

Pricing carbon financial derivatives ba assignment



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Although the Black-Scholes model presents a classic tool for option pricing, it is based on the assumption that the volatility is constant. As more and more research find that financial data exhibit fat tail and high kurtosis distribution, the assumption is not suitable. If we get the features of the random walk of prices, it will contribute much to pricing derivative carbon products. In my paper, we first analyze the carbon emissions trading market, and then use a GARCH model to reproduce the return dynamics on European Union Allowance futures appropriately.

After that we use Monte-Carlo simulations to value the derivatives under a risk neutral measure. We get two inclusions: one is that the GARCH (1, 1) model reproduces the futures dynamics well. The other is that Monte-Carlo simulated options provide an indication of fair pricing. Key Words: Kyoto Protocol; E TEST; carbon finance; GARCH; Monte-Carlo Simulation
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Dr. gave me insightful advice and clear guidance that help me not only in the organization of the paper but even the grammar and phrases in my dissertation. Would also like to thank my friends Change Chem. and Jane Millionth for their assistances in my dissertation and taking the time to share their expertise in the data mining and analysis. 1. Introduction 1. 1
International carbon emission trading Under the background of global warming, traditional fuels such as coal and petroleum are regarded as non-renewable energy resources, making huge negative externalities and pollution.

This situation sounds an alarm to people for climate change problems. More and more governments sign the Kyoto Protocol and participate into the environment protection. Global warming makes a series of bad effects on human beings, posing a threat to daily life. Many economists have researched the bad effects on economy brought by climate changes, and British economist Mr. Ernst evaluations of these effects in 2006 are the most classical ones: the whole scale of global economy will shrink by 5% to 10% if we keep the current development patterns and the situation will be worse to developing countries.

Intergovernmental Panel on Climate Change (IPCC) in 2007 indicated that global warming is obvious because the global mean temperature is going up, icebergs accelerate melting and sea level is rising. Low carbon economy first arises in UK government's energy 'white papers' and it means to reduce the pollution from using coal and petroleum and greenhouse gas emission and to achieve a win-win goal. Kyoto Protocol was put into implementation in 2005 and it entitled the greenhouse gas such as some commodity attributes and created the carbon emission trading allowances as a kind of intangible valuable asset.

With the development of carbon products, western developed countries classify the environment issues and then shape green finance system. Carbon finance is the result of finance innovation in carbon emission trading market development and it includes carbon emission trading allowances, related reparative trading, financing for low carbon programs, green credit and other financial intermediary activities. The emergency of carbon finance

has promoted the development of low carbon economy and improved the efficiency of carbon emission trading market.

As the carbon emission markets mature gradually, carbon finance has become a heated topic in finance research. 1. 1. 1 International carbon emission market components There are two forms of carbon trading commonly used in the world: one is the cap-and-trade system which is based on allowance, that is, emission allowance trading. Emission allowance trading adopts direct control and economic incentives combined system and the participants in trading are related organizations which have emission reduction obligations and they will be assigned emission allowances.

My dissertation also focuses on carbon emission trading market. The other one is project-based transactions, that is, only trade the projects that have been verified to reduce greenhouse gas emission. The market is mainly divided into two parts: Clean Development Mechanism (CDC) and Joint Implementation Mechanism (01). The Cap-and-Trade system is underway among developed countries and there have been three main individual allowance trading markets: European Union Emission Trading Scheme (E TEST), Chicago Climate Exchange (ICC) and New South Wales (NEWS).

Clean Development Mechanism (CDC) is one of the three flexible mechanisms under Kyoto Protocol between developed and developing countries. The key contents include allowing the cooperation between Annex I Parties and Non-Annex Parties and developed countries should provide money and technology support to developing countries so as to help them process sustainable development. At the same time, developed countries

can purchase Certified Emission Reduction (CERT.) from developing countries in order to perform the obligation fixed in Kyoto Protocol.

Jell is different from CDC in that only developed countries cooperate with each other in this mechanism. Figure 1-1 illustrates the organization of global carbon emission trading system. Figure 1-1 : Global Carbon Emission Trading System Organization Chart 1. 1. 2 Current development of the international carbon finance mind gusty I. Well-established carbon market system in western developed countries With improvement of carbon emission trading mechanism and legal system, several carbon trading market derivative come out such as carbon futures and carbon options, etc.

Extended scale of carbon trading market widens the refit space and pushes the carbon finance industry to a higher level. ii. Participation of multi-subjects and high speed of market development Nowadays, carbon finance has become the important area of finance innovation for overseas financial institutions and also the key part of international finance center construction under the background of global warming. So carbon market attracts a large number of investors.

This complete carbon finance CEO-nee; ark contains global financial institutions such as commercial banks, assets management companies, brokerage firms, trust and investment corporations, investment banks, insurance companies, endure investment and funds. Figurer -2 shows the market participants in carbon financial market Figurer-2: Market Participants in Carbon Financial Market As for commercial banks, doing carbon finance

business help improve their social images, strengthen their credibility and reputation and increase their income from intermediate business.

Up to 2011, the total value of carbon market hit 176.02 billion dollars and the volume got to 10.281 billion tons of carbon dioxide. These numbers are 14.61 times larger than those in 2005. According to Muckiness's report in 2010, global commercial banks can get up to 15 billion dollars only from infrastructure financing and consulting business by 2020 and this figure accounts for 6% of related investment and financing business in current banks.

1. Carbon finance practice Commercial banks in developed countries mainly operated carbon trading intermediary business at early stage and then turn to designing carbon financial products and selling these products. Meanwhile, commercial banks provide financing business directly to enterprises which need reduce the emission as well.

I. Underlying financial products In original carbon emission allowances trading process, financial institutions mainly provide business service from four aspects first, project services; That is, provide consulting services for companies with emission reduction need and charge fees.

Second, financing services; Commercial banks meet the companies' funding requirements for reducing emission such as project loan. Third, market maker in secondary markets; That is, provide liquidity for carbon finance trading and charge the fee. Forth, financial organizations can exploit the difference in pricing from secondary markets when buying CERES from developing countries through CDC trading.

ii. Derivative financial products In 2008, carbon finance derivative products come out in the market and these products have improved the development of carbon finance market.

Both of volume and trading scale of carbon finance derivative products have outnumbered those of underlying carbon financial products, increasing the scale of carbon finance market and creating huge liquidity. Financial institutions try to fit requirements of investors with various risk preferences by finance innovation and designing new financial products and they also need to provide effective risk management instruments for carbon finance markets. The derivatives are classified into three categories: the first is carbon emission allowances delivery assurance.

For example, CDC projects have great development risks so that participants have low motivation and will prefer to avoid risk by forcing down the price of original projects. This will lead to bad effects on CDC projects. Financial institutions, especially commercial banks, launch credit enhancement guarantees for companies with emission reduction need. This method controls the project risks and increases the potential gains. The second is asset characterization of carbon emission allowances. Because CDC projects have long cycle and great risks so that projects about emission reduction are short of liquidates.

To solve this problem, financial organizations noontime the profits from future emission reduction realized by investors and borrowers and this method also improves the liquidity in market. The third is arbitrage opportunities for commercial banks in secondary markets. Making use of the distinction in different means of transaction, financial institutions get profits brought by spread such as spread between CERES and ALIAS and corresponding options. 1. 2 EX. TEST and its practice Current research about low carbon economy focuses on ELI TEST.

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EX. TEST has not only occupied 70% of the global carbon emission scale in only 6 years but also become the most successful carbon emission trading market in the world. EX. TEST has well-going operating mechanism, robust operating mode and high market efficiency. The openness of data from EX. TEST guarantees the scholars' researches in this field. All in all, scholars have been confused with market efficiency for a long time. Since price is the important factor when looking into resource allocation, scholars pay more attention to pricing so as to improve market efficiency.

Pricing research goes in two directions: pricing research based on carbon emission trading system theories and pricing research based on the finance characteristics of carbon trading. 1. 2. 1 European union Emission Trading scheme (EX. TEST) operating mechanism Several decades of policy experimentation show that a properly designed emissions trading system (TEST) can deliver cost-effective emissions reductions swiftly and provide certainty in accomplishing an environmental goal.

The Ex.'s greenhouse gas TEST is the biggest of such systems in the world to date and represents the first concerted effort to develop a multinational arrest for carbon emission. The SITES closely follows the classic cap-and-trade policy design parameters developed for the IIS Acid Rain Program under the Clean Air Act Amendments of 1990. European Union Emission Trading Scheme ran in January 2005 for the first time and all the European countries are included in the list of Annex Parties. Emission reduction has legal binding.

European Union set the specific target to reduce carbon emission in Kyoto Protocol and European Union should make attempts to reduce emission by 8% compared to the number in 1990. In addition, European Union agreed to reduce emission over 20% before 2020. The following summarizes the market design features and implementation strategies that have made the EU ETS cap-and-trade program a practical and cost-effective solution to achieve multinational climate policy goals. Table 1-1 shows the key dates and stages for the implementation of EU ETS. EU ETS concept is introduced as the regional climate policy approach 2003 EU Directive mandates the creation of the EU ETS 2005 Phase I Cap-and-trade is implemented -> learning or trial period Establishment of national registries -> Robust emissions monitoring and verification systems important over-allocation Carbon market activity begins Price on carbon emissions is signaled -> Signs of 2008 Phase II Compliance period 2008-2012 -> aligned with Kyoto period 2012 Inclusion of the aviation sector 2013 Phase III(2013-2020) Implementation of EU policy goal adjustments to achieve a 20 percent reduction in GHG By 2020 compared with 1990 levels.

Possible 30 percent reduction if other major emitter countries set legally binding targets Extended phases (i.e., beyond seven years to strengthen price signals with longer time horizons), centralized allocation, and incremental use of allowance auctioning Table 1-1 EU ETS Implementation History Initially, the scheme included industries such as cement, ceramics, electric power generator, glass iron and steel, pulp and paper, and refineries based in the EU region. It regulates downstream of about 12,000 emission sources, which account for half of the EU region's emissions.

It does not include transport, small businesses, or homes. However, coverage has been expanding. There are opt-in mechanisms currently in place, and new sectors have been included through E directives. Aviation, for example, became the first transport sector to be included in the system on January 1, 2012. Under the 2013-2020 Phase III, carbon emissions from petrochemicals, ammonia, and aluminum will be covered. Under the ETS, allowances to emit emissions are commoditized as tradeable permits known as European Union Allowances (EUAs).

The term 'EUAs' defines the extent of the entitlement as an authorization allocated to covered installation to emit one ton of CO₂. Cap-and-Trade is the core of ETS. Carbon emission allowance will be issued to countries in European Union by National Allocation Plan (NAP) and a maximum emission allowance will be confirmed. This figure stands for the emission limitation to some companies and companies must have enough EUAs to offset the total volume of carbon dioxide emitted at the end of each term.

On the one side, if companies do not hit the emission target they will face two choices: buy EUAs in the market or pay the penalty for emission exceeded. On the other side, companies can sell the remaining EUAs and earn profits if they reduce the carbon dioxide emission effectively. 12. 2 Current development of ETS is built on the basis of market economy and its operation takes the advantage of resources allocation so that carbon emission trading also follows the principle 'Minimum Cost and Maximum Profits'.

European Commission (2003) thought this system should not only achieve the emission goal but also finish the plan by minimum costs. Western Scholars used serial correlation analysis and variance-ratio test to evaluate the market efficiency at the early time and subsequently turned to consider about profitability and two kinds of technical analysis and trading capabilities: Moving Average based on variable length and changes in trading rules.

Most of these researches emphasis on the theories but not on the practice so there have a lot of limitation when applying the theories into the practice. The key point of making sure that DUETS can work effectively is whether prices traded in carbon emission trading can keep effective with existed information. So scholars put the research priorities on pricing mechanism. Accurate derivative pricing can function fully as finding and correcting prices and restrain the prices of irrational up and down.

This can ensure the better development of carbon market in long term and provide the powerful tools for optimization of resource allocation. 1. 3 Influencing factors of international carbon trading prices International carbon trading prices here refer to prices in CDC secondary market and prices traded among developed countries, not prices in CDC primary market One Of the most important factors is determined by demand and supply and others include participants from different industries and international big financial organizations in finance industry.

But as a whole, international carbon trading market can be deemed as a buy- side marketplace so that in this market developed countries have

crucial advantages in carbon resource pricing and developing countries only have limited impact on pricing. I. Demand and supply of carbon trading play a key role in deciding prices From the degree of demand, the demand side of the market is developed country. Countries in Annex Parties when signing the Kyoto Protocol are allowed to emit limited greenhouse gases so that carbon emission becomes scarce resource.

In carbon emission trading system, policies issued by governments occupy the decisive position. Take EX. TEST as an example, allowance given in Phase I exceeds the market demand and industrial enterprises can trade the emission allowances they left at the end of Phase I, leading to a sharp decrease in prices. To eliminate the negative influence, European Union increased the allowance and pulled the national carbon trading prices back to normality. From the degree of supply, the supply side of the market is mainly CDC secondary carbon trading market.

The volume in the market has significant impact on prices. li. Carbon emission trading industries' effects on prices Effects caused by participants generally are presented on companies' bargaining power and relationship between their stock prices and carbon prices. For bargaining power, energy industry has become the main force in emission trading system. For example, the developments of electric power, iron and steel, coal and natural gas industries, especially electric power industry, have great impact on bargaining power.

At the beginning, allowance is set to assign for free. Electric power industry ask for more emission allowances than they really need so that supply

exceeds demand, leading to decrease in prices and no reflection of normal emission reduction costs. Step by step, mode of carbon emission allowance assignment changed from free distribution to auction. Auction is proved to be fairer and more likely to reflect the demand and supply in market and auction helps settle clearing prices of carbon trading so as to improve the resource distribution.

For relationship between stock prices and carbon prices, studies show that carbon finance derivative prices have positive correlation with stock prices of electric power companies. Therefore, the trend of stock prices of energy industries has some references for trend of carbon finance derivative prices.

iii. Participants in carbon finance industry chain influence the trading prices
Carbon emission trading market attracts numerous financial institutions such as international financial organizations, investment banks, funds, commercial banks and asset management agencies.