ERASMUS UNIVERSITY ROTTERDAM
ERASMUS SCHOOL OF ECONOMICS
MSc Economics & Business,
Specialization Financial Economics

Can We Profit From The Gas Crisis?

The Stock Market Overreaction During The EU Gas Crisis of 2022

Author: M.F. Haasjes
Student number: 543551
Thesis supervisor: Dr. J.J.G. Lemmen
Second reader: **[**tba]
Finish date: November 2023

PREFACE AND ACKNOWLEDGEMENTS

The paper extends the overreaction hypothesis within the context of the financial markets. Its principal objective is to find empirical evidence for the opportunities for abnormal returns that tend to be obtained shortly following events of significant TTF natural gas price movements. This research undertaking was motivated by the enduring tenet within financial theory, which suggests that investors consistently fail to value prices correctly based on recent information. Especially during events of substantial market consequence. Prompted a curious inquiry: “If we know that investors consistently fail to value prices correctly, why not profit from this?” The scope of the research is to investigate the opportunities for abnormal returns caused by significant fluctuations in the TTF natural gas price in Europe.

In addition, I would like to thank Dr. J.J.G. Lemmen for his guidance and patience during this educational thesis process. Especially for his valuable feedback and support. Lastly, I want to thank my family, friends and fellow students for their patience, support, and encouragement during this thesis journey.

ABSTRACT

Investors tend to overreact disproportionately to recent information. This well-established phenomenon in financial theory states that abnormal returns tend to be obtained shortly following such an event. In Europe, gas prices transpired in the period 2021-2023. Within this context, the core purpose of the paper is to investigate if regular investors can profit from the overreaction caused by investors due to significant daily fluctuations in the gas price. I obtained data from the TTF natural gas price and the STOXX-600. My analysis reveals remarkable movements of the market within the event window. Notably, small positive cumulative abnormal returns were found, albeit lacking statistical significance. In this paper, I lack evidence to conclude that regular investors can profit from the overreactions resulting from significant price fluctuations in the TTF natural gas price.

Keywords: European Market, Event Study, Investor Behavior, Overreaction Hypothesis, STOXX-600, TTF Natural Gas Price.

JEL Classification: G14 & G41.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX TABLES

LIST OF FIGURES

CHAPTER 1 Introduction

Gas prices in the EU went to the roof since the start of the Russia-Ukraine war in February 2022. Vladimir Putin started an energy war by cutting gas supplies with the expectation that the EU would drop its support for Ukraine (Cooper, 2023). Later, on 26 September 2022, known as the 2022 Nord Stream pipeline sabotage, the Nord Stream 1 and Nord Stream 2 natural gas lines leaked due to an explosion close to the surface of Denmark. All these events together had their effects on the TTF natural gas price. From February 2022 until April 2023, the TTF natural gas prices massively increased, with implications for the global economy. The Dutch TTF natural gas futures price rose from € 34 to € 310 (+812%) between January 2022 and August 2022 (Figure 1) and fell sharply to € 41 (-87%) afterward (ICE, 2023). The tight gas supply has increased prices and heightened market uncertainty (IEA, 2022). Figure 1 shows that gas prices also somewhat spiked before 2022. Even though gas prices massively increased around February 2022, the market seems volatile. From 22 February 2022 to 24 February 2022, the European share price index of the EuroStoxx 600 fell by 4%, while the European natural gas price rose by 68%. The fall in share price is in the complete opposite direction of the gas market in which the companies operate. The announcement of negative annual results could explain a deviation. However, this shift seems to be caused by an overreaction to Russia's invasion and the consequent rise in the gas price.

In general, for companies that are gas users, an increase in gas prices would hurt the share prices of these companies since profits will be affected negatively due to an increase in cost, which impacts industrial production growth (Acaravici et al. 2012). Of course, the impact on industrial production growth due to the increase in gas prices heavily depends on the flexibility of companies to switch energy sources. In general, is the switch between energy sources a costly and time-consuming process. Increases in gas prices will have a direct effect on output, inflation, and investments, which will affect the stock market. Output may decrease due to an increase in production costs. Firms must pay a higher price for gas or switch to other energy sources. Switching to other energy sources increases production costs. For example, switching to coal leads to firms buying more emission allowances. The emission allowances make the European market different from the US market. Figure 2 provides a summary of the gas price transmission channel.

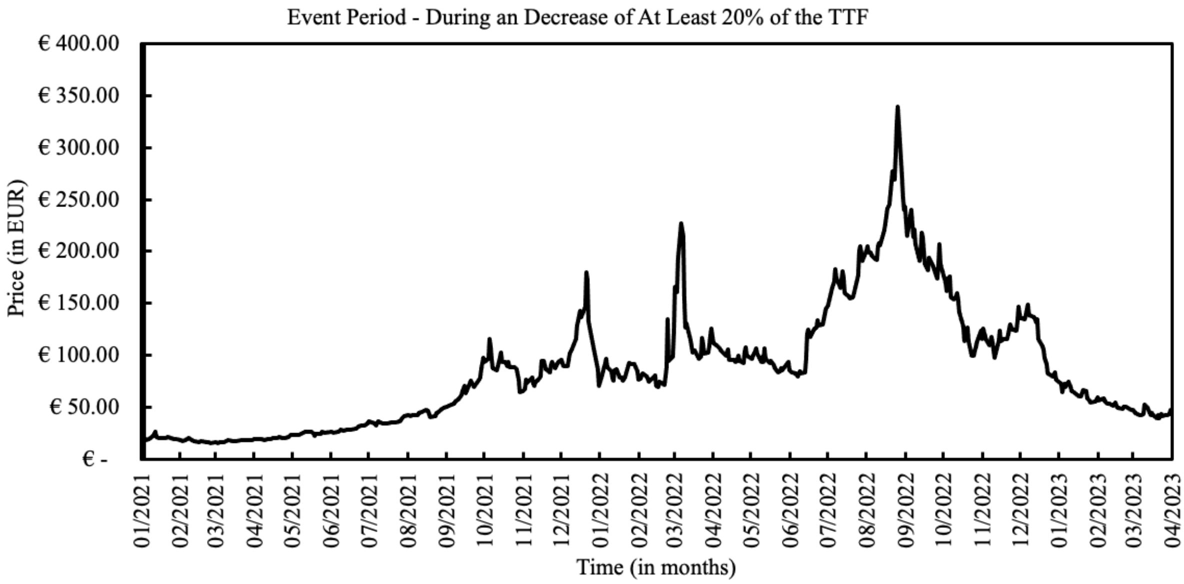
Little recent research has been carried out on the effect of gas prices on stock prices. Research focuses more often on the effect of oil prices on stock prices in recent papers. In the paper of Degiannakis et al. (2018), the authors found evidence of oil price volatility that transmits to stock market volatility. Since gas is a primary energy source, we may expect the same for gas prices. Natural gas was the EU's second supreme source for electricity creation, with a share of 20% in 2021 (Conte, 2023).

In addition, little research has been carried out on the overreaction due to gas prices on the stock market. Most overreaction hypothesis research measures/links the overreaction on the stock market to good/bad news or short-term earnings announcements.
As investors, we are more sensitive to losses than gains, known as loss aversion (Kahneman, and Tversky, 1979; UBS Quantitative Monographs, 2015). Investors tend to overreact to unexpected events (Kahneman, and Tversky, 1982; De Bondt, and Thaler, 1985).

Several researchers found evidence for the overreaction of the stock markets when investors receive good or bad news events (De Bondt, and Thaler (1985); De Bondt, and Thaler (1987); Chan (1988); Lo, and MacKinlay (1990); Piccolo, and Chaudhury (2017). An increase (decrease) in the gas price can be perceived by investors as bad (good) news, which can trigger an overreaction, as mentioned above.

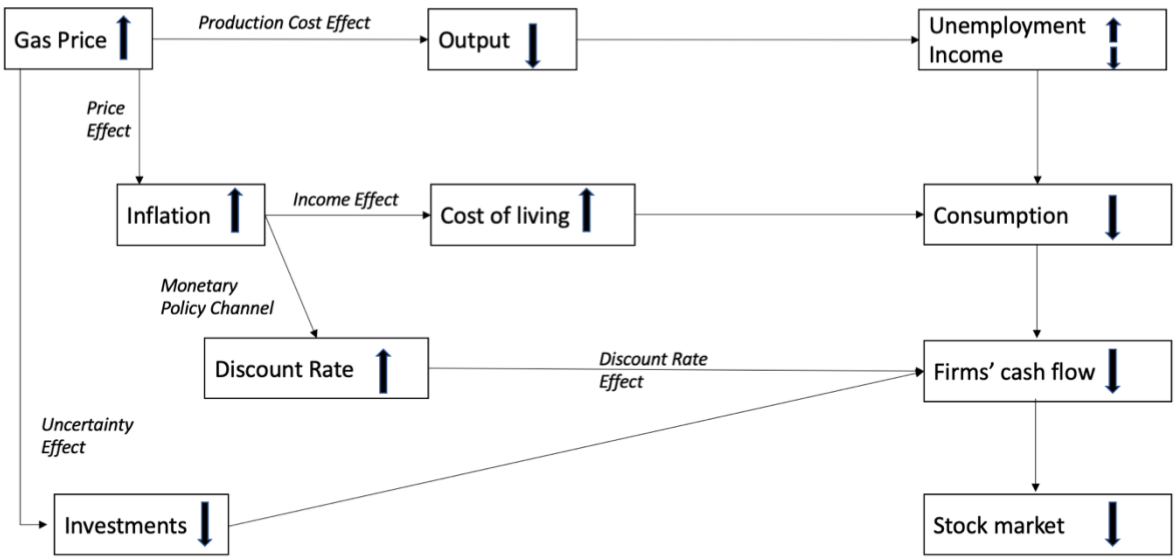
In this paper, I will investigate if we can profit from this overreaction. In other words: "*Can regular investors profit from the overreaction hypothesis in the EU, which occurred due to the gas crisis if transaction costs also have been accounted for*?" Several papers found evidence for profiting from the overreaction hypothesis (De Bondt, and Thaler, 1987; Chan, 1988; Bremer, and Sweeney, 1991; Cox, and Peterson, 1994).

Figure 1. Dutch TTF Natural Gas Futures Historical Data, from January 2021 through March 2023.



Source: ICE, 2023.

Figure 2. Transmission Channel of Positive Gas Price Changes.



Adapted from Degiannakis et al. (2018).

The results of this paper have theoretical implications. Especially for the fields of behavioral finance and financial economics, but also for psychology, since the short-term reaction of investors in the stock market based on the available news investors received from the TTF natural gas market may have relevant results. The tendency of investors to overreact is observed by the spikes in the cumulative return. Next, I found evidence that investors trade more actively around the event date. Besides, these results have relevant information for retail investors. The contrarian trading strategy evaluates if abnormal returns can be obtained by investors when the market tends to overreact based on a significant daily TTF natural gas price fluctuation. Knowing that investors uniformly overreact would indicate that they could achieve abnormal returns without bearing more risk. However, in this paper, I did not find evidence for this statement. In the post-event, where no positive significant abnormal returns were found.

The paper is structured as follows. Firstly, Chapter 2 provides the literature review. In this section, will the main previous finding of the overreaction hypothesis topic be presented. Secondly, Chapter 3 will discuss the data in the paper. This section will describe the descriptives and statistics of the data set. Thirdly, Chapter 4 provides the methodology used in this event study. This chapter discusses the methodology employed for hypothesis testing. The next chapter, Chapter 5, will discuss the empirical findings of the research. In this section, the hypotheses will be discussed and evaluated. Lastly, Chapter 6 provides the conclusion. In this section, I will answer the main research question and debate some limitations and avenues for future research.

CHAPTER 2 Literature Review

In this section, will be the main findings of existing literature discussed. First, I will start by discussing the main results of the overreaction. Next, the sub-section discusses if existing literature provides evidence of the obtainment of abnormal returns due to the overreaction of the market. Thirdly, I will examine if the contrarian strategy yields abnormal returns. The fourth sub-section will discuss the alternative explanations of abnormal returns. Finally, the discussion of the hypotheses. These hypotheses answer the inquiry: "*Can regular investors profit from the overreaction hypothesis in the EU, which occurred due to the gas crisis if transaction costs also have been accounted for*?"

2.1 The Overreaction

In violation of Bayes' rule, most people tend to overreact to dramatic and unexpected news events (Kahneman, and Tversky, 1982; De Bondt, and Thaler, 1985). "…in extreme situations individuals tend to be fearful and appear to focus on losses, largely ignoring probabilities." (Daniel, and Moskowitz, 2016, pp. 242-243). Individuals tend to overweight recent information and underweight base rate/prior data in revising their beliefs, the representativeness heuristic (Kahneman, and Tversky, 1972; De Bondt, and Thaler, 1985). The herding effect may partly explain the overreaction. The herding effect means: "…investors copying the actions of others before leading to a huge rush of investments" (Tharchen, 2012, p. 13). In the paper of Piccoli, and Chaudhury (2017), the authors tried to capture the investor sentiment index in driving individual stock price reactions to extreme movements. The authors found that the overreactions are stronger when investors' sentiment is low rather than high. "…when investors are pessimistic (sentiment is low), they are more perturbed by unusually large market movements, believing that their prior belief was grossly mistaken" (Piccoli, and Chaudhury, 2017, p. 2).

2.1.1 Abnormal Returns

J.M. Keynes was one of the first to observe overreaction in the market. "Day-to-day fluctuations in the profits of existing investments, which are obviously of an ephemeral and non-significant character, tend to have an altogether excessive, and even an absurd, influence on the market." (Keynes, 1936, pp. 153-154). The overreaction hypothesis suggests that stock prices systematically overshoot their reversal should be predictable from past return data alone (De

Bondt, and Thaler, 1985). Investors are subject to waves of pessimism and optimism. They create a “momentum” that causes prices to deviate temporarily from their fundamental values (Lo, and MacKinlay, 1990). De Bondt, and Thaler (1985) found evidence that prior “losers” tend to outperform prior “winners”, which is consistent with the overreaction hypothesis. Investors overreact to short-term earnings movements (De Bondt, and Thaler, 1987). Several researchers found significant reversals for stocks that experience one-day price declines (Brown et al., 1988; Atkins, and Dyl, 1990). On average are extremely negative rates of return followed by statistically significant higher-than-average rates of return (Bremer, and Sweeney, 1991). These findings may be explained by market illiquidity (Cox, and Peterson, 1994). To build on that, Bremer, and Sweeney (1991) found extremely negative 10-day rates of return. These returns are, on average, followed by larger-than-expected positive rates of return, over the following days. It takes approximately two days for the prices to be adjusted, which generates a cumulative return of 2.215% by the second day before transaction costs (Bremer, and Sweeney, 1991). However, Cox, and Peterson (1994) state that extreme initial declines do not lead to more extensive subsequent reversals. The authors found evidence that firms tending to have negative abnormal returns recover in the following three days of the significant price drop, generating a cumulative abnormal return (CAR) of 2% (Cox, and Peterson, 1994). Bremer, and Sweeney (1991, p. 747) state that: “… a slow recovery is inconsistent with the notion that market prices quickly reflect relevant information”. In other words, this finding is inconsistent with the efficient market hypothesis. Fama (1970, p. 383) defines the efficient market hypothesis as: “A market in which prices always ‘fully reflect’ available information is called ‘efficient’. Besides, the return and earnings pattern should be equivalent if earnings surprise drive price behavior (De Bondt, and Thaler, 1987). It is impossible to make risk-adjusted economic profits by trading on information, thereby validating market efficiency if the price did follow a random walk, which means they could not be forecasted (Tharchen, 2012).

2.1.2 The Contrarian Strategy

The objective of a contrarian strategy is to bet against naïve investors to outperform the market. Such as investing in stocks that are underpriced (overpriced) in the market to gain abnormal returns (Lakonishok et al. 1994). In the study of Mishra, and Smyth (2016), the authors tested the gas price is predictability in the United States. The authors failed to find evidence for natural gas futures prices that predict the magnitude of future natural gas spot prices. However, when applying the unit root test that allowed for heteroskedasticity, natural gas spot and futures prices are predictable. They found that simulating a contrarian trading strategy for spot and future prices is profitable, assuming that transaction costs and commissions associated with the trade are zero. Investors can profit following the contrarian strategy if mean reversion holds (Mishra, and Smyth, 2016). If significant gas price movements lead to short-term overreactions in the stock market, investors can profit using the contrarian trading strategy. That said, Chan (1988) did not find evidence of excess returns from the contrarian strategy. The authors find only weak evidence of price reversals. Chan (1988) suggests that excess return is likely to be a normal compensation for the risk in the investment strategy. Lo, and MacKinlay (1990) argue that positive expected profits of some contrarian strategies do not need to imply stock market overreaction. Over half of the expected profits of the contrarian strategy Lo, and MacKinlay (1990) examined are due to cross effects. These effects are the adaptive time-varying effects between different interactions, in this case, stocks (Wang et al. 2021). They found that these cross effects have specific patterns for size-sorted portfolios. Such as large stocks generally leading those of smaller stocks, a lead-lag relation (Lo MacKinlay, 1990).

2.2 Alternative Explanations of Abnormal Returns

The abnormal returns generated by reversals may be accounted for by (1) t*he January effect*/*seasonality*, (2) *the Monday*/*Weekend effect*, (3) *risk changes*, (4) *exchange listing*, (5) *size*, (6) *time*, (7) *bid-ask bounce*, (8) *liquidity*, (9) *limits to arbitrage*.

(1) *The January effect*/*seasonality*. Bremer, and Sweeney (1991) controlled for the *January effect*. They found that the reversal phenomenon is unrelated to the effect. De Bondt, and Thaler (1985) found that the overreaction phenomenon is qualitatively different from the *January effect*. The phenomenon is more generally from seasonality in stock prices. Also, Zarowin (1990) argues that a substantial share of the extra return, 80%, accrues to investors in January.

(2) *The Monday*/*Weekend effect*. Several papers found evidence of day-of-the-week and weekend effects on stock return (Cross, 1973; French, 1980; Gibbons, and Hess, 1981; Rogalski, 1984; Keim, and Stambaugh, 1985). However, Bremer, and Sweeney (1991) found that events unrelated to the Monday or weekend effect stimulate the relationship by almost 76%.

(3) *Risk changes*. Vermaelen, and Verstringe (1986) argue that the overreaction effect is a rational market response to risk changes. Their risk changes hypothesis states

that a decline (increase) in stock prices leads to an increase (decline) in debt-equity (D/E) ratios and risk as measured by CAPM betas (De Bondt, and Thaler, 1987). In the paper of De Bondt, and Thaler (1987), the authors did not find evidence for this view. In contrast with the paper of Chan (1988), the author found evidence for risk changes. Losers seem to be safer in the beginning but become riskier than winners in the end. Chan (1988) controlled for these risk changes and found small abnormal returns of 2.2% - 3.1%. Chan (1988) suggests that these returns are probably not economically significant after controlling for transaction costs. The paper of Daniel, and Moskowitz (2016) did not find explanations that can fully account for their findings, after accounting for compensation for crash risk and volatility risk, to other factors risks (as the Fama, and French (1993) factors). On the other hand, the overreaction effect may also lead to overvalued stocks. These overvalued stocks might increase risk since the investor must sell their stocks to the market to profit from the overvaluation, which leads to stock fluctuations and an increase in risk.

(4) *Exchange listing*. The authors in the paper of Cox, and Peterson (1994) investigated the relationship between the exchange and the degree of reversal. The authors were not able to find a consistent relationship.

(5) *Size*. Several researchers found evidence of a *size effect* (Banz, 1981; Reinganum, 1983; De Bondt, and Thaler, 1987; Lo, and MacKinlay, 1990; Zarowin, 1990). De Bondt, and Thaler (1987) show that excess returns are still significantly related to size. Smaller firms have intense reversals than larger firms (Cox, and Peterson, 1994). The authors found no consistent differences in the degree of reversals across markets after controlling for this *size effect* (Cox, and Peterson, 1994). Lo, and MacKinlay (1990) found that size-sorted portfolios display a lead-lag relation, which indicates that large stocks lead the smaller stocks.

(6) *Time*. Cox, and Peterson (1994) found evidence for reversals that gradually diminish through time. The authors used a dataset from 1963-1991. They did not find reversals after October 1987. Lo, and MacKinlay (1990) argue that security returns that differ over time may be a curcial aspect of stock-price dynamics since it affects the market expectations of investors. In the paper of Daniel, and Moskowitz (2016), the authors show that the strategy's time-varying exposure to volatility risk correlates with the momentum premium. Hence, the momentum premium is not explained by the time-varying exposure to risk (Daniel, and Moskowitz, 2016). Next were momentum crashes observed in times of market stress. An example of a

momentum crash strategy is shorting assets that drop in value to experience high gains.

(7) *Bid-ask bounce*. Cox, and Peterson (1994) found that the bid-ask bounce together with the market liquidity, this explains the short-term price reversals. After controlling for this bid-ask bounce factor, in their data set from 1963-1991, they did not find reversals after October 1987 (Cox, and Peterson, 1994).

(8) *Liquidity*. Cox, and Peterson (1994) found strong reversals in less liquid markets. The degree of reversals reduced through time as markets become more liquid (Cox, and Peterson, 1994), for instance, lower transaction costs and more traders. Note that the roles of bid-ask bounce and liquidity are not distinct. “Greater liquidity likely leads to wider bid-ask spread” (Cox, and Peterson, 1994, p. 256).

(9) *Limits to Arbitrage*. If prices move away from their fundamental value then rational investors/arbitrageurs would bring these prices back to their fundamental values by taking positions against these price movements, according to the efficient market hypothesis (Tarchen, 2012). Arbitrage may, in reality, be risky due to fundamental- and noise trader risk (Barberis, and Thaler, 2003). These risks can create a scenario where arbitrageurs must liquidate early in the event, which worsens mispricing (Tarchen, 2012). Besides, if arbitrageurs face these risks, abnormal returns seem to be more a compensation for risk.

2.3 The Hypotheses

The research question: "*Can regular investors profit from the overreaction hypothesis in the EU, which occurred due to the gas crisis if transaction costs also have been accounted for*?" will be answered with the help of 4 hypotheses:

(1) The stock market does not overreact if the Dutch TTF natural gas price volatility increases or decreases by at least 20%. As mentioned by De Bondt, and Thaler, 1985, investors tend to overweight new information. This hypothesis tests if the overreaction is there in the first place.

(2) The overreaction in the stock market is equally pronounced for an increase as for a decrease in the Dutch TTF natural gas price.

(3) Cumulative abnormal returns cannot be obtained, due to the overreaction in the stock market. This null hypothesis will test if we can profit from the overreaction in the first

place. Multiple papers found evidence for this (De Bondt, and Thaler, 1987; Chan, 1988; Bremer, and Sweeney, 1991; Cox, and Peterson, 1994).

(4) *Cumulative abnormal returns cannot be obtained, due to the overreaction in the stock market if there is accounted-for transaction costs*. Chan (1988) argues that the abnormal returns are probably not economically significant after controlling for transaction costs. During this null hypothesis, I will check if investors can profit or not from the overreaction after accounting for transaction costs.

Table 1. Meta-Analysis

Author (s) (Publication year)	Time period	Region	Method	Control variables	Results
De Bondt, and Thaler (1985)	1926-1982	US	- Market-adjsted, - Market model, and - Sharpe-Linter version of the CAPM.	- January effect, - Seasonality, - Small firm effect, - Dividend yield, and - P/E effects	Cumulative Average Residuals for Losers is +25% compared to Winners
De Bondt, and Thaler (1987)	1926-1982	US	- OLS regression (CAPM).	- Seasonal patterns, - January effect, - Tax code, - Recent share price movements, - Long-term factors, - Winner-loser effect	Annual Returns = 0.993 (Winner portfolio/W) & 1.388 (Loser portfolio/L). January returns = 0.854 (W) & 1.602 (L) February_December returns = 1.007 (W) & 1.384 (L)
Chan (1988)	1932-1983 & 1933-1985	US	- OLS regression (CAPM)	- Risk changes (Market value), and - Maximum annual performance	Abnormal return = 2.2%-3.1%
Lo, and MacKinlay (1990)	1962-1987	US	- Jointly covariance-stationary stochastic process.	- Cross-sectional interaction of security returns over time, and - Size	9% of weekly return variation is predictable using only the preceding week's returns
Bremer, and Sweeney (1991)	1962 - 1986	US	- Event Study	- The January effect, and - The Monday or weekend effect	Cumulative Excess Return (CER) for day 1 = 1.773% CER for day 2 = 2.215%, CER for day 3 = 2.641%
Cox, and Peterson (1994)	1963-1991	US	- Mean-adjusted returns approach, - Market model approach, and - Market-adjusted approach.	- Exchange listing, - Size, - Time, and - Bid-ask bounce.	CAR (1-3 days) = 2% CAR (4-20 days) = -2.09%
MacKinlay (1997)	-	-	- Constant Mean Return Model, - Market Model, - Statistical Model, and - Economic Model.	-	How to construct the methodology/ event study.
Tarchen (2012)	- Financial crisis/Housing Bubble (1997-2006?)	US	- Information cascade, and - Limits to arbitrage.	- Limits to arbitrage, and - Investor psychology	Behavioral finance could provide a more holistic understanding of the underlying factors that led to the crises.
Piccolo, and Chaudhury (2017)	1962-2010	US	- Event study - OLS regression - Fama-French three-factor model	- Investor sentiment	Overreaction is economically and statistically more pronounced when investor sentiment is low rather than high across all event window days.

CHAPTER 3 Data

I examine daily returns following a daily increase or decrease of at least 20 percent in the Dutch TTF natural gas price from January 2021 until March 2023. Daily returns for all Stoxx Europe 600 components. The Stoxx Europe 600 is selected since it is the foremost stock portfolio, including only European stocks. As mentioned, the focus of this paper is on Europe only. Testing the study only in Europe may be a limitation. However, I consider it insightful since most research on the overreaction hypothesis was in the United States. Besides, Europe is more dependent on gas than the US. The US is, followed by Russia and China, the biggest gas suppliers itself.

First, the Dutch TTF natural gas price and the STOXX data set did not have the same size. All dates omitted in both data sets, the missing data points, were removed to fix this size problem. I assumed that the gaps in the data set were randomly distributed and should not be of any problem during the analysis.

Stocks below the 10 EUR will be excluded during the event. This method is consistent with Bremer, and Sweeney (1991). Crucial to remember is that the stock market is closed will during weekends. As mentioned in the literature review, individuals tend to overweight recent information. Investors have more time to rationalize their decisions if information is received during the weekends since the market opens again on Monday. Investors' behavior may be affected due to this delay since they cannot trade immediately.

The data is obtained from Investing.com. This website provided the list of the firms in the STOXX Europe 600. Table 2 shows the statistics of the sample. In the second column are the statistics described based on the daily stock return, and in the third column are the statistics of the TTF natural gas price. All individual firms of the sample are mentioned in Appendix Table A.1. Most firms have their headquarters (HQs) located in the UK, almost ¼ of the sample, Followed by France and Germany (Table 3). Besides, the daily trade volume of the stocks is collected from Yahoo Finance.

Table 2. Descriptive STOXX & TTF Statistics		
Descriptive Table	**STOXX Daily Return**	**TTF Daily Price Movement**
Mean	0.001	0.004
Median	0.000	0.005
Standard Deviation	0.023	0.072
Sample Variance	0.001	0.005
Kurtosis	239.601	6.441
Skewness	0.861	0.751
Range	2.96	0.808
Minimum	-1	-0.297
Maximum	1.961	0.511

All numbers rounded by three decimals, except if the decimal value is zero. NB. All missing values of stocks, for example, due to establishment later in the sample's period, are excluded in this table. Besides noting that the static describes the average of all STOXX together, indicating that some extremes may be balanced out.

Table 3. Geographic Distribution of Sample Firms

Region of HQ's	**Number**	**Fraction**
UK	138	24.5%
France	80	14.2%
Germany	75	13.3%
Switzerland	50	8.9%
Sweden	47	8.3%
Italy	31	5.5%
Netherlands	30	5.3%
Spain	21	3.7%
Denmark	20	3.5%
Belgium	17	3%
Finland	16	2.8%
Norway	16	2.8%
Poland	9	1.6%
Austria	8	1.4%
Ireland	3	0.5%
Portugal	3	0.5%
Total	**564**	**100%**

All stocks are converted to EUR value at the time to standardize the data. Standardizing is crucial to overcome issues by excluding stocks that have a value below 10 EUR. All the currencies in the dataset are referred to in Table 4.

Table 4. Currencies Distribution of Sample Firms

Currency	**Number**	**Fraction**
EUR	286	50.7%
GBP	136	24.1%
CHF	49	8.7%
SEK	48	8.5%
DKK	19	3.4%
NOK	16	2.8%
PLN	9	1.6%
USD	1	0.2%
Total	**564**	**100%**

There are ten sectors, followed by multiple industries in the sample specified (Table 5). It is crucial to pay attention to the different industries into account since they may have different reactions to an increase in gas prices. For example, as assumed in Figure 2, an increase in gas prices will hurt the total stock market. Of course, this may not be precisely the case since some sectors/industries may be less dependent on gas than others. The stock prices of these less dependent sectors/industries may increase if the TTF natural gas prices increase. The largest sectors in the sample are *Financials* and *Industrials*, specified in Table 5.

Table 5. Sector & Industry of the Sample Firms

Sector & Industry	Number	Fraction
Financials		
Banking Services	42	7.4%
Insurance	27	4.8%
Investment Banking & Investment Services	23	4.1%
Investment Holding Companies	6	1.1%
Financials Total	**98**	**17.4%**
Industrials		
Machinery, Tools, Heavy Vehicles, Trains & Ships	38	6.7%
Professional & Commercial Services	21	3.7%
Aerospace & Defense	10	1.8%
Construction & Engineering	6	1.1%
Freight & Logistics Services	6	1.1%
Transport Infrastructure	4	0.7%
Passenger Transportation Services	3	0.5%
Construction & Engineering	2	0.4%
Diversified Industrial Goods Wholesale	1	0.2%
Industrials Total	**91**	**16.1%**
Consumer Cyclicals		
Automobiles & Auto Parts	16	2.8%
Homebuilding & Construction Supplies	12	2.1%
Hotels & Entertainment Services	12	2.1%
Media & Publishing	11	2.0%
Specialty Retailers	9	1.6%
Textiles & Apparel	9	1.6%
Diversified Retail	3	0.5%
Household Goods	3	0.5%
Consumer Cyclicals Total	**75**	**13.3%**
Technology		
Software & IT Services	25	4.4%
Telecommunications Services	21	3.7%
Semiconductors & Semiconductor Equipment	7	1.2%
Electronic Equipment & Parts	4	0.7%
Communications & Networking	2	0.4%
Financial Technology (Fintech) & Infrastructure	2	0.4%
Computers, Phones & Household Electronics	1	0.2%
Office Equipment	1	0.2%
Technology Total	**63**	**11.2%**
Basic Materials		
Chemicals	26	4.6%

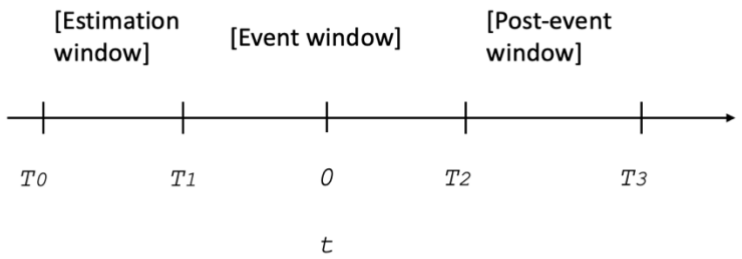
Metals & Mining	13	2.3%
Containers & Packaging	5	0.9%
Paper & Forest Products	5	0.9%
Construction Materials	3	0.5%
Construction & Engineering	1	0.2%
Basic Materials Total	**53**	**9.4%**
Consumer Non-Cyclicals		
Food & Tobacco	17	3.0%
Food & Drug Retailing	13	2.3%
Beverages	11	2.0%
Personal & Household Products & Services	6	1.1%
Consumer Goods Conglomerates	3	0.5%
Specialty Retailers	1	0.2%
Consumer Non-Cyclicals Total	**51**	**9.0%**
Healthcare		
Healthcare Equipment & Supplies	20	3.5%
Pharmaceuticals	16	2.8%
Biotechnology & Medical Research	7	1.2%
Healthcare Providers & Services	3	0.5%
Healthcare Total	**46**	**8.2%**
Real Estate		
Residential & Commercial REITs	18	3.2%
Real Estate Operations	17	3.0%
Real Estate Total	**35**	**6.2%**
Utilities		
Electrical Utilities & IPPs	14	2.5%
Multiline Utilities	9	1.6%
Water & Related Utilities	3	0.5%
Natural Gas Utilities	2	0.4%
Utilities Total	**28**	**5.0%**
Energy		
Oil & Gas	13	2.3%
Oil & Gas Related Equipment and Services	9	1.6%
Renewable Energy	2	0.4%
Energy Total	**24**	**4.3%**
Grand Total	**564**	**100.0%**

CHAPTER 4 Methodology

4.1 Event Study Methodology

The event study methodology, as defined by MacKinlay (1997), is used to evaluate the Dutch TTF natural gas prices increase/decrease effect. The event study will help to analyze if abnormal returns can be obtained, due to overreaction. The event study will stretch from -20 to +20 relative days to the event. Avoiding overlap between the *Estimation Window* and the *Event Window* (Figure 3). The start of the event, t=0, is the day that the Dutch TTF natural gas price increases/decreases by at least 20 percent.

Figure 3. Timeline for the Event Study.



Adapted from MacKinlay (1997)

4.2 Hypotheses Testing

The four hypotheses of this paper will be tested with the help of a comparison and t-static performed in *Phyton*. The data is obtained from Investing.com for both the stock prices and the Dutch TTF natural gas prices and Yahoo Finance for the stock daily volume. As mentioned in the section before, I examine daily stock returns following one-day TTF price declines/increases of 20 percent or more.

(1) The stock market does not overreact if the Dutch TTF natural gas price volatility increases or decreases by at least 20%. The overreaction will be evaluated in two ways: 1. Percentage price changes, and 2. Volatility of percentage price changes (σ).

If the stock market overreacts to the gas price increase or decrease by at least 20% on a day base, then the price will swing wildly during the *Event Window*. In this case, an overreaction in the stock price will be observed. The null hypothesis (H_0) is that there is no overreaction in the stock market if the TTF natural gas price increase or decrease at least 20% (Equation 1). In other words, the market will behave normally. For the alternative hypothesis (H_a), if there is an increase or decrease in the TTF natural gas price by at least 20%, there will be an overreaction in the stock market (Equation 2).

$$H_{0(percentage\ price\ change)[increase\ TTF\ |decrease\ TTF]}: \quad TTF_{\tau-1} \cdot (0.8 > \chi < 1.2) \neq OP_i \tag{1}$$

$$H_{a(percentage\ price\ change)[increase\ TTF\ |decrease\ TTF]}: \quad TTF_{\tau-1} \cdot (0.8 > \chi < 1.2) = OP_i \tag{2}$$

TTF = The Dutch TTF natural gas price at time t.

χ = The price change between TTF at period τ=0 and TTF at period τ=-1.
$\chi = 1 + \Delta$TTF.

OP_i = The overreaction of the stock price of firm *i*.

i = The specific firm.

τ = The period in days.

Besides, if the stock market becomes volatile and prices fluctuate over a given period, then this may be a sign of investors who are unable to deal with new information and temporarily overreact. Prices will fluctuate more during the event compared to the whole sample period. In other words, the volatility of the stock prices will be greater during the event/sample period than in the control period if there is an overreaction. In the null hypothesis (H_0), I will indicate that there is no overreaction based on the volatility (Equation 3). In other words, the volatility during the event dates will not significantly differ from the STOXX600 market volatility in the period January 2021 until March 2023. In the alternative hypothesis (H_a), I indicate that the volatility during the event dates significantly differs from the STOXX600 market volatility in the period January 2021 until March 2023 (Equation 4). Significance will be tested with the help of a *t*-test.

$$H_{0(volatility)[increase\ TTF\ |decrease\ TTF]}: \sigma P_{e,i} = \sigma P_{s,i} \tag{3}$$

$$H_{a(volatility)[increase\ TTF\ |decrease\ TTF]}: \sigma P_{e,i} \neq \sigma P_{s,i} \tag{4}$$

$\sigma P_{e,i}$ = The price volatility during the event of firm *i*.

$\sigma P_{s,i}$ = The price volatility during the whole sample period of firm *i*.

i = The specific firm.

(2) *The overreaction in the stock market is equally pronounced for an increase as for a decrease in the Dutch TTF natural gas price*. This hypothesis will follow the same logic as the first hypothesis. The percentage price changes and the volatility (σ) during the overreaction will be compared between the significant increase and decrease of the TTF. This hypothesis is based on the disposition effect, indicating that investors tend to sell winning stocks and keep holding the stocks that decreased in value. As mentioned before, an increase (decrease) of the TTF Dutch gas price will decrease (increase) the stock price. According to the disposition effect, investors will hold losing stocks, this may pronounce the overreaction effect more. On the other hand, selling the stock that increased in value, winning stocks, may balance the overreaction effect somewhat out. The null hypothesis (H_0) is that the overreaction to an increase of at least 20% in the Dutch TTF natural gas price is equal to the overreaction to a decrease of at least 20% in the Dutch TTF natural gas price (Equation 5 & 7). The alternative hypothesis (H_a) suggests that the overreaction of an increase of at least 20% in the Dutch TTF natural gas prices differs from the decrease of at least 20% in the Dutch TTF natural gas price (Equation 6 & 8). The significance will be tested with the help of a *t*-test.

$$H_{0(percentage\ price\ change)}: OP_i \uparrow = OP_i \downarrow \tag{5}$$

$$H_{a(percentage\ price\ change)}: OP_i \uparrow = OP_i \downarrow \tag{6}$$

$$H_{0(volatility)}: \sigma P_{e,i} \uparrow = \sigma P_{e,i} \downarrow \tag{7}$$

$$H_{a(volatility)}: \sigma P_{e,i} \uparrow \neq \sigma P_{e,i} \downarrow \tag{8}$$

OP_i = The overreaction in the stock price of firm *i*.

$\sigma P_{e,i}$ = The price volatility during the event of firm *i*.

↑ = Increase of the Dutch TTF natural gas price.

↓ = Decrease of the Dutch TTF natural gas price.

i = The specific firm.

(3) *Cumulative abnormal returns cannot be obtained, due to the overreaction in the stock market.* If hypothesis (1) is rejected, the stock market seems to overreact due to 'extreme' increases/decreases of the TTF natural gas price in this dataset, and the stock market does this consistently, then we can profit from this by trading on this overreaction effect, with a contrarian strategy. The *Market-adjusted return* model will be used to measure the abnormal return that can be obtained. This model is not affected by events, as with the *Market* model. The *Market-adjusted return* model assumes that alpha is zero and beta is 1 in Equation (9). The parameters for the *Market* model need to be estimated over a historical estimation period. The benchmark proxy is the average STOXX 600 return from January 2021 to March 2023.

$$R_{i,\tau} = \alpha + \beta_i R_{m,\tau} + \varepsilon_{i,\tau} \tag{9}$$

$R_{i,\tau}$	=	The normal expected return of firm *i* at time τ.
α	=	The intercept.
β_i	=	Sensitivity measure of R_m.
$R_{m,\tau}$	=	The market return at time τ.
$\varepsilon_{i,\tau}$	=	The error term/ random disturbance component.
i	=	The specific firm.
τ	=	The period in days.

With the help of Equation (9), can the abnormal return be measured of firm *i* on day τ ($AR_{i,\tau}$). This equation will measure what the raw performance of the firm is versus the estimated 'normal' performance of the firm. The $R_{m,\tau}$ is subtracted from $R_{i,\tau}$ to calculate *abnormal return* in the *Market-adjusted return* model. The benchmark proxy ($R_{m,\tau}$) is the aggregated average return generated for the Stoxx600 in the period January 2021 until March 2023.

$$AR_{i,\tau} = R_{i,\tau} - R_{m,\tau} \tag{10}$$

$AR_{i,\tau}$	=	The abnormal return of firm *i* at time τ.
$R_{i,\tau}$	=	The normal expected return of firm *i* at time τ.

$R_{m,\tau}$ = The market return at time τ.

i = The specific firm.

τ = The time period in days.

The cumulative abnormal return (CAR) can be measured by aggregating the abnormal returns through multiple periods.

$$CAR_{i,(\tau1,\tau2)} = \sum_{\tau=\tau1}^{\tau2} AR_{i,\tau} \tag{11}$$

$CAR_{i,}$ = The cumulative abnormal return of firm *i*.

$AR_{i,\tau}$ = The abnormal return of firm *i* at time τ.

i = The specific firm.

τ = The period in days.

The null hypothesis (H_0), indicating cumulative abnormal return cannot be earned, due to the overreaction of the stock market (Equation 12). The alternative hypothesis (H_a) indicates cumulative abnormal return can be earned, due to the overreaction of the stock market (Equation 13). The significance of the CAR will be measured with the help of the *t*-statistic, the same as provided in the paper of Cox, and Peterson (1994). The null hypothesis will be rejected if the CAR is positive and significant.

$$H_{0[increase\ TTF|decrease\ TTF]}: CAR_{i,(\tau1,\tau2)} = 0 \tag{12}$$

$$H_{a[increase\ TTF|decrease\ TTF]}: CAR_{i,(\tau1,\tau2)} > 0 \tag{13}$$

(4) *Cumulative abnormal returns cannot be obtained, due to the overreaction in the stock market if there is accounted-for transaction costs*. The same knowledge will be used as for hypothesis 3, except transaction costs are included. Transaction costs can consist of execution costs, commissions, fees, and opportunity costs (Collins, and Fabozzi, 1991). The fixed costs (commissions, transfer fees, and taxes) can be easily measured. Unfortunately, are the variable costs, indicating execution costs and opportunity costs hard to monetize. To calculate the

transaction costs, I will use the implementation shortfall of Perold (1988), modeled by Briere et al. (2020):

$$|TC_{i,\tau}| = IS_k(m,\tau) = \frac{s_k\ (m)}{P_k\ (0)} \left(\sum_{i=1}^{N\ trades} \frac{v_{k,m}\ (i)}{Q_k\ (m)} \cdot\ P_k(i) - P_k^{ref} \right) \tag{14}$$

$TC_{i,\tau}$	=	Transaction costs of firm stock *i* at time τ in percentage of the benchmark price. These costs cannot be negative.
$IS_k(m,\tau)$	=	Implementation shortfall of firm stock *i* at time τ.
$s_k\ (m)$	=	Side (Buy/Sell) of the order (1 for buy orders and -1 for sell orders)
$P_k\ (0) = P_k^{ref}$	=	The reference price (in our case, price at event date 0).
$v_{k,m}\ (i)$	=	Size of execution at date τ.
$Q_k\ (m)$	=	Size of the order.
$P_k(i)$	=	The price at the end of the event.
$N\ trades$	=	Number of trades.
i	=	The specific firm stock.
τ	=	The period in days.

Equations (11) and (14) are combined to measure the cumulative abnormal returns accounting for transaction costs. The transaction cost will be settled when executing the contrarian strategy.

$$CAR_{i,(\tau1,\tau2)[corrected\ for\ TC]} = \sum_{\tau=\tau1}^{\tau2} (AR_{i,\tau}) - TC_{i,\tau} \tag{15}$$

$CAR_{i,}$	=	The cumulative abnormal return of firm *i*. after accounting for transaction costs.
$AR_{i,\tau}$	=	The abnormal return of firm *i* at time τ.
$TC_{i,\tau}$	=	Transaction costs of firm stock *i* at time τ.
i	=	The specific firm.
τ	=	The period in days.

The null hypothesis (H_0) indicates cumulative abnormal returns cannot be earned, after accounting for transaction costs (Equation 16). The alternative hypothesis (H_a) indicates cumulative abnormal returns can be earned, after accounting for transaction costs (Equation

17). Significance of this hypothesis will be tested with the help of a *t*-statistic, same as for the third hypothesis. Note that if the outcome of the *t-statistic* is not significant in hypothesis three, then it is worth nothing measure the significance in this hypothesis.

$$H_{0[increase\ TTF|decrease\ TTF]}: CAR_{i,(\tau 1,\tau 2)[corrected\ for\ TC]} = 0 \qquad (16)$$

$$H_{a[increase\ TTF|decrease\ TTF]}: CAR_{i,(\tau 1,\tau 2)[corrected\ for\ TC]} > 0 \qquad (17)$$

CHAPTER 5 Results

In this chapter I will discuss the results of the hypotheses stepwise. At the end of the hypothesis discussion will a small summary be provided that summarizes which hypotheses are rejected or not rejected. Lastly, is a robustness test conducted.

5.1 Is there an Overreaction in the first place?

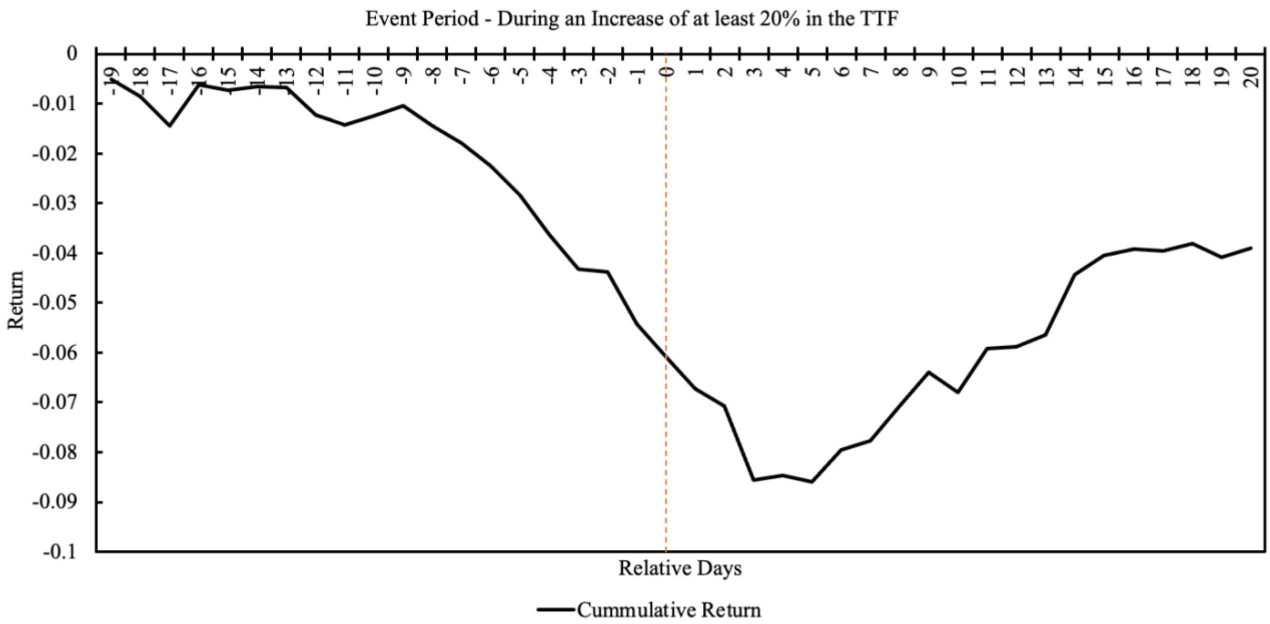
In this sub chapter, I will test if there is an overreaction in the first place before abnormal returns can be tested. That may occur due to the overreaction. In other words, as stated in the hypothesis chapter:

(1) *The stock market does not overreact if the Dutch TTF natural gas price volatility increases or decreases by at least 20%*. This overreaction will be tested in two ways: 1. Percentage price changes, and 2. Volatility of percentage price changes (σ).

First, I test if there is an overreaction graphically based on the cumulative returns of the stocks in the portfolio. Note that the *Financial* and *Utilities* are dropped from the sample since these sectors differ much from the non-financial sectors. Besides, are the stocks excluded that have a value lower than 10 EUR at event data 0, since these small stocks have generally higher volatility and are generally less liquid. As mentioned before, stock prices are converted to Euros to overcome issues with the threshold of 10 EUR. Next, do I separately test the overreaction due to an increase or decrease in the TTF natural gas price. That is to overcome the issue of both overreactions balancing each other out. In other words, if an increase in the TTF natural gas price leads to a decrease in the stock price and a decrease in the TTF natural gas price and vice versa, then the overreaction could be elusive.

The increase in the TTF natural gas price affects the stock market in Europe (Figure 4). At event date 0, the vertical red dotted line, there is a decrease in the aggregated cumulative return. However, based on this graph there cannot be concluded if this decrease has a direct effect on the stock market since the cumulative returns start dropping nine days before the event date. The results shown in Figure 4 are assumptions in the transmission channel of positive gas price changes, described in Figure 2. The assumption was that if gas prices increased, that would have a production cost effect, a price effect, an income effect, and a discount rate effect, which eventually would lead to a decrease in the stock returns on the stock market. Interesting to see is that returns recover around five days after the event. That may be due to the overreaction of investors. However, no significant immediate movement is observed at the event date. However, the price at event date 0 dropped 12.3% compared to the day before. To conclude, the null hypothesis ($H_{0(percentage\ price\ change)[increase\ TTF]}$), which indicates that the stock market does not overreact, can be rejected based on Figure 4. This figure demonstrates that the stock market overreacts to this significant movement in the Dutch TTF natural gas market in the first five days since the aggregated cumulative returns increase afterward. (Figure 4). The aggregated cumulative return increased by 25.6% from five to nine days after the event date.

Figure 4. Cumulative Stock Return If the TTF Natural Gas Price



I zoomed in on the volatility during the event and compared this with the general volatility of the market to check if there is an overreaction.

Table 6. The Volatility During the Event if Gas Prices Increase by at least 20% vs. the Market

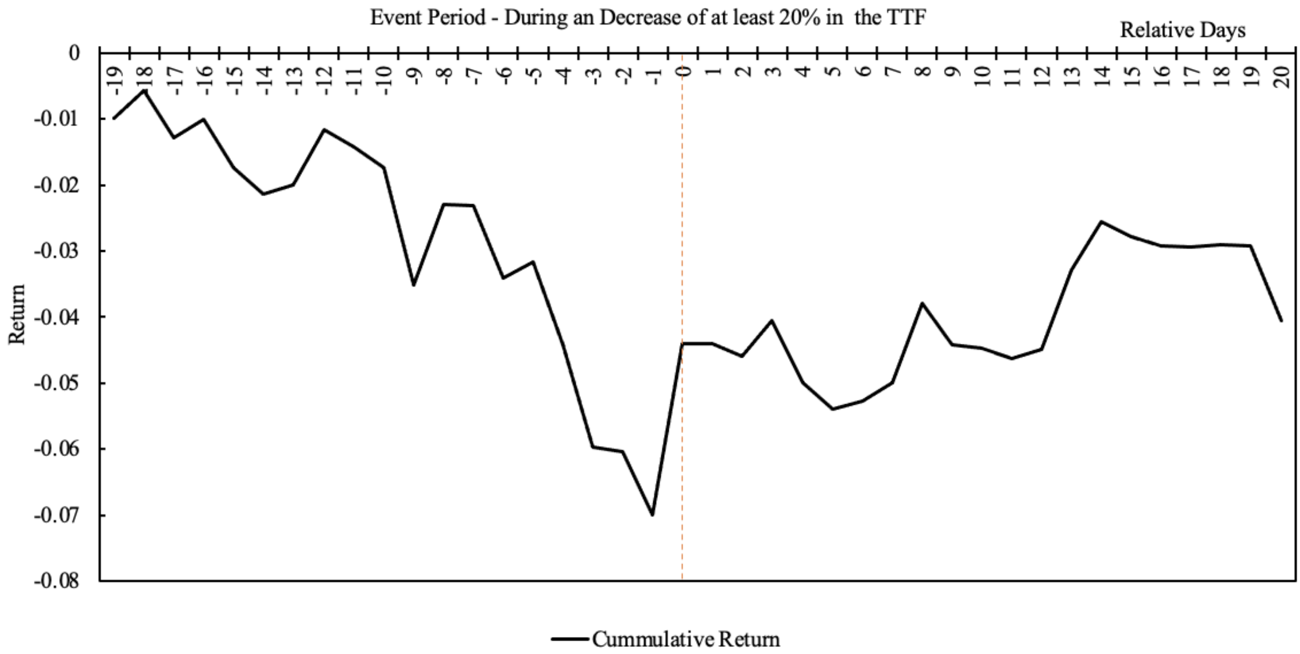
Period	**Volatility**	**P-value**
During Event (increase in the gas price)	0.006	(0.000) ***
Benchmark (STOXX600)	0.023	

Note that the volatility is rounded by three decimals.

The null hypothesis ($H_{0(volatility)[increase\ TTF]}$), which indicated that the volatility during the event would be equal to the benchmark volatility, will be rejected based on the information in

Table 6. The volatility during the event is significantly (at a 1% level) lower than the average market volatility (0.006 > 0.023). Higher volatility indicates that the prices of the stocks are moving steeper and quicker. Besides, volatility is frequently used as an indication of risk. In other words, during the events, the risk is lower than the average market. However, this outcome was against prior expectations.

Figure 5. Cumulative Stock Return If the TTF Natural Gas Price Decreases



A decrease in the TTF natural gas price has a significant positive effect on the aggregated cumulative stock return (Figure 5). The cumulative return increased by 36.9% compared to the day before. The cumulative return line somewhat fluctuates and drops shortly after this increase at the event date. However, there seems to be an upward trend after the event date. The market appears to overreact in the first five days after the event date since the price drops sharply after. To conclude, the null hypothesis ($H_{0(percentage\ price\ change)[decrease\ TTF]}$), which indicates that the stock market does not overreact, will be rejected based on Figure 5. This figure indicates that the stock market overreacts to this significant movement in the Dutch TTF natural gas market since the cumulative return moves upwards at the event date (Figure 5).

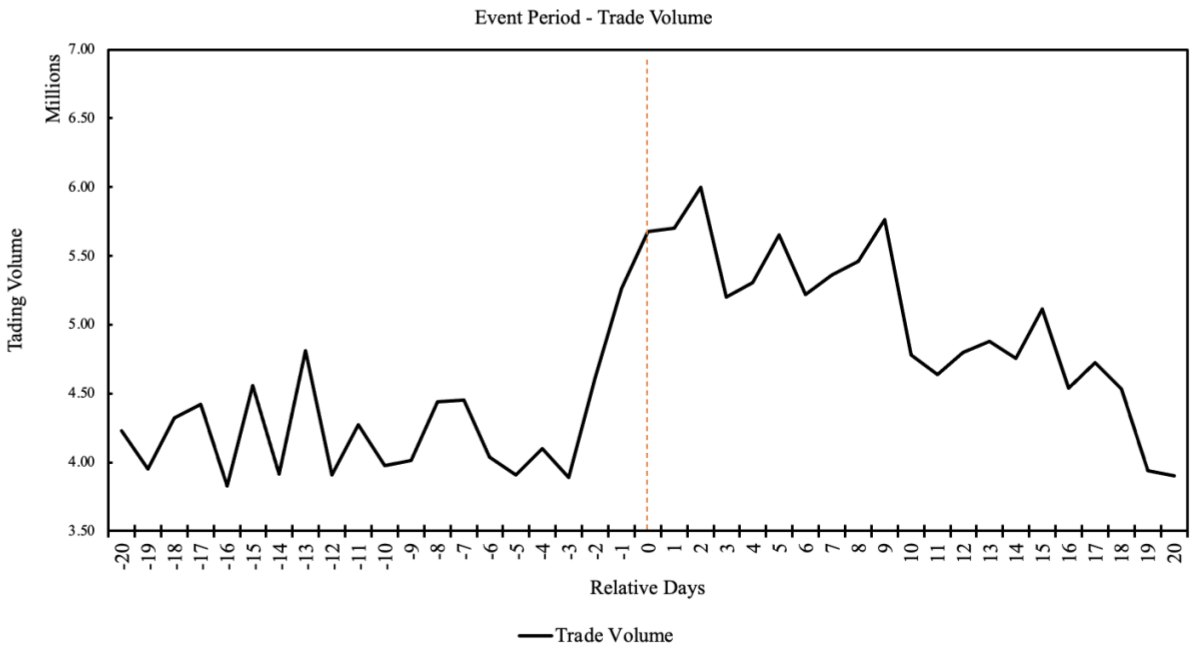
The volatility of this event is checked and compared with the market volatility, same as for the increase of the Dutch TTF natural gas price.

Table 7. The Volatility During the Event if Gas Prices Decrease by at least 20% vs. the Market		
Period	**Volatility**	**P-value**
During Event (decrease in the gas price)	0.009	(0.000) ***
Benchmark (STOXX600)	0.023	

Note that the volatility is rounded by three decimals.

The null hypothesis ($H_{0(volatility)[decrease\ TTF]}$), which indicated that the volatility during the event would be equal to the benchmark volatility, will be rejected based on the information in Table 7. The volatility during the event is significantly (at a 1% level) lower than the average market volatility (0.009 > 0.023), the same as with the event of an increase in the gas price, indicating a lower risk during the event. Interestingly similar to an increase in the TTF natural gas price, the volatility during the event is significantly lower than the benchmark.

Figure 6. Trade Volume During the Event



Next to looking at the movements of the stocks and volatility, it is also interesting to look at the trading volume during the events, as plotted in Figure 6. Note that this is the trading volume of all the stocks included in the STOXX600. The trading volume increases significantly three before the event date and softens around ten days after the event date, indicating that investors seem to trade more actively around the event date. This trading activity dampens around ten days after the event day. In other words, investors seem to react quickly to the recent information they received, which is consistent with the papers of Kahneman, and Tversky (1972); De Bondt, and Thaler (1985). Interesting, is that investors trade more actively, and nonetheless the volatility during the event is lower than the benchmark.

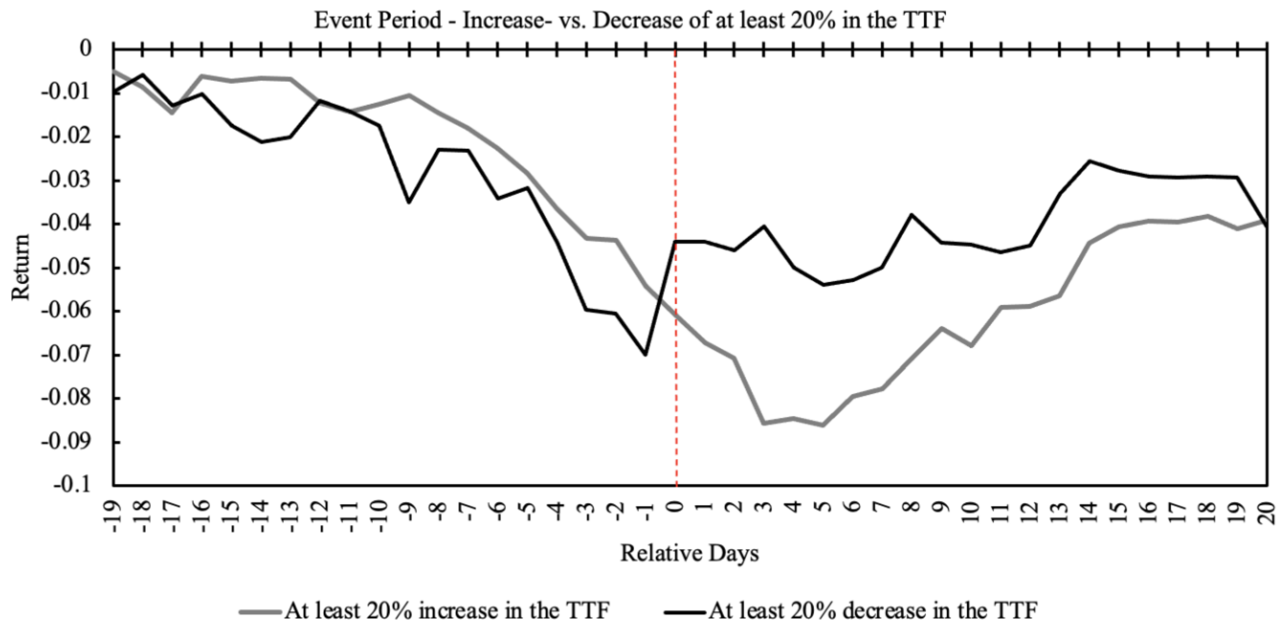
5.2 Overreaction in the Stock Market is Most Pronounced if the TTF Increases

This subchapter will discuss which significant sign in the daily fluctuation movement in the TTF natural gas price will have the most effect on the stock market.

(2) The overreaction in the stock market is equally pronounced for an increase as for a decrease in the Dutch TTF natural gas price.

Both effects are evaluated in Figure 7. The figure mapped Figures 4 and 5 show their contribution to the stock market in one figure. To conclude, which significant sign of the daily fluctuation has the most effect on the market's return.

Figure 7. Increase- vs. Decrease of At Least 20% in the TTF



Again, the red dotted line shows the event date at t=0. The grey line presents the aggregated cumulative return on the stock market during the event period when the TTF natural gas price increased by at least 20%. The black line visualizes the TTF natural gas price decreased by at least 20%.

As expected, move both lines in opposite directions shortly after the event date. The increase in the TTF of at least 20% seems to have a sharper effect in the first five days since prices keep dropping shortly after the event. The aggregated cumulative return for a significant increase in the TTF fell by 41.4% between the event date and five days after the event date. However, the decrease in the TTF of at least 20% has the most significant effect directly at the event date.

Figure 7 provides evidence for an unequal pronounced overreaction during a significant increase compared to a significant decrease in the Dutch TTF natural gas price. The cumulative return for an increase spiked deeper than for a decrease after the post-event period. In the post-event, the increase of aggregated cumulative return is steeper for a significant increase in the TTF than the decrease of the aggregated cumulative return for a significant decrease in the TTF. Based on this evidence is the null hypothesis $H_{0(percentage\ price\ change)}$, which indicated that there would not have been a difference in the amount of overreaction if there is a significant increase or decrease of the TTF natural gas price, rejected.

Table 8. Volatility of an Increase vs. a Decrease

Period	**Volatility**	**P-value**
During Event (increase in the gas price)	0.006	(0.000) ***
During Event (decrease in the gas price)	0.009	(0.000) ***

Note that the volatility is rounded by three decimals.

The null hypothesis ($H_{0(volatility)}$), will be rejected based on the results in Table 8. The overreaction seems not equally pronounced for both events. The volatility during an increase of the gas price is during the event lower than for a decrease in the gas price (0.006 < 0.009). This indicates that the stock returns of the Europe stock market fluctuate more during the events of a decrease of at least 20% in the Dutch TTF natural gas price, compared to an increase of at least 20% in the Dutch TTF natural gas price. As previously mentioned, is volatility frequently used to indicate risk. In other words, this indicates that the risk for a decrease (of at least 20% of the TTF natural gas price) is higher than for an increase (of at least 20% of the TTF natural gas price).

All in all, both tests have shown equal results that the overreaction effect differs based on the movement of the TTF natural gas price. The overreaction effect is not equally pronounced for an increase of at least 20% of the Dutch TTF natural gas price than for a decrease of at least

20% of the Dutch TTF natural gas price. This evidence contradicts the null hypothesis, which indicates that both will have an equal effect on the overreaction hypothesis. Based on the above evidence, I reject the null hypothesis.

5.3 Can we earn Cumulative Abnormal Returns?

In Hypothesis 1, I found overreaction in the stock market based on the significant movements around the event date. Interestingly volatility during the event window was smaller than outside the event window. Of course, this can be the case because the overreaction will be most pronounced closely around the event date instead of in the whole event window. With the help of a contrarian strategy will be checked if CARs can be retrieved. The graphical interpretations have shown some remarkable drops in the returns shortly after the event date.

(3) Cumulative abnormal returns cannot be obtained, due to the overreaction in the stock market.

Both a short-and long strategy will be used as a contrarian strategy since Figures 4 and 5 have shown that a significant increase and a significant decrease in the TTF led to a decrease in the return in the stock market in the following five days, which creates possibilities for the short strategy. However, both a significant increase and a significant decrease in the TTF show that the cumulative stock returns increased from five to twenty days after the event date. Indicating possibilities for a long strategy. The short strategy for retail investors means selling the stock since retail investors cannot/hardly can go short. Their profit will be the depreciation of the asset. For the long strategy, retail investors will buy the stock. Their profit will be the appreciation of the stock.

Table 9. CAR During an Increase in the TTF Natural Gas Price of at least 20%

CAR Period	CAR - Short	t-test[1]	CAR - Long	t-test
CAR(1)	0.63%	0.00	-0.63%	0.00
CAR(1-2)	0.95%	0.01	-0.95%	0.01
CAR(1-3)	2.44%	0.03	-1.48%	0.02
CAR(1-4)	2.32%	0.03	-2.32%	0.04
CAR(1-5)	2.44%	0.03	-0.12%	0.00
CAR(1-6)	1.79%	0.02	-1.79%	0.02
CAR(1-7)	1.58%	0.01	0.21%	0.00
CAR(1-8)	0.87%	0.00	-0.87%	0.01
CAR(1-9)	0.18%	0.00	0.68%	0.00
CAR(1-10)	0.56%	0.00	-0.56%	0.00
CAR(1-11)	-0.34%	0.00	0.90%	0.01
CAR(1-12)	-0.38%	0.00	0.38%	0.00
CAR(1-13)	-0.63%	0.00	0.25%	0.00
CAR(1-14)	-1.85%	0.02	1.85%	0.03
CAR(1-15)	-2.25%	0.03	0.40%	0.00
CAR(1-16)	-2.40%	0.03	2.40%	0.04
CAR(1-17)	-2.38%	0.03	-0.01%	0.00
CAR(1-18)	-2.53%	0.04	2.53%	0.05
CAR(1-19)	-2.27%	0.03	-0.26%	0.00
CAR(1-20)	-2.48%	0.03	2.48%	0.05

The cumulative abnormal returns (CARs) in Table 9 are for the short strategy positive until CAR(1-10). Unfortunately, none of these values is significant, which indicates that I do not have enough evidence to assume that cumulative abnormal returns can be achieved, due to an overreaction of the stock market. However, the long strategy generates some positive CARs at the end of the event window. Unfortunately, the same as for the short strategy are these CARs insignificant. In other words, there is not enough evidence to reject the null hypothesis ($H_{0[increase\ TTF]}$), that cumulative abnormal return cannot be earned, due to overreaction of the stock market. That is the case since no positive significant cumulative abnormal returns were achieved, when using a short or long strategy in times of a significant increase in the Dutch TTF natural gas price.

[1] Portions of cumulative abnormal returns significant at the 90% interval are marked with an *, at the 95% interval are marked with an **, at the 99% interval are marked with an ***.

Table 10. CAR During a Decrease in the TTF Natural Gas Price of at least 20%

CAR Period	CAR - Short	t-test	CAR - Long	t-test
CAR(1)	-0.02%	0.00	0.02%	0.00
CAR(1-2)	0.15%	0.00	-0.15%	0.00
CAR(1-3)	-0.40%	0.00	0.55%	0.00
CAR(1-4)	0.53%	0.00	-0.53%	0.00
CAR(1-5)	0.91%	0.01	-0.38%	0.00
CAR(1-6)	0.77%	0.01	-0.77%	0.01
CAR(1-7)	0.48%	0.00	0.30%	0.00
CAR(1-8)	-0.73%	0.00	0.73%	0.01
CAR(1-9)	-0.12%	0.00	-0.61%	0.00
CAR(1-10)	-0.09%	0.00	0.09%	0.00
CAR(1-11)	0.06%	0.00	-0.15%	0.00
CAR(1-12)	-0.11%	0.00	0.11%	0.00
CAR(1-13)	-1.31%	0.02	1.21%	0.02
CAR(1-14)	-2.07%	0.04	2.07%	0.05
CAR(1-15)	-1.85%	0.03	-0.22%	0.00
CAR(1-16)	-1.73%	0.03	1.73%	0.03
CAR(1-17)	-1.73%	0.03	0.00%	0.00
CAR(1-18)	-1.78%	0.03	1.78%	0.04
CAR(1-19)	-1.77%	0.03	-0.01%	0.00
CAR(1-20)	-0.65%	0.00	0.65%	0.00

Table 10, same as Table 9, is for the short strategy low and mostly negative CARs observed. Besides, are these CARs insignificant, which indicates that I do not have enough evidence to assume that the short strategy will generate cumulative abnormal returns when the stock market overreacts due to a significant decrease in the TTF natural gas price. However, does the long strategy generate several positive returns after a holding period of CAR(1-13). However, the highest cumulative abnormal return (2.07%) is observed for a holding period of CAR(1-14). However, none of these are significant. Based on this lack of evidence will the null hypothesis ($H_{0[decrease\ TTF]}$) not be rejected.

5.4 Can we earn Cumulative Abnormal Returns if we Account for Transaction Costs?

In the post-event period, positive CARs, especially if the TTF natural gas price had a significant daily increase, were observed. Of course, there should also be accounted-for transaction costs to measure the CAR. In this subchapter, I will measure if the cumulative abnormal return can be achieved after accounting for transaction costs, even though the CARs are insignificant.

(4) Cumulative abnormal returns cannot be earned due to the overreaction of the stock market even if there are accounted for transaction costs.

Table 11. CAR Corrected for Transaction Costs During an Increase in the TTF Natural Gas Price of at least 20%

CAR Period	TC	CAR - Short	t-test[2]	CAR - Long	t-test
CAR(1)	2.62%	-2.00%	0.00	-3.25%	0.02
CAR(1-2)	1.84%	-0.89%	0.00	-2.80%	0.01
CAR(1-3)	5.05%	-2.61%	0.01	-6.53%	0.06
CAR(1-4)	5.34%	-3.01%	0.01	-7.66%	0.08
CAR(1-5)	2.02%	0.42%	0.00	-2.15%	0.01
CAR(1-6)	0.14%	1.65%	0.00	-1.92%	0.01
CAR(1-7)	0.70%	0.88%	0.00	-0.50%	0.00
CAR(1-8)	0.00%	0.87%	0.00	-0.87%	0.00
CAR(1-9)	8.67%	-8.49%	0.08	-7.98%	0.09
CAR(1-10)	9.70%	-9.14%	0.10	-10.26%	0.15
CAR(1-11)	0.00%	-0.34%	0.00	0.90%	0.00
CAR(1-12)	0.00%	-0.38%	0.00	0.38%	0.00
CAR(1-13)	8.91%	-9.54%	0.11	-8.65%	0.11
CAR(1-14)	11.00%	-12.86%	0.19	-9.15%	0.12
CAR(1-15)	11.64%	-13.89%	0.23	-11.25%	0.18
CAR(1-16)	11.76%	-14.16%	0.24	-9.37%	0.13
CAR(1-17)	9.84%	-12.22%	0.18	-9.85%	0.14
CAR(1-18)	9.64%	-12.17%	0.17	-7.10%	0.07
CAR(1-19)	9.17%	-11.44%	0.15	-9.43%	0.13
CAR(1-20)	10.89%	-13.37%	0.21	-8.41%	0.10

In the period when the TTF natural gas price increased by at least 20%, were the highest CARs earned. However, after accounting for transaction costs, which capture opportunity- and execution costs, CARs become mostly negative (Table 11). Some positive CARs were found, especially for the short strategy in the CAR holding period CAR(1-5) until CAR(1-8). However, these CARs were insignificant before the correction of transaction costs (TC). Note that the transaction cost shifts across the CAR periods. This is partly caused, due to the opportunity cost, the costs of the sales and buys that were not executed (Perold, 1988). Besides, this is also partly due to price impact, which the execution costs account for. This price impact is specified

[2] Portions of cumulative abnormal returns significant at the 90% interval are marked with an *, at the 95% interval are marked with an **, at the 99% interval are marked with an ***.

by Perold (1988, p. 5) as: '…*the difference between the price you could have transacted at on paper (the average of the bid and ask at the time of the decision to trade) and the price you actually transacted at*…'..

In the period when the TTF natural gas price increased by at least 20%, were the highest CARs earned. However, after accounting for transaction costs, which capture opportunity- and execution costs, CARs become mostly negative (Table 11). Some positive CARs were found, especially for the short strategy in the CAR holding period CAR(1-5) until CAR(1-8). However, these CARs were insignificant before the correction of transaction costs (TC). Note that the transaction cost shifts across the CAR periods. This is partly caused, due to the opportunity cost, the costs of the sales and buys that were not executed (Perold, 1988). Besides, this is also partly due to price impact, which the execution costs account for. This price impact is specified by Perold (1988, p. 5) as: '…*the difference between the price you could have transacted at on paper (the average of the bid and ask at the time of the decision to trade) and the price you actually transacted at*…'..

The cumulative abnormal return when using a short-and-long strategy during a decrease of the TTF natural gas price of at least 20% was before accounting for transaction costs (TCs) generally negative or slightly positive. Unfortunately, all CAR values became negative for both strategies after accounting for transaction costs (Table 12). Indicating that the short-and-long strategy works poorly to generate abnormal returns in the case of a decrease in the TTF natural gas price of at least 20%. Besides, as shown previously, were none of these values significant before accounting for transaction costs.

To conclude, accounting for transaction cost made trading on an increase of the TTF natural gas price of at least 20% somewhat interesting for some holding periods. However, trading on a decrease in the TTF natural gas price of at least 20% is worth nothing. As mentioned in hypothesis 3 and as provided in Tables 11 & 12, none of the CARs were significant, which means that I lack evidence to reject the null hypothesis $(H_{0[increase\ TTF|decrease\ TTF]})$ which indicates cumulative abnormal return cannot be earned after accounting for transaction costs.

Table 12. CAR Corrected for Transaction Costs During a Decrease in the TTF Natural Gas Price of at least 20%

CAR Period	TC	CAR - Short	t-test[3]	CAR - Long	t-test
CAR(1)	4.75%	-4.77%	0.03	-4.73%	0.03
CAR(1-2)	4.36%	-4.21%	0.02	-4.51%	0.03
CAR(1-3)	2.77%	-3.17%	0.01	-2.22%	0.01
CAR(1-4)	1.12%	-0.60%	0.00	-1.65%	0.00
CAR(1-5)	3.78%	-2.87%	0.01	-4.16%	0.02
CAR(1-6)	2.98%	-2.21%	0.01	-3.76%	0.02
CAR(1-7)	6.21%	-5.74%	0.04	-5.91%	0.05
CAR(1-8)	6.56%	-7.30%	0.06	-5.83%	0.05
CAR(1-9)	3.21%	-3.33%	0.01	-3.82%	0.02
CAR(1-10)	7.49%	-7.58%	0.07	-7.39%	0.07
CAR(1-11)	8.00%	-7.94%	0.07	-8.15%	0.09
CAR(1-12)	5.66%	-5.77%	0.04	-5.55%	0.04
CAR(1-13)	3.83%	-5.15%	0.03	-2.63%	0.01
CAR(1-14)	9.97%	-12.04%	0.17	-7.89%	0.08
CAR(1-15)	12.02%	-13.87%	0.22	-12.24%	0.20
CAR(1-16)	4.90%	-6.64%	0.05	-3.17%	0.01
CAR(1-17)	10.19%	-11.92%	0.17	-10.20%	0.14
CAR(1-18)	12.30%	-14.08%	0.23	-10.52%	0.15
CAR(1-19)	12.94%	-14.71%	0.25	-12.95%	0.23
CAR(1-20)	13.04%	-13.69%	0.22	-12.39%	0.21

[3] Portions of cumulative abnormal returns significant at the 90% interval are marked with an *, at the 95% interval are marked with an **, at the 99% interval are marked with an ***.

5.5 *Hypotheses Summary*

In this sub-chapter, a quick overview is provided in Table 13 to summarize the outcome of the hypothesis.

Table 13. Hypotheses Summary Overview

Hypothesis	**The Null Hypotheses** $(\boldsymbol{H_0})$	$(\boldsymbol{H_0})$ **Rejected / Not Rejected**	**Hypothesis Rejected/ Not Rejected**
(1) *The stock market does not overreact if the Dutch TTF natural gas price volatility increases or decreases by at least 20%*	(1.1) $H_{0(percentage\ price\ change)}$ (1.2) $H_{0(volatility)}$	Rejected Rejected	Rejected
(2) *The overreaction in the stock market is equally pronounced for an increase as for a decrease in the Dutch TTF natural gas price.*	(2.1) $H_{0(percentage\ price\ change)}$ (2.2) $H_{0(volatility)}$	Rejected Rejected	Rejected
(3) *Cumulative abnormal returns cannot be obtained, due to the overreaction in the stock market.*	(3.1) $H_{0[increase\ TTF \mid decrease\ TTF]}$	Not Rejected	Not Rejected
(4) *Cumulative abnormal returns cannot be obtained, due to the overreaction in the stock market if there is accounted-for transaction costs.*	(4.1) $H_{0[increase\ TTF \mid decrease\ TTF]}$	Not Rejected	Not Rejected

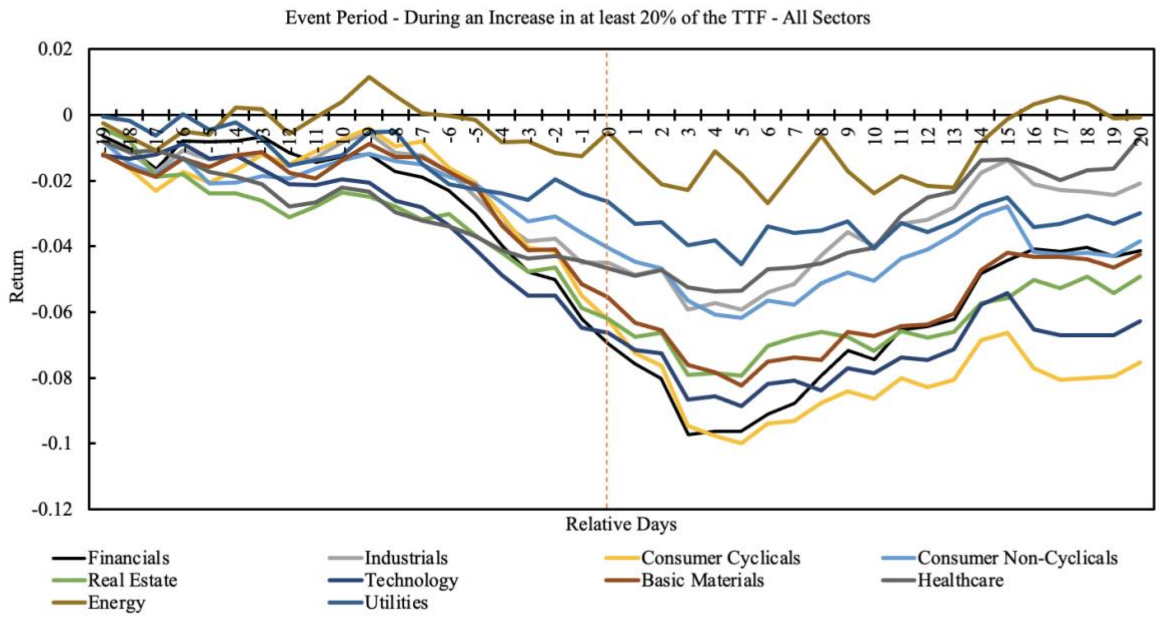
As mentioned in Table 13, no evidence found for profiting from the overreaction hypothesis by regular investors. Significant daily fluctuation in the Dutch TTF natural gas price provided some slightly positive CARs in the stock market. However, were all these CARs insignificant. In this paper, I did find evidence of a significant reaction to the stock market. Besides, does a significant increase and a significant decrease in the Dutch TTF natural gas price does not generate an equivalent overreaction in the stock market.

5.6 Robustness Check

Robustness checks have been conducted first by changing the TTF natural price daily fluctuation trigger to 10% and 15%. Both show similar results. However, was the event overlap for a trigger of 10% or 15% much larger than the used trigger of 20%. These event overlaps caused by the lower triggers could bias the results. These event overlaps occurred because gas prices change constantly. A 10% increase in the Dutch TTF natural gas price was pursued by another 10% increase a day later. Two issues arise. First, events should be excluded, since event overlap will occur, but which events to exclude? This problem is partly reduced by increasing the trigger to 20% to lower the event overlap since a trigger of 20% is less pronounced than the other two triggers. Second, event overlap obtained by a 10% or 15% trigger can be concerning, since it will be unclear if price moments on the stock market are due to the overreaction of investors or due to new price movements of the TTF natural gas price.

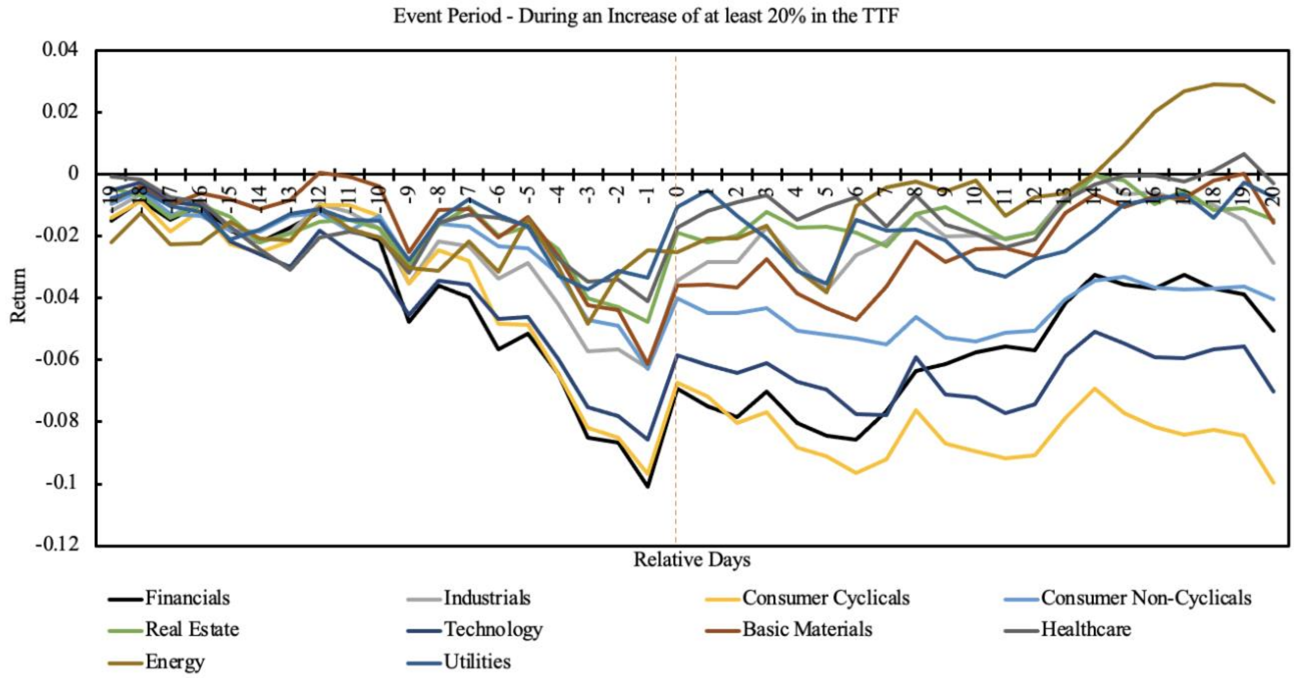
Next to changing the trigger, I zoomed in on all sectors, including in the STOXX600, individually. That is to observe if CARs of individual sectors behave the same as the aggregated CARs. Besides observing if some sectors drive the aggregated CARs. For example, due to extreme movements during the event period. Lastly, to observe the cumulative abnormal returns across sectors. First, I want to check the differences between different sectors for a significant increase in the Dutch TTF natural gas price. The appeal is that all sectors behave in line with the aggregated return. Almost all sectors have, as previously expected, a decrease in their cumulative return at the moment that the TTF significantly increases (Figure 8). However, most sector cumulative returns worsen around ten days before the event date. That may be because gas prices diminish (improve) over time and not necessarily within a day. In other words, for investors, the significant increase in the TTF natural gas price is just another price increase instead of a radical change. However, returns start increasing around five days after the event date. That may indicate that investors process the information of the significant increase within five days after the event and seem to correct this afterward. Of course, as mentioned previously, gas price change from day to day, so this could also indicate that gas price somewhat decreases five days after the event date and improve afterward. That may also be a valid reason for improvement in the cumulative returns of the different sectors. Interesting, is that Energy returns significantly spike during an increase of at least 20% in the Dutch TTF natural gas price. The observed increase in cumulative return was for the Energy sector, an increase of 58%. However, would this have a minor impact on the aggregated cumulative return since all other sectors experienced a drop in their cumulative returns. Remarkable is that the cumulative return of Energy sharply drops three days after the event date. That may be the case due to the misperception of retail investors: "buying the energy stocks since gas prices increase which leads to higher revenue". However, they probably overlook that these forced price increases were not only to push revenues/profits but mainly due to the scarcity of natural gas in Europe. The sectors which experienced the most negatively impacted by the significant increase in the TTF were Consumer Cyclicals (-13.4%), Consumer Non-Cyclicals (-12.5%), Financials (-12.2%), and Utilities (-11.2%). The short strategy and the long strategy were both applied to measure cumulative abnormal returns across the sectors (Appendix 2 & 3). For both strategies were small positive returns found. Unfortunately, all these cumulative abnormal returns are insignificant, even before accounting for transaction costs. This observation of the cumulative abnormal returns is consistent with the observed aggregated cumulative abnormal returns.

Figure 8. Event Period - During an Increase of at least 20% in the TTF - All Sectors



Second, the sector difference across sectors during a significant decrease in the Dutch TTF natural gas price. For the aggregated cumulative return in Figure 5, there was a significant increase in the return observed at the event date, which led to a minor decrease in return around five days after the event. This flow is in line with all sectors shown in Figure 9. All sectors have an upward trend at the event date. Besides, does their cumulative return sharply drop around five days after the event date. Except the Energy sector, which had a slight decrease of 3% at the event date. The sectors influenced the most during the significant decrease in the Dutch TTF natural gas price were Healthcare, Real Estate, and Utilities. For the Healthcare, the cumulative returns increased by 58%, for the Real Estate by 61%, and for the Utilities by 69%. Small positive returns were found, both for the short strategy and long strategy. However, none of these cumulative abnormal returns were significant before accounting for transaction costs (Appendix 4 & 5). Both the flow of the sectors and their returns are consistent with the aggregated cumulative return flow and cumulative abnormal returns.

Figure 9. Event Period - During a Decrease of at least 20% in the TTF - All Sectors



CHAPTER 6 Conclusion

In this paper I investigated the research question: “*Can regular investors profit from the overreaction hypothesis in the EU, which occurred due to the gas crisis if transaction costs also have been accounted for*?” This question was divided into four hypotheses to answer the main question.

First, I tested if an increase and a decrease of the TTF natural gas price of at least 20% on a day base would result in an overreaction of the European stock market. On a graphical base was observed that the stock price moved significantly around the event date. Also, the volatility during the event did differ significantly from the benchmark volatility. However, the market was more volatile outside the event period than during the event period. Of course, this could be affected by other market factors, such as economic indicators, interest rates, or consumer confidence. To conclude, there is enough evidence to reject the null hypothesis based on percentage price change as volatility.

The second hypothesis tested if the market is more prone to overreact due to a significant increase or decrease in the TTF natural gas price. The overreaction effect seems to be more pronounced during an increase of at least 20% of the TTF natural gas price than a decrease of at least 20% of the TTF natural gas price, based on the data in the graph. However, based on the volatility, it seems that the overreaction is more pronounced during a decrease of at least 20% of the TTF natural gas price than an increase of at least 20% of the TTF natural gas price. The null hypothesis is rejected since both the significant increase and the significant decrease in the Dutch TTF natural gas price were not equally pronounced in the stock market.

Thirdly was tested if investors can profit from this overreaction by generating positive cumulative abnormal returns. A contrarian strategy, going short and long, was used to obtain cumulative abnormal returns. This strategy resulted in some positive CAR results for a significant increase in the TTF natural gas price. Especially for the short strategy, shortly after the event date, and at the end of the even period for the long strategy. However, poor CAR results in a significant decrease in the TTF natural gas price were generated. Unfortunately, none of the CAR results were close to significance. This result is consistent with the results of Chan (1988), suggesting that the abnormal return is a normal compensation for the risk in the investment strategy. In other words, I lack evidence in this paper to reject the null hypothesis for hypothesis 3, that CAR results are equal to zero.

Fourthly was tested if the trade was still interesting if we accounted for transaction costs. CAR results became generally negative for both a significant increase as a significant decrease in the TTF natural gas price. The opposite was the case for a significant decrease in the TTF natural gas price. None of the CARs were positive. Again, none of the results were significant, which indicates that the null hypothesis cannot be rejected due to a lack of evidence.

Lastly, was in the robustness section tested if individual sectors behave differently than the aggregated market, as used for the hypotheses testing. The aggregated market used in the hypothesis testing excluded the sectors Financials and Utilities. Interesting was that almost all sectors generally behaved the same as the aggregated market for the hypotheses testing. Besides no positive significant cumulative abnormal returns were found in one of these sectors, which is consistent with the aggregated market. This indicates that I did not find evidence that investors can profit from investments in certain sectors.

All in all, based on these results, I am now ready to answer the research question: "*Can regular investors profit from the overreaction hypothesis in the EU, which occurred due to the gas crisis if transaction costs also have been accounted for*?". I cannot confirm that regular investors can profit from the overreaction hypothesis due to a significant increase or decrease in the TTF natural gas price. Not even in one of the sectors individually. Clearly, the market seems to react to the significant price change of the TTF natural gas price, especially for an increase in the TTF. However, are none of the cumulative abnormal returns significant. This may be the case because the TTF natural gas price changes day by day. So, investors who traded based on a significant fluctuation in the TTF natural gas prices may be partly correct, because gas prices may have increased (decreased) in the following days. This may somewhat approve their trading decision and will dampen the 'overreaction effect'. Besides is the reaction of trading on the daily movement of gas prices harder to capture, than for example dividend policies. It may also be the case that gas prices worsen (improve) overtime. Investors maybe do not realize this 'significant' price increase (decrease), because of the worsen (improve) overtime.

Some limitations may have influenced the results. First, some event overlaps may have influenced the results, since the research sample size was relatively small. Second a threshold of 20% to find a significant TTF natural gas price increase or decrease is not the best method. This is because prices move frequently. Maybe government or news announcements that indicate a significant gas price increase/decrease or a significant increase in the volatility in the TTF natural gas price would have led to different outcomes. As mentioned, gas is next to oil, the second largest energy source. It may be the case that Europe is not as dependent on gas as on oil as previously expected, which may have dampened the overreaction effect. Additionally, the CARs I measured all started at event date 1. A different starting point may could have led to different outcomes. Next, I used the adjusted-market model to measure normal returns. The results probably heavily depend on the chosen model, for example using the market model may had different outcomes. Lastly, I assumed that the stock market was only influenced by the TTF gas price increase or decrease in the event window. Of course, various market factors influence the stock market as well. Future research could account for these market factors to investigate if positive significant CARs can be achieved. Besides, I have shown that a significant TTF gas price increase and decrease have an effect on the stock market around the event date but without evidence of positive and significant abnormal returns shortly after the event. It would be interesting for future research to investigate if the market overreacts in the long-term, if gas prices massively increase or decrease, such as long-term reversal effects.

REFERENCES

Acaravci, A., Ozturk, I., and Kandir, S. Y. (2012). Natural gas prices and stock prices: Evidence from EU-15 countries. *Economic Modelling*, *29*(5), 1646-1654.

Atkins, A. B., and Dyl, E. A. (1990). Price reversals, bid-ask spreads, and market efficiency. *Journal of Financial and Quantitative Analysis*, *25*, 535-547.

Banz, Rolf W. (1981). The relationship between return and market value of common stocks. *Journal of Financial Economics*, *9*, 3-18.

Barberis, N., and Thaler, R. (2003). "A survey of behavioral finance," Handbook of the Economics of Finance, in: G.M. Constantinides & M. Harris & R. M. Stulz (ed.). *Handbook of the Economics of Finance*, *1*(1), 1053-1128.

Bremer, M., and Sweeney, R. J. (1991). The Reversal of Large Stock-Price Decreases. *The Journal of Finance*, *46*(2), 747-754.

Briere, M., Lehalle, C. A., Nefedova, T., and Raboun, A. (2020). Modeling transaction costs when trades may be crowded: A Bayesian network using partially observable orders imbalance. Machine Learning for Asset Management: *New Developments and Financial Applications*, 387-430.

Brown, K. C., and Harlow, W. V. (1988). Market overreaction: Magnitude and intensity. *Journal of Portfolio Management*, *14*, 6-13.

Chan, K. C. (1988). On the Contrarian Investment Strategy. *The Journal of Business*, *61*(2), 147-163.

Collins, B. M., and Fabozzi, F. J. (1991). A methodology for measuring transaction costs. *Financial Analysts Journal*, *47*(2), 27-36.

Conte, N. (February 10, 2023). Mapped: Europe's Biggest Sources of Electricity by Country. *Visual Capitalist*. Retrieved on April 18, 2023, from: https://www.visualcapitalist.com/mapped-europes-biggest-sources-of-electricity-by-country/.

Cooper, C. (January 13, 2023). Whisper it, but Europe is winning the energy war with Putin. *Politico*. Retrieved on April 18, 2023, on: https://www.politico.eu/article/europe-winning-energy-war-putin/.

Cox, D.R., and Peterson, D.R. (1994). Stocks Returns Following Large One-Day Declines: Evidence on Short-Term Reversals and Longer-Term Performance. *The Journal of Finance*, *49*(1), 255-267.

Daniel, K., and Moskowitz, T. J. (2016). Momentum crashes. *Journal of Financial economics*, *122*(2), 221-247.

De Bondt, W. F. M., and Thaler, R. H. (1985). Does the Stock Market Overreact? *The Journal of Finance*, *40*(3), 793-805.

De Bondt, W.F.M., and Thaler, R.H. (1987). Further Evidence on Investor Overreaction and Stock Market Seasonality. *The Journal of Finance*, *42*(3), 557-581.

Degiannakis, S., Filis, G., and Arora, V. (2018). Oil prices and stock markets- A review of the theory and empirical evidence. *The Energy Journal*, *39*(5).

Fama, E.F. (1970). “Efficient capital markets: a review of theory and empirical work”. *Journal of Finance*, *25*, 383−417.

Fama, E.F., and French, K.R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, *33,* 3–56.

ICE (April 18, 2023). Dutch TTF Natural Gas Futures. ICE Endex. Retrieved on April 18, 2023, from: https://www.theice.com/products/27996665/Dutch-TTF-Gas-Futures/data?marketId=5544919&span=3.

IEA (2022). Gas Market Report, Q2-2022. *IEA*, Paris. Retrieved on April 18, 2023, from: https://www.iea.org/reports/gas-market-report-q2-2022.

Investing.com (n.d.). Retrieved on May 1, 2023, until May 30, 2023, from: https://www.investing.com/equities.

Kahneman, D., and Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive psychology*, *3*(3), 430-454.

Kahneman, D., and Tversky, A. (1979). "Prospect Theory: An Analysis of Decision under Risk". *Econometrica*, *47*(4), 263–291.

Kahneman, D., and Tversky, A. (1982). Intuitive prediction: Biases and corrective proce- dures. In D. Kahneman, P. Slovic, and A. Tversky (eds.), Judgement under Uncertainty: Heuristics and Biases. New York: Cambridge University Press.

Keynes, J.M. (1936). The General Theory of Employment, Interest, and Money. *International Relations and Security Network*. (Reprint in 2008).

Lakonishok, J., Shleifer, A., and Vishny, R. W. (1994). Contrarian investment, extrapolation, and risk. *The journal of finance*, *49*(5), 1541-1578.

Lo, A.W., and MacKinlay, A. C. (1990). When Are Contrarian Profits Due to Stock Market Overreaction? *The Review of Financial Studies*, *3*(2), 175-205.

MacKinlay, A.C. (1997). Event Studies in Economics and Finance. *Journal of Economic Literature*, *35*(3), 13-39.

Mishra, V., and Smyth, R. (2016). Are natural gas spot and futures prices predictable? *Economic Modelling*, *54*(February 2007), 178–186.

Perold, A. F. (1988). The implementation shortfall: Paper versus reality. *Journal of Portfolio Management*, *14*(3), 4-9.

Piccolo, P., and Chaudhury, M. (2017). Overreaction to extreme market events and investor sentiment. *Applied Economics Letter*, *25*(2), 115-118.

Reinganum, M. (1983). The anomalous stock market behavior of small firms in January. *Journal of Financial Economics*, *12*, 89-104.

Tarchen, T. (2012). How Can Behavioural Finance Help Us in Better Understanding the Recent Global Financial Crisis? *European Journal of Business and Management*, *4*(5), 7-14.

UBS Quantitative Monographs: Lessons from Behavioural Finance. (2015). A research article from the 'field'.

Vermaelen, T., and Verstringe, M. (1986). "Do Belgians Overreact?" *Working Paper*, Catholic University of Louvain, Belgium.

Wang, C., Ma, W., Zhang, M., Lv, C., Wan, F., Lin, H., Tang, T., Liu, Y., and Ma, S. (2021). Temporal cross-effects in knowledge tracing. In *Proceedings of the 14th ACM International Conference on Web Search and Data Mining*, 517-525.

Zarowin, P. (1990). Size, Seasonality and Stock Market Overreaction. *Journal of Financial and Quantitative Analysis*, *25*, 113–25.

APPENDIX

Appendix 1. Sample Firm Name List

Firm Name List			
3I Group	Derwent	JD Sports Fashion	Sampo Oyj A
A2A	Deutsche Bank AG	Jde Peets	Sandvik AB
AAK	Deutsche Boerse	Jeronimo Martins	Sanofi
Aalberts Industries	Deutsche Post	John Wood	Santander
ABB	Deutsche Telekom AG	Johnson Matthey	Santander Bank Polska
ABN AMRO	Deutsche Wohnen	Julius Baer	SAP
Abrdn	Diageo	Jupiter FM	Sartorius AG VZO
Accor	Diasorin	Just Eat Takeaway	Sartorius Stedim
Ackermans	Dino Polska	K&S AG	SBM Offshore
ACS	Direct Line Insurance	KBC Groep	SCA B
Adecco N	DnB	Kering	Scatec Solar OL
Adidas	Dometic Group publ AB	Kerry Group	Schibsted A
Adler	DS Smith	Kesko	Schindler Ps
Admiral Group	DSV	KGHM Polska Miedz	Schneider Electric
Adyen	Dufry	Kingfisher	Schroders
Aedifica	E.ON SE	Kingspan	SCOR
Aegon	Edenred	Kinnevik B	Scout24 AG
Aena	EDP	Kion Group AG	SEB A
Aeroports Paris	Eiffage	Klepierre	Securitas B
Afry AB	Electricite de France	Knorr-Bremse	Segro
Ageas	Electrolux B	Kojamo	SES
Ahold Delhaize	Elekta B	KONE Oyj	Severn Trent
AIB	Elia	Koninklijke DSM	SGS
Air France KLM	Elis Services SA	Koninklijke KPN	Shell
Air Liquide	Elisa Oyj	Kuehne & Nagel	Siemens AG
Airbus Group	Ems Chemie Hld	L'Oreal	Siemens Healthineers
Aker BP	Enagas	Lagardere	SIG Combibloc
Akzo Nobel	Endesa	Land Securities	Signify
Alcon	Enel	Lanxess AG	Sika
Alfa Laval AB	Engie	LEG Immobilien AG	Siltronic AG
Allegro	Eni SpA	Legal & General	Simcorp A/S
Allianz	Entain	Legrand	Skanska B
Allreal Holding	Epiroc A	Leonardo	SKF B
Alstom	EQT AB	Lindt & Spruengli N	Smith & Nephew
Alten	Equinor	Lloyds Banking	Smiths Group
Amadeus	Erste Group Bank AG	LM Ericsson B	Smurfit Kappa
Ambu	EssilorLuxottica	Logitech	Snam
Amplifon	Essity B	London Stock Exchange	Societe Generale
AMS	Etablissementen Franz Colruyt	Londonmetric Property	Sodexo

Amundi	Eurazeo	Lonza Group	Sofina
Andritz AG	Eurofins Scientific	Louis Vuitton	Softwareone
Anglo American	Euronext	Lufthansa	Soitec
Anheuser Busch Inbev	Eutelsat	Lundbergforetagen B	Solvay
Antofagasta	Evolution Gaming	M&G	Sonova H Ag
ArcelorMittal	Evonik	Man Group	Sopra Steria
Argen-X	Evotec AG	Marks & Spencer	Spectris
Arkema	Experian	Mediobanca	Spie
Aroundtown	Fabege	Melrose Industries	Spirax-Sarco Engineering
Ashmore	Fastighets AB Balder B	Mercedes Benz Group	SSE
Ashtead Group	Faurecia	Merck	SSP
ASM	Ferguson	Merlin Properties SA	St. James's Place
ASML Holding	Ferrari NV	Metro Wholesale	Stadler Rail
ASR Nederland	Ferrovial	Michelin	Standard Chartered
ASSA ABLOY B	FinecoBank	Moller Maersk B	Stellantis NV
Assicurazioni Generali	Flughafen Zurich	Moncler SpA	STMicroelectronics
Associated British Foods	Flutter Entertainment	Mondi	Stora Enso Oyj R
AstraZeneca	Fortum	Morphosys AG	Storebrand
Atlas Copco A	Freenet AG	Mowi	Straumann Holding AG
Atos	Fresenius Medical Care	MTU Aero	Subsea 7
Auto Trader Group Plc	Fresenius SE	Munich Re Group	Svenska Handelsbanken A
Aviva	Fresnillo	National Grid	Swatch Group
AXA	Fuchs Petrolub AG VZO Pref	Naturgy Energy	Swedbank A
B&M European Value Retail SA	Galapagos	NatWest Group	Swedish Orphan Biovitrum
BAE Systems	Galenica Sante	Nel ASA	Swiss Life Holding
Baloise Holding	Galp Energia	Nemetschek AG	Swiss Prime Site
Banco Bpm	GBL	Neste Oil Oyj	Swiss Re
Banco de Sabadell	GEA Group AG	Nestle	Swisscom
Bank Ireland	Geberit	Nexi	Symrise AG
Bank Polska Kasa Opieki	Gecina	Next	Tag Immobilien
Bankinter	Genmab	NIBE Industrier B	Tate&Lyle
Barclays	Georg Fischer	NN Group NV	Taylor Wimpey
Barratt Developments	Getinge B	Nokia Oyj	Tecan Group
Barry Callebaut	Getlink	Nokian Renkaat	TechnipFMC
BASF	Givaudan	Nordea Bank	Tele2 AB
Bayer	Gjensidige Forsikring	Norsk Hydro	Telecom Italia
BBVA	Glanbia PLC	Novartis	Telefonica
Beazley	Glencore	Novo Nordisk B	Telefonica Deutschland AG
Bechtle AG	GN Store Nord	Novozymes B	Telenet
Beiersdorf AG	Grand City	OC Oerlikon Corp	Telenor
Beijer Ref	Grenke	Ocado	Teleperformance
Belimo Holding	Grifols	OMV AG	Telia Company
Bellway	Groupe SEB	Orange	Temenos Group AG

Berkeley
BHP Group Ltd
Biomerieux
BMW ST
BNP Paribas
Boliden
Bollore
Bouygues
BP
Brenntag AG
British American Tobacco
British Land Company
Britvic
BT Group
Bunzl
Burberry Group
Bureau Veritas
Caixabank
Campari
Capgemini
Capita
Carl Zeiss AG
Carlsberg B
Carnival
Carrefour
Casino Guichard
Castellum AB
CD PROJEKT
Cellnex Telecom
Cembra Money Bank AG
Centrica
Chr Hansen
Cineworld
Clariant
Close Brothers
CNH Industrial NV
Coca Cola HBC AG
Cofinimmo
Coloplast
Commerzbank
Compass
Continental AG
ConvaTec Group
GSK plc
H&M B
Halma
Hammerson
Hannover Rueckversicherung SE
Hargreaves Lansdown
Hays
Heidelbergcement
Heineken Holding NV (HEIO)
Heineken (HEIN)
Hella KGaA Hueck & Co
HelloFresh
Helvetia
Henkel VZO
Hera
Hermes International
Hexagon B
HEXPOL B
Hikma Pharma
Hiscox
Holcim
Holmen
Howden Joinery
HSBC
Hugo Boss AG
Huhtamaki Oyj
Husqvarna B
IAG
Iberdrola
ICADE
IG Group
IMCD NV
IMI PLC
Immofinanz
Imperial Brands
Inchcape
Inditex
Industrivarden A
Indutrade AB
Infineon
Informa
ING Groep
Inmobiliaria Colonial
Orion Oyj B
Orkla
ORLEN SA
Orpea
Orron Energy AB
Orsted
Pandora
Partners Group
Pearson
Pennon
Pernod Ricard
Persimmon
Philips
Phoenix
Pirelli & C
PKO Bank Polski
Polymetal
Porsche
Poste Italiane
Prosiebensat
Prosus
Proximus
Prudential
Prysmian
PSP Swiss Property
Publicis Groupe
Puma SE
PZU SA
Qiagen
Quilter
Raiffeisen Bank
Randstad
Reckitt Benckiser
Recordati
Red Electrica
Relx
Remy Cointreau
Renault
Rentokil
Repsol
Rexel
Rheinmetall AG
Richemont
Tenaris
Terna
Tesco
Thales
THG Holdings
Thyssenkrupp AG
Tomra Systems
Topdanmark A/S
TotalEnergies SE
Travis Perkins
Trelleborg B
Tritax Big Box
Tryg
Tui
Tullow Oil
Ubisoft
UBS Group
UCB
Umicore
Unibail-Rodamco
UniCredit
Unilever PLC (ULVR) UK
Unilever PLC (ULVR) NL
Uniper SE
Unite
United Internet AG
United Utilities
UPM-Kymmene
Valeo
Valmet
Varta
VAT Group
Veolia Environnement
Verbund AG Kat. A
Vestas Wind
Viaplay AB
Victrex
Vinci
Virgin Money UK
Vivendi
Vodafone Group PLC
Voestalpine
Volkswagen VZO

Corbion	InterContinental	Rightmove	Volvo B
Covestro	Intermediate Capital	Rio Tinto PLC	Vonovia
Covivio	International Distributions Services	Roche Holding Participation	Vopak
Credit Agricole	Interpump	Rolls-Royce Holdings	Warehouses de Pauw
Credit Suisse	Intertek	Rotork	Wartsila
CRH	Intesa Sanpaolo	Royal Unibrew	Weir Group
Croda Intl	Investec	RS PLC	Wendel
CTS Eventim AG	Investor B	Rubis	WH Smith
Danone	Inwit	RWE AG ST	Whitbread
Danske Bank	Ipsen	SAAB B	Wienerberger AG
Dassault Aviation	ISS A/S	Safran	Wolters Kluwer
Dassault Systemes	Italgas	Sagax B	Worldline SA
DCC	ITV	Sage	WPP
Dechra Pharma	IWG	Saint Gobain	Yara International
Delivery Hero	J Sainsbury	Saipem	Zalando SE
Demant	JC Decaux	SalMar	Zurich Insurance Group

Appendix 2. CAR During an Increase in the TTF Natural Gas Price of at least 20% across Sectors using a Short Strategy

Car[4] / Sector	Basic Materials	Consumer Cyclicals	Consumer Non-Cyclicals	Energy	Financials	Healthcare	Industrials	Real Estate	Technology	Utilities
CAR(1)	0.77%	1.01%	0.41%	0.83%	0.60%	0.23%	0.34%	0.53%	0.52%	0.66%
CAR(1-2)	0.98%	1.37%	0.60%	1.57%	1.02%	0.04%	0.17%	0.40%	0.61%	0.60%
CAR(1-3)	2.01%	3.18%	1.56%	1.71%	2.72%	0.53%	1.38%	1.65%	2.01%	1.28%
CAR(1-4)	2.22%	3.47%	1.96%	0.53%	2.61%	0.66%	1.16%	1.58%	1.88%	1.12%
CAR(1-5)	2.61%	3.70%	2.06%	1.21%	2.58%	0.60%	1.36%	1.66%	2.17%	1.83%
CAR(1-6)	1.88%	3.06%	1.52%	2.08%	2.03%	-0.06%	0.81%	0.72%	1.48%	0.64%
CAR(1-7)	1.74%	2.98%	1.62%	1.07%	1.71%	-0.13%	0.54%	0.47%	1.37%	0.85%
CAR(1-8)	1.79%	2.40%	0.96%	-0.01%	0.85%	-0.27%	-0.36%	0.27%	1.65%	0.75%
CAR(1-9)	0.93%	2.06%	0.62%	1.04%	0.07%	-0.59%	-1.07%	0.40%	0.96%	0.45%
CAR(1-10)	1.03%	2.26%	0.84%	1.71%	0.33%	-0.76%	-0.67%	0.82%	1.08%	1.27%
CAR(1-11)	0.71%	1.62%	0.16%	1.17%	-0.58%	-1.75%	-1.35%	0.20%	0.59%	0.47%
CAR(1-12)	0.65%	1.87%	-0.14%	1.47%	-0.72%	-2.33%	-1.50%	0.38%	0.66%	0.75%
CAR(1-13)	0.31%	1.64%	-0.60%	1.48%	-0.96%	-2.52%	-1.90%	0.19%	0.32%	0.41%
CAR(1-14)	-1.05%	0.41%	-1.21%	0.08%	-2.35%	-3.48%	-2.97%	-0.69%	-1.07%	-0.10%
CAR(1-15)	-1.57%	0.18%	-1.49%	-0.62%	-2.78%	-3.52%	-3.34%	-0.86%	-1.42%	-0.36%
CAR(1-16)	-1.48%	1.24%	-0.13%	-1.09%	-3.14%	-3.27%	-2.63%	-1.43%	-0.33%	0.53%
CAR(1-17)	-1.49%	1.59%	-0.06%	-1.32%	-3.08%	-2.94%	-2.49%	-1.21%	-0.16%	0.41%
CAR(1-18)	-1.44%	1.52%	-0.13%	-1.14%	-3.22%	-3.25%	-2.44%	-1.55%	-0.19%	0.16%
CAR(1-19)	-1.19%	1.43%	-0.04%	-0.72%	-2.96%	-3.31%	-2.34%	-1.07%	-0.19%	0.38%
CAR(1-20)	-1.61%	1.00%	-0.52%	-0.74%	-3.13%	-4.29%	-2.71%	-1.60%	-0.66%	0.03%

[4] Portions of cumulative abnormal returns significant at the 90% interval are marked with an *, at the 95% interval are marked with an **, at the 99% interval are marked with an ***.

Appendix 3. CAR During an Increase in the TTF Natural Gas Price of at least 20% across Sectors using a Long Strategy

Sector / Car[5]	Basic Materials	Consumer Cyclicals	Consumer Non-Cyclicals	Energy	Financials	Healthcare	Industrials	Real Estate	Technology	Utilities
CAR(1)	-0.80%	-1.05%	-0.44%	-0.86%	-0.63%	-0.26%	-0.37%	-0.56%	-0.55%	-0.69%
CAR(1-2)	-1.04%	-1.43%	-0.66%	-1.63%	-1.08%	-0.10%	-0.23%	-0.46%	-0.67%	-0.66%
CAR(1-3)	-2.10%	-3.27%	-1.65%	-1.81%	-2.81%	-0.62%	-1.47%	-1.74%	-2.10%	-1.37%
CAR(1-4)	-2.34%	-3.59%	-2.08%	-0.65%	-2.73%	-0.79%	-1.28%	-1.70%	-2.00%	-1.24%
CAR(1-5)	-2.76%	-3.85%	-2.21%	-1.37%	-2.73%	-0.75%	-1.51%	-1.81%	-2.32%	-1.98%
CAR(1-6)	-2.06%	-3.24%	-1.70%	-2.26%	-2.21%	-0.12%	-0.99%	-0.90%	-1.66%	-0.83%
CAR(1-7)	-1.95%	-3.20%	-1.83%	-1.28%	-1.92%	-0.08%	-0.75%	-0.68%	-1.58%	-1.06%
CAR(1-8)	-2.04%	-2.64%	-1.20%	-0.24%	-1.09%	0.02%	0.11%	-0.51%	-1.89%	-0.99%
CAR(1-9)	-1.20%	-2.33%	-0.89%	-1.31%	-0.35%	0.32%	0.79%	-0.67%	-1.23%	-0.72%
CAR(1-10)	-1.33%	-2.56%	-1.14%	-2.02%	-0.63%	0.46%	0.36%	-1.12%	-1.38%	-1.57%
CAR(1-11)	-1.04%	-1.95%	-0.49%	-1.50%	0.25%	1.42%	1.02%	-0.53%	-0.93%	-0.80%
CAR(1-12)	-1.01%	-2.23%	-0.22%	-1.83%	0.35%	1.97%	1.14%	-0.74%	-1.02%	-1.11%
CAR(1-13)	-0.70%	-2.03%	0.21%	-1.88%	0.56%	2.13%	1.50%	-0.59%	-0.71%	-0.80%
CAR(1-14)	0.63%	-0.83%	0.78%	-0.51%	1.92%	3.05%	2.54%	0.27%	0.64%	-0.32%
CAR(1-15)	1.12%	-0.63%	1.03%	0.17%	2.32%	3.07%	2.88%	0.41%	0.97%	-0.10%
CAR(1-16)	0.99%	-1.73%	-0.36%	0.61%	2.65%	2.78%	2.15%	0.95%	-0.15%	-1.01%
CAR(1-17)	0.98%	-2.10%	-0.45%	0.81%	2.57%	2.43%	1.97%	0.69%	-0.35%	-0.92%
CAR(1-18)	0.89%	-2.06%	-0.41%	0.60%	2.68%	2.70%	1.90%	1.01%	-0.35%	-0.70%
CAR(1-19)	0.62%	-2.01%	-0.53%	0.14%	2.39%	2.74%	1.77%	0.50%	-0.38%	-0.96%
CAR(1-20)	1.01%	-1.61%	-0.09%	0.14%	2.53%	3.69%	2.11%	0.99%	0.05%	-0.64%

[5] Portions of cumulative abnormal returns significant at the 90% interval are marked with an *, at the 95% interval are marked with an **, at the 99% interval are marked with an ***.

Appendix 4. CAR During a Decrease in the TTF Natural Gas Price of at least 20% across Sectors using a Short Strategy

Car[6] \ Sector	Basic Materials	Consumer Cyclicals	Consumer Non-Cyclicals	Energy	Financials	Healthcare	Industrials	Real Estate	Technology	Utilities
CAR(1)	-0.03%	0.43%	0.45%	-0.48%	0.54%	-0.55%	-0.61%	0.29%	0.31%	-0.55%
CAR(1-2)	0.03%	1.25%	0.43%	-0.50%	0.90%	-0.83%	-0.62%	0.06%	0.54%	0.28%
CAR(1-3)	-0.91%	0.90%	0.28%	-0.90%	0.05%	-1.09%	-1.75%	-0.72%	0.20%	0.99%
CAR(1-4)	0.19%	2.02%	0.98%	0.48%	1.03%	-0.32%	-0.67%	-0.22%	0.81%	2.03%
CAR(1-5)	0.65%	2.30%	1.08%	1.21%	1.45%	-0.72%	0.24%	-0.28%	1.06%	2.40%
CAR(1-6)	1.03%	2.82%	1.21%	-1.59%	1.55%	-1.08%	-0.92%	-0.10%	1.83%	0.35%
CAR(1-7)	-0.06%	2.35%	1.38%	-2.22%	0.63%	-0.11%	-1.37%	0.32%	1.83%	0.67%
CAR(1-8)	-1.55%	0.76%	0.48%	-2.43%	-0.69%	-1.16%	-2.27%	-0.73%	-0.06%	0.61%
CAR(1-9)	-0.89%	1.83%	1.11%	-2.12%	-0.93%	-0.21%	-1.56%	-0.97%	1.14%	0.96%
CAR(1-10)	-1.30%	2.07%	1.24%	-2.47%	-1.34%	0.06%	-1.61%	-0.44%	1.21%	1.87%
CAR(1-11)	-1.35%	2.27%	0.95%	-1.37%	-1.54%	0.48%	-1.52%	0.05%	1.70%	2.11%
CAR(1-12)	-1.13%	2.15%	0.86%	-1.97%	-1.44%	0.20%	-1.74%	-0.19%	1.42%	1.51%
CAR(1-13)	-2.53%	0.94%	-0.17%	-2.12%	-2.97%	-1.07%	-2.91%	-1.15%	-0.16%	1.26%
CAR(1-14)	-3.15%	-0.02%	-0.79%	-2.77%	-3.89%	-1.59%	-3.66%	-2.06%	-0.97%	0.54%
CAR(1-15)	-2.77%	0.74%	-0.91%	-3.69%	-3.59%	-1.90%	-3.02%	-1.91%	-0.61%	-0.31%
CAR(1-16)	-3.11%	1.19%	-0.59%	-4.78%	-3.48%	-1.91%	-3.09%	-1.16%	-0.18%	-0.47%
CAR(1-17)	-3.08%	1.41%	-0.54%	-5.46%	-3.96%	-1.75%	-2.79%	-1.62%	-0.16%	-0.64%
CAR(1-18)	-3.67%	1.24%	-0.59%	-5.72%	-3.52%	-2.11%	-2.70%	-0.99%	-0.47%	0.09%
CAR(1-19)	-3.89%	1.43%	-0.66%	-5.69%	-3.33%	-2.64%	-2.21%	-1.07%	-0.55%	-1.05%
CAR(1-20)	-2.32%	2.93%	-0.27%	-5.18%	-2.18%	-1.72%	-0.88%	-0.73%	0.88%	-0.60%

[6] Portions of cumulative abnormal returns significant at the 90% interval are marked with an *, at the 95% interval are marked with an **, at the 99% interval are marked with an ***.

Appendix 5. CAR During a Decrease in the TTF Natural Gas Price of at least 20% across Sectors using a Long Strategy

Car[7] / Sector	Basic Materials	Consumer Cyclicals	Consumer Non-Cyclicals	Energy	Financials	Healthcare	Industrials	Real Estate	Technology	Utilities
CAR(1)	0.00%	-0.46%	-0.48%	0.45%	-0.57%	0.52%	0.58%	-0.32%	-0.34%	0.52%
CAR(1-2)	-0.09%	-1.31%	-0.49%	0.44%	-0.96%	0.77%	0.56%	-0.12%	-0.60%	-0.34%
CAR(1-3)	0.82%	-0.99%	-0.37%	0.81%	-0.15%	1.00%	1.66%	0.63%	-0.29%	-1.08%
CAR(1-4)	-0.31%	-2.14%	-1.11%	-0.61%	-1.16%	0.20%	0.55%	0.10%	-0.93%	-2.15%
CAR(1-5)	-0.81%	-2.45%	-1.23%	-1.36%	-1.60%	0.57%	-0.39%	0.13%	-1.21%	-2.55%
CAR(1-6)	-1.21%	-3.00%	-1.39%	1.41%	-1.73%	0.90%	0.74%	-0.08%	-2.01%	-0.53%
CAR(1-7)	-0.15%	-2.57%	-1.60%	2.01%	-0.84%	-0.10%	1.16%	-0.54%	-2.04%	-0.88%
CAR(1-8)	1.30%	-1.00%	-0.72%	2.19%	0.45%	0.91%	2.03%	0.49%	-0.18%	-0.85%
CAR(1-9)	0.61%	-2.10%	-1.39%	1.85%	0.66%	-0.06%	1.29%	0.70%	-1.41%	-1.23%
CAR(1-10)	1.00%	-2.38%	-1.54%	2.17%	1.04%	-0.36%	1.31%	0.14%	-1.51%	-2.18%
CAR(1-11)	1.02%	-2.61%	-1.28%	1.03%	1.21%	-0.82%	1.18%	-0.38%	-2.03%	-2.45%
CAR(1-12)	0.77%	-2.51%	-1.23%	1.61%	1.08%	-0.56%	1.38%	-0.18%	-1.79%	-1.88%
CAR(1-13)	2.14%	-1.33%	-0.22%	1.72%	2.57%	0.68%	2.51%	0.76%	-0.23%	-1.65%
CAR(1-14)	2.73%	-0.40%	0.36%	2.35%	3.47%	1.17%	3.24%	1.63%	0.55%	-0.97%
CAR(1-15)	2.32%	-1.19%	0.46%	3.24%	3.14%	1.44%	2.57%	1.45%	0.16%	-0.14%
CAR(1-16)	2.63%	-1.67%	0.10%	4.30%	2.99%	1.43%	2.61%	0.67%	-0.31%	-0.02%
CAR(1-17)	2.57%	-1.92%	0.03%	4.94%	3.45%	1.24%	2.28%	1.10%	-0.35%	0.13%
CAR(1-18)	3.13%	-1.78%	0.04%	5.18%	2.98%	1.57%	2.15%	0.45%	-0.08%	-0.63%
CAR(1-19)	3.32%	-2.01%	0.09%	5.12%	2.75%	2.07%	1.63%	0.49%	-0.02%	0.48%
CAR(1-20)	1.71%	-3.53%	-0.33%	4.58%	1.58%	1.12%	0.27%	0.13%	-1.48%	-0.01%

[7] Portions of cumulative abnormal returns significant at the 90% interval are marked with an *, at the 95% interval are marked with an **, at the 99% interval are marked with an ***.