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Are European Renewable Energy Equities Experiencing an Asset Price Bubble, and When Should Monetary Policy Respond?

An empirical study of European equity markets.

Master's Thesis Spring 2021
Oslo Business School
Oslo Metropolitan University
MSc in Economics and Business Administration

ABSTRACT

The purpose of this thesis is to identify whether European renewable energy equities are experiencing an asset price bubble, and when monetary policy should respond. Dillian (2020) speculated in the possibility of a stock market bubble in ESG investing, whereas Wimmer (2016) suggested that a bubble could potentially be evolving within renewable energy. To answer the research question, we examine and compare the pricing of renewable and conventional energy companies in five European countries, as well as benching both groups against the overall markets. We are not able to conclude certainly that European renewable energy equities are currently experiencing an asset price bubble. However, we are also not able to conclude that it is not. We suggest that monetary policy should respond to an eventual future asset price bubble within the renewable energy sector ex-post.

ACKNOWLEDGEMENTS

We would like to thank our supervisor, Associate Professor Muhammad Azeem Qureshi, for his valuable insights and availability during this project. Furthermore, we would like to thank our families and friends for all their backing throughout our studies. Without their support, we would not be where we are today.

Oslo, June 2021

Peder Braarød Østby & Fredrik Grøttum

CONTENS

FIGURES

TABLES

1.0 INTRODUCTION

In this introductory section, we will outline the background for why we chose to study this phenomenon in the first place. Furthermore, we will assess some major regulatory shifts that are taking place in the industry. Finally, we explain the project itself and its contribution to further research.

1.1 Background for the project

After the stock market crash in February/March 2020 due to the outbreak of the COVID-19 pandemic, many new companies have been listed for public trade on Oslo Stock Exchange (AksjeNorge, 2020). Most of them were listed on the deregulated exchange called Euronext Growth, previously Merkur Market. The market rebounded in record time after the crash, and the OSEBX index has since continuously been hitting all-time highs (Euronext Live Markets, 2021). Simultaneously, the Norwegian economy is still suffering from the effects of the COVID-19 pandemic (Statistics Norway, 2021). In other words, there is a clear discrepancy between the two. Dillian (2020) explained that many financial sector journalists speculate in the possibility of a stock market bubble in so-called ESG-companies.

We do not have to go many years back to find a time where most investors rarely had heard of ESG, as it is a relatively new concept. However, today most investors know and are aware of the term. The Corporate Finance Institute define ESG as a rating system where companies are judged on how their business are conducted in terms of environmental footprint, social responsibility, and corporate governance, hence the acronym “ESG”. And in the markets, so-called “ESG companies” experience quite abnormal returns, however volatile. We suspect that a substantial share of these returns can be traced back to one of the three ESG areas, namely the environmental aspect. We can see these trends all around; people are becoming increasingly more concerned about the environment and want to reduce their carbon footprint. In general, people throughout the world have never been more aware of the adverse negative effects of climate change.

There are few times in history where the way everything is done has been disrupted and changed. We can think of e.g., the industrial revolution or the birth of the internet. Such changes can, and have previously, led to the rise of asset price bubbles. In the late 90’s, we experienced the so-called Dotcom bubble. New companies were rapidly listed on stock exchanges, and the pricing of these companies went through the roof. Companies with little or no revenue experienced enormous returns that could not be justified by traditional fundamental pricing models, as long as a company name ended with ".com". We suspect that the same mechanisms are to some extent in place now. If companies are deemed or labeled "green", they experience highly abnormal demand. Therefore, this thesis will be dedicated to the perhaps greenest of all the green sectors: the renewable energy sector. Our research question is as follows:

Are European renewable energy equities experiencing an asset price bubble, and when should monetary policy respond?

To further understand why this sector is experiencing increased demand, we will have to examine which macro-tendencies have affected the energy-sphere recently.

1.2 A Paradigm Shift

There is a reason why human beings are the superior species. Our cognitive abilities have led us to explore new ways of managing life. The industrial revolution completely changed the world we know and take for granted today, with the development of machines and processes have made us significantly more effective and productive in terms of production capabilities. However, such machines and processes, much like us humans, need energy to function. Dincer (2018) explains that, according to the first law of thermodynamics, energy is constant. Although it can change form, it cannot be made or destroyed. Energy must be taken from somewhere, stored in some form and utilized elsewhere. For more than a century, the fossil fuels, i.e., coal, oil, and gas, have been our main sources of energy.

1.2.1 The Norwegian Oil Adventure

The Norwegian Ministry of Petroleum and Energy (2020) has reported that ever since oil were discovered on Norwegian soil in 1967, our national economy has risen to become one of the richest per capita in the world. Numerous oil fields have since been discovered and tapped. Through The Government Pension Fund Global, the so-called Oil-fund, revenues from oil and gas related industries are invested in a well-diversified portfolio of stocks, bonds, and real estate worldwide. Each year, 3% of the funds average annual return are used to finance the deficit in the government budget (The Ministry of Finance, 2019). This has made the development of a large welfare system possible, with all the benefits this brings for the Norwegian population. But as time has progressed, it has become clear that such methods of energy consumption have disadvantages. Acid rain, destruction of ecosystems and global warming are all results of the climate change triggered by human activity. Something had to be done, or the world would soon crumble. Given that Norway has been a prominent producer of yesterday's energy source, politicians wanted to make us a guiding star in the new wave. A new way of capturing, storing, and utilizing energy: The Green Shift (Olerud & Halleraker, 2021).

1.2.2 The Paris Agreement

As climate change is something that affects everyone regardless of geographical location and national borders, countries came together through the United Nations to construct a common framework on how to deal with the critical situation. Thus, 197 countries jointly entered into the Paris Agreement on December 12, 2015 (United Nations, n.d.). The agreement commits its members to reduce emissions, adapt to climate changes and call on countries to strengthen their commitments over time. It consists of three key elements:

1. Limit temperature rise to 1.5 degrees Celsius.
2. Review countries' commitments to cutting emissions every five years.
3. Provide climate finance to developing countries.

The agreement was ratified on November 4, 2016. And in terms of business, this was one of the biggest "purchase orders" in history.

The Paris Agreement was an important step in a green direction, but nevertheless it has one major weakness: it does not stipulate requirements (United Nations, 2016). As the opportunity cost of fossil fuels exceeds the cost of utilizing the well-established infrastructure of energy based on coal, oil and gas, the incentives of transferring to other green alternatives were absent. The European Union sought to tackle this challenge, by setting a goal to become the first climate-neutral continent. And as a result, The European Green Deal was written (The European Commission, n.d.).

1.2.3 The European Green Deal & the EU Taxonomy Regulation

The European Green Deal is EU's plan to make the union's economy sustainable. It seeks to turn climate and environmental challenges into opportunities and making the transition just and inclusive for all. Overall, it is a new growth strategy that will transform the Union into a modern, resource-efficient, and competitive economy where:

- There are no net emissions of greenhouse gases by 2050.
- Economic growth is decoupled from resource use.
- No person and no place are left behind.

In contradiction to the Paris Agreement, EU proposed to turn the political commitment into a legal obligation. Knowing that reaching the goal of climate neutrality by 2050 will require action by all sectors of the economy, the EU Taxonomy was put in motion (The European Commission). The taxonomy is a classification framework to commonly define what "sustainable economic activities" are. The system lists environmentally sustainable economic activities seeking to scale up sustainable investment and implementing the European Green Deal. It does so by providing appropriate definitions to companies, investors, and policymakers on which economic activities can be considered environmentally sustainable. The taxonomy is expected to create security for investors, protect private investors from greenwashing, help companies to plan the transition, mitigate market fragmentation and subsequently assist the shift of invested capital to where it is needed most. The Taxonomy Regulation stipulates six environmental objectives:

1. Climate change mitigation
2. Climate change adaptation
3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

The purpose of the Taxonomy Regulation is to be able to classify the actions of companies and investment choices of investors as "environmentally sustainable", thus, making green alternatives more accessible and simplifying the shift of capital flow to meet The European Green Deal.

1.3 The Empirical Contributions of this Research

As mentioned, the EU seeks to shift capital investment according to its Green Deal. Furthermore, to secure such a shift, the Green Deal is reinforced in regulatory terms by the Taxonomy. As a result, the traditional way of assessing corporate sustainability is already, and will continue, experiencing change. The green shift is coming, and how we consume energy will consequently be affected, but the most important aspect is how and from what the energy is produced, i.e., a shift from fossil to renewable sources. With such a paradigm shift, new opportunities will arise, and the demand for green investments is already increasing. As a result, new renewable-labeled companies are being listed for public trade rapidly. Even companies without previously proven earnings, nevertheless experiencing relatively high demand which increases prices. Similar behaviours were seen in the Nasdaq boom in the late 1990s and in the housing boom in 2007/08, both being asset price bubbles resulting in adverse effects to the affected economies. Based on this, we suspect that an asset price bubble could potentially exist within the renewable energy sector in the European equity markets. As we saw in the aftermath of both aforementioned bubbles, effective responses from both monetary- and fiscal policy play a critical role in stabilizing the economy.

Today, the world is suffering from the economic damage due to the COVID-19 pandemic. Both the monetary- and fiscal policy framework has responded to this in multiple ways to mitigate adverse economic ramifications from the pandemic to a minimum. As such, analyzing how both regulatory frameworks should collectively respond to a potential asset price bubble in the current market alongside their responses to the pandemic would be very complex. Potential regulatory responses must not counteract each other, and the process of isolating responses to affect only a price bubble in a relatively small share of the overall economy is truly complicated. As such, we have chosen to limit our research to only include an assessment of *when* monetary policy should respond to a bubble in general (i.e., ex-ante vs ex-post), and the monetary policy implications from the current situation in these terms. Thus, the purpose of this research is twofold: The main focus is to attempt to identify the existence of an asset price bubble in European renewable equity securities. In addition, we will discuss when the monetary regulatory framework should respond in face of it.

To answer the research question, we will first outline some basic concepts revolving capital asset prices. These theories and models help to create a foundation to understand how capital assets are priced through an equilibrium of demand represented by buys, and supply represented by sells. Hence, what drives the development of prices in the marketplace. Furthermore, they explain market behaviour, human behaviour, and our failure to stay rational which affects both supply and demand, consecutively influencing market prices of capital assets. Following this, we will outline some previous asset price bubbles that have occurred throughout history, and how their bursts affected the economies. This will provide a foundation on which we will bench our results from the current markets, while also yielding monetary policy implications which we will assess in a separate section later in the paper. Then we will present the data analysis and results, explaining our methodology and reasoning. We will examine and compare the pricing of various energy-related securities in a number of selected European equity markets, followed by a discussion of our results. Finally, after an assessment of the monetary policy implications of our results, we will conclude this study.

2.0 CAPITAL ASSET PRICES

An asset price bubble starts with a new opportunity or expectation. Munger (2021) claimed that bubbles are a biproduct of unsustainable speculation, human greed, and irrationality. However, Blanchard & Watson (1982) and Brunnermeier (2001) rather emphasizes that bubbles can be rational. Attempting to address the factors giving rise to such bubbles are complicated, but there are some fundamental changes in market behaviour that can generally be seen as abnormal in terms of conventional pricing models. In this section, we will assess asset price theories to understand why and how asset price bubbles occur.

2.1 The Opportunity Cost of Capital

Investors have multiple alternatives regarding capital allocation in financial markets. Thereby, choosing a specific investment opportunity means that other alternatives are not chosen. In addition, the investor must also postpone the spending of said capital by making the investment. Hence, multiple aspects are taken into consideration in the investment decision process. In relation to this, a prominent metric is the opportunity cost of capital.

$$The\ Oppurtunity\ Cost\ of\ Capital = Risk\ free\ rate + Risk\ Premium,$$

where the risk-free rate offsets the cost of inflation and time value of money, and the risk premium covers the risk aspect (Bredesen, 2015). Therefore, the compensation that is required when allocating capital is called the opportunity cost of capital. If the expected return of an investment is below the investor's opportunity cost of capital, the investment will reduce the investor's fortune and should thereby not be chosen and vice versa.

When facing multiple alternative investments, the opportunity cost of capital is used as a discounting factor to determine the value of future cash flows today. However, the risk profile of different investments may vary substantially. Therefore, the opportunity cost of capital for an investment in e.g., Equinor ASA is also defined as the expected return on other securities with the same risk profile as Equinor. Many stocks will be deemed as "safer" investments than Equinor, and many riskier. But in the financial markets where thousands of stocks are being traded, there will be a group with essentially the same risk profile as Equinor. We call this Equinor's risk class. Brealey, Myers & Allen (2020) explain that all stocks in this class must be priced to offer the same expected rate of return. Expected return, expected rate of return, the market capitalization rate and the cost of equity capital are just alternative names for the opportunity cost of capital.

2.1.1 Risk and Return

The relationship between risk and return is of high importance when it comes to asset pricing. US Treasury bills (T-Bills) are often regarded as one of the least risky choice of investment, and since the return on T-Bills are fixed, it is not affected by market movements. Therefore, we say that T-Bills have a *beta*[1] of 0. Another riskier alternative is the market portfolio of common stocks. Here the investor will obtain the average market risk, i.e., systematic risk, with a beta of 1. To compensate this risk, the investor will require a higher rate of return on the market portfolio compared to the treasury bill. As per Sharpe (1964), the difference between the return from the market and the interest rate from the T-Bills is called the market risk premium, denoted as:

$$Market\ Risk\ Premium = r_m - r_f$$

Brealey et al. (2020) state that, since 1900, the market risk premium has averaged 7.7% per year. However, what risk premium is required for investments with beta not equal to 0 or 1? An alternative answer is the capital asset pricing model.

2.1.2 The Capital Asset Pricing Model

The capital asset pricing model (CAPM) states that in a competitive market, the expected risk premium varies in a direct relation to a given asset's beta (Brealey et al., 2020).

$$Expected\ Risk\ Premium = Beta\ \times Expected\ Risk\ Premium\ in\ the\ market$$

$$E(r) - r_f = \beta(r_m - r_f)$$

As Bodie, Kane & Marcus (2018) explain, the model is based upon two sets of assumptions.

1. Individual behaviour.

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[1] A stock's sensitivity to changes in the value of the market portfolio is known as beta (β). Hence, beta measures the marginal contribution of a stock to the risk of the market portfolio (Brealey et al., 2020).

a) Investors are rational and optimizes mean-variance.
b) A common single period planning horizon.
c) Investors have homogenous expectations, and all relevant information is publicly available.

2. The market structure.
    a) All assets are publicly held and traded on public exchanges.
    b) Investors can borrow and/or lend at the same risk-free rate and are able to take short positions on traded securities.
    c) Absence of taxes and transaction costs.

By reformulating the formula, we obtain an expression for the expected return.

$$Expected\ Return\ \big(E(r)\big) = r_f + \beta(r_m - r_f)$$

Hence, by assessing a stock's beta value, we can theoretically estimate a reasonable opportunity cost of capital for investments with equal risk. This metric is then again used for discounting purposes in valuation of stocks.

2.2 Methods of Common Stock Valuation

A company's stock is divided into shares, and these shares are securities obtaining ownership rights on the company's equity. The value of said shares is derived from the investors' future expectations in terms of e.g., dividend yield/growth or general increase in the company's market value. However, valuation of stocks is often based upon cash flows that can potentially be paid out in dividends to investors without new financial transactions; *free cash flow*[2]. We distinguish between the value of future cash flows, valuation based on multiples and the value of growth opportunities.

2.2.1 The Discounted Cash Flow

The discounted cash flow (DCF), also called the dividend discount model is a well-known model in stock pricing. A company generates cash flows and pays them out to investors (e.g., in the form of dividends), and the model states that the value of a stock today is equal to the

[2] Free cash flow (FCF) are the cash generated from operations after accounting for capital expenditure needed to support operations and maintaining assets (Fernando, 2021).

sum of all future free cash flows[3] discounted at the opportunity cost of capital[4] for the given risk class. The model is formulated as:

$$P_0 = \sum_{t=1}^{\infty} \frac{DIV_t}{(1+r)^t}$$

The DCF is derived from the assumption that the price of a security at any given time is determined by investors' expectancy of dividends and expectations in terms of how the company's market capitalization will develop over the next period, i.e., expected capital gains. However, according to Brealey et al. (2020), the model has received criticism for its incapacity of considering said capital gains. If we were to formulate the DCF under the assumption of infinite periods discounted at the opportunity cost of capital *r* and a constant growth rate *g* in free cash flow in terms of for example dividends, we can determine that the present value of a common stock is equal to:

$$Present\ Value = \frac{DIV}{r-g}$$

The utilization of market-, strategic- and accounting analyses to estimate future cash flows/dividends and discounting it at a reasonable opportunity cost of capital considering both interest rate expectations and risk to determine the proper stock price is a form of fundamental valuation[5]. An issue regarding this method is the fact that gathering all the relevant data to estimate a reasonable stock price would be very time consuming for a non-professional investor, if possible at all in terms of access to relevant information etc. And as most humans are present-biased[6], we tend to look at quicker alternatives.

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[3] FCF, as defined above, must not be confused with earnings.
[4] The opportunity cost of capital used in the DCF is formatted as a constant discount rate for all future cash flows. This implies that the company is equity financed or that the fractions of debt and equity will stay constant in the future (Brealey et al., 2020).
[5] Fundamental valuation is a technique that bases the estimated price of a stock on the fundamental underlying values of the business' assets and operations. E.g., by analyzing balance sheets, income statements and cash flow statements (Bodie et al., 2018).
[6] Present-biased preferences means placing a higher value on today (the present) than tomorrow (the future) (Cartwright, 2018).

2.2.2 Valuation Multiples

Another way to estimate the value of a stock is to use so-called multiples. Two prominent multiples in stock valuation are the price earnings (PE) ratio and the price to book value ratio (PBV). They are defined as:

$$Price\ Earnings\ Ratio = \frac{Market\ Value\ of\ Equity}{Earnings}$$

$$Price\ to\ Book\ Value\ Ratio = \frac{Market\ Value\ of\ Equity}{Book\ Value\ of\ Equity}$$

The method of stock valuation through multiples involves gathering these ratios for comparable companies and assessing how the market pricing of the different stocks vary to seek out profitable investment opportunities. E.g., if two similar companies trade at different PE-ratios, one can assume that the company trading at the lowest PE-ratio is relatively cheaper and vice versa (Brealey et al., 2020). As such, through valuation multiples one can assess the pricing of individual securities in relation to their peers.

2.2.3 Present Value of Growth Opportunities

A third method of common stock valuation is through estimation of the present value of growth opportunities (PVGO). It is defined as the value today of opportunities to increase earnings in the future.

$$PVGO = \frac{EPS_2 - EPS_1}{(1+r)^2} + \frac{EPS_3 - EPS_1}{(1+r)^3} + \cdots$$ [7]

We generally say that the stock price is the capitalized value of average earnings under an assumption of no growth (also called *intrinsic value*), plus PVGO (Brealey et al., 2020). Therefore, the expression for the stock price after this method is defined as:

$$P_0 = \frac{EPS_1}{r} + PVGO$$

[7] EPS denotes earnings per share. (I.e., the company’s earnings divided by the total number of company shares.)

A possible challenge utilizing this model is the actual quantification of said future opportunities.

As we have discussed, there are multiple ways to assess asset prices in a competitive market. Reasonable price estimates can be derived from a theoretical viewpoint using the aforementioned models and methods. However, the accessibility of information needed to acquire price estimates through said models might be difficult to obtain. So, can we trust that the market is pricing assets correctly? To answer this question, we will introduce a famous theory in financial literature: the efficient market hypothesis.

2.3 The Efficient Market Hypothesis

The efficient market hypothesis (EMH) states that securities being traded in open markets will always have prices reflecting the information in the markets (Fama, 1970). Of course, it is possible to be lucky and to increase expected return by taking on more risk. However, the theory points out that it should be impossible to systematically beat the market through clever transactions. If securities pricing followed a predictable pattern, intelligent investors would estimate future prices and trade/speculate accordingly, and thereby securing a safe return. However, prices would almost instantly adjust aligned with new future expectations, and the intelligent investors would have to compete to secure the safe bets. Thereby, it follows that cheap prices in the market are only an exception and not the other way around.

The article written by Eugene Fama in the Journal of Finance in 1970 titled "Efficient Capital Markets: A Review of Theory and Empirical Work" creates the foundation for much of the financial literature written on EMH[8]. The main point is that prices reflect the information obtained by the agents participating in the market.

2.3.1 Different forms of Market Efficiency

Brealey et al. (2020) argued that the theory distinguishes between three different forms of market efficiency:

[8] Statement made by Associate Professor Einar Belsom through a lecture note in the course ØABED4000 Corporate Finance, 9th of September 2019.

Weak Market Efficiency

Prices always reflect all information included in previous pricing, following a *random walk*[9] where it is not possible to beat the market by studying previous prices.

Semi-strong Market Efficiency

In addition to the aspects included in the weak form of market efficiency, prices also reflect all publicly available information and analyses that can be based upon it. Followingly, it is not possible to beat the market by systemizing and analysing said available information.

Strong Market Efficiency

In addition to the aspects obtained in the two previously mentioned forms of market efficiency, this form states that prices also include information not known to the public[10].

One can argue that EMH is a contradiction: generating extraordinary returns from good buys and sales are regarded as an impossibility, alongside the fact that investors who try to secure these deals for themselves are the ones who make it impossible. The natural interpretation of EMH thereby becomes that the expected risk adjusted return from activities in the market does not exceed the expected return from other work.

2.3.2 Abnormal Return

So how does the market react to new information being introduced? If markets were strongly efficient, no information would be unknown. But as we know, this is not the case. Therefore, studying how the stock market reacts to news about earnings, dividends or other company related news is measure one can use to test how much semi-strong efficiency features the market possessed. Brealey et al. (2020) specified that following EMH, the market should price in new information quickly and completely. Consequently, there should be no discrepancy between the actual security price change and the value change effect of the news itself. Be that as it may, markets have a tendency to over- or underreact, depending on the news (e.g., is the news market related, or firm specific?). These deviations are calculated and

[9] A random walk is a statistical phenomenon in which a variable, in this case stock prices, moves seemingly at random and follows no discernible trend (Corporate Finance Institute).

[10] Information such as e.g., inside information.

analysed through e.g., event studies[11]. Such studies analyse abnormal return, which is defined as:

$$Abnormal\ Return = Actual\ Return - Expected\ Return$$

Price changes due to new information may very well be aligned with EMH, as bad news may consequentially affect the underlying value of a security. And prices should, according to EMH, equal their respective stocks' fundamental values. But, as we know, this is not always the case. Prices do differ from their fundamental values, and extraordinary returns are being made. But why is that? To answer this question, we will introduce a section that combines aspects from both finance and psychology: behavioural finance.

2.3.3 Behavioural Finance & Anomalies

If humans were to behave like "*Homo economicus*[12]", financial crises or large volatile swings in asset prices would never occur. However, due to its lack of tangibility, factors like jealousy, greed, pride, fear, lack of sufficient knowledge or just incompleteness of information are not modelled through EMH under the assumption of Homo economicus (Kamalodin, 2011). As a result, distress, and panicky sales of securities during crises due to incomplete information, a *bear market*[13] reinforces itself through the appearance of unknown unknowns. Former Chairman of the U.S. Federal Reserve, Mr. Bernanke (2010), stated that humans do not behave rationally under conditions of profound uncertainty. In an attempt to model such psychological factors into the standard economic model on economic terms, behavioural economics and behavioural finance are often used. Behavioural finance seeks to study the underlying factors driving investors' behaviour in contradiction of EMH.

Phenomena that contradict EMH, possibly resulting from irrational decision making, are called anomalies. Here, securities' prices differ from their fundamental values. With the existence of anomalies, abnormal returns can be experienced. In this thesis, we will focus on a

[11] Event studies are done to analyze the news effect on a sample of stocks encountering the same news (Brealey et al., 2020).

[12] In the standard economic model, as well as EMH, humans are considered as "Homo economicus": a completely rational, calculating, selfish and utility maximizing being entirely stripped of empathy and emotion (Cartwright, 2018).

[13] A bear market occurs when the prices of securities fall for a sustained period of time, as opposed to a bull market in which is the opposite (Gallagher).

specific anomaly in capital markets contradicting the efficient market hypothesis, namely, asset price bubbles.

2.4 Asset Price Bubbles

So far, we have discussed asset pricing in general. But how can we determine whether a group of stocks are priced correctly? For example, let us say that an investor wanted to assess whether the stocks forming the Standard & Poor's Composite Index were valued fairly in mid-2017. In 2017, the total amount of dividends paid out by the companies in the index amounted to approximately $420,000,000,000 (Brealey et al., 2020). In addition, we assume that investors base their decision making upon an expected rate of return, or an opportunity cost of capital of 6%, and the constant dividend growth rate equals 3% per year. If we use the model introduced in section 2.2.1 assuming an infinite number of future periods and a constant dividend growth rate, we obtain the following:

$$PV_{S\&P\ Composite} = \frac{DIV}{r-g} = \frac{\$420}{0.06-0.03} = \$14{,}000\ billion$$

But how certain can we be of our estimates? Now, let us say that the actual dividend growth rate per year only amounts to 2.5%, i.e., a reduction of half a percentage point. The present value of the index would then be equal to:

$$PV_{S\&P\ Composite} = \frac{DIV}{r-g} = \frac{\$420}{0.06-0.025} = \$12{,}000\ billion$$

Relatively speaking, it would yield a value reduction in the common stocks of 14.3%. This showcases the extreme difficulties of precise valuation of common stocks. Consequently, investors often take yesterday's price as a correct price estimate, and adjusts the value based on new information after the fact. This indicates that EMH should price securities correctly, given that proving a correct price in relation to the stock's fundamental value is close to impossible (Brealey et al., 2020). And every now and then, investors get caught up in speculative frenzies where asset prices can no longer be justified by their underlying fundamental values. Such occasions are called *asset price bubbles*.

An asset price bubble starts with a new opportunity or expectation. As explained by Sornette & Cauwels (2014), this may be the result of a new technology being developed, access to a new market, or a significant technical trading event. The new development can then lead to a temporary upward acceleration of prices above the underlying value. In the beginning, innovators will invest, and this will lead to a first wave of price appreciation. As a consequence of this wave, more investors will follow the prospect of higher returns. The economy will at some point reach a level where demand increases as the price increases, and price increases as the demand increases. This result in a positive feedback mechanism being established, a mechanism that will lead to a swirling growth away from the market equilibrium. A rational “good buy” can only be made if the investor is willing to take on enormous risk and is under the impression that other more foolish investors are willing to buy the asset at an even higher price in the future (Brunnermeier, 2001).

Attempting to address the factors giving rise to such bubbles are complicated, but there are some fundamental changes in market behaviour that can generally be seen as abnormal. Broadly speaking, a divergence in the supply and demand equilibrium arises. In times of unprecedented pricing of a certain type of assets, the demand for a scarce good drive up the price. This can be a result of either changes in investors preferences, changes in domestic and/or foreign policy, or most likely a combination of many different factors. However, the very definition of an asset price bubble is that at some point, it bursts. Such crashes occur as a result of the market having entered a highly unstable phase proceeded by a long maturation and inflation of the bubble. And much like balancing a ruler on top of one finger, just the slightest disturbance can trigger a fall.

Asset price bubbles may well be a cause of misallocation of resources that leads to inefficiencies in the economy. During the Dotcom bubble, several high-tech companies had a high level of investment spending relative to the rest of the economy. Research from Japan has shown that this misallocation problem was costly for the overall economy and contributed to persistent economic stagnation after the bubble burst, according to the Congressional Research Service (2001). Hence, the financial system could experience difficulties as a consequence of an asset price bubble. It can cause a large firm, or several firms holding assets that are declining in value, to experience insolvency or illiquidity. If financial firms are independent, and are unable to honor their obligations, there could be a ripple effect. This could result in an adverse domino effect throughout the general economy. Labonate (2007) indicate that asset price bubbles affect the economy indirectly. In response to changes in the price signal, economic agents alter their behaviour. This was apparent in the data following the Dotcom bubble in 2000. Physical capital investment spending increased in the preceding years up to 2000, and following the stock market crash, investment spending declined in the years after.

Munger (2021) claimed that bubbles are a biproduct of unsustainable speculation, human greed, and irrationality, which contradicts the assumptions under the CAPM. However, Blanchard & Watson (1982) and Brunnermeier (2001) rather emphasizes that a bubble can be rational. They explain that a rational bubble could form when the expectations of future returns drive a rational participant to purchase a bubble-asset because they are under the impression that other agents in the marketplace will buy it at an even higher price later. Such research does have support, as there has been an element of rational speculation under some bubbles: well informed investors know that the price has exceeded the fundamental value of the asset, nevertheless choosing to “ride” the bubble and make speculative returns due to a lack of information and/or knowledge among other market participants. Brunnermeier & Nagel (2004) proved this phenomenon in their analysis of hedge fund holdings during the Dotcom bubble in the late 1990’s.

Asset price bubbles is not a new phenomenon. They have a recurring history derived from the cyclical nature of the development in a market economy, according to Munger (2021). They come and go, potentially causing severe adverse effects on the financial system. Moving on, we will outline some of the major bubbles that have taken place throughout history.

3.0 ASSET PRICE BUBBLES THROUGHOUT HISTORY

In this part, we will outline some major previous asset price bubbles, including when they happened, how they happened and what the economic ramifications were. Hopefully, this will provide a better understanding of implications of bubbles and strengthen our research as history often seems to repeat itself.

3.1 The Dutch Tulip Bulb Bubble

The first well documented asset price bubble in history was the Dutch Tulip Bulb Bubble in 1636 (Kindleberger & Aliber, 2005). The price of tulip bulbs increased by several hundred percent, and some more exotic tulip bulb types had even greater price increases. Kamalodin (2011) reported that at its peak in February 1637, an auction of tulips netted 90,000 guilders. In comparison, the annual salary of a prosperous merchant at the time was about 900 guilders. Inevitably, the bubble burst and prices fell drastically. However, the bubble was not followed by a depression. How severe the effect of a burst bubble has on the real economy depends on the nature of the bubble. This is an interesting note that we will elaborate on further later in this thesis.

3.2 The South Sea Bubble

The next two notable bubbles occurred at about the same time, around 1720. The South Sea Bubble originated from London. The House of Lords passed a bill granting the South Sea Company a monopoly in trade with South America, in exchange for a loan of £7 million to finance Great Britain's war against France (Castelow, 2013). The company underwrote the British national debt which stood at approximately £30 million at the time and were given an interest of 5% from the British government. This led to an almost instant ten-fold increase in the shares in the South Sea Company, and speculation went wild. Many new companies were launched, fraudulent as well as legitimate, and prices kept skyrocketing. Eventually, the bubble burst and prices fell dramatically. Many people all over the UK lost all their money.

3.3 The Mississippi Bubble

The Mississippi Bubble took place at about the same time. In the years prior to 1720, France was practically insolvent. The costs of warfare bore a hole in the French treasury. The government tackled the issue by raising taxes to extreme levels, but it was not sufficient. Inevitably, France began defaulting on its debt, and their currency declined in value (Beattie, 2021). In an attempt to save its currency, France’s standard was swapped from gold and silver to paper. This way, economic growth was decoupled from the unpredictable supply of gold and silver. The French government contracted an exiled Scottish man by the name of John Law to run this currency transfer. His bank took deposits in coin but issued loans and withdrawals in paper. After making good profits handling the government’s needs, Law expanded by purchasing the Mississippi Company which held monopoly in trade outside of Europe. The stock price increased dramatically, and eventually the amount of money needed to buy company stock was so high that more money had to be printed. However, as people wanted gold and silver when taking profits, the system fell. The paper currency became worthless, and the bubble had burst. Due to this event happening around the same time, the Mississippi Bubble is often confused or mistaken with the South Sea Bubble. Yet, the Mississippi incident was more of a currency blunder as opposed to a true speculative bubble.

3.4 The Latin American Bubble

In 1825, a new bubble arose. After the Spanish empire was overthrown, Latin American republics were opened to trade. This led to the establishment of international trade between England and Latin America with massive capital inflows from London to finance government deficits, infrastructure, and mining in the developing countries (Kamalodin, 2011). As a result of this, a massive boom in the London Stock Exchange took place. However, as the vast capital outflows weakened the Bank of England’s gold reserve, policy rates were raised. This led the stock market into a crash and caused banking panic. Additionally, the sudden loss of capital inflows in Latin America led to debt defaults, currency crashes and banking panic across the continent. The bust of this bubble led the world into its first international financial crises.

3.5 The German & Austrian Property Bubble and the Baring Crisis

The next global financial crises occurred because of the collapse of the German & Austrian property bubble in 1873. As European investors wanted to mitigate their losses through selling US railroad stock, which had also been undergoing a considerable boom resulting from the capital inflows from Europe. The sudden halt of European capital inflows also caused debt default and banking panic in Peru (Kindleberger & Aliber, 2005). Soon after, in 1890, the Baring crisis started. As Kamalodin (2011) state, it was arguably the worst crises developed countries had suffered since the end of the Napoleonic era. In the 1880s, western European countries made significant infrastructural investments, mostly in Argentina, Uruguay and Brazil. The result of the capital flows was a land boom financed primarily by generous bank lending. Inevitably, a burst took place when the Bank of England and other European central banks instigated increased policy rates to stem losses on their gold reserves. The burst created a severe banking, debt and currency crisis in Argentina. A leading London based bank at the time, Barings Brothers, was heavily exposed to Argentine national debt and went insolvent. Due to this bankruptcy, the financial crisis spread across Europe and eventually also affected USA and Asia.

3.6 The Great Depression

In the "roaring 1920s", the stock markets over the world experienced several booms and euphoria. But such a bubble always bursts, and the result was one of the most severe financial crises the world has ever seen: The Great Depression (Kamalodin, 2011). A series of banking panics spread across the US in late 1930. Friedman & Schwartz (1993) explain that the Federal Reserve failed in allaying the desperation, which turned the situation from bad to outright ugly. The depression transmitted throughout the world by the fixed exchange rate linkages of the gold exchange standard. Consequently, a great many countries experienced debt and currency crises. After WWI, The Great Depression and WWII, countries rebuilt their economies. Although Barro & Ursua (2009) outlined some bubbles and crashes occurring between 1940 - 1995, none were as vast as the bubble that build up through the late 1990s and spread all over the world: The Dotcom bubble.

3.7 The Dotcom Bubble

This bubble arose from a rapidly increasing US technology equity valuations fueled by high leveraged investments in new internet-based companies during the bull market in the late 1990s, as explained by Dalio (2021). The total value of equity markets grew exponentially, rising five-fold between 1995 and 2000. When the bubble burst, the Nasdaq index fell from its peak at 5,048.62 on March 10, 2000, all the way down to 1,139.90 on October 4 , 2002. A 76.81% index drop, where multiple billions of dollars were lost (Geier, 2015). By the end of 2001, most Dotcom stocks had gone bankrupt, while other blue-chip technology stocks like Cisco, Intel, and Oracle had lost more than 80% of their market value. On April 24, 2015, the Nasdaq index finally regained its peak value from 2000, showing that it took the US economy more than 15 years to recover from the Dotcom and the 2007/08 US housing market bubble (Hayes, 2019).

3.8 The Subprime Mortgage Bubble

The most recently experienced bubble we will outline in this thesis is the US housing market bubble in 2007, the so-called Subprime Mortgage Bubble which led the world into a severe financial crisis (Kosakowski, 2020). To understand what happened this time, we must initially outline the concept of securitization. If you want a loan, you go to the bank and ask for it. Traditionally, banks primarily funded their loans with money from their client's deposits. But as time went by, the U.S. banks saw that there was a discrepancy between the demand for loans and the supply of deposits available to banks. This led to the establishment of so-called MBSs (Mortgage-Backed Securities). Portfolios of mortgages went through a process called securitization, where the mortgage-portfolios were packed as own securities that generated cash flow for investors. These portfolios of income producing assets were sold by banks to so-called special purpose vehicles (SPVs) and the resulting cash flows were split into different trances (with different levels of risk) which were again sold to investors as securities (Hull, 2015). When the bubble burst in the fall of 2008, the world was led into a financial crisis ranked as among the most horrific in world history.

As we can see from these incidents, bubbles usually originate from something new: a trend, a new standard, a disruption, and then a change. So, moving on: is the same phenomenon taking place in the current European markets within renewable energy?

4.0 METHODOLOGY & DATA COLLECTION

Now that we have outlined the concepts of asset pricing in general, asset price bubbles and their occurrence throughout history, we will move on to our analysis of whether such a bubble currently exists in European renewable energy sectors. This section consists of presentations of our methodological reasoning, and the data upon which we will conduct our analyses.

4.1 Methodology

As we outlined in section 2, various methods can be utilized in estimation of reasonable asset prices based on fundamentals. However, as many renewable energy companies are relatively young, estimation of future cash flows and/or dividends involves profound uncertainty. Therefore, we assume that the DCF and PVGO are not sufficient to assess the prices of said companies traded in the market. Furthermore, estimating asset prices on relatively young renewable companies based on valuation multiples from similar companies would not yield the intuition we are seeking. This because of the infrastructural differences between conventional and renewable energy companies. We will assess asset prices in a holistic manner, comparing returns obtained in renewable energy securities with conventional energy securities' returns, as well as the overall market.

Our method in analyzing the obtained data will be three-fold, where we will: I) run hypothesis tests, II) examine daily logarithmic returns in the groups and III) evaluate their respective R-squared values.

I) Hypothesis Tests

This analysis is inspired by the intuition behind an event study. Hayes (2020) outlined that an event study is an empirical analysis where the goal is to examine the impact of a significant catalyst, e.g., event, on the value of a security. In essence an event study provides data on how the security reacted to the event. Binder (1998) presents different ways in which event studies have been conducted. Event studies have been used to test null hypotheses and to test the impact an event has on a firm´s held securities under the assumption of the efficient market hypothesis. The first of these tests whether the market efficiently incorporates information, while the later tests what impact an event will have on the value of a firm, under the assumption that traders have equal available public information. In our case, there is no event date as such. However, we assume news regarding sustainability, climate change and other environmentally connected areas to be events occurring on a continuous basis. Thus, the events we are testing the effects of run continuously throughout the entire dataset. We used weekly returns from the companies and benched them against the return from the overall market as a proxy for expected return, or the opportunity cost of capital in each country. Thereby, we can estimate abnormal return. This is the metric that will be used in comparison across entities, i.e., country and sector, by using t-tests. These are a type of inferential statistic that tests for significant differences between the means of two groups. The independent two-sample t-test compares the difference between the means for the two groups to a given value. That is, it tests whether the difference between the means is zero. We used Stata to conduct our t-tests. The t-statistics and p-values produced by Stata use the assumption that the samples comes from approximately normal distributions (UCLA: Statistical Consulting Group, 2021).

T-statistics is a statistic typically used when performing hypothesis tests. By using a confidence interval of 95% where the associated *critical value*[14] under the assumption of a normal distribution is 1.96, we ran our tests with a *significance level*[15] of 0.05% (Stock & Watson, 2020). If the p-value associated with the t-tests is smaller than the threshold[16], there is evidence that the mean is different between the groups. However, in the instances when associated p-value is not smaller than the threshold, $p > 0.05$, we fail to reject the null hypothesis meaning that there is not significant statistical evidence to state a difference in the mean of the groups. In our t-test we allow for differences in variances across groups (coded as *une* in Stata).

II) Daily Logarithmic Return

According to Atkinson (2012), bubble tendencies can be identified by a study of daily logarithmic return. He presents a model that emphasizes breaches of 1 and 2 standard deviations away from the mean. To further strengthen our research, we created separate portfolios including every company in the relevant country and sector. In this part, we used daily log return throughout the period to observe trends in the markets through graphs, which also allowed us to observe other events that influence the development of the pricing of these

[14] The critical value is the value of a test statistic where the test just rejects only the null hypothesis at the given level of significance (Stock & Watson, 2020).
[15] The significance level is the prespecified rejection probability of a statistical hypothesis test where the null hypothesis is true (Stock & Watson, 2020).
[16] 0.05 is the threshold used in this thesis.

companies. This is done through generating representations of standard deviation from the mean, computed as 1, -1, 2 and -2 standard deviations. Our focus will be on the observations that breach 2 and -2 standard deviations from the mean (i.e., highly volatile trading days). As demonstrated by Atkinson (2012), this procedure is conducted to examine extreme values of return as these days/periods could possibly give indications on what causes fluctuations in the portfolio and thereby uncovering bubble tendencies when compared to peer groups.

III) R-Squared

As discussed by Morris & Alam (2012), during the Dotcom bubble, the adjusted R-squared for "high tech companies" was significantly lower than the "low tech". Hence, we will also conduct an analysis of the related R-squared measurements of our two groups. Morris' & Alam's methodology controlled for several accounting variables, which we will not. Our models were OLS-based simple linear regressions with one dependent and one explanatory variable. We constructed separate portfolios including all companies from both the conventional and renewable sector, which were our dependent variables. Then, we regressed their returns against the return of the market index, as the explanatory variable. This process was conducted country by country, generating R-squared and adjusted R-squared measures. Morris & Alam (2012) analyzed the adjusted R-squared values, as their models consisted of multiple explanatory variables[17]. However, in simple linear regressions, R-squared is the relevant metric. This will indicate how much of the total variance obtained in each portfolio can be explained by general market movements. These results will be comparable between entities.

By these measures, we believe that we will have obtained a sufficient basis to assess whether an asset price bubble currently exists within European renewable energy equities benched against both the conventional energy sector and the overall markets.

4.2 The Data

We have gathered all the data utilized in this thesis through Refinitiv Eikon. We suspected that an asset price bubble could be under formation, based on the developments of renewable energy equities listed on Oslo Stock Exchange (OSE). Thereby, we initially wanted to embark

[17] When including additional explanatory variables, R-squared automatically increases. Hence, adjusted R-squared is better suited when comparing big regression models (Stock & Watson, 2020).

on this thesis only looking at OSE. However, after careful consideration and discussion, we decided to broaden our dataset to increase the validity of our results. Consequently, we expanded the dataset to include companies and data from four additional developed European countries. We selected countries that are similar to Norway in terms of political landscape, demographics, and economic patterns. The selected countries are:

- *France*
- *Germany*
- *Italy*
- *Norway*
- *The United Kingdom*

Our dataset included 298 companies. Given that these economies are all affected by the European Union's regulations[18], we believe that our results will be applicable across the entirety of our dataset. Even though the United Kingdom has left the European Union, we assume that the UK will still be heavily affected by regulations formed in Brussels, based on the still ongoing large amount of trade between the UK and the EU (House of Commons Library, 2020). We believe that a combined analysis of these countries will provide a better understanding and hopefully yield an increased ability to determine the presence of a "green" bubble in the energy sector in European stock markets.

Refinitiv Eikon provided a broad overview of companies in both the Energy and Utility sector in the selected countries. For our sample, we classified each company as either conventional or renewable, based on The European Green Deal, EU Taxonomy, and corporate information from Financial Times' market data (Financial Times, 2021) After the classification, we created a binary variable[19]. This variable split the sample into two separate groups: one being companies operating directly or indirectly in the conventional energy sector e.g., including both all of the oil, gas, and coal companies, as well as seismic and supply. The other group include the companies operating within the renewable sector.

[18] European Green Deal & EU Taxonomy
[19] A binary variable can only obtain the value of either 0 or 1. A binary variable is used to indicate a binary outcome, i.e., a general term that implies only two possible outcomes to a certain situation (Stock & Watson, 2020).

The next step was determining the time frame of our data. We chose a time frame of one year, partly due to the high volatility in pricing of renewable companies during the previous year. Another element is the fact that many of the renewable companies were listed on stock exchanges during 2020 and have thereby been listed for less than one year (especially in Norway). Our assumption is that setting our time frame of the analysis, both on conventional and renewable energy companies equal to one year, we will be able to investigate the presence of an asset price bubble by better obtaining the effects of the newly listed companies on the overall market.

The financial metric we based our analysis upon was *market capitalization*[20]. Market capitalization (market cap) is an economic variable that is often used to divide companies according to size (Fernando & Boyle, 2021). It is defined as:

$$Market\ Cap = Share\ Price * Number\ of\ Shares\ Outstanding$$

We chose this metric, because it controls for both volume and price, while also providing the relative weight associated to every single company, being an important characteristic needed later in the analysis when benching against the market. In addition, we believe that weekly trading data provides the best fit as opposed to daily trading data which could include more irrelevant noise. The weeks were defined as a categorical variable on the ratio level, starting at week 1 and ending at week 52. The starting point for our data is April 16, 2020. With our choice of weekly data, our dataset consisted of a total number of 15,493 observations (Table 4.1).

[20] Market capitalization refers to the total market value of a company´s outstanding shares of stock (Brealey et al., 2020).

Table 4. 1: Descriptive statistics for each country separated into Conventional & Renewable.

Descriptive Statistics:

France: Conventional

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	619	.002	.081	-.670	.880

France: Renewable

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	714	.012	.109	-.519	.955

Germany: Conventional

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	690	.013	.200	-.813	2.018

Germany: Renewable

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	1121	.065	.499	-.950	7.759

Italy: Conventional

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	742	.001	.045	-.190	.378

Italy: Renewable

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	424	.007	.061	-.148	.360

Norway: Conventional

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	3188	.016	.192	-.977	6.808

Norway: Renewable

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	743	.023	.129	-.327	1.192

UK: Conventional

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	5412	.018	.184	-1.0	6.111

UK: Renewable

Variable	Obs	Mean	Std. Dev.	Min	Max
ret	714	.038	.187	-.436	1.713

5.0 ANALYSIS

In this section, we will present the results of our analyses. Our discussions of said results and their implications will be outlined in section 6.

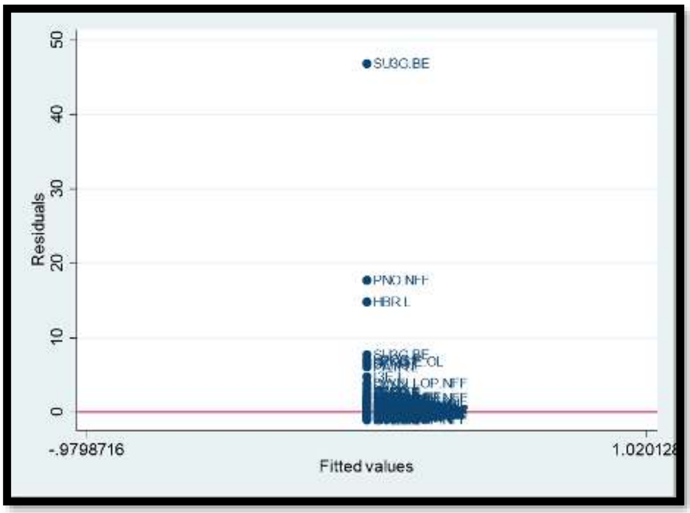
5.1 Return

We calculated the nominal returns, i.e., the net profit or loss on marketable securities of the company expressed in nominal terms (Brealey et al., 2020). The return variable is defined as follows:

$$Ret = \frac{Market\ Cap}{Market\ Cap_{n-1}} - 1$$

By making use of this newly created return variable, we conducted t-tests to determine the statistical significance of our data. After the transformation was conducted, we found some observations that could be deemed as potential outliers (Stock & Watson, 2020). We utilized a residual plot to identify them and assess whether they should be included or not, as shown in Figure 5.1.

Figure 5. 1: Residual Plot



Outlier number 1)

SU3G.BE (Germany) at week 14 – due to this observation obtaining an extreme value, we suspect a misregistration of market cap development this week. By checking this observation against price history in the relevant time frame, we concluded that taking out this observation is the correct solution.

Outlier number 2)

PNO. (Norway) at week 17 – we assume this observation as general market noise, and thereby taking it out of the dataset.

Outlier number 3)

HBR.L (UK) at week 51 – we assume this observation as general market noise, and thereby taking it out of the dataset.

Consequentially, we believe to have a theoretical foundation to remove the outliers form our dataset.

5.1.1 Entire Sample

Table 5. 1: Return

Return: Two-sample t test with unequal variances
(C = Conventional) (R = Renewable)

Entire Sample

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ret by Dummy: C R	10651	3716	.015	.035	-.019	.177	.297	-4.75	.000

France

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ret by Dummy: C R	619	714	.002	.012	-.010	.081	.109	-1.90	.059

Germany

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ret by Dummy: C R	690	1121	.013	.065	-.052	.200	.500	-2.60	.009

Italy

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ret by Dummy: C R	742	424	.001	.007	-.005	.045	.061	-1.75	.079

Norway

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ret by Dummy: C R	3188	743	.017	.024	-.007	.192	.129	-0.95	.341

United Kingdom

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ret by Dummy: C R	5412	714	.018	.038	-.020	.184	.187	-2.75	.007

The output from the t-tests on the entire sample with return as the dependent variable reported associated t-statistic larger than the critical value, as we can see from Table 5.1. This implies a difference in mean between the two groups, conventional and renewable companies. Given the evidence gathered through the t-tests, statistically significant evidence points in the direction of a difference in mean between the two groups.

Another important aspect that should be analyzed from the output is the standard deviations. Brealey et al. (2020) explained that standard deviation is one of the standard statistical measure of spreads. The standard deviation is dependent on the variance, which is the expected squared deviation from the expected return. Hence, the standard deviation is the squared root of the variance (Brealey et al., 2020). When analyzing the standard deviation in the t-tests, the output shows higher standard deviation for the renewable companies. This indicates larger fluctuations in the return of renewable companies. This could potentially be an indication of an asset price bubble.

5.1.2 Individual Countries

There are differences in the output when conducting the test on individual countries. More specifically, the test on the two groups in Germany and the UK yielded significantly different outputs, as we can see from Table 5.1. Hence, we reject the null hypothesis of no difference in the means between the groups. However, there was no such support of differences in France, Italy, and Norway (Table 5.1), resulting in failure to reject the null hypothesis.

As for reported standard deviations, the same tendency for the entire sample was present in four countries: France, Germany, Italy and the UK had higher standard deviation in the renewable energy sector compared to conventional energy, whereas Norway had a higher standard deviation for companies within conventional energy. A possible explanation for the difference could be the large difference in number of conventional energy companies compared to renewable energy companies in Norway.

In finance, standard deviation is often used as a measure of risk associated with price fluctuations of an asset (Hargrave & Anderson, 2021). The standard deviation observed in the t-tests indicates higher risk associated with renewable energy companies, potentially being caused by a ripple effect from a possible asset price bubble. Such excess fluctuations imply a higher degree of unique risk, contributing to more uncertainty associated with renewable energy companies.

5.2 Abnormal Return

We concluded that the natural next step would be to bench the results against the overall market, but to do that, further data was needed. We gathered data on market capitalization for all active equities in the selected countries, which we merged into the existing dataset. Now, we were able to bench individual company returns against return in the overall market for each individual country. We specified overall market return as:

$$Ret\_Mkt = \frac{Market\ Cap\_Mkt}{Market\ Cap\_Mkt_{n-1}} - 1$$

With the existing companies' return and market return, we are able to create a variable for abnormal return. The definition of abnormal return is performance that diverges for the company´s expected rate of return (Barone & Estevez, 2021). Our proxy for the expected return for the companies is the rate of return for the market in each company´s country. With abnormal return being any return that deviates from an investment´s expected return, it is defined as:

$$Abnormal\ Return = Ret - Ret\_Mkt$$

The result is a variable that both controls for the return of the company and the overall market return in the company´s country.

5.2.1 Entire Sample

Table 5. 2: Abnormal Return

Abnormal Return: Two-sample t-test with unequal variances
(C = Conventional) (R = Renewable)

Entire Sample

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ar by Dummy: C R	10651	3716	.019	.038	-.019	.177	.298	-4.75	.000

France

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ar by Dummy: C R	619	714	.005	.015	-.010	.084	.110	-1.85	.064

Germany

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ar by Dummy: C R	690	1121	.017	.069	-.052	.201	.500	-2.60	.009

Italy

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ar by Dummy: C R	742	424	.004	.009	-.005	.050	.0.66	-1.60	.108

Norway

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ar by Dummy: C R	3188	743	.024	.030	-.007	.193	.132	-0.95	.349

United Kingdom

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
ar by Dummy: C R	5412	714	.021	.041	-.020	.183	.188	-2.75	.007

We conducted the same tests as we ran on *return*, but now on *abnormal return*. Hence, we were able to determine if and where abnormal returns were present. Such periods are of major interest, as an asset price bubble could potentially reinforce itself through increased prices and an increased will to buy due to irrational enthusiasm. For the entire sample, the associated t-statistics are above their critical values, as shown in Table 5.2. Hence, implying a statistically significant difference in the mean of the groups. Therefore, the null hypothesis of no difference in mean between the two groups is rejected.

When analyzing the related standard deviations in the output for the t-tests, the output has similarities to the output generated when the dependent variable was return. The standard deviation of the renewable companies is higher, indicating larger fluctuations in abnormal return for renewable energy companies. This supported the hypothesis of larger movements in abnormal return for renewable energy companies, potentially due to an asset price bubble.

5.2.2 Individual Countries

When conducting t-tests on an individual country basis with abnormal return as the dependent variable, the output is similar to that observed with return as the dependent variable. This implied that Germany and the UK had statistically significant output, while the others did not (Table 5.2). As a result, we fail to reject the null hypothesis of no differences in mean in France, Italy, and Norway separately.

These similarities in output would imply no significant difference in standard deviations. Nonetheless, even when benching return from single companies against the expected rate for return, i.e., market return, the associated risk is greater for renewable energy companies. In other words, the uncertainty is higher for the renewable companies. This uncertainty could be a consequence of the relatively high pricing of renewable securities, and their lack of connection to their underlying fundamental values.

5.2.3 Comparison: Return vs Abnormal Return

The difference between the variables for return and abnormal return, is the inclusion of market control on individual country basis. By using market cap on all active equities in the respective countries as a benchmark, we are able to control for whether movements observed are common across the specified country or if the return of the specific sector is in fact abnormal[21]. The inclusion of the market variable resulted in close to no difference in the associated t-statistic and p-values, respectfully (Tables 5.1 and 5.2). The outcomes are similar. For the entire sample, the output yielded support to a statistically significant difference in means being present, both in return and abnormal return. This trend is also observed when t-tests are conducted on specific countries.

[21] I.e., deviating from the overall market.

5.3 Three-Week Moving Average

In an effort to eliminate noise in the dataset, we smooth out our data by constructing a simple moving average. Equal wight is given to every observation included in the calculation of the moving average, which means that the previous, the current and next week have equal weighting and are equally important and affecting the moving average. However, this method can be criticized as many traders actually prefer the exponential moving average instead, which allocates different importance to different periods (Hayes & Potters, 2021). The reason why traders might prefer an alternative approach is based upon the assumption of too much weight being placed on old data with a simple moving average.

We have decided on a three-week moving average. As our observations is limited to 52 weeks, any larger span on the moving average would not be able to pick up sudden movements. In our case with three data points, we are able to offset the adverse effect of too much weight being given to old data. By the nature of our data selection, we assume that both a simple moving average and an exponential moving average will produce nearly the same result.

Figure 5. 2: Graph: Return: France Renewable

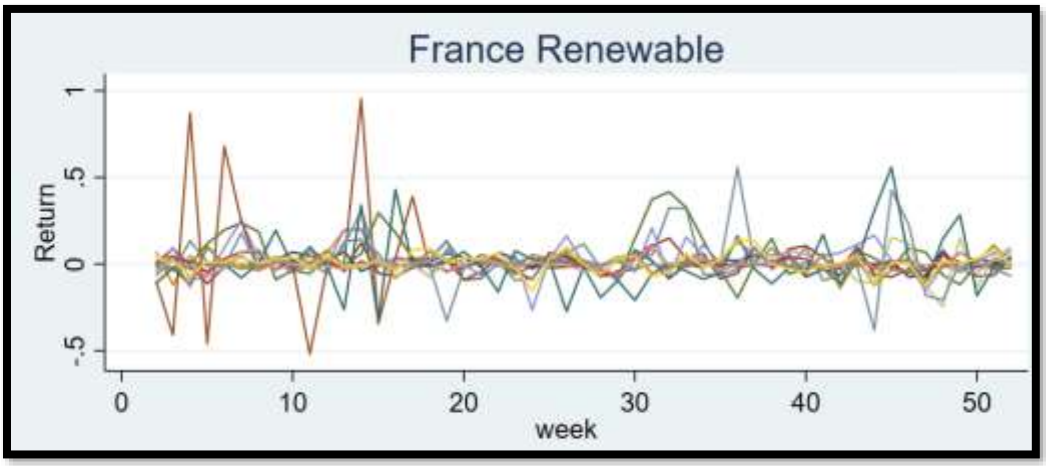


Figure 5. 3: Graph: Three-Week Moving Average Return: France Renewable

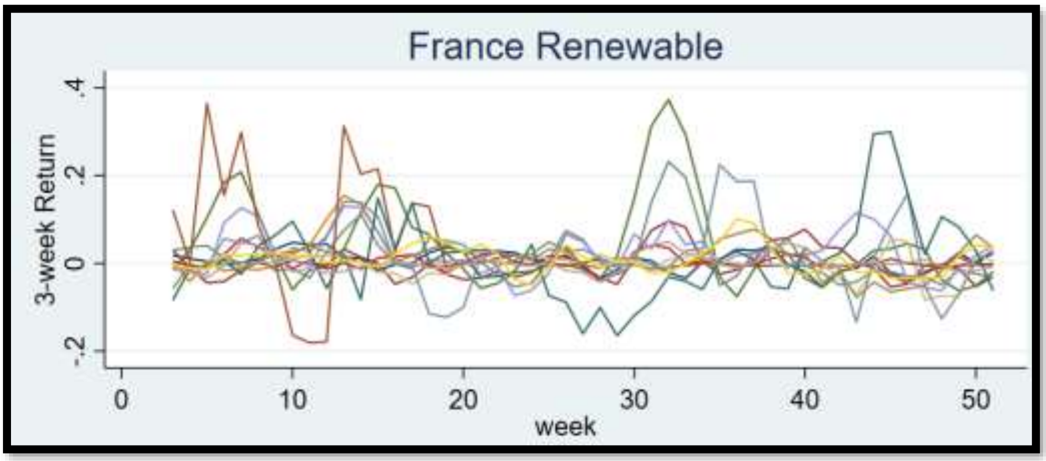


Figure 5. 4: Graph: Abnormal Return: UK Renewable

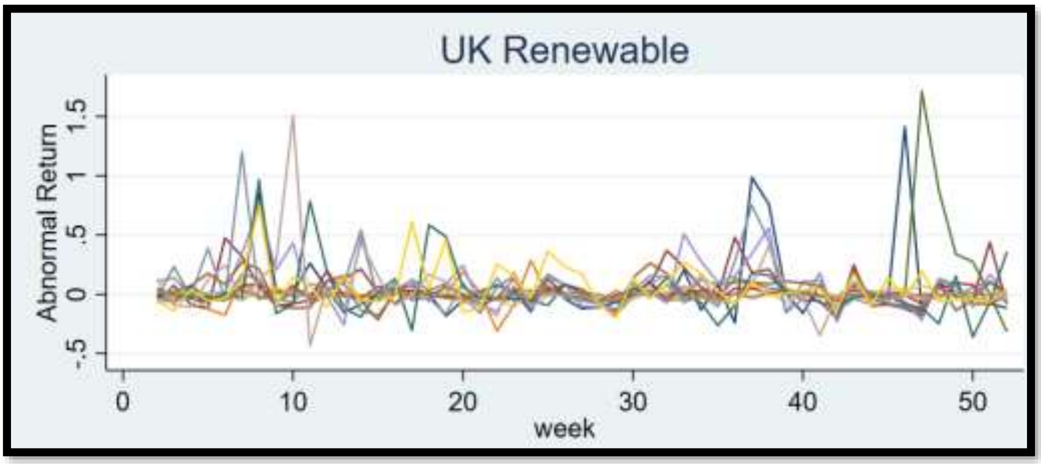
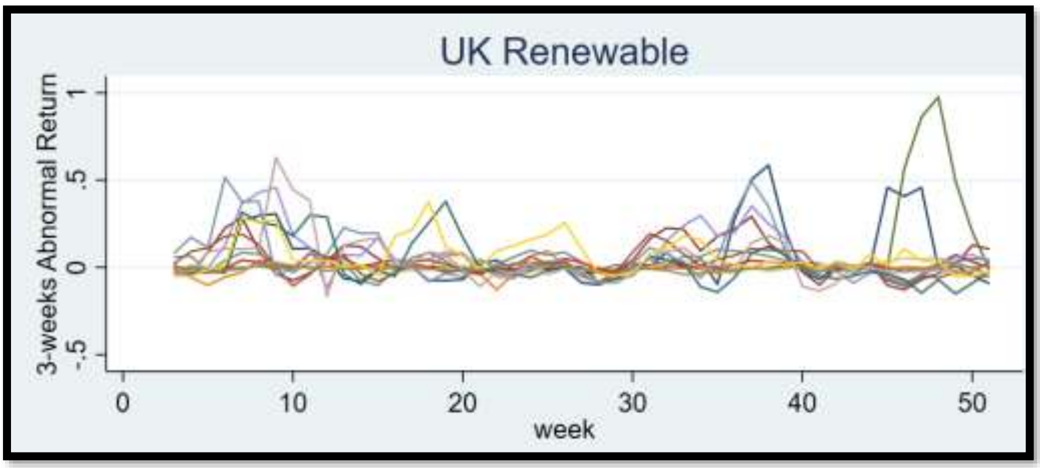


Figure 5. 5: Graph: Three-Week Moving Average Abnormal Return: UK Renewable



One prominent trend observed in the moving average is that it trends higher when prices move up and lower as prices decrease. We observed the same trend in our data, which gives strong support to that simple moving average following the forementioned trend (Figures 5.2 and 5.3). By making use of the three-week moving average, we smooth out the spikes while also obtaining a clearer picture of the trends that return and abnormal return follow in the specific country (Figures 5.4 and 5.5). One advantage of the simple moving average is that it offers smoothed lines, which is in fact less prone to moving up and down in response to slight, temporary price fluctuations. On the other hand, one disadvantage with simple moving average is that it is quite slow to respond to rapid price changes which often occur at market reversal points. Throughout financial literature there seems to be a consensus that traders operating with longer time frames, e.g., weekly, prefer simple moving average as opposed to alternative approaches (Hayes & Potters, 2021), which in result strengthen our choice of utilizing a simple moving average.

5.3.1 Entire Sample

When a t-test is conducted on abnormal return with a three-week moving average as the dependent variable, the associated t-statistic is well above its critical value (Table 5.3), i.e., implying that the difference in mean between the groups is statistically significant and therefore, the null hypothesis is rejected. Across the entire dataset there is a clear trend in the mean of renewable companies being larger than the mean of conventional companies. This trend is also present in standard deviation, which in turn implies larger fluctuation in the abnormal return of renewable companies. Consequentially, higher risk and uncertainty is associated with renewable energy companies. Even though the return is benched against the market there is still higher risk associated with the renewable energy sector, pointing out that some of the price development is not justified by their fundamentals explained by established pricing models. This result in further uncertainty which points in a direction of a developing environment experienced in previous asset price bubbles as we outlined earlier in chapter 3.

Table 5. 3: Three-Week Moving Average: Abnormal Return

Three-Week Moving Average Abnormal Return: Two-sample t test with unequal variances

Entire Sample

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
moveavear 3weeks by Dummy: C R	10220	3546	.020	.041	-.021	.098	.174	-8.70	.000

France

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
moveavear 3weeks by Dummy: C R	593	686	.005	.017	-.012	.041	.061	-4.0	.000

Germany

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
moveavear 3weeks by Dummy: C R	662	1075	.020	.072	-.052	.104	.287	-4.50	.000

Italy

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
moveavear 3weeks by Dummy: C R	710	406	.005	.011	-.006	.026	.037	-3.30	.001

Norway

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
moveavear 3weeks by Dummy: C R	3058	693	.024	.031	-.007	.108	.08	-2.0	.042

United Kingdom

	Obs (C)	Obs (R)	Mean (C)	Mean (R)	dif	St. Dev. (C)	St. Dev. (R)	t value	p value
moveavear 3weeks by Dummy: C R	5197	686	.022	.043	-.022	.102	.116	-4.75	.000

5.3.2 Individual Countries

The output from the t-tests on each single country indicates that all countries have the same trend. With both t-statistics and p-values indicating a statistically significant difference in mean, between the sectors (Table 5.3). For each country, the reported mean value for renewable companies is higher than for conventional companies, which is an indication of higher abnormal return associated with the renewable energy companies, which could result in higher valuations attributed to the companies.

5.3.3 Comparison: With vs Without Three-Week Moving Average

A comparison of results with and without a three-week moving average showed that the t-statistics were more statistically significant when employing a t-test using three-week moving average (Table 5.3). When t-tests are conducted on specific countries without a three-week moving average, Germany and the UK are statistically significant, while the others are not (Table 5.2). With a three-week moving average, all countries are statistically significant (Table 5.3). Considering this, we concluded that a three-week moving average coded variable was the best fit for our data when conducting t-tests.

5.4 Control Variables: Summer

There are certain periods during the year with less trading activity on stock exchanges. We controlled for this effect in our analysis by testing whether European countries experienced a drop in activity during the summer months. In these periods one would expect less activity as a consequence of the summer holiday season. Therefore, we generated a binary variable to test for such an effect. With week 1 of the dataset being in mid-April, the starting point of the defined summer period was from week 12 until 19. When conducting a t-test on abnormal return for the entire sample and deploying *summer* as the grouping variable, we found no statistically significant difference for the entire sample. However, when the t-test was conducted only on the conventional energy sector, the associated t-statistic was statistically significant (Table 5.4), which suggested a difference in means between the stated summer period and rest of the year for conventional energy companies. This was not true for the renewable sector, which yielded no statistically significant evidence. This supports the hypothesis of renewable companies' returns being less correlated with general market movements.

Table 5. 4: Summer

Summer: Two-sample t test with unequal variances
(NS = not Summer) (S = Summer)

Abnormal Return: Entire Sample

	Obs (NS)	Obs (S)	Mean (NS)	Mean (S)	dif	St. Dev. (NS)	St. Dev. (S)	t value	p value
ar by Summer: NS S	12169	2198	.025	.018	.007	.218	.201	1.48	.138

Abnormal Return: Conventional

	Obs (NS)	Obs (S)	Mean (NS)	Mean (S)	dif	St. Dev. (NS)	St. Dev. (S)	t value	p value
ar by Summer: NS S	8996	1655	.021	.009	.012	.187	.107	2.55	.011

Abnormal Return: Renewable

	Obs (NS)	Obs (S)	Mean (NS)	Mean (S)	dif	St. Dev. (NS)	St. Dev. (S)	t value	p value
ar by Summer: NS S	3173	543	.005	.015	-.009	.286	.358	-0.56	.573

Three-Week Moving Average: France: Conventional in Summer

	Obs (NS)	Obs (S)	Mean (NS)	Mean (S)	dif	St. Dev. (NS)	St. Dev. (S)	t value	p value
moveavear 3weeks by Summer: NS S	497	96	.007	-.005	.012	.0.43	.024	2.60	.010

Three-Week Moving Average: United Kingdom: Conventional in Summer

	Obs (NS)	Obs (S)	Mean (NS)	Mean (S)	dif	St. Dev. (NS)	St. Dev. (S)	t value	p value
moveavear 3weeks by Summer: NS S	4349	848	.024	.011	.013	.105	.081	3.30	.001

When the test was conducted using a three-week moving average, there was no statistically significant difference. Nevertheless, this would be expected considering that the three-week moving average results would indeed be affected by the period right before and right after the selected summer sample period, as equal weights are assigned.

5.4.1 The Significant Output

Figure 5. 6: Graph: Three-Week Moving Average Abnormal Return: France: Conventional in Summer

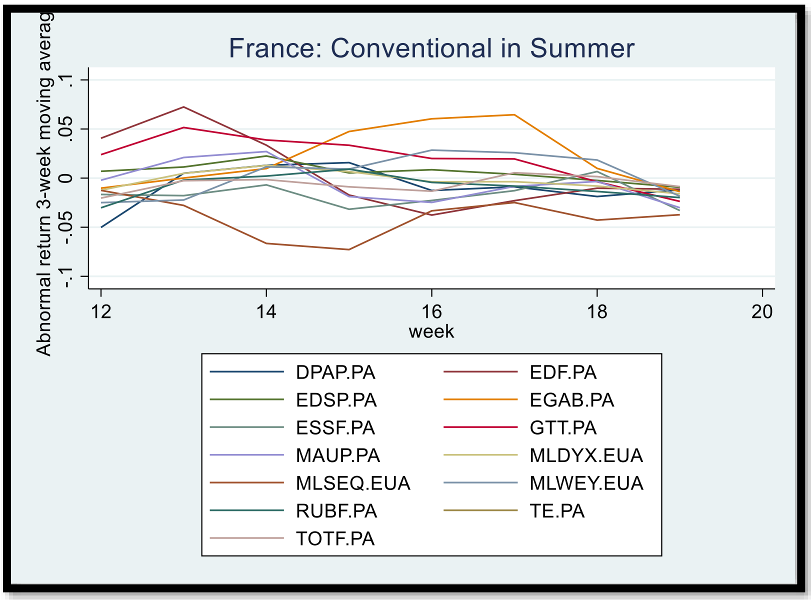
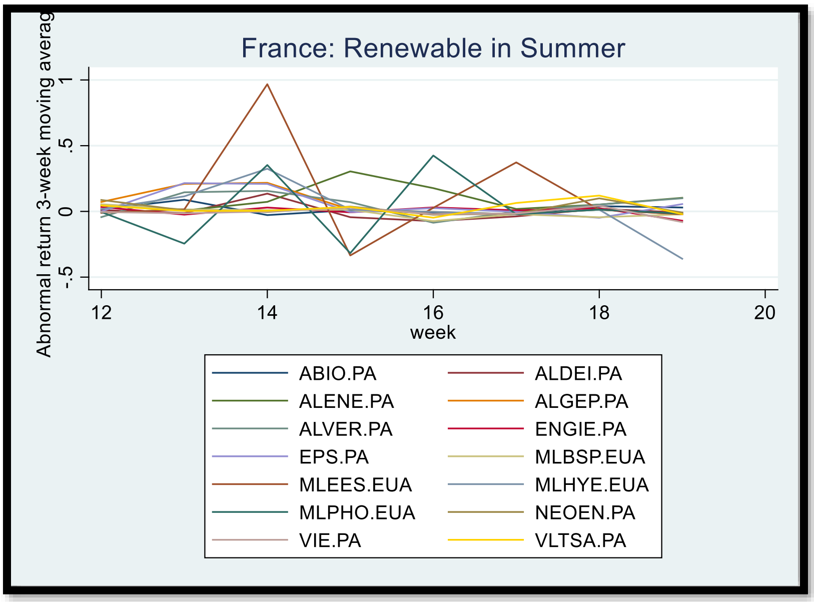


Figure 5. 7: Graph: Three-Week Moving Average Abnormal Return: France: Renewable in Summer



The results of using the binary variable suggest that differences in trading activity during the summer months were not very explanatory. Even so, some tests produced statistically significant results. For one, there is a statistically significant difference between the summer period and the rest of the sample period in France on abnormal return with a three-week moving average, suggesting a difference during the summer months in France (Figures 5.6 and 5.7). This holds true for both sectors (Table 5.4). Another country that displays statistically significant output is the UK. In the UK, only the conventional energy sector showed statistical significance (Table 5.4).

5.5 Control Variables: 2020 vs. 2021

We are interested in examining whether the development that was prominent in the market and in the media in 2021 was present in our data, e.g., the downturn in revenue associated with renewable energy companies (Ballentine, 2021). To examine for this, we created a new dummy variable using the same principal as the variable *summer*. However, the new variable was 1 for the sample period within year 2021 and 0 for that within 2020. If these tests were to lead to statistically significant results, we are able to determine whether our data represents the development observed in the markets, while also being subjective to news and other events that would have an effect on the pricing of companies.

5.5.1 Entire Sample

For abnormal return as the dependent variable, the results were not statistically significant, which means that the data in our sample did not show a difference between the years 2020 and 2021. Nevertheless, when the sample is divided, with one t-test conducted on renewable energy companies and another on conventional energy companies, the output show a statistically significant difference (Table 5.5). We regard these findings a positive indication for further analysis.

Table 5. 5: 2020 vs. 2021

2020 vs. 2021: Two-sample t test with unequal variances

Three-Week Moving Average Abnormal Return: Entire Sample

	Obs (2020)	Obs (2021)	Mean (2020)	Mean (2021)	dif	St. Dev. (2020)	St. Dev. (2021)	t value	p value
moveavear 3weeks by 2021: 2020 2021	9414	4352	.025	.025	-.001	.117	.135	-0.08	.932

Three-Week Moving Average Abnormal Return: Conventional

	Obs (2020)	Obs (2021)	Mean (2020)	Mean (2021)	dif	St. Dev. (2020)	St. Dev. (2021)	t value	p value
moveavear 3weeks by 2021: 2020 2021	7263	3388	.018	.022	-.004	.086	.121	-2.40	.015

Three-Week Moving Average Abnormal Return: Renewable

	Obs (2020)	Obs (2021)	Mean (2020)	Mean (2021)	dif	St. Dev. (2020)	St. Dev. (2021)	t value	p value
moveavear 3weeks by 2021: 2020 2021	2439	1277	.044	.028	.017	.178	.165	2.80	.005

Three-Week Moving Average Abnormal Return: France: Renewable

	Obs (2020)	Obs (2021)	Mean (2020)	Mean (2021)	dif	St. Dev. (2020)	St. Dev. (2021)	t value	p value
moveavear 3weeks by 2021: 2020 2021	476	210	.022	.007	.015	.064	.052	2.95	.003

Three-Week Moving Average Abnormal Return: Norway: Renewable

	Obs (2020)	Obs (2021)	Mean (2020)	Mean (2021)	dif	St. Dev. (2020)	St. Dev. (2021)	t value	p value
moveavear 3weeks by 2021: 2020 2021	393	300	.043	.015	.028	.075	.082	4.65	.000

Three-Week Moving Average Abnormal Return: Italy: Conventional

	Obs (2020)	Obs (2021)	Mean (2020)	Mean (2021)	dif	St. Dev. (2020)	St. Dev. (2021)	t value	p value
moveavear 3weeks by 2021: 2020 2021	476	234	.002	.009	-.007	.027	.024	-3.05	.003

When comparing the output between 2020 and 2021, there was a statistically significant difference in the means between the two years for the conventional energy sector (Table 5.5). For the renewable energy sector, the mean difference was over 4 times greater than the one observed in the conventional sector (Table 5.5). The means of the two sectors were similar in 2021, but in 2020, the mean for renewable companies was much higher than it was for conventional energy companies. These are interesting results and suggest that there has been a downturn in the value associated with renewable energy companies after the turn of the year, confirming what has been reported by Ghosh (2021). Another aspect that further reinforce the hypothesis is the reported standard deviation. The same trend is apparent here: the renewable energy sector had higher associated risk and uncertainty in 2020 with more extreme observations being the case when the reported standard deviation is relatively high, which is apparent in renewable energy companies during 2020.

5.5.2 Individual Countries

Figure 5. 8: Graph: Three-Week Moving Average Abnormal Return: France: Renewable in 2020

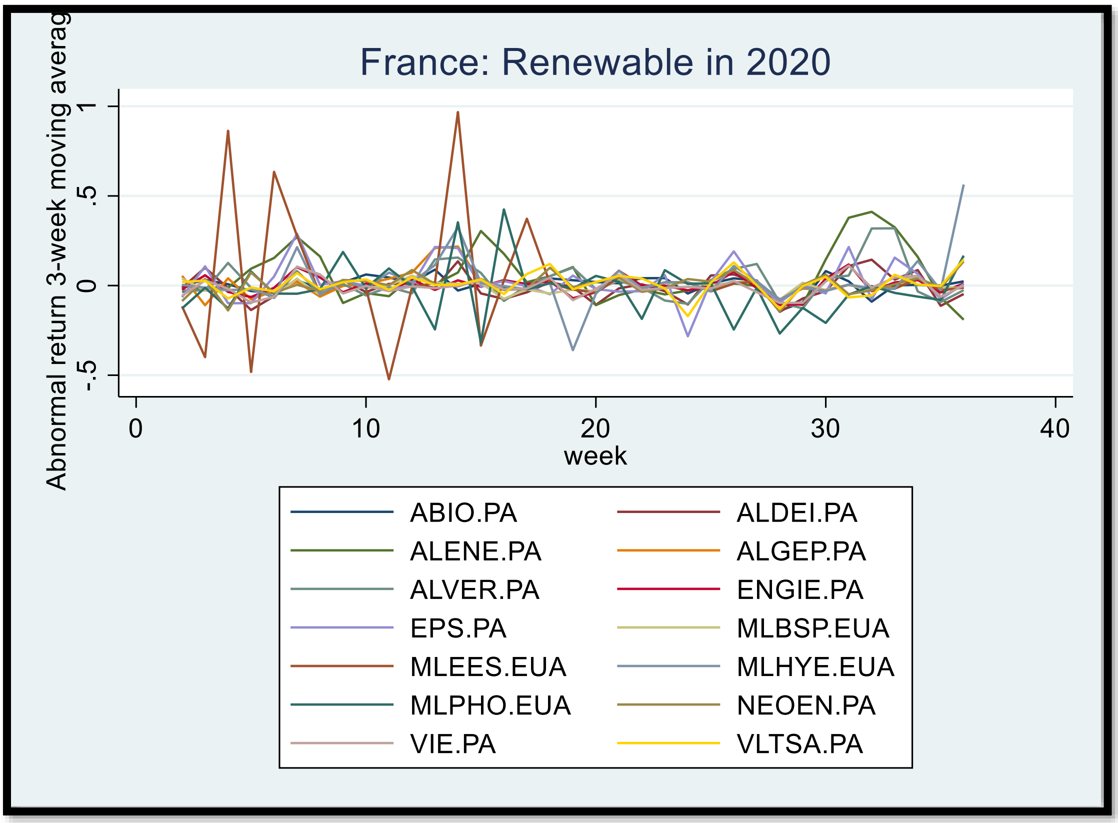
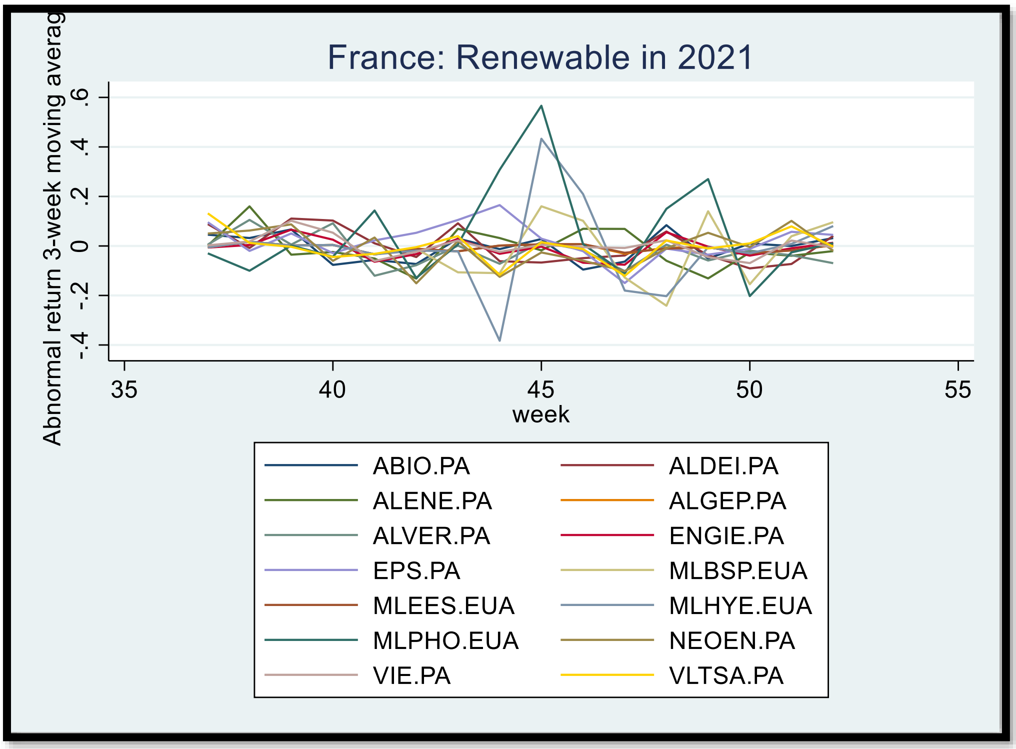


Figure 5. 9: Graph: Three-Week Moving Average Abnormal Return: France: Renewable in 2021



In Norway, the conventional energy sector displayed no statistically significant differences in means between years. When testing the significance of the renewable energy sector only results was statistically significant (Table 5.5). Hence, we reject the null hypothesis of no difference in the mean in the renewable energy sector in Norway between 2020 and 2021. The valuation of renewable energy companies has taken a downturn in 2021, which are expected given the development on OSE in 2021 (Teigen, 2021).

For France, the difference in means was statistically significant. Even so, there was a viewable difference between the renewable energy companies when separating the sample between 2020 and 2021 (Figures 5.8 and 5.9), which was collaborated by a statistically significant difference in the means between the periods (Table 5.5). This indicates that in both France and Norway there is a difference in mean between 2020 and 2021 for renewable energy companies. A potential explanation is that both countries have well-developed energy network, providing a potential competitive advantage for renewable energy companies in these countries.

On the other hand, there was a viewable difference between conventional energy companies in Italy (Figures 5.10 and 5.11), which was confirmed by the statistically significant t-tests (Table 5.5). In Italy, the driver for the energy sector is conventional energy companies because of the large dependency on conventional energy, with fossil fuels being the main source of energy (IEA – Italy, 2021).

Figure 5. 10: Graph: Three-Week Moving Average Abnormal Return: Italy: Conventional in 2020

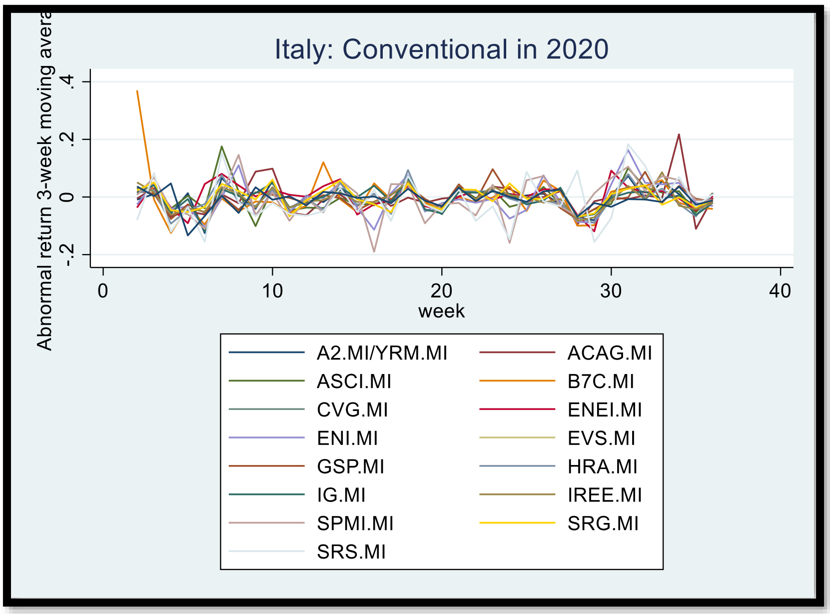
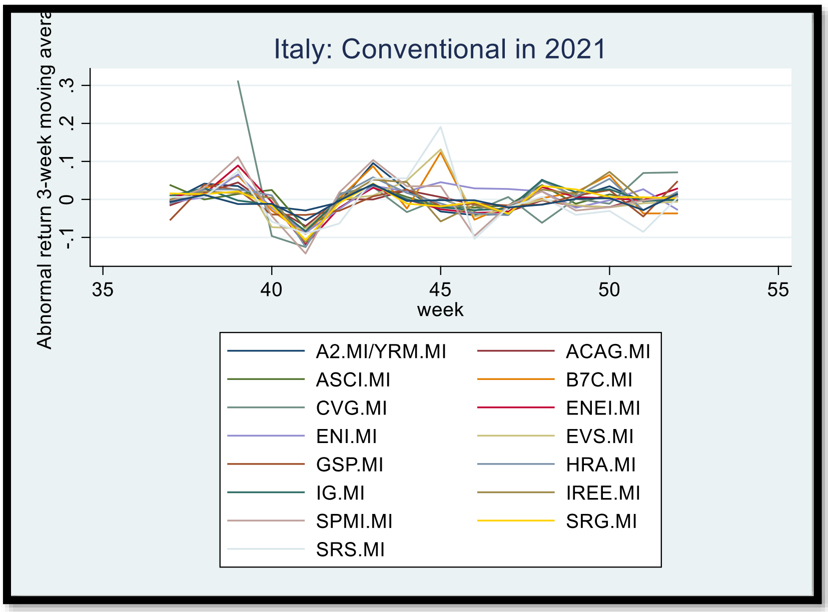


Figure 5. 11: Graph: Three-Week Moving Average Abnormal Return: Italy: Conventional in 2021



In Germany and the UK there were no statistically significant tests to support any difference between 2020 and 2021. This holds for both the conventional and renewable energy sectors, which implies that the energy sectors in Germany and the UK have not been equally affected by the change of narrative in 2021.

5.6 Control Variables: Big vs Small Companies

Another aspect that would be interesting control for is how company size affects the results (Fernando & Boyle, 2021). To differentiate companies we use market cap, namely coding companies with market cap above NOK 1,000,000,000 to be classified as *big*. Companies with a lower market cap were naturally classified as small, i.e., obtaining the value of 0 in the dummy coding. The reason behind the binary variable is that we want to be able to describe different policy responses that could be implemented in the face of an asset price bubble. An important consideration in policy making is the effects on companies depending on their size. If there are statistically significant differences between small and big companies, it would indicate the necessity of requiring policy makers to include the effects potential policy changes could have on companies depending on their market cap (i.e., size).

5.6.1 Entire Sample

Table 5. 6: Big

Big: Two-sample t test with unequal variances
(NB = not big) (B = Big)

Three-Week Moving Average Abnormal Return: Entire Sample

	Obs (NB)	Obs (B)	Mean (NB)	Mean (B)	dif	St. Dev. (NB)	St. Dev. (B)	t value	p value
moveavear 3weeks by Big: NB B	8052	5714	.031	.017	.013	.148	.073	6.45	.000

Three-Week Moving Average Abnormal Return: Conventional

	Obs (NB)	Obs (B)	Mean (NB)	Mean (B)	dif	St. Dev. (NB)	St. Dev. (B)	t value	p value
moveavear 3weeks by Big: NB B	6257	3963	.025	.013	.012	.120	.045	5.95	.000

Three-Week Moving Average Abnormal Return: Renewable

	Obs (NB)	Obs (B)	Mean (NB)	Mean (B)	dif	St. Dev. (NB)	St. Dev. (B)	t value	p value
moveavear 3weeks by Big: NB B	1795	1751	.053	.028	.026	.217	.112	4.40	.000

Three-Week Moving Average Abnormal Return: Germany: Conventional & Renewable

	Obs (NB)	Obs (B)	Mean (NB)	Mean (B)	dif	St. Dev. (NB)	St. Dev. (B)	t value	p value
moveavear 3weeks by Big: NB B	805	932	.088	.022	.067	.313	.133	5.90	.000

Three-Week Moving Average Abnormal Return: United Kingdom: Conventional

	Obs (NB)	Obs (B)	Mean (NB)	Mean (B)	dif	St. Dev. (NB)	St. Dev. (B)	t value	p value
moveavear 3weeks by Big: NB B	3948	1249	.025	.012	.013	.114	.050	3.75	.000

Three-Week Moving Average Abnormal Return: United Kingdom: Renewable

	Obs (NB)	Obs (B)	Mean (NB)	Mean (B)	dif	St. Dev. (NB)	St. Dev. (B)	t value	p value
moveavear 3weeks by Big: NB B	340	346	.053	.033	.022	.143	.081	2.40	.017

Three-Week Moving Average Abnormal Return: Italy: Conventional

	Obs (NB)	Obs (B)	Mean (NB)	Mean (B)	dif	St. Dev. (NB)	St. Dev. (B)	t value	p value
moveavear 3weeks by Big: NB B	259	147	.008	.015	-.008	.037	.040	-2.05	.040

For the entire sample, the associated t-statistic was statistically significant both when running the test on abnormal returns with and without a three-week moving average (Table 5.6). Even so, the most significant results are achieved through use of the three-week moving average, implying a better fit.

This also holds true for both conventional and renewable energy companies, as demonstrated by Table 5.6. Again, the output yields most statistical significance when a three-week moving average is used. This would suggest that our data should be smoothed out to deal with any potential lingering effects from price fluctuations.

5.6.2 Individual Countries

Figure 5. 12: Graph: Three-Week Moving Average Abnormal Return: Germany: Conventional if not Big

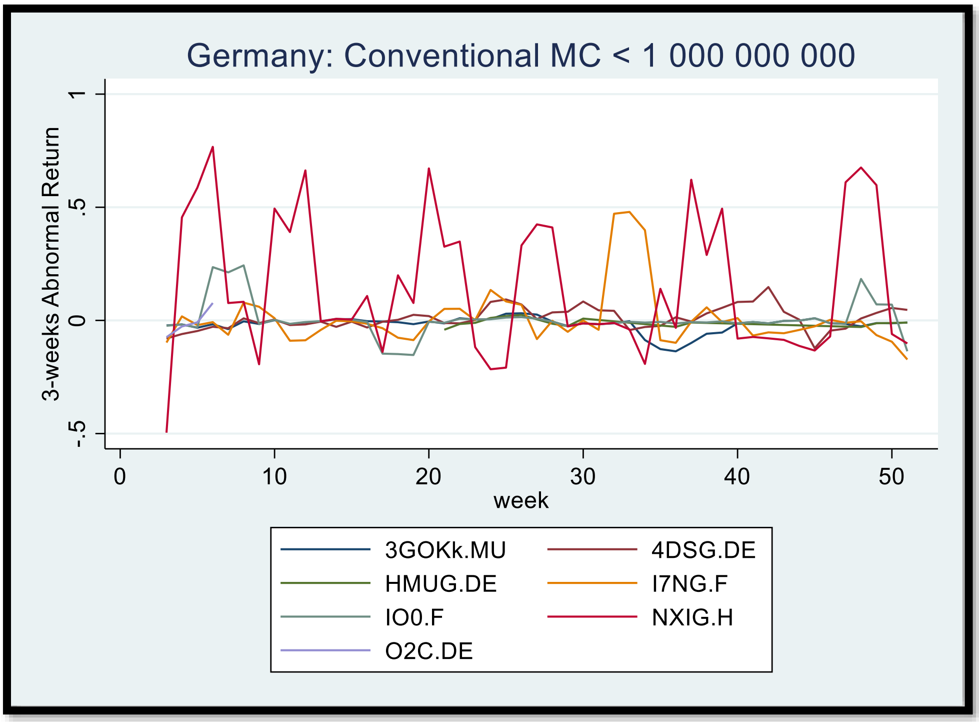


Figure 5. 13: Graph: Three-Week Moving Average Abnormal Return: Germany: Conventional if Big

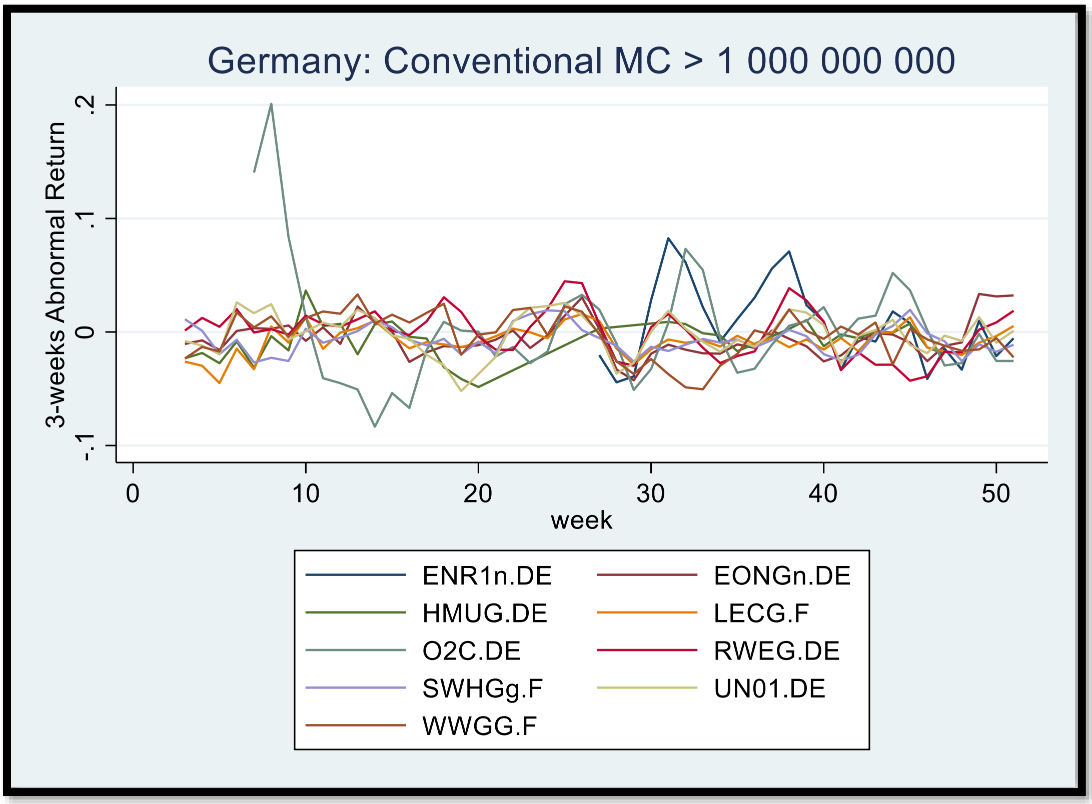


Figure 5. 14: Graph: Three-Week Moving Average Abnormal Return: Germany: Renewable if not Big

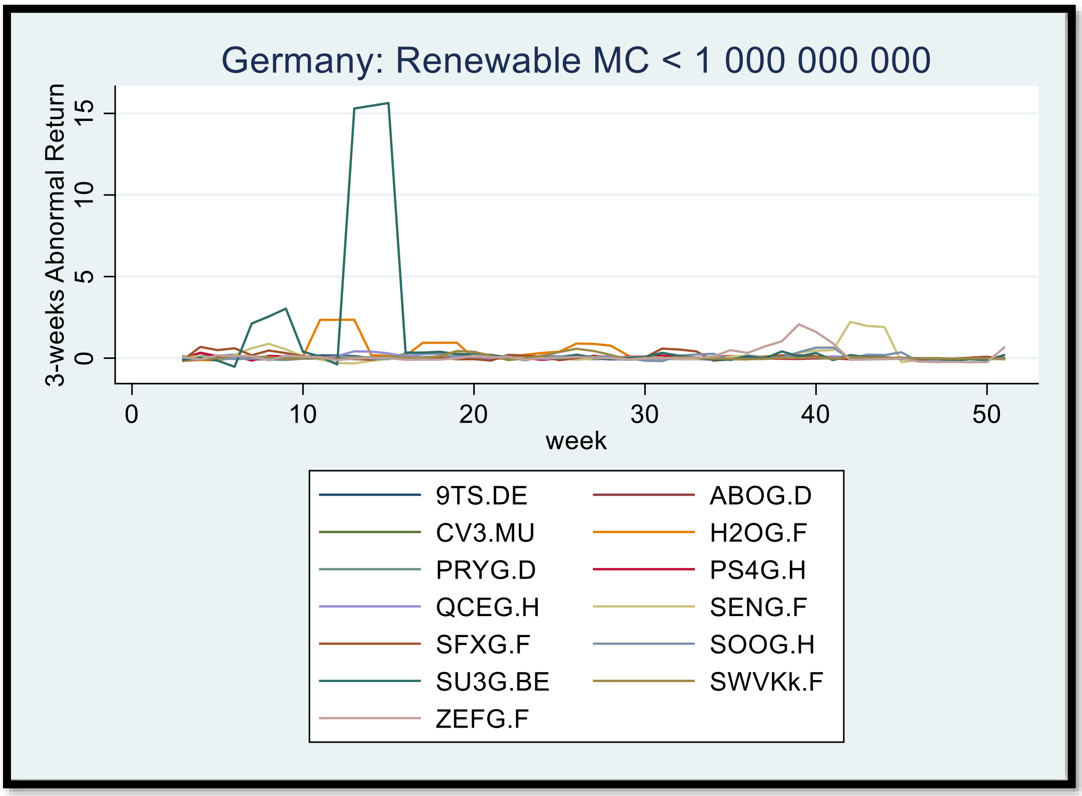
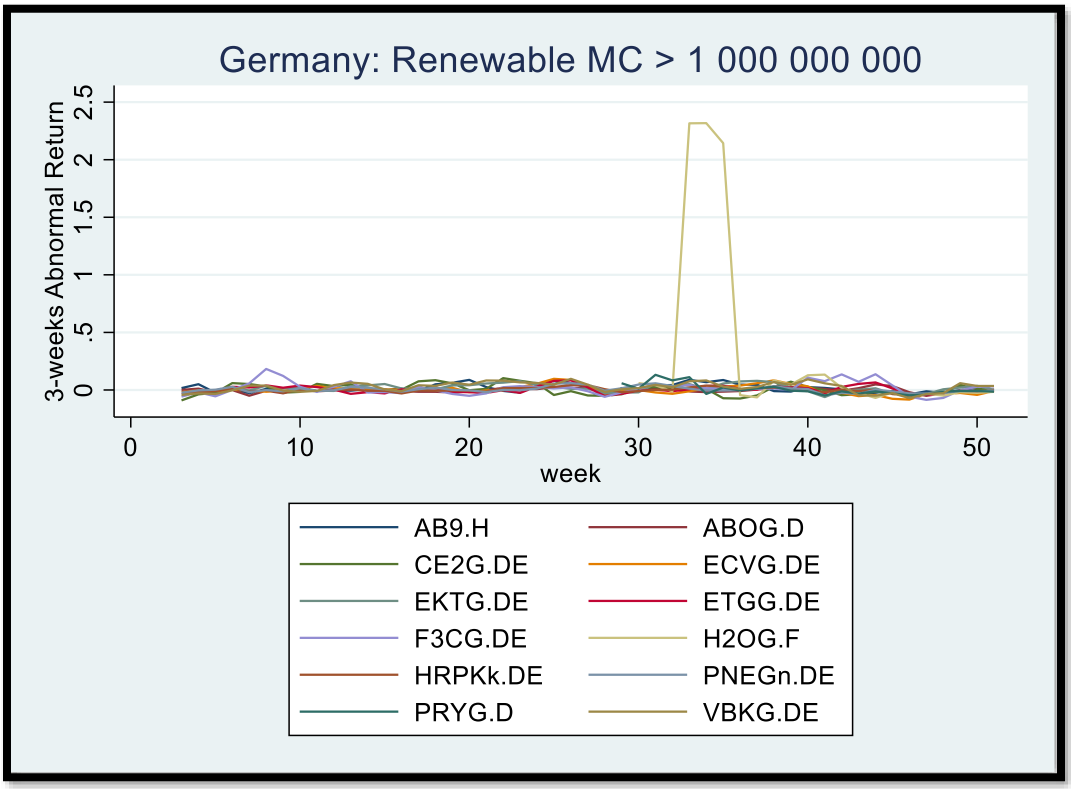


Figure 5. 15: Graph: Three-Week Moving Average Abnormal Return: Renewable if Big



In Germany there are statistically significant differences in means between companies that are coded as small and big (Table 5.6). Similarly, this was the case for companies both in the renewable and conventional energy sectors, where there also was a viewable difference between the two (Figures 5.12, 5.13, 5.14 and 5.15).

Figure 5. 16: Graph: Three-Week Moving Average Abnormal Return: UK: Renewable if not Big

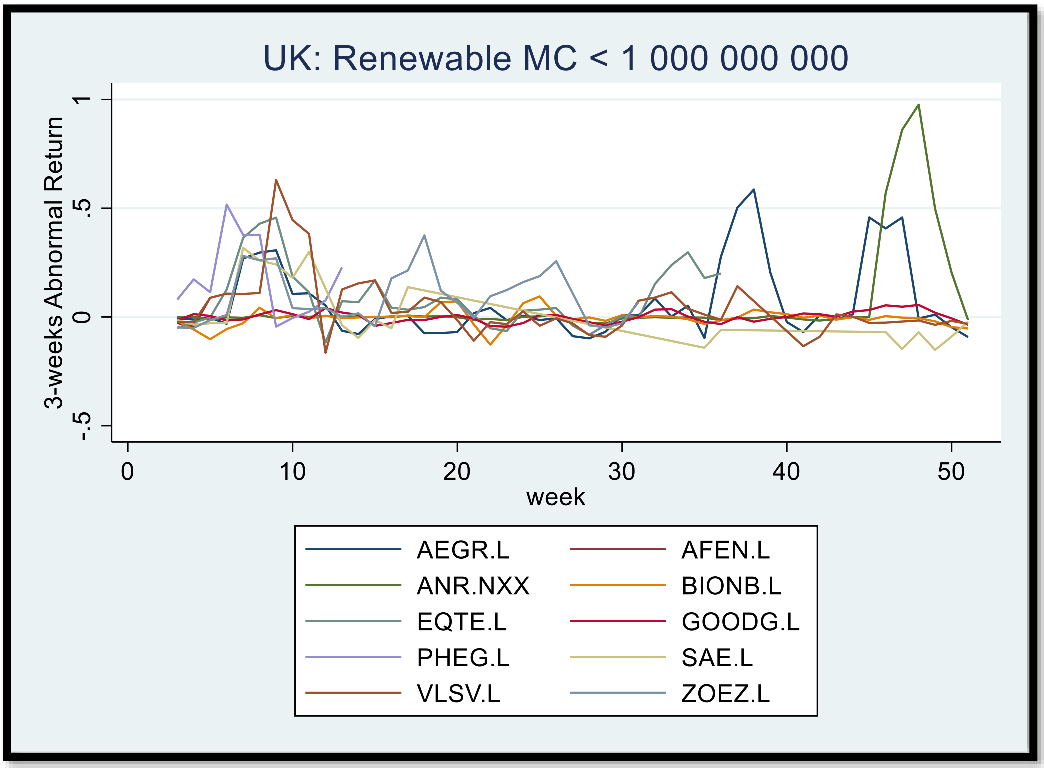


Figure 5. 17: Graph: Three-Week Moving Average Abnormal Return: UK: Renewable if Big

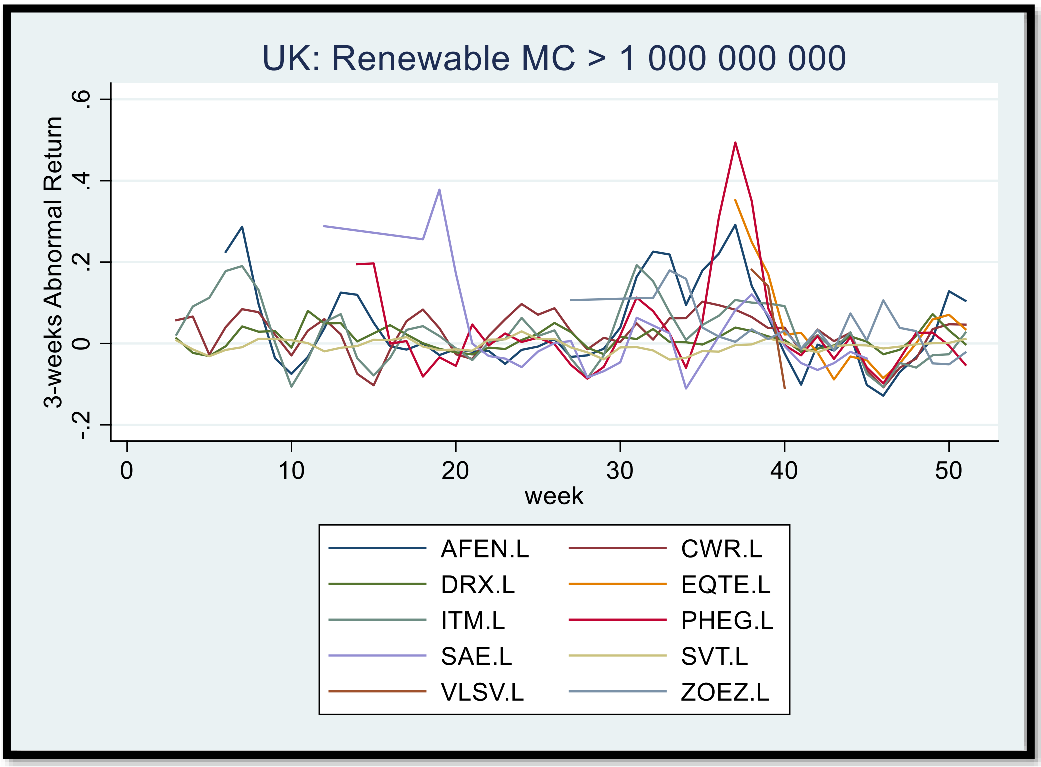


Figure 5. 18: Graph: Three-Week Moving Average Abnormal Return: Italy: Renewable if not Big

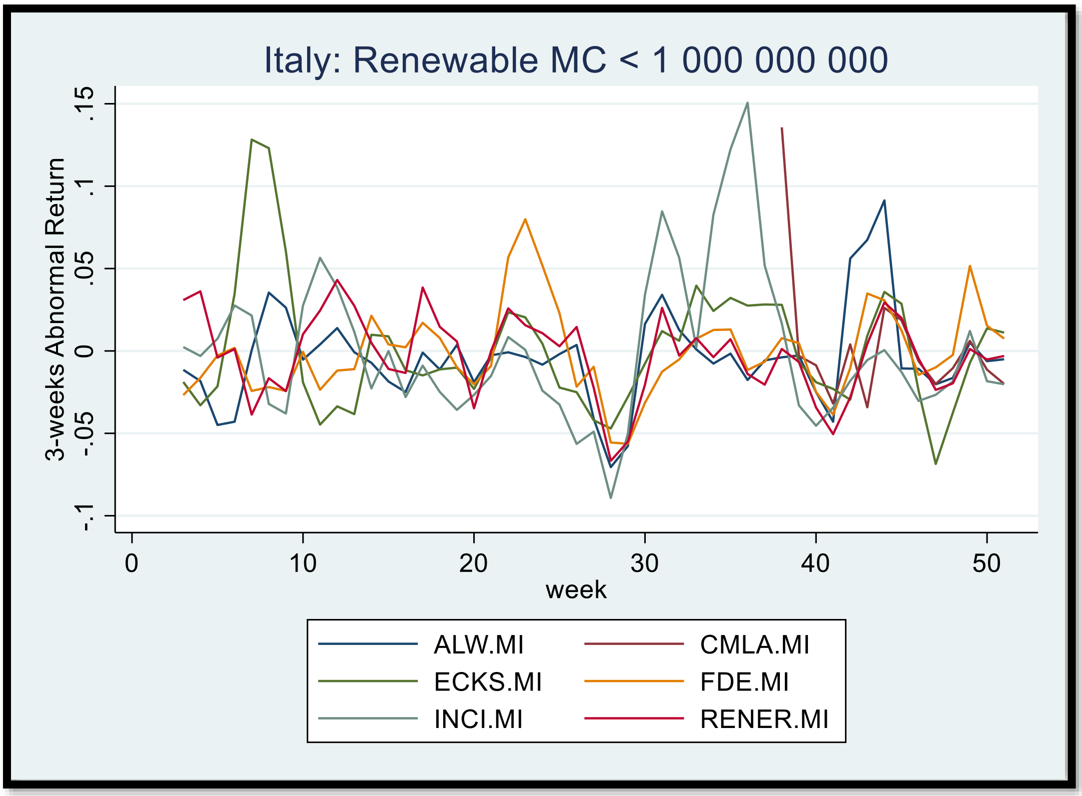
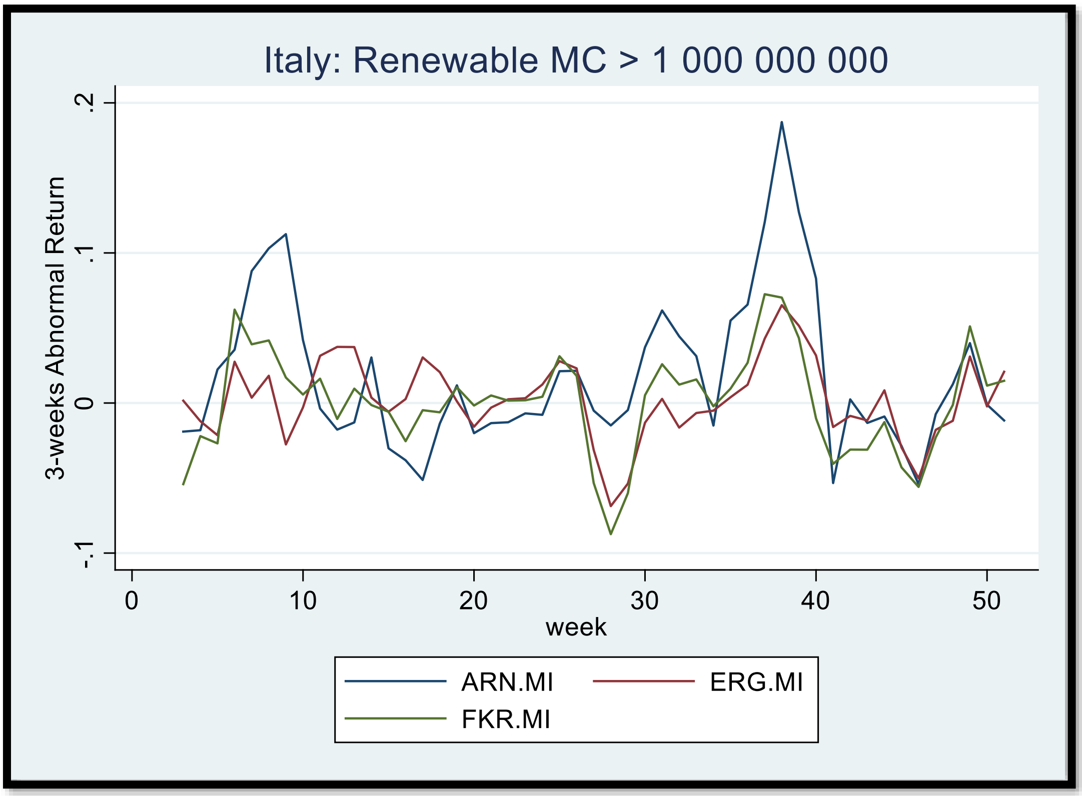


Figure 5. 19: Graph: Three-Week Moving Average Abnormal Return: Italy: Renewable if Big



In the UK, the tests also yield statistically significant output for both the renewable (Table 5.6 and Figures 5.16 and 5.17), - and conventional energy companies (Table 5.6). However, in Italy, we were only able to show a statistically significant difference in means between small and big companies in the renewable sector (Table 5.6 and Figures 5.18 and 5.19). This means that if any event occurs, such as for instance, a negative demand shock as a result of a bubble burst, responsive policy changes or other political interferences should consider the possibility that it can affect the companies differently depending on their size.

In France and Norway there was no statistically significant evidence that points towards any differences in means between big and small companies. This could be beneficial for policy makers, potentially making a sufficient response less complex with a decrease in the number of considerations needed when developing policies. Our output suggest they will be able to implement policies that would be equally efficient towards small and large companies based on the hypothesis test for these two countries.

5.7 Daily Logarithmic Return

To further strengthen our identification process towards a potential asset price bubble, we believe that inclusion of daily log returns for the entirety of our sample period would be beneficial to analyze the price fluctuations thoroughly. Therefore, graphs on both conventional- and renewable energy have been created for the five selected countries.
The reasoning behind switching from weekly to daily trading data in this section is that with the created portfolios, daily pricing will provide detailed description of occurring events which will provide helpful information of the sectors’ unique fluctuations.

The figures are constructed with standard deviation bounds, namely: the mean, 1 standard deviation from the mean, -1 standard deviation from the mean, 2 standard deviations from the mean and -2 standard deviation from the mean. This provides a clear picture of the developments in the sector in question while also making it easier to single out periods of interest and investigate if there is some news, or new companies listed that could be the reason behind breaches of said bounds. In this analysis we will focus on breaches of both the 2 and -2 standard deviation bounds (i.e., the big fluctuations). By investigating these breaches, we are able to provide an understanding of what causes increases and decreases in the sectors that will be comparable across entities. We will progress country by country.

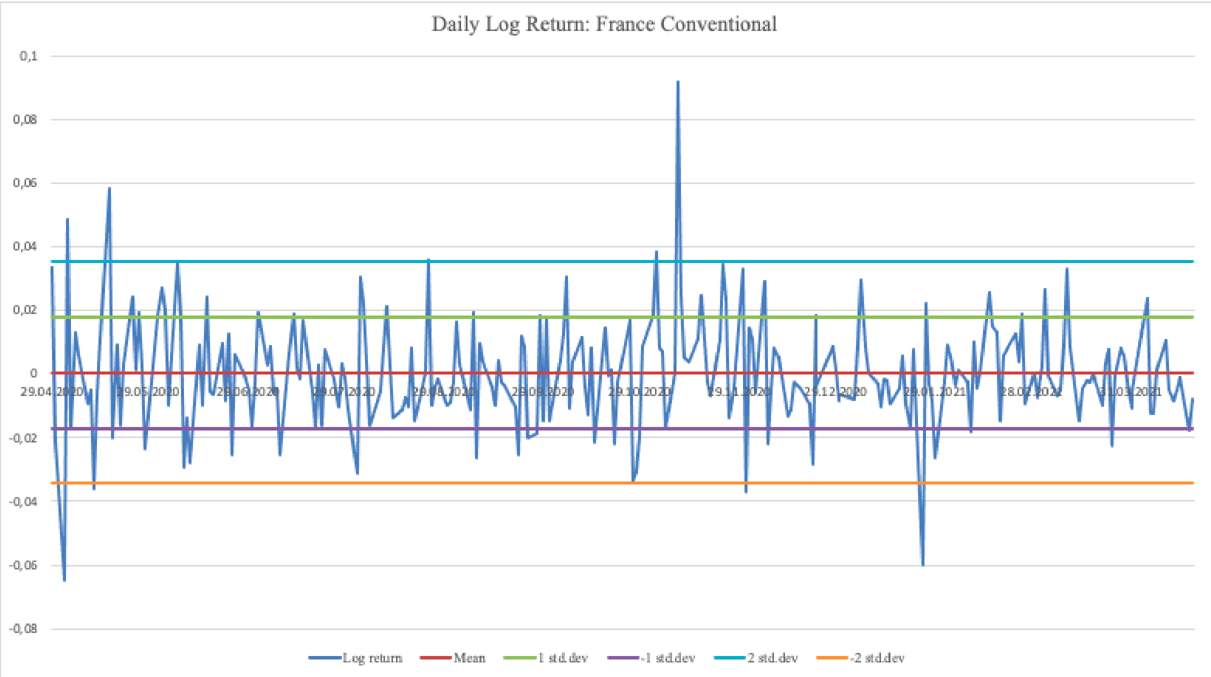
5.7.1 France – Conventional

Total Sample Variance of this group: 0.0003044

At the start of the sample period, there is high volatility in the conventional energy sector in France (Figure 5.20), with a number of breaches of both the 2 and -2 standard deviation bounds during the first month. The next event of interest is in mid-November when there is a high spike that breaches the 2 standard deviation bound. The apparent reason behind the breach was the development in the company Total SE, which incurred a rise in market cap of over NOK 100,000,000 between days. The following breach is in early December with a breach of the –2 standard deviation bound, which is the start of a period with a small tendency of a negative cluster[22].

At the end of January there is a breach of -2 standard deviation bound that can be explained by a significant drop in Electric de Strasbourg SA, namely of NOK 70,000,000 between days.

Figure 5. 20: Daily Logarithmic Return: France Conventional



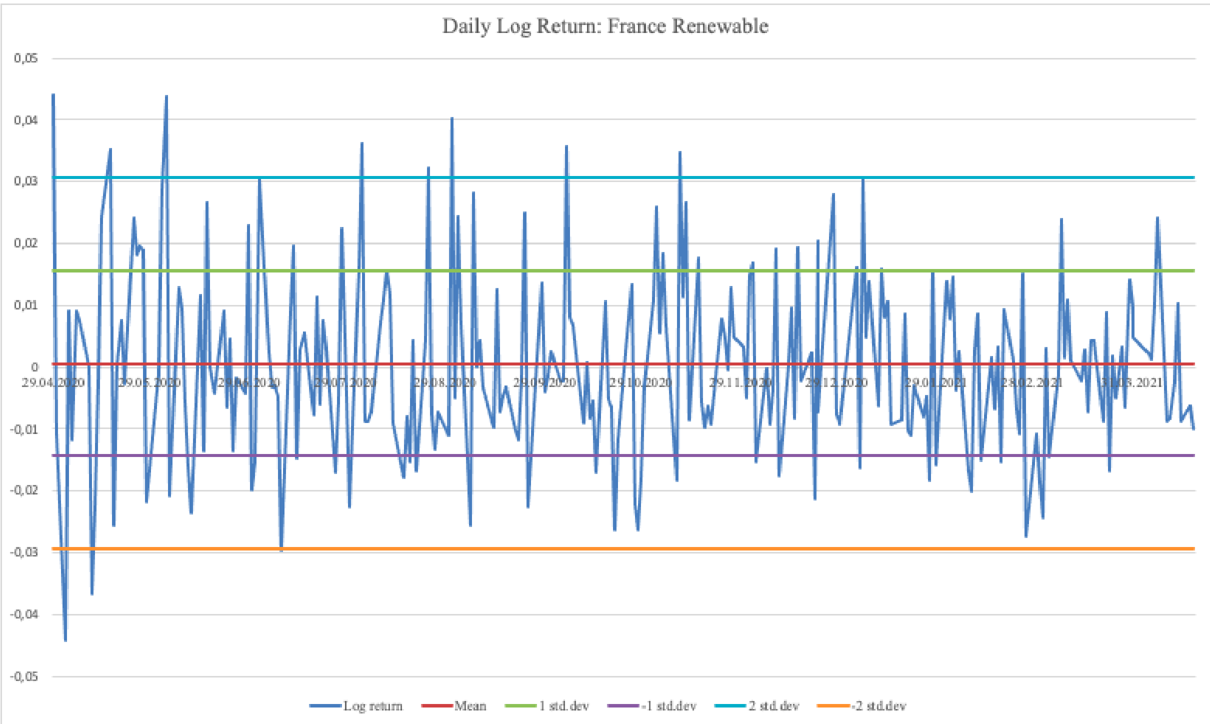
[22] Periods of high or low volatility exhibited by the variable. (Stock & Watson, 2020)

5.7.2 France - Renewable

Total Sample Variance of this group: 0.00022514

At the start of the period there is a breach of the 2 standard deviation bound, immediately followed by a breach of -2 bound (Figure 5.21). In an 18-day period there is another breach of both 2 and –2 bounds. Throughout the rest of the year (2020) there is a number of breaches of the 2 bound, and one of the -2. Yet, after the turn of the new year, there is a clear downturn in fluctuations, both positive and negative (i.e., a reduction in volatility). There is a negative cluster around one month into the new year, a cluster that could be expected considering the development of the renewable energy sector in 2021 which has experienced a downturn following the record-breaking year 2020 (Chestney, 2021).

Figure 5. 21: Daily Logarithmic Return: France Renewable

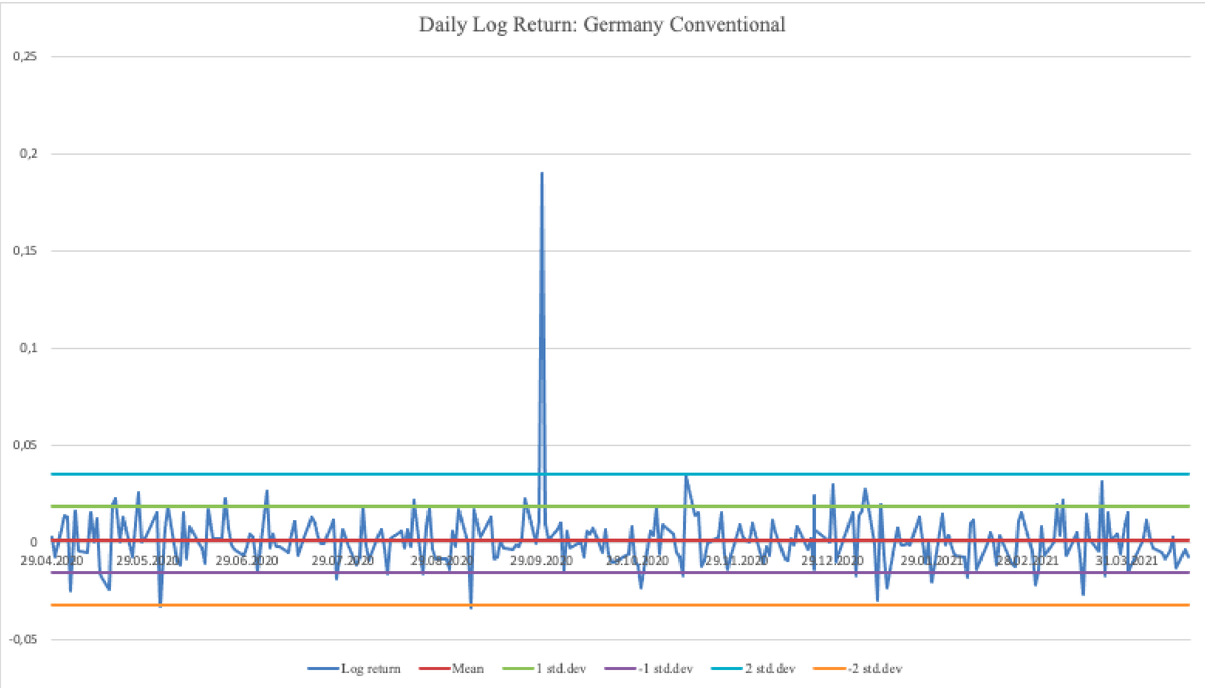


5.7.3 Germany - Conventional

Total Sample Variance of this group: 0.00027999

In the conventional energy sector in Germany there is one event that is all consuming and that affects the results in a great way. The event is caused by the listing of Siemens Energy AG (Figure 5.22). With the overall portfolio experiencing an increase of around NOK 170 Billion, which had a massive effect on the entire data period.

Figure 5. 22: Daily Logarithmic Return: Germany Conventional

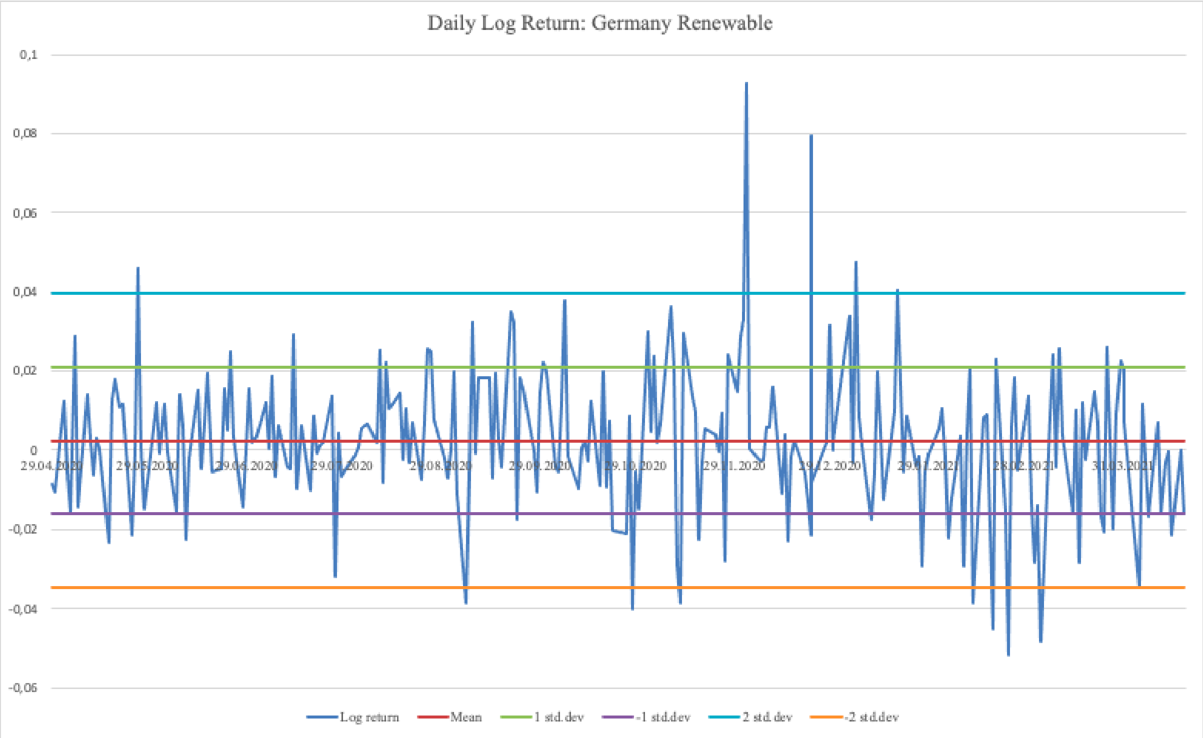


5.7.4 Germany - Renewable

Total Sample Variance of this group: 0.00034419

There are positive fluctuations at the beginning of the dataset, however, they are limited (Figure 5.23). Even so, there is movement in log returns of 1 or -1 standard deviation away from the mean. The first breach is at the end of May, with a breach of the 2 standard deviation bound. After that, there was a breach of –2 bound occurring at the end of August. About two months later, there were two breaches of -2 bounds, both occurring within a two-week span from end of October to early November. Yet, shortly after there is two breaches of the 2 bound. These breaches took place in early December and the later one at the start of the new year. After the start of the new year there is four breaches of –2 standard deviation bound between mid-February and early March.

Figure 5. 23: Daily Logarithmic Return: Germany Renewable

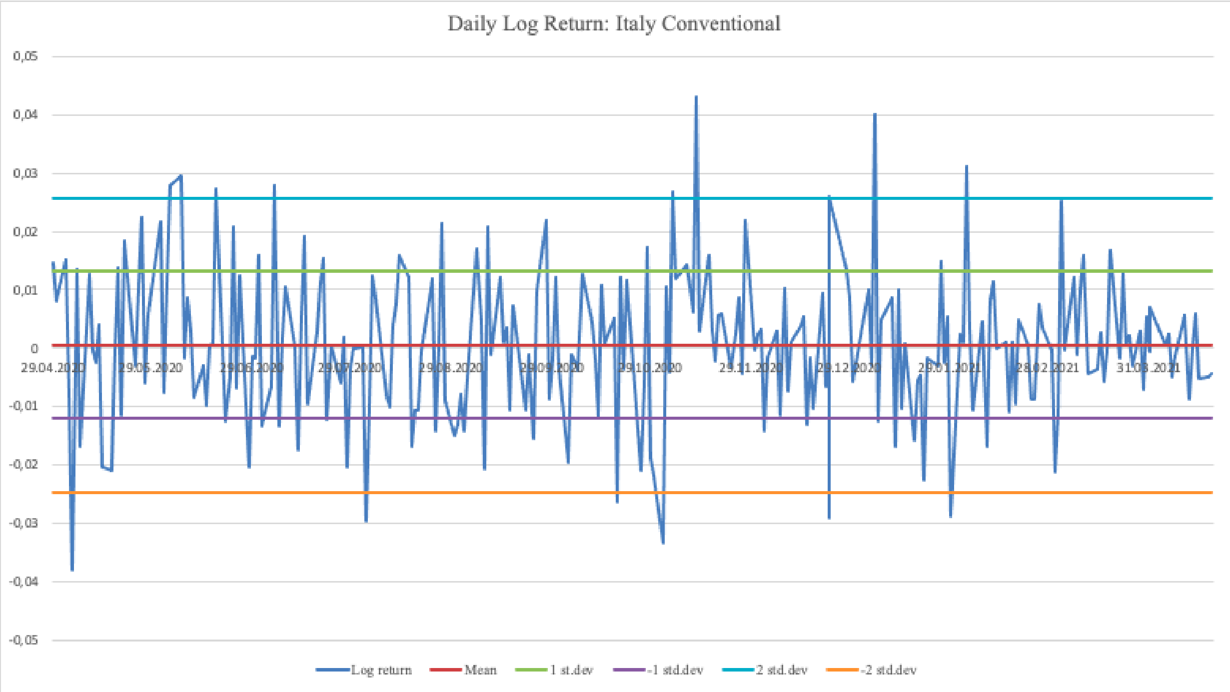


5.7.5 Italy - Conventional

Total Sample Variance of this group: 0.00015941

The graph for Italy´s conventional energy sector shows a highly volatile market with massive fluctuations between days (Figure 5.24). Most of these fluctuations are within the 2 and -2 standard deviation bounds. The first breach is at the start of May, with a breach of the -2 bound, immediately followed by a breach of the 2 bound at the beginning of the following month during which there is an event of interest with a two-week period at the end of the month with a number of breaches. In fact, there are two breaches of 2 bound. The next is at the start of August, with a breach of -2 bound. Which is followed by a couple of less volatile months. The drop in volatility last until late October, when there is a breach of –2 standard deviation bound. In November, there is a number of breaches both of 2 and –2 standard deviation bounds: a period that is indeed interesting when assessing the Italian conventional energy sector. At the end of December, another breach of both 2 and –2 standard deviation bounds occurred within close proximity. At the start of 2021 there is a breach of the 2 bound, then a breach of –2 bound, followed swiftly by a breach of the 2 bound once more. This time occurring at the start of February, with only a couple of days between the breaches. Needless to say, Italy experienced a highly volatile year in terms of their conventional energy companies.

Figure 5. 24: Daily Logarithmic Return: Italy Conventional

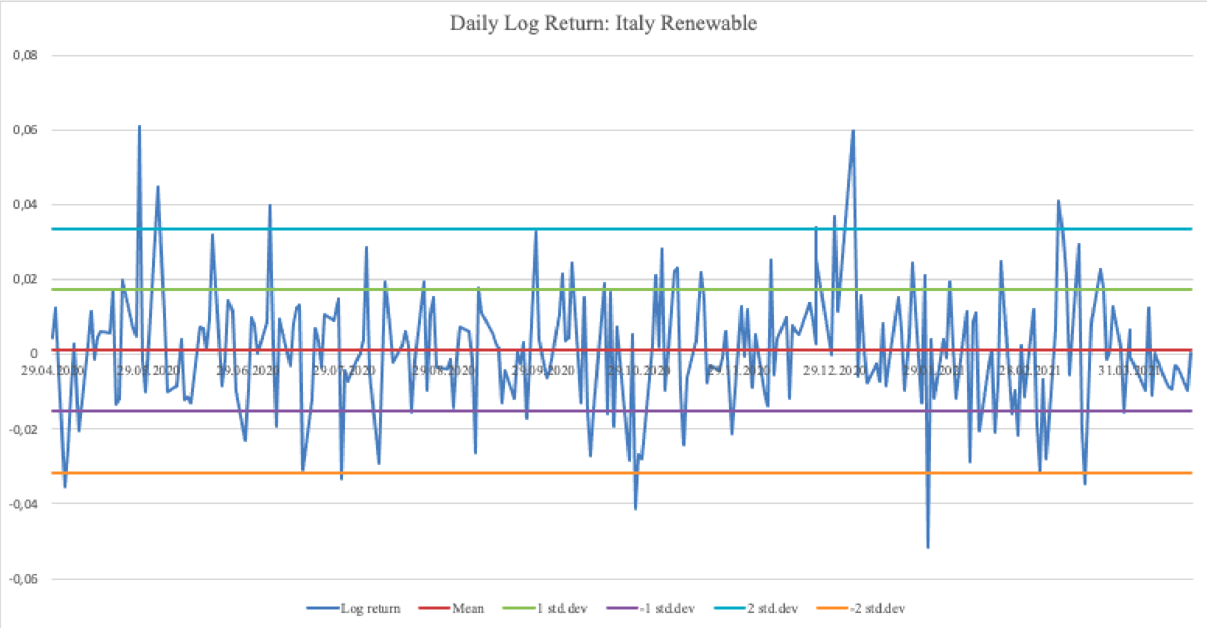


5.7.6 Italy - Renewable

Total Sample Variance of this group: 0.00026534

At the start of the sample period, there is a breach of the -2, which is followed by a couple of breaches of the 2 bound at the end of the month (Figure 5.25). At the start of July there is a breach of the 2 bound, immediately followed by a couple of breaches of the -2 at the end of the month. The fluctuation is less extreme in the following months. Nevertheless, there is a breach of -2 at the end of October, while at the end of the year there is a number of breaches of the 2 bound. At the start of the new year, there is less volatility, lasting until a breach of –2 standard deviation bound at the end of January. The next breaches happened in March, where within a week there is a breach of both the 2 and –2 standard deviation bounds.

Figure 5. 25: Daily Logarithmic Return: Italy Renewable

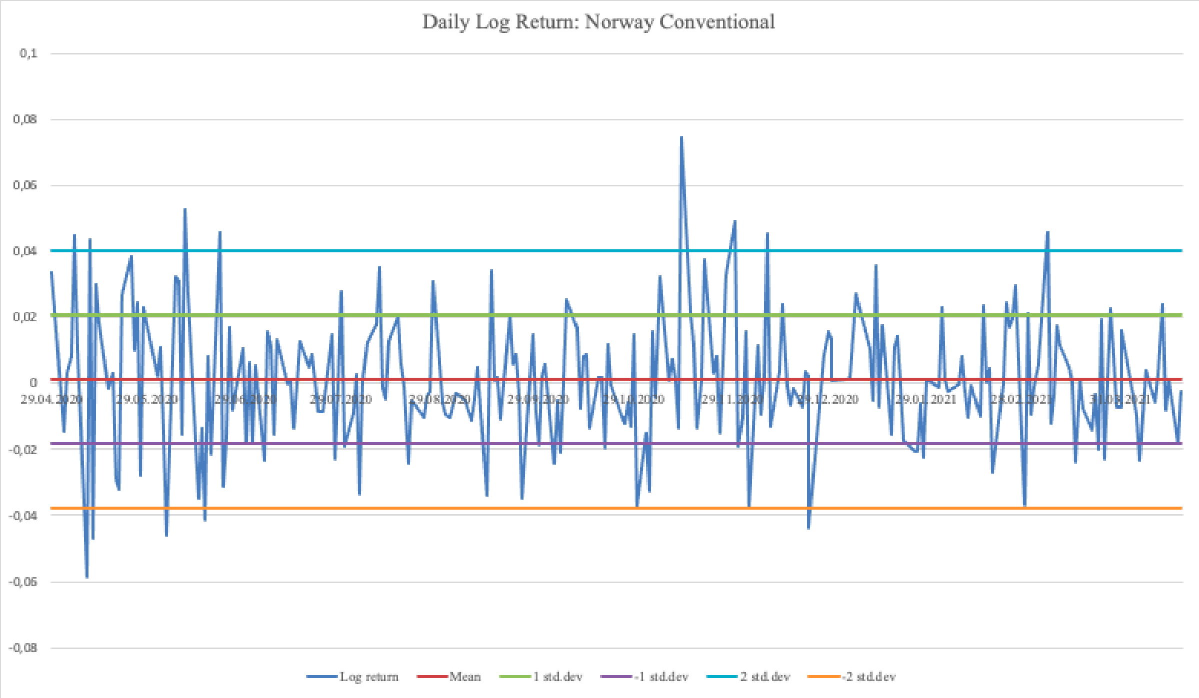


5.7.7 Norway - Conventional

Total Sample Variance of this group: 0.00038206

In the Norwegian conventional energy sector, we observed high volatility at the start of the period (Figure 5.26). Throughout the first month there is a number of breaches, both of 2 and -2 standard deviation bounds. The high volatility endures until the end of the following month which has similar trends as the previous month. After these two months, there is a period of less volatility. The next interesting period follows in mid-November, when there is a breach of the 2 bound which is followed by a number of similar breaches in early December. At the end of 2020 there is a breach of –2. In 2021 there is only one breach in our sample data, namely of the 2 standard deviation bound taking place in early March.

Figure 5. 26: Daily Logarithmic Return: Norway Conventional

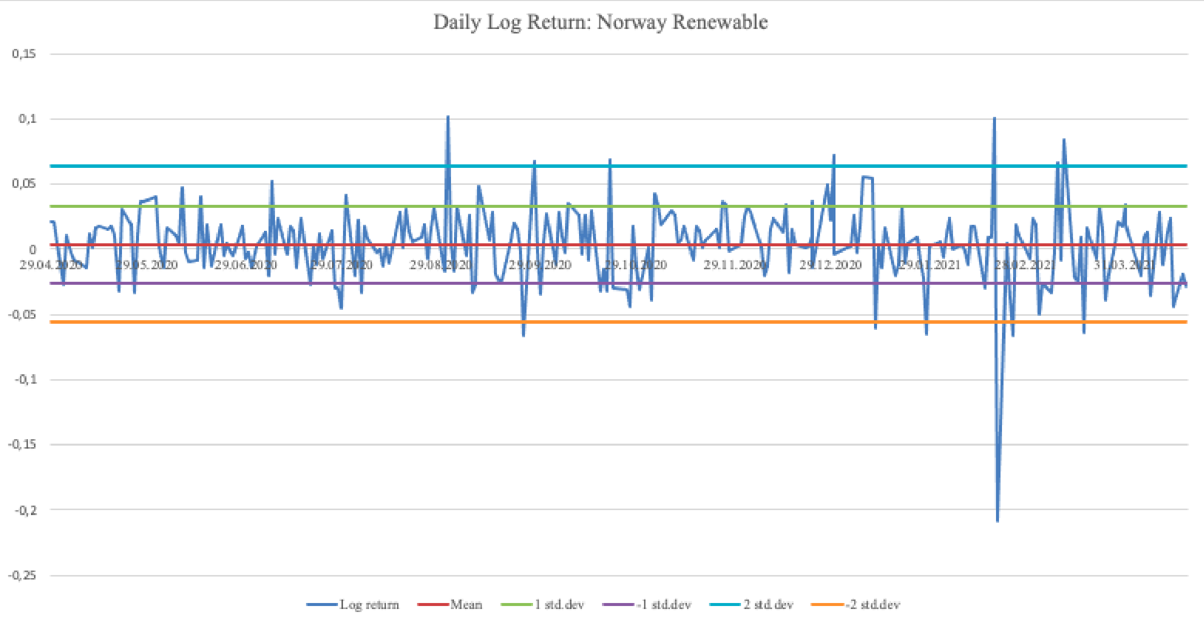


5.7.8 Norway - Renewable

Total Sample Variance of this group: 0.00088025

In Norway´s renewable energy sector, there is no breach of either 2 or –2 standard deviation bounds at the start the sample data (Figure 5.27). There are some breaches of the 1 and -1 standard deviations, but overall, it was a relatively calm start to the period. The first interesting event occurs at the end of August, with a breach of the 2 standard deviation bound. This is followed by breaches of 2 and -2 bounds at the end of September, with five days separating the breaches. For the rest of 2020, there are a couple of breaches of the 2 bound. In 2021 there is a development with increased volatility: during January there are two breaches of –2 standard deviations. Followingly, a breach of 2 standard deviations in mid-February occurs with a subsequential immediate downturn to breach the –2 standard deviation bound. With such close vicinity between the breaches, this particular period is interesting. For the rest of the sample, there are a couple of breaches both in 2 and -2 standard deviations. There is especially one week of interest, with a total of 3 breaches within that one week.

Figure 5. 27: Daily Logarithmic Return: Norway Renewable

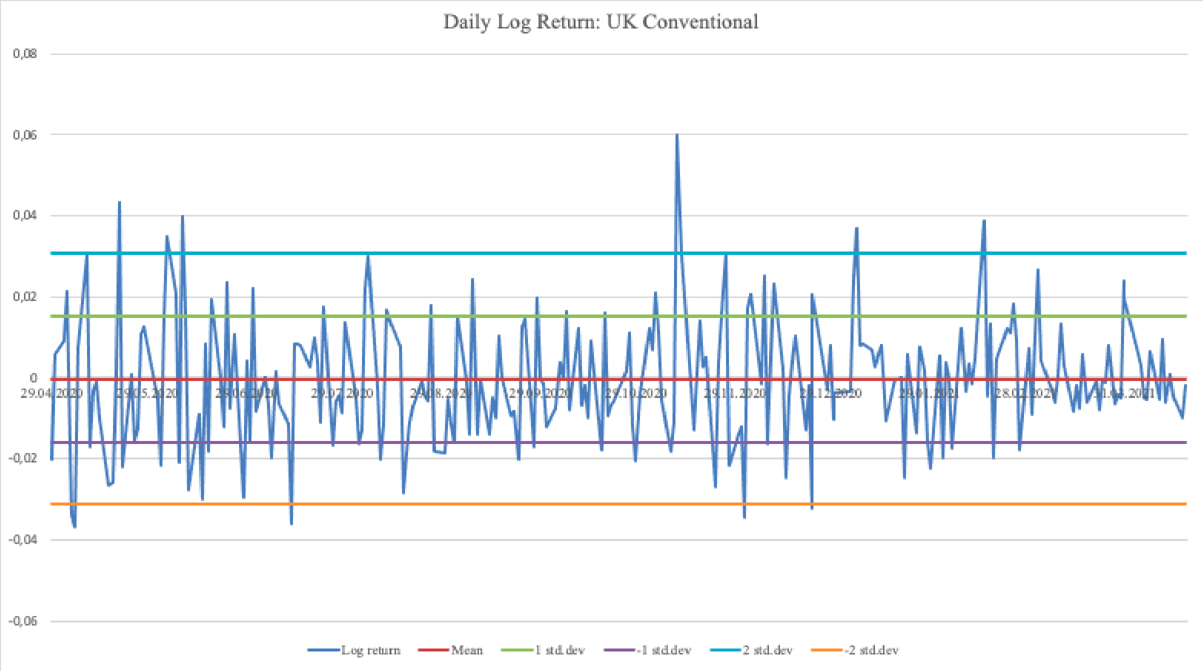


5.7.9 UK – Conventional

Total Sample Variance of this group: 0.00024

In the United Kingdom, there is breaches of -2 bounds on consecutive days in early May, while at the end of May there is a breach of 2 standard deviation (Figure 5.28). This is followed by a couple of 2 standard deviation breaches in early June, while the next event occurring is in mid-July with a breach of the –2 bound. The following months have less volatility, with breaches only of the 1 or –1 standard deviation bounds. This period of lower volatility last until mid-November, where it is a breach of 2, followed identically in late November which is immediately corrected by a breach of -2 standard deviation in early December. At the end of December, there is another breach of –2 standard deviation, implying another event of interest at the end of 2020. In early January, there is a breach of 2 standard deviations from the mean log returns. The last breach of the sample is in mid-February, with a breach of the 2 standard deviations bound.

Figure 5. 28:Daily Logarithmic Return: UK Conventional

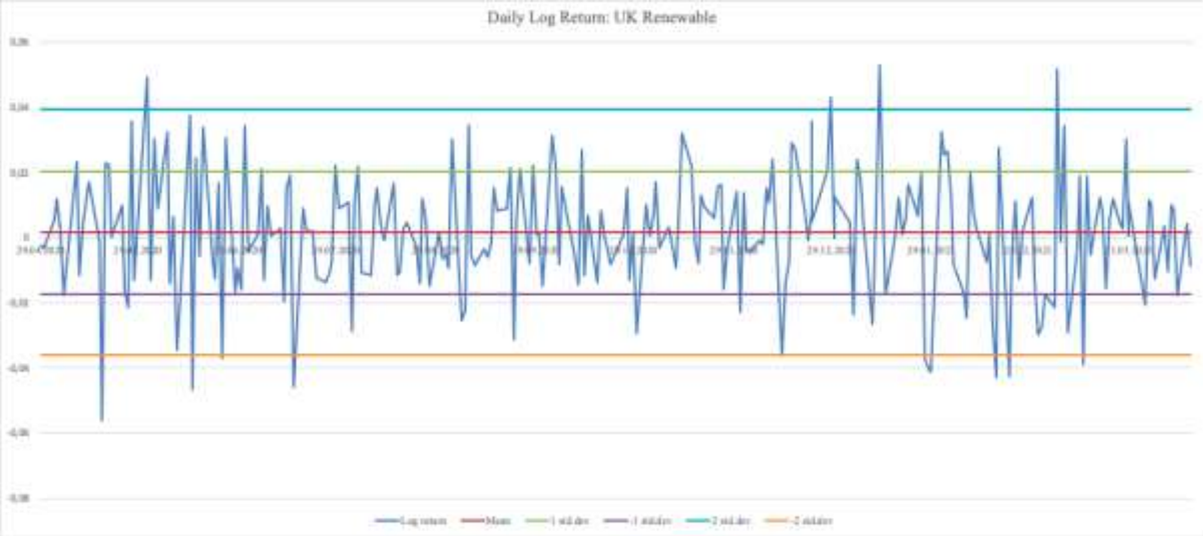


5.7.10 UK - Renewable

Total Sample Variance of this group: 0.0003556

At the start of the period there was no breaches of either the 2 or -2 standard deviation bounds (Figure 5.29). The first breach of the -2 occurs one month into the sample period. This is followed by a breach of 2 standard deviations at the start of the next month. From mid-June and running until the end of the month there are a couple of breaches of -2 standard deviations, implying there being an event of interest. The next point of interest is in mid-July, with another breach of the -2 bound. In the following months there is less volatility in the data, lasting until mid-December, when there is yet again a breach of -2 standard deviations. A breach that is immediately followed by a breach of 2 standard deviation, with another breach occurring right at the start of 2021. The increasing trend in breaches of –2 standard deviation in 2021 is also present in the UK as well. After the end of January and onwards there is two breaches of –2 standard deviations. At the start of March there is a corrective breach of 2 standard deviation, which is followed immediately by a breach of –2 standard deviations about a week later.

Figure 5. 29: Daily Logarithmic Return: UK Renewable



5.8 R-Squared

To test for a difference between the two sectors, we will assess the overall market variance's capacity to explain the variance in the test groups. Morris & Alam (2012) showed that during the Dotcom bubble the adjusted R-squared was lower than in years prior and after the bubble. In our approach, we created a portfolio of return, such as France Conventional, where we took each company´s closing price return and multiplied by its *relative weight*[23]. The portfolio we constructed was tested against the return of a market index for the country. Hence, generating *R-squared*[24] and *adjusted R-squared*[25] values from regression models where the market index act as the regressor, and the constructed portfolio would be the dependent variable.

[23] That market capitalization of each company was summarized to a total market cap for the sector. The relative weight associated with each company is calculated by dividing a single stock's market cap on the total market cap in the group.

[24] In a regression, the fraction of the sample variance of the dependent variable that is explained by the regressors (Stock & Watson, 2020).

[25] A modified version of R-squared that does not necessarily increase when a new regressor is added to the regression (Stock & Watson, 2020).

Table 5. 7: R-Squared

R-Squared:

France: Conventional

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.675	.456	.454	.007

France: Renewable

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.627	.393	.391	.007

Germany: Conventional

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.504	.254	.251	.001

Germany: Renewable

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.179	.032	.028	.011

Italy: Conventional

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.864	.747	.746	.005

Italy: Renewable

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.400	.160	.156	.010

Norway: Conventional

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.811	.657	.656	.006

Norway: Renewable

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.527	.278	.275	.009

United Kingdom: Conventional

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.743	.553	.551	.006

United Kingdom: Renewable

Obs	Multiple R	R-Squared	Adjusted R-Squared	Standard Error
251	.451	.200	.199	.009

5.8.1 France

The conventional energy portfolio is more in line with the market index, compared to its renewable peer (Table 5.7). In France, we selected CAC – All Equities as our market index. As we infer from the output, the overall market yields a higher explanatory power in terms of variance obtained in the conventional energy companies. Although there is an equal number of companies in both industries, with 13 conventional – and 14 renewable energy companies. The generated market cap shows a big discrepancy. The conventional energy companies had a combined value over NOK 1,000,000,000,000 higher than the renewable energy companies.

5.8.2 Germany

In Germany, much of the variance in the conventional portfolio is accounted for by the market index. This would be expected as, again, the overall market cap of conventional energy companies is larger even though there are more companies in renewable energy. Once again, that would mean that the most established companies would be in the conventional energy sector. A problem emerged when developing the analysis for Germany, due to the choice of market index. Our selection process ended with the DAX Index, but as we can see from production, particularly for the renewable energy companies, it has a relatively small explanatory power. However, due to the lack of a good replacement, our analysis uses the DAX Index, but we are aware of this weakness.

5.8.3 Italy

In Italy, there is a great difference in the overall market's explanatory power of the two sectors (Table 5.7). This is partly because of the difference in market cap. Conventional energy companies generated NOK 1,500,000,000 more than the renewable energy companies. This is astonishing considering that there are 16 companies in this sector compared to 9 renewable energy companies. When compared to the market index in Italy using the FTSE – Italy – All Stocks, we obtained an estimate of the real magnitude of the difference (Table 5.7). The market index explains about 75% of the variance in the conventional portfolio, a figure which means that a major part of the Italian market capitalization is attributed to this sector, and that these companies hold a very influential position in the Italian economy.

5.8.4 Norway

The same tendency is apparent in Norway as in Italy (Table 5.7). The total market capitalization for conventional energy companies is NOK 872,552,378,908. This is approximately 7 times higher than the accumulated market cap of renewable energy companies. Of the 325 companies listed on OSE, 64 are included in our portfolio of conventional and 25 are in the renewable portfolio. This is due to the well-known fact that OSE is strongly influenced by oil companies. All of this implies that most of the variance in the conventional portfolio is explained by OSEBX (Table 5.7). This supports our assumption that there is a difference between the market's ability to explain the total variance obtained in conventional and renewable energy companies in Norway.

5.8.5 UK

The pattern that has been evident throughout is also evident in the UK (Table 5.7). Nevertheless, there is a great divergence in the number of companies affiliated to the various sectors, with 107 conventional – and 14 renewable energy companies out of 1,147 active securities traded in the UK. In the UK, our market index of choice is FTSE – All Equities. Also here it is evident that the market capitalization accumulated by conventional energy companies is larger. This again provides, in part, a comprehensive explanation of why the market index has a higher explanatory power of the variance of the conventional portfolio.

In this chapter we have analysed all selected countries with subsequent sectors and presented the results accordingly. Moving on, we will discuss them: does the results indicate the presence of an asset price bubble in European renewable energy equities?

6.0 RESULTS AND THEIR DISCUSSION

In this section, we will discuss the results presented above. Initially, we will take a broad perspective on both the conventional and renewable groups in all countries collectively. That is, which tendencies are apparent in the overall European renewable energy securities. Furthermore, we will discuss the countries results individually. Then we will assess three other factors currently affecting the energy markets that are important when identifying a potential asset price bubble: interest rates, the crude oil price and the COVID-19 pandemic. As we mentioned in section 3, interest rates especially have been a prominent factor in previous asset price bubbles throughout history. We assume these factors to be of high importance in terms of understanding the current market conditions. Lastly, we will briefly outline some viewpoints regarding the future of renewable energy before we conclude on whether a bubble exist.

6.1 Hypothesis Testing on the Entire Sample

For all the different variations of t-tests conducted throughout chapter 4, a common occurrence is statistically significant differences in mean abnormal returns between conventional and renewable energy companies (Table 5.2). These are elements which could create an asset price bubble, by the fact that prices start to differ from their fundamental value. The divergence between the expected rate of return and the actual rate of return, i.e., abnormal return, indicating that conventional pricing models such as CAPM and DCF fails in estimating market prices for renewable energy companies, which violates the EMH. When such pricing models fail, it yields support to the hypothesis of a potential asset price bubble. For instance, with CAPM, there are a number of assumptions associated with the model. One of which states that investors are rational and optimizes mean-variances. However, as we pointed out in section 2.3.3, investors do not always act rationally. As a result, anomalies start to appear, and security prices begin to differ from the fundamental value. In the case of an asset price bubble, EMH will have failed, as one of the underlying assumptions of the EMH is that an asset price bubble cannot occur. Under EMH, all traders have equal ability and should be able to create the same profit. However, this has been proven to be false at several times throughout history. Our finding of statistically significant differences in the means for conventional and renewable energy companies can indicate the possibility of an asset price bubble. As we have not found empirical reasoning to disprove our results, we fail to reject the hypothesis of an asset price bubble not existing in the green energy sector.

6.1.1 Additional Binary Control Variables

With no evidence strong enough to reject our hypothesis in the previous part of the analysis, we introduced some additional control variables to dissect the nature of the reported abnormal return. In terms of *summer*, we are not able to find any statistically significant evidence for the overall sample. Hence, we are unable to prove any divergency experienced in the data during the summer period for renewable equities. However, in the conventional energy sector, a statistically significant difference in abnormal return during the summer months is apparent (Table 5.4). This provides support for the assumption that the two sectors are different, implying that reduced activity in trading on stock exchanges would not influence the renewable energy sector. In this period, a reduction in production can also be expected as an increased number of employees will be on summer holiday. This can imply that the abnormal return experienced in the renewable energy sector is less dependent production level compared to the conventional energy sector, showing returns in renewable energy companies to be less coupled to fundamentals. However, to fully test which effects *summer* has on abnormal returns, the dataset should include more summer months (i.e., a longer time frame of the dataset). We are aware of this weakness.

When introducing the dummy variable separating abnormal returns into 2020 & 2021, we investigated whether the data were correlated with media coverages. If there is a correlation, it would be reasonable to assume that being apparent in the rest of the data. We were able to justify such a conclusion statistically (Table 5.5). We will discuss the media coverage surrounding both the US election, the ongoing pandemic, and their effects on the equity capital markets in sections 6.2.1 and 6.6.

Throughout the analysis, we did not find any statistically significant evidence that contradicts our hypothesis of a bubble being present. This was upheld after we included the binary variable on company size as well. Instead, it yielded an even further statistically significant evidence that conventional and renewable energy companies are priced differently. The mean abnormal return is, as before, higher for the renewable energy sector, which suggests that, on average, the valuation of renewable companies is higher than their conventional counterparties.

If we consider paid out dividends, they generally are more apparent and higher in the conventional energy sector. This suggests that renewable companies are able to reinvest earnings at a higher opportunity cost of capital than its investors, which is obtained in valuations through PVGO. However, many renewable companies do not yet have earnings as they are relatively young, making estimations of reasonable pricing of their stock through traditional pricing models close to impossible. However, many renewable companies experience high returns, possibly explained by irrational exuberance leading into an asset price bubble. Nevertheless, we fail to reject the hypothesis of the existence of an asset price bubble. Furthermore, through the inclusion of these control variables we have presented more statistical evidence potentially indicating an asset price bubble.

6.2 Daily Logarithmic Returns

In this section, we will outline the tendencies that we observe in the analysis of daily log returns across both groups collectively before finally moving on to assessing each county individually.

6.2.1 Conventional Energy Companies

Across all companies within conventional energy, the data sample begin with a drop. This is arguably caused in large by the Covid-19 pandemic and the reduction in crude oil prices during the period, with the price of crude oil being at one of its lowest points in recent years at the end of April 2020. During the following months, there was a rise in the price of crude oil, which is represented in our graphs with less fluctuations, and fewer breaches of both the 2 and -2 standard deviation bounds from the mean (Figures 5.20, 5.22, 5.24, 5.26 and 5.28). At the end of the year, there is a common spike in return across all countries. The spike occurs after a small downturn period in the development of oil prices in October 2020. This is followed by a further increase in the price of oil, which leads to a vast reaction in the entire sector. After President Biden was elected in the United States of America, there was an increase in stock prices (CNN, 2020). This combined with news regarding the development of vaccines with respect to the ongoing pandemic, may well be part of the explanation behind the development around that time for conventional energy companies. The two events were in close proximity to the sharp rise in equity prices for companies in conventional energy. This development is apparent throughout the rest of the data, accompanied by a steady increase in the price of crude oil. There was a clear expectation that 2021 would be a better year all around for conventional energy companies, compared to the previous year. This is reinforced by the market through the general pricing of said companies. Even though the pandemic is still ongoing, there is a clear optimism for better future conditions in the sector.

6.2.2 Renewable Energy Companies

When analyzing the development in returns across all countries, there is a clear tendency of a downturn after the turn of the year. With an upturn in frequency of breaches of -2 standard deviations from the mean about one month into the new year as a common occurrence. Even though our starting point is during the COVID-19 pandemic which has affected almost all equities listed on stock exchanges around the world, there is a greater number of breaches of 2 standard deviations from the mean in 2020 for renewable energy companies compared to the conventional ones, which is an indication of a positive momentum for the related companies. As stated before, there has been a change in narrative surrounding for renewable energy companies in 2021, which is displayed by an increase in both number and frequency of –2 standard deviation bounds breaches: a downturn in return and performance of the companies in 2021 compared to the record-breaking year 2020 (Chestney, 2021). An apparent cluster tendency is present in the data, irrespective of the country (Figures 5.21, 5.23, 5.25, 5.27 and 5.29). Throughout the entire period all countries follow approximately the same trend. This could be an indicator that an event occurring in one country will (most likely) affect the other countries.

6.3 Individual Countries

In this section of our discussion, we will outline the results of our analysis in the hypothesis tests, daily logarithmic return and R-squared on an individual county basis.

6.3.1 France

Hypothesis Tests

In France there is a statistically significant difference in the mean abnormal returns of the two groups when a 3-week moving average is used (Table 5.3), which is a trend that holds true for all conducted t-tests on France. All throughout the conducted t-tests the mean value associated with the renewable energy sector is larger, meaning the renewable energy sector on average yields higher abnormal returns which is an estimate that would point in the direction of the existence of an asset price bubble.

Daily Logarithmic Returns

Overall, there are more and larger fluctuations in the renewable energy sector, as seen in Figure 5.20 and 5.21. One of the possible reasons behind the divergence is the value associated with the different sectors, where conventional energy companies accumulate a significantly higher overall market value. One element that was of keen interest is the large spike in the conventional sector around the time of the US election results and news breaking about COVID-19 vaccines. This is not as apparent in the renewable sector and indicates that the pricing in the renewable energy sector is not equally affected in the same extent by news and other events as the conventional energy sector. This gives support to there being other elements that are the drivers behind the price development, possibly an asset price bubble.

R-Squared

There is a great difference in market capitalization in France. Even so, there is little difference in the overall market's explanatory power, compared to the level seen in other countries. A possible explanation is that, relative to other countries, there is an equal division of the companies included in both portfolios. Despite this, it is still true that the conventional portfolio has the largest R-squared. Again, we found support for the fact that standard pricing models are unable to address the factors underlying asset pricing in renewable energy companies.

6.3.2 Germany

Hypothesis Tests

Our results yields statistically significant differences in the mean abnormal returns of the two groups both with and without a three-week moving average (Tables 5.2 and 5.3). However, the associated t-statistic is more significant with a three-week moving average, implying a better fit. The mean abnormal return in the renewable energy sector is larger in our sample data, indicating higher yield of abnormal return in Germany´s renewable energy sector compared to the conventional, providing support to the hypothesis. Conclusively, we are not able reject the hypothesis of a green energy asset price bubble in Germany in terms of the hypothesis tests.

Daily Logarithmic Returns

Germany´s conventional energy sector is heavily affected by the listing of Siemens Energy AG. However, there are some affects that are recognizable: there is a spike around the time of Covid-19 vaccine news, even though it is a smaller spike than it was for the other countries. As for the renewable energy sector, there is a negative cluster at the start of the new year with a downfall in the average log return in 2021, a tendency that is common across all countries. One important point is the increase in return for the renewable energy sector. Throughout 2020, there is a clear increase in the value associated with renewable companies, implying similarities in development to what has been the case during previous asset price bubbles, e.g., the dotcom bubble.

R-Squared

In Germany, there is a major difference in the overall market's explanatory power between the two portfolios. However, that is to be expected as a result of our market index proxy. The DAX Index includes the 30 largest companies based on market cap in Germany. It would be fair to assume that more of them would be associated with conventional rather than renewable energy. As we have observed throughout this thesis, conventional energy companies are generally more established and as a result generate, on average, higher market capitalization. This implies that a higher degree of companies will be included on the DAX Index, which will provide a more accurate explanation of the variance.

6.3.3 Italy

Hypothesis Tests

In Italy there is further support to the assumption that a three-week moving average provide the best fit, with t-tests only providing statistically significant results when a three-week moving average is used (Table 5.3), resulting more evidence for a difference in mean between conventional and renewable energy sectors across Europe, as the mean value is larger in the renewable energy sector in Italy as well, implying higher abnormal return. Conclusively, renewable energy companies yield higher abnormal return than the conventional companies.

Daily Logarithmic Returns

There is a great difference in valuation between the conventional and renewable energy sector, as the conventional energy sector accumulates a larger part of the overall Italian energy market. As illustrated by IEA – Italy (2020), when comparing these sectors in Italy it is important to keep in mind that Italy´s energy network is currently very dependent on fossil fuels. This in part can explain the massive difference between the conventional and renewable energy sector. For the better part of 2020, there is indeed an upswing in the valuation of renewable energy companies displayed in the high spikes occurring. In addition, for the most part of the year, daily log return are well above the mean, although there is more fluctuations in Italy´s conventional energy sector. This can partly be explained by the total number of companies being greatly different between the sectors, 16 in the conventional group compared to 9 in renewable energy. Once again, the conventional energy sector has a large spike around the time when the news around a vaccine for COVID-19 was announced, a spike that is not prominent in the renewable energy sector here either (Figures 5.24 and 5.25). This suggests that the conventional energy sector is affected to a higher degree by news surrounding the pandemic.

R-Squared

As shown in Table 5.7, there is a significant divergence in the associated R-squared values in Italy. This suggests that it is difficult to predict how the portfolio of renewable companies will evolve in the future through using general market movements. As for the conventional portfolio, one could be reasonably confident that it will be strongly linked to the overall market index. Such a statement cannot be made about the renewable portfolio, implying the potential of an asset price bubble or other price drivers.

6.3.4 Norway

Hypothesis Tests

In Norway, statistically significant results are only apparent with a three-week moving average (Table 5.3), which indicates that our assumption holds true, the mean value indicates a higher yield of abnormal return associated with the renewable energy sector. This means that we are not able reject the existence of an asset price bubble.

Daily Logarithmic Returns

At the start of the period, the largest movements are found in the conventional energy sector. There seems to be a divergence between the two sectors at the beginning of our data period. Given that our data period starts at the end of one of the periods greatly affected by the global pandemic, the correlation between Norway´s conventional energy sector and the pandemic would be assumed to be high. Another important aspect is the effect the pandemic has on the crude oil price, given the large quantity of companies on the OSE that are operating in the petroleum industry. Even so, it was an interesting finding that renewable energy companies were apparently relatively unaffected, implying different factors that explain the increase in prices seen across renewable energy companies throughout 2020. Another factor that supports this claim is the spike occurring in Norway´s conventional energy sector around the time when vaccine news became public. Following the weak form of the EMH and its claim that all available public information is incorporated into the pricing if a company, this element is apparent in all countries. A natural conclusion would be that there were high correlation between COVID-19 vaccine news and conventional energy companies.

As well as for the other countries, there is a downswing in the performance of the renewable energy sector in Norway in 2021. The downturn is a common occurrence across all stock exchanges we have examined. In Norway, there was especially one event which stands out in the renewable energy sector in 2021, which was caused by a decrease in value of NOK 35,000,000,000 between days (Figure 5.27). Whilst the conventional energy sector is on the rise at the start of 2021, this can be associated with the rise in the price of crude oil.

R-Squared

The same trend as in Italy is apparent in Norway, with a great divergence between the two portfolios. Again, the market index is able to explain a high level of variance in the conventional portfolio, unlocking the potential for unexpected and abnormal price drivers in the renewable energy sector, which will be less affected by the entire market and will have a higher degree of excess variance.

6.3.5 UK

Hypothesis Tests

For the UK, our results are statistically significant for both instances (Tables 5.2 and 5.3). However, a three-week moving average is a better fit with our data. The associated mean value is again the highest for the renewable energy sector, which suggests that the renewable energy sector in the UK yield higher abnormal return, creating a possible environment for an asset price bubble to grow. Throughout the results from the UK, we detected no evidence against the possibility of the existence of an asset price bubble.

Daily Logarithmic Returns

Also in the UK, the conventional energy sector accumulates a higher market valuation, compared to its renewable counterparties. This is to be expected given how much of the energy produced and used in the UK is fossil (IEA – UK, 2021). All throughout 2020, there is a clear tendency for the renewable energy sector to yield a higher mean return (Figures 5.28 and 5.29). This is a common trend in all countries and would imply that renewable energy companies are experiencing higher returns overall in our data sample. This happens even though the money and dividends paid in the conventional energy sector are much larger, implying that investors are expecting future growth in the renewable energy sector to exceed the conventional. They are trading on the expectation that there will be even higher revenues generated from renewable energy companies in the future (which is captured in traditional pricing models through e.g., PVGO). In the meantime, traders are neglecting the possibility of dividends from the conventional energy sector at the present time, a trend that holds true for all countries included in our thesis.

R-Squared

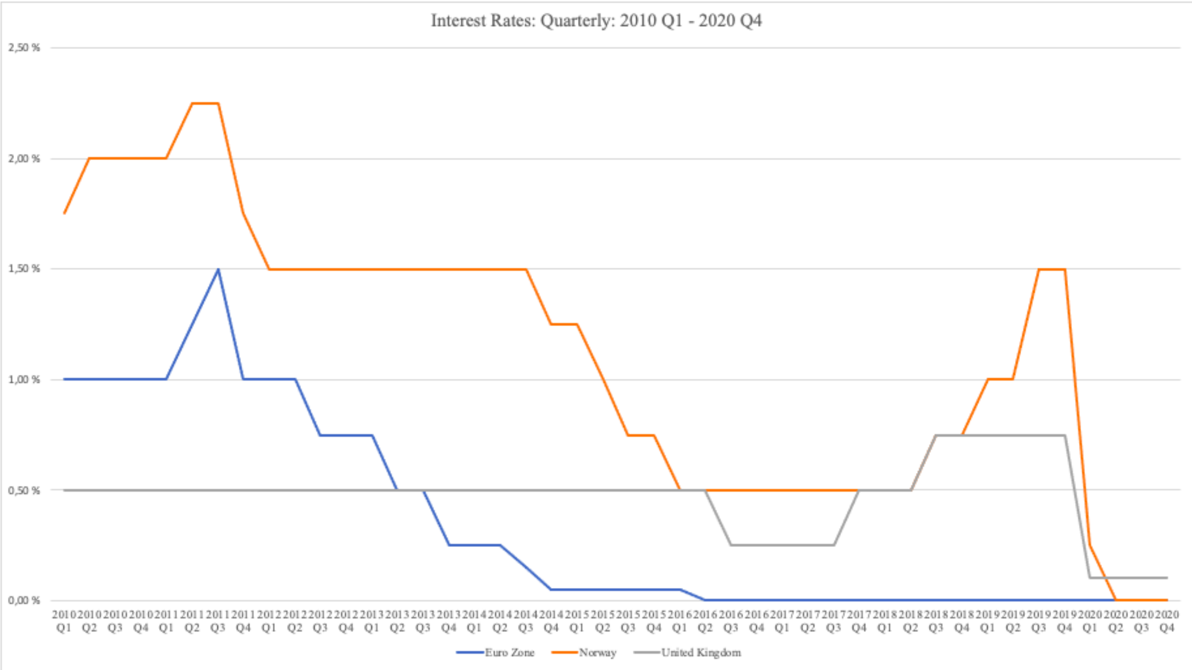
Again, a pattern similar to the other countries appears (Table 5.7), where the market index better explains the variance of the conventional portfolio. As noted, there is a large difference in the number of companies in both portfolios. However, this could imply that there are other factors at play in terms of price development e.g., an asset price bubble.

6.4 Interest rates

Interest rates are another element which influence stock markets. Generally, the interest rate is regarded as the price of money (Brealey et al., 2020). In terms of a borrower, the interest rate is the cost of borrowing money. As far as lenders are concerned, the interest rate is the fee charged. Interest rates significantly affect the economy. In most countries, interest rate policy is used to monitor inflation and seek full employment (Carlin & Soskice, 2015). Whether interest rates rise or fall may be related to general economic conditions. If the economy appears to be slowing down or even heading into a recession, interest rates may be reduced. This is a significant step, as banks will follow suit with lower interest rates on loans and lines of credit. This encourages borrowing and expenditures, which can help stimulate the economy. Furthermore, with low interest rates, the opportunity cost of capital decline. Lending is less expensive to businesses which can increase the number of projects being launched. Furthermore, it can increase the number of investors looking to invest in the company, creating a trigger mechanism for an increase in the equity price. Of course, it might create a selling opportunity for the investor, but if this is repeated with multiple companies, it could lead to a surge in market equity prices.

In Figure 6.1, we see the interest rates development over the past decade in the selected countries.

Figure 6. 1: Interest Rates



[26]

As three of our selected countries are EU-countries (France, Germany, and Italy), their interest rates are determined by the European Central Bank (2021). We chose to display these as the Euro Zone.

As we see, there has been a steady downward trend, even though some fluctuations have taken place. The Euro Zone experienced 0 percent interest rates already in 2016 and it has remained low in recent years. In the UK, the level of interest has been relatively stable. Whereas for Norway, Norges Bank maintained a flexible conduct of interest, thereby creating room to maneuver in terms of monetary policy in the event of a crises. And as we know, in Q1 2020, the COVID-19 pandemic spread contagiously and led to policy responses by setting record low interest rates worldwide. The sudden halt in economic activity was responded to with low interest rates to stimulate the economy. Additionally, major quantitative easing took place as central banks purchased both governmental and corporate bonds to insert liquidity into the markets.

[26] Data collected via FX Empire (2021).

Low interest rates can create bubbles by decreasing the total cost of ownership of assets. Interest rates and bond prices are mutually linked. Low interest rates make it easy to borrow money cheaply, which increases investment expenditures. However, investors cannot obtain a good return on their investments at these rates, so they shift their money to high-yield, high-risk asset classes, driving asset prices up. Dalio (2021) showed that now, as during the Dotcom bubble, the access to risk tolerating capital is enormous. With low interest rates, the opportunity cost of capital falls. And as a result of low interest, money-printing, and quantitative easing, we face inflation risk. This could be derived from the increase in the rate of a 10-year US Treasury Note, which has risen from approx. 0.5% in August 2020 to around 1.6% as of June 2021 (Market Watch). The market expects inflation to increase, when at the same time, interest rates are record low. Inevitably, the real interest rate could become negative. Thereby, in the absence of incentives to save money due to lost purchasing power over time, investors spend their money in the markets. Thus, a broad general price increase is expected.

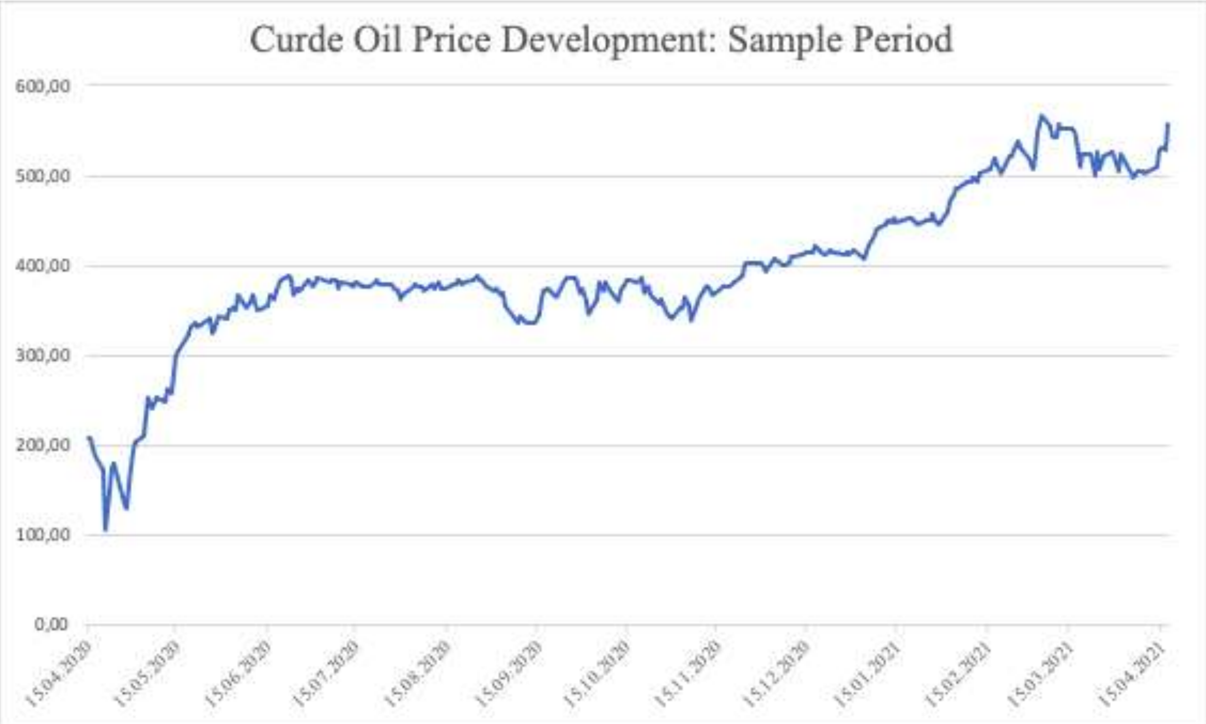
Jordá, Singh & Taylor (2020) indicated that interest rates appear to remain at this low level for coming years, an element that will make investments more attractive and reduce risk. However, it also accelerates prices in equity markets over time as the opportunity cost of capital decreases. And in terms of the discounted cash flow (DCF) model, more investments appear profitable and higher prices could be justified. Hermanrud (2021) suggests that the low interest has led the general pricing on OSEBX upwards, where the market now on average trade the index on a price to book value (PBV) ratio of approx. 2.7. There has never been such a high PBV ratio on the OSEBX index that has not been followed by a subsequent crash. However, the current interest level worldwide is also unprecedented, and with the risk-free rate being this low, there are few incentives to not allocate capital to risky investments in the pursuit of returns.

6.5 The Crude Oil Price

Another important factor to consider that was affected by the pandemic, while also being highly correlated with the conventional energy is the crude oil price (DailyFX, 2021). This correlation was confirmed by Asche & Dahl (2017). The price of crude oil is an important metric within the energy markets. Part of the reason behind the movements in the conventional energy sector could be explained by the change in the crude oil price. Thereby, we will assess the relationship between all of our entities and the price of crude oil as it affects both conventional and renewable equity prices. Conventional energy's forecasted future earnings depend highly on the development in the crude oil price, which affect the investment prospects of conventional energy companies through e.g., DCF.

In Figure 6.2, we present the development in the crude oil price throughout our sample period. As observed in 2021, there has been a steady increase in the crude oil price from its low in April of 2020, where our data begins, all the way throughout 2020 and further into 2021.

Figure 6. 2: Crude Oil Price Development



[27]

Moving on, we will estimate how our groups correlate with the price of crude oil to better understand the development in the pricing of energy equities.

[27] Daily price history for NYMEX West Texas Intermediate (WTI) Crude Oil (CLc1) from Refinitiv Eikon.

Table 6. 1: Correlation Crude Oil

Correlation: Crude Oil (WTI)

France: Conventional
Correlation
-0,1197597

France: Renewable
Correlation
-0,0673101

Germany: Conventional
Correlation
-0,0341806

Germany: Renewable
Correlation
0,0615955

Italy: Renewable
Correlation
0,1754417

Italy: Renewable
Correlation
-0,0133554

Norway: Conventional
Correlation
0,01978597

Norway: Renewable
Correlation
-0,0330773

United Kingdom: Conventional
Correlation
0,27898811

United Kingdom: Renewable
Correlation
-0,0617304

As shown in Table 6.1, the correlation is strongest for Italy and the UK, and their respective conventional energy companies. This is to be expected, considering how these two nations' conventional energy sectors are primarily based on oil companies. Although the Norwegian conventional portfolio is also heavily reliant on oil, the correlation between the two is weaker. As for France and Germany, it is difficult to say much about the results, other than the conventional energy companies and the relevance of our selected index did not provide a good fit.

As we have mentioned, there is a negative correlation between the crude oil and renewable portfolios, for most countries, with the exception of Germany´s renewable sector. This implies that the rise in crude oil prices observed in 2021 will actually reduce the price of renewable energy as a whole. This could be an indication of no price bubble in European renewable energy equities.

The price of crude oil has risen in our sample period (Figure 6.2). Although this period was greatly affected by the pandemic, there are a number of factors that would indicate that it would be a trend for the foreseeable future. With increased incentives to reduce costs associated with renewable energy, as we have pointed out with the new European Green Deal and Taxonomy. Policy makers have created a new environment for investments in green energy. Since interest rates are at an all-time low, there are also funds available at low costs. All of this will also affect the price of crude oil. As a result of our findings, we believe that the premise of *simultaneous causality*[28] is a fair assessment in view of the impact of crude oil prices on renewable energy, but also the effect of renewable energy on crude oil prices. This will have a major impact on the future evolution of both.

6.6 The COVID-19 Pandemic

Throughout our study, some events can be attributed to the ongoing pandemic. Most of these events are observed in the conventional energy sector, implying high correlation between the pandemic news and conventional energy companies. The reasoning behind such a claim is as follow: with the data sample starting at the end of one of the periods on stock exchanges most affected by the pandemic outbreak, influencing much of the fluctuations observed in the conventional energy sector across the different countries. Hence, this is an indication of a correlation between the two. This phenomenon is less apparent in the renewable sector. Perhaps the most prominent news event influencing our results is the public announcement by the American multinational pharmaceutical cooperation Pfizer of its vaccine results (Pfizer, 2020). In the time after the press release, there were large movements, especially in the conventional energy sector, which imply correlation between pandemic news and conventional companies. These spikes do not occur as frequently in the renewable energy companies.

The fall in return experienced in renewable energy companies in early 2021 could be explained by the decrease in investment in the sector in early 2020 due to the pandemic. IRENA & Climate Policy Initiative (2020) reported that in early 2020 investments decreased by 34% compared to the same period in 2019. As a consequence of being a sector under development, the effects of the decrease were not beginning to become apparent until 2021, which would in turn explain the delay in response to the experienced decrease in investments caused by the pandemic. Even so, there seem to be an increased interest in renewable investments during the pandemic, as we explained in the introduction. However, we cannot disregard that this interest is self-fulfilling, resulting in increased demand for renewable companies which makes renewable investments seem more resilient to the volatility generated

[28] Where, in addition to the causal link of interest from *X* to *Y*, a causal link from *Y* to *X* exists. Simultaneous causality results in *X* being correlated with the error term in the function of interest which connects Y *to X* (Stock & Watson, 2020).

by the pandemic (Hale, 2020) (i.e., which relationships are causal, and which are spurious and mediating?).

6.7 The Future of Renewable Energy

According to Allied Market Research (2021), the global renewable energy market was valued at a total of US $928 billion in 2017. By their projections, it will grow with a CAGR[29] of 6.1% and amount to a total of $1,512 billion by 2025, hence, an overall market growth of 62.9% during the time period. Market Research Future (2021) suggests that the global renewable energy market will amount to a valuation of $2,900 billion by 2027, with an estimated CAGR of 8.53%. This implies a total market growth of 212.5% from 2017 to 2027. Needless to say, this sector is experiencing substantial growth as environmental concerns is currently being put into legislation through the EU Taxonomy in Europe and President Biden's New Green Deal in the US. And as such regulatory changes are put into place, the sector will inevitably keep growing at a high pace as economic incentives shift capital investments from conventional to renewable energy.

Now, we will bring our discussion to a conclusion.

[29] CAGR = Compounded Annual Growth Rate.

6.8 Conclusion – Does an Asset Price Bubble Currently Exist in European Renewable Energy Equities?

As per our hypothesis tests, renewable companies have experienced a higher degree of abnormal return during the sample period compared to conventional companies. In addition, the analysis of daily logarithmic returns displays a higher variance (more price fluctuations) in the renewable groups, except for France. Lastly, the assessment of R-squared values of all countries indicate that the overall markets are able to explain less of the total variance in the renewable groups compared to their conventional peers. Hence, other mechanisms drive the price in these companies. In isolation, these are all indications of an asset price bubble.

Dalio (2021) stated that among other things, prices and their relation to fundamental values as well as conditions discounted in the prices are important aspects to consider when seeking to identify a bubble. According to Lie (2021), the general pricing in equity markets have never been higher compared to their fundamentals since the Dotcom bubble. This is a result of the low price of money through interest rates and future expectations. In essence, the PBV-ratio is peaking, and the same is true within renewable energy companies (Hermanrud, 2021). Furthermore, as interest rates fall, the opportunity cost of capital decreases, both due to the reduction in the risk-free rate, as well as a higher degree of risk tolerance aligned with the expectations of low future interest rates. This again leads to a lower denominator in the DCF which inevitably makes more investments seem profitable. Hence, when subtracting the intrinsic values, the implied PVGO increases. Thereby, the question becomes: are investors discounting unsustainable conditions (a too high PVGO), which again is manifested in bubble-looking prices?

As we discussed, the global renewable energy market is estimated to grow over 200% in total market capitalization from 2017-2027. Whether such projections are over- or underestimating the effects of legislative changes such as the EU Taxonomy is hard to say. However, it will without a shadow of a doubt keep growing. Moreover, basic economics of scale indicate that the marginal costs of production will decline as an industry grows. New technology and enhanced processes make the renewable choice more financially convenient, which is reinforced by regulators through the taxonomy. Inevitably, this will continuously put more pressure on conventional energy companies through e.g., reduction in the crude oil price as economic incentives strengthens the choice of going renewable. Hence, this reinforces an ongoing decline in the profitability of conventional energy companies. And when we combine said conditions with continuous low interest rates- and expectations, the access to risk tolerating capital is relatively high. Thus, increasing demand is to be expected. And as demand increases, and the supply side is constrained by its relatively young age and uncertainty, prices increase. This again leads to a higher expected rate of return in renewable equities, hence, to some extent justifying the high price of renewable companies.

There are aspects of the current markets that point in the direction bubble, but there is also many aspects that contradicts it. And as we have previously explained, an asset price bubble is very difficult to identify. We have not able to confirm conclusively that an asset price bubble currently evolves in European green energy. However, we are not able to reject its existence either. Hence, if a bubble is present, it might continue to grow and with low interest rates, combined with a rich flow of risk tolerant capital, prices will likely continue to increase. This begs the question: when should monetary policy respond to an asset price bubble?

7.0 ASSET PRICE BUBBLES & MONETARY POLICY

Even though we are not able to identify an asset price bubble as of now, we are not neglecting the fact that it can possibly occur in the near future. Here, we will outline how monetary policy can be utilized in face of an asset price bubble. An optimal policy implementation under an asset price bubble involves both monetary- and fiscal regulation. However, as we mentioned in section 1, our focus will be on monetary policy. Initially, we will outline the mandate of monetary policy. Then, we will discuss when monetary policy should respond to an asset price bubble?

7.1 The Mandate of Monetary Policy

In the developed world, the mandate of governing monetary policy is often allocated to central banks, e.g., Norges Bank in Norway. Their ultimate purpose should be to promote the public good through policies that foster a stable economy and prosperity. As explained by Mishkin (2008), this is done through a dual mandate:

1) Keeping inflation close to its target rate.
2) Keeping the economy close to equilibrium- output and unemployment[30].

Carlin & Soskice (2015) points out that central banks seek to achieve these objectives through e.g., setting the official policy interest rate, where the adequate policy response is given by the constraint they face from the behaviour of wage and price setters. As Bergo (2004) explains, Norges Bank conducts monetary policy in Norway through flexible inflation targeting (i.e., a trade-off between point 1) & 2)). However, not all inflation targeting central banks have the exact same mandate. The objectives are often aligned, but the weighting of price stability (inflation) compared to unemployment and economic growth (the real economy) varies (Carlin & Soskice, 2015).

It is important to allocate the governance of monetary policy to an independent party (e.g., central banks) to secure a credible and optimal monetary policy. If the mandate were a governmental responsibility, politicians could be incentivized to inflate the economy in order

[30] A level of production (output & unemployment) aligned long-term with the inflation target rate.

to decrease unemployment to increase their popularity and thereby securing re-election. Carlin & Soskice (2015) argue that this could lead to unstable inflation expectations.

7.2 Monetary Policy in Face of Asset Price Bubbles

When deciding how monetary- and/or other policy should respond to an asset price bubble, it very much depends on the nature of the bubble. Therefore, we must examine how asset prices influence both inflation and overall aggregate economic activity. Asset prices have indicatory influence through multiple channels: signaling effects in terms of profitable investments, the wealth of households as well as it affects both households and businesses' opportunity cost of capital (Mishkin, 2008). Increasing equity prices, whether they are driven by bubble-type factors like irrational exuberance[31], or fundamental factors such as low interest rates or higher productivity, incentivize investments as they lower the opportunity cost and raise demand in households as a result of increased wealth. This again yields oscillatory utilization of resources which can potentially cause changes in inflation.

Therefore, as discussed by Dupor (2005), if asset prices depart from their fundamentals, it can compromise economic efficiency. If resources are allocated based on signal effects through bubble prices, inappropriate investments can be made. For example, during the housing price bubble, too many houses were built as a result of incorrect housing prices due to the bubble. The aforementioned implied influences fall within the scope of monetary policy as it affects inflation and aggregate demand. However, not all asset price bubbles are alike, and at times they raise issues outside the direct mandate of monetary policy. In such cases, the broader regulatory framework (i.e., fiscal policy controlled by the government through the Ministry of Finance) can be an alternate solution. In particular, some asset price bubbles have more severe economic effects, thus raising concerns for policymakers as they contribute to financial instability.

The question to ask when considering when/whether to respond to an asset price bubble with monetary policy is: are bubbles inherently a bad thing? The answer is uncontentious. In their nature, asset price bubbles distort resource allocation that can potentially affect the central bank's target variables. The real question then becomes: should the central bank try to burst

[31] Irrational exuberance refers to investors' excitement and enthusiasm in financial markets that increase prices above their fundamentals.

asset price bubbles? Carlin & Soskice (2015) outlines that the argument for doing so relies on the central bank's ability to:

1. being able to identify the bubble before the general financial markets,
2. refraining from identifying bubbles that actually does not exist, and
3. bursting the bubble in a way that does not cause excessive damage to the wider economy.

Financial asset prices are an aggregation of the views of all various market participants, whereas the view of a central bank is likely to be affected by far fewer people. Hence, the risk of increasing the policy rate to burst a bubble that does not exist is apparent and can potentially cause an adverse effect on overall economic growth and prosperity. The former Chairman of the U.S. Federal Reserve, Alan Greenspan, believed that central banks were inevitably unable to meet these criteria (Carlin & Soskice, 2015), thereby strongly advocating to respond ex-post rather than ex-ante (i.e., waiting to increase the policy rate until after an eventual bubble has busted).

7.3 Monetary Policy Implications of the Green Boom

The question now becomes: should, and if so, when should the involved European central banks respond to a potential asset price bubble? As explained by Hermanrud (2021), renewable energy companies in Norway amounted to an overall economic market share of approximately 9% around their peak earlier this year[32]. How big of a risk does this sector pose on the overall financial system? History has shown that the need for monetary regulatory responses is greatest when the banking system is on the verge of collapse. This particular case was materialized in 2008 when the US Federal Reserve chose to let the Lehman Brothers go bankrupt. A central bank is meant to function as a lender of last resort, and for it to maintain its credibility, it is important to keep in mind: what is the actual mandate of monetary policy? Every war is fought with yesterday's technology, and the same goes for solving financial difficulties. Today, central banks have printed vast amounts of money to mitigate adverse effects of the pandemic on the overall economy. These actions come on top of the reduction of interest rates worldwide. This begs the question: have the aforementioned actions tightened monetary policy's flexibility in face of an asset price bubble in the future?

[32] I.e., 9% of the total OSEBX index.

Another highly important aspect, as monetary policy is forward-looking and manifested long-term, is what will the renewable energy sector look like in five to ten years? There are clear projections of growth as we discussed in section 6.7. However, how regulatory changes, such as the EU Taxonomy, will affect the overall markets long-term is hard to state. As Carlin & Soskice (2015) outline, a central bank should only try to burst an asset price bubble if it is able to identify the bubble <u>before</u> the overall markets, not identifying bubbles that do not actually exist and if it is able to burst an eventual bubble in a way that does not excessively damage the overall economy. If not, it should await responses until after an eventual burst.

8.0 CONCLUTION AND FINAL REMARKS

We collected weekly and daily trading data from five different countries over the course of a year. Through hypothesis testing, we were able to determine that all countries experienced higher abnormal return for renewable companies than their conventional peers during the sample period. The *2020 vs. 2021* binary variable showed a decrease in average abnormal return obtained in all countries' renewable companies in 2021, as compared to 2020. The variable *Big* produced a statistically significant difference in average abnormal return between large and small companies in terms of market capitalization. However, when controlling for *Summer*, the results yielded no statistical significance for the renewable groups. Hence, we found no differences in average abnormal return obtained for renewable companies during the summer months. This is aligned with the results of our assessment of R-squared, as the R-squared values are highest for the conventional groups, indicating that the variance of the overall markets is able to explain less of the variance experienced in the renewable groups. Lastly, the analysis of daily logarithmic returns showed higher variance in the renewable portfolios, except for France.

There is no doubt that the future lies in green energy. If we are to fulfill the terms of the Paris Agreement, investments need to be shifted from fossil energy sources to renewable and sustainable solutions that do not cause harm to the environment. When the EU Taxonomy regulation is put into place, more investments will be allocated to green alternatives as the Taxonomy incentivizes such investor behaviour. And as we have outlined, paradigm shifts can potentially lead to asset price bubbles. So, does an asset price bubble exist in European renewable energy equities today? We are not able to conclude about this conclusively. However, we are not able to reject the possibility of its existence through this research, either. The very nature of bubbles is that they are hard to identify, and they are often unique in their development and the scope of the overall economy. If new evidence occurs in the future to confidently identify an evolving bubble, one has to be absolute certain in order to respond with monetary policy ex-ante. If not, the best solution is to let it live its life and use both monetary and fiscal policy to mitigate the economic ramifications after an eventual burst. When considering that the world economy is seeking to regain momentum after the adverse ramifications of the pandemic, we suggest that monetary policy should respond to an eventual future asset price bubble within renewable energy ex-post.

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