1). In efficient markets there is no private information, and everyone has the same goals (Porras, 2016:55). Thus, for the efficient market hypothesis to hold, all investors should be in position of the same information. Further, Porras (2004) describe how the EMH implies that changes in stock prices result from changes in expectations, due to new information about fundamentals becoming available to investors (Porras, 2004). However, as uncovered in most markets there are frictions, private information and personal circumstances, such as taxes and liquidity needs, which affect the agent's decision making. Hence, information asymmetry, which is when market participants hold different information, negatively affect market efficiency. It enables investors with only partial information, instead full transparency and knowledge, to more easily imagine that there is a limitless growth potential. Investors with full knowledge on the other hand, knows that there is top to the growth due to their ability to assess whether the price-value relation is out of its boundaries and above its fundamentals (Porras, 2016:24). Hence, bubbles can only grow in inefficient markets.

Fama (1970) further poses three different forms of market efficiency. The weak form suggest that market prices instantly and fully reflect all past information derived from market trading data. The semi-strong form suggest that market prices instantly and fully reflect all past and publicly available information. Lastly, the strong form suggest that market prices instantly and fully reflect all available information which is past, public, and private information. Whether markets in reality are efficient is debated, as there is research with supportive evidence (e.g. Busse and Green 2002) and research with contradicting evidence confirming a market anomaly (e.g. Rouwenhorst, 1998). Generally, most empirical research, especially in developed markets, support the semi-strong form of efficient market hypothesis. This implies that market prices instantly and fully reflect all past and publicly available information and stock prices follow a random walk and therefore are unpredictable (Fama, 1995).

Fama (2014) has in more recent years made specific research on bubbles. The author found that it was not possible to detect bubbles looking solely at past history of stock prices. Hence, the researcher was testing whether it was possible to detect bubbles according to the weak form of market efficiency and confirmed that the weak form of market efficiency could not detect a bubble (Fama, 2014). This means that the semi-strong form of market efficiency ability to detect bubbles has not yet been opposed. In fact, Greenwood, Shleifer and You (2017) found that looking at stock return together with publicly available information like turnover, issuance, patterns of volatility, and fundamentals, in conjunction with rapid price increase could be helpful in predicting crashes or future returns.

2.3.6 Consequences of a bubble

During a bubble's lifecycle from birth to implosion the bubble's resulting prices dislocates resources and drain resources from the system. With the current degree of globalization, which also affect the financial systems, the burst of a bubble may have widespread consequences. On the other side, some argue that there are benefits associated with a bubble. The next sections will elaborate on the consequences of a bubble.

2.3.6.1 Resulting misallocations

Long-lasting bubbles that bring on a long period of sustained significant mispricing together with above average volatility in financial markets negatively impacts the economy. Porras (2016) describe how "bubbles create "fictitious" wealth and destroy real wealth" (Porras, 2016:27). The bubbles resulting high prices affect the real allocation of resources in the economy and can be destructive particularly to the unsophisticated and less liquidity-wealthy participants. In some cases, it may even be destructive to innocent bystanders (Porras, 2016:27). Further, a bubble drain resources from the system as the burst of a bubble causes a deflationary period where wealth vanishes from the overall economy. Porras (2016) further elaborates on how the burst of a bubble may "affect the balance sheets of firms, financial institutions, and households, reducing the overall economic activity" (Porras, 2016:6).

2.3.6.2 Global markets

As described above, the consequences of a bubble can be negative to an economy. However, with the current degree of globalization, the burst of a bubble in one economy may also have disruptive effects on other related financial markets and economies. Financial markets transfer value across nations and sectors, transfer value over time and allocates risk among market participants. Additionally, financial markets supply information on the expectations and value of the asset. Thus, the global financial systems are complex and interdependent (Porras, 2016:35).

The worldwide interaction between economies and financial systems forms market conditions which may affect the contaminative effect of bubbles. Financial contagion, or contamination, refers to “the phenomenon that occurs when one asset or basket of assets is affected by changes in prices in other markets of this asset or basket of assets” (Porras, 2016:4). Contagion in this context should not be inferred with the trading pattern meaning of contagion, which later in this thesis will be described. Thus, to avoid confusion the term contamination will be used as a synonym of contagion. The global economic system operates in a series of interdependencies which allows financial contamination to spread.

In order to understand how bubble implosions, spread throughout the economic system it is necessary to recognize the interdependencies that exist among markets, sectors, and asset classes (Porras, 2016:39). A holistic perspective which considers the effects within a system and across countries deriving from monetary, fiscal, and financial stability policies is needed. In examining these structures three main considerations are important. Firstly, the structures are dynamic, meaning that the relations between parties such as governments, corporations and banks changes over time. Secondly, the macro risks are accrued in a non-linear style. Lastly, when entities such banks, governments, and corporations are guaranteeing for each other, the risk rises. This enables that the weakness of one entity may spread to the other, magnifying the feedback loops of the risk. This shows that the complexity of the financial systems may also be a vulnerability (Porras, 2016:39). The global financial system also means that a bubble may not only be limited to a specific geographic economy, but the bubble can be present on a global basis.

2.3.6.3 Possible benefits associated with a bubble

Looking at the overall economy bubbles are harmful and destroy real wealth. However, although in the grand scheme bubbles are harmful, there can in some cases be beneficial consequences of financial bubbles. Some bubbles may support transformations in different sectors. For example, the bubble preceding the great depression during the 1930’s contributed to electricity’s spread into rural areas in the U.S. Further, the dot-com bubble fostered many great technology companies present today, and may in that way have pushed society’s tech capabilities. Along these lines, some bubbles may be transformational in the way that they can benefit human’s quality of life and give room for future innovation (Glaeser, 2017:141).

2.4 Asset price dynamics

The first part of the literature review highlights the increased focus on a green economy and describes the energy industry. This is followed up by presented theory on financial bubbles which describes the characteristics and phases of financial bubbles in addition to the needed macro conditions. The coming section will elaborate on asset price dynamics to further explain the methodology that will be undertaken in the aim of indicating a run-up to a green bubble.

2.4.1 Introduction

The coming section will present founding theory on asset pricing and bubble theory on asset pricing.

2.4.1.1 Founding theory on asset pricing

Essential theory on pricing of assets are the Capital Asset Pricing Model (CAPM) that by looking at risk, expected market return and the risk-free interest rate can determine a theoretically appropriate required rate of return on an asset or portfolio (Sharpe, 1964) (Lintner, 1965) (Black, 1972). However, the CAPM model is a simple model and has created reservations according to its reliability (Berk and DeMarzo, 2017:424). The renowned Fama and French Factor Model builds upon the concept of CAPM and extends the model by including three variables explanatory effect on asset returns (Fama and French, 1992). Furthermore, Connor (1995) define three types of factor models, macroeconomic factor models, fundamental factor models and statistical factor models, where all types are used to estimate stock returns. Multifactor models are widely used in financial and macroeconomic time series where the purpose is to estimate expected returns on assets based on a wide range of different factors. Asset pricing and asset dynamics are complex topics and it can be challenging, if not impossible to determine the fair value of an asset in a dynamic environment (Porras, 2016:18).

Porras (2016) argues that average explanatory power of factor models incorporating the relationship between earnings and stock returns are minimal. In other words, such factor models have shown to have small coefficients and low R^2 scores. To summarize, there is a collective opinion that stock returns are difficult to model and predict. Instead of applying a factor model to investigate this relationship, Porras (2017) rather investigates the explanatory effect of fundamental and contagion variables on stock prices. If assets are fairly priced there should be a statistical positive relationship between the development in earnings and the development in prices over time. However, if a bubble component is suspected, contagion proxies are also included as an explanatory factor of asset return. Contagion proxies refers to variables representing volatility, volume and money flow.

2.4.1.2 Bubble theory

Literature and history have shown that the price of an asset may have a bubble component to it, or commonly named the asset has a bubble price. In the light of financial asset bubble theory, it is important to distinguish between the price of an asset and the value of value of it. The price refers to the amount someone is willing to pay to own an asset. Whereas, the value of an asset refers to the net present value of the expected earnings, i.e. cashflows that the owned asset will generate in the future. If an asset has a bubble component to its pricing, it means that the price of the asset and the value of the asset is not equal (Porras, 2017:1). Thus, the bubble priced assets' price cannot be justified with the future expected earnings from owning that asset.

Financial asset prices are dynamic and will change over time. There are several factors that can influence how the pricing of an asset will develop (Porras, 2017:2). Such factors can be innovation, changes in market conditions, changes in market sentiment and news articles. For example, an innovation within a sector can make companies more efficient and hence more valuable which again affects the price of the stock. In general, the price of an asset is affected by supply and demand for the asset. Little supply and high demand drives prices up, and conversely little demand and high supply pushes prices down. In the run-up phase of a bubble there is a lack of supply compared to the demand, as many investors want to buy a certain type of asset and the asset price is rising. However, when the bubble bursts there is excess supply and the asset price drops (Porras, 2016:97).

In line with existing theory, this thesis argues that the asset price can be explained by its fundamentals and contagion proxies. As previously shown, the world economy is facing a green transition to a low carbon economy. This transition may affect the growth potential for some industries, such as pro-environment industries including the green energy industry. The new growth potential may influence investors' expectations for the industry, in which can influence these stocks price development. However, it is difficult to disentangle whether the asset price change comes from investors new growth expectations for the industry, or whether the price change simply can be explained by the industry's companies own fundamental performance. Fundamental variables can explain whether the assets price development is according to the assets' value, meaning that the price is just and in line with the future expected earnings from holding the asset. Thus, by performing a historical analysis on companies' fundamental characteristics, performance and growth, it may show whether the price change comes from the companies' fundamentals or from investors new growth expectations. The contagion proxies described in the next section, may be an indicator of investors new growth expectations and investors associated herding behavior, which both are related to the formation of a bubble (Porras, 2017:130;235). Hence, performing a historical analysis on whether contagion proxies are explanatory in the asset price development, can further disentangle the drivers behind the assets price development. If, the contagion proxies can explain the companies' price development, it may be an indication of a run-up to a bubble.

2.4.2 *Fundamental value*

The fundamental value, also referred to as intrinsic value, is the true, inherent and essential value of an asset (Ballentine, 1916) independent on its market value. This intrinsic value is determined by the factors that that ensures sustainable future growth of the company and of the various owners' shares. Generally, the value of a company can be determined either by its book value or market value. The market value is often fairly higher than its book value and can be determined by following formula (Berk and DeMarzo, 2017).

$$Market\ Value\ of\ Equity_t = Shares\ outstanding_t * Market\ price\ per\ share_t$$

In theory, under the assumption of efficient markets, the market stock price and the intrinsic value of the stock is equal (Fama, 1970). In reality, the assumption of perfect markets does not always hold (e.g. Rouwenhorst, 1998), and the market stock price and the intrinsic value of the stock may differ. There are many possible causes to why the two terms may differ, and a bubble component to the pricing of the financial asset is one of them.

Within financial bubble theory, Barucci and Fontana (2017) provides a model that represent the stock price constituted by two components. Firstly, the price of a stock is determined by the fundamental value of company (F_t). Secondly, the price can also include a bubble component which is unrelated to the fundamental value of the company (B_t). Porras (2016) represent this relationship in the model shown below:

$$x_t = F_t + B_t$$

$where;$
x_t = the price of the asset today
F_t = the part of the price that correspond to its fundamentals
B_t = The part of the price that correspond to the bubble component which cannot be justified by the company's fundamentals (will be proxied contagion variables reasoned in next section)
When $x_t = F_t$ there is no bubble component related to the price

As shown above, the stock price can be explained by the company's fundamentals and possibly a bubble component. If the stock price is equal to the fundamental value, there is no bubble component to the pricing of the financial asset. Hence, in order to identify if there is a bubble component, the correct fundamental value of the asset needs to be determined.

2.4.2.1 Determinants of fundamental value

The determinants of the fundamental value of the company (F_t) are the factors that affect the company's growth outlook. These determinants can be captured by growth in earnings and dividends, the risk of the future expected cash flows generated by the firms, profitability ratios, capital structure and the cost of financial capital (Porras, 2016:5). As displayed, there are many determinants that affect the fundamental value of a financial asset. Consequently, defining the fundamental value and thus the correct market price of the asset is challenging. The main difficulties in defining the correct market price of a stock, lies in the analysts ability to develop correct expectations about the future of the company (Porras, 2016).

2.4.2.1 a) Discounting cash flows and forecasting

Theoretically, the fundamental value is the present value of cash flows that the owner of the asset expects to receive over time (Porras, 2016:101). The cashflow of a company refers to the cashflows that comes as a result of the wealth creation process from the firm's operations. However, some investors in referring to cashflow, refer to the cashflow derived from selling the stock in the future. This referral to cashflows should not be confused with the cashflows used to determine the fundamental value of the asset, since market price and fundamental value do not always coincide. Thus, when referring to cash flows in determining fundamental value, it refers to the cash flows derived from the company's wealth creation process, which may be distributed as dividends or further invested to generate future value (Porras, 2016). When determining the fundamental value of a company valuation methods such as discounted cash flow (DCF) to calculate the present value of future expected free cash flows (FCF) can be applied. This process involves numerous considerations and calculations and the future expected cash flow of the company needs to be forecasted into an unknown future.

In general, when forecasting free cash flow, the firm's revenue and expenses needs to be projected. Revenue growth is normally limited to demand and development in inflation (Porras, 2016:101). Overall, demand is affected by various factors such as the growth and income level of the population. Expenses can be fixed and variable, and often trails the revenue growth. Thus, there can be factors that affects both revenue and expenses. Such factors can be innovation, market development and sector specific changes which can make businesses more profitable. These factors can be difficult to foresee and to estimate the factors specific impact on the business. It is often assumed that a firm's future earnings are limited to the underlying growth factors that affects the future expected cash flow. If asset prices are growing at levels that cannot be justified by important underlying drivers such as demand, inflation growth and innovations, the market stock price may be higher than the assets fundamental value. In summary, if the value of an asset cannot increase beyond the impact of the underlying growth factors, it may indicate that the asset price contains a bubble component (Porras, 2016).

2.4.2.1 b) Fundamental financial variables

There are several variables that can represent a firms' fundamentals, F_t. Derived from firms' financial statements, Porras (2017) use the following variables to capture F_t:

- Earnings before interest and tax (EBIT)
- Research and Development (R&D)
- Depreciation
- Net working capital (NWC)
- Capital expenditure (Capex)
- Free cash flow (FCF)
- Debt-to-equity ratio

Normally, the company financials listed above will be affected by the underlying economic growth factors. The economic environment which can be measured through variables like inflation, the cost of credit, or tax expenditures, impacts a firms' business activities and thus is expected to be somewhat reflected in a company's financials (Porras, 2016:35). For example, if demand increases as a consequence an economy in expansion, the revenue growth is also expected to rise. Further, if an innovation has a positive impact on the business it is expected to show in financials such as an improved operating profit, EBIT, and increase in free cash flow. Porras (2017) argues that if the expectations on average are formed correctly, there should be a relationship between the firms operating earnings and changes in stock prices over time. The author does not provide a single specific model and definition of what variables represent the fundamentals but focuses rather on the company earnings. The researcher's reasoning is that "in the long-run operating revenues are the only source from which any payments can be made, including dividend payments" (Porras, 2017:232). Further, Porras (2017) describe how earnings is a better measure compared to revenues, since if operating expenses are growing at a higher rate than revenues, the net effect is negative.

As will be elaborated on later, the term operating earnings, EBIT, can have different operational components linked to it. For example, depreciation is a non-cash expense and is therefore added back to the operating profit, EBIT. Variables such as net working capital, capital expenditure and R&D can reflect the company's investment into expanding its operations, which later can drive revenue growth. In addition to looking at the term earnings, it is also relevant to investigate firms' capital structure. A company's value, in an imperfect market, is also affected by its capital structure, often measured with the debt-to-equity ratio. An unfavorable high debt-to-equity ratio may signal financial distress, and an unfavorable low debt-to-equity ratio may represent inefficient use of the firms' assets and agency problems, which both may affect the firms' value (Berk and DeMazaro, 2017). Hence, according to theory the company's financials, representing fundamental value, should be able to explain changes in stock prices.

2.4.2.2 Bubble effect on financial statements

Taking a closer look at how the bubble formation affects firms' financial statements provides a deeper insight into the financial variables explanatory effect on companies. Overall, in a bubble's growth, the company's financial statements are affected. For example, when the bubble forms, credit is easily available and savings are discouraged, and this affects the income statement. Corporate profits are boosted by firstly, private households' easier access to borrowing and willingness to spend, and secondly the firms' surrounding growing environment. When profits and asset prices rise, companies may feel more confident in making new investments. Higher investment spending implies a stronger growth outlook. Overall, Porras (2016) points to the connection between credit creation, asset inflation and profit formation. Higher borrowing results in higher profits and asset prices (Porras, 2016:38). However, it should be noted that these factors alone do not format a bubble but may contribute to it. In summary, if the value of the stock and the price of the stock is equivalent, the changes in fundamentals, should in theory have explanatory effects on the stock returns. Hence, if there is no mispricing of the assets, the stock price should in the long run be related to the corporate revenue.

2.4.3 CONTAGION PROXIES

The bubble component, B_t, may be a part of the stock price, and contagion proxies are measures that aims to capture the bubble component (Porras, 2017:233). The contagion proxies in this thesis are represented by the following three variables;

- Volume
- Volatility
- Money flows

Contagion proxies can capture the bubble component since the proxies capture investors herding behavior, which is one of the factors that leads to a bubble. Herding behavior can induce people to assimilate their behavior in masses which can amplify the perceived value of the asset (Porras, 2017:235). Porras (2017) defines contagion as the trading patterns resulting from herding behavior, and in this way, contagion may be the result of informational externalities or psychological factors (Porras, 2017:235).

The chosen contagion proxies, volume, volatility and money flows, derives from noise trader models that suggest a relationship between each of these variables and stock returns (Porras, 2017:234). The noise trading models include, noise traders that are less than fully rational, and sophisticated traders with rational expectations (Porras, 2017:184). There are two assumptions made in the noise trading models which point to the relationships between the contagion proxies and stock prices. Firstly, the trading strategies undertaken by the noise trader cause stock prices to move. Secondly, the noise traders use positive feedback trading strategies, where traders extrapolate past price trends on to expected future trends (Porras, 2017:226;239). Thus, the noise traders make investment decisions based on past trends and this may drive the asset price away from its fundamental value (Porras, 2017:226). Generally, the noise trading model may indicate that bubbles arise solely from the trading process and the expectations formed by the different agents (Porras, 2017:188). Accordingly, by looking at contagion proxies, which captures this trading process which implicitly convey agents’ expectations, the bubble may be recognized.

2.4.3.1 Volume and volatility

Volume is a proxy for herding behavior as it measures the common shares traded for a given period (Porras, 2017:234). If there is a large volume traded, many stocks change hands, and this may imply a fast and large stock price change. This way, volume can describe information flow and the speed of adjustment to information (Porras, 2017:69). Causality between volume and stock price, have been tested on the basis of the idea that large positive price changes result in capital gains. With higher returns, comes higher willingness to follow the crowd, which provokes further transactions and higher volume (Porras, 2017:239).

In stock markets the term volatility refers to the rate of change in asset prices (Porras, 2017:6). Volatility is usually estimated using the standard deviation of the historical returns of the asset. However, Porras (2017) measures the changes in volatility by using percentage changes in the price range, which is, the difference between price high and price low. Porras (2017) explains how herd behavior can rationalize some of the excessive stock market volatility, since a large group who undertake the same trading strategy, dealing towards the same direction, often will magnify price shocks and consequently increase volatility (Porras, 2017:239). The ideal breeding ground for a bubble to start growing is an environment characterized by low volatility (Brunnermeier and Oehmke, 2013). In this environment the difference in returns of risky and risk-free assets are less and this results in a low-risk premium available. The low-risk premium makes financing easy (Porras, 2017:69). However, when the bubble bursts there will be high volatility as a consequence of excess supply (Porras, 2016:97).

Many studies have shown that, trading volume and volatility, are positively correlated, and it is difficult to disentangle the volume effect from the volatility effect (Porras, 2017:68). Narayan, Mishra, Sharma, and Liu (2013) describe how both trading volume and volatility have a positive effect on financial bubbles. Bubble episodes are often associated with increase in trading volume due to increased volatility in beliefs that results in boost of the value of the resale option. In other words, traders want to buy the asset because they can sell it at an even higher price.

2.4.3.2 Money flow

Money flow describes additional capital invested each period to purchase companies' stock (Porras, 2017:243). Money flow is derived from multiplying the stock price mean with volume and is hence directly correlated with volume. Thus, money flow captures some of the same herding behavior aspects as volume do but captures an additional price effect. In other words, when noise traders which uses positive feedback strategies see a positive stock price development, the group extrapolates the positive price development on to the future. The noise traders continue buying the stock, increasing volume, and at a higher price, increasing mean stock price. Porras (2017) found that money flow could explain positive price changes, and the greater the price change the greater the significance of the variable. However, on the other side, money flow was not significant for companies with on average negative price changes (Porras, 2017:252).

2.4.3.3 Contagion proxies as a bubble indicator

Several studies have established positive relationships between the contagion proxies, volume, volatility and money flow, and stock price. These contagion proxies can capture investors herding behavior which is part of forming a bubble. Although a positive relationship between the contagion variables and stock price can be found, it is not the equivalence of that there is a bubble. The reason for this, is that there can a be a bubble in the economy without contagion. Correspondingly, there can be contagion without the existence of a bubble. Consequently, the concept of a bubble and contagion is disjointed (Porras, 2017:233). Although their relationship is not direct, the contagion proxies still serve as a relevant indicator of a bubble. To establish for certain that a bubble has existed is a challenging task, as there are many factors affecting the stock price development. Hence, establishing a definite existence of a bubble is out of scope for this thesis.

Summing up, if explanatory effects between the changes in contagion proxies and the stock return can be found, this may indicate the existence of a bubble. Also, if the fundamental variables have little explanatory effect, and the contagion does have explanatory effect, the indication of a bubble is even more significant.

2.4.4 Defining the test model

Stock returns will be investigated using the model portrayed by Porras (2017). The authors' theory on bubble's and contagion theory suggests that stock prices can be explained by fundamentals and contagion proxies (Porras, 2017:231). Porras (2017) presents a method to investigate whether stock prices of the S&P500 companies are explained by fundamentals or contagion proxies and analyzes historical data looking at 1988-1998, the period building up to the dot-com bubble in the US in 2001. Findings show that the stock prices could not be explained by fundamentals in any of the models presented. However, the contagion proxies could explain the stock prices, presenting an indication of a bubble (Porras, 2017).

This thesis will apply the same method presented by Porras (2017). Hence, the explanatory effects of fundamental value proxies and bubble proxies on stock prices will be assessed in the statistical analysis applied in this thesis. In order to analyze stock prices through time series, stock returns will be analyzed by looking at changes in fundamental proxies and contagion proxies. The equation below shows how stock return will be analyzed with the possible explanatory variables changes in fundamentals and changes in a bubble component. As shown, proxies for fundamental value are earnings and capital structure. The bubble component will be proxied by contagion proxies which are volume, volatility and money flow.

$$\underbrace{\Delta P_t}_{\substack{\underline{\text{Stock return}}}} = \underbrace{\Delta F_t}_{\substack{\underline{\text{Fundamental proxies}} \\ \text{E = Earnings} \\ \text{D/E = Capital structure}}} + \underbrace{\Delta B_t}_{\substack{\underline{\text{Contagion proxies}} \\ \text{C = Volume} \\ \text{C = Volatility} \\ \text{C = Money flow}}}$$

The bubble and fundamental proxies will be tested in a joint model as illustrated above, and individually as illustrated below.

$$\underbrace{\Delta P_t}_{\substack{\underline{\text{Stock return}}}} = \underbrace{\Delta F_t}_{\substack{\underline{\text{Fundamental proxies}} \\ \text{E = Earnings} \\ \text{D/E = Capital structure}}} \quad \text{and} \quad \underbrace{\Delta P_t}_{\substack{\underline{\text{Stock return}}}} = \underbrace{\Delta B_t}_{\substack{\underline{\text{Contagion proxies}} \\ \text{C = Volume} \\ \text{C = Volatility} \\ \text{C = Money flow}}}$$

The benefit of testing the variables individually is that it may give insight into whether changes in fundamental, or bubble variables, do have explanatory effect in explaining stock returns. Testing the variables in a joint model can give further insight how the variables together explains stock returns. Further, below an overview and explanation will be given on how the presence and absence of the explanatory effect of the fundamental proxies and contagion proxies may indicate a run-up to a bubble.

These tests may provide a little indication of a run-up to a financial bubble;

1) If stocks return cannot be explained by changes in fundamental proxies
2) If stocks return can be explained by changes in contagion proxies

If the first point, stocks return cannot be explained by changes in fundamental proxies, it may indicate that there is another factor explaining stock returns. If the second point, stocks return can be explained by changes in contagion proxies, it may indicate the presence of herding behavior which is a mechanism involved in the growth of a bubble. If only one of these points are present it can provide a little indication of a run-up to a bubble, however, if both points are present at the same time, it may strengthen the indication of a bubble. Furthermore, if stock return can be explained by changes in contagion proxies, is present together with that stock return **can also** be explained by changes in fundamental proxies, the explanatory effects yield different signals, one confirming and the other contradicting a bubble, and the bubble indication is thus not clear. Lastly, if neither of the above outlined points are present, a bubble indication is not found.

The models and relationships outlined above will be tested on the three samples. Bubble confirmative relationships for the green sample may indicate a direct run-up to green bubble. Bubble confirmative relationships for the grey sample may indicate a run-up to a bubble, possibly explained by a green reward deriving from transitioning to renewables. However, if the bubble confirmative relationships are present in all samples, also present in the black sample, a bubble may be indicated in the general energy industry. Thus, the statistical chapter in this thesis will apply the above outlined models to investigate the three different samples to disclose if there are any differences in the explanatory effects of the changes in fundamental proxies and the changes in contagion proxies on stock returns.

3. DATA SAMPLE

The following chapter will introduce the data samples that will be used for the statistical analysis. Firstly, data on the surrounding market conditions in the sample time period will be presented, as this lays the foundation for further bubble indication study. Secondly, elaboration of sector specification for the three samples will be discussed. Thirdly, an overview of the three data samples, namely green (fully renewable energy), grey (both renewable and fossil fuel energy) and black (fossil fuel) will be displayed, which will be followed by the fourth section which describes the three samples characteristics. The fifth section will introduce the specific independent variables used as proxies for fundamentals and contagion. The last and sixth section will describe how the data has been transformed in order to perform the statistical analysis.

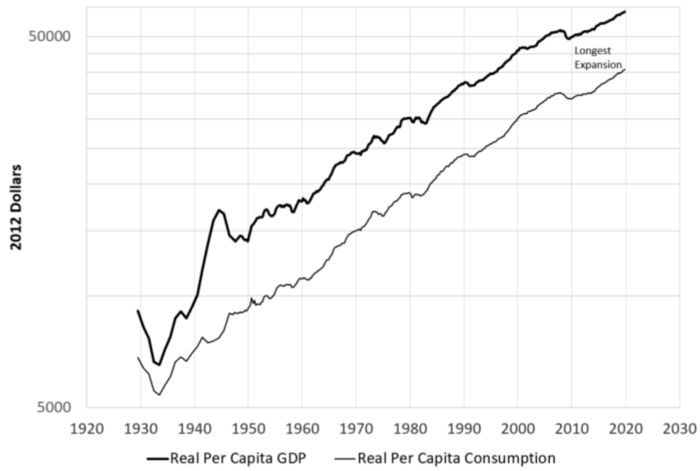
3.1 SAMPLE PERIOD MARKET CONDITIONS

As presented in the previous chapter, there are three market conditions that needs to be present for a bubble to cultivate. Firstly, the economic environment has to be a scene where the “right mood” can fostered, which often is the case when the market is in expansion. Secondly, there must be sufficient credit availability, which can be indicated by looking at interest rates that the monetary authorities set. Lastly, the market needs to be incomplete with asymmetric information. The coming section will investigate if these market conditions were present in the U.S. within the data samples time period of 2009 – 2019, compared with historical numbers. Overall, the coming section will examine whether the conditions for a bubble to form has been present in the time period analyzed.

3.1.1 MARKET EXPANSION

Shiller (2020) describes how a US economic expansion began in June 2009 after the financial crisis, which led to the markets passing a historical length record ten years later in June 2019 with 120 months of expansion. To illustrate the longest expansion Shiller (2020) displays graph below, showing the development in U.S. Real Per Capita GDP and Real Per Capita Personal Consumption Expenditures in the time period of 1929 - 2019.

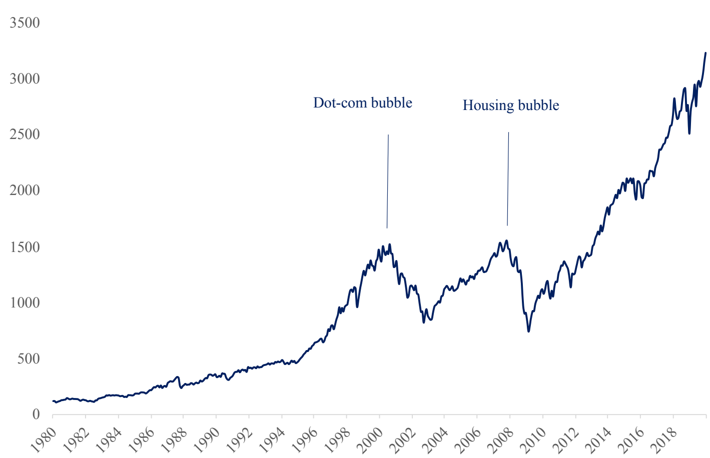
FIGURE 3.1: U.S. REAL PER CAPITA GDP AND REAL PER CAPITA PERSONAL CONSUMPTION EXPENDITURES



Source: U.S. Bureau of Economic Analysis; Shiller (2020)

Additional statistics conveying the U.S. market expansion the last decade is the development of S&P500. A general market expansion is often also associated with a rise in the stock market and looking at the development of S&P500 is therefore valuable (Jermann and Quadrini, 2007). S&P500 index is often used as an indicator that represents how the general stock market performs. As conveyed in the graph below, since after the financial crisis in 2008, the S&P500 has been growing with a CAGR of 11,22% in the time period of 2009 - 2019.

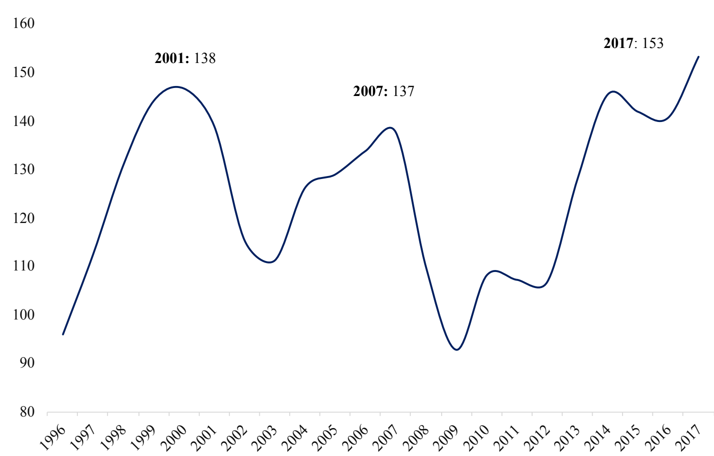
FIGURE 3.2: S&P 500



Source: S&P 500; Federal Reserve Bank of St. Louis (2020a)

A third indicator of the U.S. market expansion is the U.S. equity market capitalization to GDP ratio, also known as the Buffet indicator. The market capitalization to GDP ratio is a valuation indicator on a country's stock market and can be used to determine whether the stock market is over or undervalued compared to a historical average (Mislinski, 2020). The graph below shows the ratio in the years of 1996 – 2017 (data until 2019 was not available) and shows that it reached a record height in 2017, with a ratio of 153%. Furthermore, Haver Analytics (2020) stated that this ratio reached another new record high in the beginning of 2020. This information may indicate that the general stock market is overvalued in relation the overall economy. A drawback with comparing historical numbers using this measure is that the last 20 years is characterized with increasing globalization, and thus the market capitalization on the U.S. stock market do not only reflect American wealth creation, which the GDP does. Hence, the larger share of market capitalization may come from wealth creation made in other countries, and not only in the U.S (Berg, 2015).

FIGURE 3.3: MARKET CAPITALIZATION TO GDP RATIO



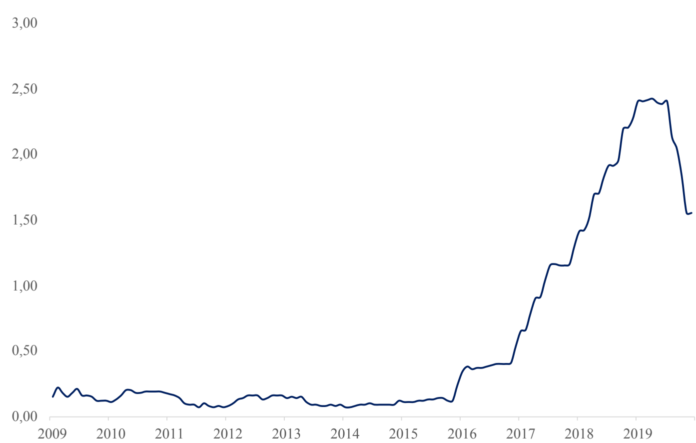
Source: World Bank; Federal Reserve Bank of St. Louis (2020b)

Consequently, the data above shows that the first condition for a bubble to cultivate, namely market expansion, is present in the data samples time period.

3.1.2 SUFFICIENT CREDIT AVAILABILITY

The second economic condition that needs to be present for a bubble to grow is sufficient credit availability as it is the aggregate speculative capacity of the market that drives the bubble. A high speculative capacity enabled by easily accessible credit can be identified by looking at interest rates (Hiferding, 2019) If interest rates are low it enables investors to borrow more cheaply, and thus invest loaned money into a possible bubble. The monetary authorities in the U.S. is the U.S. Federal Reserve System, which uses the effective federal funds interest rate to influence the economy. This interest rate is used as a benchmark for interest rates for credit cards, mortgages and bank loans (Sellon, 2002). The graph below conveys that the interest rate has been kept low since after the 2008 financial crisis and until 2016. In the years of 2016-2019, the interest rate has gradually risen. The U.S. Federal Reserve System can as previously discussed use interest rates as an instrument to stimulate the economy. As seen, the U.S. Federal Reserve set the interest rate low after the 2008 financial crisis to support the growth of the economy in its recovery phase. In the years after 2016, the economy has been doing well in its expanding phase, which allows the U.S. Federal Reserve to push interest rates up in order to make sure the inflation is not too high (Alvarez, Lucas and Weber, 2001). Although, interest rates have been slowly increasing in the last three years, it is concluded the interest rates are sufficiently low to make the credit access easily available for investors.

FIGURE 3.4: EFFECTIVE FEDERAL FUNDS INTEREST RATE



Source: *Federal Reserve Bank of St. Louis (2020c)*

3.1.3 *ASYMMETRIC INFORMATION AND INEFFICIENT MARKETS*

The third condition that needs to be present for a bubble to cultivate is that the market is inefficient, and that information is asymmetric. For the purpose of this thesis' analysis, asymmetric information, will be assumed to be a premise for investors. Furthermore, the study performed in this thesis, is in itself a test of whether markets are efficient. As previously described, the semi-strong form of market efficiency's ability to detect bubbles, has been shown helpful in predicting bubble crashes or future returns (Greenwood, Shleifer and You, 2017).

The method applied later in this thesis will apply past stock price movements and trading patterns together with publicly available information in the form of fundamentals. Thus, the applied statistical method is testing the semi-strong efficient market theory by analyzing the effect of public information in form of fundamentals, and trading patterns explanatory effect on stock returns. It should be noted that the method does not seek to predict a crash or predict returns but seeks to find the explanatory effect of these variables on stock returns over time, as an indication of, if there has been a run-up to a green financial bubble. Further, if a green bubble can be detected by using the past stock return and publicly available information, this contradicts the semi-strong efficient market hypothesis. As described, the semi-strong form of the efficient market hypothesis poses that market prices fully reflect all past and publicly available information. However, if the test applied later shows that the market price do not fully reflect the public information, fundamentals, it may indicate that the semi-strong form of efficient market hypothesis do not hold in this case, since fundamentals should be reflected in the stock price. If this contradicting indication of the semi-strong EMH will be present, it would be a weak contradiction, as the test only applies one parameter of public available information.

3.2 Sector specification and sample considerations

The coming section will elaborate on the considerations made in focusing on the energy industry, on the U.S., on public companies and on the specific period of time, in investigating a run-up to a green bubble.

3.2.1 U.S. Energy industry

The thesis investigates whether a green bubble for American renewable energy companies can be indicated. The attention, attractive returns, need for investment, and relevance that renewables has in the green transition yields some of the reasonings that investors may have in investing in renewable energy stocks. The renewable stocks represented fully by the green sample, and partly in the grey sample, will be compared to the black fossil fuel sample, by investigating companies involved in the general energy industry. Ideally, in order to the best way compare companies with somewhat the same underlying fundamentals and structure, analysis based on companies operating in only one part of the energy value chain, such as the power generation industry would be optimal. However, there are two main reasons why this methodology turned out to be counterintuitive, mainly restricted by the energy industry structure.

Firstly, the number of companies that is fully focused on only green and renewable energy is limited, and if looking at only one part of the energy value chain the number of exchange-listed companies is small. For example, only looking at green power generation companies with a sole focus on renewable energy would result in a sample of only nine companies. The low number of fully renewable energy generation companies can be explained by the recent decades transition from fossil fuel energy to adding renewable energy to the fossil fuels companies' portfolio. Since there are high barriers to entry within the energy industry (Marketline, 2019), the entry into developing energy from renewable sources, has mainly been possible for existing players in the industry, and can have served as a way to diversify themselves in order to get customers that are conscious about the environment (Marketline, 2019). The low focus on only renewable energy, is also the case for companies before and after in the value chain. The suppliers supply equipment and other services to a range of different companies, not only green energy companies. The buyers, which are the utility electricity retailers sell energy from both fossil and renewable energy sources, only some focus solely on renewable energy sources (Marketline, 2019). Summing up, there is a limited number of companies that focus solely on green and renewable energy, which makes the possibility of making analysis in only one step of the energy value chain challenging.

Secondly, many companies are involved in several stages of the energy value chain, so looking at companies in only one part of the value chain would yield a little number of sample companies. For example, many of the black fossil fuel companies are involved in assessment, acquisition, exploration, and development of oil, gas, and other hydrocarbon properties. This is also the case for the green energy companies that are involved in several steps in the value chain such as generating power and distributing the power out to the consumers (EIA, 2019f).

To sum up, looking at companies within the same part of the energy value chain would be valuable when comparing companies' fundamentals and structure, as it would be more similar in regard to type of assets it would hold and sensitivity to the economic environment. However, the energy industry structure limits firstly, the number of companies focused solely on renewable energy, and secondly, the number of companies that are only involved in one part of the energy value chain. If only analyzing data in one part of the value chain, with very little data, would in turn decrease the validity of the findings. Therefore, in order to analyze on the basis of sufficient amounts of data, the general energy industry will be analyzed. Although, it can be more difficult to draw conclusions based on companies that are less similar, it may be argued that the total validity of the results will increase by increasing the sample size significantly (e.g. for the case of the green companies it means going from only 9 companies to 19 companies). Additionally, it is possible to argue that since the companies are within the same industry their fundamentals and reaction to the surrounding environment is comparable.

Overall, three samples will be analyzed to see whether there is difference in the explanatory variables dependent on the degree of involvement will be analyzed. A green sample with fully renewable energy, a grey sample with hybrid companies in transition from fossil fuels towards renewables and a black sample with fossil fuel companies. The black sample is analyzed to differentiate whether a bubble can be indicated for the broad energy industry, or whether it is only for companies involved with renewable energy. The grey sample is also investigated to see whether transitioning to renewables from fossil fuels can have an additional green positive effect on their stock price, as transitioning to renewable energy can be seen as decreasing their carbon risk (Görgen et al., 2016).

3.2.2 AMERICAN COMPANIES

The data collected consists of companies listed on American stock exchanges. The American stock market is the largest stock market in the world, making up 54,5% of the total global stock market in 2020 (Statista, 2020), and it may be argued that it can represent the world market. In addition, comprehensive and detailed data is more accessible on the American stock exchanges, and complete data may improve the validity of the thesis's findings. Additionally, according to a global study about global warming awareness, the U.S. was ranked as top second most aware, with 97,7% of respondents saying they were aware of climate change (Lee, Markowitz, Howe, Ko and Leiserowitz, 2015). Although, amongst the most aware countries, the U.S. is not top amongst the countries that regards the climate change as a serious threat, with only 50%-69% of the respondents seeing the threat of global warming to them and their family as serious (Lee et al., 2015). With the climate-crisis-denying republican Donald J. Trump as president, it may be argued that the seriousness of the climate crisis may be further viewed as negligible to many Americans. This is in line Lee et al. (2015) conveying that American liberals and Democrats are more likely to express concern about climate change than the conservatives and Republicans (Lee et al., 2015:1016). As shown through a study made by Bonaparte, Kumar and Page (2017) the political affiliation and the current political climate affects investors optimism towards financial markets. When the preferred party is in power "investors increase allocations to risky assets and exhibit a stronger preference for high market beta, small-cap, and value stocks, and a weaker preference for local stocks" (Bonaparte et al., 2017:69). Consequently, with the republicans as a ruling party, that typically has less concern about climate change, and with higher optimism amongst republican investors, may affect the rise of the green stocks negatively in the U.S. On the other side, there is also many international investors on the American market, where foreign ownership of U.S. equities was at a share of 35% in 2018 (U.S. Department of the Treasury, 2019). International investors, with high awareness, and higher risk and seriousness perception towards climate change, may give the American green stocks a positive push upwards. Furthermore, many of the American energy companies are global and thus have operations in other countries, and international circumstances may therefore affect the American companies.

3.2.3 Public companies listed on NYSE and Nasdaq

The sample companies are listed on the American stock exchanges New York Stock Exchange (NYSE) and National Association of Securities Dealers Automated Quotations (Nasdaq). These are the world's largest stock exchanges by market capitalization of listed companies (Statista, 2020). Thus, these stock exchanges contain data on numerous companies, in a wide range of industries, over a long time period. Hence, sampling data from these exchanges on public established companies, provides the analysis with broad and extensive info. This can increase the validity of the analysis findings, compared to if data was sampled from a less reliable and smaller stock exchange.

3.2.4 Time period

The time period of 2009 – 2019 has been chosen as the focus on the field of green transition seems to particularly commence this year. In 2009, ministers from 34 countries signed a green growth declaration, for the Organization for Economic Cooperation and Development (OECD) to develop a green strategy that brings together "economic, environmental, social, technological, and development aspects into a comprehensive framework" (OECD, 2011). Hence, the time sample will be started from 2009 until 2019, with quarterly data. The method applied requires data on stock prices, trading data and data on company's financials. Hence, since the norm for companies is to publish only quarterly data on their financials, a quarterly interval will be applied. As described previously, the samples time period does not include data from 2020, and changes in the economic environment and data on the first quarter of 2020 will be enlightened in the discussion.

3.3 OVERVIEW OF SAMPLE

This section will give a brief overview of the three samples, their structure and the companies included. As depicted in the table below, there are three samples, green, grey and black, which are grouped on the basis of degree of involvement in renewables in order to capture the degree of "greenness." Further elaboration on the three samples composition of companies will be given below the table. The table also presents the range of number of companies included in the sample. This because, within all samples, and especially the green and black sample, the number of companies included in the sample will change over time, as a result of new companies getting listed on the stock exchanges. Hence, when new companies within the same industry enter the stock market through initial public offerings, the sum of the market capitalization for that sample increases, and the companies relative share of the total market capitalization changes. As later will be elaborated on, in 3.5 transformation of dataset, the time series variables for each sample will be calculated using weighted average, with market capitalization as the weight factor. Thus, the matter of changing number of companies entering the samples is accounted for using the weighted average method, so that the companies which have not entered the market yet will not count before their stocks are publicly listed. The table below shows an overview of the three samples, its key characteristics and the range of number of companies.

TABLE 3.1: SAMPLE OVERVIEW

Sample	Description	Number of companies
a: Green companies	Companies only involved in renewable energy	Low number; 10 Top number; 19
b: Grey companies	Companies primarily involved in oil and gas with a transition to renewable energy	Low number; 26 Top number; 29
c: Black companies	Companies only involved in oil and gas	Low number; 51 Top number; 68

Below a small elaboration on the samples composition of companies will be given. The composition of large and small companies is important to mark since the larger companies, with a large market capitalization, will with the weighted average method have a greater influence on the time series data line. For a full list on the companies within each sample, see appendix B.

3.3.1 GREEN: RENEWABLE ENERGY

The energy companies with the largest market share in 2009 is First Solar with around 50% and Quanta services with 20% of market capitalization. However, the distribution changes over time, and in 2019 the companies Avangrid had 30% of the market capitalization, Enphase Energy Inc, Quanta services and Portland General electric company with around 10% each of the market capitalization. Hence, the green sample has had large changes in the market capitalization share distribution, compared to the black sample, as will be described below, large companies has had stable market capitalization share over the eleven-year period.

3.3.2 Grey: Renewable energy and fossil fuels

The grey sample can be characterized as more fragmented, where no company exceeds more than 20% of the market capitalization at any point, in the time period. In 2009 Exelon Corporation and The Southern Company had the largest market capitalization share with 15% and 11%, respectively. However, this distribution changed in 2019 where NextEra Energy had 20% of the market, and Duke Energy and The Southern company had 10% each of market capitalization.

3.3.3 Black: Fossil fuels

The black samples companies are more consolidated, as there is a few and large fossil fuel companies with the majority of the market capitalization. These companies are amongst others, Chevron corporation, Exxon mobile and ConocoPhilips, where the sum of their market capitalization is in the range of 57% - 76% in the time period. Thus, the development in these companies will have a large impact on the development of the time series. The remaining market capitalization is approximately evenly distributed between the remaining companies

3.4 Sample characteristics

The following section will plot key numbers of the three data samples in order to get an overview and initial grasp of the data's characteristics. The key numbers which are valuation ratios, capital structure and profitability ratios, will be visually presented over the time period to show the development in these characteristics. The P/E ratio will show the development of the valuations, the debt-to-equity ratio will exhibit the capital structure and the EBIT/Revenue ratio will display the profitability. The samples' ratios, based on data points from individual companies, are calculated using the weighted average method described in section 3.5 transforming the dataset.

3.4.1 P/E RATIO

The price-to-earnings ratio, (P/E ratio) can be used get an insight into the valuation of a company and can be used to determine the relative value of a company compared to peers and to compare a company, or industry, valuation development over time. The price earnings ratio is calculated using the following formula;

$$P/E\ ratio_t = \frac{Market\ Share\ price_t}{Earnings\ per\ share_t} \tag{3.1}$$

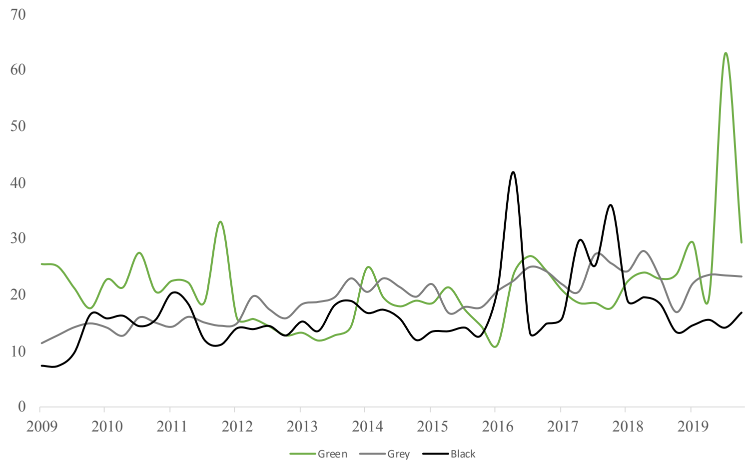
The P/E ratio can also be used to analyze whether a stock price is over or under valued. The ratio represents the relationship between the earnings a company can generate to its shareholder and the price investors are willing to pay. Furthermore, if a P/E ratio equals 30, it implies that investors are willing to pay over 30 times the company's current earnings to purchase the stock. Hence, companies with high P/E ratios tend to have strong growth outlooks to justify the high price investors are paying (Berk and DeMarzo, 2017).

Further, P/E ratios depends on the nature of the industry, and high P/E ratio industries are typically characterized has high growth. Some may argue that the P/E ratio is a too simple measure. Although, the simplicity of the assessment, it can be valuable as an initial indication on whether stocks have an irregularly high value. For example, the average P/E ratio for S&P500 in the time period 2000-2020 has been 26, while right before the crash of the financial crisis in 2008 the ratio exceeded 100 which could imply prices that could not be justified by growth outlook (Macro trends, 2020). Moreover, for the energy industry the P/E ratio has been in the range of 10-20 the past 20 years, while the utility sector has been in the range of 15-25 (Gurufocus, 2020).

As seen on the graph beneath, the P/E ratio for the grey sample has been relatively stable between 10 – 30, which is in line with an average ratio of the energy and utility sector of 10 – 25. The green and black sample has more spikes in the development of the P/E ratio and seem more volatile than the grey sample. A possible explanation to the green samples' high spike may be the attention and funds the renewable energy stocks has received in recent years as previously shown. Further, according to (Volz et al., 2015), there still exist some uncertainty related to green projects and their growth potential due to new technology and business models, pushing the average P/E valuation down. Hence, these factors may also influence the growth outlook for green companies and result in more volatile P/E ratios than the black and grey sample. The high spike in the green sample in

2019 comes as a result of First Solar and Enphase energy, which both in 2019 had P/E ratios of over 200. These high P/E ratios should in general be a concern for bubble pricing.

FIGURE 3.5: P/E RATIOS



3.4.2 DEBT-TO-EQUITY RATIO

The debt-to equity ratio is a measure of the capital structure of a company (Berk and DeMarzo, 2017). The debt-to-equity ratio is calculated using the following formula:

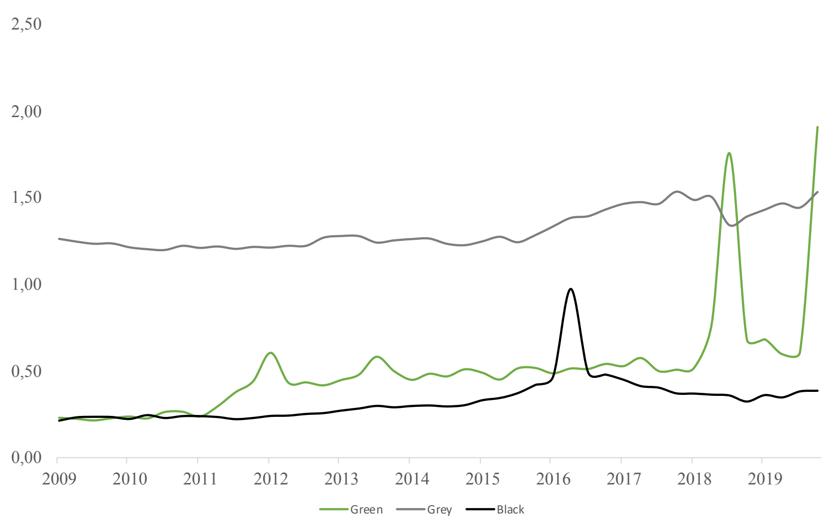
$$Debt - to - equity\ ratio_t = \frac{Total\ debt_t}{Total\ equity_t} \tag{3.2}$$

A debt-to-equity ratio above one means that the company has more debt than equity. Furthermore, as the case for P/E ratio, the debt-to-equity ratio also varies by industry. Capital intensive industries often tend to have more debt than other industries (Rao, 1989). Thus, this is the case for the energy and utility sectors since these industries requires extensive upfront investments (Volz et al., 2015). Furthermore, the renewable energy sector requires more investments into R&D as green innovation are needed to increase the applicableness and cost-efficiency for the renewables (Feng and Chen, 2018). The average debt-to-equity ratio for the renewable energy sector has been in the range of 0,7 to 0,8 (IRENA and CPI, 2018). For the fossil fuel sector, the average debt-to-equity ratio has been in the range of 0,6 and 0,9.

The graph below shows the three samples debt-to-equity ratios. It depicts that until 2012 the green sample had approximately the same debt-to-equity ratio as the black fossil fuel sample. However, in 2011 as a consequence of changes in the political landscape, brought uncertainty to whether the renewable companies would continue receive subsidies from the government (REN21, 2011). The renewable companies are very reliant on these subsidies, and which may have caused them to take up extra debt to finance their operations, increasing the debt-to-equity ratio. After 2011 companies within renewable energy has in general had a higher debt-to-equity ratio compared to the fossil fuel companies. The higher debt-to-equity ratio is in line with that the renewable energy industry in general, is more capital intensive than the fossil fuel industry (Volz et al., 2015), and may thus find it necessary to deploy more debt in order to operate and finance new investments, especially when governmental subsidies disappear.

The green sample also exhibits large spikes in the debt-to-equity ratio exceeding 1,5 in 2018 and 2019. These spikes may be related to debt-to-equity changes in the companies Enphase Energy and SunPower, which had ratios of 27 and 39 in 2018, respectively. For example, in 2018 Enphase Energy acquired SunPower's microinverter business. SunPower's possible motive to sell its microinverter branch is described as being motivated by a possible bankruptcy (Osborne, 2018). This can be reasoned by that SunPower has struggled with liquidity issues and has sold several assets in addition to increasing its debt financing. Consequently, the increased debt-to-equity ratios in 2018 and 2019 may come as a result from Enphase Energy taking on additional debt to acquire the SunPower's microinverter branch, in addition to the debt taken on by SunPower. Further, the grey sample has a stable high debt to equity ratio, possibly deriving from financing new renewable plants and operations which all of the grey largest companies seem to have invested heavily in (NextEra, 2020) (Duke Energy, 2020) (The southern company, 2020) (Exelon, 2020).

FIGURE 3.6: DEBT-TO-EQUITY RATIOS



3.4.3 PROFITABILITY RATIO

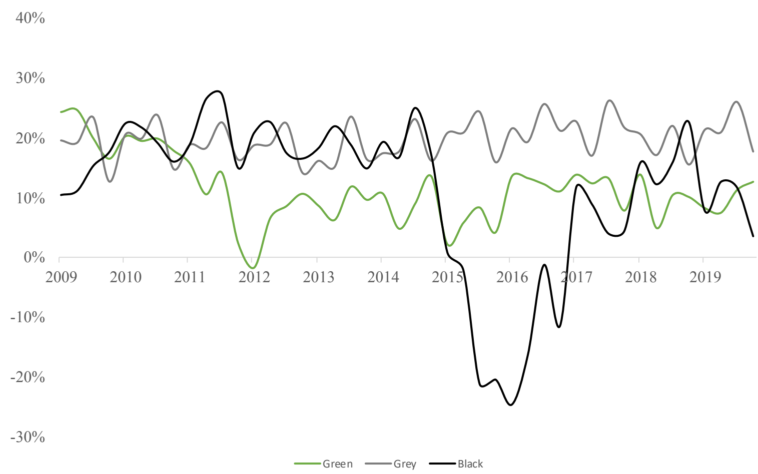
The EBIT-margin is one way to measure a firm's profitability (Berk and DeMarzo, 2017). By comparing profitability ratios across firms' it is possible to determine the efficiency of the firm's operations. The EBIT-margin is calculated the following way:

$$EBIT - margin = \frac{EBIT}{Revenue} \tag{3.3}$$

EBIT is the operating profit and is the earnings before interest and tax. Hence, EBIT is overall driven by the company's revenues and operating costs. The average EBIT-margin also varies across industries, and for the case of the energy industry both revenues and costs are dependent on the regulatory landscape. As previously shown, the U.S. energy sector is dependent on governmental support, in the form of receiving subsidies (EIA, collected 09.05.2020). Renewables cost efficiency is another important profitability driver. Overall, the renewable energy technologies have become more cost effective over the past ten years, improving the profitability for renewables. The fossil fuel companies are also dependent on low costs, however not to the same extent as renewables, and receives subsidies to make oil products cheaper (Birol, 2020).

Outlined under is a graph showing EBIT/Revenue margins for the three samples. The first two years display somewhat similar profitability margins for the three samples. However, in 2011 - 2012 the green sample experiences a severe drop in the profitability. Again, this can be explained by issues related to government support (REN21, 2012). Since the renewable energy companies is reliant on government support, negative changes in this, negatively affects the green samples profitability. However, although the hybrid grey sample also is involved with renewables, this change does not seem to affect the grey sample in the same way. The relatively stable profitability which the grey sample exhibits may be explained by that the grey sample being involved with both renewable and fossil fuels and are thus more diversified. The black sample's drop in profitability in 2014, can be explained by the oil price crash in 2014, which at that time, was the fastest and most severe decline in oil prices in history (Fantazzini, 2016).

FIGURE 3.7: EBIT/REVENUE



Having provided an overview of the key development and characteristics, the next section will describe the variables that will be used in the statistical analysis.

3.5 CHOICE AND DESCRIPTION OF VARIABLES

The variables depicted in the table below will be applied in the statistical analysis to analyze the fundamental proxies and contagion proxies explanatory effect on stock price. The choice of variables comes from Porras (2017) framework and has a few changes. The EBIT/Revenue ratio is added since it is interesting to investigate whether the fundamental profitability ratio has an effect on stock returns. Further, in lack of data the R&D variables will not be applied. The tables' explanations are elaborated on, using Berk and DeMarzo (2017) for the fundamental variables and Porras (2017) for the contagion variables.

TABLE 3.2: CHOICE AND DESCRIPTION OF VARIABLES

Dependent variable	
Adjusted stock price	These prices are adjusted for all security level corporate actions such as stock splits, reverse stock splits, cash dividends, rights offerings, and spin-offs.
Independent variables	
Fundamental variables	
EBIT	Earnings before interest and tax (EBIT) is a common measure of operating income.
EBIT/Revenue	Operating margin which shows how much a company earns before interest and taxes from each dollar of sales. Can be used as a profitability measure and an indicator of effectiveness.
Capex	Capital expenditures. Cash outflows used to supplement to the company's existing property, plant and equipment
Net working capital	Current assets – current liabilities
Depreciation	Non-cash charges for obsolescence of and wear and tear on property, allocation of the current portion of capitalized expenditures
Debt to equity ratio	Measure of capital structure. D/E = Debt / Equity.
Free cash flow	Free cash flow = Net income + Depreciation – changes in NWC - CAPEX
Contagion variables	
Money flows	Money flow (MF) captures the additional capital invested each quarter to purchase each companies' stock.
Range (Volatility)	Price high minus Price low. (Is used to calculate volatility).
Volume	Number of shares traded

Further description of the contagion variables can be found in appendix C. In order to analyze the variables described above, the variables will be transformed with the method described in the next section.

3.6 TRANSFORMING THE DATASET

The variables stock prices, the fundamental proxies and contagion proxies, presented in the previous section, is collected on company level. These variables need to be transformed in order to analyze it in the statistical analysis. Elaboration on how these proxies are transformed will be given in this section. Porras (2017) describe how changes in stock prices can be explained by changes in a company's fundamentals and contagion proxies, if a bubble component is suspected. Porras (2017) investigates three contagion variables, volume, volatility and money flow, and investigates fundamentals by looking at earnings and capital structure, represented in the debt-to-equity ratio.

3.6.1 Fundamental proxies: different definitions of earnings

The fundamental variables, earnings, can be measured in several ways and therefore have several definitions. The first definition is the base case of using EBIT as a measure of earnings, the second definition is adding depreciation to EBIT, and in the third and fourth definition net working capital and capital expenditure is added. Different definitions of earnings are applied to see whether the different definitions of earnings can provide different explanatory effect. Furthermore, other literature has also used dividends as a measure for earnings. However, Porras (2016) explain that dividends can be misleading measurement of earnings as not all corporations pay out dividends. Below is a table with the six different definitions of earnings and their abbreviation which will be applied in the statistical analysis.

TABLE 3.3: OVERVIEW OF DIFFERENT DEFINITIONS EARNINGS AND ABBREVIATION

Definition	Calculated	Abbreviation (applied in analysis)
1	EBIT	EBIT
2	EBIT + Depreciation	EBITD
3	EBIT + Depreciation + NWC	EBITDN
4	EBIT + Depreciation + NWC + CAPEX[2]	EBITDNC
5	Free cash flow	FCF
6	EBIT/Revenue	EBITREV

3.6.2 Creating indexes and changes for each of the three samples

Data on the three samples, green, grey and black, is collected on a company level on a eleven-year quarterly basis, specifically from 31.12.2008 – 31.12.2019. Explanation on the procedure for calculating the times series for a sample will be given here. The same procedure will be repeated for all samples. The initial dataset has 45 data points (quarters), for each variable investigated, for each company. The changes in the time series, which will be used in the statistical analysis, will be calculated with the following procedure. Step 1: Calculating the market capitalization weights for

[2] It should be noted that NWC and CAPEX are added as absolute and positive numbers to capture the effect of current investments in future growth. Hence, definition four and five are not the same.

each quarter using formula 3.4. Further, now a given variable will be transformed followingly. Step 2: Calculating a weighted average for each variable at a given quarter using formula 3.5, this is repeated for all 45 quarters. Now the time series is created for the variable with 45 quarters. Step 3: Calculating changes in the variable, using formula 3.6. Now the changes in time series for a given variable is calculated. This procedure is repeated for all variables. Below the procedure will be shown using the variable price as an example. The weighted average method has been applied where the weights are calculated by dividing each company's market capitalization by total market capitalization in the given quarter (Berk and DeMarzo, 2017).

$$w_{i_t} = \frac{Market\ cap\ _{i_t}}{Total\ market\ cap_t} \tag{3.4}$$

Using price as an example, the price at a given quarter is calculated by the following formula,

$$P_t = w_{1_t} P_{1\,t} + w_{2_t} P_{2\,t} + \cdots + w_{N_t} P_{N\,t} = \sum_{i=1}^{N} w_{i_t} P_{i\,t} \tag{3.5}$$

Where, (applies to both formula 3.4 and 3.5)
i = company
t = time

$w_{1_t} + w_{2_t} + \cdots + w_{i_t} = 1$

In order to analyze the variables using time series regression, stationary variables are needed. Hence, the time series of all variables are calculated as a percentage change, by using the following formula:

$$\Delta P_t = \frac{P_t - P_{t-1}}{P_{t-1}} \tag{3.6}$$

After this step, the number of observations is now 44. Here, again presented with price as an example for transforming price time series into price change, also called stock return. All other variables like the time series of the contagion proxies, volume, range (volatility) and money flows is found the changes for. Further the time series' of the six definitions of earnings, EBIT/Revenue and capital structure is also estimated the change for using the same change formula above (3.6).

3.6.3 MISSING DATA

Missing data in time series is a common problem and can be caused by several factors. If not dealing with missing data in an appropriate way it can influence the reliability of the estimated model (Stock and Watson, 2015:371). The initial data samples presented had missing data for all companies in the two quarters Q3 2013 and Q3 2018, for the variables stock prices high and stock prices low. These data points are used in the process of calculating the contagion variables (appendix, C). There are several ways to handle missing data. In some cases, missing data periods can be omitted from the dataset, but in time series this will change the frequency of the data. In other words, it would result in quarterly data for the data sample, except two periods where it would be semi-annually. This could affect the results and is hence not an appropriate method. Another way to handle missing data in time series is by applying linear interpolation. This method calculates the missing quarters based on the previous period and the next period. Since, the missing values has all been in a regular interval, the missing values can simply be calculated by finding the arithmetic mean between the preceding and succeeding period.

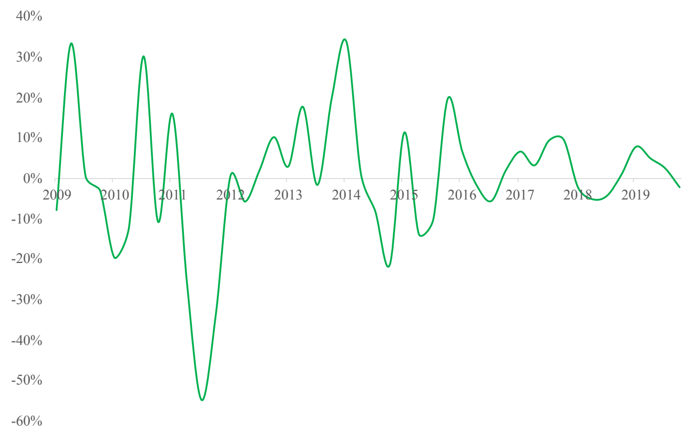
3.7 DESCRIPTIVE STATISTICS SAMPLES

Economic time series behave differently, and by plotting the data, its behavior can be conveyed. Furthermore, time series is frequently analyzed after calculating changes (Stock and Watson, 2015). Changes can either be referred to as absolute change, where the difference between two variables are calculated in the following way: $\Delta Y = Y_t - Y_{t-1}$. Relative change is the second term which changes can refer to, and it is calculated with the following formula $\Delta Y = \frac{Y_t - Y_{t-1}}{Y_{t-1}}$. Such adjustments are made to account for non-stationarity and trends that often occur in time series. As previously presented relative change is applied in this thesis's analysis. The coming sub-sections will elaborate on the behavior of stock returns in the three samples.

3.7.1 GREEN SAMPLE STOCK RETURNS

The graph below shows the green samples stock return. The green sample has an average quarterly return for the period 2009 - 2019 of -0,05%. The little negative return can in a large scale be explained by the large negative spike in 2011 where the stocks had a negative return of -55%. The green samples' returns seem more volatile, compared to the grey and black sample, with its maximum return of 34% in Q1 2014 and a minimum of -55% in Q3 2011.

FIGURE 3.8: GREEN SAMPLE STOCK RETURNS

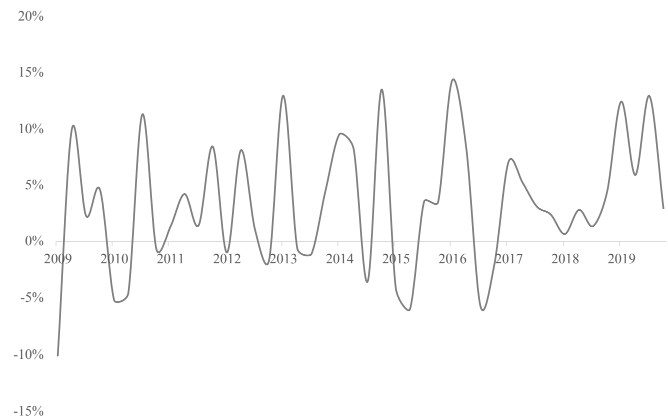


The significant drop in returns in Q3 2011 for the green sample is a mainly a result of the stock price drop of FuelCell Energy, First Solar and American Superconductor. The stock price fall in 2011 can be explained by changes in the political landscape in 2011 which increased the risk of losing government support. Future revenues that had already been counted on valuing renewables stocks with the expectations of receiving subsidies, was suddenly uncertain, and led to a negative return in the green stocks. The many bankruptcies happening in the industry, may have had a further negative impact on the green samples stock prices. On the upside, looking at the returns of the grey sample after Q3 2011 conveys an average return of 2,71%, which is similar to the returns in the grey sample.

3.7.2 GREY SAMPLE STOCK RETURNS

For the grey sample, the average quarterly return is 3,34%. This return is approximately twice the return of the black sample, which is in line with this thesis' curiosity of whether companies involved with renewables benefit from greater returns. Furthermore, the maximum quarterly return is 14%, while the lowest return in the period is -10%. The grey sample can thereby be seen as less volatile than both the black and green sample, possibly explained by that being exposed to both sectors diversify the risk. However, it seems like the graph may exhibit that the last period of the data is following an upward trend. This might be an indication of non-stationary data and this assumption will further be investigated in chapter five.

FIGURE 3.9: GREY SAMPLE STOCK RETURNS



3.7.3 BLACK SAMPLE STOCK RETURNS

The average quarterly return for the black sample is 1,8%. Furthermore, the maximum return over the given period is 30,29% while the minimum return is -18,75%. Compared to the green and grey sample, the black sample has a lower return over the period. The lower return compared to the grey sample may indicate that the companies involved with renewables generate more returns.

FIGURE 3.10: BLACK SAMPLE STOCK RETURNS

4. Time series methodology

The statistical analysis will investigate changes in fundamental proxies and contagion proxies' effect on stock return using Porras (2017) framework. Hence, this chapter will present the toolbox needed to investigate these relationships presented in the statistical analysis. In order to estimate the econometric model presented in 2.4.4 several definitions and assumptions need to be presented. Furthermore, time series as a methodology will be presented with its relevant terms, specifications and characteristics. Section 4.1 will explain the reasoning for applying the chosen time series approach compared to the statistical method applied in the original framework presented by Porras (2017). Section 4.2 will introduce and define time series. Section 4.3 will elaborate on the term stationarity in time series. Section 4.4 will present theory on dynamic causal effects and present the distributed lag model which will be used to investigate the changes in fundamental and contagion proxies explanatory effect on stock returns.

4.1 Introduction

When analyzing financial and economic data several econometric methods such as time series, cross sectional and panel data can be used. Cross sectional data is used for a single time period where data on different entities are collected. Such entities can be workers, firms, governmental units and so forth (Stock and Watson, 2015). Further, time series data are data for a single entity collected at multiple time periods often used to analyze economic data and financial data. Panel data are data for multiple entities, where each entity is analyzed for more than one time period.

The bubble and contagion theory presented by Porras (2017:231) describes how stock prices can be explained by fundamentals and contagion proxies. The author presents a method to investigate these relationships using a range of statistical methods. These methods include panel data, quantile regression, random and fixed effects estimation and pooled OLS estimation. These methods are extensive and panel data, although its precise results, may be hard to interpret and challenging to generalize findings from each entity to the overall sample. Time series data is more frequently used and may be more convenient to work with. Consequently, this thesis will analyze the samples using time series data.

4.2 Time series defined

Kirchgässner (2012) describe how time series is a set of observations collected over multiple time periods in a chronological order. Time series can be used to forecast and to estimate dynamic causal effects (Stock and Watson, 2015). As previously described, stock prices are hard to forecast as they rely on expectations about the future. Hence, the estimation of dynamic casual effects is relevant. A dynamic causal effect measures the effect one variable has on another over time. A causal relationship is not needed to forecast, and in some scenarios the purpose is not to forecast but to estimate causal relationships (Stock and Watson, 2015). In the same way that panel data may cause econometric problems, analysis with time series may also have its issues. Fortunately, these problems can be handled as long as the data is treated adequately. The next section will present models and techniques to overcome the main associated econometric problems.

4.3 Stationarity

Time series are said to be stationary if the distribution of the data does not change over time (Stock and Watson, 2015:587). Having stationary data is especially important when models are used for forecasting, since the stationarity of the data says something about whether the past is a useful predictor of the future. Stationary data implies that the probability distribution of the variables does not change over time. Furthermore, a time series is said to be covariance stationary if the mean, variance and autocovariance are constant over time (Pagan and Schwert, 1990). If the time series variables are not stationary, several problems may occur, such as biased and inefficient forecasts which may lead to misleading results. Further, in practice many time series tend to be non-stationarity, for example, when collecting data from financial markets over time, where the probability distribution will change over time (Porras, 2017:40).
The concrete problem created by non-stationarity depends on the source of the non-stationarity. The most common types of non-stationarity in time-series data are trends and structural breaks.

4.3.1 Trends

A trend is defined as a repeated long-term movement in a variable over time (Stock and Watson, 2015:597). Trends can be both deterministic and stochastic, where both causes non-stationarity. While a deterministic trend is non-random, the stochastic trend is random and varies over time. In econometrics, it is more convenient modeling economic time series having stochastic trends rather than deterministic. However, both trends may occur, but the stochastic trend will be discussed in more detail. To better understand and deal with stochastic time trends, the following two models are presented:

1) A random walk presented by the following equation: $Y_t = Y_{t-1} + u_t$
2) A random walk with a drift presented by the following equation: $Y_t = \beta_0 + Y_{t-1} + u_t$

The concept of a random walk is that the value of the time series tomorrow, is its value today plus an unknown change (Stock and Watson, 2015:598). Hence, if Y_t follows a random walk, then the best way to forecast tomorrows value is by using the value of today. Further, the random walk with a drift is an extension of the first model where it also includes a constant. The constant β_0, is the "drift" and indicates that the time series has a tendency to move in one direction or another, also referred to as a drift. To summarize, if a time series Y_t follows a random walk, then it is characterized by non-stationarity and the variance of a random walk increases over time. Hence, the distribution of Y_t will change over time and not be stationary. If a stochastic trend is overlooked, there are in particular three problems that may occur. Firstly, the estimator of the autoregressive coefficients could be biased towards zero which implies that the least square assumptions for times series do not hold. Further, the distributions of the t-statistics can have non-normal distribution and making confidence intervals not valid. Lastly, spurious regression may arise and give misleading results of the relationship between two time series (Stock and Watson, 2015).

Overall, it is important to detect stochastic trends in time series to avoid such problems. Stochastic trends can be identified by statistical procedures, such as the Augmented Dickey-Fuller (ADF) test. Stochastics trends are often referred to as times series having unit roots. Hence, if a time series has a unit root, it implies that it has a stochastic trend. This term will help us in the process of testing for a stochastic trend, using the ADF approach (Stock and Watson, 2015:600). Under the null hypothesis of an ADF test the time series Y_t has a stochastic trend, while under the alternative hypothesis it is stationary.

The ADF test uses the autoregressive model (AR) as a base, when testing for unit roots. Forecasts can be made using autoregression, a model that forecasts a time series based on its past values (Stock and Watson, 2015:578). For instance, the AR(p) model with p equal to 1 is presented the following way:

$$AR\,(1):\; Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t \qquad (4.1)$$

Where,
p = number of lags.

The lag length of p is unknown but can be determined by using information criterion (Stock and Watson, 2015:604). Adding more lags can be beneficial but also result in more estimation uncertainty. Thus, making the right choice can be done by estimating p by minimizing the information criterion. One frequently used information criterion in econometrics is the Bayes information criterion (BIC), while another one the Akaike information criterion (AIC). Studies of the ADF test propose that it is better with too many lags than too few, hence it is best to use the AIC rather than the BIC. Furthermore, when a stochastic trend is detected it needs to be handled the correct way in order to analyze the time series adequately. One way to handle a stochastic trend in a time series is to transform the series by taking the first difference (absolute change). For instance, if Y_t follows a random walk with a drift so that $Y_t = \beta_0 + Y_{t-1} + u_t$, the first difference of this model then becomes $\Delta Y_t = \beta_0 + u_t$ and commonly is then stationary.

4.3.2 Structural break

Another type of non-stationarity is structural breaks. A structural break arises when the regression function changes over time. Furthermore, structural breaks can arise when there are policy changes in an economy, changes in the economic structure or industry specific changes due to an innovation (Stock and Watson, 2015:608). Breaks can occur specifically as a result of policy changes or more slowly if the regression coefficient changes over time. Structural breaks cause problems in the regression model because the coefficients will estimate a relationship that holds on average. Furthermore, the average can be significantly different than the true regression coefficient for the specific period. Testing for breaks can be done in different ways. Firstly, in some cases it may be suspected that there is a specific date in the time series that a break arises. For example, if a major change happened at a specific date this might be a good indicator. If this is the case, the sample can be split into two parts and the regression function in these two parts will be the same if there is no break present (Stock and Watson, 2015:609). In more detail a Chow test can be used, where the null hypothesis of no break using a binary variable interaction regression is tested. The regression is thereby presented the following way:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + d_t X_{t-1} + g_0 D_t(t) + g_1[\, D_t(t) * Y_{t-1}\,] + g_2[\, D_t(t) * X_{t-1}\,] + u_t \tag{4.2}$$

Where, $D_t(t) =$ a binary variable that equals 0 before the break date and 1 after

Under the null hypothesis of no structural break, $g_0 = g_1 = g_2 = 0$. Hence, if there is no break, the regression function is the same over both parts of the sample and the terms involving the break variable $D_t(t)$ does not enter equation 4.1. On the other hand, if the date of the break is unknown or known only within a range, for example between two specific dates then the Quandt likelihood ratio (QLR) statistic test can be used. That is, a F-statistic test that tests for a break at an unknown date. In practice, the QLR test is computed over a subperiod, also referred to as a "trimmed" range of the sample. Furthermore, with a 10% trimming the F-statistic is computed for breaks in the 80% central of the total sample (Stock and Watson, 2015:610). Through a QLR test it is also possible to detect if there are multiple discrete breaks over a time period or if there is a slow evolution of the regression function instead of specific break. Structural breaks can be adjusted for and the procedure depends on the source of the break. If the structural break occurs at a specific date, the break date can be detected by a QLR test and estimated using a binary variable for the two subperiods. However, if the break arises from a slow evolution over time the model becomes more difficult to estimate.

4.4 Estimation of dynamic causal effects

To estimate dynamic causal effects a distributed lag model and an autoregressive distributed lag model can be applied.

4.4.1 Distributed Lag (DL) model

Dynamic causal effects occur over time. The dynamic causal effect is defined as estimating the effect on past and current changes in an independent variable X on a dependent variable Y (Stock and Watson, 2015:635). The econometric model used to determine dynamic causal effects needs to include lags of a dependent variable and is defined a as a distributed lag (DL) model. A distributed lag model with r lags of X is presented the following way:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 Y_{t-2} + \cdots + \beta_{r+1} Y_{t-r} + u_t \tag{4.3}$$

4.4.2 AUTOREGRESSIVE DISTRIBUTED LAG (ADL) MODEL

Dynamic causal effects can also be estimated through an extended version of a distributed lag model, an autoregressive distributed lag (ADL) model including both lags of the dependent variables and the independent variable. The autoregressive distribute lag model builds on the autoregressive model (AR) and the distributed lag model (DL) previously presented (Stock and Watson, 2015:586). The model is presented mathematically as follows:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + \delta_1 X_{t-1} + \delta_2 X_{t-2} + \ldots + \delta_q X_{t-q} + u_t \tag{4.4}$$

p = lags of the dependent variable
q = lags of an additional predictor
u_t = the error term with the assumption that $E(u_t \mid Y_{t-1}, Y_{t-2}, \ldots, X_{t-1}, X_{t-2}, \ldots) = 0$

Further, this kind of econometric model can also include lags of several predictors, also referred to as time series with multiple predictors (Stock and Watson, 2015).

$$\begin{aligned} Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + \delta_{11} X_{1t-1} + \delta_{12} X_{1t-2} + \ldots + \delta_{1q_1} X_{1t-q_1} + \cdots \\ + \delta_{k1} X_{kt-1} + \delta_{k2} X_{kt-2} + \cdots + \delta_{kq_k} X_{kt-q_k} + u_t \end{aligned} \tag{4.5}$$

The autoregressive distributed lag model will not be elaborated further on since the distributed lag (DL) model will be applied to explain the dynamic causal effects. Since this analysis seeks to find relationships between stock prices and fundamental proxies and contagion proxies, there is no value in including stock returns own lagged values in the model. Thus, for the purpose of this analysis the DL model is the optimal model.

4.4.3 STATISTICAL ASSUMPTIONS

The distributed lag model has four fundamental assumptions. Firstly, the dependent variable needs to be exogenous. Secondly, the random variables X and Y needs to have a stationary distribution and that (Y_t, X_t) and (Y_{t-j}, X_{t-j}) turn into being independent as the number of lags j gets large. Thirdly, large outliers should be unlikely. Lastly there should be no perfect multicollinearity.

Exogenous variables are defined as variables that are uncorrelated with the error term. The dependent variable is said to be exogenous if the conditional mean of the error term u_t does not depend on past and current values of X. Mathematically this is shown the following way:

$$E(u_t|\, X_t, X_{t-1,} \ldots) = 0 \tag{4.6}$$

In other words, a variable is exogenous if it is set randomly and are beyond human control (Stock and Watson, 2015). Furthermore, it is determined outside of the model. Exogeneity comes in two different forms, exogeneity and strict exogeneity. Exogeneity implies that u_t is uncorrelated with current and past values of X_t. However, when X_t is strictly exongonus then u_t is also uncorrelated with future values of X_t. However, if X is not just exogenous, but strictly exogenous the autoregressive distributed lag (ADL) model can be used (Stock and Watson, 2015).

Perfect multicollinearity arises when one variable is perfectly correlated with another, meaning if one variable is a linear function of the other (Stock and Watson, 2015: 245). If this is the case, it will not be possible to estimate an OLS regression with the two variables. On the other hand, imperfect multicollinearity refers to the problem that two independent variables X_1 and X_2 are highly correlated. However, multicollinearity in time series regression can also appear. Majid, Aslam and Altaf (2018) describe how multicollinearity is a problem in time series as the lags of the explanatory variables tend to be highly correlated. This will cause imprecise estimations and should be carefully considered.

4.4.4 MODEL SELECTION CRITERIA

Estimation of a distributed lag model starts with determining a maximum number of lags reasonable to include. Further, several model selection criterions are used to determine the appropriate number of lags to include in the model. Determining the correct number of lags in a time series regression model is important and it exists several statistical methodologies to help through the process. Including too many lags in the model might result in estimation of unnecessary coefficients and affect the validation of the model (Stock and Watson, 2015:593). On the other side, by excluding lags valuable information may be lost.

Stock and Watson (2015) describe a method to deal with the lag selection process by using information criterion. Bayes information criteria (BIC) is one possible criterion and is presented the following way;

$$BIC(p) = \ln\ [\frac{SSR(p)}{T}] + (p+1)\frac{\ln\,(T)}{T} \tag{4.7}$$

Another information criterion is Akaike information criterion (AIC) and is presented the following way;

$$AIC(p) = \ln[\frac{SSR(p)}{T}] + (p+1)\frac{2}{T} \tag{4.8}$$

The only difference between the two criterions is the last term in the equation. The correct model is found by choosing the model with the lowest value of AIC or BIC (Stock and Watson, 2015:596) The consequence of using AIC, is that the estimated model will sometimes overestimate the number of lags included into the model. However, AIC is commonly used in cases where BIC estimates a model with too few lags. Furlan, Diniz and Franco (2010) describe how the appropriate information criterion for a distributed lag (DL) model depends on the size of the sample, in other words the size of N. N measures the number of observations on Y. The results from their comparative study shows that by using the information criterion AIC to estimate the number of lags, the technique estimated the correct order of an DL model only if n is large. On the other side, if n is small AIC overestimates the number of lags in the model. This is consistent with the theory in Stocks and Watson (2015) where AIC is said to most likely to overestimate number of lags. Furthermore, by combining AIC and BIC in the lag selection process one can come closer to finding the correct number of lags to include in the model.

If the estimated model includes lagged values of more than one explanatory variable, the process becomes more challenging. In practice, to deal with the challenges one usually estimates models with the same lag length of all predictors. Furthermore, if one were to estimate a distributed lag model including two independent variables, the model will be set with the same q for both independent variables (Stock and Watson, 2015:597)

Another frequently used model selection criterion is R^2, which is the fraction of variance of Y that is explained by the regressors (Stock and Watson, 2015:242). For regression models including multiple regressors, the R^2 increases for each regressor that is added. Thereby, some argue that the adjusted R^2 is a better measure for model fit, due to the reason that it does not necessarily increase when a new variable is added. However, heavily relying on the adjusted R^2 is not appropriate, but it can be a good indicator if the model captures the variance in the dependent variable.

4.4.5 *Heteroskedasticity and Autocorrelation Consistent Standard Errors*

In the distributed lag model, the error term u_t can be correlated with its own lags and cause autocorrelation. This can potentially occur because the factors included in u_t can be serial correlated with themselves. If this is the case, the statistics results when estimating the distributed lag model may turn out to be misleading. The problem can be solved by computing heteroskedasticity-and autocorrelation consistent (HAC) standard errors for the variance (Stock and Watson, 2015). To better understand the HAC standard errors, the variance of OLS estimator $\widehat{\beta}$ is presented and can be written as:

$$Var(\hat{\beta}) = var\left(\frac{\bar{v}}{\sigma^2 x}\right) = \frac{var(\bar{v})}{(\sigma^2 x)^2} \tag{4.9}$$

If the assumption in cross sectional data holds, that is $\bar{v}$ is independent and identically distributed (iid), then var ($\bar{v}$) = var (v_t)/T. However, if X_t, and u_t is not independently distributed then (v_t) can be serial correlated and var ($\bar{v}$) ≠ var (v_t)/T. To handle the possible serial correlated variance, the heteroskedasticity and autocorrelation consistent (HAC) estimator of the variance can be estimated (Stock and Watson, 2015).

4.4.6 *Sample size*

Another important topic in time series regression is the size of the sample. The number of observations is crucial in order to estimate a reliable model. Hyndman and Athanasopoulos (2018) explains how the required sample size for model estimation increases with the number of parameters to be estimated. Further, they argue that the sample size is often characterized as being small or large. Further, providing a minimum sample size for models can be misleading because the appropriate sample size depends on the variability of the data and the model to be estimated. However, some argue that samples with less than 30 observations are characterized as small and may affect the model estimation process.

4.4.7 Granger causality

In order to test whether one variable is good at predicting another the granger causality test can be applied. A granger causality test, tests whether a variable X is a good predictor of variable Y. Hence, it tests for predictive content (Stock and Watson, 2015:589). The granger causality statistics is a F-statistic tests that test for the following hypothesis: X_{1t-1}, X_{1t-2},… X_{1t-q1} = 0

Furthermore, if the coefficients of all explanatory variables equal zero then the coefficients have no predictive content. A granger causality test can be applied when the model is to be used for forecasting or to estimate dynamic causal effects. However, even if a variable X granger causes a variable Y, it does not necessarily imply that there is a causal relationship between the variables. More precisely, it tells whether one variable is useful in predicting another.

5. Statistical analysis

In the previous sections, theory and literature has been presented and examined in the light of the sample period. Based on theory presented in the energy section, data has been divided into three samples, namely with green, grey and black companies. Further, the econometric methodology presented in chapter four is the main approach in analyzing the data samples. The main approach will test for the explanatory effect of changes in fundamental proxies and bubble proxies has on stock returns. Precisely put, a distributed lag model for each of the samples will be estimated. These models will be evaluated with a granger causality test between the returns and the explanatory factors and a test for structural break. As a consequence of a violating some of the assumptions in the estimated models, the green and grey sample will be further tested with an alternative approach. Overall the analysis will first introduce an overview of the statistical approaches and findings, secondly the main statistical analysis will be performed, and lastly the alternative statistical analysis will be implemented.

5.1 Overview of analysis and results

The table below presents an overview of the steps involved in the main approach and the alternative approach for the three samples. The table also exhibits whether the main and alternative approach statistical analysis gave a bubble indicator for each of the three samples.

Table 5.1: Overview of statistical analysis

	Green	**Grey**	**Black**
5.2 Main approach			
5.2.1 Assumption verification	**Yes**	**No**	**Yes**
5.2.2 Estimation of significant models	**Yes**	N/A	**Yes**
5.2.3 Evaluation			
Granger causality	**Yes**	N/A	**Yes**
Structural break	**Yes**	N/A	**No**
→ Bubble indicated?	**Inconclusive**	N/A	**Inconclusive**
5.3 Alternative approach			
5.3.1 Green: New model estimation	**Done**	N/A	N/A
5.3.2 Grey: Cointegration	N/A	**Done**	N/A
→ Bubble indicated?	**Inconclusive**	**Yes**	N/A

As the table above depicts, the three samples have been analyzed using the main approach. First assumptions are verified, followed by a model estimation, which later are evaluated using a granger causality test and testing for a structural break. An alternative approach is only applied to the green and grey sample as they both break a model assumption. The main approach gave inconclusive bubble indications for the green sample, which later on in the alternative approach gave no green bubble indication. The grey sample did not fulfill the assumption requirements, namely with non-stationary stock returns, and further analysis using the main approach on this sample was not deducted. However, applying an alternative approach on the grey sample exhibited a grey bubble indication. The black samples' analysis applying the main approach gave inconclusive bubble indications, but an alternative analysis was not need as all assumptions, both in the terms of stationarity and structural break, was fulfilled. The coming sections will elaborate on these findings.

5.2 Main approach

5.2.1 Assumption verification

As stated in chapter four the distributed lag model relies on four assumptions that needs to be present in order to estimate a reliable model. The following assumption will be presented and verified in this subchapter. The first assumption is stationary time series.

5.2.1.1 Assumption 1: Stationarity

The stock returns of all three samples seems to fluctuate around zero which could indicate a stationary time series with a constant mean, variance and autocorrelation. Although it is possible to get an impression of whether the time series are stationary by looking at the plotted returns, a statistical procedure, such as an ADF test, is necessary to verify the stationarity assumption.

By using an ADF test, the time series can be tested for stochastic trends, which is one cause of nonstationary time series. Setting the correct specification of the ADF test is necessary to generate valid results. Furthermore, the plotted data of the time series can convey whether a trend or drift should be tested for. However, the plotted data do not always exhibit clearly whether a trend or drift is present in the data, and an alternative approach may be applied. This method incorporates first testing for a trend, if the trend coefficient is insignificant, the test with a drift will be applied. Stock and Watson (2017) describe that studies of the ADF test propose that it is better to include too many lags, rather than too few, hence it is best to use the AIC rather than the BIC to decide the number of lags. Hence, the number of lags in the ADF model is set by the frequency of the dataset plus two additional lags. Hence, six lags are used. Below is the hypothesis applied for the ADF test testing for stationarity.

Hypothesis:
H0: Y_t is nonstationary and contains a stochastic trend (Y_t has a unit root)
H1: Y_t is stationary

Comparing the test statistics of the ADF test to the critical value, which is subject to the different significance levels, will show whether the null hypothesis of a stochastic trend can be rejected. Thus, if the ADF test statistics is greater than the critical value in absolute numbers, the null hypothesis of a stochastic trend can be rejected, and the data can be concluded to be stationary. The 1% significance level is most commonly used as a decision criterion. However, for the matter of this analysis, which has a relatively small sample size, variables at the 5% and 10% significance level, will also be used as decision criterion. This because the small sample size may lessen the chance of confirming stationary data. Furthermore, all variables in the time series data are computed as relative changes, and thus the nature of these variables are expected to be somewhat stationary. Hence, if the test exhibits non-stationarity, it is evaluated that it is not appropriate to further difference the variables.

5.2.1.1 a) Green sample

Variables within the green sample seems to verify the assumption of stationarity data, except from one variable, namely DTE, representing changes in the debt-to-equity ratio. This variable has large spikes in the end of the time period which previously discussed in chapter three and represented in the plotted data in appendix E. Hence, because of the non-stationarity of the DTE, this variable will not be applied in the model estimation.

5.2.1.1 b) Grey sample

The stock returns in the grey sample in the time period of 2009 – 2019, are non-stationary at all levels, and hence breaks the first assumption needed to be present in making a distributed lag model. The ADF test show a test statistic of –1,8922 which is far away from the critical value at -2,6 for the 10% significance level, see appendix D. Further, the stock return variable has a trend, since when testing for a trend with an ADF test, the t-test statistics is greater than the critical value at a 5% level and the trend coefficient is significant at 10% level. In investigating the plot of the grey sample, a significant trend is evident in the years of 2018 and 2019, and this may contaminate the stationarity result of the stock return variable in the ADF test. Hence, by excluding the two years, where the trend is evident, from the data sample, the grey sample may be better fitted for analysis.

A new data sample with the years of 2009 - 2017 is created and this again is tested for stationarity using the ADF test, see appendix D. This test depicts that the grey returns are still not stationary at any levels, again violating the stationarity assumption. However, the data shows that the data now is closer to being stationary to the 10% significant level. Furthermore, the trend coefficient is no longer significant, which may be a result from excluding the two years with the visual trend. The independent variables, DTE and volatility are non-stationary and seems to exhibit trends, as shown in appendix E.

5.2.1.1 c) Black sample

The stock returns in the black sample are stationary at all levels according to the ADF test (see appendix D). However, not all independent variables are stationary, specifically three different definitions of earnings are non-stationary. See appendix E for plots of the non-stationary definitions of earnings. The plots exhibit how some of the variables seem to have trend, while other variables have irregular spikes within the sample that seems to violate the stationarity assumption. Hence, three of the earnings variables violate the stationarity assumption, and if they were included in the model it will affect the reliability of the model estimation.

5.2.1.2 Assumption 2: Exogeneity

The second assumption for the distributed lag models is exogenous explanatory variables, meaning they are not correlated with the error term and determined outside of the model (Stock and Watson, 2015). Determining if variables are exogenous requires economic intuition and experience, and the task can be challenging. Tirole (1982) describe how the stream of dividends for a given firm is assumed to follow an exogenous stochastic process. The DL models estimated later, are built using Porras (2017) framework, where fundamental proxies and contagion proxies' effect on stock returns is investigated. Porras (2017) determines the variables as exogenous, since previous research on the area establishes these variables as exogenous. Consequently, this thesis's analysis will also treat the variables as exogenous, as earnings and contagion proxies can be said to be determined outside of the model.

5.2.1.3 Assumption 3 and 4: Multicollinearity and large outliers

The third assumption that should hold in the building of a DL model is that large outlier should not exist in the data set. A possible way to make sure this assumption holds is to estimate HAC standard errors for the variance (Stock and Watson, 2015) The fourth assumption that should hold in DL modelling is that there should be absence of multicollinearity. This problem can be comprehended by limiting the number of lags estimated in the model.

5.2.1.4 Additional consideration affecting the model: Small samples

A small sample size can be a problem in time series regression and should be taken into consideration while estimating models since the estimated results may come as a consequence of a small sample size. Although a small data sample may be problematic, research on small data samples like ten-year quarterly data, is still widely performed. The transformed data consist of quarterly data in the time period 2009 – 2019, hence the number of observations is 44. The purpose of this analysis is to investigate dynamic causal relationship between variables where the maximum number of explanatory variables (X and Z) tested together is two, thereby, the sample size of N=44 should be sufficient. However, a small sample size may decrease the validity of the findings.

5.2.2 Model estimation and selection

As the research question states, the analysis will aim to see whether a run-up to a green bubble can be identified. The analysis will by estimating distributed lag (DL) models, examine the explanatory effects of fundamental proxies and contagion proxies on stock returns. Hence, several DL models with different definitions of earnings, and contagion proxies has been estimated. Fundamental proxies and contagion proxies will be estimated individually and jointly. A presentation of all models that will be tested can be found in appendix F. The distributed lag model, with one explanatory variable, is presented with the following equation:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 X_{t-2} + \cdots + \beta_{r+1} X_{t-r} + u_t$$

TABLE 5.2: OVERVIEW OF DEPENDENT AND INDEPENDENT VARIABLES

Type of variable	General term	Relative change	Sub terms
Dependent variable	Stock returns	$Y_t = \Delta P_t = \frac{P_t - P_{t-1}}{P_{t-1}}$	P = Stock price adjusted dividends and corporate events
Independent variables	Contagion proxies	$X_t = \Delta C_t = \frac{C_t - C_{t-1}}{C_{t-1}}$	C = Volume, range(volatility) and money flow
	Fundamental proxies	$X_t = \Delta E_t = \frac{E_t - E_{t-1}}{E_{t-1}}$	E = Earnings (has several definitions, see appendix F)
		$X_t = \Delta DE_t = \frac{DE_t - DE_{t-1}}{DE_{t-1}}$	DE = Debt-to-equity ratio, representing capital structure

As the table above depicts, X_t for the purpose of this analysis can represent different variables. For example within contagion proxies, X_t can be volume, and within fundamental proxies X_t can be changes in E = EBIT + DEP + NWC, which are one of the definitions of earnings.

When setting up a DL model, the number of lags need to be determined. Furthermore, the combination of AIC and BIC is used to select the appropriate number of lags to include into the model. The maximum number of lags are set to six, for the same reasons as in the ADF test. The information criterion used for the estimated models are specified beneath the model seen in the appendixes related to the models. For the models that includes more than one explanatory variable, the estimation is done by including maximum lags equal to the maximum lag in the individual model. The coefficients are estimated using HAC standard errors to adjust for serial correlation. When the lag length and specification for standard error is specified, the model can be estimated.

5.2.2.1 Overview of results

Models are in the first round estimated solely with one explanatory variable, either fundamental proxies or contagion proxies. In the second round, models with both significant fundamental and contagion variables are estimated to confirm the findings in the individual model. An overview of all estimated models and their significance and insignificance can be found in appendix G and H. Below is an overview of the significant individually tested variables for the green, grey and black sample. The table depicts the significant lags and their significance level, it depicts the coefficient notion of the estimated coefficient and shows the models explanatory power represented in Adjusted R^2.

TABLE 5.3: OVERVIEW OF INDIVIDUALLY ESTIMATED MODELS

	Sig. Lags	Coefficient notion	Adjusted R2
Green sample			
Fundamentals			
EBITD	1 .	+	0,06548
EBITDN	1. 3* 4***	-	0,2605
EBITDNC	1. 3** 4**	-	0,1954
Contagion			
VOLTAILITY	1. 3.	-	0,1087
VOLUME	4**	+	0,1322
Black sample			
Fundamentals			
FCF	1***	-	0,03722
Contagion			
VOLATILITY	1.	+	0,05
Notes: BIC/AIC is used as information criteria Standard errors are estimated usin HAC Significance level: ‘***’: 0.001, ‘**’: 0.01, ‘*’: 0.05, ‘.’: 0.1			

Overall the individual tests found five significant models in the green sample, zero significant models in the grey sample and two significant models in the black sample, see appendix I. These significant variables were later tested jointly in the same model and all variables except EBITD were confirmed to have explanatory effect together, adding four additional joint models in the green sample and one additional joint model for the black sample, see appendix J. Furthermore, estimated models with no significance, is also a finding as it represents no explanatory effect of the variables investigated. For example, if there are no or a few number of significant fundamental variables explaining stock returns, it may indicate that the stock return is unrelated to its fundamentals. On the other hand, if there are no or few significant contagion variables explaining stock returns, it may indicate that the bubble proxies cannot explain stock return, and thus no indication of a bubble according to the presented theory by Porras (2017).

As previously presented theory conveys, positive relationships between the above found explanatory variables and the dependent variable are sought for. Firstly, a positive increase in the fundamental proxy earnings is expected to positively affect stock return, as an increase in earnings can affect the fundamental value and thus the stock return. Secondly, the contagion variables are also expected to exhibit a positive relationship with stock return, if they should be indicative of a bubble. An increase in the contagion variables can indicate an increase in herd behavior which is related to bubble growth. For example, an increase in volume stocks traded is expected to lead to an increase in stock return, since if many stocks are traded that may lead to a higher price change, and a higher return, which again may lead to more investors trading increasing the volume and again affecting the price positively. An increase in volatility may exhibit a large group undertaking the same trading strategy dealing towards the same direction which leads to magnified price shocks, which for the case of a bubble growth is expected to be a positive price shock. Thus, an increase in volatility is expected to increase price.

5.2.2.2 Estimated models for the three models

The models presented in the table 5.3 above will in the coming paragraphs be elaborated on and will describe the size and notation of the coefficients of the lags, their significance and the Adjusted R^2. In general, large coefficients can be interpreted as having greater impact on the dependent variable, while the significance is incorporated as the likelihood that this relationship is true. The Adjusted R^2 represents the explanatory power of the model. The findings relation to the research question will also be commented.

5.2.2.2 a) Green sample

The significant estimated fundamental models in the green sample is with the earnings variables EBITD, EBITDN and EBITDNC. The EBITD model shows a positive relationship with stock returns and is significant at a 10% level and has a low Adjusted R^2 (0,0654). This model is in line with fundamental theory stating that stock prices should be explained by changes in fundamentals and the low adjusted R^2 is consistent with previous research on fundamentals explanatory effect on stock returns. The EBITDN and EBITDNC models exhibit a negative relationship with stock returns, both models have high significance, high adjusted R^2 and large coefficients compared to the model estimated with EBITD. Thus, the EBITDN and EBITDNC estimated models give reason for concerns regarding spurious regression for three main reasons. Firstly, the inverse relationship between returns and fundamentals cannot be backed up theory. Secondly, the overall characteristics of the models, such as a high adjusted R^2 (0,26 and 0,19, respectively), large coefficients and high significance compared previous research investigations the relationship between fundamentals and returns should rise concern for spurious regression. Lastly, it is puzzling that the different definitions of earnings, in which variables are quite similar, show different notations.

The contagion models volume and volatility are significant and also exhibit different notations. The volume model shows a positive relationship between the contagion proxy $Volume_{t-4}$ and stock returns Y_t. The model has a high significance at the 1% level and a large coefficient (0,31), compared to the findings presented by Porras (2017). On the other side, the volatility model show a negative relationship between the contagion proxy $Volatility_{t-1}$, $Volatility_{t-3}$ and stock returns Y_t. This relationship does not make sense according to contagion theory which seeks to find positive relationships. Again, the two contradicting relationships is puzzling. Overall, these findings do neither reject nor confirm indications of a bubble in the green sample. Lastly, estimated models within this sample have several significant lag coefficients, and multicollinearity problems should also be a concern.

5.2.2.2 b) Grey sample

The grey sample do not verify the assumption of stationary data as previously shown. A new data sample was created removing eight quarters, creating a smaller sample size (n=32), and still exhibited non-stationarity. Although there still was a break of the stationarity assumption the model estimation process was still implemented. The results show only significant intercept coefficients for all variables, which do not demonstrate any valuable information. An alternative analysis for the grey sample will be performed later, and the grey sample will not be further investigated using the main approach.

5.2.2.2 c) Black sample

The most significant model in the black sample is an earnings model which show negative relationship between the earnings proxy FCF_{t-1} and stock returns Y_t, with a small coefficient of -0,0021. However, this does not make sense according to theory presented and is further seen as irrelevant as the coefficient is relatively small and has low explanatory power (Adjusted R^2 of 0,0372). Further, the contagion variable volatility has a small positive significant coefficient of 0,067, on the 10% level, and a low adjusted R^2 of 0,05. Compared to Porras (2017) findings when investigating contagion effects on the S&P 500, this effect is small and will not be deemed as an important finding. It may seem like there are other variables that explains the stock returns in the black sample. For example, Kang, Gracia and Ratti (2017) find that on average oil demand-side shock has a positive effect on stock returns of oil and gas companies. Overall, findings within the black sample do neither reject nor confirm indications of a bubble.

5.2.3 Model evaluation

The following section will evaluate the significant distributed lag models for the green and black samples. A granger causality test will be performed to test the models for predictive content and test for structural break which if present, would imply non-stationarity and thus assumption violation.

5.2.3.1 Granger causality

As the distributed lag (DL) models are estimated in the previous section, the models can be now tested for predictive content using a granger causality test. Through a F-statistic test, the lags of the independent variables will be tested to see whether they are useful predictors of the dependent variable (Stock and Watson, 2015:589).

TABLE 5.4: GRANGER CAUSALITY

Sample	Variable	Number of lags	Significance	Conclusion
Green				
	EBITD	2	-	No
	EBITDN	4	**	Yes
	EBITDNC	4	*	Yes
	VOLUME	4	***	Yes
	VOLATILITY	3	-	No
Black				
	FCF	1	***	Yes
	VOLATILITY	1	.	Yes

Notes:
Significance level: ‘***’: 0.001, ‘**’: 0.01, ‘*’: 0.05, ‘.’: 0, 1‘-’: NS
Standard errors are estimated using (HAC)

For the black sample the null hypothesis can be rejected at a 0,001 level for the variable FCF and at a 0,1 level for the variable VOLATILITY, meaning that past values of FCF contain information that is useful to predict changes in stock returns. The same conclusion can be established for the green samples' variables EBITDN, EBITDNC and VOLUME. However, the green samples' variables EBITD and VOLATILITY exhibits no predictive effect according to the granger causality test. This can be seen in relation to that the variables models in the first place were only significant at a 10% level.

In the next section, the variables that still shows to have predictive content will be tested for a structural break, to rule out the possibility of a structural break present in the models, possibly causing non-stationarity.

5.2.3.2 Structural breaks

Non-stationarity may also come as a result of structural breaks. One way to detect breaks, is by plotting the data. However, to verify the assumption of a break seen in the plotted data, a statistical test for the break can be necessary. Breaks can be tested for at both a known and an unknown date. The QLR test for structural breaks will be applied at an unknown break date since it is challenging to detect when the break occurred (Stock and Watson, 2015). The QRL statistics is a F-statistics test but differ from other F-statistics due to its size. Hence, the critical values will thereby be obtained from a special distribution (Andrews, 2003) based on a trimming level as well as a number of restrictions. For the QLR test to be appropriate the trimming should not be too close to the endpoints of the sample (Stock and Watson, 2015:610). Hence, using 15% trimming seems reasonable. The number of restrictions refers to the number of lags being tested for. The QLR test statistics tests for a structural break in the estimated coefficients, furthermore the number of lags is thereby set equal to the number of lags in the estimated models. Furthermore, setting the number of restrictions (q) equal to 5 implies 4 lags plus the intercept. Overall, the QLR test will identify whether there has been a break in the estimated coefficients in the models, possibly violating the stationarity assumption.

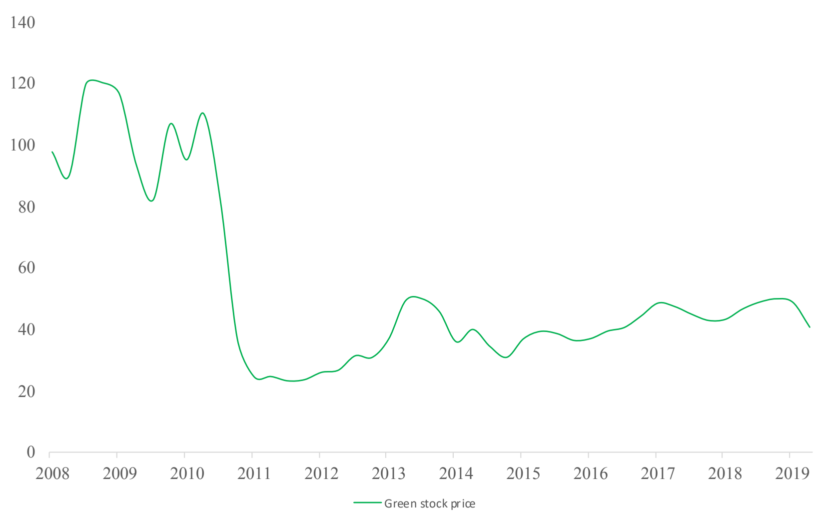
If a structural break is detected, the result from the estimated distributed lag model can be misleading. If the structural breaks arise at a specific date the sample can be split into two parts, to avoid the structural break. However, this methodology only works if the structural breaks arise from a single discrete break and will not work if there is a slow evolution of the regression function.

TABLE 5.5: QUANDT LIKELIHOOD RATIO (QLR) RESULTS

Variable	Critical value	Max F.stat	Break year	Conclusion
Green				
EBITDN	3,66	16,19466	2011	Structural break
EBITDNC	3,66	15,88324	2011	Structural break
VOLUME	3,66	48,668	2011	Structural break
Black				
FCF	5,86	3,66814	-	No structural break
VOLATILITY	5,86	4,241858	-	No structural break
Notes: Trimming is set to 15% Critical values are collected from 5% basis (Andrews, 2003) Number of restrictions is set to the lag length of the estimated model				

As shown in the table above, the QLR statistics shows no structural break in the coefficient of the estimated models for the black sample, and all assumptions for these estimated DL models are confirmed. However, the test shows structural breaks in 2011 for all three models in the green sample. As previously discussed, the regulatory environment for renewable energy companies changed in 2011 and the structural break may come as a consequence of this. The break can also be shown visually on the graph below exhibiting the stock prices in the green sample.

FIGURE 5.1: GREEN SAMPLE STOCK PRICES



Hence, as a consequence of the structural break in the green sample, the stationarity assumption is broken and the previously discussed findings needs to be seen in light of this, and possibly scrapped.

5.2.3.3 Spurious regression

A general concern in the econometric process is the context between correlation and causation. Correlation between two variables does not mean causal inferences (Stock and Watson, 2015: 601). Hence, a great concern with distributed lag models are spurious regression. Spurious regression is when the results of the t-statistics is significant and the model has a high R^2 score, which may indicate a good model. However, if the model has no economic meaning it can be a result of spurious regression (Enders, 2015). Spurious regression comes as a result of violating the assumptions of the model. Thus, violating the stationarity assumption is one way of causing spurious regression. As seen in the green sample, all three models suffer from a structural break in 2011. Furthermore, meaning that the results in the estimated models is not necessarily correct. Thus, the inferences deriving from the main approach in the green sample has not provided any information that can be used to disclose indications of a green bubble. The results may even be the result of assumption violation. Therefore, alternative approaches will be performed to further investigate the green and the grey samples.

5.3 Alternative approach

As seen in the main approach both the green and grey sample seems to experience non-stationarity in terms of trends and breaks. In order to analyze the samples further two alternative approaches will be presented for the samples. The green sample will be analyzed after the structural break with the same method applied in the main approach, and the grey sample will be analyzed using a cointegration method.

5.3.1 Green sample

In order to further investigate the possibility of a run-up to a bubble in the green sample without the structural break in 2011, the analysis was re-done with a shorter time period, investigating the years of 2012 - 2019. The shorter time period also leads to a smaller data sample (n=32) which may influence the new results. The results from analyzing this new time period shows stationary data similar to the first original green sample, see appendix K. The estimated model exhibits a positive relationship between FCF_{t-1} and stock returns. The model has a high significance at the

1% level, small coefficient and a high adjusted R^2 (0,28). As formerly mentioned, previous research on the relationship between fundamentals and stock returns are characterized by low adjusted R^2 and is around 0,05 (Porras, 2017) and it should therefore be a concern that these results may come as consequence of a small sample size. According to the granger causality test, past values of FCF contain information that is useful to predict changes in stock returns and the coefficients in the model exhibit no structural breaks according to the QLR test, see appendix L. The model should be seen in perspective of the small sample, which may decrease the validity of these findings. Again, these findings neither reject nor confirm indications of a bubble in the green sample.

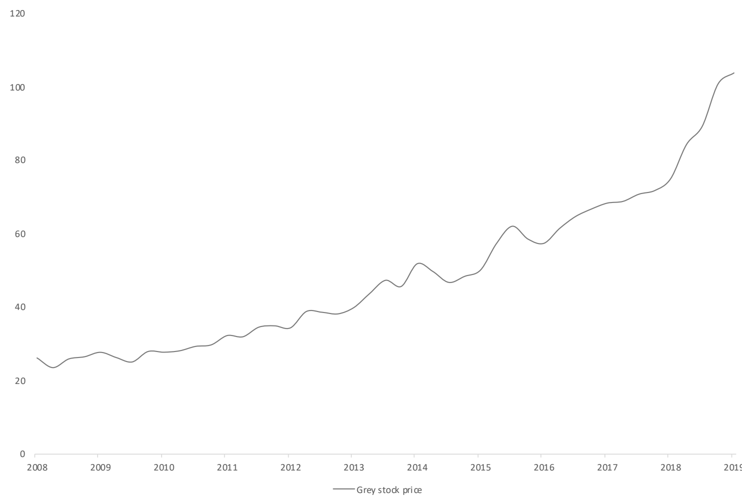
5.3.2 GREY SAMPLE

Stock returns in the grey sample are characterized by non-stationarity and a significant trend which is visible from the graph depicted in chapter three. A cointegration test can applied on non-stationary data as a method to indicate a run-up to a bubble. Porras (2004) proposes an extension of time series tests using cointegration between fundamentals and stock prices.

If the long run stock prices are not backed up by the fundamentals, it should be a general concern that bubbles exist. Further, Arshanapalli and Nelson (2016) express that if stock prices are more explosive over time compared to dividends or earnings, it could be an indication of a financial asset bubble. Hence, an alternative methodology to test for asset price bubbles is to test for cointegration between two variables, namely between stock prices and earnings. Cointegration can be referred to as when two time series with stochastic trends move together closely over the long run. In other words, they tend to have a common trend (Stock and Watson, 2015:702). If the variables tend to have a common trend before a stock price run-up, but are no longer cointegrated during the run-up, it may indicate a presence of a bubble (Arshanapalli and Nelson, 2016:37). Furthermore, if no cointegration is found between prices and fundamentals, there exists no long-run equilibrium relationship between the two variables. This means that if no cointegration is found the fundamental proxies is not explanatory of financial asset prices, and may this indicate a bubble (Porras, 2004).

Stock and Watson (2015) describe how there are several ways to check whether the variables have a common stochastic trend and hence are cointegrated. One way is to graph the time series and see if they appear to have a common stochastic trend, however this is not always easy to spot. The graph below depicts that the grey samples' stock prices an upward exponential trend. Furthermore, if comparing this graph to an earnings graph, see appendix O, the stock prices exhibit a more exponential growth than earnings. In general, this can be a warning sign. In comparison, the green and black sample, do not have the same trend in stock prices, see appendix P.

FIGURE 5.2: GREY SAMPLE STOCK PRICES



Cointegration can also be tested by using statistical procedures. One possible statistical procedure to test for cointegration between two variables is a two-step Engle Granger-Augmented Dickey Fuller (EG-ADF) (Stock and Watson, 2015). Before perming this test the variables needs to be non-stationary at the same level. Further, the procedure involves two steps. In the first step the cointegrating coefficient θ is estimated by OLS estimation, as showed in the equation below.

$$Y_t = \alpha + \theta X_t + z_t$$

Where,

$Y_t = stock\ price$

$X_t = earnings$

$\theta = time\ specified\ common\ effect$

The next step involves an ADF test with intercept and no trend and is used to test for a unit root in the residuals (z_t) from the regression performed in the first step.

Hypothesis:

H0: Residuals are non-stationary and Y_t and X_t are not cointegrated.

H1: Residuals are stationary and Y_t and X_t are cointegrated.

If the null of a unit root in the ADF test can be rejected, the residuals are stationary, and it is possible to state that the two variables are cointegrated. In order to perform an EG-ADF test, the variables need to be integrated at the same order and need to be non-stationary. Furthermore, this test was performed on the grey sample in the full time period from 2009 - 2019 with the variables stock prices and earnings in absolute numbers, and not stock returns used in the main approach. As previously discussed, earnings can be measured by several definitions. The previously presented definitions of earnings will be further used in this cointegration analysis. The method applied involves as described several steps. Firstly, all variables are tested for stationarity to verify that both earnings and stock prices are non-stationary using the ADF test (see appendix M). Secondly, the OLS regression with stock price and earnings is estimated. Lastly, the EG-ADF test show that **neither** of the earnings variables seemed to be cointegrated with the stock prices as we cannot reject null hypothesis and residuals are thereby non-stationary and Y_t and X_t are not cointegrated (see appendix N).

Since the earnings variables and stock price within the grey sample do not exhibit common stochastic trends in the time period analyzed, it may indicate a run-up to a financial asset bubble. As seen in appendix O, the relationship between the plots earnings and stock prices do not follow the same growth rate and is thereby consistent with the findings from the cointegration analysis. The implication of this finding will be discussed in the next chapter.

6. FINDINGS, IMPLICATIONS AND RESEARCH REVIEW

This section will present the findings from the statistical analysis and its implications on whether a run-up to a green bubble can be indicated. Lastly, it will provide a review of the research approach, and discuss other possible methods that could have been applied.

6.1 FINDINGS

Bubbles may take many forms and hence there is not any bubbles that are identical (Virtanen, Tölö, Virén, and Taipalus, 2016). Hence, the analysis possible findings indicative of a bubble is only an indication, as the existence of an indication may be present without a bubble in reality being present. Whether this analysis findings of whether the indication in reality was present, can only be proven after the burst of a bubble, since long growth periods for stocks within an industry can be present without a bubble being present (Fama, 2014). Thus, as previously discussed the findings withdraw from concluding that a run-up to a bubble has existed, but rather seeks to find indicators.

The analysis sought to find whether an indication of a run-up to a green bubble could be indicated. The purpose of the statistical analysis was to investigate if the contagion and fundamental variables have explanatory effect on stock returns. The analysis investigates historical data observing realized earnings, serving as a proxy for fundamentals, and therefore withdraws from measuring fundamental value based on future expectations. Three samples were investigated. Black sample, with only fossil fuels, to see if its dynamics were similar or different from the samples involved with renewable energy which could show whether the bubble would be present in the entire energy industry or only the companies involved with renewable energy. Grey sample were included to investigate whether there could be indications of a run-up to a bubble, deriving from a possible green reward as a result from transitioning from fossil fuels to renewables. Lastly, the green sample were investigated to see whether there could be a direct indication of a run-up to a green bubble.

The initial analysis performed in chapter five displayed significant fundamental variables and contagion variables for the green and black samples. Overall, the findings could neither reject nor confirm indications of a bubble. In evaluating these models the black models fulfilled all assumptions, in contrast to the green sample which had a structural break. An alternative analysis was applied on the green and grey samples, whom both exhibited non-stationarity, in order to further disclose whether a bubble could be indicated. The alternative analysis performed on the green sample again did show findings that neither could reject nor confirm indications of a bubble. Within the grey sample, the alternative analysis showed an indication of a run-up to a bubble for the firms transitioning to renewable energy. This was indicated by seeing that the grey stock returns and the earnings variables did not exhibit common stochastic trends in the time period analyzed, meaning that the stock returns moved upwards while the earnings did not follow this trend and remained stable.

The sum of the findings from the main statistical method and the alternative method found that there is no indication of a run-up to a bubble in the green and black samples. However, an indication of a run-up to a bubble in the grey sample was found. The indication for a run-up to a bubble within the grey sample may be explained by a range of factors. It may on the one hand, be unrelated to the green reward that this thesis seeks to investigate, but may rather be related to the fact that the hybrid businesses are more diversified and other non-green factors. On the other hand, the grey samples' exponential growth may in fact be related to a green reward. A possible green reward deriving from the transitioning to renewables may positively affect the grey samples growth. Hence, in this thesis, the term green reward, will refer to a positive effect impacting a company's price, deriving from exhibiting eco-friendly involvement and investments. Further, the term, green reward, can be seen in relation to the term carbon risk investigated by Görgen et al. (2019) which found that "green[3]" companies with less carbon risk outperformed black companies. Hence, a green reward may positively affect those companies exposed to little carbon risk. Having this stated, it is possible to wonder, that if it is the green reward positively affecting the grey sample, why is not the green reward evident for the green sample with companies that are fully green, and thus should have "double" the green reward? Görgen et al. (2019) further argues that even though "green" companies may be exposed to carbon today, their investment into innovation and clean technologies today may signal less carbon emissions in the future, and thus less carbon risk. This effect of signaling less future carbon emissions, although exposed to carbon today, may

[3] The term green companies Görgen et al. (2019) use, is broader compared to the term green used in this thesis, which includes only companies currently exposed to very little carbon emissions. The term green applied by Görgen et al. (2019) may include companies that are exposed to carbon emissions today, but however, are taking significant initiatives to become more environmentally friendly, and hence decreases their carbon risk.

give the grey sample less carbon risk and thus a positive green reward which positively affects its growth. Furthermore, as the analysis showed, although the black sample exhibited a little degree of explanatory effect in both one earnings and one contagion proxies, it was deemed that the black sample did not have any clear indications of a run-up to a bubble due to the low explanatory power and small coefficient in the estimated models. Hence, no clear indication of a run-up to a bubble in the black sample, vs. the little indication of a run-up to a bubble in the grey sample, supports that there is a difference between energy companies involved with no renewable energy and energy companies involved with renewable energy. That difference may stem from a positive green reward.

6.2 Implications

The indicated grey bubble may indicate that there is a positive green reward in the case of the grey sample transitioning to renewable energy. The implication of the positive green reward indicated in the grey sample, may have implications for whether a bubble in the future may grow within renewables. As previously enlightened the green sample, solely involved with renewable energy, is dependent on government subsidies. Hence, the fact that the green sample companies is dependent on government policies and future innovation, and may represent a risk factor for investors, compared to the grey sample which may seem more diversified and thereby hedged. This risk factor for the green sample may explain why the green sample is not growing in the same fashion as the grey sample, which is possibly benefitting from the green reward. If the green reward is in fact true and is the reason for the grey samples' exponential growth, it may indicate that the green sample in the future may start growing in the same fashion when the risk factor related to government support, and future innovation, is smaller. Hence, if the green reward is the reason for the grey samples' growth, it may imply that fully renewable companies may start growing exponentially in the same fashion as the grey sample, increasing risk of bubble formation.

The possible positive green reward inferred may have implications for other green industries outside of the energy industry. As seen in Görgen et al. (2019) smaller carbon risk had a positive effect for a broad range of industries, even for those industries not directly exposed to carbon. For example, banks and financial services firms have limited exposure to carbon risk, but the indirect exposure coming from carbon risk of the firms they finance affected the valuations of these banks. Thus, companies in a range of industries was affected by carbon risk and may with a low carbon risk also be affected with a green reward. Hence, if the green reward inferred in this thesis' analysis in fact is real, the green reward may also be evident in other green stocks outside of the energy industry. This may possibly imply that a green bubble may form for the broad range of green stocks.

The little indicated grey bubble possible relation to a positive green reward, and its possible implications for a possible green bubble forming in the future may be in the interest for a range of stakeholders. The government may want to monitor the development in order to affect a possible harmful bubble development, investors may want to be more critical when investing in green stocks as it may be a future risk of investing in a green bubble. Further, if the grey bubble indication is true, it may add case-specific knowledge to the research field of bubbles. If the green reward is in fact true, it may be another evidence of the impact of carbon risk, contributing to the research field of green finance. Further, the green reward may be in the interest of businesses that can see that there is risk attached to carbon exposure, and a positive green reward to collect from transitioning to a green economy. Hopefully, the findings can motivate researchers to do more research within these fields.

6.3 Research approach review

The analysis is performed using quarterly data in the time period 2009 – 2019 using the framework of Eva Porras (2017), in addition to one alternative cointegration approach (Porras, 2004) applied on the grey sample. There are several shortcomings the analysis performed and several alternative methods that could have been applied.

The analysis performed in this thesis have not performed the exact same analysis as Porras (2017) and has made a few changes to variables analyzed and to the statistical method applied. This thesis' statistical method uses time series data instead of panel data as is applied in Porras (2017) analysis. Hence, in the creation of time series data, weighted averages on the three samples has been made. The companies in the data samples and the weighted averages created largely affects the outcome of the analysis and may bias the findings. Furthermore, the analysis is subject to a somewhat small data sample, as a consequence of using quarterly data, which is affects the validity of the findings. If monthly data was available, that could have significantly helped one of the analysis shortcomings. Additionally, as the green equites as described only has received significantly great attention and funding the past years (Financial Times, 2020), it is possible to argue that this analysis is too early, and that analyses made in the future maybe will find more significant indications on a run-up to a green bubble.

The current method applied inspired from Porras (2017) method could have been extended with looking at other markets where the green transition is more evident and investigating other variables. For example, Ditimi et al. (2018) found that inflation, interest rates and GDP growth can affect asset prices, and thus looking at these variables could also be valuable in the analysis. Furthermore, a business cycle control variable could have been applied to remove business cycle variations in the variables (Wen, 2019). Additionally, a dummy variable representing large-cap and small-cap companies could have further refined and added depth to this thesis' analysis. The analysis could have been further extended by investigating the companies in green sample to see to which degree they are involved in building, developing and operating, in addition to mapping of the amount of installed capacity, the number of projects under construction and location of the companies. This is valuable to this thesis analysis as differences in this involvement for the green companies may affect the analysis findings, and further knowledge on this field could provide reasoning in whether the results for the green sample makes intuitive sense.

The thesis could have applied alternative methods in investigating a run-up to a green bubble. One of the possible methods is applying a factor model (Fama and French, 1992) in investigating if there is excess return related to green companies compared to black companies. This method could have been supported by using Environmental-scores from ESG-data to segment green and black returns or segment a green and a black data sample. Using P/E ratios as a factor could also been applied, where a high P/E ratio could represent a bubble component (Fong, 2006). Possible issues with using this approach is that high P/E ratio does not necessarily reflect bubbles prices if the growth outlook of the company can be justified. The second possible alternative method is performing an industry valuation of the renewable industry. A green industry valuation would represent the fundamental value of the industry, whereas the sum of the market capitalization on industry players involved would represent the market price. If the market capitalization on industry players were higher than the industry valuation, that would indicate a bubble. The drawback of using this approach is that the authors own assumptions would be a large determiner of the fundamental value of the industry.

The analysis performed is in the time period of 2009 – 2019, and thus do not incorporate the 2020 coronavirus pandemic and market recession. This had an impact on the three samples stock prices. Further investigation into the three samples reaction to the market recession may give further insight into the mechanisms involved in the three samples. It may also provide insight into whether a green bubble may form in the future. This will be discussed in the coming chapter.

7. Discussion

The findings and implications above need to be seen in context with the new economic environment that the green stocks now are facing. Covid-19, the global pandemic hitting the U.S. and the world in the first quarter of 2020 has changed the economic environment from being in expansion to entering a recession. Thus, the economic conditions that needs to be present for a bubble to cultivate is not present anymore. Consequently, the little indication of a run-up to a bubble in the grey sample that was found, possibly stemming from a positive green reward, is unlikely to grow under these conditions. The discussion will consider the impact of the pandemic and the recession on the energy industry, and its effect on the three samples. Lastly the discussion will consider the possibility of a green bubble formation in the future.

7.1 Changed economic environment

The two economic conditions that needs to present for a bubble to rise is an environment where the "right mood" can be fostered and sufficient credit availability. The coming section will show that as a consequence of covid-19 these conditions are not present anymore. Thus, the little indication of the process of a run-up to a grey bubble is unlikely to be present now.

7.1.1 U.S. Market recession

The U.S. longest-running expansion ended in the first quarter of 2020 due to the covid-19 caused lockdown which severely restricts economic activity. Federal Chair, Jerome H. Powell stated in a video news conference that "we are going to see economic data for the second quarter that's worse than any data we've seen for the economy" (CNBC, 2020a). This is also supported by a survey made based on 45 economists, saying that the U.S. will remain in the recession for the first half of the year (NABE, 2020).

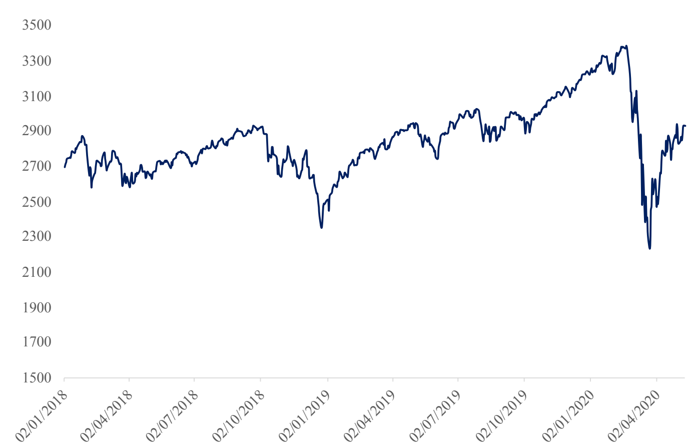
The recession can be shown through the sharp decline in percentage change real GDP of a -4,8% drop in first quarter of 2020, compared to the preceding quarter, see graph below. This is the sharpest decline since the great recession in 2008.

FIGURE 7.1: REAL GDP: PERCENTAGE CHANGE FROM PRECEDING QUARTER

Source; U.S. Bureau of Economic Analysis (2020)

Furthermore, the recession can also be seen in a decline in the U.S. stock market, where S&P 500 has fallen -20,6% from start of the first quarter to the end of the first quarter. See graph below.

FIGURE 7.2: S&P500 POST COVID-19



Source: S&P 500; Federal Reserve Bank of St. Louis (2020a)

Summing up, the ongoing recession in the U.S., is an environment where it is hard to foster the "right mood" which is needed for a bubble to grow.

7.1.1.1 Credit availability

As a consequence of the U.S. recession the central bank has cut the effective federal funds interest rates to near zero in the range of 0,0 – 0,25 in effort to support the economy (Federal Reserve, 2020a) (Appendix Q). The -1,5% lowering of the interest rate is done to "help support economic activity, strong labor market conditions, and inflation returning to the Committee's symmetric 2 percent objective" (Federal Reserve, 2020a). Additional stimulus actions undertaken is the issuance of 2,3 trillion dollars in loans for small businesses and consumers (Federal Reserve, 2020b). Although, the credit availability seems sufficient, the volatile markets and uncertain economic future, may withhold investors from investing borrowed money into stocks. Although, the effective federal funds interest rate is low, banks may however, be more reluctant to lend money to businesses and consumers, reasoning the uncertain economic climate (Ivashina and Scharfstein, 2010).

7.1.1.2 Data samples stock price fall

If looking at change in stock prices between 31.12.2019 and 31.03.2020[4] there is a clear fall in all of the three samples' stock prices. The stock prices of the black fossil fuel sample fell drastically with a rate of -41,9%, followed by the green renewable sample which declined by -16,6% and lastly the grey hybrid sample had the smallest fall with only -4,8%[5]. In general, all of the three samples stock prices, are affected by the coronavirus pandemic and its related recession, which makes the future demand for energy uncertain (EIA, 2020c). The drastic fall in the black sample can be explained by the great oil price fall. The green sample was not as negatively affected as the black sample, but its decline can be explained by the renewable energy dependency on government support and a decline in initial growth expectations. Lastly, the hybrid grey sample, which includes companies involved with both fossil fuel and renewables, was only affected with a decline of -4,8%. Further elaboration on the coronavirus and the recessions impact on the green, grey and black samples will be made in the next section.

Overall, due to the economic recession, it is concluded that the conditions that is needed for a bubble to form is not present anymore. The recession has had an impact on the three samples stock prices, both in its direct form of setting more uncertain economic conditions, and in an indirectly form of affecting the energy market. Changes in the energy market may further explain the green, grey and black samples differential price falls. Hence, the changed economic environment prevents the small indication of a run-up to grey bubble, if it is in reality present, to grow further at this

[4] The first quarter of 2020 will be taken as a reference point to the impact of covid-19 on the three samples, however it is taken into consideration that collecting data from other dates can provide other change rates and other inferences.

[5] These returns are calculated by using weighted average dividend adjusted stock prices, with the same approach specified in section 3.7.

moment. If the exponential growth of the grey bubble in reality stems from a positive "green reward," the restrictions for the grey bubble not to grow, may also affect the possibility of a green bubble to form in this environment. However, although the conditions are currently not present, a recovery phase and its following market expansion phase may in the future open up for a bubble formation. The next section will elaborate on in changes in the energy industry in order to explain the green, grey and black samples different price falls.

7.1.2 CHANGES IN THE ENERGY INDUSTRY

The economic recession and lockdown of societies has and will have implications of the energy industry. The International Energy Agency (IEA) (2020) describes how the U.S. energy demand fell by 6% compared to Q1 in 2019. IEA (2020) further estimates that the average energy demand for 2020 in the U.S. is expected to fall around 10% below 2019 levels. In comparison, this fall is almost the double the impact of the financial crisis in 2008 (IEA, 2020). The next sections will investigate changes in the energy industry as a consequence of covid-19 and its impact on the price fall of the green, grey and black samples. Overall, it is natural that the stocks fall in a recession, however, the next sections will assess additional industry specific factors affecting the fall. The changes in the energy market may largely affect the little indication of a green reward and the possibility of a future bubble formation.

7.1.2.1 The decline in green stocks

The stock prices of the green sample fell with -16,6% on the closing date of the first quarter of 2020. This negative decline is in relative terms not as drastic when looking at the green samples' previous movements. In total during the eleven-year period, the green sample has had five periods with a greater fall than -16,6%, whereas the largest fall was in the third quarter of 2011 with a decline of fully -54,9%. The most recent fall decreasing with more than -16,6% was in the last quarter of 2014 with a decline of -21,47% (Appendix S). Hence, the stock price fall in relation to covid-19 pandemic and its recession is in reality not so severe, especially compared to the fall in the black sample. The green sample also fell less than the S&P500 which experienced a decline of -20,7%, between the first and second quarter of 2020. Whether the fall in green stocks in reality should have decreased more or less is arguable, as there are several main factors in relation to covid-19 affecting green renewable stocks. Firstly, there may be a negative impact from the possibility of receiving less government support. Secondly, there may be a negative impact from the decrease on the initial estimated growth outlook for renewable stocks. Lastly, it is possible that the underlying expectations for the green economy is still present, which may affect the price fall positively.

7.1.2.1 a) Government support: Possible less focus on green transition

As previously described, 70% of the world's clean energy investments are government driven (Birol, 2020). Thus, the actions undertaken by the government in the coronavirus crisis will have a large impact on the future of renewable energy. The coronavirus pandemic, and its economic shock waves, has the possibility of derailing the current and future expected progress in renewable energy (Bahar, 2020). Fatih Birol, the executive director of IEA, stated that "this situation is a test of governments and companies' commitment to clean energy transitions" (Birol, 2020). The three main challenges renewables face derived from the coronavirus crisis is related to supply chain disruptions, inability to benefit from government incentives ending this year, and decrease in investment (Bahar, 2020). Heymi Bahar, Senior Analyst in Renewable Energy Markets and Policy of IEA, describes how renewables will face a "likely decrease in investment because of pressure on public and private budgets combined with uncertainty over future electricity demand" (Bahar, 2020).

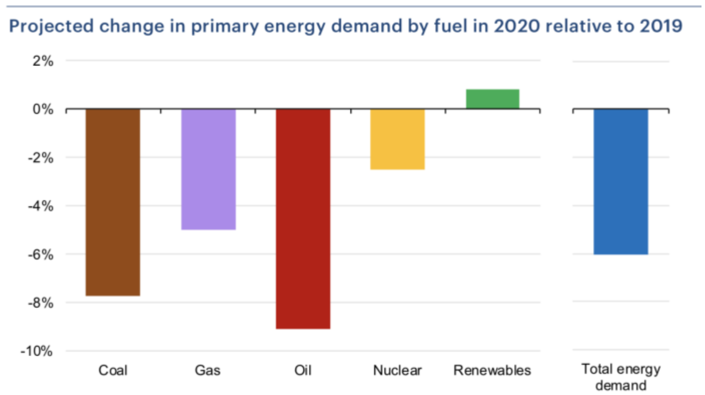
The expected decrease in public renewable investment is anticipated since governments have immediate priorities related to public health challenges caused by the covid-19 pandemic and taking the necessary actions in order to prevent a widespread financial crisis (Bahar, 2020). As a consequence of handling the covid-19 outbreak and the economic recession the U.S. government spending has risen. The U.S. government is also facing less tax income from citizens as a result of the higher unemployment rate. These aspects increase the government debt which is likely to keep increasing the next year (Congressional Budget Office, 2020). Consequently, the health crisis and the economic shock may drive attention away from the transition to renewable energy (Bahar, 2020). A decrease in U.S. renewable investments was for example seen after the financial crisis in 2008, which led to a nearly a -34% decline in renewable investment (Statista, 2019). However, the renewable industry is today in a better position compared to when the government launched stimulus packages after the 2008 financial crisis. The cost of key renewable technologies, like wind and solar, is today lower and there has been made significant technological advancements in these renewable sources (Birol, 2020). These progressions strengthen the economic benefits of using renewable energy, which strengthens the renewable energy position compared to the 2008 financial crisis.

If taking the perspective of previous movements into account, the 2011 decline of -54,9% was set of reasoning uncertainties regarding future government support (REN21, 2012). Hence, the current little reaction of only -16,6% decline is very little compared to the -54,9% decline in 2011, stemming from the same issue of uncertainty of government support. The current economic situation is also worse than in 2011 which is a period characterized by a market expansion. Hence, although the recent years technological advancements in renewable energy strengthens its position, it is remarkable that renewable energy only fell by -16,6% in a period of market recession compared to the fall of -54,9% in 2011 happening in a market expansion.

7.1.2.1 b) Decrease in expected demand

The U.S. Energy Information Administration (EIA) (2020) expects the renewable energy to be the "fastest growing source of electricity generation in 2020" but the effects of covid-19 and the resulting economic slowdown is likely to have a negative impact on the initially expected growth in capacity (EIA, 2020c). For example, the annual wind and solar capacity additions are 5% and 10% lower, respectively, compared to initial estimates (EIA, 2020c). Further, projections for U.S. renewable energy consumption in 2020, convey that before covid-19 renewables was expected to grow 6,8% in 2020, however, after the breakout it was expected to grow 2,53%, meaning a -4,3% absolute decline in growth expectations for renewables (EIA, 2020c) (EIA, 2020d) (Appendix R). This decrease in initially expected consumption for renewables may have a negative impact on the green samples' stock prices. However, the decline in initial expected U.S. 2020 consumption for renewables is lower compared to the decline in initial expected U.S. 2020 consumption for oil and coal, with a -7,3% and -7,9% absolute decline in growth expectations, respectively (Appendix R). IEA (2020) further shows how the renewable sources have proven as the most resilient energy source during the covid-19 crisis. IEA (2020) conveys that, on a global scale, the renewable energy is the only energy source that had a positive growth of 1,5% in global demand in the first quarter of 2020. The EIA (2020) further explains how "the share of renewables in the electricity generation mix rose considerably, with record-high hourly shares of variable renewables" in a handful of countries including the eastern parts of the United States (EIA, 2020). Furthermore, IEA (2020) projects that renewables is the only energy source that will experience a positive growth in global demand in 2020, see graph below.

FIGURE 7.3: PROJECTED CHANGE IN PRIMARY ENERGY DEMAND BY FUEL IN 2020 RELATIVE TO 2019



Source: International Energy Administration (2020)

The above graph shows that while the total energy demand, including all energy sources, will experience a decline in growth compared to 2019, the renewable energy is projected to have a positive growth of nearly 1%. Thus, the decline in absolute expected growth may affect the stock prices of the green sample negatively, but the comparatively positive resilience of the renewable may again give a little positive push to the prices and explain a part of the comparatively little fall of renewables stock prices of -16,6%.

Overall, in addition to the economic recession, there are several factors affecting the little stock price fall of -16,6% in the green sample. Compared to the green samples' previous periods with a larger decline than -16,6%, which has an average decline of -31,1%, the little fall of -16,6% seems small, especially when happening in a recession. The relative positive performance of the renewables compared to the other sources of energy is supportive of a little fall. However, on the other side, the uncertainty of government support and the fall in growth expectations, would suggest a greater fall. Hence, there may be an additional factor affecting the green stock sample positively.

Although there were found no clear indication of a green bubble, the underlaying mechanisms of the green reward may still be present, and positively affect the fall. The smaller carbon risk associated with green companies (Görgen et al., 2019), and the underlying expectations of a green transition, which what a possible green bubble is founded upon, may still be present. This theory will be discussed further in the following paragraph.

7.1.2.1 c) Underlying green transition expectations

The covid-19 pandemic has as described affected the global and U.S. economy and the energy industry. However, what may still remain unaffected is investors' expectations of a transition to a green economy. The pause in travel activity and other polluting activities, and its positive implications to the environment, may even have served as a "green eyeopener" to additional people (Chakraborty and Maity, 2020). Hence, the expectations regarding the green transition, which is the foundation of a possible green bubble, may still stand, and affect the green samples stock prices positively. Hence the little price reduction of the green sample may be explained by investors still withstanding positive expectations of a green transition, with the help of renewable energy. In other words, although the economic recession is present, investors may still have positive expectations to the green renewable industry and thus to their green stocks.

7.1.2.2 The decline in grey stocks

Overall, the relatively little decline in the grey sample compared to the black and green sample is puzzling as it is involved with both fossil fuels and renewables and can be seen as being exposed to "double risk". However, on the other side, since the hybrid companies are exposed to both fossil fuels and renewables, it may also be seen as more diversified relative to companies only involved with one energy source. Although the future energy demand is uncertain, it is certain that societies need energy, regardless of whether it comes from fossil fuels or renewables. Hence, this diversification and exposure to both energy sources, may create a sense of a safer investment, which may serve as a possible explanation to the small decline of -4,8%.

An additional possible explanation to the grey samples' little fall is related to the thesis findings. As showed the grey stock prices had experienced a somewhat exponential growth, in addition to its proxy for earnings not following that growth trend, hence a little indicator for a run-up to a bubble formation in the grey sample. This indication was seen in line with Görgen et al. (2019) which found that firms that invest in innovation and clean technology instead of investing in "dirty" black technologies, were associated with a smaller carbon risk, although being exposed to carbon today. As a consequence of this, these companies outperformed black companies (Görgen et al., 2019). Hence, there seems to be a positive green reward from transitioning to a green economy. As described in previous section elaborating on the green samples fall, the expectations for a transitioning to a green economy still seem to exist. Hence, the little price fall for the grey sample may also be explained by that the expectations for a green economy still is present.

If the indication of a bubble in the grey sample in fact was true, and the bubble would burst as a consequence of the recession, it would be expected that the prices would go down more drastically. As shown, the stock prices only had a fall of -4,8%. This raises the question of whether, on the one hand, if the little indication of a bubble is not real, and that the inexistence of a bubble may explain the little price fall. On the other hand, if the little indication of a green bubble is real, the little price fall may be explained by that the founding beliefs of the grey bubble are still present. If the latter is the case, and the positive green beliefs and expectations still are present, the growth of the grey bubble may have been set on pause and has not yet experienced a burst. If the indication of a grey bubble is true, there is a higher risk of future grey and green bubble growth. There is higher risk for grey bubble growth as the growth may start again at the same pace as before when the economy is back in an expansion phase. Additionally, this also implies a higher risk for green bubble growth as the same green reward inferred for the grey sample, may positively affect the green sample when their state is more certain and independent from government subsidies. In other words, since the expectations for a transitioning to a green economy, which is the underlaying foundation for a green bubble, still seem to be present, a green bubble formation in the future is not unlikely.

Although investors may still believe in the green transition, the current economic environment do not allow for a bubble to grow. The little indication of a grey bubble cannot further grow in the current environment since the uncertain economic future and uncertain demand for energy makes investors reluctant to borrow money in order to further invest in grey hybrid shares. Hence, the exponential growth pauses, or stops, as it in this recession environment, cannot grow furtherly. Whether the green reward on stocks will affect the potential bubble formation for the grey and green sample in the future, is dependent on the happenings and actions occurring through the coming months of the recession. These aspects will be discussed later in the section investigating the risk of a green bubble forming in the future.

7.1.2.3 The decline in black stocks

The coronavirus has helped ignite one of the sharpest oil price falls in the last 30 years (Stevens, 2020). The significant disruptions to business and economic activity, and travel restrictions caused by covid-19 has significantly decreased the demand for oil (EIA, 2020c). The decreased demand coupled with OPEC deal failure igniting a price war has significantly decreased oil prices (CNBC, 2020b). For example, U.S. West Texas Intermediate (WTI) crude oil fell by 24,6%, making it WTI's second worst day on record, since 1991. The oil price plumb is largely driven by the economic contraction and a sudden increase in crude oil supply (CNBC, 2020b). Further, projections for U.S. oil and coal consumption in 2020 made before the recession, show small expected growth in oil and phasing out of coal with a decline in expected consumption. In detail, oil consumption was expected to grow with a small rate of 0,78% from 2019 to 2020, and consumption coal was expected to decline with a rate of -10,74% from 2019 to 2020 (EIA, 2020c) (EIA, 2020d) (Appendix, R). Hence, the initial growth estimates made for fossil fuels was not promising even before the coronavirus and the recession. Furthermore, after the corona crisis the estimates for the fossil fuel and coal declined additionally, where oil consumption was expected to decline with -6,5% rate from 2019 to 2020, and consumption coal was expected to decline with a rate of -18,64% from 2019 to 2020 (EIA, 2020c) (EIA, 2020d) (Appendix, R). The International Energy Agency (IEA) (2020) further expects global oil demand to decrease to 9% on average across the year. This decline is also expected for the fossil fue1 source coal, where the global demand is expected to drop to 8% average across the year. Hence, the factors above seem to have negatively affected the black samples large fall of -41,9%. This is the largest fall the black sample has experienced in the eleven-year period of analysis, where the second largest fall was of -18,75% happening in the last quarter of 2018 as a consequence of a drop in the oil price this year of 25% (CNBC, 2018). The black samples fall may be further explained by the large carbon risk attached to its activities, which may have further altered the decline. The risk of a future green bubble formation will be further discussed in the coming section.

7.2 EXPECTATIONS OF A FUTURE GREEN BUBBLE?

The analysis showed no clear indication of a run-up green bubble in the green sample but showed an indication of run-up to a bubble in the grey sample, possibly stemming from positive "green reward." The first part of the discussion posed the theory of that the expectations of a green transition still seem to be present, positively affecting the fall of the grey and green sample. Whether the grey sample in future will exhibit continued tendencies of growing exponential returns, depends on factors involved with fossil fuel and renewable tendencies and is an intricate analysis. For the purpose of investigating the research question, the risk of a possible green bubble formation will be discussed below. The currently existing green expectations and the inferred green reward may increase the risk of a green bubble forming in the future. The altitude of that risk depends on the actions undertaken during the next months of recession. Hence, this section will elaborate on aspects that may form that possibility, and on how governments and then investors actions during the next months of crisis may harm or support the risk of a future green bubble growth.

7.2.1 Government possibly removing subsidies

As previously showed the oil prices and demand has drastically fallen in relation to the coronavirus crisis and the economic recession. The Executive Director of the International Energy Agency (IEA), Dr Fatih Birol, has urged governments to use the global downturn in oil prices to "lower or remove subsidies for fossil fuel consumption" where more than 40% of the 400 USD billions of subsidies worldwide make oil products cheaper (Birol, 2020). Birol (2020) further describes how cutting the fossil fuel subsidies could instead be used to prioritize education or health care. If governments would pick up on this advice, fossil fuels prices would become more expensive, and thus make renewable energy more price competitive. Improvement in the renewables' competitiveness can create additional excitement regarding the renewables, which may increase the risk of a future green bubble cultivating. On the other hand, two of the tax benefits related to investments and production within renewables, which previously have been key drivers for wind and solar growth in the U.S. renewable energy market, expires and steps down in 2020 (Deloitte, 2020). This may negatively affect the renewables growth and thus the risk of green bubble forming.

7.2.2. Government using renewable as a part of stimulus packages

Including renewable energy in governments stimulus packages could be a strong driver in the next years economic growth. Dr Fatih Birol, Executive Director of IEA and Dan Jørgensen, Danish Minister for Climate, Energy and Utilities, has together explained why clean energy should become an integral plan of governments stimulus packages. Birol and Jørgensen (2020) believes that by integrating clean energy in stimulus packages "governments can deliver jobs and economic growth while also ensuring that their energy systems are modernized, more resilient and less polluting" (Birol and Jørgensen, 2020). The renewable energy industry is already a significant global employer, and in an increasing number of countries the cost of generating electricity from key renewables sources, such as solar, wind and hydropower, are now comparable to or lower compared to the costs of newly built fossil-fuel alternatives (Bahar, 2020). Furthermore, including energy efficiency in stimulus programs can improve competitiveness, lower energy bills and quickly create jobs (Birol and Jørgensen, 2020). Hence, a large-scale investment created to boost the development, deployment and integration of clean energy technologies can have the benefit of both stimulating economies and further accelerate the green energy transition (Birol, 2020). The 24th of April a virtual ministerial roundtable, took place between ministers from various countries, including the U.S. Deputy Secretary General, Amina Mohammed. The aim of the meeting was to discuss "recovery packages, with special attention on energy efficiency and renewable energy"

(Birol and Jørgensen, 2020). Hence, if the U.S. government do take this advice into consideration it could have a significant effect on the growth of the renewable energy and the future risk of a green bubble. However, on the other side, as previously enlightened, if governments take the opposite direction and provide less government support, it can decrease the risk of a future green bubble cultivation.

As shown the green sample has not grown in the same scale as the grey sample. This relatively less growth may be related to the higher risk attached to governmental support that the fully renewable companies are subject to. Hence, if this risk would decrease the future of renewables would become more certain, the green stock prices could potentially start behaving the same way as the grey hybrid companies, increasing the risk of green bubble development.

7.2.3 Private investors

The actions undertaken by the government, either in form of cutting fossil fuel subsidies or providing more or less government support in favor or renewables, can either increase or decrease private investors incentive to invest in green renewable stocks. If governments support renewables in the form of investments and create incentives for consumers and businesses to use renewables, it may both increase renewables competitiveness and applicableness, increasing renewables business case, in addition to sending a positive signal to private investors. However, for private individuals to hop on the wave of renewables is very unlikely to happen during times of crisis but may slowly happen in the recovery phase as the economy is getting a more positive outlook and investors are ready to borrow money to invest again. The current low interest rates, which is promised to stay low for many years, which is also likely given the large debt of the U.S. government, may help investors investing their money into green stocks in the future.

Investors mindset may also have been affected by the covid-19 crisis. On the one side, investors may see the positive impact that cutting polluting fossil fuels has had on the environment and thus value renewable energy even more. On the other side, investors view upon the term sustainable finance may have changed. Some investors may as a consequence of the pandemic have seen the value of the social and governance aspect of sustainable investing, and will in turn shift their focus away from the green aspect of sustainable investing (Morgan Stanley, 2020). Hence, increased incentives and more focus on renewables may increase the risk of the future bubble growth, and decreased incentives and less focus on renewables may lessen the risk of the future bubble growth.

7.2.4 General conditions

As previously shown, the renewables are also dependent on future innovation and technological advancements in order to enhance renewables costs and applicableness. Hence, progressions within this field may further support the risk of future bubble growth.

7.2.5 Government policies and the debated bubble prevention

Overall, there are many aspects that affect the risk of a future growth of a green bubble within renewables. The current economic environment does not allow for a green bubble to grow at the moment, but actions taken in this environment may greatly affect the risk of when and whether a green bubble may cultivate in the future. The government should be aware of that the actions they take can largely shape the future of renewable energy. The incentives the government create can foster further investments from private investors, which is essential for renewables further growth. The government also has a great impact on the market conditions. Uncertainty of federal policies may gauge for greater volatility in the market and may create difficulties assessing an assets value (Hartley, 2015). Further, whether the federal government should be involved in trying to detect and prevent a bubble is debated. Federal Reserve Board Vice Chairman, Stanley Fischer, argues that financial asset bubbles, similar to business cycles, will continue to form in new ways and eventually burst. He further reasons that the federal reserve needs to be "vigilant in both trying to foresee it and seeking to prevent it" (Forbes, 2014). On the other hand, Bernanke and Gertler (2001) debate that the government should not be involved in identifying and preventing bubbles as it is difficult to identify bubbles and to predict their magnitude. The authors further argues that "even if the central bank is certain that a bubble is driving the market (…) there is no consequential advantage of responding to stock prices" (Bernanke and Gertler, 2001). Further, Fama (2014) identifies how "confident statements about "bubbles" and what should be done about them are based on beliefs, not reliable evidence" (Fama, 2014).

Nevertheless, if the price of green stocks in the future grows in a fashion that seem too good to last, investors should be critical and try to gauge an independent view of the fundamental value of these stocks. Although, renewable stocks receives great attention, there are incentives created, and renewable stocks operations drive the green transition, investors should have a real view of is the assets intrinsic value. As previously shown, there are many human factors, that may hinder rational and independent actions. Further, market conditions may even make it rational for investors to speculate on a bubble and become a part of a "speculative game" (Porras, 2016).

Overall, the possibility of a green bubble growing in the future when the market is in an expansion phase again, is dependent on actions and initiatives undertaken in both times of recession and expansion. The future is unknown, and times will show whether a green bubble will cultivate in the future.

8. CONCLUSION

The research question was inspired from tendencies observed in the market. Some of these tendencies were that green equities received great attention, had high valuations indicated by P/E ratios, there had been large sums of investments flowing into responsible funds. Further, some research observed green stocks outperforming black stocks, which was also confirmed for the grey sample and the green sample after 2011. The analysis investigated the explanatory effects of contagion proxies and fundamental proxies on stock return. Three samples were analyzed and grouped according to involvement in renewable energy. The green sample with a sole focus on renewables, the grey sample in transition to renewables from fossil fuels and the black sample with a sole focus on fossil fuels. The analysis performed gave no clear sign of a direct bubble in the green sample but gave an indication of a possible run-up to a bubble within the grey sample. The indicated bubble run-up may be a cause of a positive green reward deriving from the grey sample transitioning to renewables (Görgen et al., 2019).

Observing the three samples stock price fall after the coronavirus and the economic recession in 2020 showed that the black sample fell the most drastically, the green sample had a small fall and the grey sample had a minor fall. The examination of the possible reasons explaining these falls indicated that the underlying expectations of transitioning to a green economy may still be present, which may have positively affected the fall of the samples involved with renewables. These expectations can be seen as the underlying foundations needed for a green bubble to grow. Thus, if these expectations still are present, coupled together with if the green reward in reality, is the driver behind the grey samples' indication of a run-up to a bubble, that may imply that a green bubble may grow in the future. Whether this can happen depends on a range of factors, but it is specifically very dependent on renewables government support and future innovation. If the renewables risk related to government support decreases in addition to further innovation enhancing the cost efficiency and applicableness of renewables, the risk of green renewables bubble development may increase. In times of recession these factors may be extra exposed as the government is facing a deficit and the companies and investors generally do not have the same liquidity to invest in renewables innovation. Hence, the renewables future and possible risk of green bubble growth formation when the market is back in expansion again, is specifically dependent on actions and initiatives taken in the current times of recession.

Overall, this thesis has not disclosed any indication of a run-up to a bubble in the green sample, but indications of a green reward positively affecting the grey samples' indicated run-up to a bubble, have been deduced. In times of recession the underlying expectations of a green transition seem to remain, and these coupled together with development in government support and innovation affects the risk of a green bubble growing in times of future market expansion.

9. BIBLIOGRAPHY

Books and articles
Alvarez, F., Lucas, R. E., & Weber, W. E. (2001). Interest rates and inflation. *American Economic Review*, *91*(2), 219-225.

Arshanapalli, B., & Nelson, W. B. (2016). Testing for stock price bubbles: a review of econometric tools. The International Journal of Business and Finance Research, 10(4), 29-42.

Ballentine, James Arthur (1916). A Law Dictionary of Words, Terms, Abbreviations and Phrases which are Peculiar to the Law and of Those which Have a Peculiar Meaning in the Law: Containing Latin Phrases and Maxims with Their Translations and a Table of the Names of the Reports and Their Abbreviations

Berg, T. (2015). Quicksilver markets. Office of Financial Research.

Bamber, P., Guinn, A., Gereffi, G., Muhimpundu, G., & Norbu, T. (2014). Burundi in the energy global value chain: Skills of private sector development.

Barucci, E., & Fontana, C. (2017). Financial Markets Microstructure. In *Financial Markets Theory* (pp. 583-659). Springer, London.

Berk, J., & DeMarzo, P. (2017). Corporate Finance, 4th global ed. *Harlow: Pearson*.

Bernanke, B. S., & Gertler, M. (2001). Should central banks respond to movements in asset prices?. *american economic review*, *91*(2), 253-257.

Best, Rohan. (2017). Switching towards coal or renewable energy? The effects of financial capital on energy transitions. *Energy Economics.*

Bhalla, V. K. (1997). Financial management and policy. Crescent News.

Black, Fischer. (1972). Capital market equilibrium with restricted borrowing, *Journal of Business 45*, 444-455.

Bordo, M. D., & Wheelock, D. C. (2004). Monetary policy and asset prices: a look back at past US stock market booms (No. w10704). National Bureau of Economic Research.
ISO 690

Bowen, F. (2014). After greenwashing: Symbolic corporate environmentalism and society. Cambridge University Press.

Brunnermeier, M. K., & Oehmke, M. (2013). Bubbles, financial crises, and systemic risk. In *Handbook of the Economics of Finance* (Vol. 2, pp. 1221-1288). Elsevier.

Chakraborty, I., & Maity, P. (2020). COVID-19 outbreak: Migration, effects on society, global environment and prevention. Science of The Total Environment, 138882

Connor, G. (1995). The three types of factor models: A comparison of their explanatory power. Financial Analysts Journal, 51(3), 42-46.

Ditimi, A., & Ifeoluwa, B. (2018). A Time Series Analysis of the Nexus Between Macroeconomic Fundamentals and Stock Prices in Nigeria. Studies in Business and Economics, 13(2), 69-91.

Edward L. Glaeser. (2017). "Real Estate Bubbles and Urban Development." Asian Development Review 34.2 114-51. Web.

Enders, W. (2015). Applied Econometric Time Series. 4th ed. John Wiley and Sons, Inc.

Fama, Eugene. (1970). "Efficient Capital Markets: A Review of Theory and Empirical Work". *Journal of Finance*. **25**(2):

Fama, Eugene. (1995). "Random Walks in Stock Market Prices" *Financial analysts journal*, *51*(1), 75-80.

Fama, E. F. (2014). Two pillars of asset pricing. *American Economic Review*, *104*(6), 1467-85.

Fama, E. F., & French, K. R. (1992). The cross-section of expected stock returns. *Journal of Finance*, *47*(2), 427-465.

Feng, Z., & Chen, W. (2018). Environmental regulation, green innovation, and industrial green development: An empirical analysis based on the Spatial Durbin model. *Sustainability*, *10*(1), 223.

Fantazzini, D. (2016). The oil price crash in 2014/15: Was there a (negative) financial bubble? Energy Policy, 96, 383-396.

Fong, H. G. (Ed.). (2006). *The credit market handbook: advanced modeling issues* (Vol. 340). John Wiley & Sons.

Franke, J., Härdle, W. K., & Hafner, C. M. (2004). Statistics of financial markets (Vol. 2). Berlin: Springer.

Frankel, R. M., & Lee, C. M. (1996). *Accounting diversity and international valuation*. New York Stock Exchange.

Frumkin, N. (2015). Tracking America's economy. Routledge.

Furlan, C. P. R., Diniz, C. A. R., & Franco, M. (2010). Estimation of lag length in distributed lag models: A comparative study. Adv. Appl. Stat, 17(2), 127-142.

Galbraith, J. K. (1955). *Economics and the Art of Controversy* (Vol. 2). New Brunswick: Rutgers University Press.

Goswami, D. Y., & Kreith, F. (Eds.). (2015). *Energy efficiency and renewable energy handbook*. CRC Press.

Greenwood, R., Shleifer, A., & You, Y. (2019). Bubbles for fama. *Journal of Financial Economics*, *131*(1), 20-43.

Görgen, Maximilian and Jacob, Andrea and Nerlinger, Martin and Riordan, Ryan and Rohleder, Martin and Wilkens, Marco. (December 16, 2019). Carbon Risk.

Hiferding, R. (2019). Finance capital: A study in the latest phase of capitalist development. Routledge.

Holmberg, J. (Ed.). (2019). *Policies for a small planet: from the international institute for environment and development* (Vol. 4). Routledge.

Humpe, A., & Macmillan, P. (2009). Can macroeconomic variables explain long-term stock market movements? A comparison of the US and Japan. Applied Financial Economics, 19(2), 111-119.

Hyndman, R. J., & Athanasopoulos, G. (2018). Forecasting: principles and practice.

Ibikunle, G., & Steffen, T. (2017). European green mutual fund performance: A comparative analysis with their conventional and black peers. *Journal of Business Ethics*, *145*(2), 337-355.

Ivashina, V., & Scharfstein, D. (2010). Bank lending during the financial crisis of 2008. Journal of Financial economics, 97(3), 319-338.

Jareño, F., Ferrer, R., & Miroslavova, S. (2016). US stock market sensitivity to interest and inflation rates: a quantile regression approach. Applied Economics, 48(26), 2469-2481.

Jermann, U. J., & Quadrini, V. (2007). Stock market boom and the productivity gains of the 1990s. Journal of Monetary Economics, 54(2), 413-432.

Johansson, T. B., Patwardhan, A. P., Nakićenović, N., & Gomez-Echeverri, L. (Eds.). (2012). Global energy assessment: toward a sustainable future. Cambridge University Press.

Jordan, P. G. (2013). Solar energy markets: An analysis of the global solar industry. Academic Press.

Kang, W., de Gracia, F. P., & Ratti, R. A. (2017). Oil price shocks, policy uncertainty, and stock returns of oil and gas corporations. Journal of International Money and Finance, 70, 344-359.

Kirchgässner, G., Wolters, J., & Hassler, U. (2012). Introduction to modern time series analysis. Springer Science & Business Media.

Lee, T., Markowitz, E., Howe, P., Ko, C., Leiserowitz, A. (2015). Predictors of public climate change awareness and risk perception around the world. Nature Clim Change 5, 1014–1020 https://doi.org/10.1038/nclimate2728

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: The role of affect, imagery, and values. Climatic change, 77(1-2), 45-72.

Lesser, K., Lobe, S., & Walkshäusl, C. (2014). Green and socially responsible investing in international markets. *Journal of Asset Management*, *15*(5), 317-331.

Lintner, John. (1965). The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets, *Review of Economics and Statistics 47*, 13-37.

Lo, A. W., & MacKinlay, A. C. (1988). Stock market prices do not follow random walks: Evidence from a simple specification test. The review of financial studies, 1(1), 41-66.

Majid, A., Aslam, M., & Altaf, S. (2018). Efficient estimation of distributed lag model in presence of heteroscedasticity of unknown form: A Monte Carlo evidence. Cogent Mathematics & Statistics, 5(1), 1538596.

Mahalingam, A., & Reiner, D. (2016). Energy subsidies at times of economic crisis: A comparative study and scenario analysis of Italy and Spain.

Merton, R. C. (1973). Theory of rational option pricing. *Bell Journal of Economics*, 4: 141–183.

Mislinski, J. (2020). Market Cap to GDP: An Updated Look at the Buffett Valuation Indicator. Advisor Perspectives.

Munk, C. (2015). Financial Markets and Investments. Lecture Notes at CBS (M. Sc. Finance and Investments).

Narayan, P. K., Mishra, S., Sharma, S., & Liu, R. (2013). Determinants of stock price bubbles. Economic Modelling, 35, 661-667.

Allison, P. D. (1999). Multiple regression: A primer. Pine Forge Press.

Pagan, A. R., & Schwert, G. W. (1990). Testing for covariance stationarity in stock market data. Economics letters, 33(2), 165-170.

Porras, E. R (2016). *Bubbles and Contagion in Financial Markets, Volume 1: An Integrative View*. Springer.

Porras, E. R. (2017). *Bubbles and Contagion in Financial Markets, Volume 2: Models and Mathematics*. Springer.

Porras, E. R. (2004). *An Extension of Time Series Tests to Panel Data.*

Rao, P. M. (1989). Debt-equity analysis in chemical industry. Mittal Publications.

Sachs, J., Woo, W. T., Yoshino, N., & Taghizadeh-Hesary, F. (Eds.). (2019). *Handbook of Green Finance: Energy Security and Sustainable Development*. Springer Singapore.

Scharfstein, D. S., & Stein, J. C. (1990). Herd behavior and investment. *The American economic review*, 465-479.

Sellon, G. H. (2002). The changing US financial system: some implications for the monetary transmission mechanism. Economic Review-Federal Reserve Bank of Kansas City, 87(1), 5-36.

Sharpe, William F. (1964). Capital asset prices: a theory of market equilibrium under conditions of risk, *Journal of Finance 19*, 425-442.

Shiller, R. J. (2020). Popular Economic Narratives Advancing the Longest US Economic Expansion 2009-2019 (No. w26857). National Bureau of Economic Research. ISO 690

Stock, J. H., & Watson, M. W. (2015). *Introduction to econometrics*.

Svilokos, T. (2013, September). Monetary policy effectiveness in the period of economic crisis. In DIEM: Dubrovnik International Economic Meeting (Vol. 1, No. 1, pp. 0-0)

Tirole, J. (1982). On the possibility of speculation under rational expectations. Econometrica: Journal of the Econometric Society, 1163-1181.

Thornhill, A., Saunders, M., & Lewis, P. (2009). Research methods for business students. Prentice Hall: London. ISO 690

Taipalus, K. (2012). *Detecting asset price bubbles with time-series methods*.

Ugarte, S., Larkin, J., Van der Ree, B., Swinkels, V., Voog, M., Friedichsen, N., ... & Villafafila, R. (2015). Energy Storage: Which market designs and regulatory incentives are needed?. *European Parliament Committee on Industry, Research and Energy: Brussels, Belgium*, 1-5.

Virtanen, T., Tölö, E., Virén, M., & Taipalus, K. (2016). Use of unit root methods in early warning of financial crises. Bank of Finland Research Discussion Paper, (27).

Volz, U., Böhnke, J., Knierim, L., Richert, K., Roeber, G. M., & Eidt, V. (2015). Financing the green transformation: How to make green finance work in Indonesia. Springer.

Wen, Q. (2019). Asset growth and stock market returns: A time-series analysis. Review of Finance, 23(3), 599-628.

Yosef Bonaparte, Alok Kumar, Jeremy K. Page. (2017, June). Political climate, optimism, and investment decisions. Journal of Financial Markets Volume 34, Pages 69-94. ISSN 1386-4181,

Ziolo, M., & Sergi, B. S. (Eds.). (2019). Financing Sustainable Development: Key Challenges and Prospects. Springer.

Webpages and news articles

Amadeo, Kimberly. (2020, January). Shale Oil and the Pros and Cons of Fracking. *The Balance*
Collected from:
https://www.thebalance.com/what-is-shale-oil-and-how-is-it-produced-3306195

Bahar, Heymi. (2020, April). The coronavirus pandemic could derail renewable energy's progress. Governments can help. *International Energy Agency.*
Collected from;
https://www.iea.org/commentaries/the-coronavirus-pandemic-could-derail-renewable-energy-s-progress-governments-can-help

Birol, Fatih. (2020, March). Put clean energy at the heart of stimulus plans to counter the coronavirus crisis. International Energy Agency.
Collected from;
https://www.iea.org/commentaries/put-clean-energy-at-the-heart-of-stimulus-plans-to-counter-the-coronavirus-crisis

Birol, Fatih and Jørgensen, Dan. (2020, April). How clean energy transitions can help kick-start economies. *International Energy Agency.*

Collected from;
https://www.iea.org/commentaries/how-clean-energy-transitions-can-help-kick-start-economies

Board of Governors of the Federal Reserve System. (2020, March). Federal Reserve issues FOMC statement.
Collected from;
https://www.federalreserve.gov/newsevents/pressreleases/monetary20200315a.htm

CNBC. (2020a, April). Fed Chair Powell says we'll see economic data in second quarter that's 'worse than any data we've seen.'
Collected from;
https://www.cnbc.com/video/2020/04/29/fed-chair-powell-says-well-see-economic-data-in-second-quarter-thats-worse-than-any-data-weve-seen.html

CNBC. (2020b, March). Oil plunges 24% for worst day since 1991, hits multi-year low after OPEC deal failure sparks price war.
Collected from;
https://www.cnbc.com/2020/03/08/oil-plummets-30percent-as-opec-deal-failure-sparks-price-war-fears.html

CNBC (2018, December). Oil prices just had their worst year since 2015 – here´s what went wrong
Collected from:
https://www.cnbc.com/2018/12/31/oil-prices-are-set-for-their-worst-year-since-2015.html

Congressional Budget Office. (2020, April). CBO's Current Projections of Output, Employment, and Interest Rates and a Preliminary Look at Federal Deficits for 2020 and 2021.
Collected from:
https://www.cbo.gov/publication/56335

Conserve Energy Future. (2020, collected 13.04.2020). What are Non-Renewable Sources of Energy?
Collected from;
https://www.conserve-energy-future.com/nonrenewableenergysources.php

Conservation International. (2019). Nature now.
Collected from;
https://www.conservation.org/video/nature-now-video-with-greta-thunberg

Deloitte U.S. (2020). 2020 renewable energy industry outlook.
Collected from;
https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/renewable-energy-outlook.html?fbclid=IwAR2ouzIit97R97WtoZbuEHG1k9N8YI_TmQ8gV8mqbROV87f_PjkmNHunsAA

Dlouhy, Jennifer A. (2019, June). Trump Makes His Biggest Move Yet to Try to Save Coal Plants. *Bloomberg.*

Collected from;
https://www.bloomberg.com/news/articles/2019-06-18/trump-s-biggest-move-to-end-war-on-coal-won-t-rescue-industry

Duke Energy. (2020). Renewable Energy Solutions for a Cleaner Future. (collected 06.05.2020)

Collected from;
https://www.duke-energy.com/renewable-energy

(EIA, IRENA and REN21, 2018). Renewable Energy Policies in a Time of Transition
Collected from:
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_IEA_REN21_Policies_2018.pdf

(EIA, 2019a). U.S. Energy Information Administration. (2019, July). What is energy?
Collected from;
https://www.eia.gov/energyexplained/what-is-energy/

(EIA, 2019b). U.S. Energy Information Administration. (2019, August). U.S. Energy Facts Explained.
Collected from;
https://www.eia.gov/energyexplained/us-energy-facts/

(EIA, 2019c). U.S. Energy Information Administration. (2019, August). Use of energy explained. How the United States uses energy.
Collected from;
https://www.eia.gov/energyexplained/use-of-energy/

(EIA, 2019d). U.S. Energy Information Administration. (2019, June). Energy and the environment explained. Where greenhouse gases come from.
Collected from;
https://www.eia.gov/energyexplained/energy-and-the-environment/where-greenhouse-gases-come-from.php

(EIA, 2019e). U.S. Energy Information Administration. (2019, December). Renewable energy explained. Types & usages.
Collected from;
https://www.eia.gov/energyexplained/renewable-sources/types-and-usage.php

(EIA, 2019f). U.S. Energy Information Administration. (2019, October). Electricity explained. How electricity is delivered to consumers.
Collected from;
https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php

(EIA, 2020a). U.S. Energy Information Administration. (2020, March). Electricity explained. Electricity is a secondary energy source.
Collected from;
https://www.eia.gov/energyexplained/electricity/

(EIA, 2020b). U.S. Energy Information Administration. (2020, January). Nuclear explained. Nuclear power and the environment.
Collected from;
https://www.eia.gov/energyexplained/nuclear/nuclear-power-and-the-environment.php

(EIA, 2020c). Energy Information Administration. (2020, April). Short-term energy outlook.
Collected from;

https://www.eia.gov/outlooks/steo/

(EIA, 2020d). Energy Information Administration. (2020, January). Short-term Energy Outlook (STEO). Collected from;
https://www.eia.gov/outlooks/steo/archives/jan20.pdf

(EIA, collected 13.04.2020). U.S. Energy Information Administration. (collected 13.04.2020). Energy Explained.
Collected from;
https://www.eia.gov/energyexplained/

(EIA, collected 09.05.2020) Renewable energy explained. Incentives.
Collected from;
https://www.eia.gov/energyexplained/renewable-sources/incentives.php

European commission. (collected 24.04.2020). Sustainable Finance
Collected from;
https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance_en

Exelon. (2020). Sustainability. We need the earth today, it needs us. (collected 06.05.2020)
Collected from;
https://www.exeloncorp.com/sustainability

E&M Combustion. (2018). The Oil and Gas value chain: a focus on oil refining.
Collected from;
https://emcombustion.es/en/oil-and-gas-value-chain-focus-on-oil-refining/

Fidelity investments (2020): Energy industry
Collected from:
https://eresearch.fidelity.com/eresearch/markets_sectors/sectors/sectors_in_market.jhtml?tab=learn&sector=10

Financial Times. (2020, February). 'Monstrous' run for responsible stocks stokes fears of a bubble. Inflows into ESG funds are driving up stock prices for companies with green credentials.
Collected from;
https://www.ft.com/content/73765d6c-5402-11ea-90ad-25e377c0ee1f

Forbes. (2014, July). Another Financial Crisis Is Inevitable, Promises The Fed Vice Chairman.
Collected from;
https://www.forbes.com/sites/robertlenzner/2014/07/19/another-financial-crisis-is-inevitable-promises-the-fed-vice-chairman/#54af978510ad

Fred Economic Data (2019). Stock market Capitalization to GDP for United states
Collected from:
https://fred.stlouisfed.org/series/DDDM01USA156NWDB

Frewin, Chris. (Collected 12.04.2020). Renewable energy. *Student Energy.*
Collected from;
https://www.studentenergy.org/topics/renewable-energy

Gurufocus. (2020): Industry overview. Historical P/E ratio

Collected from:
https://www.gurufocus.com/industry_overview.php?sector=Utilities

Hartley, Jon. (2015, April). Can The Fed Prevent Financial Asset Bubbles? *Forbes.*
Collected from;
https://www.forbes.com/sites/jonhartley/2015/04/29/can-the-fed-prevent-financial-asset-bubbles/#cbd611a7e2d7

International Energy Agency. (2018). World Energy Investment, 2018.
Collected from;
https://webstore.iea.org/download/direct/1242

Kell, G. (2014, August). Five trends that show corporate responsibility is here to stay.
Collected from;
https://www.theguardian.com/sustainable-business/blog/five-trends-corporate-social-responsbility-global-movement

Leblanc, Rick. (2019, June). The Importance of Battery Storage for Sustainable Energy. The Balance Small Business.
Collected from;
https://www.thebalancesmb.com/importance-of-battery-storage-for-sustainable-energy-4163010

Macrotrends (2020): S&P500 P/E ratio – 90 years historical chart
Collected from:
https://www.macrotrends.net/2577/sp-500-pe-ratio-price-to-earnings-chart

Maverick, J.B. (2020, 4. January). What price-to-earnings ratio is average in the utilities sector?
Collected from;
https://www.investopedia.com/ask/answers/070715/what-pricetoearnings-ratio-average-utilities-sector.asp

Ministry of Economic Affairs and Employment of Finland, (2017). What is a Green Financial System?
Collected from;
http://greenfinance.kz/index.php?id=18

Morgan Stanley Research. (2020, April). Why the coronavirus puts a new lens on ESG investing.
Collected from;
https://www.morganstanley.com/ideas/coronavirus-corporates-esg-investing

Mortensen, Fie. (2020, April). Amerikanske stater tar klimakampen i egne hender. *Verdens beste nyheter.*
Collected from;
https://verdensbestenyheter.no/nyheter/amerikanske-stater-tar-klimakampen-i-egne-hender/

NASA. (collected 23.04.2020). Climate change: how do we know?
Collected from;
https://climate.nasa.gov/evidence/

NextEra. (2020). Sustainability. (collected 06.05.2020)
Collected from;
http://www.nexteraenergy.com/sustainability.html

Osborne, Mark (2018, October). SunPower to sell more assets to avoid bankruptcy in 2019
Collected from:
https://www.pv-tech.org/news/sunpower-to-sell-more-assets-to-avoid-bankruptcy-in-2019

Rhodes, Richard. (2019, July). Why Nuclear Power Must Be Part of the Energy Solution
Collected from;
https://e360.yale.edu/features/why-nuclear-power-must-be-part-of-the-energy-solution-environmentalists-climate

Saxo Bank Group. (2020, 9. January). Green stocks are the next mega trend in equities.
Collected from;
https://www.home.saxo/content/articles/equities/green-stocks-are-the-next-mega-trend-in-equities-09012020

Sciences learning hub. (2008). Non-renewable energy sources.
Collected from;
https://www.sciencelearn.org.nz/resources/1570-non-renewable-energy-sources

The Irish Times. (2020, March). Are green stocks a mega trend or a bubble in the making?
Collected from;
https://www.irishtimes.com/business/personal-finance/are-green-stocks-a-mega-trend-or-a-bubble-in-the-making-1.4183507

The Federal Reserve. (2020a, April). Federal Reserve issues FOMC statement.
Collected from;
https://www.federalreserve.gov/newsevents/pressreleases/monetary20200429a.htm

The Federal Reserve. (2020b, April). Federal Reserve takes additional actions to provide up to $2.3 trillion in loans to support the economy
Collected from;
https://www.federalreserve.gov/newsevents/pressreleases/monetary20200409a.htm

United Nations Environment Programme. (UNEP). (Collected 23.04.2020). Green Economy
Collected from;
https://www.unenvironment.org/regions/asia-and-pacific/regional-initiatives/supporting-resource-efficiency/green-economy

United Nations. (2015, December). Paris Agreement.
Collected from;
https://sustainabledevelopment.un.org/?menu=1300

United Nations. (2016, April). List of Parties that signed the Paris Agreement on 22 April
Collected from;
https://www.un.org/sustainabledevelopment/blog/2016/04/parisagreementsingatures/

United Nations. (collected 23.04.2020a). About the Sustainable Development Goals.
Collected from;
https://www.un.org/sustainabledevelopment/sustainable-development-goals/

United Nations. (collected 23.04.2020b). Sustainable Development Goals.
Collected from;
https://sustainabledevelopment.un.org/?menu=1300
(slette i Paris Agreemen UN kildeliste 2015->2016

United Nations Environment Programme, (2016). Design of a Sustainable Financial System, - definitions and concepts Background Note, Working Paper 16/13 September
2016

United Nations Environment Programme (UN Environment). (2017). Design of a Sustainable Financial System - Green Finance Opportunities in ASEAN.
Collected from;
https://www.dbs.com/iwov-resources/images/sustainability/img/Green_Finance_Opportunities_in_ASEAN.pdf

United Nations Environment Programme Finance Initiative (UNEP FI). (collected 24.04.2020). About the United Nations Environment Programme Finance Initiative.
Collected from:
https://www.unepfi.org/about/

U.S. Bureau of Economic Analysis. (2020, April). Gross Domestic Product, 1st Quarter 2020 (Advance Estimate).
Collected from;
https://www.bea.gov/news/2020/gross-domestic-product-1st-quarter-2020-advance-estimate

U.S. Department of Energy. (Collected 13.04.2020). Our Mission.
Collected from;
https://www.energy.gov/congressional/office-congressional-and-intergovernmental-affairs

Westley, James. (2017, October). Energy versus electricity.
Collected from;
https://www.cambridgeconsultants.com/insights/energy-versus-electricity

Reports

AXA Investment Managers and AQ Research. (2008). Investment Professionals vote 'ESG' and 'Sustainability' as top descriptions. With 16 descriptions, surely it's time to agree what to call it?
Collected from;
http://www.ga-institute.com/fileadmin/user_upload/ESG_Uploads/AXA_20IM_20-_20RI_20Survey_20Results_20Release.pdf

Belfer Center for Science and International Affairs, with Daniel Poneman. (2017, April). American Energy Policy: Building a Safe, Secure, and Prosperous Future
Collected from;
https://www.belfercenter.org/publication/american-energy-policy

Climate transparency. (2019). Brown to green report. The G20 transition towards a net-zero emissions economy.
Collected from: Statista

Deloitte. (2018, April). Power Market Study 2030. A new outlook for the energy industry
Collected from;
https://www2.deloitte.com/content/dam/Deloitte/de/Documents/energy-resources/Deloitte-Power-Market-Study-2030-EN.pdf

Deloitte. (2019, October). Moving organizational energy use toward 100 percent renewables—aspiration or destination? Insights from the Deloitte 100 Percent Renewable Transition Survey.
Collected from;
https://www2.deloitte.com/us/en/insights/industry/power-and-utilities/organizational-energy-use-100-percent-renewables.html

Intergovernmental Panel on Climate Change. (2020, October). Special Report: Global Warming of 1.5 ºC. Chapter 4. Strengthening and implementing the global response.
Collected from;
https://www.ipcc.ch/sr15/chapter/chapter-4/

International Energy Agency. (2019, November). World Energy Outlook 2019.
Collected from;
https://www.iea.org/reports/world-energy-outlook-2019

IRENA and CPI (2018), Global Landscape of Renewable Energy Finance, 2018, International Renewable Energy Agency, Abu Dhabi.
Collected from:
https://www.irena.org//media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_Global_landscape_RE_finance_2018.pdf

IRENA (2019), Renewable Power Generation Costs in 2018, International Renewable Energy Agency, Abu Dhabi.
Collected from:
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf

Marketline. (2019, December). Power Generation in North America.

McKinsey. (2019, January). Global Energy Perspective 2019: Reference Case.
Collected from;
https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-energy-perspective-2019

National Association for Business Economics, NABE. (2020, April). COVID-19 Drags U.S. Economy into Recession; NABE Panel Expects GDP Declines in Q1 and Q2 2020, but Upticks in Q3 and Q4
Collected from;
https://files.constantcontact.com/668faa28001/765a4afd-4ed3-4ea0-b98b-ae631771042b.pdf

National Renewable Energy Laboratory. (2012). Renewable Electricity Futures Study. Hand, M.M.; Baldwin, S.; DeMeo, E.; Reilly, J.M.; Mai, T.; Arent, D.; Porro, G.; Meshek, M.; Sandor, D. eds. 4 vols. NREL/TP-6A20-52409. Golden, CO: National Renewable Energy Laboratory.
Collected from;
http://www.nrel.gov/analysis/re_futures/

New climate economy. (2018, August). Unlocking the inclusive growth story of the 21st century: Accelerating climate action in urgent times.
Collected from;
https://newclimateeconomy.report/2018/wp-content/uploads/sites/6/2018/09/NCE_2018_FULL-REPORT.pdf

Organization for Economic Cooperation and Development (OECD). (2011). Towards green growth. A summary for policy makers May 2011.
Collected from;
https://www.oecd.org/greengrowth/48012345.pdf?fbclid=IwAR1YmRNOHgbYaRIfo_nuXo7dqXII9MsV-Fisw2WZCUXEMKaI2AzOAEsQKp4

REN21. (2011). *Renewable 2011 Global Status Report* (Paris: REN21 Secretariat).
Collected from:
https://www.ren21.net/wp-content/uploads/2019/05/GSR2011_Full-Report_English.pdf

Southern company. (2020). How are you preparing for tomorrow? (collected 06.05.2020)
Collected from;
https://www.southerncompany.com/innovation.html

Statista. (2020a, January). Stock exchanges.
Collected from;
https://www-statista-com.esc-web.lib.cbs.dk:8443/study/25684/global-stock-exchanges-statista-dossier/

Statista. (2019). Renewable energy sources in the United States.

United Nations. (2018). Financing for development: Progress and prospects 2018
Collected from;
https://www.un.org/development/desa/publications/financing-for-development-progress-and-prospects-2018.html

U.S. Department of the Treasury. (2018, 29. June). Annual Cross-U.S. Border Portfolio Holdings.
Collected from;
https://www.treasury.gov/resource-center/data-chart-center/tic/Pages/fpis.aspx
https://ticdata.treasury.gov/Publish/shla2018r.pdf

Economic graphs
Federal Reserve Bank of St. Louis. (2020a). S&P500. S&P Dow Jones Indices LLC. (collected 27.04.2020)
Collected from;
https://fred.stlouisfed.org/series/SP500

Federal Reserve Bank of St. Louis. (2020b). Stock Market Capitalization to GDP for United States. (collected 30.04.2020)
Collected from;
https://fred.stlouisfed.org/series/DDDM01USA156NWDB

Federal Reserve Bank of St. Louis. (2020c). Effective Federal Funds Rate. (collected 27.04.2020)

Collected from;
https://fred.stlouisfed.org/series/FEDFUNDS
U.S. Bureau of Economic Analysis. (2020, April). Gross Domestic Product, 1st Quarter 2020 (Advance Estimate) Collected from;
https://www.bea.gov/news/2020/gross-domestic-product-1st-quarter-2020-advance-estimate

10. APPENDICES

Appendix A: Overview of calculation P/E graph and growth

Condtions

Number of years with growth	10
Growth rate (next ten years)	45%
Growth rate maturity	4%
Payout ratio growth years	50%
iInterest rate	3%
Risk premium	3%
Fair value P/E	317,34

Year	Earnings	Earnings to shareholder	Discount factor	PV earnings to shareholder
0	100,0	50,00	1,00	50,00
1	145,0	72,50	1,06	68,40
2	210,3	105,13	1,12	93,56
3	304,9	152,43	1,19	127,98
4	442,1	221,03	1,26	175,07
5	641,0	320,49	1,34	239,49
6	929,4	464,71	1,42	327,60
7	1 347,6	673,82	1,50	448,13
8	1 954,1	977,04	1,59	613,01
9	2 833,4	1 416,71	1,69	838,55
10	2 946,8	2 946,76	1,79	1 645,46
11	3 064,6	3 064,63	1,90	1 614,41
12	3 187,2	3 187,22	2,01	1 583,95
13	3 314,7	3 314,71	2,13	1 554,06
14	3 447,3	3 447,30	2,26	1 524,74
15	3 585,2	3 585,19	2,40	1 495,97
16	3 728,6	3 728,60	2,54	1 467,75
17	3 877,7	3 877,74	2,69	1 440,05
18	4 032,9	4 032,85	2,85	1 412,88
19	4 194,2	4 194,16	3,03	1 386,23
20	4 361,9	4 361,93	3,21	1 360,07
21	4 536,4	4 536,41	3,40	1 334,41
22	4 717,9	4 717,86	3,60	1 309,23
23	4 906,6	4 906,58	3,82	1 284,53
24	5 102,8	5 102,84	4,05	1 260,29
25	5 307,0	5 306,96	4,29	1 236,51
26	5 519,2	5 519,23	4,55	1 213,18
27	5 740,0	5 740,00	4,82	1 190,29
28	5 969,6	5 969,60	5,11	1 167,83
29	6 208,4	6 208,39	5,42	1 145,80
30	6 456,7	6 456,72	5,74	1 124,18
			Total	**31 733,64**

DATA SAMPLE

APPENDIX B: SELECTION OF COMPANIES

Green	Grey	Black
Quanta Services, Inc. (NYSE:PWR)	Duke Energy Corporation (NYSE:DUK)	Diamondback Energy, Inc. (NasdaqGS:FANG)
American Superconductor Corporation (NasdaqGS:AMSC)	Exelon Corporation (NasdaqGS:EXC)	Oasis Petroleum Inc. (NasdaqCM:OAS)
TPI Composites, Inc. (NasdaqGM:TPIC)	FirstEnergy Corp. (NYSE:FE)	Concho Resources Inc. (NYSE:CXO)
Argan, Inc. (NYSE:AGX)	NRG Energy, Inc. (NYSE:NRG)	Laredo Petroleum, Inc. (NYSE:LPI)
ALLETE, Inc. (NYSE:ALE)	CMS Energy Corporation (NYSE:CMS)	MV Oil Trust (NYSE:MVO)
Portland General Electric Company (NYSE:POR)	The AES Corporation (NYSE:AES)	Epsilon Energy Ltd. (NasdaqGM:EPSN)
Avangrid, Inc. (NYSE:AGR)	The Southern Company (NYSE:SO)	Sundance Energy, Inc. (NasdaqGM:SNDE)
Sunrun Inc. (NasdaqGS:RUN)	Black Hills Corporation (NYSE:BKH)	Denbury Resources Inc. (NYSE:DNR)
Enphase Energy, Inc. (NasdaqGM:ENPH)	NextEra Energy, Inc. (NYSE:NEE)	Dorchester Minerals, L.P. (NasdaqGS:DMLP)
ReneSola Ltd (NYSE:SOL)	New Jersey Resources Corporation (NYSE:NJR)	Kosmos Energy Ltd. (NYSE:KOS)
Sunworks, Inc. (NasdaqCM:SUNW)	PNM Resources, Inc. (NYSE:PNM)	Matador Resources Company (NYSE:MTDR)
Ameresco, Inc. (NYSE:AMRC)	Xcel Energy Inc. (NasdaqGS:XEL)	Antero Resources Corporation (NYSE:AR)
First Solar, Inc. (NasdaqGS:FSLR)	American Electric Power Company, Inc. (NYSE:AEP)	Cimarex Energy Co. (NYSE:XEC)
SunPower Corporation (NasdaqGS:SPWR)	DTE Energy Company (NYSE:DTE)	Natural Resource Partners L.P. (NYSE:NRP)
The Peck Company Holdings, Inc. (NasdaqCM:PECK)	El Paso Electric Company (NYSE:EE)	Zion Oil & Gas, Inc. (NasdaqCM:ZN)
Ormat Technologies, Inc. (NYSE:ORA)	WEC Energy Group, Inc. (NYSE:WEC)	Bonanza Creek Energy, Inc. (NYSE:BCEI)
Infrastructure and Energy Alternatives, Inc. (NasdaqCM:IEA)	Sempra Energy (NYSE:SRE)	Gulfport Energy Corporation (NasdaqGS:GPOR)
Renewable Energy Group, Inc. (NasdaqGS:REGI)	OGE Energy Corp. (NYSE:OGE)	Pioneer Natural Resources Company (NYSE:PXD)
FuelCell Energy, Inc. (NasdaqGM:FCEL)	Avista Corporation (NYSE:AVA)	Cross Timbers Royalty Trust (NYSE:CRT)
SUM = 19	Genie Energy Ltd. (NYSE:GNE)	BP Prudhoe Bay Royalty Trust (NYSE:BPT)
	Pinnacle West Capital Corporation (NYSE:PNW)	Cabot Oil & Gas Corporation (NYSE:COG)
	Public Service Enterprise Group Incorporated (NYSE:PEG)	Chesapeake Energy Corporation (NYSE:CHK)
	Entergy Corporation (NYSE:ETR)	VAALCO Energy, Inc. (NYSE:EGY)
	PPL Corporation (NYSE:PPL)	Chaparral Energy, Inc. (NYSE:CHAP)
	Babcock & Wilcox Enterprises, Inc. (NYSE:BW)	EOG Resources, Inc. (NYSE:EOG)
	Vistra Energy Corp. (NYSE:VST)	VAALCO Energy, Inc. (NYSE:EGY)
	South Jersey Industries, Inc. (NYSE:SJI)	W&T Offshore, Inc. (NYSE:WTI)
	PG&E Corporation (NYSE:PCG)	WPX Energy, Inc. (NYSE:WPX)
	Ameren Corporation (NYSE:AEE)	Sabine Royalty Trust (NYSE:SBR)
	SUM = 29	Permian Basin Royalty Trust (NYSE:PBT)
		San Juan Basin Royalty Trust (NYSE:SJT)
		Whiting Petroleum Corporation (NYSE:WLL)
		Mesa Royalty Trust (NYSE:MTR)
		SilverBow Resources, Inc. (NYSE:SBOW)
		Abraxas Petroleum Corporation (NasdaqCM:AXAS)
		Westwater Resources, Inc. (NasdaqCM:WWR)
		Range Resources Corporation (NYSE:RRC)
		PrimeEnergy Resources Corporation (NasdaqCM:PNRG)
		Alliance Resource Partners, L.P. (NasdaqGS:ARLP)
		Devon Energy Corporation (NYSE:DVN)
		Arch Coal, Inc. (NYSE:ARCH)
		PDC Energy, Inc. (NasdaqGS:PDCE)
		Continental Resources, Inc. (NYSE:CLR)
		U.S. Energy Corp. (NasdaqCM:USEG)
		Unit Corporation (NYSE:UNT)
		Marine Petroleum Trust (NasdaqCM:MARP.S)
		Apache Corporation (NYSE:APA)
		Callon Petroleum Company (NYSE:CPE)
		Murphy Oil Corporation (NYSE:MUR)
		Hallador Energy Company (NasdaqCM:HNRG)
		Noble Energy, Inc. (NasdaqGS:NBL)
		Southwestern Energy Company (NYSE:SWN)
		Panhandle Oil and Gas Inc. (NYSE:PHX)
		EQT Corporation (NYSE:EQT)
		Hess Corporation (NYSE:HES)
		Occidental Petroleum Corporation (NYSE:OXY)
		ConocoPhillips (NYSE:COP)
		NACCO Industries, Inc. (NYSE:NC)
		Berry Corporation (NasdaqGS:BRY)
		SM Energy Company (NYSE:SM)
		Texas Pacific Land Trust (NYSE:TPL)
		Marathon Oil Corporation (NYSE:MRO)
		Peabody Energy Corporation (NYSE:BTU)
		Penn Virginia Corporation (NasdaqGS:PVAC)
		Chevron Corporation (NYSE:CVX)
		Black Stone Minerals, L.P. (NYSE:BSM)
		Exxon Mobil Corporation (NYSE:XOM)
		CNX Resources Corporation (NYSE:CNX)
		SUM = 68

APPENDIX C: CALCULATION OF CONTAGION VARIABLES

Description contagion proxies	
$Adj.close\ price_{i_t}$	Adjusted market stock price per corporation at time t
$Price\ high_{i_t}$	Absolute high market price per corporation at time t
$Price\ low_{i_t}$	Absolute low market price per corporation at time t
$Mean_{i_t}$	$Mean_{i_t} = \frac{Price\ high_{i_t} + Price\ low_{i_t}}{2}$
$Range_{i_t}$	$Range_{i_t} = Price\ high_{i_t} - Price\ low_{i_t}$
$Stock\ return_{i_t}$	$Stock\ return_{i_t} = \frac{Adj.close\ price_{i_t} - Adj.close\ price_{i_{t-1}}}{Adj.close\ price_{i_{t-1}}}$
$Volatility_{i_t}$	$Volatility_{i_t} = \frac{Range_{i_t} - Range_{i_{t-1}}}{Range_{i_{t-1}}}$
$Volume_{i_t}$	The sum of shares traded per company at time t
$Money\ flow_{i_t}$	$Money\ flow_{i_t} = Mean_{i_t} * \text{Volume}_{i_t}$

EMPIRICAL ANALYSIS

APPENDIX D: MAIN APPROACH: AUGMENTED DICKEY FULLER TEST RESULTS

APPENDIX D: BLACK	ADF ciritcal value	ADF test statistics	Significance level
Returns	-3,58	-5,6161	1pct
Fundamentals			
EBIT	-2,6	2,6353	10pct
EBIT + DEP	-	-1,8725	-
EBIT + DEP + NWC	-2,93	-3,1292	5pct
EBIT + DEP + NWC + CAPEX	-	-2,5468	-
FCF	-3,58	-4,437	1pct
DTE	-3,58	-4,6504	1pct
EBITREV	-	-2,0364	-
Contagion			
Volatility	-2,6	-2,8645	10pct
Volume	-3,58	-6,5352	1pct
Money supply	-3,58	-7,1438	1pct

Notes:
All variables are tested with "drift"
AIC is used as information criteria
Number of lags are set to frequency plus a couple (4+2=6)

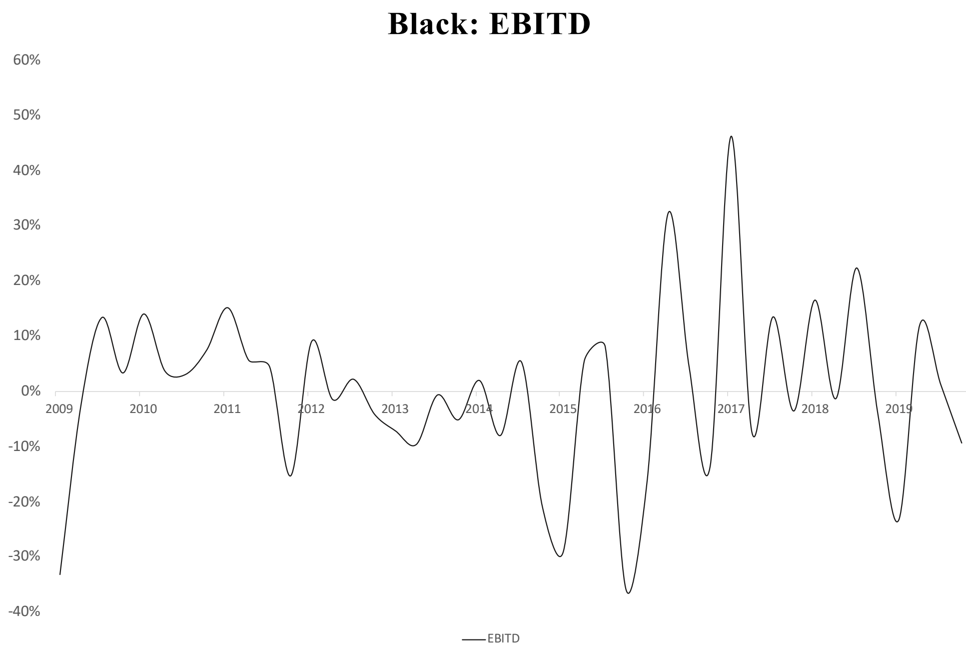
APPENDIX D: GREEN	ADF ciritcal value	ADF test statistics	Significance level
Returns	-2,93	-3,5748	5pct
Fundamentals			
EBIT	-3,58	-4,1381	1pct
EBIT + DEP	-3,58	-4,9153	1pct
EBIT + DEP + NWC	-3,58	-6,9328	1pct
EBIT + DEP + NWC + CAPEX	-3,58	-6,5358	1pct
FCF	-3,58	-4,9582	1pct
DTE	-	-1,5051	-
EBITREV	-3,58	-3,7414	1pct
Contagion			
Volatility	-3,58	-7,2797	1pct
Volume	-3,58	-4,9449	1pct
Money supply	-3,58	-3,9446	1pct
Notes:			
All variables are tested with "drift"			
AIC is used as information criteria			
Number of lags are set to frequency plus a couple (4+2=6)			

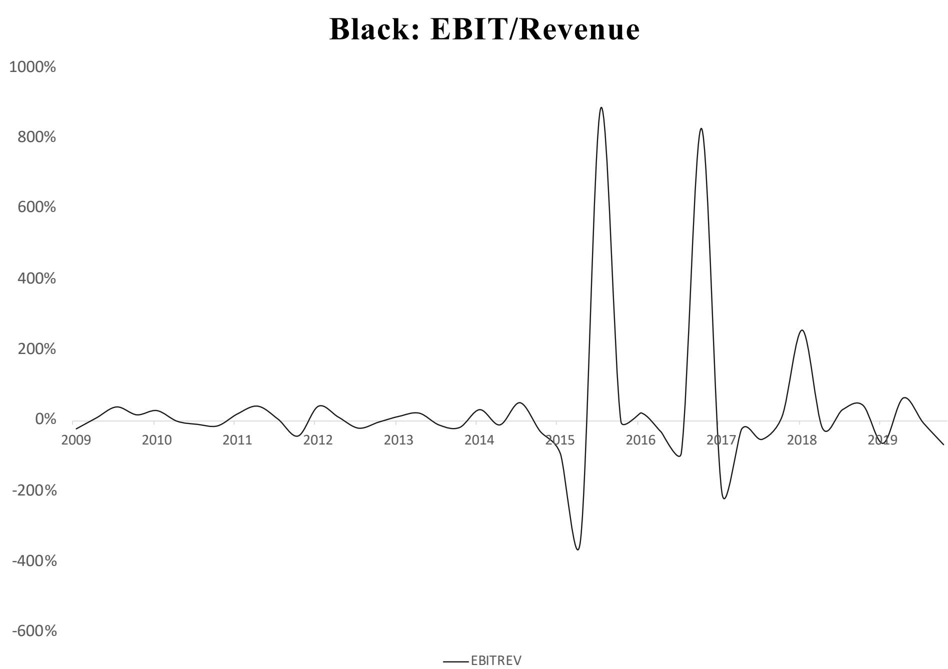
APPENDIX D: GREY	ADF ciritcal value	ADF test statistics	Significance level
Returns	-	-1,8922	-
Fundamentals			
EBIT	-3,58	-4,6301	1pct
EBIT + DEP	-3,58	-5,0698	1pct
EBIT + DEP + NWC	-2,93	-3,3629	5pct
EBIT + DEP + NWC + CAPEX	-3,58	-3,7615	1pct
FCF	-3,58	-4,3208	1pct
DTE	-2,6	-2,9099	10pct
EBITREV	-3,58	-4,968	1pct
Contagion			
Volatility	-	-2,5699	-
Volume	-3,58	-4,8355	1pct
Money supply	-3,58	-6,3274	1pct
Notes:			
All variables are tested with "drift"			
AIC is used as information criteria			
Number of lags are set to frequency plus a couple (4+2=6)			

APPENDIX D: GREY (2009-2017)	ADF ciritcal value	ADF test statistics	Significance level
Returns	-2,6	-2.5426	-
Fundamentals			
EBIT	-2,93	-3,0891	5pct
EBIT + DEP	-3,58	-11,6404	1pct
EBIT + DEP + NWC	-2,93	-3,5074	5pct
EBIT + DEP + NWC + CAPEX	-3,58	-6,5422	1pct
FCF	-2,93	-3,196	5pct
DTE	-	-1,7496	-
EBITREV	-3,58	-10,4218	1pct
Contagion			
Volatility	-	-1,8458	-
Volume	-3,58	-4,8391	1pct
Money supply	-3,58	-4,9999	1pct

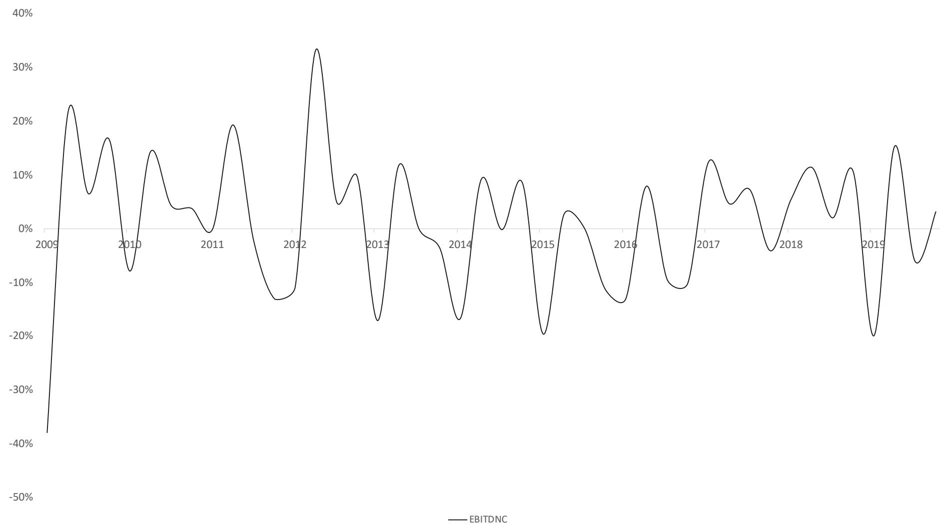
Notes:
All variables are tested with "drift"
AIC is used as information criteria
Number of lags are set to frequency plus a couple (4+2=6)

APPENDIX E: MAIN APPROACH: PLOTS OF NON-STATIONARY VARIABLES

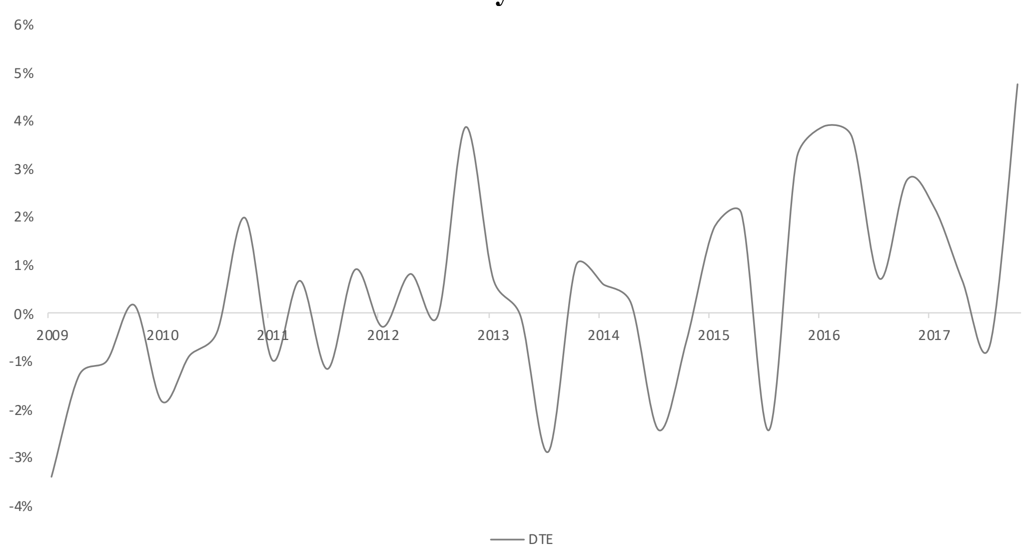




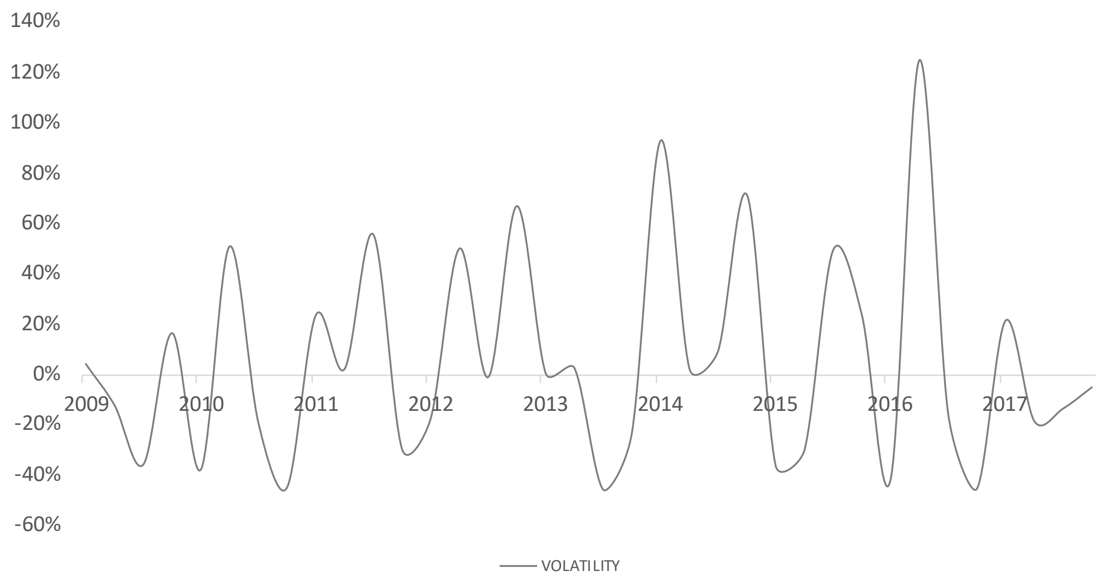
Black: EBITDNC



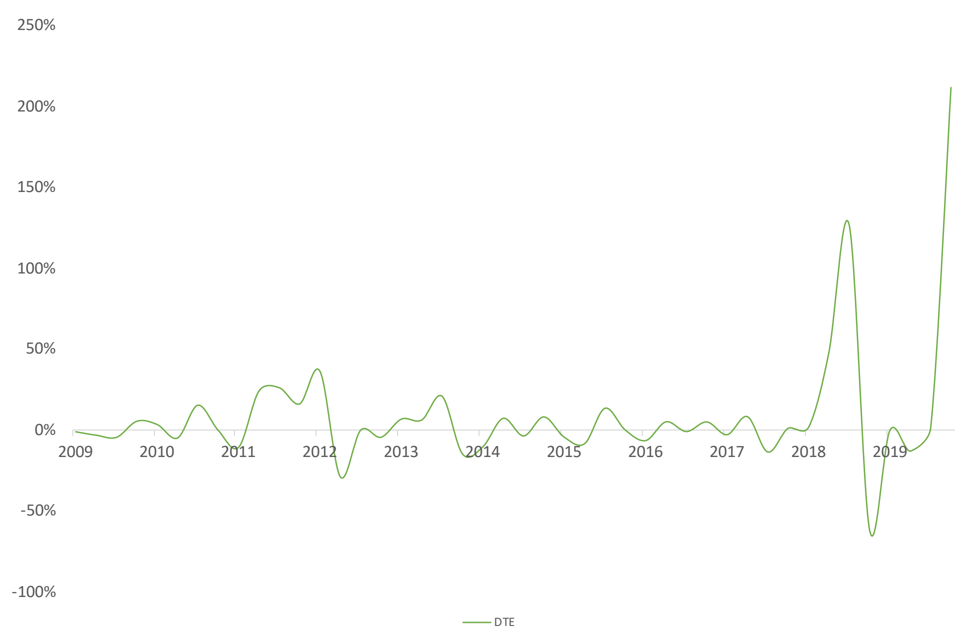
Grey: DTE



GREY: VOLATILITY



Green: DTE



APPENDIX F: MAIN APPROACH: PRESENTATION OF ALL ESTIMATED MODELS

Fundamentals			
Dependent variable		Independent variables	
$\Delta P = \frac{P_1 - P_{1-t}}{P_{1-t}}$		$\Delta E = \frac{E_1 - E_{1-t}}{E_{1-t}}$	$\Delta DE = \frac{DE_1 - DE_{1-t}}{DE_{1-t}}$
Model			
1	P	E = EBIT	
2	P	E = EBIT + Depreciation	
3	P	E = EBIT + Depreciation + NWC	
4	P	E = EBIT + Depreciation + NWC + CAPEX	
5	P	E = FCF	
6	P	E = EBIT/REVENUE	
7	P		DE
8	P	E = EBIT	DE
9	P	E = EBIT + Depreciation	DE
10	P	E = FCF	DE
11	P	E = EBIT/REVENUE	DE
Contagion			
Dependent variable		Independent variable	
$\Delta P = \frac{P_1 - P_{1-t}}{P_{1-t}}$		$\Delta C = \frac{C_1 - C_{1-t}}{C_{1-t}}$	
Model			
1	P	C= Volume	
2	P	C = Volatility	
3	P	C= Money flow	
Notes; (R) is different defintions of earnings (DE) is debt-to-equity ratio (C) is different definitions for contagion			

Appendix G: Main approach: Overview of result of individual models

Fundamentals			
Model	Black	Grey	Green
1	NS	NS	NS
2	NS	NS	S
3	NS	NS	S
4	NS	NS	S
5	S	NS	NS
6	NS	NS	NS
7	NS	NS	NS
8	NS	NS	NS
9	NS	NS	NS
10	NS	NS	NS
11	NS	NS	NS
Contagion			
	Black	Grey	Green
1	NS	NS	S
2	S	NS	S
3	NS	NS	NS
Notes: NS is not significant at any levels S is signifianct and level is spesficed in the model			

Appendix H: Main approach: Overview of result of jointly models

Fundamentals + Contagion			
Description	Black	Grey	Green
FCF + VOLATILITY	S	N/A	N/A
EBITD + VOLATILITY	N/A	N/A	NS
EBITD + VOLUME	N/A	N/A	NS
EBITDN + VOLATILITY	N/A	N/A	S
EBITDN + VOLUME	N/A	N/A	S
EBITDNC + VOLATILITY	N/A	N/A	S
EBITDNC + VOLUME	N/A	N/A	S
Notes: NS is not significant at any levels S is signifianct and level is spesficed in the model			

APPENDIX I: MAIN APPROACH: SUMMARY AV ALL INDIVIDUAL ESTIMATED MODELS

Model	**coefficient**	**standard error**	**t-stat**	**p-value**	**Adjusted R2**	**Criterion**
Black 1						
VOLATILITY_1	0,064789	0,037916	1,7087	0,09506 .	0,05	BIC
Black 2						
FCF_1	-0,0021775	0,00054813	-3,9725	0,0002809 ***	0,03722	BIC
Green 1						
EBITD_2	0,134559	0,068278	1,9708	0,05588 .	0,06548	BIC
Green 2						
EBITDN_1	-0,545748	0.269944	-2,0217	0,0509039 .	0,2605	BIC
EBITDN_3	-0,243213	0.091776	-2,6501	0,0119993 *		
EBITDN_4	-0,35269	0.090588	-3,8933	0,0004246 ***		
Green 3						
EBITDNC_1	-0,561162	0,303625	-1,8482	0,073036 .	0,1954	AIC
EBITDNC_3	-0,344196	0,122962	-2,7992	0,008279 **		
EBITDNC_4	-0,364445	0,125449	-2,9051	0,006324 **		
Green 4						
VOLUME_4	0,3150542	0,1138104	2,7682	0,008949 **	0,1322	AIC
Green 5						
VOLATILITY_1	-0,1511672	0,0845137	-1,7887	0,08186 .	0,1087	AIC
VOLATILITY_3	-0,1239444	0,0693364	-1,7876	0,08204 .		

Notes
Standard errors are estimated usin HAC
Significance level: ‘***’: 0.001, ‘**’: 0.01, ‘*’: 0.05, ‘.’: 0.1

APPENDIX J: MAIN APPROACH: SUMMARY AV ALL JOINTLY ESTIMATED MODELS

Model	coefficient	standard error	t-stat	p-value	Adjusted R2
Black 1					
FCF_1	-0,00181578	0,00061476	-2,9537	0,005363 **	
VOLATILITY_1	0,0715081	0,04129448	1,7317	0,091446 .	0,0432
Green 1					
Intercept	0.050744	0.027410	1.8513	0.0736710 .	0,367
EBITDN_1	-0,459453	0.176142	-2,6084	0.0138719 *	
EBITDN_3	-0,246749	0.128325	-1,9228	0.0637283 .	
EBITDN_4	-0,432542	0.114907	-3,7643	0.0007001 ***	
VOLATILITY_1	-0,133357	0.065525	-2,0352	0.0504563 .	
VOLATILITY_3	-0,133667	0.058150	-2,2986	0.0284293 *	
Green 2					
EBITDN_1	-0,591862	0.210735	-2,8086	0.0085361 **	0,4418
EBITDN_3	-0,179999	0.104297	-1,7258	0.0943328 .	
EBITDN_4	-0,298157	0.081460	-3,6602	0.0009301 ***	
VOLUME_4	0,328787	0.104326	3.1515	0.0035885 **	
Green 3					
EBITDNC_1	-0.653097	0.268301	-2,4342	0.020880 *	0,377
EBITDNC_4	-0,290673	0.116443	-2,4963	0.018078 *	
VOLUME_4	0.320984	0.105716	3.0363	0.004823 **	
Green 4					
EBITDNC_1	-0,48024	0,229853	-2,0893	0,04498 *	0,2853
EBITDNC_3	-0,320363	0.168036	-1,9065	0,06589 .	
EBITDNC_4	-0,386926	0.160234	-2,4148	0,02184 *	
VOLATILITY_4	-0,121998	0,067791	-1,7996	0,08166 .	
Notes					
Standard errors are estimated usin HAC					
Significance level: ‘***’: 0.001, ‘**’: 0.01, ‘*’: 0.05, ‘.’: 0.1					

Appendix K: Alternative approach: ADF test for green sample

GREEN (2012-2019)	ADF ciritcal value	ADF test statistics	Significance level
Returns	-3,58	-3,6861	1pct
Fundamentals			
EBIT	-3,58	-4,1964	1pct
EBIT + DEP	-3,58	-4,4223	1pct
EBIT + DEP + NWC	-3,58	-4,1994	1pct
EBIT + DEP + NWC + CAPEX	-3,58	-4,4527	1pct
FCF	-3,58	-3,6461	1pct
DTE	-	-0,8664	-
EBITREV	-3,58	-5,2977	1pct
Contagion			
Volatility	-	-1,5248	-
Volume	-3,58	-6,4662	1pct
Money supply	-3,58	-3,4161	1pct

Notes:
All variables are tested with "drift"
AIC is used as information criteria
Number of lags are set to frequency plus a couple (4+2=6)

APPENDIX L: ALTERNATIVE APPROACH: GREEN MODEL ESTIMATION AND EVALUATION

Distributed lag model and granger causality test results						
	coefficient	**standard error**	**t-stat**	**p-value**	**Adjusted R2**	**Granger causality**
Intercept	0,0394438	0,017822	2.2132	0,035524*	0,2841	
FCF_2	0,031205	0,0099315	3,142	0,004045**		*
Notes						
BIC is used as information criteria						
Standard errors are estimated usin HAC						
Significance level: ‘***’: 0.001, ‘**’: 0.01, ‘*’: 0.05, ‘.’: 0.1						

QLR test for structural break				
Variable	Critical value	Max F.stat	Break Year	Conclusion
FCF	4,71	4,41	-	No structural break
Notes:				
Trimming is set to 15%				
Critical value are collected from 5% basis (Andrews, 2003)				
Number of restrictions is set to the lag lenght of the estimated model				

APPENDIX M: ALTERNATIVE APPROACH: CONFIRMATION OF NON-STATIONARITY IN GREY SAMPLE

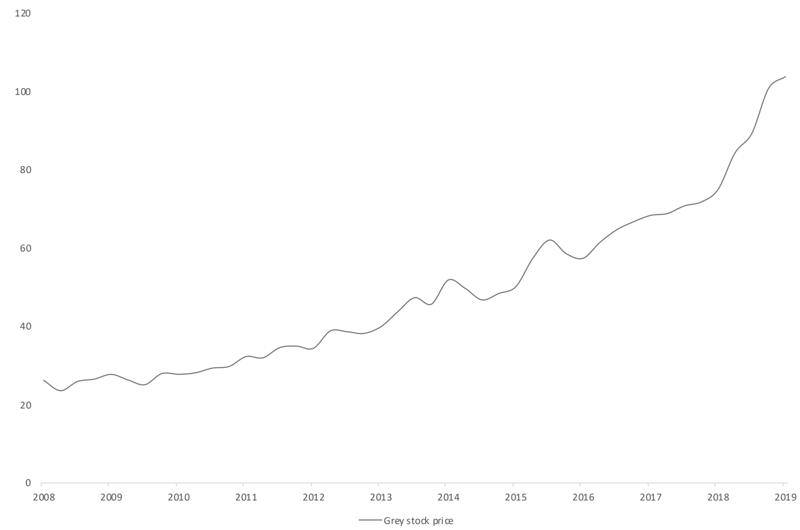
ADF test to confirm non-stationary variables			
	ADF ciritcal value	ADF test statistics	Significance level
Stock price	-2,6	-0,7541	-
Fundamentals			
EBIT	-2,6	-0,7541	-
EBIT + DEP	-2,6	-0,151	-
EBIT + DEP + NWC	-2,6	-1,5369	-
EBIT + DEP + NWC + CAPEX	-2,6	-1,9354	-
FCF	-2,6	-0,229	-
Notes:			
All variables are tested with "drift"			
AIC is used as information criteria			
Number of lags are set to frequency plus a couple (4+2=6)			

APPENDIX N: ALTERNATIVE APPROACH: RESULTS FROM COINTEGRATION EG-ADF TEST IN GREY SAMPLE

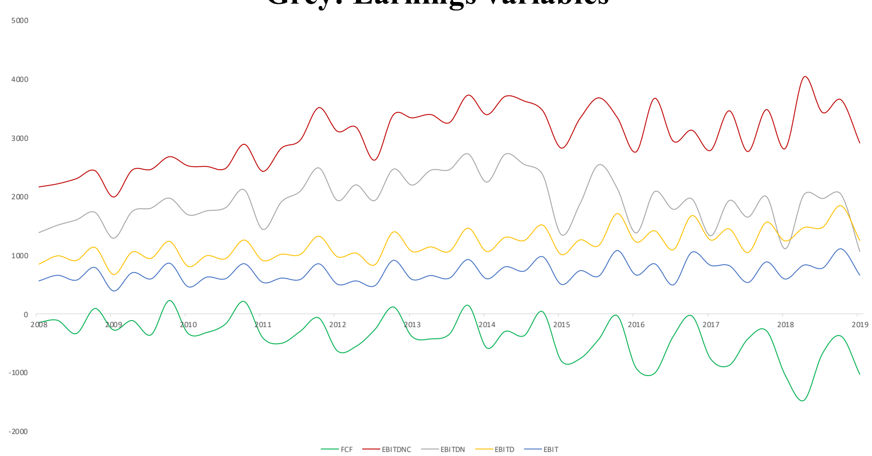
EG-ADF test			
	ADF ciritcal value	ADF test statistics	Conclusion
Fundamentals			
EBIT	-2,62	0,3235	Keep H0
EBIT + DEP	-2,62	-0,8902	Keep H0
EBIT + DEP + NWC	-2,62	0,839	Keep H0
EBIT + DEP + NWC + CAPEX	-2,62	1,034	Keep H0
FCF	-2,62	-2,3963	Keep H0
Notes:			
All variables are tested with "drift"			
1% significance level is used			
AIC is used as information criteria			

Appendix O: Alternative approach: Plots of variables

Grey: Stock price

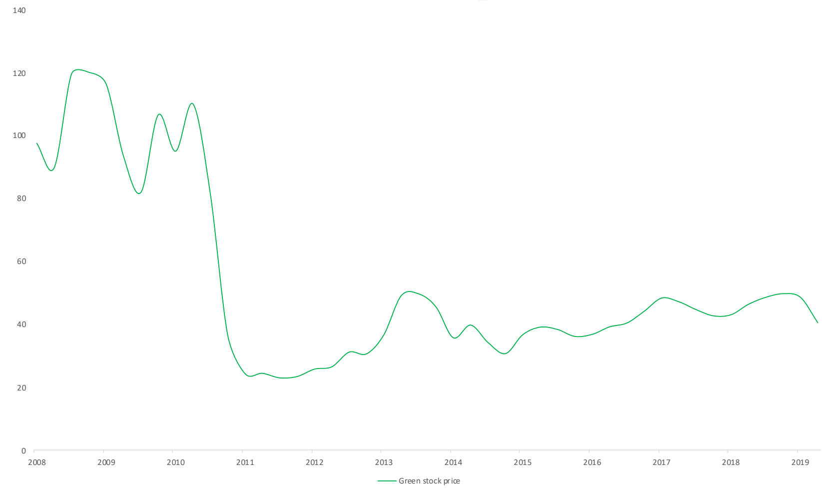


Grey: Earnings variables

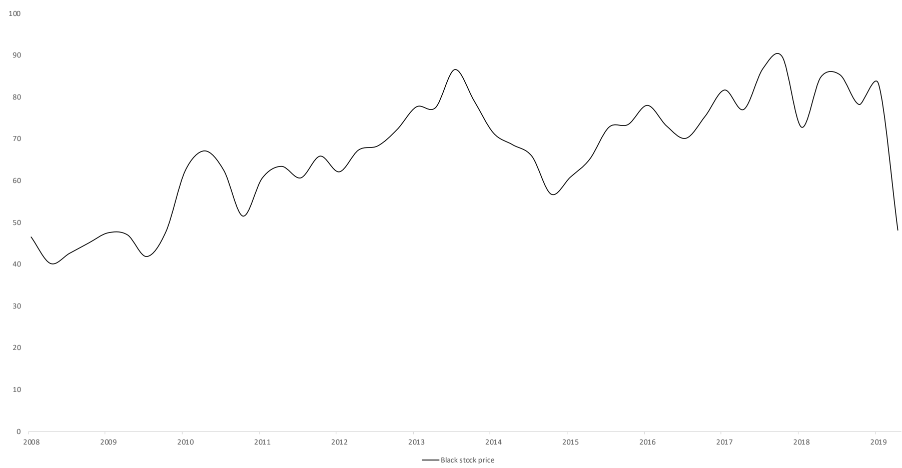


APPENDIX P: ALTERNATIVE APPROACH: COMPARISATION OF STOCK PRICES

Green: Stock price

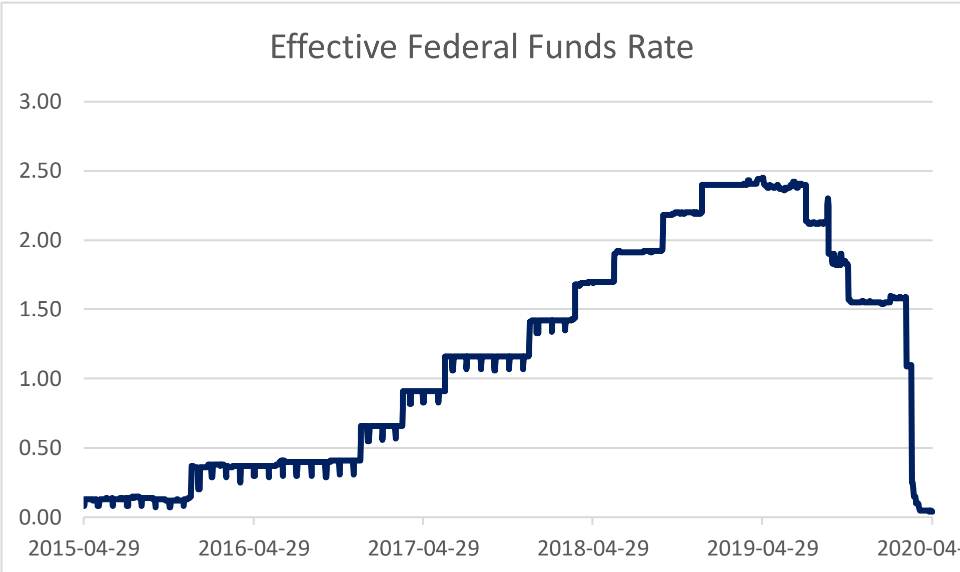


Black: Stock Price



DISCUSSION

APPENDIX Q: EFFECTIVE FEDERAL FUNDS RATE



Source: Board of Governors of the Federal Reserve System;

APPENDIX R: TABLE OF PROJECTIONS OF U.S. ENERGY CONSUMPTION IN SHORT-TERM OUTLOOK REPORTS

Table over projections of U.S. Energy consumption in STEO			
Estimates before the corona crisis (January, 2020)			
	2019	**2020E**	**Growth/decline**
Oil	20,48	20,64	0,78%
Coal	596	532	-10,74%
Renewables	11,46	12,24	6,81%
Estimates after the corona crisis (April, 2020)			
	2019	**2020E**	**Growth/decline**
Oil	20,46	19,13	-6,50%
Coal	590	480	-18,64%
Renewables	11,48	11,77	2,53%
Difference in expectations for energy sources			
Oil	-7,28%		
Coal	-7,91%		
Renewables	-4,28%		
Units			
Oil: million barrels per day			
Coal: million short tons			
Renewables: quadrillion Btu			

Source: EIA, 2020c and 2020d.

APPENDIX S: GREEN SAMPLE: PREVIOUS DECLINES ABOVE -16,6%

31/03/2010	-19,77%
30/06/2011	-26,04%
30/09/2011	-54,93%
30/12/2011	-33,49%
31/12/2014	-21,47%
Average decline	-31,14%

Source: Green sample data

OTHER

APPENDIX T: R-CODES FROM STATISTICAL ANALYSIS

Michellebjorgensen/Main approach: Green sample
Michellebjorgensen/Main approach: Grey sample
Michellebjorgensen/Main approach: Black sample
Michellebjorgensen/Alternative approach: Green sample
Michellebjorgensen/Alternative approach: Grey sample