Research and Advisory Report

# Is investment in carbon emission allowances in Europe a profitable proposition?

*A comparison of returns and volatility of early Phase III European carbon markets to commodity and equity markets.*

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*Version: 1, August 2016*

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*Graduating period: August 2016*

*Date: August 26th 2016*

# Abstract

The research covered in this paper provides an analysis of carbon allowance spot price trends during the early parts of Phase III of the EU ETS in order to provide an answer to the question “Is investing in carbon emission allowances profitable?”. By conducting a literature review of past research papers that cover similar topics and analyse the European allowance market, the research sets the framework for the cap-and trade system – a market that is defined by high uncertainty due to the multitude of factors that affect allowances’ prices.

By reviewing price patterns in the end of Phase II and the beginning of Phase III, the research is able to establish that there is still a high uncertainty on the market, brought about by the lack of clear policy by the European Union and mixed messages of support from legislative bodies. Along with that, factors like the movements of power and natural gas markets and weather also greatly affect the spot markets of allowances, leading to high price volatility. Bearing this in mind, the research then examines carbon futures contracts with regards to convenience yields and establish that short-term contracts provide a beneficial hedging option that mitigates the volatility - but long-term trading is still made risky and complicated by the market uncertainty.

In order to not evaluate allowances in isolation, but to have a benchmark against which to measure their performance, the data analysis then moves to compare allowance markets to other commodity markets - power and gas. By comparing logarithmic returns and using a GARCH model to chart volatility, the analysis establishes that on average the EU ETS outperforms both markets in terms of returns, though gas under the right circumstances could potentially be a profitable investment. Nevertheless, the volatility that was amongst the defining characteristics of the market in the past – as discovered in the literature review – still remains, with only power being a more uncertain market.

The research draws a further comparison to equity markets, using alternative energy indices as a benchmark and observes that in all cases equity markets outperform the European carbon allowance market - both in terms of higher returns and lower volatility.

Along with findings from previous research and contact with businesses on the market, the research suggest that the early period of Phase III of the EU ETS has been successful in improving carbon markets as an investment option, but ultimately the market does not appear to be as inviting as others. Most companies use the cap-and-trade system only as a means of meeting their emissions’ cap. It appears that the major market opportunities exist either for brokers using their know-how to trade on the market on behalf of their clients and thus mitigating their own risk; or large companies that have the required capital and liquidity to actually take advantage of the small returns on the market. Ultimately, investing in carbon allowances could bring a profit to an interested person, but doing so requires dedication in terms of time and resources, which leads to most businesses looking towards other markets – predominantly equity markets – for profits.

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# 1. Introduction

## 1.1 Global Warming and Climate Change

The latter years of the 20th century and first decade of the 21st century have been in no small part permeated by debates on climate change and questions surrounding it. What is climate change? Does it exist? What is causing it? What is the potential damage? How long will it take? Can it be prevented? Scientists around the world have been debating this phenomenon, trying to come up with solutions. The facts remain, however, that global warming is without a doubt one of the clearest threats faced - today and in the future as well, as the repercussions of our actions in the present can spell severe consequences for future generations.

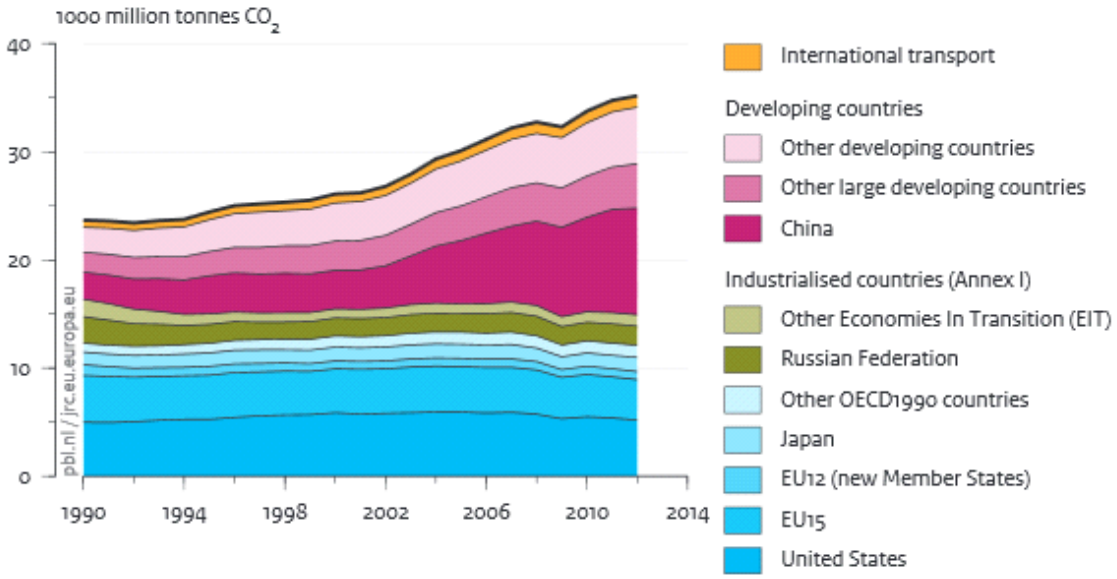
In “real life terms”, this boils down to the following - the average temperature in 2013 was 0.6 degrees Celsius above the 20th century baseline; since the year 2000 we have witnessed 9 of the top 10 hottest years in the 134 year history of record-keeping (NASA 2014). And while this may not immediately seem like much, we ought to consider that our planet and its eco-system is a finely tuned mechanism - much like a clock, perfectly balanced in order to work in a certain way. And even the most miniscule of change can drastically alter the entire system.

The Intergovernmental Panel on Climate Change (IPCC) summarises that “Taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time.” Some of the more specific dangers, looking only to the continent of Europe are given as “Increased risk of inland flash floods; more frequent coastal flooding and increased erosion from storms and sea level rise; glacial retreat in mountainous areas; reduced snow cover and winter tourism; extensive species losses; reductions of crop productivity in southern Europe”.

Governments around the world have finally started taking steps in order to prevent what seems like the greatest disaster that mankind has faced in its history. Even though at this point the damage may be irreparable **,** it is still possible to at the very least mitigate some of the potential backlash - mitigation being defined by the IPCC as “activities that reduce greenhouse gas (GHG) emissions, or enhance the capacity of carbon sinks to absorb GHGs from the atmosphere” (IPCC 2014).

Amongst the greenhouse gasses, carbon dioxide is clearly shown by numerous agencies to be the main contributor to climate change. It is for this reason that most governments and organisations strive towards reducing and controlling primarily the emission of CO2, key sources of which include heavy industries, energy companies, automobiles, etc.

Turning to scientific data, CO2 output in the past ten years has gone from 29 mln. kilotones (kt) to just below 34 mln kt. Data from EDGAR (Emissions Database for Global Atmospheric Research - a joint project of the European Commission Joint Research Centre and the Netherlands Environmental Assessment Agency that provides global past and present day anthropogenic emissions of greenhouse gases and air pollutants by country and on spatial grid) estimates that in 2014 mankind has clearly surpassed the 34 mln kt. mark and are proceeding towards the next milestone in this very negative trend.




*Graph 1: EDGAR data on CO2 emissions*

Each industry has had its own unique mitigation activities implemented. For the energy industry, it's been a push towards "green" energy - solar, wind, hydro, nuclear: all sources of energy that drastically decrease the output of CO2. Car models today are sold with hybrid engines and outright electrical automobiles are currently on the agenda for manufacturers. "Carbon sinks" - anything that absorbs more carbon than it releases, whilst a carbon source is anything that releases more carbon than is absorbed. (FERN 2014) - for example planting forests that absorb excess carbon - have also been considered as one of the possible mitigating projects worldwide.

All of these solutions have brought about some improvement - and with increased governmental and industrial backing - while the process of climate change cannot be entirely averted - it may at least be stalled and put under control. The key here is not that global warming has been solved - it is, rather, that people have understood that the problem exists and steps are being taken to avert the catastrophe.

## 1.2 An overview of GHG allowances and Kyoto Protocol systems

Amongst the myriad of solutions proposed and implemented, few are as fascinating as the issue and trade of greenhouse gas allowances. Otherwise called the "cap-and-trade" system, it was originally tested and implemented in the late 60s and early 70s in the United States as a means of controlling air pollution.

Fundamentally, this system is based on the government issuing a limit - or cap- for the total amount of a certain type of gas that an industry is allowed to output. Companies within the industry are then issued or buy allowances (or permits) for the amounts of GHGs that they will be emitting during the period. If a company is about to go over its limit, it must either buy more allowances from another company that does not need them - or face punitive actions from the governmental body. As a result, companies are incentivised to reduce their emissions levels - and then as an added bonus they can sell-off their excess

to underperforming companies. The net result, theoretically, is that GHGs are put under control and a clear financial bonus is set up to incentivise reaching goals for cleaner operation.

The brilliance of this system is that it doesn't rely on the fear of global warming - because, after all, who cares that in a hundred or two hundred or a thousand years from now the Earth may be uninhabitable? Who cares that clear energy is cleaner, when fossil fuels are cheaper and with a better profit margin? Instead, the trade scheme relies on companies seeing profit in GHGs reduction. Rather than punish over-emission, it instead recognises and rewards reduction schemes. For companies that set and meet targets for cleaner operation, this means that there is a clear profit to be made by selling the leftover and unused allowances to other companies. Who, in return, recognise the expense coupled with exceeding their cap - and therefore strive to reduce their emission or face and ongoing extra business expense.

In essence, the cap-and-trade system is a market system - it relies on the well-known market dynamics of supply and demand; it relies on companies nature to seek profit wherever profit can be found.

As mentioned above, originally the cap-and-trade system was first implemented in the United States. However, its modern descendant takes its roots to the Kyoto Protocol, established in 1997. The Kyoto Protocol is an international treaty between 83 original signers, however the total participants are now 192. The treaty established which GHGs are to be reduced; limits and goals for the participants to achieve; rules for achieving the goals; the form of allowances and the mechanisms for trading.

Under the guidelines of the Kyoto Protocol, the European Union set up its own cap-and-trade system, broken into several phases. The European Union Emission Trading Scheme (EU ETS) is divided into several phases. Phase I, starting in 2005 and finishing in 2007 was more of a fact-finding phase, in which the EU aimed to better understand how a cap-and-trade market operates. The subsequent Phase II ran from 2008 till 2012 and aimed to improve upon the first Phase, making up for some of the mistakes that had occurred under it - most notably that of overallocation and too lenient goals and limits set.

As of 2013, Europe is officially find in Phase III of the EU ETS. For it, the European Union has implemented numerous changes and improvements:
1) an overall cap for the entire EU was set up, from which allowances were given to the countries for them to then distribute to companies;
2) tighter limits on the use of offsets - particularly with regards to the use of Kyoto credits (Clean development mechanisms) which are used to cover emissions in Europe with reductions made abroad.
3) limiting banking of allowances between Phase II and III
4) move from allowances towards auctioning

## 1.3 An introduction to the EU ETS

As of 2013 (the start of Phase III) the Emissions Trade Scheme's default means of allocating allowances is via auctions. However, "default" in this case does not mean "only" - or even "dominant". In fact, just 40% of allowances in 2013 were auctioned - the rest were allocated by governmental organisations to the manufacturing industry - carried out on the basis of ambitious benchmarks for GHGs reductions and rewards for best practices. As part of its ongoing desire to improve the EU ETS and enforce stricter

reductions and better performance, allocations are set to be reduced to 30% of overall allowances by 2020. There can be no doubt that the EU is siding directly with auctions and sees them as the most beneficial method for allocation.

The ETS is completely backed by, regulated and monitored by the European Union. The EU sets up the limit, it keeps a database of allowances and trades, enacts legislation for monitoring and operations of the installations that emit GHGs - and is making steps to fully include emissions trading within the revised scope of rules for financial markets. In that sense, allowances traded under it are clearly seen as financial instruments - as they are to be regulated as such.

As discussed above, allowances are auctioned on two platforms - The European Energy Exchange (EEX) in Leipzig is considered the primary and largest platform, while the ICE Futures Europe. Within these platforms and on the secondary market (whether via direct B2B transactions or through third party resellers), allowances are traded like any financial instrument - there are spot transactions on a daily basis, however there is also the possibility to purchase futures and options for allowances - much like one would purchase futures for commodities or stocks on a financial market. Prices are therefore dictated by the market - with supply and demand playing a key part in determining how much an allowance costs.

The European Energy Exchange was established in 2002 after the merger of the power exchanges of Leipzig and Frankfurt. Today the EEX boasts as the leading energy exchange in Europe. **(**EEX 2014)**.** Assets traded on the EEX include power, gas, coal, and - of course - CO2 allowances, either via auctions or on the secondary market or in the form of futures. The types of allowances traded include standard EUA (European Union Emission Allowance) - representing an allowance to generate 1 tonne of CO2 - and EUAA (European Union Aviation Allowances) - emissions generated by air travel, which account for 3% of EU GHGs, which is why the EU has singled them out and designed specific allowances catered to reducing emissions from the aviation industry.

For 2014, the European Commission estimates a total amount of 462,179,500 EUAs to be traded - at each allowance equaling a tonne of CO2, this means that nearly half a billion tonnes of CO2 are to be auctioned off during the year. Auctions are structured in a single round, sealed bid format with uniform price - meaning bids are submitted during the same bidding window by all participants, with bidders being unable to see other participants' bids. The uniform price refers to the fact that all bidders will pay the same auction clearing price. In effect, the price at which the sum of volumes bid matches or exceeds the total amount of allowances auctioned (in a descending order from top bid to lowest) is determined as the auction clearing price. All bids above that price are successful, whereas tied bids are sorted via a random algorithm. The lot size is 500 EUAs - meaning all bids can be placed for that amount or a multiple of it.

To illustrate this, imagine that there is an auction for 10,000 EUAs - or 20 lots. There are six bidders:
Bidder A - bids for 9 lots at a price of 5 EUR per allowance (4,500 EUAs)
Bidder B - bids for 6 lots at a price of 4.5 EUR per allowance (3,000 EUAs)
Bidder C and D - bid for 5 lots at a price of 4 EUR per allowance (2,500 EUAs each)
Bidder E - bids for 2 lots at a price of 3 EUR per allowance (1,000 EUAs)

Bidders C and D are the point at which the total amount of 10,000 EUAs auctioned is reached - meaning that it's their price at which lots are auctioned (4 EUR per allowance). Bidders A and B will still receive the amount of lots they bid for - at the uniform price of 4 EUR. The algorithm of the EEX determines how the remaining allowances will be split between Bidders C and D who have tied their price. Bidder E has bid below the auction clearing price and therefore his bid does not go through.

| Volume | States | Details |
|---|---|---|
| 321,717,000 | 25 participating Member States | Weekly auctions on Mondays, Tuesdays and Thursdays |
| 127,127,500 | Germany | Weekly auctions on Fridays |
| 13,335,000 | Poland | 3 auctions on Wednesdays |

*Table 1: An overview of auctions on the EEX for 2014*

Moreover, alongside taking part in auctions, on the EEX one can participate in the secondary market for the so-called "Kyoto credits" - either Certified Emission Reductions (CERs) or Emission Reduction Units (ERUs). Both of these, while not standard EU allowances, cover the requirements of the Kyoto Protocol and as such are accepted emission credits and can be used by companies to meet their cap. CERs are a type of Clean Development Mechanism - broadly speaking they are similar to standard auctioned allowances, however there has been criticism against their use within the EU - which will be covered later as part of evaluation their value and effect on the market.

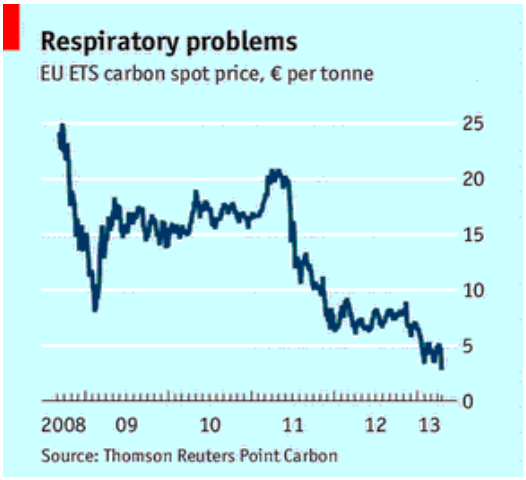
ERUs are another product of the Kyoto protocol - falling under the category of Joint Implementations - projects implemented by a member country of the Kyoto protocol in another country in order to reduce greenhouse emissions. The achieved reduction is counted towards the company's cap, thus increasing the amount of emissions they are allowed. Alternatively, the reduction can be sold off on the secondary market - and another company could buy it to meet its own targets.

Apart from the EEX, the other major market for trade of allowances within the EU is the ICE Futures Exchange. The ICE, established in 1981 - then as the International Petroleum Exchange - is another major market for energy and related commodities, hosting more than 50% of the world's crude and refined oil futures traded volume. Unlike it's German counterpart - the EEX, the ICE trades in futures and futures options. There are no primary auctions here, instead all transactions on this platform are secondary market transactions. The range of products is identical - with EUAs, EUAAs, CERs and ERUs traded regularly.

Naturally, there exists a direct B2B market for allowances - if companies, instead of going through the above-mentioned platforms, prefer to do business directly for speed or convenience. Overall, the market

for allowances does not appear to be any different from that of any other commodity or financial market. The same market principles of supply and demand apply here, prices are dictated by them.

However, it should not be forgotten that the intrinsic value of these allowances stems from the EU creating the legislation for reducing GHGs and setting up fines for non-compliers. Their value comes from the government, they are regulated by it, and governments can issue more or reduce quantities. If the EU decides that it will seek other means to combat climate change, the value of allowances will plummet - or they could outright become worthless




*Graph 2: Spot price of allowances; Source: The Economist 2014*

On the graph on the previous page (Graph 2) one can immediately note the fall of prices in 2007 - the end of the first Phase. With knowledge that emissions had been grossly overestimated and a surplus of allocated allowances by the EU and governments, companies had an excess of allowances that nobody needed - leading to a crash of the price.

Therefore, it is not purely supply and demand that determines the value of a tonne of CO2. Whereas oil or energy prices will always be dependent on the availability of these commodities, the value of allowances is much more heavily linked to EU legislation - and any movement by the governing bodies can have severe repercussions for the market.

## 2. Research question and aim of the research

The subject of carbon allowances trade is a broad and fascinating one, with various questions one might and should ask when examining this topic. Upon reviewing existing literature, most economic research focuses on the practical effect that allowance trading and in particular, the EU ETS, has had on markets. Perdan & Azapagic (2011), for example, take a broad-stroke approach, with a paper that "reviews the existing emissions trading systems and discusses possible futures of such schemes". Betz and Sato (2006), as well as de Perthuis & Trotignon (2014) look to the EU ETS for lessons to be learned and make suggestions of future improvements to the cap and trade system. Such high-level evaluations are

common in the research topics, but many authors identify more specific subjects. Cong & Wei (2010) ask "What would be the impact of CET on the electricity price and final portfolio of power plants?".

They examine the carbon emissions trade from the perspective of the Chinese energy market. Smale et al (2006) look towards the effect of the EU ETS on firm profits and market prices. There is plenty of literature and research which focuses on examining prices and price drivers in the market - Alberola et al (2007), Anger (2007), Blyth et al (2009), Creti et al (2012) and many more.

The research carried out and presented in this paper aims to further develop the topics and theories covered before and look at the subject of the EU ETS and that of the price behaviour of allowances from a different point of view - that of profits. By asking "Is investment in carbon emission allowances in Europe a profitable option" the research will examine how the cap-and-trade system can be used by a business venture for business-to-business trades. The goal is to understand whether a profit can be made by entering the allowance market - or if the only reason for entering the market is simply to meet legislative requirements - something that many of the previously mentioned authors have hinted at.

The underlying assumption of the paper is that should carbon allowances be determined to be a profitable investment in comparison to other instruments - then one could conclude that the EU ETS has achieved its goal of assigning value to greenhouse gases reduction. After all, where there's a profit - companies will flock. If not - then it could be argued that the cap-and-trade system is still not effective in achieveing its set goal. Either way, this would greatly contribute to the ongoing discussions of similar systems and provide a different take on the field.

To achieve its goal, the research must first provide an answer to the question of "How is value assigned to carbon emission allowances?" - what defines their price, what drives the market and pushes trades. From there, the next topic to be discussed is how prices affect trades - both subjects have already been researched in depth by previous literature. The current research, however, aims to combine existing research - by looking at both primary and secondary markets, in order to asses which is better for the purposes of a single business. In order for the research to not be simply a discussion of allowances in a vacuum, it will aim to compare the profitability of trading with emissions to that of trading with similar financial instruments - commodities like energy and equity of companies in the sector. By identifying common traits between the instruments and comparing them to allowances, a conclusion can be made on which is more profitable. Combining all aspects together, the research will answer whether as a business one should invest in allowances in the hopes of making a profit - much like investments in commodities or shares are made, or if the cap-and-trade system is not yet beneficial to such entrants.

# 3. Methodology

The first step for the current research is to establish a theoretical framework on which to base the further discussion. Bearing in mind the fact that the cap-and-trade system in Europe is a relatively new system - it has been operational for less than a decade - it has still been the subject of many research papers. These range from discussion on the overall structure and operation of the system and its effectiveness in reducing carbon emissions to discussion on price performance, returns and volatility. All topics can provide invaluable insight into the market, but the most important benefit of previous research is a definition of "value" for allowances.

Allowances are actively traded - they have a price, which is the basis of their value. The goal is to understand how these prices move - what are the driving factors behind them, how do previous researchers examine the market. Once this is understood, the focus can switch to finding a method of examining and assessing the market - what factors are appraised, what drives purchasing and selling decisions of allowances. Most easily and readily, the EU ETS marketplace can be assessed and analysed by calculating the returns and examining the volatility of the market - something that previous literature has already done in some extent. All this gives one part of the equation - the "value" of emissions. Yet there is another side to the research - as the goal is to compare allowances to other instruments and goods, the research needs to also establish a way of comparing the two. In essence, the literature review will give a mathematical means of rating both allowances and other instruments, so that a comparison can be made between the two.

Following the literature review, the next step is to collect the necessary empirical data. As discussed beforehand, the two largest markets for carbon allowances are the EEX and the ICE Futures Exchange - with the EEX being considered the primary market, through which the EU conducts its auctions. Therefore, the EEX is the primary source of data - particularly where the primary market is concerned. Additionally, the ICE also conducts some auctions. It follows that an ideal starting point is to collect the daily information for auctions from both markets and as an initial step - compare the prices and volumes of both markets, in other to identify and explain any deviations or dependencies. What this allows is to first of all corroborate previous research and verify that market conclusions made beforehand are still in effect. This in turn verifies that past conclusions are still applicable and the current research is well grounded.

When considering the time-period to take under account, one needs to consider that the EU ETS is divided up into phases, with the most recent phase (Phase III) initiated in 2013. Therefore data for 2013 and up till July 2014 will be used. This will allow the research to focus in on a specific timeframe and go into detail, rather than setting up a too ambitious and unachievable aim of analyzing an entire phase or a longer period. Coupled with this, analyzing the period at the start of a new Phase can be used to draw conclusion for the overall trends that in the market and what could occur should they hold true in the future. Furthermore, by looking at the early portion of a new Phase, one could draw a rudimentary comparson between the start of Phase III and the end of Phase II – whether the conclusions that were made by previous research hold true or if there has been a paradigm shift in the market. Any differences between the two phases could aid in identifying the effect of the transition and provide useful insight into the market – while similarities would mean that past conclusions could be extrapolated over the current research.

The next step is to obtain information regarding the secondary market of allowances. If auctions are defined as the “primary” market, than the Business-to-Business transactions - companies selling or purchasing the excess allowances of other companies - are the secondary market. The movements here when compared to auctions - with regard to price, volume and any significant deviations in comparison to the primary market - are the key factors to analyse. The secondary market analysis will be sourced, again, from the EEX, who maintain a database of transactions passing through them, with the same periods used as the primary market analysis to ensure compatibility of the data. Advantages of the

secondary market is that trades are performed on an "as needed" basis, not on an auction basis - therefore it should be a more accurate representation of the market and variances in prices should smoothen out due to lack of a time lapse between opportunities for trades (auctions).

While the EEX keeps information on the primary and secondary market, the ICE Futures Exchange is the main source for most widely implemented type of EUA derivatives - futures. The ICE is the biggest market for futures and the information will be used to analyse the futures market with regards to the spot market. As with any financial market - be it equity, commodity or currency - the spot/future relationship brings invaluable insight into market behaviour on the investor side - how do people trade allowances, do they purchase when they're needed or do they use futures to secure an influx or outflow a month from now? Furthermore, a comparison can be drawn between returns and volatility when comparing the spot and futures market - thus answering the question which market represents a better value proposition.

The analysis so far would bring to light the basic interactions within the market and introduce a general understanding of how it operates. However, from a market-to-market comparison it is important to know two other factors: returns and volatility. The next step, therefore, is to calculate these for each market - auction, secondary and futures. For volatility calculation, the GARCH system will be implemented - as shall be seen, the literature supports and identifies it as the most applicable model for evaluating the allowance markets.

Having returns and volatility for the types of allowance markets allows an internal comparison - to identify which is the most profitable instrument within the allowance family. However, the goal of the paper is to compare that market to the already established financial instruments markets. Therefore, it is key to perform similar analysis for comparable markets.

The EU defines carbon allowances as a commodity - meaning that other commodities fall within the same class of instruments. Allowances are part of a wider “green” initiative by the European Union - meaning that commodities of industries that are affected by environmental policy are the most immediately comparable instruments.  Power and natural gas are immediately identifiable as the main commodities, with once again the EEX and more specifically EPEX spot market being a prime source of data, as they provide indices for these two commodities

When looking at the commodities, one also looks to the companies dealing with them - the key players on the energy market in Europe. Naturally, one immediately can consider large companies such as Shell, Total, BP, Gazprom, E.ON - and so on. However, looking at all of them is not feasible, while simply cherry-picking one or two companies may not provide a wide enough sample size for the analysis. To counteract this, the current research will instead look towards alternative energy indices - such as the CreditSuisse Alternative Energy Index, the DAX Global Alternative energy Index, the ALTEX index, and the iShares Global Clean Energy ETF. These four indices track the performance of alternative energy companies or companies that deal in the power/natural gas/wind/etc. markets. Each index systemizes information on several companies and together they should give a grounded enough impression of the (alternative) energy equity markets that is comparable to carbon emission allowance markets.

Applying similar models for the estimation of returns and volatility for all markets will make certain that all the data and results are comparable. A final analysis of the results, comparing the factors across time and instrument should provide insight into whether allowances are a worthwhile investment or not.

To further validate the information and findings, contact will be established with companies on the allowance market in order to establish a link between the theoretical and empirical data and the practical views of business on the market. The information and conclusions drawn will be presented and discussed in order to ground the research with a practical view and understand if companies on the market have reached similar conclusions.

# 4. Literature review

As established earlier, the aim of the research is to answer the question of "is investment in allowances profitable". To answer this, there are a number of sub-questions that need to be addressed beforehand in order to create a baseline for the paper and guide the process towards completion. A literature review is the first place start, as looking to past research offers an invaluable framework and can aid in giving context and direction to the current research. The following chapter is structured by the sub-questions that have been devised – each sub-question represents a sub-chapter, with the corresponding past research articles and information collected used in that sub-chapter to give an answer to the sub-question or to devise a means of answering it with the data analysis later on.

In order to begin the literature review, the first step is to choose databases on which to search for relevant articles. The Library of Saxion School of Applied Sciences provides access to a host of such databases, amongst which Science Direct, WorldCat.org, OAlster, etc. Additionally, Google Scholar has been used for supportive texts and elaborative articles.

To access articles with subject matter that is relevant to the aim of this paper, the following keywords were used: carbon allowance; EU ETS; volatility; GARCH; returns; power; natural gas; equity. Additionally, when a relevant article was found and the database suggested any related articles covering similar topics, this paper has examined those as well and in some cases included them as additional material.

## 4.1 What is the future of the European Union Emissions Trading Scheme (EU ETS) and is the market sufficient in size and scope to support trade?

The first order of business for the research is to first establish an understanding of the EU ETS. While the introduction to this paper has covered the base mechanics and the history, there is another question, another aspect that needs to be addressed – the future, size and scope of the market and what the expected developments are. If the market does not have the necessary legislative support or its size simply does not permit trades – then the answer to the main question of whether trade is profitable is a moot point. If the EU cap-and-trade system is destined to fail, there is little value in understanding whether a profit could be made on it.

In order to begin creating an understanding of the EU ETS market, the first thing necessary is a look towards research commenting on the overall efficiency of the system as a means of reducing carbon emissions. If previous research sees value in the system, if concrete carbon emissions reductions can be achieved by using it – this could be used as an incentive for the legislative branch of the EU to further support it. Perdan & Azapagic (2011) examine GHG emissions trading schemes - not just the EU ETS, but also the American Regional Greenhouse Gas Initiative (RGGI), the New South Wales Greenhouse Gas Reduction System (GGAS), the New Zealand Emissions Trading Scheme (NZ ETS) the Tokyo's carbon trading scheme (Tokyo-ETS). All four of the systems focus on CO2 reductions, with some further diversifying by setting goals for the reduction of other GHGs.

Discussing the EU ETS, they identify it as "the largest carbon market in the world by a substantial margin, both by value and by volume". Quoting reports by Point Carbon (a consultant agency that tracks carbon markets and performs analysis) and the World Bank they determine that the scheme has been successful in leading to a 2-5% decline in emissions just in its trial period of 2005-2007 and a survey by Point Carbon demonstrates that "an outright majority of respondents [to the survey] said that EU ETS has caused emissions reductions"

The usefulness of CET - carbon emissions trading - is further mirrored by Cong & Wei (2010), declaring that such a system "would have a significant impact on the power source structure". In their paper they state that "environmentally friendly power generation technologies such as nuclear power and natural gas power would increase", "solar power would develop significantly" and "coal-fired power, whose emissions are high, would decrease significantly by 18%".

Along with this, however, they also point that this would spill over to power markets - with both increases to average power price and a transfer of the volatility of the carbon market to the power market. Therefore, there is an inherent trade-off between carbon and power markets - at least initially, while electrical companies are adjusting to the cost of reducing emissions and implementing alternative energy technologies. Clearly, there are some trade-offs and initial hurdles to be overcome with regards to implementing an allowance trading system.

On the topic of the future of carbon trading schemes, Perdan & Azapagic point to geographical expansion and linking between the different systems as a key step for the future - "linking current and emerging carbon markets at a global level would have distinctive advantages . . . the establishment of a level playing field for the covered sectors . . . a consistent regulatory framework across national borders. Linking schemes would also aid international co-operation on emissions reductions, reduce price volatility, help address competitiveness concerns, and reduce costs by increasing access to low cost abatement opportunities". However, they stress that there are many difficulties in accomplishing the linking and it will certainly take a long time before it is done.

Anger (2007) further supports the thesis that linkage is beneficial, indicating that if EU ETS is linked to Canada, Japan and the Former Soviet Union countries, as well as Australia and the USA "total EU compliance costs can be reduced by more than 60%" with regards to meeting Kyoto Protocol targets. He continues by stating that "from an efficiency perspective, a desirable future climate policy regime represents a joint trading system that enables international emissions trading between ETS companies

and governments under a post-Kyoto agreement. Such a joint regime is de facto equivalent to full where-flexibility, establishing international trading activities between all regions and sectors."

However, both Anger's and Perdan & Azapagic's concluding remarks concerning the changing political environments and policy and regulatory uncertainty point to the fact that not all is rosy in terms of the allowance trading schemes. The uncertain future of the Tokyo and Australian exchanges - with the Japanese government postponing an implementation of a national trading scheme and the Australian government putting off plans for a "flagship trading scheme" until 2013. Combined with the US president Barack Obama announcing that "the USA would not be pursuing an emissions trading scheme", the authors conclude that "in light of considerable uncertainties surrounding the further evolution of international climate policy and the future architecture of carbon markets, the planned expansions . . . are likely to be put on hold". The closing line of the paper by Perdan & Azapagic - "carbon trading enters an uncertain period" - indicates that only the EU ETS remains as a stalwart supporter of the cap-and-trade system, however, faced with global moves away from the system, it is not unlikely that changes may occur in the EU as well.

Despite past research indicating that there are positives to be extracted from implementing an allowance trade scheme, it seems that outside of Europe there is already some movement away from this. However, so far there has been nothing but support from the European Union with regards for their trading scheme and it has been shown that it has led to some reductions in emissions. Going back to Perdan & Azapagic, they conclude that "the fact that companies have achieved true emission reductions regardless of trade volumes and in the presence of sophisticated financial instruments is critical to the political viability of the EU ETS and its future". Add to this, the EU's stated commitment to the 2020 goals of carbon emission reduction and new changes implemented with phase 3 to improve the efficiency of the cap and the situation appears a lot more certain.

Quoting statements from EU officials, Perdan and Azapagic summarise: "The scheme itself will be substantially strengthened and extended from 2013, enabling it to play a central role in the achievement of the EU's climate and energy targets for 2020. As the latest amendments to the Emissions Trading Directive indicate, in Phase 3 we will see broadening of the scheme to incorporate more industrial sectors and greenhouse gases, gradually phasing out the free allocation of allowances that took place in Phases 1 and 2 as well as more challenging emission reduction targets for participating installations". Therefore, the final conclusion can be made that the EU ETS is a sufficiently big market and one that is seeing government support. While developments after 2020 are still uncertain, for the near future the market represents a viable option for trading.

## 4.2 How do businesses evaluate the EU ETS? How do companies use the market, how are trades carried out?

Accepting this, the research now points towards the private sector. In order to understand whether there is profit in the market, the research must understand how companies approach the EU ETS, what are common trading behaviours and in general how companies use allowances. Understanding this can aid in answering if there are missed opportunities or if there are unavoidable bottlenecks in place that prevent

successful trading. Sandoff & Schaad (2009) map companies' behaviour in terms of participation on the allowance market. They conclude that a "majority of the companies make use of brokers to engage in trade", instead of participating personally and developing their own understanding of the market - "few companies seem to be taking an active interest in the market" and "companies primarily engage in trade to minimize risks or for compliance purposes". In terms of explanation, the authors posit that "many participants estimate that they have an allowance surplus under the first trading period". Overall, it appears that initially there was little benefit for developing the expertise needed to take advantage of carbon markets - despite reductions being achieved in turns of actual carbon emissions, from a company perspective there was little financial benefit to reducing emissions, apart from complying with the cap and avoiding fines. Therefore, it is obvious that investment and active speculative trading is not something that has been fully examined and used by the majority of companies.

Making overall conclusions on the carbon market and its volatility, Feng, Zou & Wei (2010) state that "the carbon market is weak and unstable despite having general market characteristics." Bredin, Hyde & Muckley (2014), basing their conclusion on Kalaitzoglou and Ibrahim (2013), state "that the EU ETS can be viewed as a buyer orientated market, where a greater proportion (in terms of volume) of trades are buyer rather seller initiated. Our empirical results for duration and its relation with both volume and volatility are consistent with this view. The implications are that liquidity trades are dominating any informed trader behavior".

In an earlier paper, Kalaitzoglou & Ibrahim (2012), state that "the carbon market can be described as a pool of uninformed, non-discretionary, compliance trades with episodes of information arrival that trigger fast information-related strategic trading initiated mainly by an informed group, followed by two less informed groups of varying learning speeds."

Hoffmann (2007), addressing the manager perspective to markets, suggests that "companies should improve their understanding of carbon constraints as a long-term challenge within their business environment "and advises that "efforts to improve risk management in the context of carbon regulation and to increase flexibility are also viable strategies the companies employ".

From a business perspective the main goal seems to be to meet the cap and not suffer sanctions, not so much to use leftover allowances after meeting the cap as a means to a profit. The only visible barrier to trades appears to be the lack of knowledge and desire by the companies – not so much that there is an intrinsic fault in the market. There is an opportunity for trades, yet business are hesitant – clearly there are additional factors that affect its appeal.

## 4.3 What are the factors that have so far prevented the trading of allowances?

Thus the research is faced with its next question – the previous sub-chapter demonstrated that trades are more used as a tool for complying with regulations, rather than as a profit-maximising venture for enterprises. Therefore the obvious conclusion is that there is some other issue that prevents the cap-and-trade system from becoming a successful trade platform.

De Perthuis & Trotignon (2014) summarise three issues that have affected the the EU ETS:

- “economic conditions, which had a strong influence on the change of expectation occurring over Phase 2 in the short term (production decrease) as well as in the longer term (degraded growth outlooks”. In essence, they posit that the economic crisis’ negative effect on production levels for company meant there was a decreased need for consumables - power, gas, etc. This lead to a decrease in GHG emissions, leading to less allowances needed. Furthermore, a negative expectation for recovery meant that companies weren’t planning to increase their production in the future - which meant that they weren’t expecting to increase their emission of CO2.

Secondly, the use of offsets - defined as “a unit of carbon dioxide-equivalent that is reduced, avoided, or sequestered to compensate for emissions elsewhere” - greatly influenced the market. A decision to limit their usage for Phase III of the EU ETS meant that the use of offsets “surged over the rest of Phase 2 to represent a cumulated amount of around 1 Gt over five years.” The price of the offsets fell to less than 1 EUR per tonne, “allowing participants to comply with the ETS restraints at a very low cost”. The authors conclude that the “lesson is that if the domestic cap is unchanged by the the authorized use of offsets over time is changed, this is strictly equivalent to changing the cap.” They further elaborate that outside of Europe this flaw has been countered by “measures such as conversion rates between offsets and allowances, or price threshold above which more offsets become allowed in the system”.

Lastly, they allude to the effect of policy making on the price, postulating that “there will be policy interactions between the EU ETS and other policies. European climate energy policies are concerned, but also unilateral national policies”. They give an example with the UK’s tax on electricity sectors emissions, which creates a weakness for the overall market efficiency - “the advantage of having an uniform CO2 price falls when individual countries or sector “force” a carbon price that is higher than the market price”. In their opinion all policy needs to support the cap-and-trade system, otherwise there will always been an inherent weakness for some companies.

Continuing on the topic of price formation and factors affecting allowances, there are numerous papers discussing the three key factors in price formation. Hintermann (2009) analyses factors affecting EUAs price during Phase I, noting the collapse from EUR 30 to next to zero by mid 2007. He concludes that “allowance price exhibited high volatility and followed a peculiar path”. He postulates a model that expresses allowance price change as “a function of fuel prices, temperature, availability of hydroelectric power and stock market indices”; he continues to state that “the most important price determinants after the crash are fuel prices, summer temperatures and precipitation”.

Seifert, Uhrig-Homburg & Wagner (2008) further note a relationship between excess allowances and spot price behaviour. In their model, the correlate the publishing of emission reports in 2006 by countries with the spot price. As the reports indicated emissions levels far beyond expectations, this meant that in their model “this would correspond to a large negative change . . . thus immediately translate to a negative change in the spot price”, meaning that the overabundance of allowances hit the value of EUAs, leading to a devaluation. This can be described as simple supply-and-demand in action – too much supply leads to devaluation when there is not sufficient demand to meet it.

Alberola, Chevallier & Cheze (2008), while performing an analysis of price behaviour during Phase I make similar observations - they state that “during Phase I of the EU ETS, the stringency of the cap did

not appear sufficient for market agents, and consequently the price collapsed", verifying that there is an overabundance of allowances on the market and the cap was too lenient in that regard. Furthermore, they observe and evaluate "three types of carbon price fundamentals: institutional design issues, energy prices and temperatures events", indicating once more that carbon markets are linked to policy news by the EU, energy markets and utilisation and the weather.

Creti, Jouvet & Mignon (2011) conduct research on price drivers in Phase II, in order to answer whether the same fundamentals are still applicable. By applying co-integration techniques, they concluded that "equilibrium relationships exist for both phases of the EU ETS, with an increasing role of fundamentals in Phase II. In particular, while all the considered explanatory variables—namely, oil price, equity price index, and the switching price between gas and coal—are significant long-run determinants of the carbon price in the second phase of the EU ETS, the switching price does not play a key role in the first phase".

The relationship between the fundamentals and allowances prices is further elaborated on by Blyth & Bunn (2011), who state that "policy risks are particularly strong when carbon prices are low", while "market drivers (fuel prices and electricity demand) tend to dominate the risk factors when carbon prices are higher". They point out that "policy interactions of other technologies tend to further suppress carbon prices in the EU-ETS".

Blyth et. al. (2009) further delve into the effect of policy uncertainty on price. The conclusion they reach is that "climate policy not only has a direct effect on the expected price, but also strongly affects the risk characteristics of the carbon market". To illustrate this point they discuss the effect of abatement costs. In their model, "Under a 20% EU-wide abatement scenario, gas price variability continues to be a strong driver of variability . . . Under a more ambitious 30% EU-wide abatement scenario. . . fuel price variability has little effect . . . This result indicates that climate policy affects not only the expected price, but also the risk characteristics of the carbon market." Therefore policy will not only affect carbon price, but will have severe repercussions on the market itself. Especially if the policy concerns another interlinked market, such as power or gas. And when it comes to "green" policy, this will often be the case.

While discussing a conclusion for price determination in all three phases, Koch et. al. (2014) posit three key factors: "the economic recession, renewable policies and the use of international credits". They further summarise that "90% of the EUA price variation remains unexplained by abatement-related fundamentals". Their analysis "suggests that policy events and a lack of credibility may be alternative explanations for the weak price".

It is clear that there are many factors affecting prices – ranging from the weather, to general economic factors, down to specific policy concerning the EU ETS and news relating to it. As Hintermann (2009) states, there is a lot of volatility in the market – prices are moving a lot due to the multitude components affecting them. The constant uncertainty and price movements mean that it is difficult for a company to devise and implement a strategy for using trades to maximize its profits. Regardless if the price is up or down – companies appear to prefer to keep their allotted allowances as a reserve in order to ensure they meet their cap. The uncertainty can therefore be described as the one clear factor that acts as a barrier to trades.

## 4.4 What is the derivative market like for allowances and could it be used to mitigate the uncertainty in the spot market?

If there is a high variance in a market – as was seen in the previous sub-chapter, a derivative market, one with futures and similar instruments, will crop up to mitigate the uncertainty and allow trades to be made at a set price. But does the European allowance market have derivatives and how do they compare to spot trades?

The answer is - EU ETS supports such a derivatives market, with the main instrument on offer being futures contracts for allowances. To compare spot and futures prices, Koch et al (2009) discuss the concept of contango and backwardation: "The futures market is said to exhibit backwardation when the futures price $F_{t,T}$ is less than or equal to the current spot price $S_t$; it exhibits normal backwardation when the futures price is less than or equal to the expected spot price $E_t$ ($S_T$) at time T .On the other hand, the term (normal) contango is used to describe the opposite situation, when the futures price $F_{t,T}$ exceeds the (expected) spot price at time T". The table below summarises this concept:

| Market Situation | Relation between (expected) spot and futures price |
|---|---|
| Backwardation | $F_{t,T} \leq S_t$ |
| Normal Backwardation | $F_{t,T} \leq E_t(S_T)$ |
| Contango | $F_{t,T} > S_t$ |
| Normal Contango | $F_{t,T} > E_t(S_T)$ |

*Table 2: Summary of backwardation and contango*

In terms of a model for relating spot and future prices, they apply the theory of cost and convenience of holding inventories, illustrated via the convenience yield: "The convenience yield is usually derived within a no-arbitrage or cost-of-carry model which is based on considerations on a hedging strategy consisting of holding the underlying asset of the futures contract until maturity." To illustrate the concept, they use the following formula:

$$\gamma_{(T-t)} = S_t e^{r(T-t)} - F_{t,T}.$$

*Formula 1: Convenience yields*

Applying these models to Phase I and II of the EU ETS they conclude that "both for the pilot trading and Kyoto commitment period the market has changed from initial backwardation to contango. Thus, we observe futures prices that are clearly higher than the current spot price and deviate from the standard cost-of-carry approach".

For convenience yields, they posit that "convenience yields in futures contracts are significantly different from zero, in particular for contracts with longer maturities. Considering the first Kyoto commitment period (2008-2012), we find that the market has changed from initial backwardation to contango with significantly negative convenience yields in futures contracts".

The explanation they suggest for these relations are the extremely low risk-free rates in the Eurozone from 2009 onwards. The second - “market participants are interested in buying insurance against rising prices and, therefore, may be willing to pay an additional premium in the futures market for a hedge against changes in regulation or future shortage of EUAs that would increase permit prices”. Finally, the last factor relates to what was seen in spot price behaviour with regards to excess and oversupply of allowances. As the increasing surplus affects the spot price, so too does it affect the convenience yield. In conclusion, they state that “given the negative relationship between convenience yields and the level of inventory this fact may also explain the significant negative convenience yields during Phase II”.

To summarise, it is clear that there is a derivatives market and one which is related to and easily comparable to the spot market. Previous research has already covered the relationship between the two for the previous phases – what remains to be seen is whether this relationship has remained the same in the beginning of Phase III or if there is a change in the status quo. This will be seen in the current research as part of the empirical data collection and analysis and also to answer whether futures can offer a safe hedge option with regards to spot trades and in general if they can be seen as a sound investment choice.

## 4.5 What markets are linked to the EU ETS or exhibit comparable behavior? Can they be readily compared to one-another?

Overall, what the literature review has shown so far is that the allowance market is a very volatile market, but nevertheless one with potential – and one that is here to stay, with the EU stated. The next step for the research is to look towards other markets and how the EU ETS can be compared to them. What are similar or comparable markets, do they exhibit similar behavior, and are their prices influenced by similar factors? The ultimate goal of the research is to find a common trait, a common value that can be calculated between several markets and to establish that value as the “profitability” of the respective market. To do so the paper now looks to past research comparing the EU ETS to other trade goods.

A number of papers have modeled comparisons and correlations between the EUA markets and various other markets. Koening (2011) models a correlation between carbon and energy markets. Using models such as a GARCH-type estimation framework and a Dynamic Conditional Correlation model, he calculates a “a statistically significant decoupling of electricity, fuel and carbon month-ahead returns during periods in which fuel-choices in the power sector are set in either hard coal or natural gas”. He further states that “during those periods there is no incentive to switch input-fuels as a response to price changes and the link between fuel and carbon prices is broken”.

Further elaborating on the link between power/gas and carbon markets, Boersen & Scholtens (2014) stated that “gas and oil prices, switching costs and the German one-month ahead electricity prices can be regarded as significant determinants of the EUA carbon futures price in Phase II of the EU ETS”. Their findings indicate that there are “differences
among the various European electricity exchanges” and point to a “need to account for European electricity exchanges on a market-specific basis when studying carbon futures price determinants”.

In both case studies, however, it is clear to see that data for power and natural gas is relatable to allowances prices and therefore a comparison can be drawn between the two. Gas and power can act as price drivers for allowances, indicating a link between the markets. If changes to one market affect the other, this means that the two are comparable and can be juxtaposed.

To further broaden the scope of benchmarks to which EUAs can be compared, it is also worthwhile to look to previous research that finds other comparable markets. Kumar, Managi & Matsuda (2011) compare allowances to clean energy stock prices and coal. In the establishment of their theoretical framework they conclude that "the prices for technology stocks, clean energy stocks and general economic stocks should be positively associated when oil prices are increasing". They expect that "concerns over global climate change to drive the growth of alternate energy sources, which are less carbon-intensive than conventional energy sources" and hypothesize that "higher carbon permit prices induce the development of alternate energy technologies and that there is a positive association between carbon permit prices and the stock prices of alternate energy sources."

Therefore, the conclusion is that a correlation exists between carbon emission rights and the stock prices of alternative energy companies. Further on in the paper, they model carbon price returns and conclude that they "are not a significant factor in stock price movements for clean energy firms. This result might be because carbon prices have been lower than oil prices. Therefore, carbon prices have not been able to create a stimulus for the switch to clean, low carbon technologies from conventional fossil fuels".

Oberndorfer (2008) aims to "address the impacts of EU Emission Allowance price developments on stock performance of European electricity corporations". Instead of looking at the relationship that power has on allowances, in this case a mirrored approach is taken. Using a GARCH approach to test for correlation between EUA return volatility and European electricity stock volatility, he states that "EUA price increases (decreases) positively (negatively) affect stock returns from the most important electricity corporations covered by the EU ETS".

However, the results tend to vary from country to country: "Spanish corporations are shown to exhibit a negative EUA-to-stock market relationship", while "the effect is positive for corporations from other countries such as Germany and the UK". Moreover, he adds that "electricity stock return and EUA price change volatility are not shown to be positively related".

There therefore seems to be a difference between the two research papers, which indicates an interesting subject for future research. It is possible that Kumar, Managi & Matsuda, taking into account global companies, hove somewhat diluted the effect of allowances, which would naturally be far more expressed in local European companies - and especially local European power companies, that are most heavily affected by allowances.

Nevertheless, it is clear that at the very least allowances and clean/alternative energy company stocks are comparable, regardless of whether a strong correlation exists. Thus, it can be concluded for the purposes of this paper, that the EU ETS can be compared in terms of prices, returns and volatility to both power markets/gas markets and to equity markets – as long as it is the equity of clean/alternative energy

companies. Judging these factors for each market for a comparable time period and contrasting the results would give an indication of which market is the best – which type investment is the most profitable option.

## 4.6 How can profitability be defined for the EU ETS and other similar markets? How can they be compared? What mathematical model best charts the relationship between the markets?

From all the previous chapters and sub-questions that have been answered, one trait of the EU ETS remains centre-forward – stressed by almost all previous research. That is the volatility of the market. The huge swings between prices, the multitude of factors either adversely or positively affecting prices. Allowance trading is a very unsure prospect – yet one with potential. The market exhibits returns – there is profit there, in pure monetary terms. One might invest a thousand Euro and later be able to sell it for two thousand. The opposite is just as likely – invest a thousand and you could be left with nothing.

Precisely this relation – between returns and the market volatility – is the key to understanding the European allowance market. Maybe the market has higher returns than gas market or energy companies' equity markets – yet if the volatility is greater, if there returns are unsure – then the point is moot.

The question remains though – which mathematical model is best suited to calculate volatility and evaluate the markets in terms of returns? During the course of the literature review, different papers have mentioned a variety of models used to evaluate allowance markets. The most often used one, however, is the GARCH model framework.

In their paper "Modeling the price dynamics of CO2 emission allowances", Benz & Truck (2008) implement the model in order to evaluate the returns and volatility of the emissions market. After reviewing the price behaviour of the carbon market, they posit that "allowance prices and returns will exhibit different periods of price behavior including price jumps or spikes as well as phases of high volatility and heteroscedasticity in returns". Heteroskedasticity refers to the fact athat the volatility and future prices of allowances cannot be forecasted with any degree of certainty, as they do not exhibit any seasonal trends, but are rather dependent on a myriad of environmental factors.

To evaluate the returns they propose a number of models, amongst which is GARCH, for which they provide the following description:

"While the traditional linear ARMA-type models assume homoscedasticity, i.e. a constant variance and covariance function, the autoregressive conditional heteroskedastic (ARCH(p)) time series model . . . was the first formal model which successfully addressed the problem of heteroskedasticity. In this model the conditional variance of the time series . . . is represented by an autoregressive process (AR), namely a weighted sum of squared preceding observations".

To illustrate this they define the GARCH model with the following model:

$$\sigma_t^2 = k + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2,$$

*Formula 2: GARCH (1,1) model illustrated*

What this means is that the volatility - expressed by the variance is a function of today's squared residual, today's variance and the weighted average long-term variance.**,** and are empirical parameters - weights for each fundamental, determined by a maximum likelihood observation.

A maximum likelihood for a normal distribution is defined with the following formula:

$$f(x_1, \ldots, x_n \mid \mu, \sigma^2) = \prod_{i=1}^{n} f(x_i \mid \mu, \sigma^2) = \left(\frac{1}{2\pi\sigma^2}\right)^{n/2} \exp\left(-\frac{\sum_{i=1}^{n}(x_i - \mu)^2}{2\sigma^2}\right),$$

*Formula 3: Maximum likelihood calculation*

The formula illustrates that the maximum likelihood is determined via a logarithmic function of the variance multiplied with the mathematical constant e (equal to 2.71828182845904) raised to the power of a function of the squared return and the variance.

Further on in their paper Benz & Truck (2008) use logreturns (yt= log(St)−log(St−1)) to evaluate volatility, concluding that "the data show heteroskedasticity and volatility clustering". Conrad, Rittler & RotfuS (2011) further contribute to the understanding of price dynamics, by testing several GARCH models. Their conclusion is that "the price dynamics of the EUA futures contracts . . . are very well captured by a fractionally integrated asymmetric power GARCH specification". Moreover, they back and expand upon the findings of Benz & Truck (2008) by establishing that "that high-frequency EUA returns do not only obey conditional heteroscedasticity, but are also characterized by long memory, power effects and asymmetry in their second conditional moments."

On the subject of applying GARCH to futures, Byun & Cho (2013) confirm that the model is applicable and further elaborate that "the GJR-GARCH model performs better than other models" when futures are concerned. Liu & Shi (2013) and Lv & Shan (2013) apply different GARCH models to power and gas markets respectively, reaching a conclusion that the models provide a good fit for estimating volatility.

All of this confirms – the relationship between returns and volatility, as calculated by a GARCH model is applicable to the EU ETS. But it is also applicable to its derivatives markets, as well as to other comparable markets – gas and power, and the equity markets for linked companies in adjacent sectors.

## Conclusion on the literature review

Having performed an extensive, though by no means all-inclusive literature review, a fundamental understanding of the carbon market in Europe has been established. Previous researches indicate that policy uncertainty has been a key factor in determining market trends, with linked markets such as power and natural gas also contributing to market dynamics - and vice versa. Overall there are a multitude of factors that drive the market and affect allowance prices – and therefore trading behaviours.

Numerous papers describe the market as “volatile” and use a variety of systems and methodologies to model this. The most dominant and proven to be efficient model is the GARCH and its variations, which graphs volatility as a function of returns, previous day variance and the average variance across the period. The model has also been applied to comparative markets - power and natural gas, equities.

Thus, for the purposes of this research the following statement can be made: the European allowance market is a volatile market, affected by a multitude of factors which also affect energy and some equity markets. A comparison can be made between the three markets – charting prices, returns and volatility using a GARCH model – in order to establish which market is the most profitable. “Profitable”, in this case, being the market that offers the best combinations of return and volatility. Judging the allowance market against the other two by comparing empirical data for a set period of time for all three will allow the research to therefore answer the question “are allowances a profitable investment?” This will be covered in the following chapter.

# 5. Price analysis for auctions

Following the conclusion of the literature review, the current chapter begins an analysis of the price dynamics of auctions. The following paragraphs will cover the spot market: in order to understand how the market moves and to establish a baseline for comparison to allowance futures and other instruments. As discussed beforehand, the main method for obtaining EUAs is to participate in the auctions - either at the EEX or ICE markets. To start off the analysis, therefore, it is necessary to first compare the two auctions. If the two exhibit similar behaviours in terms of price fluctuations, etc. the result is simple – the research will use the auction with the most trades as the surrogate for the overall spot market. Even more interestingly, should the two markets exhibit different behaviours, this would immediately lead to the conclusion that even the spot market is highly volatile and unpredictable and a more complex method will be needed in order to establish a baseline for comparison.

The structure of EEX auctions has already been covered in the Introduction chapter. By comparison, the ICE operates in the same sealed bid manner, with a clearing price determined via the same methodology and bids matched to offers just like the EEX. On a functional level, therefore, there is no difference.

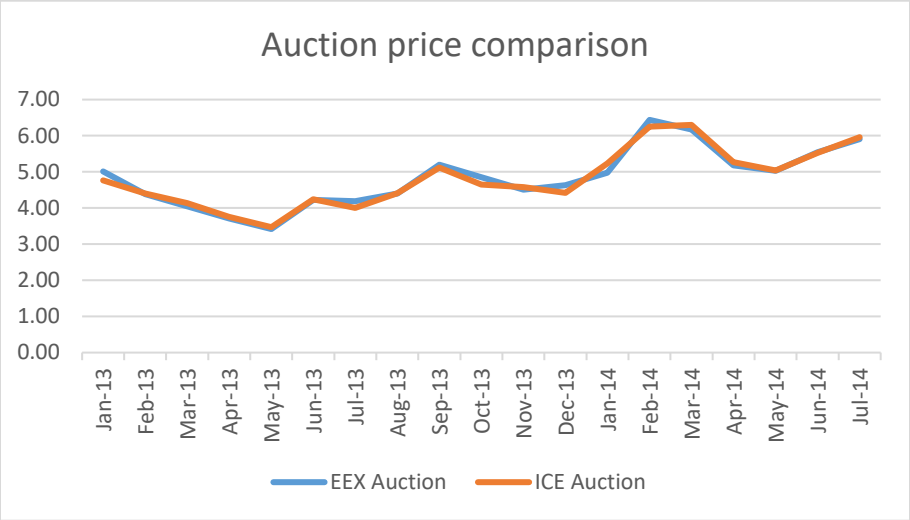
| Volume | Auction platform | States | Details |
|---|---|---|---|
| 541,197,000 | EEX | 24 participating Member States, Poland and EEA-EFTA States | Weekly auctions on Mondays, Tuesdays and Thursdays |
| 182,560,500 | EEX | Germany | Weekly auctions on Fridays |
| 95,098,000 | ICE | United Kingdom | Fortnightly auctions on Wednesdays |

*Table 3: European Commision Climate Action summary of auctions for 2013*

The only difference between the auctions, organisationally, are the territory they cover and the days of the week on which trades take place. Table 3 summarises these differences.

Functionally, therefore, there is little difference between the two. The key distinction is size, quantity and frequency of trades – the EEX is clearly the larger market. From this the conclusion is that there should be no difficulty in comparing prices, as the trade format is identical and there shouldn't be significant unique factors affecting either market.

By collecting price data for both markets and plotting them on a graph, a quick comparison of trends can be made and significant deviations are identified:




*Graph 3: EEX and ICE spot auctions price comparison*

Graph 3 plots the average prices on both Auction markets for an identical period of time – January 2013 till July 2014. In general, this will be the time period covered by the research for several reasons: firstly, to avoid analyzing a large period, as doing so is too ambitious and simply not achievable with the scope and resources of the current paper. Secondly, this is the first year and a half of Phase III of the EU ETS. Knowing the conclusions regarding Phase I and Phase II – as established by the literature review – the research stands on the knowledge that previous phases were marred by experiments and volatility, due to legislators still being unsure how best to utilize the cap-and-trade system. The current Phase – Phase III – is the next stage in development and it could be seen as the phase in which sufficient knowledge is gathered by legislators and the system should stabilize. Moreover, seeing how it is unlikely that conclusions made in Phase 2 are directly applicable to Phase 3 and that analyzing the two phases together would lead to conflicting and difficult to compare results. Looking to just the early stages allows the research to remain ground to a specific and easy to analyse time period, while the characteristics of the period are such that any conclusions drawn could potentially be used and extrapolated for future periods.

Looking to graph 3, the EEX appears to be, as a whole, the market where prices tend to be a bit higher, with average prices being EUR 4.83, whereas on the ICE the average price is slightly lower, at EUR 4.82. On average, there is an EUR 0.08 difference between the two auctions, with the EEX being priced higher.

In terms of volumes traded, on average the ICE auctions more EUAs (average of 3,744,902 tonnes per auction, whereas for EEX the number is 2,882,512 tonnes per auction). However, for the EEX the total number is vastly greater (1,161,652,500 tonnes versus 153,541,000 for ICE), due to the fact that there are simply more EEX auctions, occurring more often (403 auctions since November 2012, whereas for ICE only 41 auctions have taken place since then).

The dramatic difference in volume - nearly eight times as many EUAs traded on the EEX in comparison to the ICE- does indeed verify the claim that it is the main platform for trades. The differences, wherever they exist, are most likely due either to daily swings (differences in timing, with daily prices fluctuating due to difference factors). In effect, this means that there is no reason not to focus on EEX data as the primary auction data - there are more auctions, more often and more allowances are traded, while the prices remain reasonably consistent to the other auction platform, ensuring that it gives a wide enough data point.

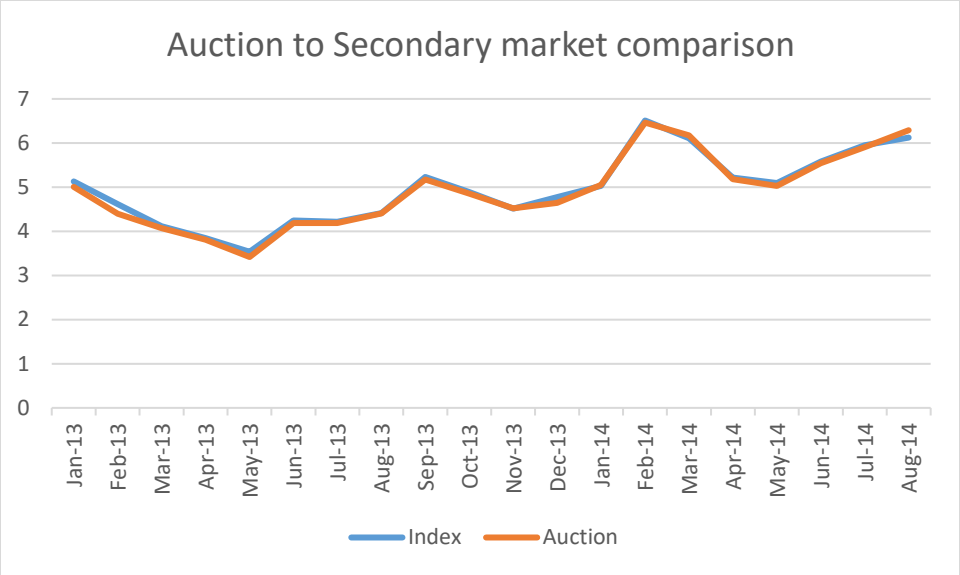
This covers the primary market - however it is also important to compare primary markets to secondary markets. In this case, the EEX also collects and publishes daily information on secondary market transactions.

For the comparison the relevant information to be collected starts at 2012 and finishes in august 2014 - covering two Phases of the EU ETS - covering also two relevant contracts for trading, as each Phase allowance is only applicable to that specific phase.

To calculate secondary market average price, it is important to weight contracts accordingly - in the end of 2012 and beginning of 2013 both Phase II and III contracts were traded. Therefore, for the purposes of the paper the average price will be calculated as follows: Sum (Trade Volume * Trade Price) for each contract month divided by Total Daily Volume.

Calculating a secondary market index in this way and comparing it to action prices, the information quickly becomes incompatible, due to the nature of auction data. Whereas in Phase III auctions take place twice a week, this is not the case for Phase II, meaning that any comparison here would be time-costly and potentially may give conflicting indications.

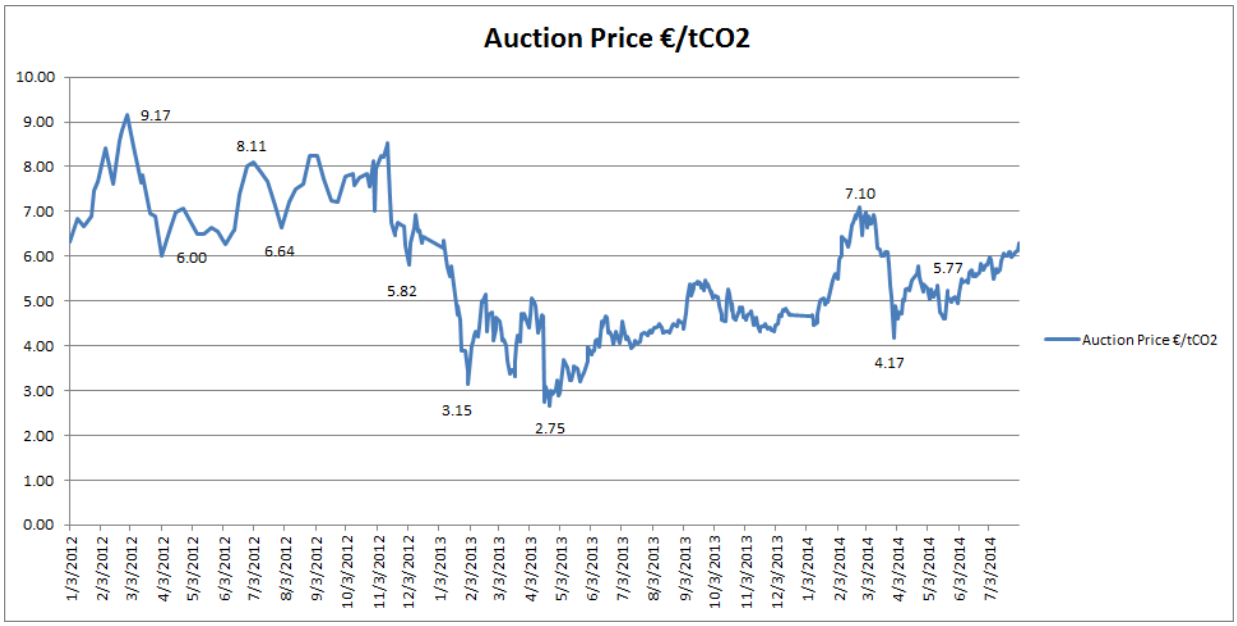
Therefore, a monthly average for EEX auction and secondary market data is calculated and compared:




*Graph 4: Monthly price comparison between EEX auction and secondary market*

Here it is visible that the data is highly similar, with on average differences floating around EUR 0.04 - which is easily explained with daily fluctuations not covered by the auctions (as such do not take place daily). The largest deviations - at around 21 cents - appear in February 2013. As these were still the early days of Phase 3 and considering that the differences are a statistical outlier, rather than a trend, it can be explained with the uncertainty of the new Phase and traders and businesses still being very unsure of the new value of allowances for the new period of trading.

Overall, the difference is not significant enough to warrant an individual look at both markets. Instead, simply taking auction data and charting it in order to visualise key points should prove sufficient. Charting the results of the calculated average prices, the following graph is obtained:




*Graph 5: Daily EEX auction prices*

Looking at the graph, several high and low points can be identified, starting off in 2012 - the closing days of Phase II. While the previous graphs charted only Phase 3 prices, for the current graph the last year of Phase II has been used as well. The reasoning behind the decision is that the literature review has established the conclusions for the previous period of trading – the goal now is to see whether the same conclusions can be carried over to the next phase, or at least its early moments. If the same trends remain in place and similar factors affect both phases, a conclusion can be made that the knowledge gathered in the literature review can be readily applied to make conclusion regarding the next stage in the European cap-and-trade system.

For the time-period that the graph covers, the EU ETS had already been functioning for half almost a decade. If Phase I was the "beta test" for the system, then Phase II was the first real run of the European cap-and-trade scheme. The following paragraphs will consist of an analysis of the significant movements in prices and what has led to those peaks or drops. The analysis is based on information collected in the literature review and corroborated by third-party analysis – most notably articles released by Saga Commodities, a carbon emissions allowance broker firm. The goal is to look at significant events and whether they had caused a movement or not in price – ultimately with an eye to showcasing the market factors that influence prices. If, as the literature interview suggests, there are a multitude of factors that affect prices – the conclusion can be made that market is indeed volatile. In turn, this allows the research to already have some assumptions as to whether or not investing in carbon allowances could be profitable – and any further examination would have to bear into account the volatility.

The graph shows that the EUAs price in the beginning of 2012 reached a high of EUR 9.17 as of February 28th 2012. At this point the biggest piece of legislation related to the EU ETS was connected to the Energy Efficiency Directive. As with any piece of potential legislation, there had been widespread rumours and speculation regarding the outcome of the vote. The main issue for the allowance market, however, was with regards to the so-called "backloading" of allowances - essentially whether the EU would allow for excess Phase II allowances to be transferred into Phase III by companies that had not needed all of their allocation.

The repercussions of this are obvious. With the end of Phase II and without the backloading, the value of those allowances would be next to nothing. The only people in need of them would be companies that could not meet their CO2 targets and needed to raise them, meaning that there would be a lot of supply - but next to no demand.

In reverse, if backloading would be permitted, allowances would retain or increase their value. If you could buy on the cheap in Phase II and then sell in Phase III, for which the EU had already made plans to further limit supply and tighten targets, an investor could greatly profit.

In effect, the curve in the beginning of 2012 demonstrates that companies and investors were willing to go long on allowances, stockpiling contracts in the hope of selling them off at a higher price in the future.

The crucial vote took place precisely on the 28th - the Industry, Research and Energy Committee (ITRE) of the European Parliament voted positively on the proposal for a binding 20% energy saving target - in

effect confirming that the European Parliament was firmly behind measures taken to improve energy efficiency, amongst which reduction in CO2 falls. While it did not directly mean that backloading of allowances would be permitted, it still showed that measures to support the EU ETS were supported and that the EU would not allow the market to crash (as it had previously in Phase I - refer to Graph 2 and the literature review).

However, the price peaked on the 28th and from there on started dropping. A number of factors will have taken effect here:

1) Uncertainty regarding the backloading legislation would still be present - companies that knew would meet their CO2 targets and saw no value in keeping their excess allowances would start releasing them on the market, increasing supply on the secondary market - diminishing the need for companies to participate on auctions.

2) Speculators, expecting a further appreciation of the price started selling amounts, once again increasing the supply. For them, allowances are not needed for meeting legislation targets. If you've bought allowances when the price was low and still appreciating and know that you stand to make a profit at the current price, you can simply opt out and collecting the windfall. Speculators selling their stockpiles meant that supply was increased on the market, further reducing prices.

The price hit its lowest point on April 3rd, after a month of a consistent downward trend. However, new rumours that legislators were planning to withhold up to 1.2 bln allowances meant that once more investors saw a chance to go long on allowances. The price at this point was at 6 EUR per allowance, over 3 EUR lower than at its peak and even lower than at the beginning of the year. Clearly, if going long is the idea – buying allowances at a low cost, in the hope that the price would eventually appreciate - this would be the perfect moment.

The initial increase between April 3rd and 17th could possibly be attributed to the looming 2012 compliance deadline - for companies that had not yet met their 2012 targets, this was the last chance to purchase the necessary allowances. The relative peak again started decreasing, when in June, amongst talks of the Spanish bail-out, all markets (not just allowances) began going up. Increased investor confidence meant an increase in trade of allowances, injecting much needed demand into the EUA market.

This increase continued until July 3rd, where the price peaked at EUR 8.11. The rally in the price would have also been driven by speculators expecting an EC report on the EU ETS alongside proposals for improvement. On June 29th measures were approved for improving PIIGS countries with furthering them with debt, further boosting markets.

The next significant market point is in November 2012 - specifically November 13th, when the price reached 8.49 EUR. On the 14th November the European Commission issued three reports, concerning a suggestion to withhold a number of allowances for Phase III and backload them to the end of 2013; an impact assessment of the backloading; and a summary report of the EU ETS functioning. And while these reports showed that the EU was considering steps to deal with the abundance and over-supply of

allowances, they would not lead to immediate reactions. In effect speculators had once again bought up and stockpiled allowances. With the increase of the price and the issuance of the report, they once again began releasing the allowances on the market, benefitting from the high price.

However, as of November 29th, the EC had announced that there would be no vote on the backloading issue, bringing the price down to a low of EUR 5.82 as of December 4th.

As of the beginning of 2013 - and Phase III - the EU ETS saw a dramatic drop-off in price. The drop is explained - but also, most likely, heavily influenced by reports of the EC that the oversupply of auctions was in the area of 900 mln. and could reach figures up to 2 billion allowances. Further issues identified were the nearly daily auctions, allowing easy access to allowances; political uncertainty; and finally the effect of Kyoto credits - easily accessible CERs and ERUs, that are cheaper than EUAs, but can still be used to increase a company's cap.

A negative vote by the ITRE on Jan 24th further pushed the price down - to a historical low at the time, with the bottom being hit on the first of February - auctions settling at EUR 3.15

February saw a small rally in price - a positive statement by Germany's Chancellor Angela Merkel in support of her Environment Minister's reforms (her minister being a known supporter of the backloading proposals). On February 19th the ENVI - the Environmental Committee of the European Parliament - backed an amendment to the ETS directive, allowing the European Commission to intervene and amend the schedule of EU ETS auctions.

The all-time low was reached on the 18th of April - auctions were closed at EUR 2.75. The previous weeks were dominated by discussions on backloading policy, once again indicating the importance of the political factor in the price-determination. A plenary vote took place on the 18th, rejecting the backloading proposal.

The subsequent price increase is most likely linked with the looming compliance deadline for 2012 - and for Phase II. Further price appreciation during the year could be attributed to the measures taken by the EU to reduce the surplus as part of the measures for implementing Phase III. This, alongside further murmurings and positive indications that the backloading proposal may be passed boosted markets - if slightly - for the remainder of the year.

The backloading discussions spilled over into 2014, with more support coming through and indications that the initiative will be pushed through, though the extent. Particularly by the end of January/beginning of February the backloading proposal was further discussed, with the ENVI blocking objections. The appreciation continued in February, with the price reaching a high of EUR 7.10 on the 24th of February. Along with the backloading discussion, there was also a delay of allocations for 2014 - further pushing the price up.

The price started declining and by the end of March it had outright crashed - March 31 auctions were settled at EUR 4.17. A plethora of factors influenced this - installations started receiving their allocations, flooding the market with new allowances; the mild weather affected power installations - a lesser demand

for power meant less consumption of fuels - in turn decreasing carbon output, meaning that installations started appearing on the seller side of the equation; and finally, the potential derogation of Poland - meaning that the implementation of Phase III measures to the country may be delayed or another form of dispensation may be provided for the country to aid in the implementation of the cap and trade system.

A rally of power markets meant that allowance prices were also supported in April - along with the support of the looming April 30 compliance deadline that is consistently present throughout all periods - meant that prices reached EUR 5.77 on April 24th.

Decreases in May were driven by news of higher than expected EUA surplus (2.1 billion EUAs), low energy demand and low coal prices. By the end of the month and spilling over in June, markets rallied - possibly bolstered by news that the German government is pushing for an implementation of reforms in carbon markets by 2017 - 4 years earlier than the previously agreed deadline.

The slow appreciation continued up until August, the final data point for the purposes of this paper.

## Conclusions on price dynamics

By comparing price data across the two main auction markets - the EEX and the ICE Futures Exchange, the research establishes that the difference is minimal and overall it can be concluded that the primary market is best monitored by following EEX auctions – simply due to more frequent trades and also the higher volume.

Comparing the primary to the secondary market, it is evident that there is once again not a significant difference. The secondary market, however, operates daily - meaning that, again, it is a better timed indicator of the price. However, the differences are by no means significant enough, meaning that in effect price can be monitored either on the primary auction market or on the secondary B2B market - it makes no difference.

By placing significant price points on a graph and noting key trends throughout the period of 2012-2014, an analysis of the data can be made and as a result three key indicators that affect price are established:

1) Political decisions and policy by the EU - even rumours of an upcoming decision by a committee have shown to have a drastic effect on the price of carbon. Traders hang on every word of the politicians and set their strategy accordingly, which in turn reflects on the market.

2) Linked markets and economic conditions - other commodities, such as power and coal, gas, etc. which in turn affect the power market - have shown to affect carbon prices. Higher demand for energy means higher demand for natural resources - the utilisation of which boosts carbon emissions, leading to industries requiring more allowances than originally expected. Along with this the overall economic outlook of Europe also seems to play a part in price formation – news of the Spanish bailout and the overall uncertainty in Europe’s economy were seen to influence price behaviour.

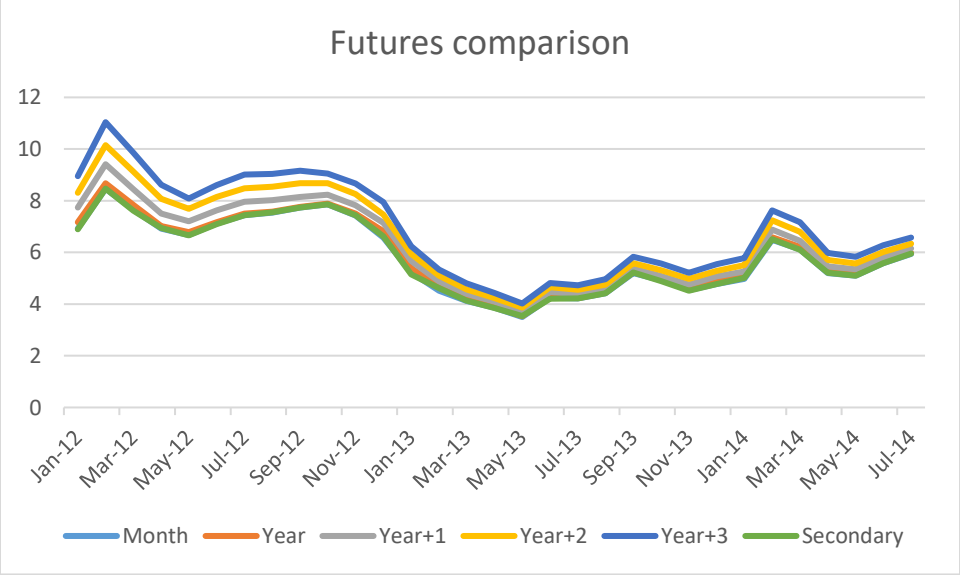
3) Weather - the weather affects allowances in so much that it affects power markets and commodity utilisation. However, weather and power may not always move together so it is important to judge and monitor each factor separately to ascertain whether a warmer than usual winter or a colder than usual spring would have any effect spilling over to carbon markets.

To summarise, the findings of the price behaviour analysis of the spot market confirm the findings of the literature review. It is clear that the spot market is highly volatile, with large swings in prices, driven by a multitude of factors. This should mean that forming any sort of cohesive trading strategy on the spot market would be difficult – as an investor, one could never know how prices would behave. One could gamble, hoping, for example, that by going long and purchasing allowances on the cheap in the hope that the price would appreciate and then sell them off for a profit. However, this is first of all risky and second of all a very slow and uncertain means of achieving a profit.

Therefore, the paper now moves towards an analysis of futures markets. The following chapter will look to form a similar understanding of the derivatives market to the one established here for the spot market and following that – a comparison can be made between the two, and further on – that comparison can be used to contrast the allowance market to other markets.

# 6. Futures analysis

Having analysed and gained an understanding of the spot market, the next step is to examine its relation to the futures market. Similarly to how this was performed in the previous chapter, the following paragraphs will compare price movements and analyse whether they are comparable to the spot market. Furthermore, the relationship between the two will be reviewed – using the concepts of backwardation and contango, as was mentioned in the literature review. The ultimate goal is to understand whether futures provide a viable hedging option to decrease some of the risk related to the volatility of the spot market.

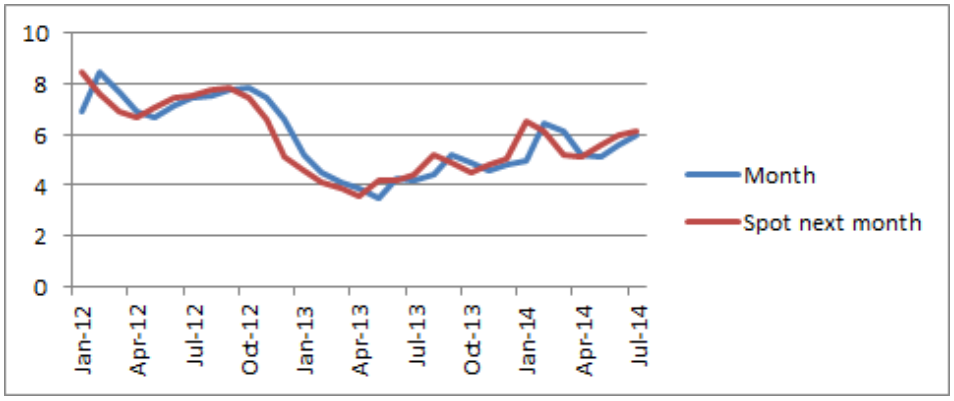



*Graph 6: Relationship between secondary market spot prices and future prices*

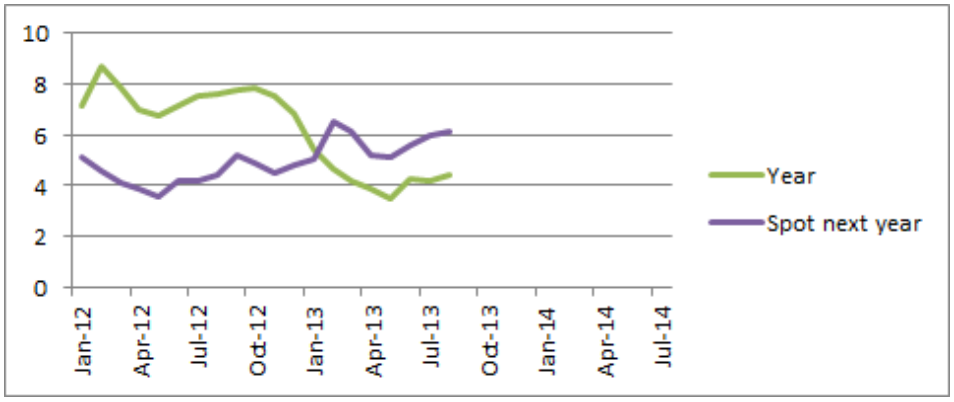
Graph 6 summarises the ICE futures index price for the period of January 2012 till July 2014 on an average monthly basis. As was in the previous chapter – figures from 2012 have been included as well, for the purposes of having a general overview of the transition from Phase II to Phase III and whether any significant changes are in place. ICE provides indices for the Monthly, Annual, Bi-Annual, Tri-Annual and Quad-Annual futures that are sold on the exchange. In effect, this means that the spot for one day can be compared to the expected price (the future) a month from now, a year from now, or two, three and four years from now.

What is clearly visible is that future markets almost ubiquitously move above the spot market (line in orange named “Secondary” on the graph) - the monthly future price is on average less than a percent higher than the spot price, with the highest observed deviation being 2%. On average the annual futures exhibited higher deviations from the spot price, however only the 1-year future ever fell below the actual spot price at a given moment. What this demonstrates is that there is some faith in the market and the futures market provides an effective hedging instrument. An investor can protect his allowances investment today, ensuring that in the future he will receive a similar price. Considering what has been demonstrated in the previous chapter, with the dramatic swings of prices in the auction and secondary markets and the multitude of factors that can affect the price, this brings some safety and stability to the markets.

Using the terms of contango and backwardation, as mentioned in the literature review, a comparison can be made between today’s offered future price and the spot price a month and a year from now:




*Graph 7 (above) Relation between 1Month Future price and the average spot price next month*




*Graph 8 (above): Relation between 1Year Future price and the average spot at that month next year*

It is important to remember that the literature review suggest suggests that markets in Phase II switched from backwardation to contango; the futures were originally traded at prices below the spot, but then they climbed above spot values. High volatility and market swings have been an ever present trademark of the market, as has been verified in previous chapters.

The observation that can be made from the monthly graph (Graph 7) is that futures and spot prices are in a constant flux between backwardation and contango. The relationship flips every few months - with short periods of contango followed by short periods of backwardation.

In effect, this is a repeat of the highly volatile spot market that was observed previously. The offered future price today is tightly linked to the offered spot price – the analysis has previously noted that futures' prices rarely move differently in comparison to the spot price. However, very often the futures price will be different from the actual spot price for that future moment. Or to put it in another way, the spot price on the 1st of June and the futures price on the same day for allowances to be received a month from then will exhibit similar behaviours; however the price an investor would pay for that future on the 1st of June is very different from the price he would pay on the 1st of July on the spot market to purchase allowances. In fact, examining the average monthly future versus the average spot price for the following month, there is an 8% difference between the spot and future – or 0.5 EUR on average in absolute terms.

In case the spot price goes up - this is an 8% profit, as the potential investor has ensured that he purchases the allowances at the old spot price, essentially. Otherwise, that 8% is a premium that he'd pay on the allowances. If the market goes down, however – if spot prices fall, he would have made a "loss" of 8%. This is the trade-off of hedging allowances in such a way. Still, it is traditionally better to "play it safe" and ensure that one knows what price he/she would get, rather than risking an 8% either way.

Looking next to the relationship between annual futures and the spot price a year from now, a much more stable relationship can be observed (Graph 8). Initially, the market was in a state of contango, which switched when Phase III futures started being offered on the market - the annual future price offered in February 2013 was much lower than the actual spot price in February 2014 - nearly two Euros in fact. The same trend continues for the remainder of 2013.

Considering the price crash in 2012 and the record low prices experienced on the primary and secondary spot markets in the beginning of 2013, it is obvious that future prices simply carried on the established trend of following spot prices. This meant that a favourable opportunity would have arisen for anyone buying forwards in that period.

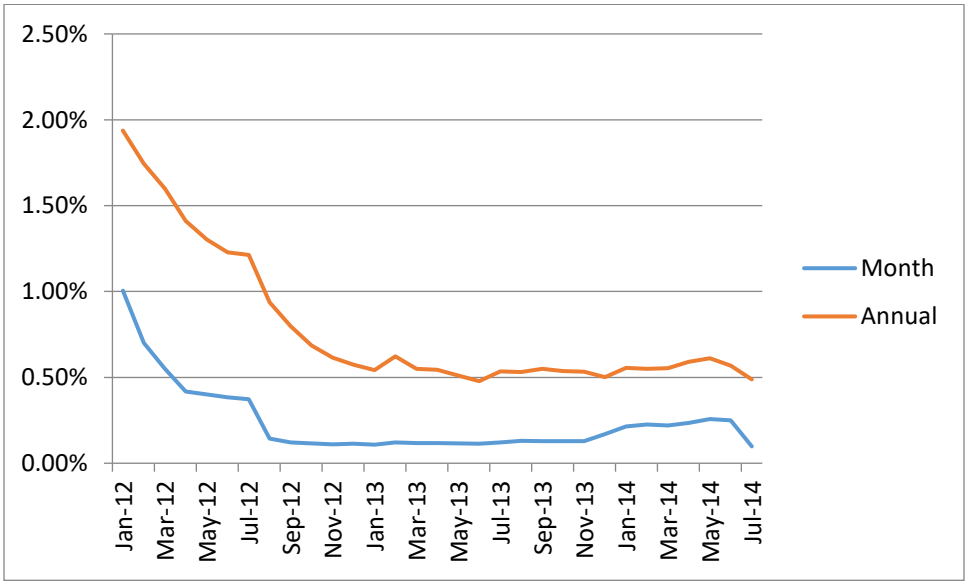
This “opportunity” is signified by the fact that on average, the difference for the observed period between the offered futures rate and the spot price in the same moment next year is 1.16 EUR in absolute terms, or 30% potential for a “profit” or “loss”.

However, this is an incredibly layman way of viewing the result of utilising futures. As seen in the literature, the key methodology for calculating the actual result - the actual benefit - of a futures contract is to calculate its convenience yield.

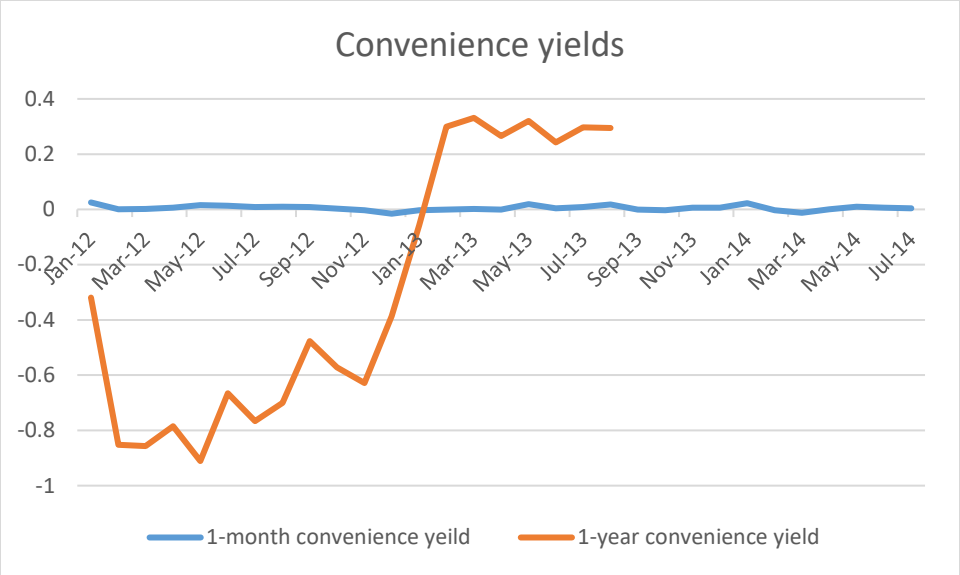
As has been discussed previously (refer to Formula 2), the convenience yield is a function of the rate of return, the time period and the spot and future price. The above analysis and graphs have already presented the average spot and future prices, on which the calculation is based. What remains is to establish an interest rate to use as the rate of return.

When calculating convenience yield, past researchers have turned to the EURIBOR. Short for Euro Interbank Offered Rate, it is a calculated rate based on the average interest rates at which a wide selection of European banks borrow funds from one another. It is, in essence, the European interest rate and is immediately a perfect fit when calculating convenience yield.

Therefore, the convenience yield can be summarized as a function of - for 1 month futures - the 1 month EURIBOR rate, the futures price today and the spot price a month from now; and for the 1 year futures it is a function of the 12 month EURIBOR rate, the futures price today and the spot price a year from now.




*Graph 9 (above): EURIBOR 1 month and 12 month rates (Source: Euribor-rates.eu, 2014)*




*Graph 10 (above): Convenience yields for 1M Futures and 1 Year Futures*

On average, convenience yields for 1 month futures are positive, ranging around 0.1% with little deviation from a month-to-month basis. On the other hand, 1 year futures convenience yields exhibit a much more volatile nature: on average convenience yields are at -31%.

What this means is that the purchase of futures for a 1m period is always advantageous - the positive convenience yield signifies this. An investor deciding to hedge his bet and decide on purchasing futures rather than entering the spot market would have reduced the risk of volatility and would have often made a small “profit” thanks to the premium. However, looking to the 1 year futures, it is clear that in fact there is a negative result when utilising the derivative instrument. While the potential for “profit” is significant, as has been demonstrated in the previous paragraphs when looking to the premium - so too is the risk that the buyer will dramatically overpay for the allowances if trading in futures. The volatility of the market is such that predictions for so long a period can often be imprecise, leading to price expectations that are highly unlikely to materialise.

## Conclusion on futures market

Looking at the relationship between the futures and spot market, it can be concluded that futures have almost always traded above the level of today’s spot price - however the difference is rarely if ever significant enough so as to discourage trade. In effect, this means that futures have been a more than adequate hedging instrument, ensuring that one can always obtain today’s price in a future period and can always remove that uncertainty.

Moreover, as there is also a clear connection between spot and futures prices - as the spot market exhibits high volatility, so too must it be assumed that this spills over to the futures market. By calculating the convenience yields for the 1 month and 1 year futures, the actual benefit of utilizing this instrument can be made clear.

In terms of short term futures - 1 month - the period is not long enough to experience the high volatility of the market, therefore it is beneficial to take advantage of futures. However, if the time horizon is expanded and the convenience yields for 1-year futures are examined, the story is very different. The long-term market is simply too volatile to take advantage of and predictions for the future spot price are rarely accurate enough to provide an advantage.

To summarise, the futures market confirms the previous conclusion that the allowance market is a highly volatile one. Long-term uncertainty makes far-horizon trades an incredibly risky proposition. However, short term trades can easily be hedged – and with the premium being sufficiently low, this means that a significant enough portion of the volatility risk, at least in the short term, can be mitigated. This is useful information both for businesses that aim to meet the cap and also for investors. While the decision whether or not to enter into futures deals is subjective and should be determined on a case-by-case basis, the broad conclusion is that futures are a worthwhile option.

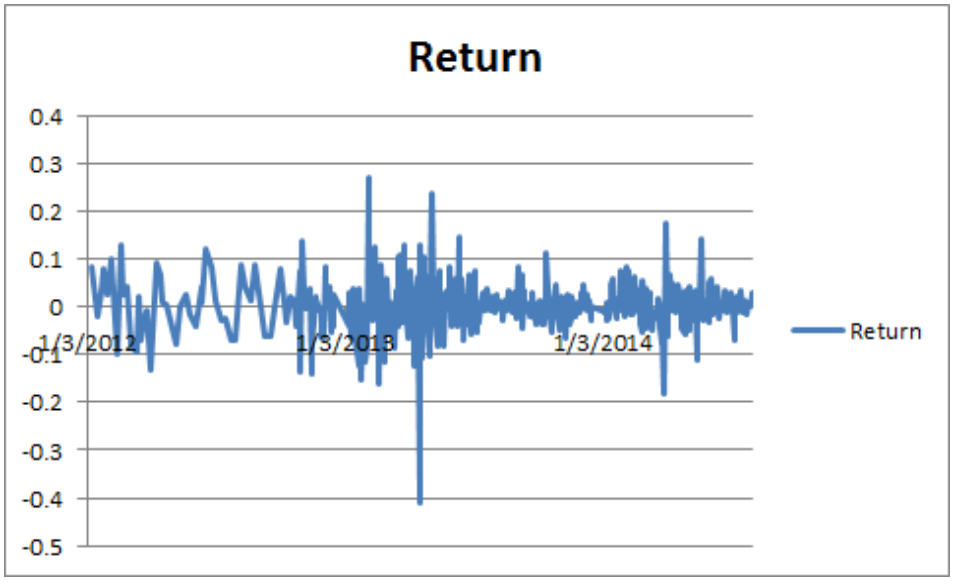
It should be noted, though, that this is a general assumption; it is possible that there are other factors in play that are not considered in the current research. Therefore, it is possible that in the future this relationship may change and futures may no longer be an effective hedging instrument. This paper does not define a statistical correlation between spot and futures, nor does it claim that the relationship will always remain thus. It is, nevertheless, a good thing to point that so far futures appear an effective hedging instrument and can mitigate some of the market volatility.

Having said this, the analysis must now turn to ask the original question – is allowance trade a profitable option? Specifically, when looking to comparing spot and futures, a comparison of returns can lead to an answer of this question. This will be covered in the following chapter.

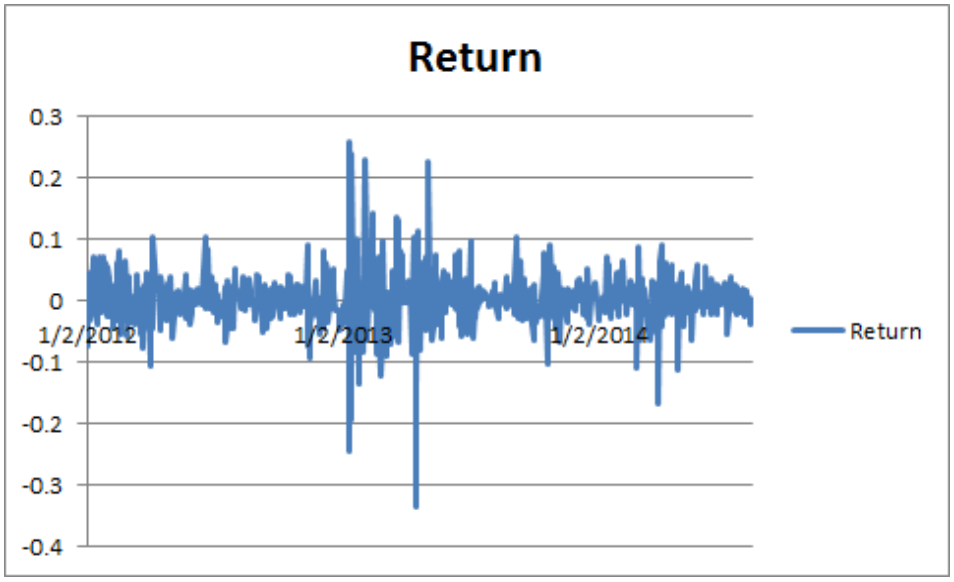
# 7. Analysis of returns and volatility of allowances

Examining the price behaviour of the EUA market - both spot and future – in the previous chapters has shown that there is significant volatility in price dynamics. However, from an investment point of view price is only a part of the equation. The actual measurement that is applicable from a financial perspective is that of returns - and, consequently, their volatility. Returns are defined as the price today less yesterday's price, divided by yesterday's price. In effect, it represents the percentage change in price – and it gives the actual answer to the question "what's the profit". Moreover, as they are expressed in percentages, returns are a metric that can easily be compared between various instruments.

High returns, coupled with low volatility points to a very lucrative market. Minimal, but stable returns also point towards a profitable investment, but if the market is showing negative returns or high volatility - this is when we can be confident in labeling it a bad market and staying away.
To perform an analysis of the returns, the first step is to select a time period and calculate returns on it. The following graphs compare arithmetic returns between primary and secondary allowance markets:




*Graph 11: Returns of the auction (primary) market*




*Graph 12: Returns on the secondary market*

What is immediately evident is that in both cases the movement of returns is staggering, which absolutely fits in with what was established the price variance in both spot markets. When prices change - returns change. So far there can be no question of the market's volatility.

Returns in the secondary market are more clustered as the data is daily - transactions on the secondary market occur every day, whereas auction transactions on the EEX occur every couple of days.

Comparatively, the average return on the auction market is 0.17% while for the secondary market it's 0.08%. It appears that the returns on the secondary market are lower, though this information is naturally affected by the fact that secondary market information is daily - therefore it covers more data points, whereas auction data is sparser. Due to the time lag in auctions, the price on day one could be EUR 10,

while the price five days later, when the next auction is held, could be EUR 15. In effect this would mean a return of 100%. By contrast, if the daily secondary market prices on average were EUR 10, 11, 12, 13, 14 and 15 – and therefore the returns would be 10%, 9%, 8%, 7.6% and 7% respectively. Frequency of trades matters. Nevertheless, it is a valuable observation to be made – the primary auction market has higher returns, but the secondary market gives the more precise picture.

Furthermore, both markets indicate positive average returns - irrespective of the size of the percentage, the mean indicates that one is more likely to sell his or her allowances tomorrow for more than he or she bought them for today.

Returns cover only part of the equation, however. Further analysis of them allows us to model the volatility of the EUA market. As per the literature review section, a GARCH model is the most applied and most applicable model for assessing volatility in the market.

$$\sigma_t^2 = k + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2,$$

*Formula 2: GARCH*

As defined before, GARCH defines volatility as a function of the weighted average of the long term historical variance, the predicted variance for the period and the previous day squared residual (or return).

In the above formula, ε is the squared return, t stands for time, ω, α and β are empirical parameters determined by maximum likelihood estimation - essentially the weights attributed to each function parameter. That estimation has already been defined as follows:

$$f(x_1, \ldots, x_n \mid \mu, \sigma^2) = \prod_{i=1}^{n} f(x_i \mid \mu, \sigma^2) = \left(\frac{1}{2\pi\sigma^2}\right)^{n/2} \exp\left(-\frac{\sum_{i=1}^{n}(x_i - \mu)^2}{2\sigma^2}\right),$$

*Formula 3: Maximum likelihood calculation*

The maximum likelihood is therefore calculated as a function of the logarithm of the conditional variance and the squared residual as its key components.

Arithmetic returns have already been calculated, which is the first necessary step towards implementing GARCH. Taking them as a starting point and inputting all the necessary data in Excel, the following table is obtained:

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | |
| 2 | | | Variance | 0.001055 | | Pi | 3.1415927 | | | |
| 3 | | | gamma | 0.000589 | | | | | | |
| 4 | | | alpha | 0.191666 | | | | | | |
| 5 | | | beta | 0.226508 | | | | | | |
| 6 | | | | | | | | | | |
| 7 | ***Date*** | ***Index*** | ***Residual*** | ***Squared*** | ***Lagged*** | ***Conditional*** | ***Likelihood*** | | ***Conditional*** | ***Unconditional*** |
| 8 | 12/30/2013 | 4.91 | | | | | | | | |
| 9 | 1/2/2014 | 4.74 | -0.01175 | 0.000138 | | 0.00105472 | 2.4429012 | | 0.03247643 | 0.03247643 |
| 10 | 1/3/2014 | 4.71 | -0.00635 | 4.03E-05 | 0.000138 | 0.00085477 | 2.5898209 | | 0.02923641 | 0.03247643 |
| 11 | 1/6/2014 | 4.65 | -0.00427 | 1.83E-05 | 4.03E-05 | 0.00079076 | 2.6407706 | | 0.02812048 | 0.03247643 |
| 12 | 1/7/2014 | 4.67 | 0.004292 | 1.84E-05 | 1.83E-05 | 0.00077204 | 2.6523707 | | 0.02778556 | 0.03247643 |
| 13 | 1/8/2014 | 4.6 | -0.0151 | 0.000228 | 1.84E-05 | 0.00076783 | 2.5185029 | | 0.02770968 | 0.03247643 |
| 14 | 1/9/2014 | 4.51 | -0.01976 | 0.00039 | 0.000228 | 0.00080706 | 2.4002373 | | 0.0284088 | 0.03247643 |
| 15 | 1/14/2014 | 4.82 | 0.013295 | 0.000177 | 0.00039 | 0.00084706 | 2.5135898 | | 0.0291043 | 0.03247643 |
| 16 | 1/15/2014 | 4.8 | -0.00416 | 1.73E-05 | 0.000177 | 0.00081517 | 2.6265142 | | 0.02855117 | 0.03247643 |
| 17 | 1/16/2014 | 5.07 | 0.054725 | 0.002995 | 1.73E-05 | 0.00077738 | 0.7346278 | | 0.02788152 | 0.03247643 |

*Table 4: GARCH (1,1) model in Excel*

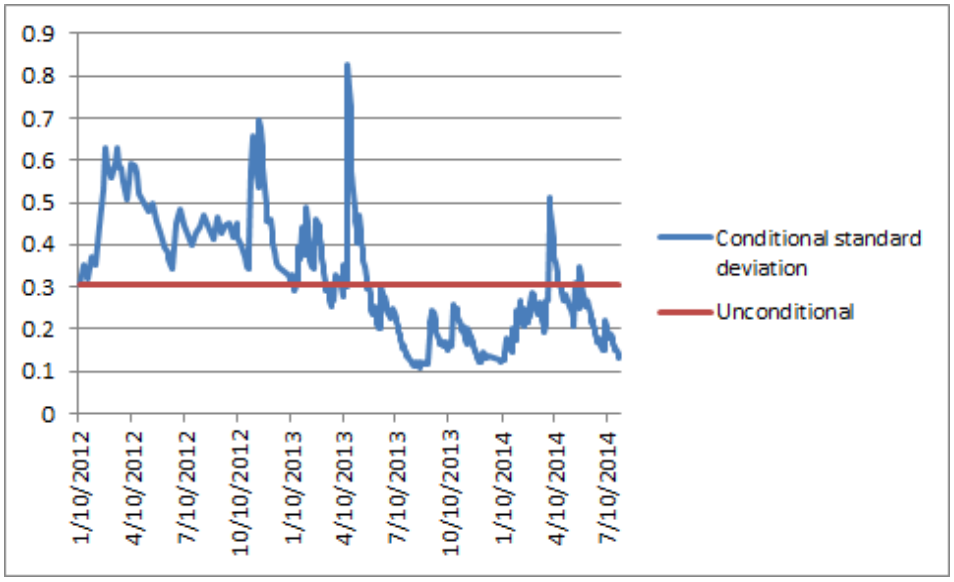
First off the Variance and the three empirical parameters are placed (Cells D2, D3, D4, D5). The Variance is calculated based on the sum of returns in column C - “Residual”.

The next column is for the squared residual; column E denotes the lagged residual, i.e. the squared residual from the previous day. Column F is the Conditional variance. In the first day the variance is equal to the variance calculated in cell D2. For the next day it is equal to “gamma” (cell D3) plus “alpha” (cell D4) multiplied with the lagged residual plus “beta” (cell D5) multiplied with the previous day conditional variance. In essence this cell calculates the daily variance as per GARCH.

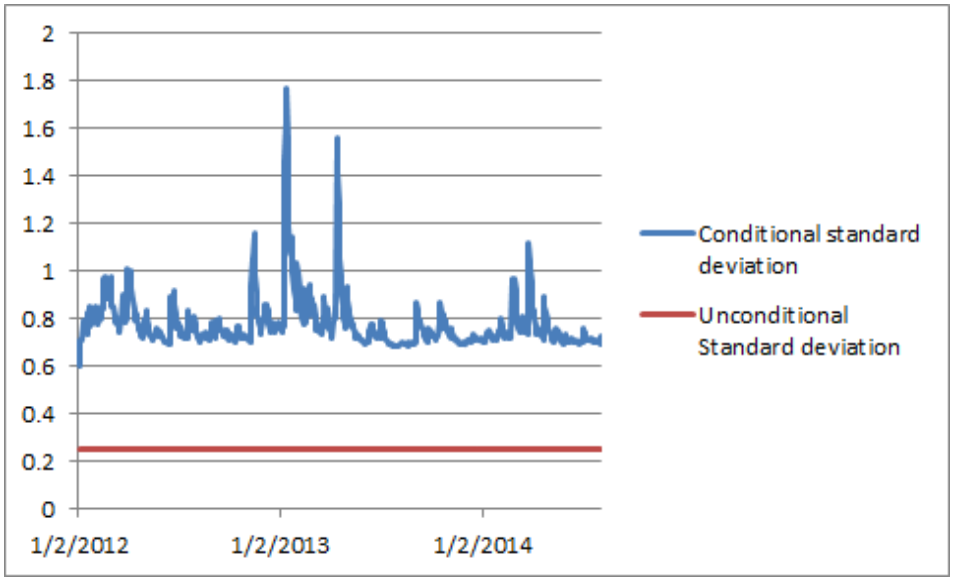
Row G contains the calculation of the maximum likelihood probability as per the formula given above. Summing the entire row G gives the maximum likelihood itself. Using the “Solver” function of the Excel Analytical Toolkit, the maximum value for the cell containing the likelihood can be calculated, thus identifying the variables to be changed. Excel calculates an answer and the table recalculates itself based on the newly calculated empirical parameters.

Calculating a conditional and unconditional standard deviation first, the second step is to then graph the volatility of returns as modeled by GARCH (1,1). The conditional standard deviation is simply the square root of the daily conditional variance calculated in Column F, while the unconditional standard deviation is the square root of the variance calculated in Cell 2.

Plotting both residuals on a graph, the market volatility for the spot market is modeled as follows:




*Graph 13 (above): Arithmetic GARCH (1,1) for EEX auction market 2012-2014*




*Graph 14 (above): Arithmetic GARCH (1,1) for EEX secondary market 2012-2014*

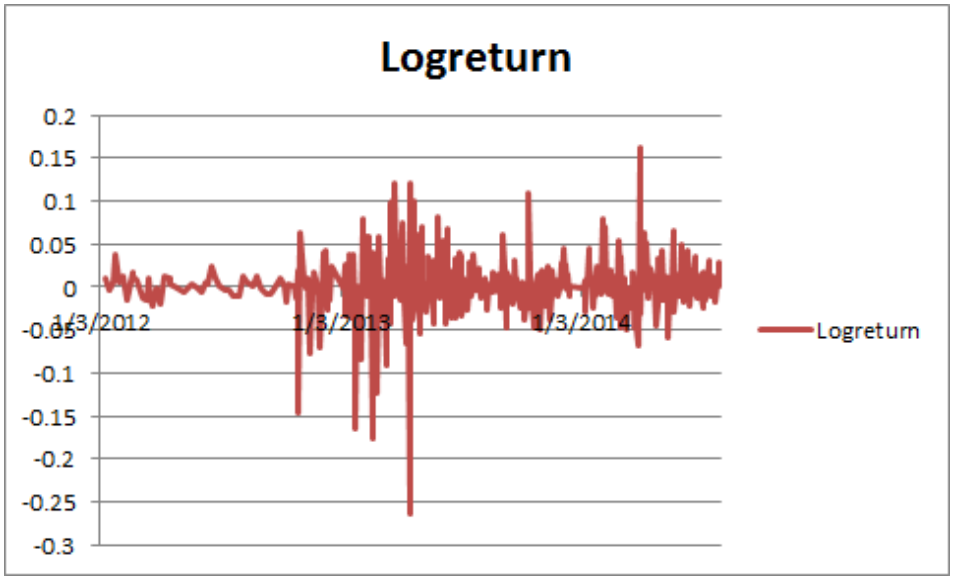
The blue line indicates the conditional standard deviation, calculated via GARCH (1,1); the red line is the standard deviation based on the arithmetic returns for each market. For the auction market, the average conditional standard deviation over the 2012-2014 period is 0.2934 - with the unconditional being 0.3049; whereas for the secondary market the conditional standard deviation is 0.7808 - clearly the secondary market is much more volatile, by a significant margin.

However, what is immediately noticeable from the secondary market graph is that in the case of the secondary market (Graph 14), there is zero overlap between the conditional and unconditional deviation (unconditional deviation measured at 0.2478). This is due to the fact that the unconditional deviation is calculated on the basis of prices from 2012 - 2014 - it contains a wider data set, bringing the mean down and giving a widely off-the-mark estimation of the market's volatility.

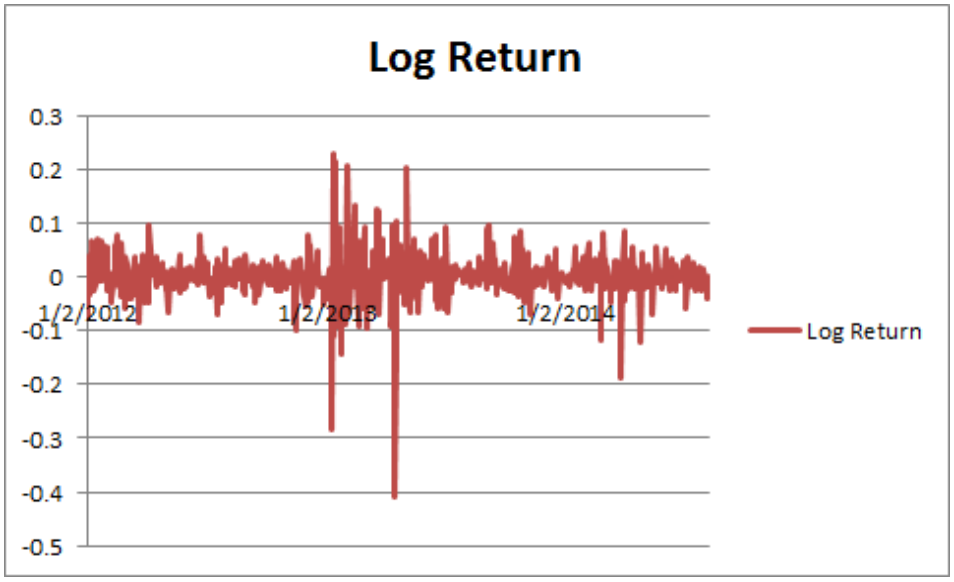
On the other hand, the GARCH lines in both cases are weighted so as to give more importance to previous day results, but also to draw back to an expectation of the moving average for the entire period. In essence, the GARCH model should give a much more accurate indication of volatility. However, it's logical that with GARCH estimations, the fact that the given calculation covers both Phase II and Phase III returns as fundamentals would lead to errors in the overall result. Using such a broad range of data leads to inconclusive results, which are difficult to understand or extract a meaningful conclusion from.

A much more accurate result can be obtained if the calculation focuses only on Phase III data - using returns calculated only on the basis of prices from Jan 2013 till July 2014. While it is a smaller sample size, the data here is more tightly correlated: EUAs fall within the legislative changes for Phase III, plus the data is not affected by the price crash at the end of Phase II - which is a statistical outlier and even if mitigated to some extent via GARCH modeling, it is still affecting our estimation.

To add further precision to the model, instead of the arithmetic return logarithmic returns shall be used. These are easily calculated in Excel with the same input as arithmetic returns – daily prices for a period. The sole difference is that the logarithm of the calculation is taken – the formula is the logarithm of (price today less price yesterday, divided by the number of days between trades). For the primary and secondary markets, charting logreturns gives the following graphs:



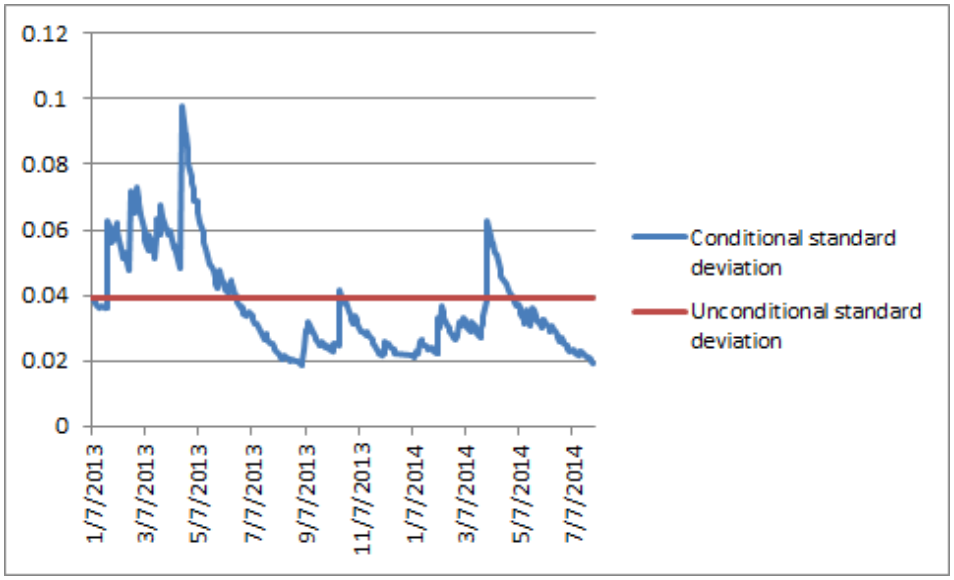

*Graph 15: Logreturns for EEX auction market for Phase III (2013-2014)*



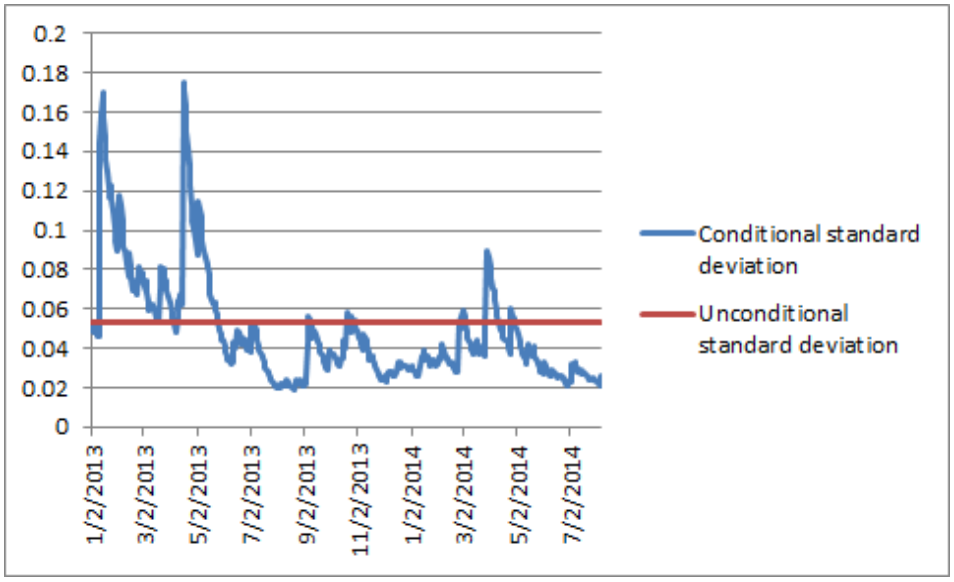

*Graph 16: Logreturns for EEX secondary market for Phase III (2013-2014)*

On the auction market, the returns are on average equal to around 0.18%, whereas on the secondary market they are significantly lower - averaging at around 0.06%. As with the arithmetic returns, similar differences between the graphs are observed - once again due to the different timing of the data for each market. As a rule of thumb, the analysis assumes that the secondary market gives a more accurate indication of returns of EUAs trading, though this doesn't mean that the auction data is irrelevant.

The observation from the arithmetic return graphs remains true - on average auction markets give a higher return than secondary markets and the difference has become even more explicit in Phase III. Returning to the GARCH model in order to ascertain the volatility of log returns, the following results are obtained:




*Graph 17: Garch (1,1) calculated on log returns for Phase III auctions EEX*




*Graph 18: GARCH (1,1) calculated on the basis of log returns for the EEX secondary market*

Average conditional standard deviation for the auction market is 0.0374 with the unconditional calculated at 0.0393; for the secondary market the conditional standard deviation is calculated at 0.0490 with an unconditional standard deviation of 0.0536. The higher standard deviation for the secondary market indicates that it is also the more volatile of the two markets - as was the case with the arithmetic returns.

However, the difference in deviation here is not as expressed as with the 2012-2014 period. It can therefore be concluded that taken as an individual segment, volatility for Phase III is decreasing.

In fact, when volatility for 2013 is calculated and compared to volatility in 2014, the following is the result:

| | 2013 | 2014 | |
|---|---|---|---|
| | Conditional | Conditional | Difference |
| Auction | 0.04387354 | 0.029371299 | 0.01450224 |
| Secondary | 0.05514817 | 0.031207295 | 0.02394087 |
| Difference | -0.0112746 | -0.001835996 | |

*Table 5: Comparison between 2013 and 2014 volatility*

Bearing in mind that the data for 2014 is not complete, as it covers the period only until July, it is still notable that volatility is decreasing - both for the auction and secondary markets. Along with that returns are also slowly increasing in terms of the average. Therefore, the conclusion of the analysis is that there is some stability entering the market - particularly with news of increased EU support and with new measures to support the cap-and-trade system. Whether this holds in the future is difficult to predict, but it is a trend worth noting.

## Conclusion on returns and volatility for the allowances market

Improved returns and lowered volatility – these were the initial signs of Phase III of the EU ETS. Again, the caveat is in place that this trend may not hold – but initially it appears that the changes between phases and the appearance of EU commitment and support to the cap-and-trade system has had an overall positive effect on the market. Looking just to allowances – if a trader had bought allowances in 2013 and was looking to sell them in 2014, he is likely to make a profit (notwithstanding any peripheral costs). That and the lowering in volatility do give the impression that there might be profit to be made in the market. Indeed, if one were to only look to this market – without taking into account other commodities – it appears that the EU ETS could present an opportunity for a business venture.

There is some stability – or at the very least, it is improving. Comparing the auction market to the secondary market, the research can make conclusions regarding the internal dependencies within the EU ETS. The relationship between volatility in the spot and secondary market has shown that overall the secondary market is the better indicator of the state of the EU ETS. Furthermore, an investor would be better off if he trades on that market due to the smaller price difference and more frequent opportunities for trades.

These are all notable conclusions – if the EU ETS was the only available market to a business. If one had no other option than to trade in allowances – than this chapter demonstrate that Phase III has made the market somewhat more reliable.

These are all valuable observations, however the goal of the research is different. Looking at allowances in isolation gives a very limited conclusion. A much more interesting observation can be made in the following chapter, where EUA markets will be compared to other markets in terms of returns and volatility. The result of that comparison gives a valuable benchmark with which allowances can be compared and would give the answer of whether returns and market volatility on the EU ETS are complimentary to trades. And after all, from a business perspective, it is important to have this comparison. Knowing that allowances markets are improving is good, but knowing where they stand in relation to other potential business niches is better – equipped with such information a business can make decisions on where to best invest its capital.

# 8. Comparison to commodities and equity

As discussed in previous chapters, the EU defines allowances as a commodity – one allowance is essentially a ton of carbon dioxide. And while it's not the physical gas itself that is being traded, but rather the allowance to emit it, it is still logical why allowances are classified as commodities.

Bearing that in mind and considering that previous chapters have seen a price dependency between the EU ETS and power markets, a conclusion can be made that the two types of commodities are not only interlinked, but also comparable. They are affected by similar legislative and environmental factors and furthermore are traded on the same markets.

The EEX trades in power, natural gas and coal - the main commodities that comprise the “power” market in Europe. As this paper examines the EEX secondary and auction markets for allowances, comparing them to EEX power markets gives an easy and convenient benchmark. Chapter 7 has already dealt with calculating returns and volatility on the allowance markets. The following paragraphs will contain similar calculations for commodities, as well as equities, in order to compare the markets and reach a conclusion on which the best one is and why.

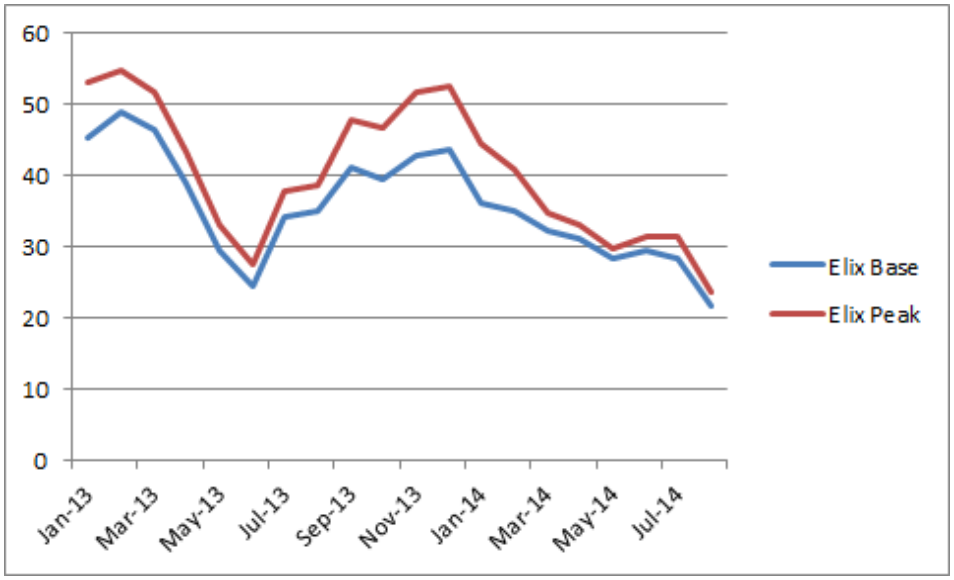
## 8.1 Power markets

On the EEX, power is traded via EPEXSpot, which covers spot trades in Germany, Austria, France and Switzerland. The main index for power is ELIX - the European Electricity Index, which was launched in 2010 as a means of tracking and indexing electricity prices across all EPEX spot markets.

It is calculated in auction, based on the aggregated bid/offer curves of existing market areas and the rules of EPEX Spot. Elix is calculated for both base load - meaning the minimum electricity that needs to be provided at each point during the day; and at peak load - when more electricity is needed, due to higher usage by consumers.

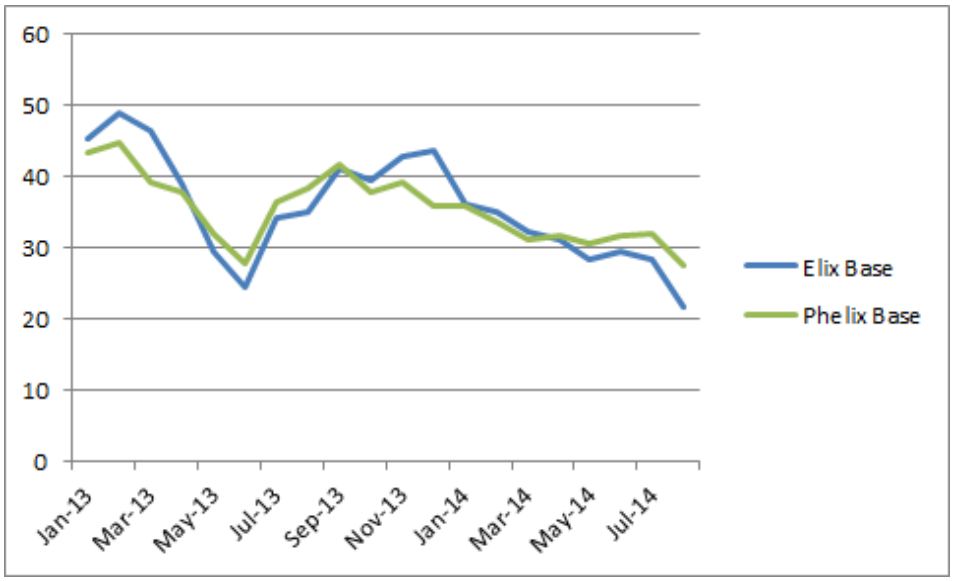
Another index is the PHELIX power index - The Physical Electricity index. Calculated in a similar fashion to the Elix, the main difference is the Phelix covers prices on the German and Austrian market specifically. As with Elix, prices are presented in both base and peak loads.

Assuming base loads are the fairest representation of power prices - or at the very least a representation of average daily power price, not accounting for peaks - the analysis shall collect the data from EPEX Spot concerning index prices for the period 2013-2014. Only that period will be covered in order to use the same time horizon as with the EUA spot markets. Calculating the average monthly prices for the indices, the following graphs are plotted:




*Graph 19: Price comparison between ELIX base and peak prices*

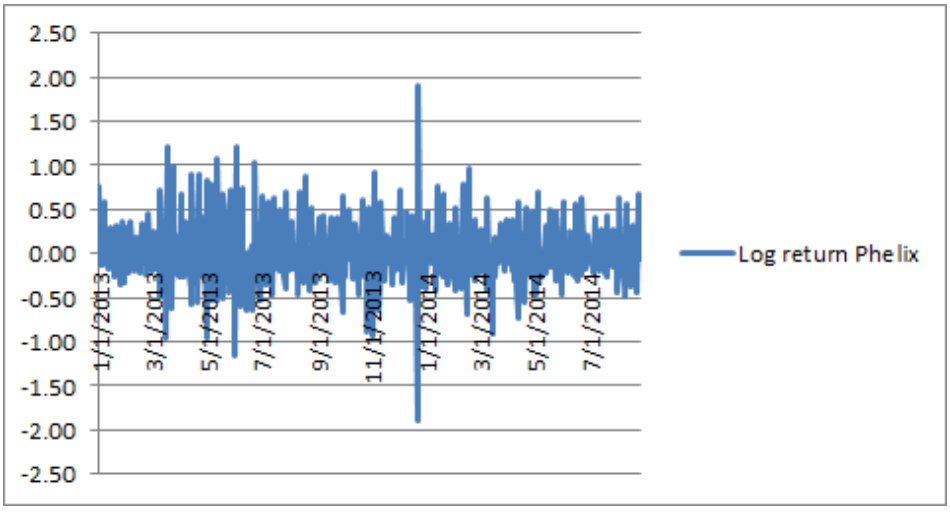
Looking at the first graph, where Elix base and peak prices are plotted against one another, we see that prices move with similar trends. Clearly peak power is more expensive, due to natural market forces of supply and demand - there is higher demand for for peak power, pushing the price up. However, for the purpose of plotting logarithmic returns, there shouldn't be any noticeable difference either way, as the relationship between prices remains the same.



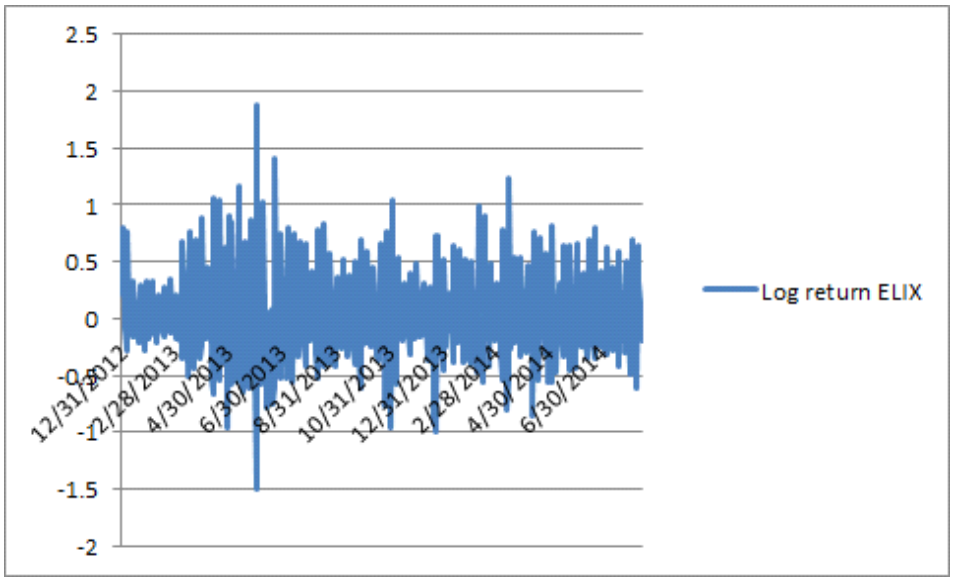

*Graph 20: Price comparison between ELIX and PHELIX base prices*

Comparing Elix to Phelix , there are some differences, that are clearly attributable to geographical factors - Phelix is affected both by overall European factors, but there is also a more expressed effect of specific local factors, that only affect Germany and Austria. Overall, however both indices have shown a downward trend for the period, indicating that the price of power is falling.

Having obtained prices for both indices, the analysis can then move to calculating the daily returns for the period as have been calculated previously for allowances:



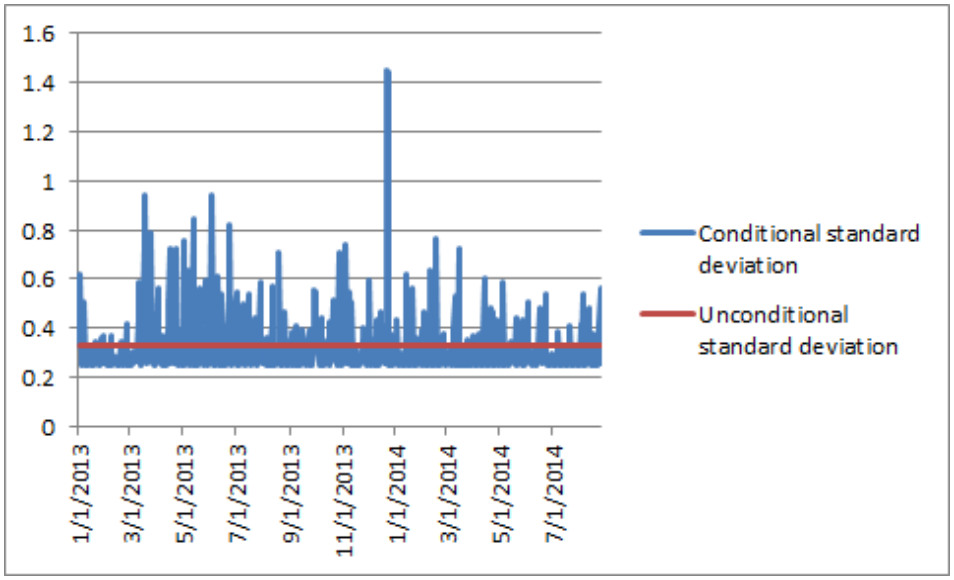

*Graph 21 (above): Daily Logarithmic returns for the PHELIX index*



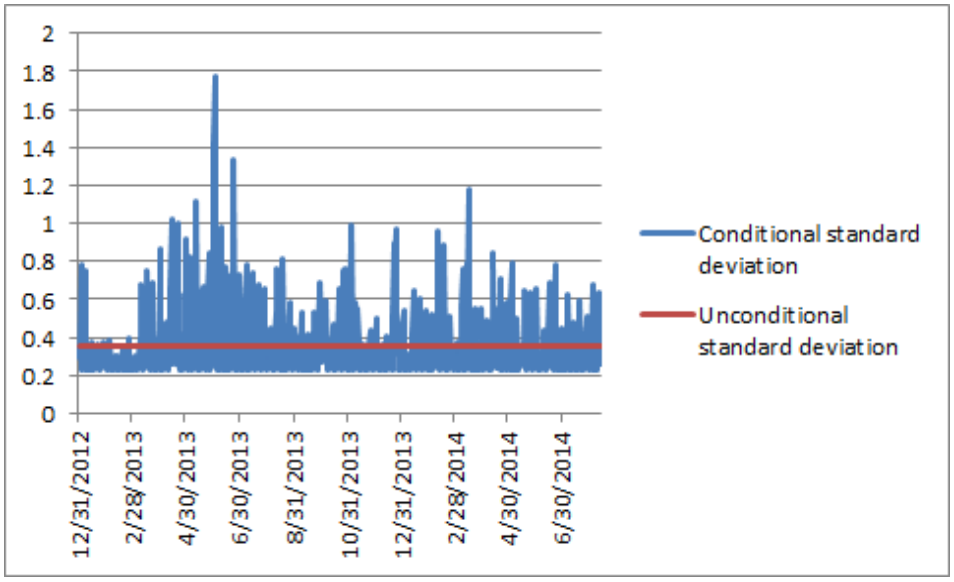

*Graph 22 (above): Daily Logarithmic returns for the ELIX index*

The findings are quite interesting. Both indices have a negative daily average return, which is supported by the dropping price trend. For Elix the average logarithmic return calculated for the 2013-2014 period is -0.15%, whereas for Phelix it is -0.18%, indicating that both indices register a loss on average, though Phelix register a marginally higher loss.

Once again, the research turns to GARCH (1,1) to model the volatility of both indices. It should be noted, that GARCH is not necessarily the best methodology for calculating volatility of power or natural gas markets, however it will be used in the paper in order to assure that similar figures are obtained to the allowance findings.




*Graph 23 (above): GARCH (1,1) calculated for Phelix*




*Graph 24 (above): GARCH (1,1,) calculated for Elix*

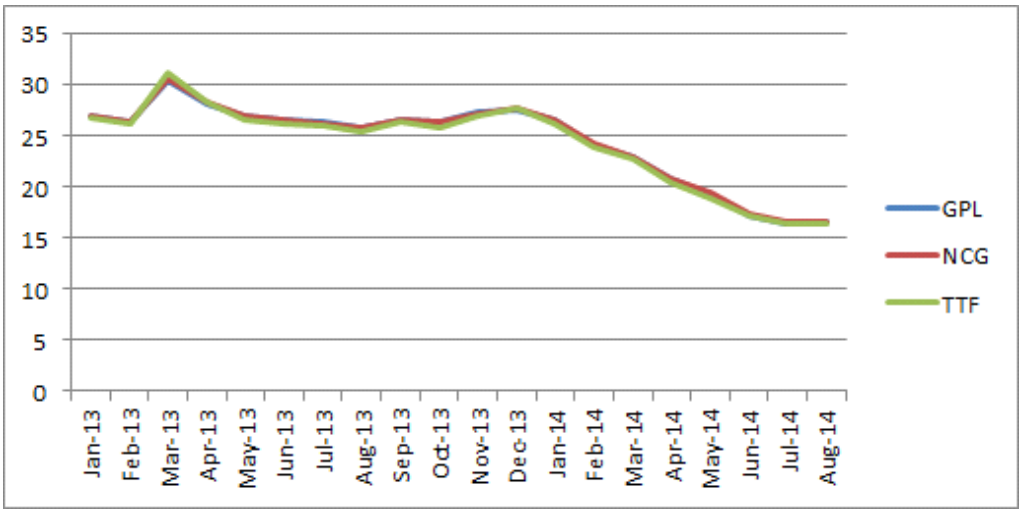
In both indices it is clear that the volatility is staggering. The average conditional standard deviation for Elix is 0.3537 with an unconditional deviation of 0.3561; for Phelix it's 0.3226 and 0.3220 respectively. Comparing this to the standard deviations the analysis saw for allowances, the result is that volatility in allowances is much lower. In fact, average volatility on the power market is near 13 times greater than the average volatility of the spot and secondary allowance markets. Using the same methodology for calculating returns and volatility as utilised for allowances, it appears that in fact allowances are a better value proposition - both in terms of returns and in terms of lower volatility of the market.

The research can therefore conclude that it makes little sense in investing in power, when allowances provide better returns at lower volatility. Should the price of power stabilise and improve, however – should a recovery on power markets occur - it is possible that the situation will reverse and power markets could outperform allowances. Power, however, is just one comparable commodity. The following pages will look towards natural gas, the markets for which are tightly linked to power markets and compare them to allowance. While natural gas is closely linked to power, it is nevertheless different in some aspects and there is value in comparing it on its own.

## 8.2 Natural gas

The next commodity that the research shall compare to allowances is natural gas. Also traded on the EEX, there are several varieties of gas spot prices provided - Gaspool (GPL - incorporating about 350 downstream natural gas transport networks in Germany), NetConnect Germany (NCG - Germany's largest market area, encompassing a distance of approximately 20,000 km and linking nearly 500 gas distribution networks) and Title Transfer Facility (TTF - the Dutch market area).

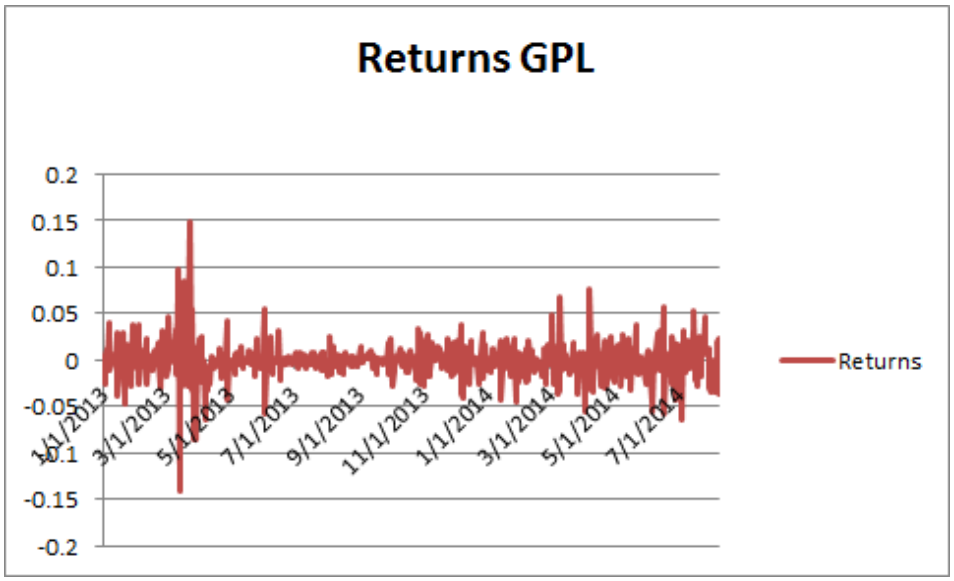
Following a similar methodology, daily reference prices have been collected from EEX for the 2013-2014 period for all three market areas and have been plotted below:



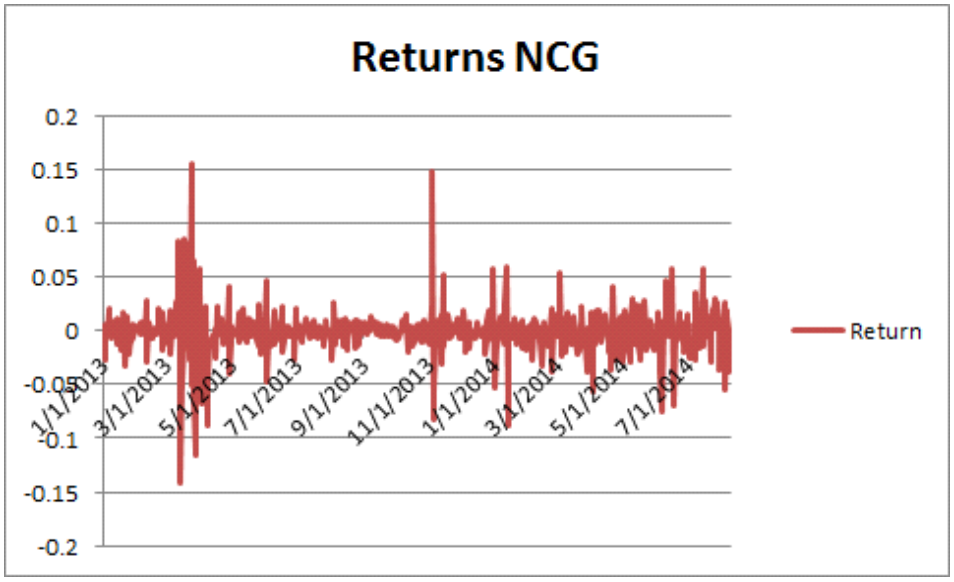

*Graph 25: Gas market area average monthly prices*

The three markets move almost identically, with very little deviations between one another: for the observed period the average price for the GPL market area is EUR 24.4967; NCG is EUR 24.5345 and TTF is EUR 24.3148. Just like the power market, natural gas prices overall show a decline. The relationship makes sense, as a decrease in natural gas prices would lead to cheaper power prices.

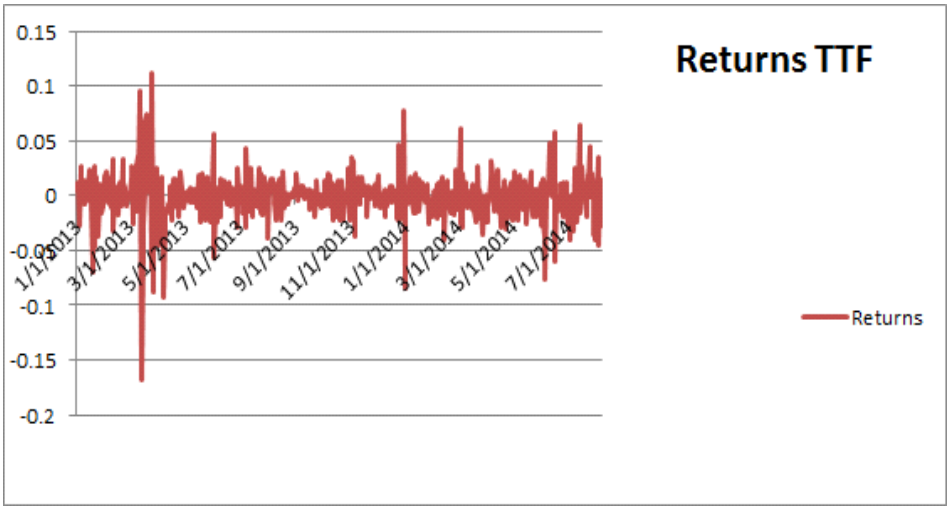
Looking to returns, the analysis further confirms the similarity in the markets - the average return for all three markets is negative: -0.088% for GPL, -0.089% for NCG and 0.085% for TTF. TTF is, overall, the market with the best returns, but the difference is so insignificant, that there is little value for the purposes of this paper in pointing that out.




*Graph 26 (above): Returns for GPL market area*

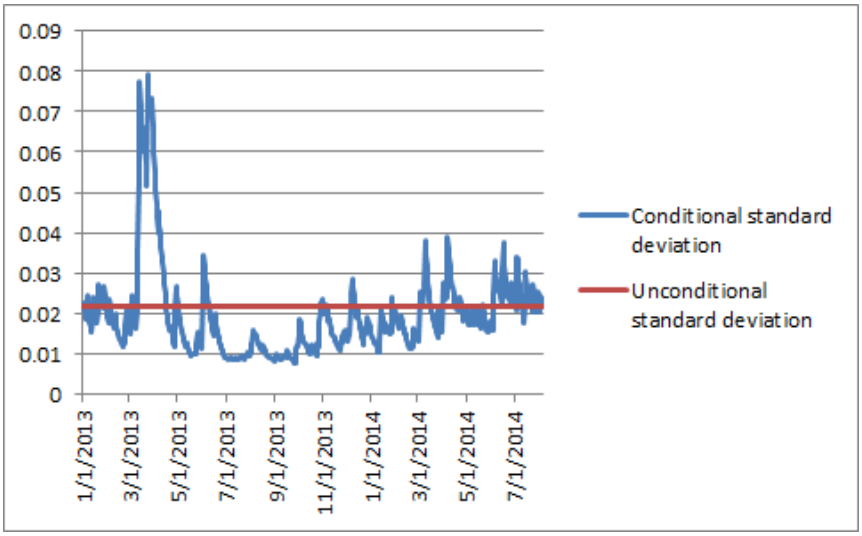



*Graph 27 (above): Returns for NCG market area*

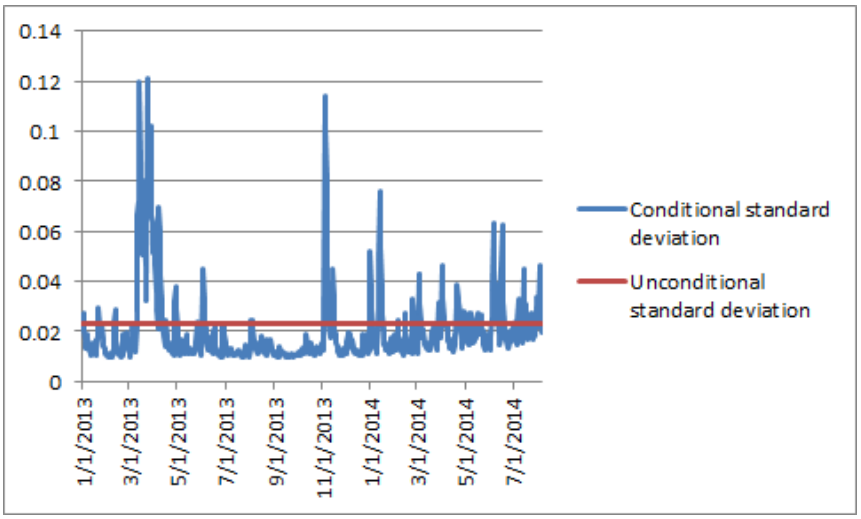



*Graph 28 (above): Returns for TTF market area*

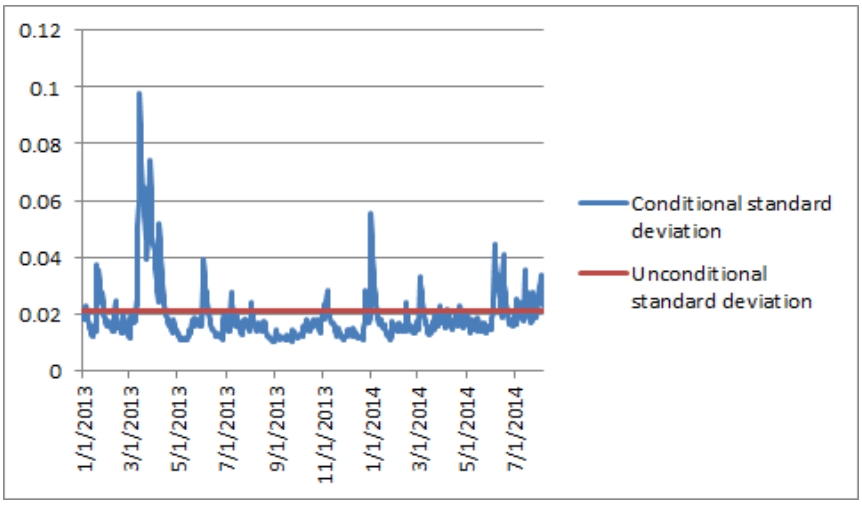
Having calculated logarithmic returns, they are next input as the fundament for GARCH (1,1) model:




*Graph 29 (above): GARCH (1,1) calculated for GPL market area*




*Graph 30 (above): GARCH (1,1) calculated for the NCG market area*




*Graph 31 (above): GARCH (1,1) calculated for the TTF market area*

Summarising the data, the following table is obtained:

| | GPL | NCG | TTF | Average |
|---|---|---|---|---|
| Conditional | 0.019561 | 0.020461 | 0.019336 | 0.019786 |
| Unconditional | 0.021451 | 0.022765 | 0.021293 | 0.021836 |

*Table 6: Summary of GARCH (1,1) for gas market areas*

What is clear is that the NCG is the most volatile market area, whereas GPL is the most stable, though the differences are by no means significant. Comparing it to the Phase III volatility data for allowances, it appears that the natural gas market is in fact more stable than the allowances market - the average spot volatility on the natural gas markets is 0.0198, whereas for the allowances markets (combining auction and secondary) the average is 0.0432.

Therefore, it can be concluded that the natural gas market is much less volatile that the EU ETS. However, in terms of returns it must still be noted that average returns are negative for the natural gas markets and the market exhibits a strong downward trend, so any investments made need to take that into account. Both instruments are a risky proposition - allowances offer better returns, but a more volatile market, meaning there is high uncertainty in actually getting those returns; on the other hand, natural gas markets are less volatile, but are on a rapid downward trend, meaning that the only logical investment is going long on gas, in the hope that prices would appreciate eventually.

The long strategy, as we've demonstrated, does not work with the allowance market, as there is next to no certainty regarding the prices in the long-term; however natural gas prices are likely to recover, particularly looking to the recent political situation in Eastern Europe.

What can be concluded is that both instruments may provide benefit, depending on the strategy utilised by traders. Returning to the discussion of power markets, an appreciation of natural gas prices will likely lead to an increase in power prices. Therefore, both power and natural gas provide a diversification option against allowances. Depending on the trading strategy, both commodities may outperform allowances - however for the period of 2013-2014 this is not the case and allowances are demonstrated to be the more secure and beneficial instrument for trading purposes.

## 8.3 Equity markets

Finally, having compared allowances to other commodities, the research now turns to equity markets as the next and final financial instrument with which a comparison will be made. To this effect, the first step is to select a valid benchmark.

For power and natural gas it was easy - the EEX already provides indices for both commodities, making it easy to analyse the price of each instrument and perform an estimation of returns and market volatility. However, there is a fundamental issue when comparing commodities to equity - this is termed cross-asset analysis and difficulties with it are connected to the fact that different factors affect different financial

instruments in variable ways. Therefore, to ensure that the data has some touching point and is comparable, the research must look at equity that is related to the trade of carbon allowances.

To that effect, this paper turns towards indices or funds that trade on the power or natural gas markets - which literature indicates that are connected to the cap-and-trade system for allowances trading; or towards companies whose business is to do with alternative energy in one way or another. These companies are affected by similar political and legislative factors that affect the allowances markets - as has already been seen during the price analysis for allowances.

To satisfy these criteria, the following benchmarks have been selected:

DAXGlobal Alternative - a DAX index that tracks 15 international companies, whose revenues are based on technologies and services designed to promote and generate alternative energy sources

Credit Suisse Global Alternative Energy Index - an index by CreditSuisse that tracks the performance of alternative energy markets by referencing the performance of 30 major companies in five sectors - Natural Gas, Wind, Solar, Bio-energy/Biomass and Geothermal/Hydropower/Fuel cells/Batteries

Firsthand Alternative Energy (ALTEX) - a fund that invests 80% of its assets into alternative energy and alternative energy technology - both in the US and internationally.

iShares Global Clean Energy ETF - an exchange traded fund that seeks to track the investment result of an index composed of global equities in the clean energy sector. For the ETF the research has specifically isolated the European companies, namely:
- GAMESA CORPORACION TECNOLOGICA S.A - Spanish company dealing with electrical equipment;
- VESTAS WIND SYSTEMS A/S - Danish company dealing with electrical equipment;
- ENEL GREEN POWER S.P.A. - Italian company dealing in power and renewable electricity;
- EDP RENOVAVEIS S/A - Spanish company dealing in power and renewable electricity;
- VERBUND AG - Austrian company in electric utilities;
- RENEWABLE ENERGY ORD - Norwegian company dealing in semiconductors;
- NORDEX ORD - German company dealing in electrical equipment;

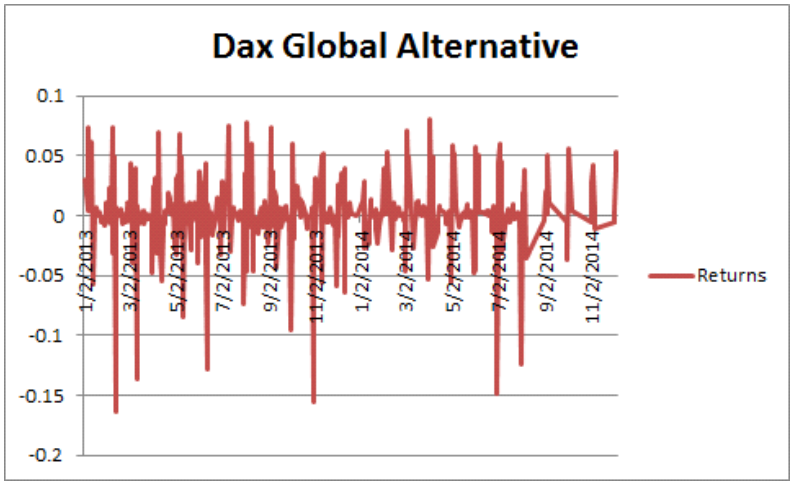
Therefore the index is now geographically focused in Europe and should give a comparable benchmark. Each of the above companies has a specific weight attributed to its share price, which is calculated as part of the total iShares ETF total. Since for the purposes of the current research non-European companies have been removed, new weights must be assigned. Below the calculated weights are given for the total ETF and the recalculated weights used in this paper to simulate that these companies are a separate index:

| Ticker | Original weight % | New Assigned Weight |
|---|---|---|
| GAM | 5.15 | 21% |
| VWS | 4.95 | 20% |
| EGPW | 4.48 | 18% |
| EDPR | 2.75 | 11% |
| VER | 2.66 | 11% |
| REC | 2.25 | 9% |
| NDX1 | 2.22 | 9% |

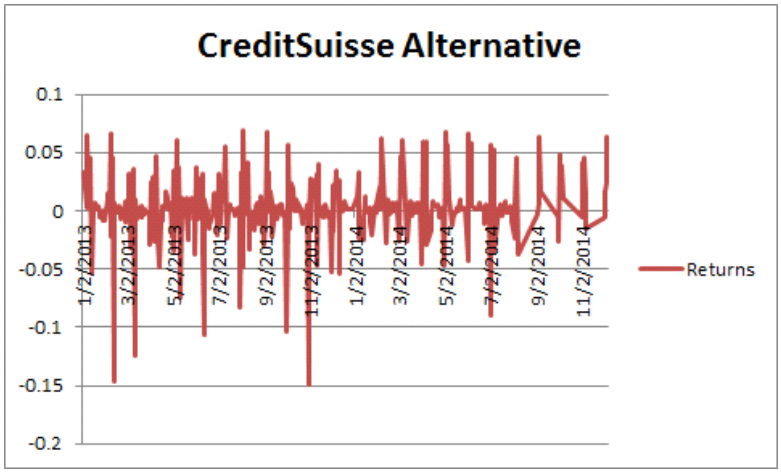
*Table 7: Weights for stocks in iShares index*

Next, the same calculation that have been performed for allowances and commodities are performed.

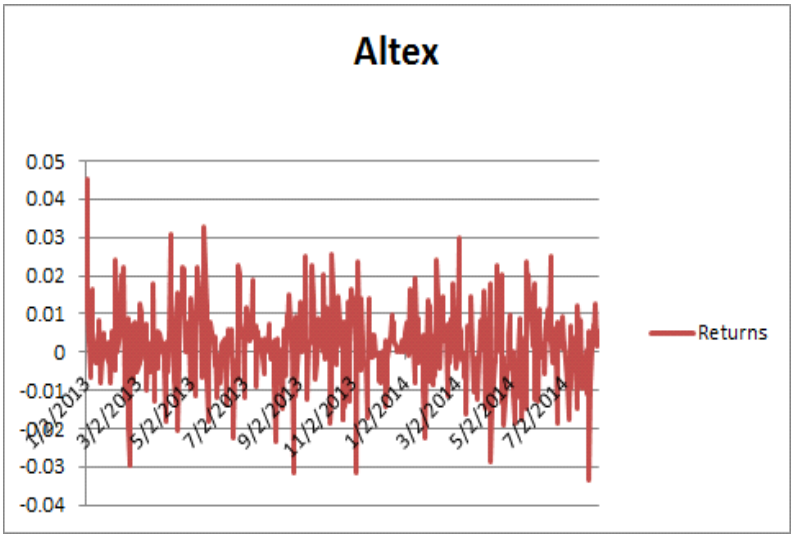
First is the calculation of returns for DAXGlobal, CreditSuisse Alternative and ALTEX indices:




*Graph 32 (above): DAX Global alternative returns*

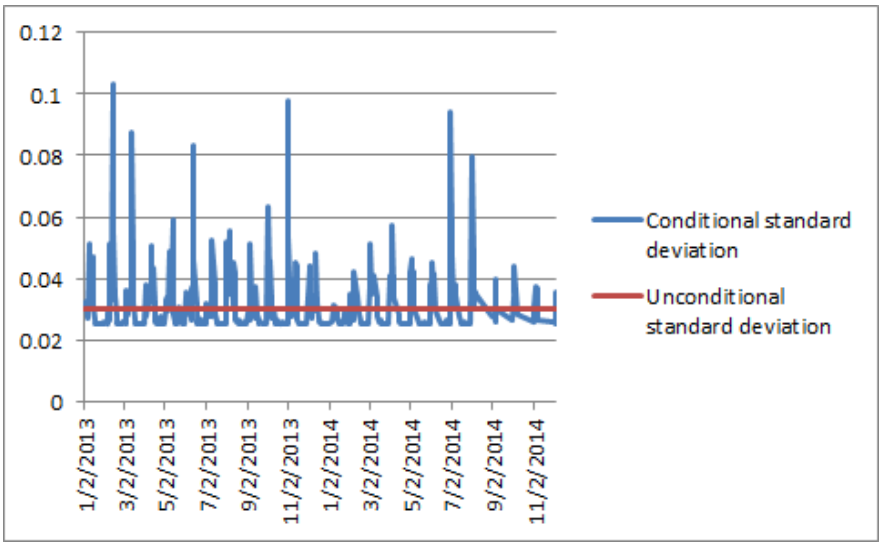



*Graph 33 (above): CreditSuisse Alternative returns*

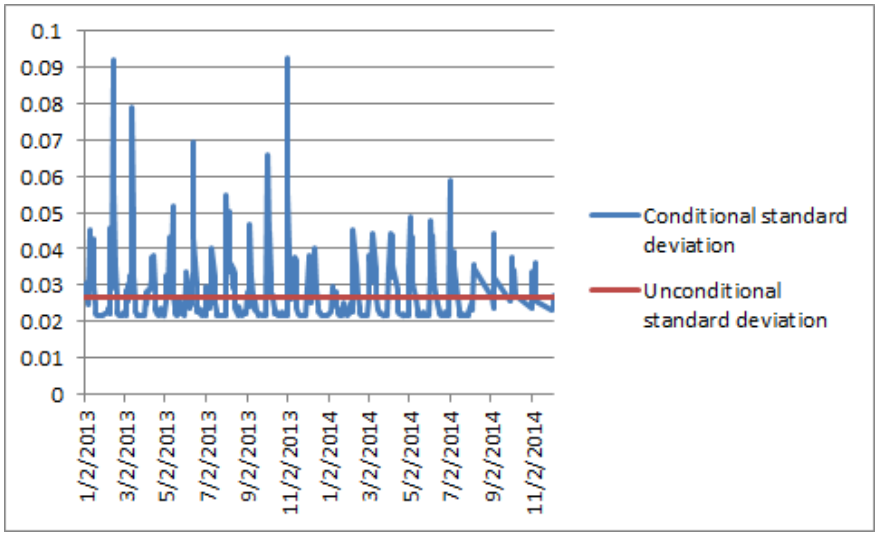



*Graph 34 (above): ALTEX returns*

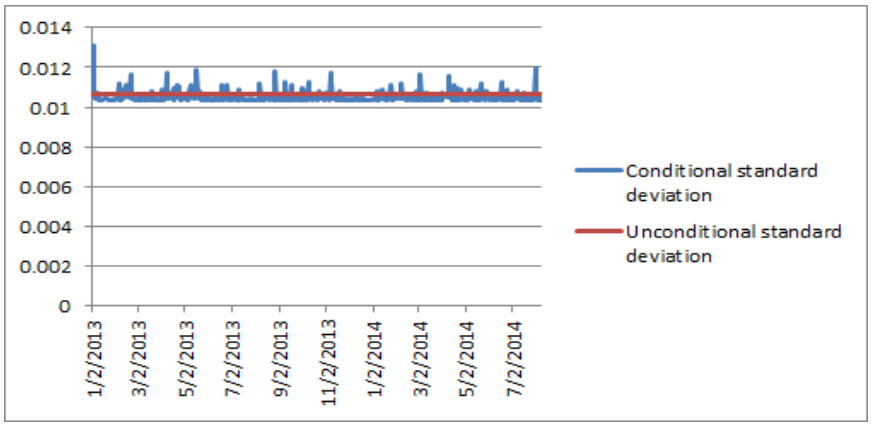
Using the data, GARCH (1,1) is implemented for each index:




*Graph 35 (above): DAX Global Alternative GARCH (1,1)*




*Graph 36 (above): CreditSuisse Alternative GARCH (1,1)*

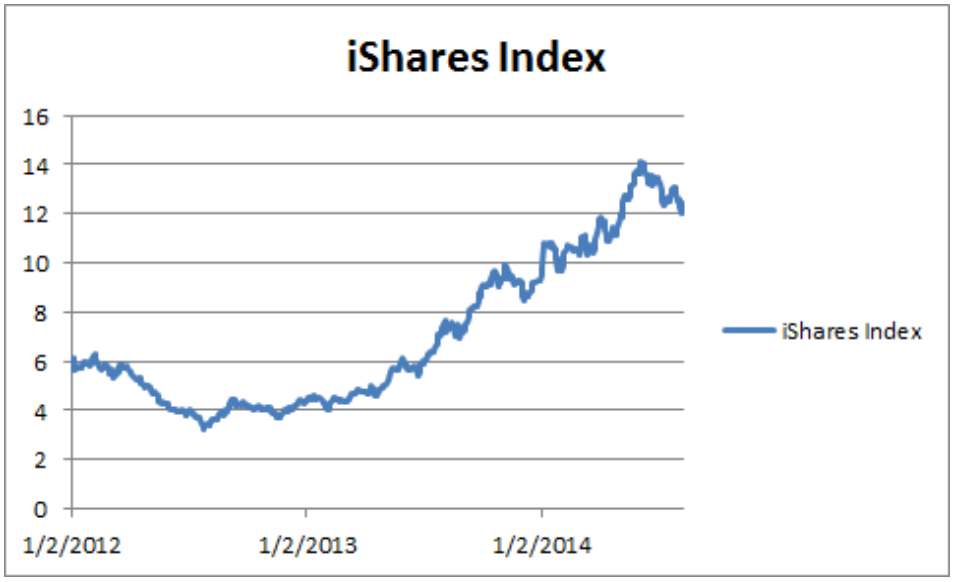



*Graph 37 (above): ALTEX GARCH (1,1)*

Summarising the data, it is clear that all three indices exhibit positive average returns, with CreditSuisse on average providing the highest returns, while Altex provides the lowest. In terms of volatility (expressed by the "Conditional" column, which represents the conditional standard deviation modeled by GARCH (1,1)) the reverse order is applicable. Altex is the most stable market, with the lowest volatility; DAX Global Alternative is actually the most volatile index, while CreditSuisse occupies the middle ground.

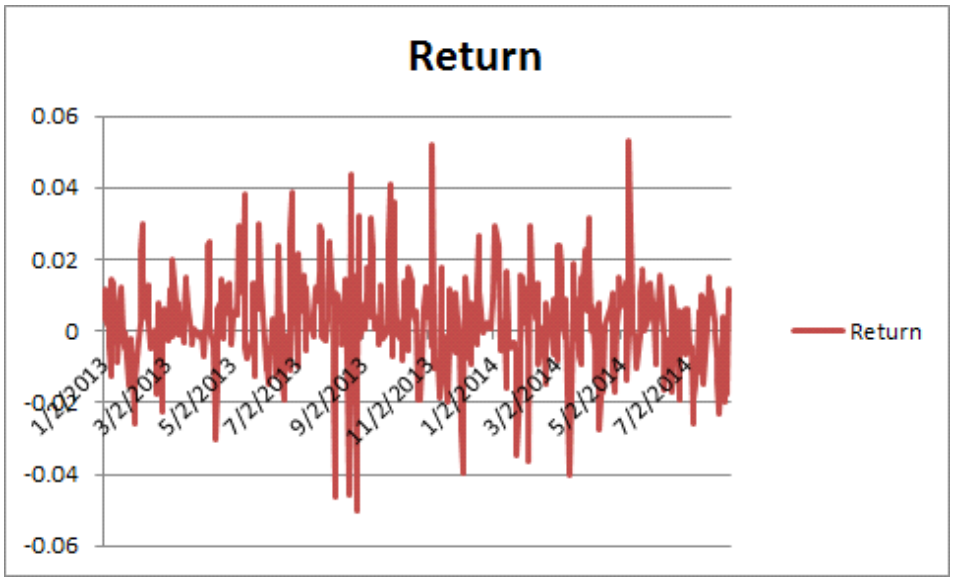
Compared to the allowances spot markets, equity markets in this case outperform them both in terms of returns and in terms of volatility - returns are higher on equity markets and the volatility is lower.

Turning the research's attention to iShares, the same returns and volatility analysis is performed, calculating a total index price using the weights previously obtained:




*Graph 38: iShares index price based on European companies*

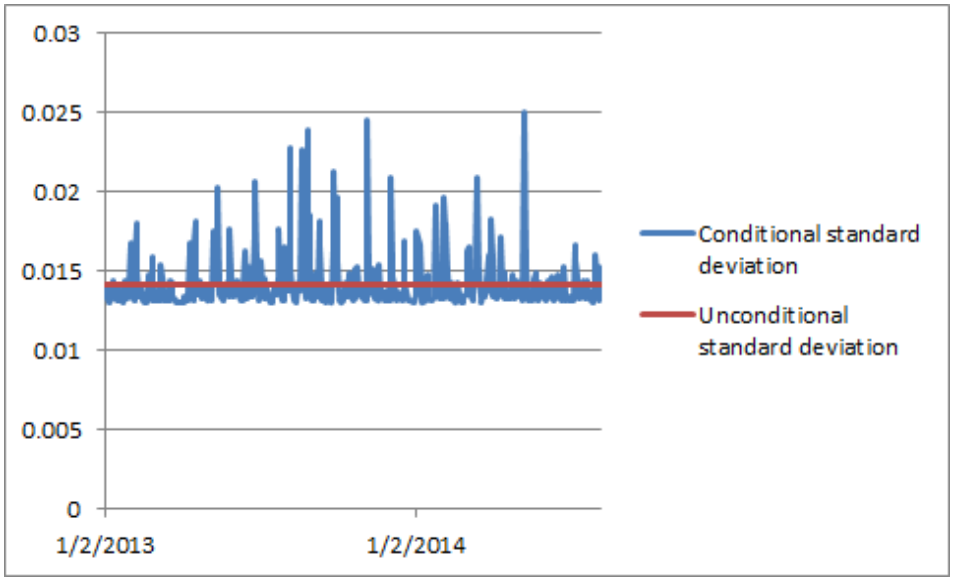
The price for the index is appreciating, therefore one should also expect returns to be similarly high:




*Graph 39: iShares log returns based on 2013-2014 index price*

The average return for the 2013-2014 period for the European companies of the iShares ETF is 0.0021 which is above ALTEX returns, though lower than DAXGlobal Alternative and CreditSuisse. Despite this, it still outperforms allowances spot returns.

Placing returns in a GARCH (1,1) model, the following graph is obtained:




*Graph 40: iShares GARCH (1,1) based on 2013-2014 index price*

As per the calculation, the conditional standard deviation is obtained, calculated via GARCH to equal 0.0143 and the unconditional equals 0.0142. Only ALTEX volatility is lower - both DAXGlobal and CreditSuisse have higher volatilities. More importantly, allowances spot market volatility - both for auctions and secondary trades - are both higher than iShares ETF volatility.

## Conclusion on equity markets comparison

Comparing equities to the EU ETS via several benchmarks, the research has consistently observed that equity returns outperform returns on the spot allowance market. Therefore, strictly speaking in terms of wanting returns, it is more profitable to invest in equity of alternative energy companies rather than allowances.

Furthermore, applying an identical GARCH (1,1) model to the equity benchmarks, the analysis charts volatility for all of the indices. The conclusion is that equity markets - at least those observed - are less volatile than allowance markets. Therefore, both in terms of returns and in terms of volatility it is more beneficial to invest in equity rather than allowances. Alternative energy companies stock for the observed period consistently outperform allowances and the only logical reason for choosing allowances over alternative energy equity is for the purposes of diversification.

Naturally, this conclusion stands under the caveat that GARCH (1,1) may not be the most accurate means of estimating volatility for stock markets. Furthermore, all indices (apart from iShares ETF) cover alternative energy companies from across the world - meaning that a plethora of environmental and political factors may affect these companies, yet not affect allowances. However, the iShares, despite being a limited sample size, does demonstrate that strictly European company shares also outperform allowances.

# 9. Field review and corroboration of the market analysis

The previous several chapters covered the empirical data analysis. Both returns and volatility of allowances were assessed and compared to similar instruments. The preliminary conclusion reached was that in some cases investors might find benefit in trading allowances. However, overall it appears that investment in securities is a much better option.

These are only the initial observations and conclusions of the data analysis and the research. To obtain a complete idea of the allowance market and whether investors' behavior actually corroborates these conclusions, the research now turns to a much necessary field review. Not only as a means of corroboration, but also in order to provide a better link of the empirical and theoretical data, meetings with businesses that have an active participation on the European markets were planned and conducted as part of the research process.

The goal of the interviews was not only to validate the data and conclusions of the research itself, but also to bring in additional insight that could only be gained if one has experience on the market and its operation acquired through daily work with it for a substantial period of time. Furthermore, in order to gain as detailed an understanding, but also one that could potentially cover all facets of the market, interviews were carried out with two different businesses. A summarization of topics discussed and conclusions from both companies follow in the current chapter.

## 9.1 Discussion with Saga Commodities JSCo

The first business which was approached was Saga Commodities JSCo. Saga is a Bulgarian company specialized in carbon trading. On their website they state they have "direct access to the most liquid carbon market, based in London, ICE/ ECX, as well as a large network of industrials and counterparts for OTC deals. With its trading experience and proved accuracy towards its clients during the years, Saga has become one of the main partners of the industrials from Central and Eastern Europe, holding installations under the EU ETS that have interest in transactions with carbon permits, power and biomass" (Saga Commodities, 2014).

The interviews held were with Nevena Petrova - Sales Director of the company. Nevena has years of experience in the allowance market, working at Saga since 2011. Before that she had worked as a regional manager of Sagacarbon SA – a French carbon asset broker, part of Powernext Carbon, whose business was over the counter trades with various counterparties. The second person at Saga commodities contacted and interviewed was Raycho Katsarov - the company's Executive Director. Similarly to Nevena, he boasted many years of experience on the market, working at various carbon trade-related companies since 2007.

Both of them had more than ample experience in the field and having worked day-to-day for many years in the market, they could provide invaluable insight in either confirming the observations made by the data analysis, or challenging inaccuracies and providing new direction and ideas.

When asked about an overview of the market and presented with the data analysis of allowances, they both agreed that volatility is one of its key characteristics. They pointed towards the high uncertainty due to political factors - massive swings if there is even a hint that new policy may be drafter; and continued by stating that other interconnected markets, such as power, gas, coal, have a significant effect as well, along with the weather which they identified as the third key factor that affects the market and that they monitor to form their strategy. Without knowledge and monitoring of all these three indicators they could not form a trading strategy.

However, in terms of pure trading their conclusion is that the market simply is not profitable enough to support speculation. Alongside the already established volatility, this leads to only banks and large consortiums possessing high enough liquidity to actually speculate on the market. For other participants the only remaining thing to do is to either try to sell-off their excess or, if they will not be able to meet their cap - purchase further allowances. The carbon trade is seen only as a means to meet the cap and not as a profitable investment by most companies.

This is exactly where their company – Saga Commodities - has carved out a niche for itself. Instead of being an alternative energy company - striving to reduce its emissions and sell excess allowances at a profit; or speculating on the volatile price in the hopes that markets will turn in a favourable and profitable way, Saga has identified that brokering is the profitable role on the market.

They are a connection between the buyers and sellers - and the carbon markets. If their clients need additional allowances, Saga are there to act on the company's behalf on the market; when there is excess allowances to be sold, Saga has the connection and knowledge to place them on the market.

The main profitability comes through the commission fees that Saga collects as payment for trading on behalf of its clients. Additionally, there is room for further profitability, as the company does also trade on its own behalf, taking advantage of positive market swings to stockpile allowances when it's cheaper. As there is no cost of storage, the only issue is whether the market will turn favourably or not.

To further reduce their risks, Saga employ a hedging policy - buying and selling allowances future, ensuring that no matter what they can always acquire or sell allowances at a previously agreed-upon price. They rarely if ever speculate on the market - they do not possess the liquidty and do not wish to bear the risk of an unfavourable market turn. Thus, they confirmed the observations made by the data analysis and comparison of futures to spot prices – they are an effective hedging instrument and companies do take advantage of that option.

By brokering deals they ensure that the actual risk is carried not by them, but by their customers. They are the ones that the market will affect - either positively or negative. For Saga the market volatility is a factor to keep track of, as it may lead to identifying lucrative opportunities - but they are not as heavily affected by it as either the speculators or the company's clients.

On the subject of clients - there is no shortage there. Apart from being a leader on the Bulgarian market in terms of brokering the deals, Saga also operates a subsidiary in Poland, with contacts in many Central European companies. In effect, there is a massive market of companies that need allowances - or want

to sell them. Every company covered by the EU ETS is affected by the carbon market, however few of them - as we have seen in our literature review as well possess the needed expertise to participate on the market themselves.

All of these companies can benefit from a broker with the necessary know-how and market connections. That's where Saga operates - providing the role of a much needed informed party on the market, for the benefit of small and middle enterprises, for whom it makes no financial sense to develop the expertise for themselves.

The interviews and discussions with Saga Commodities lead to a confirmation of the observations made in the data analysis. There is incredible volatility on the market, meaning that even if allowances could offer returns to potential investors, trading with them is too risky and marred by uncertainty. Nevertheless, by making them obligatory, the European legislative bodies have ensured that the market will be available and companies such as Saga have found a niche. By brokering deals on behalf of other companies, in order to help them in meeting their cap or selling off their unwanted companies – essentially linking supply and demand – they remain unaffected by the volatility of prices. However, making speculative trades is deemed too risky and unprofitable – with Saga's argument being that only companies with substantial capital can effectively enter the market.

To test this claim and further enrich the understanding in the field, the research has expanded the field portion by contacting and discussing the findings and the market with representatives of the banking industry – covered in the next few paragraphs.

## 9.2 Discussions with First Investment Bank

As noted by the discussions with Saga Commodities, in order for a company to make meaningful trades, a significant amount of capital would need to be invested. Considering the market volatility and small returns – confirmed both by Saga and as seen by the data analysis in the research - in order to make a significant enough profit to justify investing in allowances, finances well above the means of Saga Commodities would need to be invested - a further deterrent to trades.

Due to the specificity of the carbon allowance market - the fact that allowances are a new instrument; that many companies lack sufficient understanding; the regulated trade mechanism; the fact that trades need to cover monumental quantities and therefore - be covered by substantial liquidity - some of the largest players on the market are, naturally, banks. In order to gain a better understanding of their perspective and further the practical aspect of the research, interviews were conducted with Mr. Hristo Sugarev - a Portfolio Manager at Bulgaria's First Investment Bank (Fibank)'s Treasury Department and in charge of carbon allowance trades. Fibank was founded in 1993 and is one of Bulgaria's leading banks – in 2014 it was ranked third largest in terms of both its assets and in terms of loans granted – second in terms of loans granted to corporate clients. Mr Sugarev has been at the Bank since 2011, previously working as a securities broker at the Bulgarian branch of Raiffeisenbank. As such, he is uniquely qualified not only to give a perspective on carbon allowances trades but also to make meaningful comparisons from experience between equity trades and the carbon market.

The goal of the enquiries was to complete an understanding of business' interactions with the market and, more specifically, whether the bank with its higher liquidity, is actually active on the market and if yes - how.

In order to gain an understanding of the market and corroborate whether the paper's initial analysis - obtained during the literary review and data analysis - the interviews first focused on the broader market and Mr. Sugarev's impressions of it. He started by immediately pointing out that trades in Bulgaria are in general lower than trades in the broader European market. However, it was his opinion that, while this was in part due to the relative size of the Bulgarian market - with fewer active companies, fewer companies requiring allowances and fewer companies having the necessary capital to act on the market - overall the behaviour on the local market is not that different from the behaviour on the overall market.

Bearing that in mind, he elaborated that there are three key factors that act as deterrents for prosperous carbon allowance trade:

Profit margins - naturally, this is the biggest issue. As seen from the analysis performed in the previous pages, when compared to various instruments, carbon allowances do not offer a good enough profit margin. For companies that were looking to diversify or to gamble on potential future profits, this may not be a significant enough barrier to trade, though on the Bulgarian market it was sufficient according to Mr. Sugarev.

Lack of understanding and security on the market - this is the second point of contention that was pointed out. As the allowance trade is a relatively new market and the instrument is not yet understood by many, companies in general are hesitant to enter the market. Furthermore, the effect of regulatory changes and uncertainty related to policy create an atmosphere of apprehension in potential market entrants. Couple this with the fact that, again, other instruments are much better understood - in terms of market behaviours, prices, accounting treatment, opportunities, strategies, etc. - and it is clear that only the most enterprising of companies see the market as an opportunity. When companies trade on the local market, it is almost exclusively as a result of them wishing to stockpile allowances to ensure they'd meet their cap.

The final point discussed as an underlying drawback was the relative cumbersomeness of the allowance market. Auctions are carried out on specific days, while trades on the secondary market usually take up to 2 or 3 days to complete. This is combined with what Mr. Sugarev described as a slow and restrictive registration process in order to enter the market - having to comply with various regulations, be registered in several European systems, etc. With this it is evident that trades on the allowance market are far from instantaneous - whereas the change of hands of the right over shares or other instruments is near-instant and the confirmation of clearing is received in the same day, carbon allowance trades take time to be confirmed and carried out. As a result, this means that potential traders looking to enter the market and make profits by shorting allowances, for example, due to profitable prices, will have to wait several trades for the deal to be concluded - potentially leading to issues of liquidity and time delays for businesses.

These three factors, when put together, give an impression of a very difficult market in which to operate. On their own, they may not be enough to deter trade, but together they represent an often insurmountable obstacle. This was confirmed by Mr. Sugarev, who disclosed that Fibank acts only as a broker for its clients - in order to make purchases of allowances when they were unable to meet their caps or if they wished to build-up a stockpile. He elaborated that clients showed little to no interest in making more complex trades - even when he or his colleagues would make offers to them - and he cited these three factors as the key to making carbon allowances seem near worthless as an investment option in the eyes of clients.

He continued by stating that Fibank had initially operated its own portfolio - but like the clients today, the bank itself too was disappointed by the long time to conclude a deal and the difficulty of making speculative trades with an eye to making a profit. He mentioned that occasionally the bank receives

enquiries from potential clients, interested in the market. However, as soon as Fibank made clear the specifics of the market - few if any clients actually agreed to enter into deals.

Overall, Mr. Sugarev's position on the allowance market closely aligns with the understanding obtained as part of the research performed. This paper has substantiated the price volatility of the market and the low profit margins - confirmed by Mr. Sugarev in the performed enquiry. What the research could not confirm on its own was the precise attitude of potential investors and actors on the market. According to Mr. Sugarev and Fibank, the outlook is not positive - with carbon allowances seen only as a means to an end, that end being meeting regulatory requirements. At the current point, the only potential for profit on the market is by being a broker in order to facilitate trades - this is what Fibank does, this is what Saga Commodities does.

However, as per Mr. Sugarev's opinion, this is not because the market itself is flawed or that the cap and trade system is inefficient or outright broken. He pointed out that it was mostly the lack of understanding and the uncertainty, coupled with the long lead times that were key deterrents to speculative trade. In terms of profitability, he stated that allowances are a better investment than governmental treasury bonds and via futures deals there is a potential for making a profit on arbitrage. The key is that to do so, the initial investment - in terms of market research, capital and man hours, coupled with the lack of knowledge - mean that the system has an unusually high barrier to entry. As a means of diversification, however, allowances can still be a valuable option.

## Conclusion on field review and corroborative enquiries

As previously covered by the data analysis part of the research, it becomes clear that while there is some value to investing in carbon allowances, it is difficult to define them as "profitable". Comparing them to power markets - there is more value to allowances from an investor's perspective. Yet they are still clearly outperformed by equity instruments. Simply put, an investor is better off placing his money in the equity of companies on the energy markets, rather than seeking to enter himself via trade in allowances or commodities.

In order to confirm these findings or to find flaws in the logic and figures, the research turned to companies active in the market – not only to gain validation of the conclusions, but also to probe for a deeper understanding and a different perspective on the markets.

By conducting interviews with Saga Commodities – a leading broker of carbon allowances in Bulgaria – the conclusions of the data analysis were justified. Once again it was stressed that the market was too volatile to make speculative trades a truly profitable option for a company with limited capital. Much easier and beneficial from a business perspective is to act as a broker - thus isolating oneself from the uncertainty of the market.

In order to further broaden the understanding and potentially view if large capital could be utilized for speculative trades, the research turned to the trade desk of Bulgaria's First Investment Bank. The conclusions already established were once more corroborated there – the low profit margins, high uncertainty, market complexity and long lead times were stressed as key deterrents to trades – both from a regular business perspective, but also from the position of the Bank. Despite possessing sufficient capital to enter the market and having tried it at an earlier stage, ultimately the conclusion was reached that it is simply not a worthwhile investment when compared to the more profitable and better understood equity and securities markets.

Ultimately, both companies confirmed the conclusions of the data research. The allowance market is highly volatile and the returns it potentially offers are not sufficient to justify trades when comparing to similar opportunities in other markets.

# 10. Conclusion

The current research paper has aimed at analyzing the European carbon emission allowance market in terms of its returns and volatility in order to define its profitability and then compare it to similar markets – power, gas, and equities. The previous chapters looked individually at each of these markets and defined the parameters and characteristics of each one. The last chapter looked at establishing a practical link between the data analysed and the real business world. By conducting interviews and discussing the markets and findings with an allowance broker and an Investment bank, the research has managed to establish a fundamental understanding of the markets.

The current chapter will now look to discuss the findings with a goal to, ultimately, giving an answer to the question “Is investment in allowances profitable?”. Furthermore, the following paragraphs will look to also give some of the limitations of the research in order to place the findings in perspective and also to potentially give direction and ideas for future research in the field.

## 10.1 Discussion

Looking at the data collected and previous knowledge examined in the literature review, the one defining characteristic of the European carbon emission allowance market is its volatility. In this case, using previous knowledge from reviewing past literature on the subject, the research has defined volatility as the movement in prices – thus directly linking it to the potential returns one can make on buying and then selling allowances.

Looking at reasons for the price movement – and therefore the high volatility – the research has established several key factors that can affect the value of allowances in either a positive or negative fashion. Most notable of these is the severe political uncertainty. Reviewing the history of allowances, the research has established that ever since the origination of the cap-and-trade system in Europe, the legislative bodies of the European Union have been uncertain in what direction to take the market. This has caused severe apprehension in the market on behalf of both investors and the companies obligated to meet the emission’s cap.

Furthermore, prices can be affected by the macroeconomic outlook, as well as by factors such as weather and interlinked markets. In effect, this means that prices for allowances are incredibly difficult to product and therefore it is an immense challenge to prepare a sound investment strategy. And even if one could do so, chances are that an investor in allowances would make a lower return than an investor in equities of power companies, or “green” companies or other businesses related to these fields.

| Type of instrment | Returns |
|---|---|
| CreditSuisse Alternative | 0.2891% |
| iShares | 0.2657% |
| Dax Global Alternative | 0.2328% |
| **Allowances auction** | 0.1768% |
| Altex | 0.1545% |
| **Allowances spot** | 0.0647% |
| Gas - TTF | -0.0850% |
| Gas average | -0.0873% |
| Gas - GPL | -0.0880% |
| Gas - NCG | -0.0890% |
| Power - ELIX | -0.1534% |
| Power average | -0.1677% |
| Power - PHELIX | -0.1820% |

Table 8: Instruments sorted by returns

Looking towards table 8, a summary of returns of each market is presented. The table gives an average return for each market for the period of 2013 till July 2014 – the first year and a half of the new Phase in the EU ETS. All figures are in descending order – with the highest returns at the top. The picture is a simple one – allowances are outperformed by equity indices. Still, it should be noted – they do perform better than power and gas, which have all had negative returns for the period, stemming from the very poor market outlook of these commodities for the period. Looking purely to returns – investing in equities is the best option.

| Type of instrment | Volatility |
|---|---|
| Altex | 0.0105325 |
| iShares | 0.0168152 |
| Gas - TTF | 0.0193360 |
| Gas - GPL | 0.0195610 |
| Gas average | 0.0197860 |
| Gas - NCG | 0.0204610 |
| CreditSuisse Alternative | 0.0274256 |
| Dax Global Alternative | 0.0310068 |
| **Allowances spot** | 0.0490157 |
| **Allowances auction** | 0.0581485 |
| Power - PHELIX | 0.3225565 |
| Power average | 0.3381211 |
| Power - ELIX | 0.3536857 |

Table 9: Instruments sorted by volatility

However, returns are only part of the picture. Looking towards volatility – with figures presented in table 9 in a similar fashion to returns – with the most volatile markets at the bottom, while markets with lower volatility – therefore the “safer” markets – at the top. Here allowances are almost at the bottom – with

only power having a higher market volatility as calculated by a GARCH model. Looking back to the returns, one could make the potential connection that the relative lack of market volatility in gas markets is due to the negative returns on the markets and the commodity simply staying with a negative outlook for the period. As the research has not focused on gas in depth, this is not a conclusion that can be made, but it is rather a potential explanation.

Ultimately, however, the market with the highest returns and the lowest volatility is the equities markets – with all indices having higher returns than allowances, except Altex. However, in terms of returns, Altex still offers a better result than the spot market for allowances – and in terms of volatility, it is the least volatile trade instrument of all the reviewed.

Combining this with findings made in the discussions with business from the field and the conclusion is made. Equity is better in terms of the figures – higher returns and lower volatility – but also the market is better understood (refer to what FIB mentioned). It's easier to trade on it, trades are faster, etc, etc.

Still, it is not impossible to conduct trades – and if the market potentially stabilizes and volatility decreases, it could be a useful diversification tool. This is something that should not be understated – the market has its uses and potential. As long as meeting the cap is obligatory, the market will exist and there is a potential profit to be made. Furthermore, even if trading at the early stage of Phase 3 seems inefficient, businesses have proven that there is a way to make a profit.

The high market complexity – the variety of factors that need to be taken into account, the access to auctions and other trading businesses being somewhat limited – means that there exists an opportunity for companies to act as intermediaries. Knowing the market and being able to trade on it therefore has values – as companies like Saga Commodities and First Investment Bank have demonstrated – even in a market as limited and small as the Bulgarian market. They bear very little risk – it is not them who has to meet the cap, it is not their capital that is being spent. Their profit is based off commissions – in essence regarding their access to the markets. And moreover, they can further limit their exposure to the market's volatility by utilizing futures.

Ultimately, the market has some potential. It appears it can be used for diversification, or, with sufficient capital – speculative trades could provide returns. At the beginning of Phase III, however, there were better choices and if a business is purely profit driven – investing solely in allowances would not be a sound business proposition.

## 10.2 Limitations of the research

When looking at the conducted research, one must always bear in mind its limitations and potential areas in which future researchers could look into in order to better illuminate the topic at hand.

First of these limitations is the time period covered by the paper. The beginning of Phase III is a fascinating time-frame to examine, as it gives both insight into the early part of Phase III and how investors are potentially going to continue their patters – or not. Furthermore, it can give some validation to conclusions made in the end of Phase II by previous research – something that the current research

has aimed at doing to an extent. Nevertheless, it is outside this paper's scope to review the entirety of Phase III and see if there are any changes in patterns – and whether the conclusions made by the paper hold until the end of the Phase. Extending the period would require an investment in time and the data reviewed would be of a much more challenging scope. But the conclusions of such extended research could potentially lead to a deepened understanding of allowance trading and the market as a whole.

Speaking of the market as a whole, the current research has made no attempt to give an overall grade on the market and allowances as an instrument. Whether they are successful in reducing carbon emissions – as is the stated goal of the cap-and-trade system; whether when taking into account additional factors – for example the time required to understand the market or necessary licensing fees for trading in allowances or equities – if allowances become a better investment proposition. This research has only looked at two aspects of the market – returns and volatility. It makes no allusions that it covers all aspects of the markets. Instead, it simple looks to one side and aims to make a comparison to similar instruments.

Looking to the instruments compared – it should be noted, that the method used to assess all instruments – allowances, equities, gas and power – may not be the best one to use. Previous research has chosen it as the preferred method for evaluating allowances, but future research could give a more comprehensive comparison by using methods tailor-made for the other instruments. The limitations in resources for the current research have meant that such a task is not achievable, which is why a conscious choice was made to use an identical method. If nothing else, the results calculated for each instrument are reached using the same method, so there should be some compatibility in the figures, even if the accuracy might not be absolute.

Another limitation the research possesses is the range of businesses approached with the idea of corroborating and discussing the conclusions. While EU legislation covers all European countries similarly and in effect there shouldn't be a significant difference between countries, it should be noted that only Bulgarian businesses were approached. Future research aiming at extrapolating the conclusions over other countries, or even making comparisons between national markets and reviewing any potential differences or similarities could be an interesting topic and one that could give a deeper understanding of the allowance market as a whole.

The companies interviewed and their perspective leads to another limitation of the research – the fact that the assessment was made in a theoretical fashion. While the contacted companies corroborated the conclusions and the approach, it should be noted that the current research is based on reviewing figures and analyzing them. Another approach could have been setting up an investment portfolio in allowances and charting its performance over a period in order to fully understand price dynamics and be able to make a direct comparison to an investment portfolio in equities of companies in linked markets. Such a research direction was not possible due to the costs involved and unwillingness of business to actually engage in such a practice, due to the perceived lack of value in the market. In some regard, this does verify the research's conclusion – businesses being unwilling to sponsor an investment portfolio in allowances means they do not believe there is sufficient profit potential. Still, managing a real-life portfolio and comparing it to a similar equity portfolio could be a fascinating topic for future research and would have far more practical applications in terms of serving as a guideline and a benchmark.

Finally, the course of the research unearthed a market niche that had previously not been considered. The original approach of the research compared allowances to other instruments from the perspective of a potential speculative trader. After conducting the discussions with businesses in the field, however, a fascinating discovery was made. One of the best ways to take advantage of the allowance market is not by directly trading on it, but by instead brokering deals between companies. Connecting businesses and acting as an intermediary may be a much more advantageous business proposition than operating an allowance portfolio. It certainly appears that way when taking into account the opinions and strategies of the two companies contacted. This leads to a potential topic for future research – making a comparison in profitability between operating an allowance portfolio and acting as a broker. Such a task could be daunting, yet it could yield a fascinating case study – one with innumerable benefits to potential entrants in the EU carbon emissions markets.

## 10.3 Final conclusion

Looking back, the research started with looking towards literature in order to establish an understanding of the allowance market and to give a definition of profitability. The ultimate goal of the research was to answer whether investing in these instruments could lead to such an outcome – if it was more advantageous for a business to trade in allowances or in other similar instruments.

During the course of the data analysis portion a comparison was made in terms of returns and volatility between several connected markets – allowances, gas, power and finally – equities of companies in related fields. Comparing the results of the markets and using past research as a stepping point, one thing became clear: European carbon emission allowances are defined by their volatility. They are an incredibly risky investment, marred by uncertainty and unpredictability. Investing in them requires a deep understanding of the market and a substantial capital outflow – because ultimately the data analysis shows that returns are possible, but the high volatility would mean that it may take a lot of losses and time until they are reached.

By comparison, equities are more easily accessible, the markets exhibit lower volatility and the potential returns are higher. Trading on stock markets is better understood, is faster. Both the data analysis and the discussion with companies confirmed this conclusion. Equities are the better investment. That’s not to say that allowances cannot be profitable – but looking strictly towards the earlier parts of Phase III on the EU ETS, trading allowances is simply not profitable enough. Because of this companies appear to be turning towards acting as brokers on the market, rather than trading in their own portfolio. In this way companies mitigate their own risk and lower their exposure, while making profit not out of trading but out of commissions for carrying out the trades. The risk is borne by the client, not the broker – thus the main drawback of allowances is mitigated.

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