Risk Identification and Management of Carbon financial

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Summary

With the rapid development and continuous capacity expansion of carbon market, financial trading instruments have evolved into a decisive factor of carbon market development, and carbon financial trading has risen as an important economic means to promote greenhouse gas (GHG) emission reduction and low-carbon transition. The European Union Emissions Trading System (EU ETS), the world's second and most mature system of its kind, launched spot trading as well as carbon financial derivatives at its inception, the latter includes futures and options trading, etc.. In particular, the trading volume of financial derivatives in EU ETS has increased rapidly, once reaching more than 30 times the spot trading volume.

The domestic carbon market pilots have also developed and introduced a variety of carbon financial products, including carbon allowance forwards, carbon asset mortgages /pledges, carbon funds, and carbon bonds, etc.. The move has not only stimulated the spot markets of carbon allowances and CCERs, which is effective to improve market liquidity, but also activated the carbon assets precipitated by companies. It offers certain risk hedging tools for market participants and gives a useful impetus to business financing for energy conservation and emission reduction.

The formation and development of carbon financial markets is indispensable from the support of traditional financial markets. The design of carbon financial trading instruments, rules and mechanisms needs to draw on the mature experience of traditional financial markets. Risk management, an important component of financial market operation, has also been crucial to the establishment and development of carbon financial markets in the future. However, there are clear differences between carbon financial markets and traditional financial markets due to the nature of emissions trading policy. In order to build a carbon financial risk management mechanism, it is fundamental to analyze the characteristics of carbon financial markets and products as well as identify major risks while drawing on the risk management experience of traditional financial markets.

Carbon financial risks can be divided into endogenous risks and exogenous risks. A portion of endogenous risks can be resolved through normal market transactions between buyers and sellers, and serve as the basic endogenous factor for carbon financial sustainability by improving the liquidity and profitability of carbon financial markets. Nevertheless, carbon price volatility beyond a reasonable range and the consequent series of carbon financial risks not only dampen the normal operation of carbon financial markets, but also undermine regional economic stability. According to international and domestic experiences of carbon market operation, carbon financial risks can be classified into four categories: policy risks, credit risks, operational risks, and market risks. As carbon assets are in essence a policy instrument for emission reduction, exogenous policy risks will have the most significant impact on carbon financial markets and may lead to the generation and superposition of other risks. A risk identification mechanism should be established based on the life cycle of carbon financial transactions, taking into account the characteristics of carbon financial risks. It is also necessary to clearly define the boundaries and principles of risk prevention and control, strengthen the supervision of carbon

financial markets, and excavate risk sources. Risks which supporting market liquidity should be rationally utilized, while for risks beyond market or economic tolerance, early warning and emergency response should be made in a timely manner. All these measures are essential to ensure the sound development of carbon finance.

The national emissions trading market officially launched on December 19, 2017. According to the “National Carbon Market Emission Trading Market Construction Plan(Power Generation Industry)”, the national carbon market is designed as a policy instrument aimed to control GHG emissions. Government regulation and services will be strengthened for effective prevention of financial and other risks, in order to establish a well-regulated, smooth-circulated, transparent and open carbon market. Therefore, to build a sound and effective mechanism for carbon financial risk identification and management is an important part of the establishment of the national carbon market. In this report, policy suggestions are proposed: (1) developing a integrated system of carbon financial policies and regulations, which mainly encompasses 3 levels including the basic laws, relevant State Council regulations, and departmental rules; (2) defining the rights and responsibilities of different shareholders in the management of carbon finance risks. The primary choice for all shareholders will be risk circumvention and asset appreciation through active involvement in market transactions and use of various trading tools; (3) adopting life-cycle management of carbon finance risks against to policy, credit, operational and market risks by combining ex-ante prevention, in-process resolution, and ex-post disposal measures, based on the characteristics of carbon financial transactions at different stages.

Contents

1 Introduction

The carbon emissions trading system has created a demand and provided a platform for the development of carbon finance. Since the entry into force of the Kyoto Protocol, carbon emissions trading has flourished. The EU and some other countries and regions have successively established compulsory carbon emissions trading systems, and some areas of the United States have also launched voluntary and compulsory trading markets which are classified into the allowance based market and certified emission reduction (CER) based market according to the basic trading products. China officially launched the carbon emissions trading pilot in October 2011. The seven pilot areas, including Shenzhen, Beijing, Shanghai, and Tianjin, opened the carbon market in the second half of 2013, and saw a cumulative trading volume of 197 million t-CO_2e of allowances worth about RMB 4.5 billion yuan by September 2017 1 and 132 million t-CO_2e of Chinese Certified Emission Reductions (CCERs) worth about RMB 940 million yuan by the end of 2017.

While the carbon spot trading keeps expanding, the market of carbon financial derivatives develops rapidly. Relying on highly developed traditional financial market, the EU has evolved into the most extensive carbon market based on the European Union Emissions Trading Scheme (EU ETS). The carbon market covers spot and derivative trading products, carbon financing tools, carbon financial supporting tools, and the derivatives trading volume and turnover have far exceeded those of spot trading. In the United States, the California's Cap-and-Trade System and the Regional Greenhouse Gas Initiative (RGGI) have developed the trading of derivatives such as futures and options based on spot trading of allowances. China's pilot carbon markets have also been active in the innovation of carbon finance, and developed 15 kinds of carbon financial products, services and tools, involving funds, bonds, pledge/mortgage loans, financial leasing, and allowance forwards. For example, Beijing, Shanghai, Hubei, and Guangdong support financing on allowances / CCER pledges or mortgages; Hubei, Guangdong, and Shenzhen introduced carbon asset custody services; Shanghai and Hubei pioneered the forward trading of allowances. These practices have laid a certain foundation for exploring the development and trading of carbon financial derivatives.

The development of carbon finance gives a major impetus to the reduction of greenhouse gas (GHG) emissions and the green transition of economic structure. The trading forms and product categories of carbon finance become more diversified and refined. This is of important significance for the carbon market by improving the efficiency of resource allocation and operation, enriching and improving the market mechanism, and ensuring effective and authoritative carbon prices. Meanwhile, carbon market participants are provided with asset management tools and risk hedging and financing channels. In addition, carbon finance can effectively resolve the investment and financing bottlenecks in the low-carbon field and thereby lay a solid foundation for green and low-carbon development.

[1] Source: Press conference of the State Council Information Office on the *2017 Annual Report on China's Policies and Actions for Addressing Climate Change*

While carbon financial products show the characteristics of high policy dependence and financial leverage, the risk identification and management mechanism is not yet perfect for carbon finance. As a result, a variety of financial risks may be superimposed beyond market tolerance, and exert a huge impact on the overall carbon market. Therefore, it is necessary to define the major types of carbon financial risks with consideration to carbon market characteristics and traditional financial risk types, and make accurate identification and judgment in a timely manner. Further, a carbon financial risk management mechanism should be built, which will promote the orderly and sound development of carbon finance and maintain the stable operation of carbon market, thus providing an important guarantee for successful energy conservation and emissions reduction.

The report begins with an overview of the basic elements of carbon finance and the development path of carbon financial market, and analyzes the relations and differences between carbon finance and traditional finance. Then, based on operating experience of European and US carbon markets as well as China's pilot carbon markets, the report summarizes the major types of carbon financial risks, supplemented by case studies of risk characteristics and identification features. Finally, based on the existing international experiences of carbon financial risk management while taking into account China's actual carbon market development needs, the basic requirements and policy recommendations for constructing a carbon financial risk management mechanism are proposed, covering policies and regulations, as well as risk prevention, identification, and resolution.

2 Carbon Finance

Generally, carbon finance refers to a variety of financial institutional arrangements and financial trading activities aimed at reducing GHG emissions, which encompasses the spot trading of allowances and the trading of other financial products derived therefrom.

2.1 Elements of carbon financial market

The carbon financial market is mainly comprised of the main participants and trading products. The main market participants include demanders, suppliers, speculators, and intermediaries whose roles may overlap. For instance, entities such as emission control enterprises have demand for allowances, and meanwhile, they may serve as project developers and CER providers, as well as transaction speculators according to the composition of their carbon assets. Also among the market participants are regulators and third-party agencies, of which carbon emission verification agencies are the unique third party in the carbon financial market.

Knowledge box: Main participants of the carbon financial market

Demanders: Include enterprises and entities that need to achieve emission reduction targets, financial institutions and carbon asset management companies that invest in carbon emission rights, and enterprises and individuals that make voluntary emission reductions;

Suppliers: Include project developers, entities with lower abatement costs, technology development transferors, and etc.;

Speculators: Refer to those that use their own funds to conduct speculative trading of carbon emission rights and derivatives, in order to profit from price fluctuations;

Intermediaries: Include financial institutions (commercial banks, investment banks, insurance institutions, and etc.) and international organizations (such as the World Bank and International Finance Corporation);

Regulators and third-party agencies: Include governments, carbon emission verification agencies, and other agencies that provide relevant consulting services.

The trading products in the carbon financial market mainly include two basic assets, i.e. carbon allowances and CERs, and various financial products developed on this basis. From the perspective of production function, the carbon financial market is similar to traditional financial market, and mainly consists of trading instruments, financing instruments, and supporting instruments. In the wave of global green financial development, carbon financing instruments such as carbon bonds and carbon assets mortgage and pledge financing have entered a period of rapid development. However, the trading volume and business scale are limited due to the absence of unified international issuance or certification standards for green bonds such as carbon bonds.

Knowledge box: Main products of the carbon financial market

Trading instruments: Contain carbon spot and derivative trading products, among which spot trading products mainly include allowances and certified project emission reductions; derivative trading products mainly include forwards, futures, options, and etc.

Financing instruments: Create a way for realizing and valuating carbon assets, and expand financing channels for enterprises or project owners to carry out energy conservation and emissions reduction and further revitalize their carbon assets. They mainly include carbon bonds, carbon asset mortgages /pledges, carbon asset repurchase, carbon asset custody, and etc.

Supporting instruments: Provide a variety of indicators for market participants to understand market development trends, and also provide the basis and means of risk management and credit enhancement for their carbon asset management. They mainly include carbon index, carbon insurance, and etc.

Table 1 Main carbon financial products and services in domestic pilot markets

Pilot	Repurchase	Off-market swaps	Pledge/mortgage financing	Over-the-counter (OTC) options	Borrow carbon	Forwards	Carbon funds	Carbon trust	Financial leasing	Factoring	Carbon securities	Carbon asset custody	Carbon bonds	Corporate overdraft	Green structured deposits
Beijing	√	√	√	√											
Shanghai			√		√	√	√	√							
Hubei			√			√	√	√	√	√	√	√	√		
Guangdong	√		√									√		√	
Shenzhen							√					√	√		√

2.2 Development path of carbon financial market

According to the EU and US experiences of carbon market operations, the development path of carbon finance can be summarized as establishing a policy system, improving the market system, and building the regulatory mechanism. Since carbon allowances are essentially a policy-based emission reduction tool, the development path is fundamentally determined by the formulation of policies such as allowance allocation and compliance rules and the convergence and improvement of supporting systems. While the carbon spot market is fundamental, the secondary spot market can be activated and effective carbon prices formed by continuously strengthening the construction of market rules, trading platforms and other supporting systems. This will lay a good foundation for further expanding derivatives trading and carbon financial transactions based on other spot assets. A sound and powerful regulatory mechanism is required to provide guarantee for effective policy implementation and smooth market operation for carbon finance. Based on the actual conditions of different regions and the needs of carbon financial development, a regulatory system will be built to continuously enrich regulation content and identify priority according to different types of carbon financial risks. It is a necessary for the sustainable development of carbon financial.

Case study: EU carbon financial market

Policies and regulations: Include six directives (mainly related to allowance management and trading schemes), 12 regulations (related to the management of registry system and auction platform construction), and 3 resolutions (emission reduction targets and GHG monitoring mechanisms)

Market system: Auction allowances and issue CERs in the primary market; and carry out OTC trading and floor trading of carbon assets in the secondary market. Relying on existing mature financial trading platforms, the European Climate Exchange of the Intercontinental Exchange (ICE-ECX) occupies 92.9% of the primary and secondary market shares, most of which are futures trading.

Carbon financial market supervision: Build a regulatory framework for carbon financial market at the EU and member levels based on climate policy objectives and emission trading policies and regulations, combined with experiences of financial instrument supervision and energy commodity supervision.

2.3 Comparison with traditional financial market

Carbon financial instruments and products have the same basic properties as traditional financial instruments, including liquidity, risk, and profitability, and they are traded in similar forms as ordinary commodities and securities. In some EU and US areas, both the spot and derivatives trading relies on the original financial trading platforms and follows the trading rules of exchanges. However, the carbon financial market and the traditional financial market vary significantly in the orientation and role, as well as the connotation of trading products.

In terms of market orientation and role, carbon emissions trading originated from the needs for emission control enterprises to fulfill their compliance obligations, and aims at optimizing and allocating emission reduction resources and factors including technology and capital. The traditional financial market is a mechanism for trading financial assets and determining their prices, designed to ultimately achieve the integration of funds and credit. In terms of product connotation, carbon emission allowance is a product significantly affected by the policy and traded for eliminating negative environmental externalities and optimizing resource allocation. In the traditional financial market, the trading products are focused on credit instruments trading with loan capital, which originates from borrowing, lending, and financing needs. Hence, there are certain differences between the carbon financial market and the traditional financial market, in both market functional orientation or trading product connotation.

Due to complexity and particularity of carbon financial market and its trading instruments, carbon financial risks show characteristics significantly different from traditional financial risks. The Section 3 of the Report will probe into the causes of carbon financial risks from the perspectives of policy, credit, operation, and market, find out the main characteristics and their impacts on different market participants.

3 Characteristics and Identification of Carbon Financial Risks

Compared with the traditional financial market, the carbon financial market emerged and started relatively late. It does not have perfect supporting systems, platforms and mechanisms, and consequently faces more problems and uncertainties in the operation process. As far as transactions are concerned, carbon financial risks show characteristics such as diverse types, complex reasons, and poor predictability, given the complex and diverse objects of transaction and cross-phase trading period.

3.1 Policy risks

In the traditional financial market, policy risk is a kind of systemic risk. The introduction or adjustment of each economic policy and regulation will indirectly cause market fluctuations by affecting the supply of funds and the return of securities. Compared with the traditional securities market, the carbon financial market is more directly and deeply influenced by policy changes because this complete policy-based market is built on a policy basis and highly dependent on policy and institutional constraints. Policy risks unique to the carbon financial market include allowance allocation rules, compliance rules, and approval rules for emission reduction projects and emission reductions. These exogenous risks can exert quick and direct impacts on the carbon financial market from overall aspects.

The policy risks of carbon finance arise mainly from two aspects. First, the basic transaction objects' scarcity is determined by policies and laws, so policy sustainability (or continuity) has a decisive influence on market stability and continuity. Second, changes in policies related to emission reduction project approval and emission reduction certification may also cause risks. Given the large investment and long payback period of emission reduction projects, any uncertain or unreasonable policy related to different parts of the project's life cycle will dampen the expectations of market participants and reduce the return on projects.

Therefore, the identification of policy risks should be focused on policy timeliness and reasonableness. Taking into account the design of compliance periods and trading stages in the spot market, the competent departments may make timely and reasonable policy adjustments according to specific conditions such as economic development and energy consumption. This will be a decisive factor of the overall stability of carbon financial market. In addition to spot transactions, carbon financial transactions cover derivatives, carbon debt assets, and carbon equity assets, of which the profit and loss depend on the price of spot carbon emission allowances and the investment income of emission reduction projects. It is necessary to clarify the impact of relevant policy changes on the value of such assets according to the characteristics of different carbon financial products. On this basis, risk prediction is carried out separately for different carbon financial assets when policy changes occur.

Case study: Policy uncertainty

The first phase of Shanghai emissions trading pilot is 2013–2015, and when the first phase is nearly coming to an end in the early 2016, Shanghai relative competent department did not unveil explicit policy of the allowance carryover, this has imposed negative impact on the market expectation and most of the market participants undersold the first-phase allowances. This led to the prices of allowances fell amid irrational sell-off from RMB 10 yuan / t-CO_2e to around RMB 5 yuan / t-CO_2e within four months from the beginning of the year 2016.

Unit: Yuan

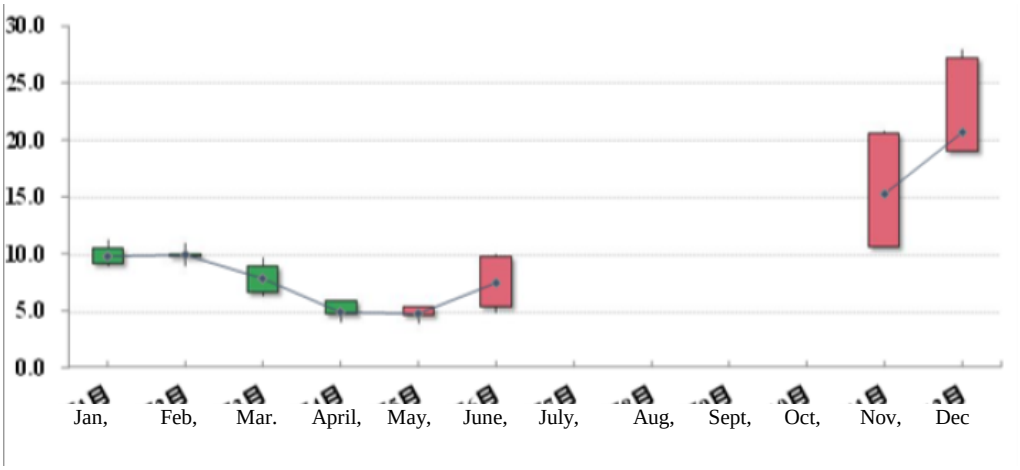

Figure 1 Changes in monthly average transaction price of listed allowances in the Shanghai emissions trading pilot, 2016

(Source: 2016 Shanghai Carbon Market Report)

In May 2016, the Shanghai Municipal Development and Reform Commission officially issued the "Notice on Relevant Matters Concerning Carrying over Carbon Emission Allowances in the Shanghai Emissions Trading Pilot" which clarified the rules and methods for carry-over of first-phase allowances. Given such clear policy direction, the prices of allowances in the Shanghai pilot began to rebound, reaching around RMB 8 yuan / t-CO_2e during the compliance period in June and hitting RMB 20 yuan / t-CO_2e at the year end.

Analysis: Risk management and response

In the Shanghai emissions trading pilot, the unclear carry-over policy and untimely policy introduction have sparked false expectations among market participants, which led to continuous sharp decline in the allowance prices. This case has revealed grave policy risks which had a serious negative impact on the market operation. The relevant competent departments did not directly intervene in the market, but rather released a policy document stabilizing market expectations before the end of the compliance period based on timely judgment of the overall operation of the market and the economy. The move was of positive significance for stabilizing market operation by alleviating the negative impacts of policy risks. It represents an effective means of managing and responding to policy risks at the government level.

3.2 Credit risks

Credit risk is one of the major non-systemic risks in the traditional financial market. Also known as default risk, credit risk generally refers to the possibility of loss resulting from failure to timely pay a principal and interest to holders of securities, which is mainly attributed to information asymmetry. In the field of carbon financial transactions, information asymmetry is exacerbated by deficiencies in such aspects as information disclosure, and it is easier to breed "adverse selection" and "moral hazard". Where commercial banks provide carbon credit services for enterprises which focus on energy conservation and emissions reduction, borrowers with poor technological capability or lower emission reduction potential are more likely to obtain credit funds and deviate from the intended use. As a result, credit risks break out that the borrowers fail to make loan repayments or deliver CERs as scheduled.

The credit risks specific to carbon financial transactions also include the default risk of CER buyers and all kinds of fraud arising from the defects of trading system and regulatory mechanism which are caused by cross-regional factors and the lack of information transparency, such as the value-added tax (VAT) fraud in the EU carbon market. In addition, "moral hazard" directly impairs financial transactions fairness and allowance allocation effectiveness in the carbon market. It is associated with the malicious subjective fraud of enterprises or verifiers in the process of data monitoring, reporting and verification of emission control enterprises, such as deliberate concealment and false report.

The credit risks of carbon finance should be identified at objective and subjective perspectives according to causes. For instance, it is easy to timely identify obvious credit risks such as those related to overall value fluctuations of carbon assets or projects as a result of policy changes, natural disasters and other irresistible force. However, difficulty increases in identifying credit risks that are caused by subjective malicious breach of contract of counterparties or data providers. It is necessary to keep track of fund circulation and actual use in the whole process of carbon financial transactions, and conduct an all-round evaluation of the counterparties' assets and credits on a regular basis, with consideration given to factors such as market prices; strengthen the process-wide supervision of data monitoring, reporting and verification, and use relevant technologies to identify data vulnerabilities in a timely manner.

Case study: Default risk of CER buyers

The clean development mechanism (CDM) project of offshore wind farm for Shanghai Donghai Bridge involves a total investment of RMB 2.365 billion yuan, of which RMB 1.892 billion yuan is supported by loans to Shanghai Donghai Offshore Wind Power Co., Ltd. from the bank consortium led by Shanghai Pudong Development Bank (SPDB). It represents China's first international pledge loan project backed by carbon assets that is offered by commercial banks. In 2012 when the repayment pressure was high, the buyer of certified emission reductions, Carbon Resources Management Co., Ltd. (CRM), suddenly declared a default under the impact of the EU carbon market depression. It means that CRM could not purchase the certified emission reductions of the project at 12.66 euros / t-CO_2e as agreed in the contract. As a result, the project revenue shrank sharply, which has a negative impact on loan recovery.

Analysis: Credit risk prevention for CDM projects

The 25-year project is a long-term investment. Market fluctuations during the project period may cause the default of buyers and further affect the project value. In this case, we can find

that the diversity and superposition characteristics of project risk. In the initial stage, SPDB adopted a combination of syndicated loan and credit enhancement, and financial institutions within the bank consortium bore respective risks according to loan quotas. In this case, SPDB also allowed the pledge of CER accounts receivable for risk management. Although CRM's default has reduced the asset value of CER accounts receivable, the pledge still represents an effective attempt to avoid carbon financial risks in market approach.

Case: VAT fraud in the EU carbon market

In 2009, the VAT fraud was found within the EU ETS, which refers to the fraudulent activity that rogue traders buy carbon credits without tax and sell them with tax to a third party through trading platforms. In the 18 months before the EU crackdown on fraud in 2011, the VAT fraud related to carbon emissions trading caused a loss of five billion euros. In this case, BlueNext (BNX) under the NYSE Euronext in pursuit of profits did not promptly announce and stop such activities, which directly led to the EU's huge VAT loss. Eventually, BNX was closed permanently for serious dereliction of duty.

Analysis: Lack of supervision and emergency response

Credit risk was exposed in the VAT fraud in the EU carbon market. Due to the lack of regulatory mechanisms and trading rules, BNX as a trading platform turned a blind eye to illegal allowance transactions out of consideration to its own maximum interests. The inappropriate performance of EU regulatory authorities of carbon market aggravated information asymmetry in the trading process and brought about the moral hazard of both frauds and trading platforms.

After the incident, the EU authorities took the measures of strengthening regulation and reforming taxation to deal with risks. In terms of market access regulation, the identify authentication of market participants was strengthened. Customers were required to provide information such as identity certificates and power of attorneys certified by the competent authorities. If potential fraud is identified in the strict check, the administrative staff may request a suspension of the registration, thereby reducing the possibility of credit risk at the source. In addition, the EU strengthened regulatory cooperation among member states and coordinated regulation of relevant departments of member states to push forward the detection of VAT fraud cases. The move also played a positive role in reducing loss associated with credit risks and maintaining the market order.

In order to prevent the recurrence of similar credit risks, the EU taxation department has reversed the VAT charge mechanism, and enhanced the informatization of emissions trading taxation. In other words, credit risk prevention, identification and management has been strengthened at both policy and technical levels.

3.3 Operational risks

Operational risks in the financial market are primarily caused by violation operation. From the perspective of transaction behavior, operational risks can roughly be divided into market manipulation and insider trading. From a technological perspective, operational risks arise due to human errors, system failures, and improper work procedures and internal control.

In carbon financial transactions, market manipulation mainly means that based on their own fund and information advantages, some brokerage service providers, trading platforms, and other personnel induce investors to make an investment decision without understanding the real situation of specific carbon financial products or emission reduction projects. Insider

trading generally refers to the act that insiders and other personnel with illegal access to insider information on carbon financial transactions, disclose the information on emissions verification, carbon financial assets and relevant transactions of enterprises in violation of relevant regulations, and recommend buying or selling carbon financial products based on the above mentioned insider information.

From a technological perspective, carbon allowances as the basic asset for carbon financial transactions are an intangible virtual e-voucher and exist only in the registry system of allowances and CERs. Allowance theft and reuse caused by human errors during operation and system vulnerabilities are all deemed operational risks specific to the carbon financial market. Compared with the traditional financial market, such risks have more profound effects because the rapid spread in a short period of time can indirectly lead to market risks and credit risks that incur massive economic losses.

Case study: Theft of carbon credit in EU ETS

Before the inception of the Union registry, the registry systems of some EU member states were attacked or hacked due to Internet technology security loopholes, which hindered the normal transactions of the carbon market. In 2010, Romanian registry accounts were stolen and 1.6 million tons of EU allowances (EUA) were lost. On January 28 the same year, the German registry was invaded by the Trojan virus and forced to close until February 4 when the account names and passwords of all users were reset. In this event, criminals obtained the account names and passwords of seven equipment operators by acting as the registry authority to send phishing emails to the users, and used their accounts in other registration systems to illegally transfer allowances the next day after invasion. In 2011, the registry hacking in some EU countries led to theft of three million tons EUA and economic losses of 50 million euros. Allowance theft incidents seriously impeded not only stable registry operation, but also market supply and demand balance, and dampened the confidence of market participants.

Analysis: Causes

In the field of carbon financial transactions, the lack of appropriate policy and regulation guidance as well as human and technical capital support makes it difficult for operating systems to establish relatively sound and safe operating mechanisms in the short term. These endogenous vulnerabilities expose carbon financial transactions to large operational risks in the early stage.

As the operational risks of carbon finance are dispersed, complex, and transformative, a comprehensive and systematic approach is needed for risk identification. First, operational risks actually cover all the links related to specific operations of carbon financial transactions. The identification and management of such wide-range risks requires multi-sector collaboration. Second, a variety of factors may cause operational risks, including not only the objective complexity of carbon financial transactions, but also subjective factors including transaction, verification, and policy making. The separate analysis of organizational structure, transaction process, trading platform and system, and employees will be necessary to identify the sources of operational risks. It is recommended to enhance the identification of operational risks by establish a model based on the existing measurement models of financial institutions such as

commercial bank and refine it by integrating the characteristics of carbon financial products and projects.

Knowledge Box: Basel Committee's three measurement approaches for operational risks of commercial banks

Basic Indicator Approach: $K=GI*\alpha$ (K represents the capital set aside for operational risks; GI denotes the average income of the financial institution in the first three years, and α is the coefficient operational risk to the gross income)

Standardized Measurement Approach: Using the refined Basic Indicator Approach, the capital set aside for operational risks is calculated based on the operational risk factors assigned for eight business lines of commercial banks according to which the gross income is divided.

Advanced Measurement Approach: It includes internal measurement approach, loyalty card approach, and loss distribution approach. Commercial banks calculate regulatory capital based on their own operational risk loss data. In other words, regulatory capital varies among financial institutions with the distribution of operational risk losses.

3.4 Market risks

In the traditional financial market, analysts set a reasonable range of asset price volatility based on macroeconomic and market data. Price volatility within the above range is considered a normal market adjustment behavior that creates operational space and profitability possibility for market participants while providing certain liquidity for the market. Such price volatility will be resolved within the market through a large number of transaction behaviors. Conversely, abnormal price volatility beyond the reasonable range is regarded as a major indicator of market risks.

In the carbon financial market, similarly, carbon price adjustments within the reasonable range are normal to maintain market liquidity and attraction to funds, while abnormal carbon price fluctuations tend to undermine the overall stability of carbon market and the value of corporate carbon assets. Excessive carbon prices will directly increase the compliance costs and hamper the normal production and operation of enterprises. Extremely low carbon prices will cause the depreciation of carbon assets held by enterprises and dampen the expectations of social investment for energy conservation, emissions reduction and low-carbon projects. Abnormal carbon price volatility will significantly reduce the liquidity of carbon assets, creating the demand for intermediaries to complete transactions between market participants. This will not only add transaction costs, but also drive carbon prices further away from the true value, resulting in a vicious circle of carbon market risks.

The periodic and spatial particularities of carbon financial transactions make carbon asset prices more vulnerable to market conditions and other uncertainties. Under the existing major carbon emissions trading systems that adopt a multi-phase approach, allowances and their derivatives with an intertemporal feature are significantly distinguished from traditional financial products, and show diversified and random price fluctuations, rather than continuous price wave in the traditional sense. In some domestic pilot carbon markets, the offline prices of allowances or CCERs vary widely from the online prices and have lower transparency and visibility. Large carbon asset owners may act as market makers and make market prices deviate from the true value, forming an important underlying factor that triggers market risks. Therefore, the

identification of market risks of carbon finance should be based on historical transaction data of different products, while taking into account the specific trading rules, macroeconomic environments, and carbon financial assets of market players themselves. A comprehensive prediction of market risks and liquidity risks can be made by setting reasonable ranges for prices or asset value fluctuations.

Case study: EU carbon price imbalance

Due to policy discontinuity and allowance oversupply, the spot carbon price in the EU carbon market was close to zero at the end of the first phase in 2007, which has incurred huge losses to the traders in the bull position. Besides, the cyclical fluctuations of the macro economy have also brought about serious market risks to the EU carbon market. Under the combined impact of the financial crisis and the European debt crisis, the EUA price dropped by nearly 90% from July 2008 to April 2013, with a decline from 28.73 euros / t-CO_2e to 3.81 euros / t-CO_2e, making EUA the largest depreciated commodity since the financial crisis. At the same time, the CER and emission reduction unit (ERU) prices shrunk dramatically, down to around 0.5 euros / ton. Given the diminishing demand for allowances, the investment in carbon finance became sluggish, which has caused huge losses to market participants including emission control companies, financial institutions, and project owners, and seriously hampered the confidence of all parties involved in carbon finance.

Analysis: Causes and responses

Macroeconomic downturn indirectly affects the total amount of GHG emissions from energy consumption. The sharp decline in demand for allowances along with the reduction of corporate emissions due to economic downturn serves as a key factor in the above market risk. In response, the EU has continued to improve the allowance allocation scheme and the carbon emission verification system; built a carbon financial system involving commercial banks and insurance companies to use the resources of financial institutions to resolve market risks in the emissions trading process; and ordered the financial regulatory authorities to establish a sound information monitoring system and the evaluation mechanism for carbon financial risks and issue risk control guidelines, so as to further monitor and control the market risks of carbon finance.

Case study: Concentrated transactions in domestic pilot carbon markets during the compliance period

Transactions show a high degree of concentration in the seven pilot provinces and cities of the emissions trading system in China. Both the volume and turnover of market transactions rose sharply one month before the compliance period, while stayed at low levels during the other periods of the year.

Unit: 10,000 t-CO_2e

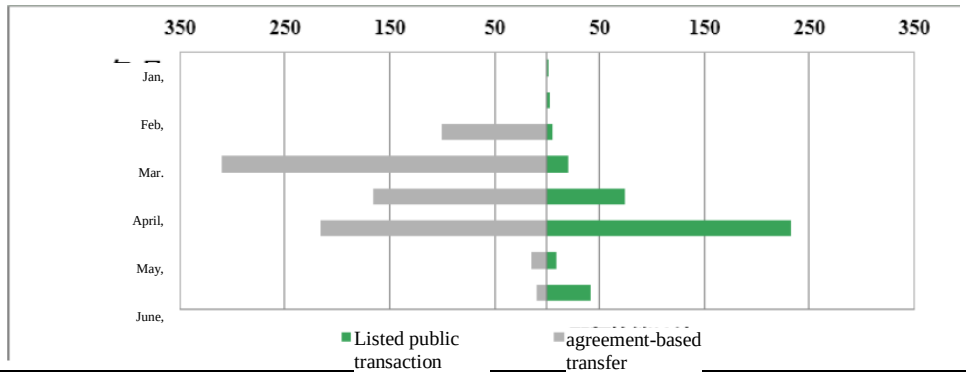

Figure 2 Spot trading of allowances in the Shanghai emissions trading pilot, 2016

(Source: 2016 Shanghai Carbon Market Report)

Analysis: Causes and hazards

The above-mentioned phenomenon is mainly caused by various factors such as insufficient understanding of emissions trading and information asymmetry among market participants such as emission control enterprises. The consequent low liquidity of allowances will hinder the timely discovery of real market price and abatement cost through effective secondary market transactions, and the price-related loss will indirectly reduce the investment value of carbon assets and the financing ability of projects, and increase the transaction cost of market players with surplus allowances. Also this may give rise to the risk of the enterprise fail to compliance.

3.5 Summary

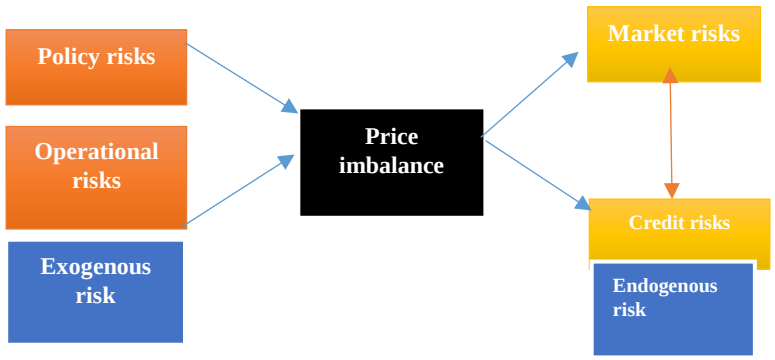

Figure 3 Relationship between major carbon finance risks

There is a possibility of mutual influence and superposition of different kinds of carbon financial risks. Since carbon allowance is a policy-based emission reduction tool, policy risks as the basic risks will induce market risks and credit risks that may transform to and superimpose on each other. Therefore, the identification and management of carbon finance risks should consider the characteristics and superimposition effects of these risks. It is not appropriate to simply apply the existing regulatory model or management approach for financial risks of stock or derivatives market. Instead, a sound and effective carbon finance risk identification and management system that reflects the characteristics of carbon financial products and transactions should be built according to the actual situation of carbon market and economic development.

Table 2 Characteristics of and responses to carbon financial risks

Carbon finance risks	Feature			Degree of influence on different groups				Identification and countermeasures
	Control difficulty	Infection speed	Magnification	Individuals	Medium-sized enterprises	Large enterprises	Financial institutions / institutional investors	
Policy risks	+++	+++	+++	++	+++	+++	++	Conduct ex-ante and ex-post evaluation of policy effectiveness, and adjust policy timely based on analysis of market response
Credit risks	++	++	++	+	++	++	+++	Strengthen information disclosure and supervision, design a carbon financial credit evaluation mechanism, and introduce innovative carbon financial products for appropriately avoiding and hedging risks
Operational risks	++	+	+++	++	++	+++	+++	Perform process-wide regulation of operations for carbon financial transaction; strengthen system functions, and improve system stability and security
Market risks	+	+++	+	+++	++	+++	+++	Use price volatility within the reasonable range to maintain and increase the value of carbon assets; keep track of changes in market conditions, and adjust the composition of assets when prices fluctuate beyond the tolerance range, with consideration given to macro economy, energy consumption, and policy adjustment

4 Recommendations on Building a Carbon Financial Risk Management Mechanism

The "*Plan for Building the National Carbon Emissions Trading Market (Power Generation Industry)*" (hereinafter referred to as the Plan), officially issued on December 18, 2017, made it clear that the national carbon market is designed as a policy instrument to control GHG emissions and government regulation and services will be strengthened for effective prevention of financial and other risks, in order to establish a well-regulated, smooth-circulated, transparent and open carbon market. As carbon finance is important part of the carbon emissions trading system, developing a sound and effective mechanism for carbon finance risk management will be a major task to build the national carbon market. Taking into account the requirements of carbon market construction and the characteristics of carbon financial transactions at different stages, this chapter will discuss the basic requirements and connotations of carbon financial risk management, covering ex-ante prevention, in-process resolution, and ex-post disposal, propose the architecture and content of policies and

regulations for carbon financial risk management, and analyze the rights and responsibilities of market participants and government departments in the management of carbon financial risks. Risks can be avoided and prevented by developing a carbon finance market regulatory system, establishing a risk early warning and emergency system, and stimulating innovation in carbon financial products and services.

4.1 Establish policy and regulation system

The system of carbon financial policy and regulation encompasses three levels: (1) Basic laws, covering all aspects of carbon financial transactions. The "Regulations on Administration of Carbon Emissions Trading" is suggested to enacted which is to set forth the types and attributes of carbon financial products, trading rules, basic market structure, trading limitations, trading platform and registry specifications, regulatory responsibilities, disclosure of information on corporate emissions and market transactions. In addition, the Corporate Law and the Securities Investment Law also contain sections applicable to carbon financial transactions; (2) Regulations on administration of carbon financial services promulgated by the State Council, which mainly includes risk control indicator measures and risk disposal regulations formulated for on-exchange and off-exchange products; and (3) Departmental regulations and regulatory documents issued by the competent departments and self-regulatory rules and guidelines of the carbon finance industry, such as the internal risk control guidelines for carbon financial transaction entities, which specifies in detail risk management in the process of carbon financial transactions. A perfect system of policies and regulations provides strong support for process-wide risk management and serves as the only basis for building the risk early warning and identification system, regulating and evaluating carbon finance transactions, and conducting ex-post risk management and response.

Knowledge box: Main EU regulations for carbon finance supervision

The EU carbon market relies on the highly mature financial market. In addition to the EU emission trading policies and regulations, the EU has expanded the scope of application and content of existing financial market regulations based on the characteristics of carbon financial transactions and their risks, in order to regulate carbon finance.

For determining the nature of allowances, the new Markets in Financial Instruments Directive (MiFID II) taking effect on January 3, 2018 established allowances as a particular category of financial instruments applicable to the secondary spot market. The new Market Abuse Regulations (MAR) also covers the EU ETS secondary market and the primary auction market. The Anti-Money Laundering Directive (Anti-MLD) clearly stipulates the counterparty due diligence review of trading licensors in the secondary spot market.

In addition to the above regulations and directives, EU carbon financial activities are also subject to directives and regulations such as Market Abuse Directive (MAD), Criminal Sanctions for Market Abuse (CSMAD), Transparency Directive (TD), Capital Requirements Directive (CRD), Investor Compensation Scheme (ICSR), and Regulation on Wholesale Energy Market Integrity and Transparency (REMIT).

4.2 Enhance different shareholder's responsibility

Carbon financial risk management involves both market participants at the micro level and government authorities at the macro level. For compliance required entities, the primary principle for carbon financial risk management is to participate in carbon financial transactions on the premise of fulfilling compliance obligations and emission reduction targets on time to ensure the preservation and appreciation of their carbon assets and to obtain stable and reliable financial support from carbon finance for their energy conservation and emission reduction projects. Commercial banks and other financial institutions are responsible for performing feasibility study on carbon financial services or projects such as carbon credits and carbon bond underwriting; identifying sources of risk to reduce or eliminate the possibility of risks; in accordance with policies, regulations and behavior guidelines, developing procedures for carbon financial risk management in the operational processes involving carbon financial projects or business, and setting up specialized positions in risk management departments; keeping track of policies and market conditions related to spot carbon products and other carbon finance products, and conducting regular risk assessments to guide trading parties to avoid carbon financial risks and obtain knowledge on carbon financial risks.

Government departments in charge of carbon finance should fully understand various factors that trigger carbon financial risks in the macro and top-level design, and timely adjust relevant policies according to the actual development of carbon finance. Meanwhile, they should build a carbon financial risk management system to strengthen the supervision of market behavior and trading platforms, increase penalties for violations, and maintain the smooth operation of national carbon market.

4.3 Ex-ante management: Risk prevention

The first step of carbon financial risk management is to timely detect the potential sources of risks and perform targeted risk aversion. Combined with the characteristics of carbon financial transactions, the ex-ante risk management can be divided into four parts according to risk categories:

First, in terms of of policy risks, emission trading authorities, together with competent departments for securities and banks, should jointly establish an evaluation mechanism that comprehensively evaluates the development of carbon finance related policies from multiple perspectives such as macroeconomics, energy, and finance to ensure policy effectiveness and rationality and guard against policy risks. Second, in terms of credit risks, the information disclosure mechanism should be enhanced, under which the methods and specific requirements for the disclosure of carbon finance related information are designed with reference to the experience of Carbon Disclosure Project (CDP), in order to minimize the possibility of information asymmetry. Financial institutions such as commercial banks should strengthen the pre-loan investigation of carbon credits to identify potential risks in the project. Third, in terms of operational risks, registration requirements and reviews of market participants should be upgraded by putting reasonable additional restrictions in China's context, so as to reduce the possibility of operational non-compliance at the source. At the same time, the registry and the trading system should be made more stable and safer. Fourth, in terms of market risks, an allowance flexibility mechanism or an allowance adjustment pool should be introduced and

combined with other spontaneous adjustment measures to improve market self-regulation and reduce the possibility of unexpected price imbalance.

4.4 In-process management: Risk identification and mitigation

Comprehensive regulation of carbon financial transactions and timely risk identification and warning is the primary prerequisite for defusing carbon financial risks and reducing losses. Both competent authorities and market participants should set up the respective regulatory mechanisms and risk identification and early warning systems according to the needs of risk control and aversion.

First, the competent authorities should keep track of policy impact and review policy effectiveness at special time points such as compliance periods, so as to identify potential policy risks and make policy adjustments in a timely manner. Market participants, as a passive recipient of policy, should pay close attention to policy changes based on their own involvement in the carbon financial market. Second, in order to minimize credit risks caused by default, the central counterparty clearing model and exchange transaction settlement should be made mandatory, and professional institutions and platforms mobilized to supervise carbon financial transactions. The regulation of monitoring, reporting and verification of GHG emissions should be enhanced to avoid concealment and misreporting. Third, the competent authorities should strengthen the real-time exchange monitoring, market surveillance, and vertical management of the registry and trading systems, so that they discover violations and system loopholes in the operation process in a timely manner, and under special circumstances, adopt emergency response to violations in the form of mandatory implementation in accordance with relevant laws or regulations. Market participants should tighten internal control by strengthening the supervision and management of departments or personnel involved in carbon financial transactions, in order to reduce the possibility of operational risks caused by internal factors. Finally, a large-trader reporting system and a position limit system for transactions are needed to prevent large allowance holders from market manipulation that fuels price volatility and triggers market risks. The competent authorities and market participants are expected to develop the risk warning indicator system for price volatility at macro and micro levels respectively, and identify and predict market risks based on the price trend monitoring of carbon financial products, and various factors such as macroeconomics and energy. Where necessary, allowance repurchase or other price interventions will be adopted to stabilize market expectations.

No matter what kind of risks, external regulation will be the focus of risk prevention and control. It encompasses regulation at two levels: (1) The national authority, local governments, and industry associations perform macro regulation of the carbon financial market; and (2) The main trading platforms and clearing and settlement agencies review and supervise all aspects of carbon financial trading activities according to service processes and rules. It is suggested that the national competent department for climate change take the lead in establishing a carbon financial management committee, and an inter-departmental regulatory system and coordination mechanism in collaboration with the energy and finance sectors. According to the actual situation of carbon finance development, carbon financial transaction management

offices can be set up at the local level, responsible for guidance and supervision of carbon financial transactions and further carbon finance development.

Table 2 Regulatory bodies, objects, and responsibilities at different levels

Regulatory authorities	Regulatory objects and responsibilities
National authorities and external associations	Spot carbon: Allowance allocation, allowance and CCER registration and transaction
	Carbon finance products: Approval and registration for the record
	Others: Regulation of verification agencies, registration agencies, trading platforms, clearing and settlement agencies, carbon asset management companies, carbon funds, and etc.
Trading platforms, clearing and settlement agencies	Market access, transaction authenticity and compliance, etc.; Margin in arrears, overbought, or oversold in the capital accounts and asset accounts of market participants.

4.5 Ex-post management: Emergency response and accountability investigation

Emergency response and ex-post management after the emergence of carbon financial risks lays the foundation for further mitigating loss and summarizing experience to boost the sound development of carbon finance. The competent authorities and market participants should respectively define the basic principles and processes of risk emergency response at the macro and micro levels, and establish the strategy database for risk emergency response based on historical transactions and risk aversion experiences. The strategy database should be linked with the risk identification and early warning system to realize automatic recommendation and match of emergency strategies when the early warning indicators exceed the thresholds.

A strict accountability mechanism should be supplementary to risk emergency response. Taking credit risks as an example, it is advisable to establish a national credit system for carbon financial transactions and network it with the national credit information system. Information on non-compliance and breach of contract of institutions, platforms or individuals will be made public to facilitate joint punishment. Where risks and losses are caused by internal personnel, market participants should pursue internal accountability, covering carbon financial transaction operators, risk management personnel, and relevant department heads. The accountability mechanism will improve the overall management by raising the risk prevention awareness of relevant personnel and simulating the enthusiasm of risk management personnel.

4.6 Summary

According to the Plan for Building the National Carbon Emissions Trading Market, in the initial stage of the national carbon market construction, allowances are mainly traded in the spot

market, and carbon financial risks will be dominated by market risks arising from abnormal spot price volatility and operational risks. Hence, the responsibilities of spot transaction supervision departments should be clarified, and special attention should be paid to the access of all market participants to real-time and accurate market price information, so as to avoid the overall price impact brought by information leakage and abuse on the national carbon market. Meanwhile, it is necessary to prevent large-scale emitters from manipulating market and hoarding allowances for market monopoly and squeeze, which causes abnormalities such as carbon price deviations from normal levels.

In the early stage of carbon finance development, relevant competent authorities should speed up the legislation and build efficient mechanisms for department coordination and regulation and also risk prevention and control that based on China's emissions trading and socio-economic characteristics. Drawing on the existing rules and methods of the capital market and summing up existing experiences, the authorities should deepen information disclosure, and strengthen national carbon market supervision to effectively guard against financial risks, and steadily promote the overall progress and smooth operation of national carbon market.

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