



Review

Review on international comparison of carbon financial market

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Abstract: With the continuous growth of the world's population and the rapid development of various economies (especially some emerging countries), environmental protection and carbon emission reduction have become the consensus of the world, which has directly promoted the formation of the global carbon market and carbon finance. This paper proceeded from the background and significance of international carbon financial transactions and sorted out related studies on the connotation, concepts, and status of carbon financial markets. Subsequently, the international comparisons and analyses of seven aspects of the carbon financial market were conducted. This paper aims for making readers understand the current situation of the development of the global carbon financial market and providing the policy suggestions for some countries whose carbon financial researches are not deep enough, as well as the theoretical references for scholars in this field.

Keywords: carbon financial market; international comparison; carbon emission; carbon trading; low-carbon

JEL Codes: G15, F36

1. Introduction

The Industrial Revolution that originated in the United Kingdom (UK) brought the gospel to the world. The advancement of the Industrial Revolution, while enriching people's material lives, also had many adverse consequences. The greenhouse gas produced by the industrial revolution has increased year by year, exceeding the total emissions of nearly two hundred years (Liu, 2016). However, the initial stage of large-scale greenhouse gas emissions did not attract people's attention.

It was not until after the huge economic losses and large numbers of casualties caused by global warming that people began to focus on the causes of climate warming. After years of research by experts and scholars, the main culprit in this series of disasters is the large amount of greenhouse gas emissions in industrial production (Sun and Wang, 1996).

In order to control global greenhouse gas emissions, the international community has issued a series of conventions after many meetings and consultations. The most important of which are the United Nations Framework Convention on Climate Change (hereinafter referred to as the Convention) and the Kyoto Protocol (Zhang, 2016). Although the Convention does not provide clear provisions, it gives positive significance for the smooth signing of subsequent conventions. The Kyoto Protocol is the continuation of the Convention, which more specifically stipulates the responsibilities and goals of industrialized countries to reduce emissions. The generation of carbon financial markets stems from these two global conventions concerning greenhouse gas emissions. However, there is currently no clear definition of carbon finance. Generally speaking, carbon finance in the broad sense refers to low-carbon economic financing activities arising from the Kyoto Protocol, that is, all financial activities that serve to limit greenhouse gas emissions, including direct investment, financing, carbon trading, and bank loans. Carbon finance in the narrow sense refers to a series of financial activities of carbon rights trading between enterprises, such as the trading of climate-based wealth management products, the trading of carbon emission rights and their derivatives, etc. (Wu, 2009).

Since the creation of the carbon financial market, with the increase of greenhouse gas emissions and the development of society, the carbon financial market has become more and more popular. It is also important for some emerging countries, which have huge carbon emissions. Although their economies have maintained a rapid development status, these are based on large amounts of energy consumption and exhaust emissions come at the cost. Therefore, both the country and the government vigorously advocate a shift to a resource-saving and environmentally-friendly sustainable development approach, which means that the emerging carbon finance has huge development potential (Lewis, 2010). With the continuous renewal of the concept of sustainable development, most countries in the world, including developed countries and developing countries, believe that the human society needs such green development even more. However, some carbon financial markets are still in its infancy. Although the governments have implemented a series of measures aimed at greenhouse gas emissions, there is still much space for improvement (Weng and Xu, 2018; Du et al., 2016; Liu, 2011). Fortunately, many countries in the world are at the forefront of the construction of the carbon financial system, especially in developed countries. There are many places in the development of carbon finance that the other countries should learn from and draw lessons from. Therefore, this paper compares the development characteristics and operation of the international carbon financial markets. On the one hand, the study and comparison of international financial markets will help the establishment and development of carbon financial market, and provide people with an effective way to use market mechanisms to solve environmental problems (Zeng and Wan, 2009). On the other hand, it has also improved the international competitiveness of commercial banks and helped to promote the transformation of its business strategy. Commercial banks are major players in the carbon financial market. Through participating in the transaction process and strengthening cooperation with international institutions, they can enhance their own innovation capabilities and international competitiveness. Finally, by a comparative analysis, it provides the possibility for further strengthening the development concept of a low-carbon green economy, and then promotes the improvement of the national carbon financial market (Li and Zhao, 2010).

As of the end of 2018, there were 19 carbon trading systems operated globally on regional, national and sub-national level, and an unified international emission trading market had not yet been formed. This paper mainly compares the international carbon financial market from seven aspects including development history, trading system, pricing mechanism, product, legal framework, service agency and regulatory system, and summarizes their respective characteristics and commonalities. The comparisons almost cover all aspects of carbon finance, which are the indispensable foundation for forming a more complete carbon financial market. This paper selects the above seven aspects for comparison, mainly considering the following two reasons. Firstly, after reading a large number of literatures, it is found that these seven contents have their own characteristics and are representative, and can describe the current international carbon financial market from all aspects and levels. Secondly, the seven aspects listed in this paper are mainly divided into three parts: the development history; the market perspective including trading system, pricing mechanism and product; the government management including legal framework, service agency and regulatory system. The structure of this paper is arranged as follows: Section 1 mainly reviews the development origin of carbon finance and related concepts. Sections 2–8 compare the international carbon financial market from seven aspects. Section 9 summarizes the paper and puts forward policy recommendations based on the research conclusions.

2. Comparison of development history

With the gradual warming of global climate as well as conventional energy depletion and other issues constantly being realized, people started to focus on low-carbon model of economic development. The low-carbon economy rises from the change of the international climate policy, specifically, involves two significant international conventions: the 1992 Convention (see Introduction for full name) and the 1997 Kyoto Protocol. The latter pushes the new low-carbon economy model of economic development directly to the stage of history. Low-carbon economy, on the surface has more to do with global climate change and energy conservation, but in practice, a huge supply of funds and financial flow mechanism has been formed. As for the real economy of low-carbon model development, it also has the characteristics of financial capital flows. The Kyoto Protocol designed three carbon emission reduction market mechanisms. Due to different business carbon emissions and carbon abatement costs, the enterprises which have more emission rights usually obtain economic benefits by selling the excess to those ones which have shortage of emission rights (Zeng and Zhang, 2011).

As early as the 21st century, the United States, Germany, the UK, and Japan have formulated relatively complete laws and regulations and a carbon trading market system. The establishment of an increasingly perfect system has accelerated the standardization and ordering of carbon finance, and promoted the rapid development of carbon finance. In 2002, Germany enacted *the Energy Conservation Act*. In 2003, *UK Energy White Paper “Our energy future: creating a low carbon economy”* came up with low-carbon economy in the first time. After 2005, the international carbon trading market began to rise. In 2007, the United States and Japan successively introduced *the Low Carbon Economy Act* and Environmental Tax (Sun, 2019). Figure 1 shows the number of implemented or scheduled initiatives on national level and sub-national level. As can be seen from Figure 1, there are 46 countries and 28 sub nations that have taken different implementations, including the group of Emissions Trading System (ETS) and carbon tax, carbon tax only and ETS

only. Besides, in these countries or sub nations, the ETS implementation is relatively higher compared with the carbon tax. The growth of regional, national and sub-national carbon pricing initiatives is illustrated in Figure 2, which shows that since 1990, the number of countries and regions that have implemented the carbon pricing mechanism has increased year by year, and the growth rate has accelerated significantly since 2006.

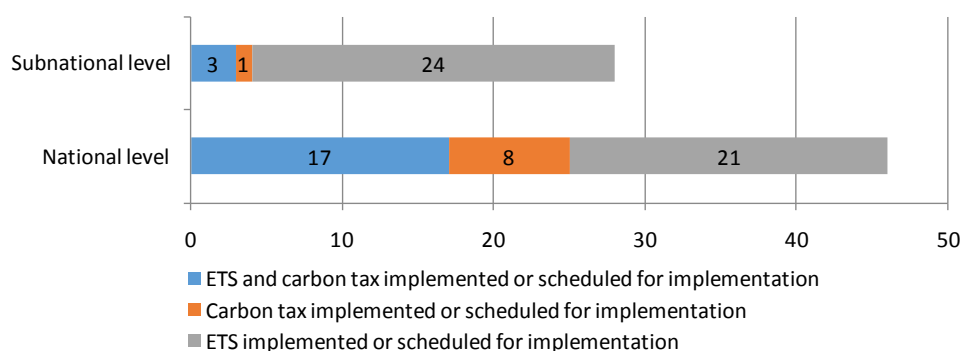


Figure 1. Numbers of carbon tax and ETS initiatives in different stages (The World Bank, 2019).

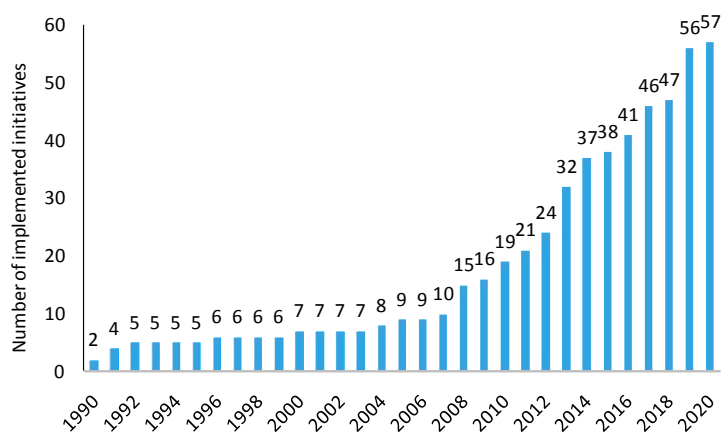


Figure 2. Regional, national and sub-national carbon pricing initiatives (The World Bank, 2019).

At present, as a developing country, China is the largest supplier of emission reduction markets and the largest supplier of Clean Development Mechanism (CDM). China is not the first country to start the operation of CDM projects, but it is the developing country that currently participates the most in CDM projects. Since mid-2013, China's carbon emission trading market pilot has been launched in seven provinces and cities. These pilot provinces and cities have accumulated valuable experience for the improvement of the national carbon pricing mechanism. In 2017, the National Development and Reform Commission issued *the National Carbon Emissions Trading Market Construction Plan (Power Generation Industry)*, marking the official launch of the national carbon emission trading system and an important milestone in the development of carbon finance. But on the whole, China's development of carbon financial trading business still lags significantly behind international financial institutions, and there is still much room for development in carbon finance (Guo, 2016).

3. Comparison of the carbon trading system

The first major carbon ETS in the world is the European Union (EU) ETS, which was put into operation in 2005. At present, 45 carbon trading systems have appeared on four continents. The cover gases of most international carbon trading markets include 6 greenhouse gases such as carbon dioxide and methane as stipulated in the Kyoto Protocol. The types of emissions covered are mainly emissions from fossil fuel combustion and process emissions. In terms of covered industries, most of the included industries are industries with relatively high carbon emissions in the country, which differ according to the industrial structure and economic development status of each country. Among them, the EU adopts progressive industry coverage, gradually expanding and optimizing coverage in phases; in contrast, the United States adopts open industry coverage, and the Western Climate Initiative (WCI) only forces industries with large emissions into the carbon market. At the same time, industries that have incomplete carbon emissions monitoring and verification technologies, including aviation and transportation, are encouraged to join voluntarily. In terms of determining the boundaries of emission sources, the boundaries of emission sources covered by major foreign carbon trading systems are defined as facilities. However, in terms of submitting greenhouse gas emissions reports, participating in carbon trading, and compliance, the facilities must ultimately be mapped to the company's name. Enterprises are directly used as the control unit. In addition, the industry access threshold is determined by the total amount and intensity of industrial carbon emissions in different countries and regions at home and abroad.

The government can adjust the design of carbon trading system to adapt to the local actual situation, so each system presents its unique characteristics. At present, the carbon trading system operates in different administrative levels of the world, from megacities (such as Tokyo), states in the United States and provinces in Canada, to national level (such as New Zealand and Switzerland), as well as supranational organizations such as the EU. The design features of carbon trading system in different regions are different, covering different greenhouse gases and industry sectors. Although most of the systems cover the industrial and energy sectors, some carbon trading systems are also used to reduce carbon emissions in other sectors, such as construction, aviation, etc.

Although each carbon trading system is unique, they are also interconnected. Two or more regions share their markets, allowing cross system carbon quota trading. In 2014, California and Quebec successfully connected their carbon trading system. In the next year, the transportation fuel industry was included in their joint system, which doubled the total carbon market share of the two places. Moreover, Ontario of Canada announced the intention of establishing carbon trading and connecting it to the above California Quebec carbon trading market. Now the system has covered more than 85% of the total social emissions of the two places. As the first city level carbon trading system in the world, Tokyo has recently successfully connected with Saitama's carbon trading system.

Tables 1–5 compare four main international carbon financial systems about policy, monitor, reporting, verification, quality assurance and control (China Carbon Forum, 2019; Li and Lv, 2019). This paper selects these four representative carbon trading systems for comparison, mainly considering their respective characteristics. (1) As the world's first multi-national carbon emission trading system, the EU emission trading system is the largest carbon emission control and trading system, covering more than 12,000 power stations, factories and other industrial facilities, accounting for almost half of the EU's total CO₂ emissions. (2) The United States has established a more mature regional carbon trading market system. As early as 2003, the United States established

the Chicago Climate Exchange, which mainly provides trading services for 10 states and some voluntary emission reduction enterprises. The United States carbon trade includes all six greenhouse gases, including SO₂. Its strict monitoring and measurement systems provide a strong support for market transactions. (3) Japan has both a national attempt to reduce greenhouse gas emissions and a local emission trading system represented by Tokyo. In addition, its relatively mature credit offset system established for domestic and foreign countries forms an important supplement to the emission trading system. Japan's strict Monitoring, Reporting and Verification (MRV) mechanism, model participation process, good legal system and credit offset system have important reference value for the construction of carbon emission trading system in other countries. (4) China is becoming a hot spot in the development of new carbon trading system. At present, seven provinces and cities are carrying out carbon trading pilot work and accumulating experience. With the joint efforts of the Chinese government and enterprises, it is believed that China will have the global largest carbon trading system in the near future.

Table 1. Comparison of international carbon financial trading systems: Policy.

	POLICY
EU	European Parliament and Council Directive 2003/87/EC, Guidelines for Monitoring and Reporting of Greenhouse Gas Emissions and Guidelines for Certification and Verification
UNITED STATES	Greenhouse Gas Mandatory Reporting Regulations
JAPAN	Law on Promotion of Global Warming Measures
CHINA	National Carbon Emission Trading Market Construction Plan (Power Generation Industry); Interim Regulations on the Management of Carbon Emission Trading (Consultation Draft)

Table 2. Comparison of international carbon financial trading systems: Monitor.

	MONITOR
EU	Monitoring subject: enterprise facilities; Monitoring method: calculation method and measurement method
UNITED STATES	Monitoring subjects: there are two types of upstream emission sources and downstream emission sources; Monitoring methods: mainly including real-time emission monitoring and calculation of emission factors
JAPAN	Monitoring subject: institutions with energy consumption of 1500kloe/a or more, 21 employees or more, and total emissions of 3000 tons of CO ₂
CHINA	The ministry of ecology and environment's notice on doing a good job in the preparation of the 2018 annual carbon emission report and verification and emissions monitoring plan requires local organizations to carry out the relevant work on the establishment of the 2018 annual emission report, verification and monitoring plan.

Table 3. Comparison of international carbon financial trading systems: Reporting.

	REPORTING
EU	Direct CO ₂ emissions only
UNITED STATES	Electronic reporting method
JAPAN	Enterprises' actual greenhouse gas emissions and their changes, carbon emission accounting methods, etc.
CHINA	CO ₂ direct emission activities and indirect emission activities have been reported in different provinces and cities.

Table 4. Comparison of international carbon financial trading systems: Verification.

	VERIFICATION
EU	Online and offline checks
UNITED STATES	Electronic system verification and on-site verification
JAPAN	The verification target is limited to the regulated companies participating in the carbon market
CHINA	Adopt a third-party verification agency system and develop a qualification system for third-party verification personnel

Table 5. Comparison of international carbon financial trading systems: Quality assurance and control.

	QUALITY ASSURANCE AND CONTROL
EU	Formulate a standardized template for the report, and add a description of the control equipment in the report
UNITED STATES	The 3-year retention period is required for the relevant materials submitted by the report subject, and the reporting and verification quality control are clearly specified in the monitoring plan
JAPAN	Increase the totals, disclosure and disclosure system, and accept the supervision of other departments and the public
CHINA	Prior to the verification work, most of the pilot areas conducted training for enterprises and verification agencies, and proposed innovative specific organizational methods. To ensure the quality of the verification, each of the pilots established a dual verification system such as random inspection or recheck of inspection reports.

4. Comparison of pricing mechanism

Since January 1, 2005, EU ETS has developed from the first carbon trading market. It is the largest carbon emission trading market in the world. EU ETS lists CO₂ emissions from about 11500 enterprises in 31 EU countries (all 28 EU countries plus Iceland, Liechtenstein and Norway). It accounts for 45% of the total EU emissions (Wang and Zhao, 2019). In 2018 alone, the EU ETS carbon pricing initiative covered 2GtCO₂e, accounting for about 3.9% of global greenhouse gas

emissions, with a total value of \$31.76 billion (Zhou, 2018). Up to now, the EU is the most important practice area of carbon emission trading pricing mechanism. The EU carbon emission trading system has become a key tool to reduce greenhouse gas emissions based on the principle of trading and the pricing mechanism of carbon tax.

Under the role of market mechanism, the United States has become the second largest carbon trading market in the world, and has built a relatively complete and mature carbon emission trading market system. Chicago Climate Exchange is the second largest carbon trading market in the world, with diversified carbon products carbon tools. The United States formulated trade policy to control carbon emissions. The establishment of a well-designed carbon trading market to carbon price developing will be a major factor for enterprises to reduce costs and promote their innovations.

The State and Trends of Carbon Pricing 2019 annual report released by the World Bank outlines existing and emerging carbon pricing initiatives around the world, while gives a summary about the progressing on carbon pricing progress made by countries, regions and localities in the past year. Of the 185 countries that have submitted their nationally determined contributions to the United Nations, 96 have stated that they are planning or considering using a carbon pricing mechanism as a tool to achieve their nationally determined contribution commitments. The total carbon emissions of these countries account for 55 percent of global emissions. As of April 1, 2019, there are 57 different carbon pricing mechanisms worldwide, of which 28 are carbon emission trading markets and 29 are carbon tax mechanisms. These carbon pricing mechanisms cover nearly 11 billion tons of carbon dioxide equivalent carbon emissions in 46 countries and 28 regions around the world, accounting for about 20% of world greenhouse gas emissions.

Between January 2018 and April 2019, 11 new carbon pricing mechanisms were added globally. As shown in Table 6, most of the new carbon pricing mechanisms are in developed countries. On June 21, 2018, Canada officially passed *the Greenhouse Gas Pollution Pricing Act*. Under the bill, the Canadian federal government sets a basic goal, and provinces and territories can independently choose a carbon pricing mechanism based on their own development characteristics. Five carbon pricing mechanisms, plus two national-level carbon pricing mechanisms, Canada has contributed a total of seven carbon pricing mechanisms, accounting for most of the 11 new carbon pricing mechanisms worldwide (The World Bank, 2019).

Some countries and regions around the world have adopted the carbon market and carbon tax to reduce emissions simultaneously. For example, Switzerland has a carbon market and a carbon tax; France has joined the EU ETS and implemented a carbon tax in 2014; Canada the New Federal Backstop System, which was newly built in 2018, conducts double-headed supervision of carbon markets and carbon taxes on different carbon sources. These practices all convey the same idea, that under the premise of reasonable borders, the carbon market and carbon tax can complement each other and promote each other to achieve the best emission reduction effect (Hong, 2019).

Although some countries have clearly stated that carbon pricing mechanism is an important part of their mitigation strategy in their submission of national Independent Emission Reduction Contribution (INDC), the progress of international carbon pricing mechanism is slow. Compared with the international carbon pricing mechanism, the national and regional carbon pricing mechanisms develop relatively rapidly.

Table 6. Global new carbon pricing mechanisms (2018.01–2019.04) (Hong, 2019).

Year	Place	Level	Type	Scope of action
2018	Massachusetts, America	Regional	Carbon market	Power industry
2018	Argentina	National	Carbon tax	Carbon tax on most liquid fuels in 2018, carbon tax on fuel oil, coal, petroleum coke from 2019
2019	Output-Based Pricing System, Canada	National	Carbon market	Power generation industry, industrial facilities with annual carbon dioxide emissions exceeding 50,000 tons, and other voluntary participants
2019	Canadian Federal Fuel Charge	National	Carbon tax	Fossil fuels
2019	Prince Edward Island, Canada	Regional	Carbon tax	Fossil fuels
2019	Nova Scotia, Canada	Regional	Carbon market	Industry, power, construction and transportation sectors
2019	Newfoundland and Labrador, Canada	Regional	Carbon market	Large industrial facilities, power generation industry
		Regional	Carbon tax	Carbon tax on fuels mainly used for transportation, building heating and power generation
2019	Saskatchewan, Canada	Regional	Carbon market	Industrial facilities with an annual carbon dioxide emissions equivalent to more than 25,000 tons
2019	Singapore	National	Carbon tax	Carbon tax on units with annual greenhouse gas emissions exceeding 25,000 tons
2019	South Africa	National	Carbon tax	8 dollars carbon tax per ton of carbon dioxide

In a word, through the comparison of international carbon pricing mechanism, the following conclusions could be listed. First of all, the design of carbon pricing tools is important. For example, the defects in the design of EU carbon market have caused huge fluctuations in the carbon market. Secondly, the choice of the two most important carbon pricing mechanisms (carbon emission trading and carbon tax) should be based on the specific environment and consistent with the national economic focus, but carbon emission trading and carbon tax can play a complementary role in different areas of emission reduction. In addition, in practice, it is found that it is difficult for most countries to set high enough carbon price in policy to effectively promote substantial emission reduction, and most carbon price designs are quite moderate. Partly for this reason, the current carbon pricing mechanism has only played a supporting role in efforts to mitigate global warming.

5. Comparison of carbon financial products

The United Nations Environment Programme (UNEP) sets forth that the four popular carbon financial products are retail, investment, asset management and insurance products (UNEP Finance Initiative, 2007).

5.1. Retail products

Retail carbon financial products are mainly targeted at individuals, households and small and medium sized enterprises. These products include home and construction loans, private accounts, low-carbon transportation, credit cards, etc. Several countries have launched green building credits for energy-efficient office and energy-saving home. ABN AMRO, Bendigo Bank of Australia, and Canada Mortgage and Housing Corporation (CMHC) provided green mortgage loans for home energy efficiency. Commercial building credit for green projects in commercial buildings or homes were provided by Wells Fargo and New Energy Bank in the United States. New Resource Bank of the United States also launched a home equity loan to provide “one-stop solar financing”.

At the same time, retail banks have also launched carbon financial products and services in the areas of automobiles, credit cards, and sales. Vancouver City Commercial Bank of Canada launched a Clean Air Vehicle Loan to provide preferential interest rates for hybrid vehicles. Bank of America in the United States provided loans to truck drivers to support their purchase of fuel-efficient equipment. Many countries in the world have launched green credit cards, such as Rabobank’s climate credit card and Barclays’s breathing credit card. Westpac Bank of Australia launched an environmentally friendly deposit product, and Barclays Bank encourages consumers to offset the carbon dioxide generated by their own travel.

5.2. Investment-based products

Investment carbon financial products are mainly targeted at large enterprises, institutions and government departments. These products mainly include low-carbon financing projects, bonds, equity and index-linked products. In July 2014, the French development agency (ADF) provided Jordan with a credit line of 38.5 million dinars for Jordanian companies and residents to invest in renewable energy. Latin American countries launched forest bonds and Europe launched catastrophe bonds. Technology leasing is a product and service offered by Deutsche Bank and ABN AMRO to provide environmental protection technology at preferential prices. Venture capital and private equity are banks’ tools to help environmental companies go public, such as the Imperial Bank of Canada conducts a \$100 million IPO for a greenhouse gas emitting company. Common carbon commodities and products include carbon custody services and carbon credit services. Various indexes include ecological market indexes and climate-friendly corporate debt indexes.

5.3. Asset management products

Funds are very popular in low-carbon asset management products, which generally include fiscal green funds and low-carbon development funds. Most carbon funds are government-led that provide green credit to businesses and individuals through various banks. ABN AMRO develops a carbon fund plan for financing environmental protection projects such as organic farms and green greenhouse labels for businesses or individuals. Carbon funds have developed well abroad. The Prototype Carbon Fund was the world’s first carbon fund, established by the World Bank. Switzerland, France and other countries have also launched carbon funds. The carbon fund has promoted the development of the carbon market. On January 12, 2015, the South Korean carbon market was officially launched, with a total of 525 companies included. The total quota for 2015–2017 was 1.687 billion tons. Table 7 lists a part of the international asset management carbon financial products.

Table 7. Carbon financial products for international asset management (Yi et al., 2014).

Product Categories	Product Features	Main Products	Financial Issuer	Distribution Area
Green Support Fund	Financing for small businesses dedicated to energy reductions, higher returns for private investors	Climate Protection Fund and DWS Global Climate Change Fund	Deutsche Bank	Europe
		Low Carbon Accelerator Fund	ABN AMRO	Europe
		Low Carbon Fixed Income Certificate	Dutch International Group	Europe
		Low-carbon open-end fund	ASN Bank	Europe
Private Equity Project Fund	Private assets can be invested in wind, solar, biofuel, biodiversity, and sustainable forest projects	Green Technology Credit Enhancement Fund	Lloyds Bank	Africa
		Sustainability Project Investment Project	Citibank	USA
		Forest Protection Project	Bank of America	USA
		Low Carbon Africa Fund	Lloyds Bank	Africa
Low Carbon Investment Fund	Higher potential returns	Ecological Realization Stock Fund	Swiss Bank	Europe
		Ecological Performance Asset Fund	UBS	Europe
		Clean Energy Target Fund	UBS	Europe
		Climate Change Strategy Certificate	UBS	Europe
		Biofuel Project Loan	ABN AMRO	Brazil

5.4. Carbon insurance products

Carbon insurance products use the form of insurance to stimulate carbon reduction in various industries, such as low-carbon automobile insurance and green building insurance. There are two types of low-carbon insurance products. One is a product that is closely related to public life, and the other is a risk product for carbon price fluctuations. The former has a small transaction amount and relatively low risk, such as automobile transportation insurance and commercial insurance for construction houses. The latter has a large transaction amount and relatively high risk. At present, the institutions that try to issue carbon insurance products are mostly large insurance companies. For example, the world's largest insurance group is France's AXA and Britain's largest insurance group, AVIVA Group. The international carbon insurance products are summarized in Table 8.

On the whole, the institutions that issue carbon financial products have certain commonalities. First of all, these financial institutions are mostly in developed countries in Europe and America, especially in the EU. This is closely related to the EU's mature financial system and market operation model, the strong support of national policies and laws, and the growing awareness of

environmental protection. Secondly, these banks have a long history, strong financial strength, a well-established brand image, branches all over the world, and rich experience in risk prevention and product innovation. Finally, these banks have tried different types of carbon financial products. For example, Citibank has both retail greenhouse mortgages and private equity funds; ABN AMRO launched greenhouse mortgage loans and low-carbon closed capital funds.

Table 8. International Carbon Insurance Products (Yi et al., 2014).

Product Categories	Product Features	Main Products	Financial Issuer	Distribution Area
Automotive and Transportation Insurance	Linked to the reduction of emissions from the use of automobiles and transportation to achieve emission reduction goals	Mileage-based Insurance	Aviva Group, General Motors Finance and Insurance Company	Europe, North America
		“Your Driving” Insurance	Aviva Insurance	Global
		Low-Car Insurance	United Financial Services	Global
		Energy saving car discounts	Cooperative Services Group, Aviva Group	Europe, North America
Private Equity Project Fund	Risk protection for green buildings and low-carbon energy	Green Building Cover Insurance	California Fire Fund	USA
		“Climate Neutral” Home Insurance	ETA Insurance Company	USA
		Small Business Green Business Insurance	French AXA Insurance Company	Europe
		Environmental Damage Insurance	Rabobank	Europe
		Energy Efficiency Home Finance Insurance	Bank of Canada	Canada
Low Carbon Investment Fund	Provide insurance against risks in the carbon trading process	Carbon Emission Trading Insurance	Swiss Re	Europe
		Clean Energy Target Fund	American International Group	USA

Through the above comparison, we can get the following conclusions. (1) Carbon financial products are very popular, and financial innovation is advancing rapidly. At present, retail, investment, asset management and insurance products are the four mainstream carbon financial products in the world. Based on the mature traditional financial products, the banking industry in developed countries has made many innovative attempts in the field of carbon finance. Carbon financial products can not only bring certain economic benefits, but also promote relevant countries to fulfill certain emission reduction obligations. (2) The rapid financing of carbon financial products can play an important role in the deep development of carbon market. From the perspective of market technology, the rapid financing of carbon financial products has attracted a large number of investment capital to participate in carbon trading, stimulated the delivery of trading, and increased the liquidity of carbon market. From the strategic point

of view, the financial and investment circles affirmed the market value of carbon financial products, recognized the important role of carbon emission trading system in the low-carbon transformation, and released a strong carbon price signal to regulatory enterprises. All these measures can enhance the confidence of enterprises to invest in low-carbon technology.

6. Comparison of legal framework

The design of the relevant legal framework can provide complete legal support for the carbon financial trading market. The development of different countries and regions is uneven, so the legal system of carbon finance is also different. According to whether or not to join the Kyoto Protocol, countries and regions are divided into Kyoto countries and Non-Kyoto countries in (Hao, 2014). Kyoto countries have compulsory emission reduction obligations, while non Kyoto countries do not have compulsory emission reduction obligations. They are voluntary emission reduction countries. Kyoto countries have more strict regulations, so it has an important impact on the development of the whole country's carbon financial system. The European Commission approved "Directive 2003/87/EC" (Ottinger et al., 2005). The New South Wales Greenhouse Gas Abatement Scheme (NSW GGAC) passed "reduce greenhouse-gas emissions associated with the production and use of electricity" (anon, 2002) (Kuch, 2015). The parliament of New Zealand passed "Climate Change Response Act 2002". Voluntary emission reductions without mandatory emission reductions and greenhouse gas trading. However, it is mainly based on the willingness of emitters to participate in the carbon emission trading mechanism voluntarily. America, for example, has issued "Regional Greenhouse Gas Initiative (RGGI)" and "Climate Action Reserve (CAR)" (Carlson et al., 2012).

After the Paris Agreement entered into force, a new model of "five-year review & national independent contribution" was opened (Yang, 2019). The global carbon financial trading market presents a new situation. The main feature of the Paris Agreement is the use of nationally-reduced emission reduction models. The carbon market established from top to bottom. This is a soft law constraint under the condition of hard law. China has always been a promoter of the world's carbon emission market. As shown in table 9, a series of policies have been adopted to actively promote the establishment of carbon market. During the establishment and development stage of the carbon trading market, the Chinese government issued several laws and policies about foreign experience to ensure the stable development of the carbon trading market.

Table 9. Laws promulgated by the Chinese government.

Year	Legal policy	Main points
2004	Interim Measures for CDM Project Operation Management	Describe the CDM project management system, application and implementation procedures, legal responsibilities
2011	Notice on the Pilot Work of Carbon Emission Trading	Start of work in the first 7 pilot cities
2014	Interim Measures for the Administration of National Carbon Emission Trading	Basic Basis of Carbon Market Operation
2017	National carbon emission trading market construction plan (power generation industry)	National carbon emissions trading market starts
2019	Provisional Regulations on the Management of Carbon Emission Trading (Draft for Soliciting Opinions)	Basic legal framework for carbon market construction and operation

The emergence and development of carbon finance is always accompanied by the regulation of carbon finance law. The risk in the carbon financial market is largely due to the imperfect or unclear legal framework and the lack of effective constraints on market subjects. The complexity of carbon financial market itself determines the necessity of establishing a sound legal framework. The conclusion of the United Nations Framework Convention on climate change and the Kyoto protocol is undoubtedly a positive response of Member States to global warming. On this basis, an authoritative, universal, comprehensive and basic international legal framework for carbon emission reduction has been jointly established. The complexity of the evolution of carbon finance is determined by the different legal frameworks of member countries. In addition, carbon finance is faced with many legal dilemmas in the process of evolution. Only through in-depth analysis and discussion and appropriate treatment can the law better serve the practice of carbon finance. In the future, more and better laws need to be established to support the carbon financial trading market.

7. Comparison of service agency

Carbon emission service agencies often include the following three types: commercial banks, carbon funds, and other tripartite service agencies. Commercial banks have been seeking a strong position in the development of carbon finance, committed to using low-carbon emissions reduction to expand their business areas. Commercial banks have become an important participant in the field of carbon finance. The creation of a carbon fund is mainly an investment vehicle for financing emission reduction projects under the auspices of Kyoto Protocol. Third-party service agencies mainly approve emission reductions generated by CDM projects and provide carbon finance information services.

7.1. Commercial bank

Commercial banks provide carbon finance-related services, which help promote the stable development of ecological economy. In order to promote commercial banks' participation in carbon financial services, a series of guidelines and measures have been formulated, as shown in Table 10.

Table 10. Commercial Banks participate in carbon finance services.

Year	Document
1990	Financial industry environment and sustainable development principles
1992	Environmental Sustainable Development Principles of the Banking Industry
1993	Environmental measures for the insurance industry
2003	Equator Principles

In June 2003, Citibank, ABN AMRO, Barclays, and Deutsche Bank participated in developing the Equator Principles to help determine, measure, and manage social and environmental risks. The adoption of the World Bank's environmental protection standards and the IFC's social responsibility approach resulted in this standard. As of January 2020, 101 financial institutions in 38 countries have adopted the Equator Principles (Principles, 2019). As shown in Table 11, China has joined the Equator Principles with Huzhou Bank, Bank of Jiangsu, Industrial Bank Co., Ltd, and Taipei Fubon

Commercial Bank, E.SUN Commercial Bank, Taishin International Bank, CTBC Bank Co., Ltd, Cathay United Bank Co., Ltd.

Table 11. The bank joins the equator principle from China.

Join Time	Bank
31-Oct-08	Industrial Bank Co., Ltd
23-Mar-15	Cathay United Bank Co., Ltd
28-Dec-15	E.SUN Commercial Bank, LTD
20-Jan-17	Bank of Jiangsu
04-Dec-17	Taipei Fubon Commercial Bank
23-Jan-19	CTBC Bank Co., Ltd
24-Jul-19	Bank of Huzhou
11-Nov-19	Taishin International Bank

7.2. Carbon fund

The Carbon Fund is an investment vehicle for financing emission reduction projects generated under the Kyoto Protocol. The International Carbon Fund was created by different countries and international organizations. However, different funds adopt different international law implementation processes, and the institutional functions produced are heterogeneous. As mentioned in the (Xiao, 2017), the international carbon fund is divided into the following categories: domestic upstream funds and downstream funds, national and international organization co-construction funds, and international organization funds.

(a) The upstream funds are used as the fund exporter's funds, mainly the foreign aid funds of developed countries, including the Global Climate Change Alliance (GCCA) established by the EU, Germany's International Climate Initiative (Reich and Wienges, 2009). Downstream funds are the admission funds of developing countries to protect climate change and the domestic environment, such as the "Amazon Fund" established by Brazil's National Development Bank (Fund, 2009) and the "Climate Change Trust Fund" established by Indonesia.

(b) The carbon funds jointly established by developed countries and the World Bank are mainly used to purchase emission credits for the projects they finance. Mainly including the Dutch Cleaner Production Mechanism Fund and the European Carbon Fund. The carbon funds jointly established by developed countries and United Nations agencies include the "Millennium Development Goal Fund" established by the Spanish government and the United Nations Development Programme (UNDP), Japan and the International Consultative Group on Agricultural Research, and "Africa New Rice" funding projects established by UNDP.

(c) Four major climate funds established in accordance with the conventions and protocols produced by the International Climate Conference: Least Developed Countries Fund (LDCF), Special Climate Change Fund (SCCF), Adaptation Fund (AF), Green Climate Fund (GCF), Global Environment Facility Climate Change Trust (GEFCCT). The carbon funds under the United Nations

agencies include the “Green Cargo Fund” and the “Millennium Development Fund” established by the UNDP. The “United Nations Forest Reduction Plan” jointly established by the UNDP, The UNEP and Food and Agriculture Organization of the United Nations (FAO).

7.3. Tripartite service agencies

The third-party service organization is mainly used as a certification body in the CDM project. Bureau Veritas Certification (BVC) is the world that has an international and authoritative independent certification body. Credit rating agencies in the United States are relatively developed. S & P, Moody’s, and Hewlett-Packard are the three largest rating agencies in the world. They include carbon finance in their ratings to guide investors. At the same time, carbon financial information service agencies have established more and more carbon financial databases to provide the latest information on the carbon market. Carbon financial insurance institutions have also effectively reduced possible losses in carbon trading.

In conclusion, the participation of carbon financial service institutions is an indispensable part of the carbon trading market. The prosperity of the EU’s carbon financial market is closely related to the number of its carbon financial service institutions. The EU has a large number of service organizations such as commercial bank, carbon funds, and other tripartite service agencies, which play an important role in promoting the development of EU’s carbon finance. In addition to commercial banks and carbon funds in the international carbon market, the introduction of institutional and individual investors can not only improve market liquidity and strengthen the price discovery function, but also provide convenience for enterprises to participate in carbon trading by developing derivative services such as carbon fund and Carbon Trust, fully tap the market value of carbon assets, so as to deepen the basic market of carbon quota and build multi-level carbon financial services agency.

8. Comparison of regulatory system

As carbon finance is valued by various countries, various risks associated with carbon finance have also been exposed during the development process. Carbon finance has more complex risks than traditional finance due to its own characteristics. Therefore, it is necessary to formulate a corresponding risk supervision system in order to develop carbon finance business.

The risks of carbon financial markets can be divided into four categories: carbon financial market risks, carbon financial operational risks, liquidity risks, and moral risks (Cheng and Xu, 2018).

(a) Due to changes in market factors, carbon financial market risks including remittances, interest rates, stock indexes, and prices. Fluctuations in the prices and costs of carbon financial assets can affect all stakeholders, including insurance institutions, banks, and fund companies. Weakness of the micro-economic will also cause carbon financial market risks. During the economic boom, a large amount of capital poured into the carbon financial market, causing a market bubble. During the economic downturn, the carbon financial market was in a downturn, and both parties to the transaction gained a lot of losses.

(b) Operational risks of carbon finance. Due to the unique trading rules of carbon finance, the lack of relevant personnel cannot effectively manage the carbon finance business. Internal operations are prone to problems and errors or accidents.

(c) Liquidity risk means that only by increasing capital investment or reducing the value of assets, otherwise the investor's liquidity needs cannot be met immediately, which may cause losses. In the practice of carbon financial transactions, due to the existence of liquidity risk, it may happen that the transaction costs of the two parties will increase significantly due to the inability of both parties to conduct transactions promptly.

(d) Moral risk. In the past, there were security incidents of repeated transactions of certified emission reductions and hacking attacks on registration systems to steal accounts. The carbon financial market has ethical risks.

The EU emissions trading system is the most comprehensive greenhouse gas emissions trading system in the world. The EU's carbon financial market supervision system has its characteristics and effectiveness. The EU has formulated a series of risk supervision laws such as the "Directive 2001/77/EC" to promote renewable energy, the "establishment of a greenhouse gas emissions trading mechanism in the EU", and the "Directive 2003/87/EC". Through the introduction of carbon financial risk regulatory agencies, the EU grants greater discretion to its member states, only stipulates the designated responsibilities of the regulatory agencies and does not establish member states' regulatory agencies. Each member state establishes a regulatory mechanism based on its own circumstances. The value of the carbon financial risk monitoring mechanism adjusts its own strategies to respond to changes in the carbon financial market risk situation. The supervisory mechanisms designed by the EU mainly include the EU's Community Independent Transaction Log (CITL), Carbon Emissions Monitoring System, and Carbon Disclosure Project (CDP), which can identify risks in advance to further eliminate or transfer them. In addition, the EU has introduced various risk control mechanisms to reduce risks, and developed risk response mechanisms according to different situations to prevent chain reaction and further expansion of losses.

Carbon financial risk supervision laws in the United States consist of federal, regional, and state regulatory laws and regulations. The United States uses a "bottom-up" loose system, that is, the government promotes government guidance to form a carbon trading supervision model of the market from the bottom up. At the federal level, a series of bills to address climate change include the "Energy Policy Act 2005", the "Clean Air Act 2005", the "Clean Energy and Security Act", the "2010 US Energy Act", and the "Electricity Act 2010". There are many regional activities in the United States carbon finance, of which the United States Regional Emissions Trading System and the Western Climate Initiative (WCI) are the most typical. Local governments in the United States have adopted separate regulatory laws to reduce carbon financial trading risks. In 2006, the California government enacted the "Global Greenhouse Governance Act".

The UK is the first country to put forward the concept of "low carbon". In order to better develop the low carbon economy, the UK government is not only committed to improving citizens' awareness of low carbon and environmental protection, but also actively issued corresponding policies to ensure the smooth operation of the carbon financial trading market. Its main measures include strategic planning, financial support, safeguard measures, etc., making the carbon financial trading trend standardize and promote its better development.

As the international financial system has been established for a long time, it has formed international standards and norms that are voluntary and legally binding, such as the international standards of Prudential Supervision established by the Basel Committee. However, as the international financial system is not mature enough, a global carbon trading regulatory system has not yet been formed. Combined with the international experience of EU, United States and UK in

carbon financial risk supervision and control, governments of all countries need to further improve the carbon financial supervision system to prevent and respond to various risks.

9. Conclusions and suggestions

The problem of climate change caused by the emission of greenhouse gases has attracted the attention of all countries in the world. At present, the mainstream view is that the greenhouse gases emitted by human activities lead to the rise of global temperature. Among the policies to reduce greenhouse gas emissions, carbon emission trading is considered to be more feasible and effective. The signing and entry into force of the United Nations Framework Convention on Climate Change and the Kyoto Protocol provide a framework and basis for carbon emission trading in the world. Carbon financial market is based on carbon emission trading, and the concept of carbon finance does not have an accurate definition. This paper selects seven contents including development history, trading system, pricing mechanism, product, legal framework, service agency, and regulatory system to compare the international carbon financial market, which are hoped to promote the researches on carbon finance. This paper finds that more and more countries actively participate in the carbon financial market. But at present, the carbon financial market of some developed countries is in the forefront, and the emerging developing countries are mostly at the stage of exploration and learning. In addition, this paper points out the shortcomings of the development of the international carbon financial market. Firstly, the market system is not advanced, and many countries have a short time to participate in the carbon financial market. Secondly, the legal framework, service agency and regulatory system are not well developed. Thirdly, the member and innovation of carbon financial products are insufficient. In a word, the existing researches on carbon finance are not deep enough, and there are many contents worth further discussion.

As the large countries in carbon emission and carbon emission reduction, some rapid development of various economies, especially the emerging countries, have huge potential for the development of carbon financial markets. However, the depth and breadth of their carbon market development are currently not high, and many challenges are faced. Based on a comparative study of international carbon finance, this article considers that they should start from the trading system, legal system, regulatory system and product to establish and improve the carbon financial market. Firstly, building a trading platform and unifying the carbon financial market are necessary. A complete and unified carbon trading market is related to whether a country can successfully develop a carbon economy. Secondly, it needs to establish a multilevel carbon financial market system and improve the legal system. Although many countries such as China and India are the voluntary emission reduction samples, they still need a complete legal system to restrict the societies in order to fully prepare for the rapid development of carbon finance. Thirdly, it is suggested to innovate carbon financial products to meet the diversified needs of enterprises. At the same time, it is also conducive to the integration of carbon financial markets with developed countries. Fourth, both broadening the channel of carbon finance circulation and cultivating talents in carbon finance are important. The fifth suggestion includes strengthening the government's guiding role, actively encouraging the financial industry to participate in carbon finance business, improving the carbon financial market international services, and promoting the development of a low-carbon economy. Carbon finance is in line with national sustainable development strategy.

The development of a low-carbon economy is green development. It lays the foundation for the organic unification of the environment and the economy, and further enhance the nation's international influence during complying with the development trends of the global carbon financial

market. However, in the development of the carbon financial market, all prior experiences and knowledge cannot fully adapt to the changes of the times. So it needs to constantly find drawbacks in the development and propose solutions to keep pace with the times.

Conflict of interest

All authors declare no conflicts of interest in this paper.

References

- Carlson J, Olivas R, Gentry B, et al. (2012) United States legislative proposals on forest carbon, In: Ashton M, Tyrrell M, Spalding D, Gentry B (eds), *Managing forest carbon in a changing climate*, Dordrecht: Springer.
- Cheng K, Xu CH (2018) International experience in carbon finance risk regulation. *J Hubei Univ Econ (Humanities and Social Sciences Edition)* 15: 44–47.
- China Carbon Forum (2019) China Carbon Pricing Survey. China Carbon Forum, December 2019. Available from: <http://www.chinacarbon.info>
- Du S, Tang W, Song M (2016) Low-carbon production with low-carbon premium in cap-and-trade regulation. *J Clean Prod* 134: 652–662.
- Fund A (2009) What is the Amazon Fund?
- Green financial products and services-current trends and future opportunities in north America: a report of the North American Task Force (NATF) of the United Nations Environment Programme Finance Initiative (2007) UNEP Finance Initiative. Available from: <https://max.book118.com/html/2016/0314/37640902.shtm>.
- Guo MX (2016) On the problems and the innovative countermeasures existing in the development of carbon finance in China. *New Econ* 2016: 67.
- Hao XM (2014) International comparative study of carbon finance system. Shanxi University.
- Hong RC (2019) The latest development of global carbon pricing mechanism and policy suggestions for the development of carbon pricing mechanism in China. Available from: <https://www.huanbao-world.com/green/lshr/108457.html>.
- Kuch D (2015) Governing carbon emissions: NSW GGAS, In: *The rise and fall of carbon emissions trading*, Springer.
- Lewis JI (2010) The evolving role of carbon finance in promoting renewable energy development in China. *Energy Policy* 38: 2875–2886.
- Li NX, Zhao Y (2010) Some Considerations on the Low-carbon Economy. *Energy Technol Econ* 8: 1–3.
- Li YB, Lv RW (2019) Research Progress of China's Carbon Trading System. *J Shanghai LiXin Univ Accounting Financ* 2019: 42–52.
- Liu C (2011) Low-carbon economy: theoretical study and development path choice in China. *Energy Procedia* 5: 487–493.
- Liu Z (2016) China's carbon emissions report 2016. Working Paper.

- Ottinger RL, Robinson N, Tafur V (2005) *Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC*, Cambridge University Press, 379–393.
- Principles E (2019) The equator principles: official website.
- Reich H, Wienges S (2009) *Germany's international climate initiative—a bilateral fund as innovative financing mechanism*, The 2009 Amsterdam Conference on the Human Dimensions of Global Environmental Change—Earth System Governance: People, Places and the Planet.
- State and Trends of Carbon Pricing (2019) The World Bank. Available from: <http://documents.worldbank.org/curated/en/191801559846379845/State-and-Trends-of-Carbon-Pricing-2019>.
- Sun L, Wang M (1996) Global warming and global dioxide emission: an empirical study. *J Environ Manage* 46: 327–343.
- Sun ZK (2019) Understanding and Thinking on the current development of carbon finance in China. *Manage Obs* 2019: 58–59.
- Wang WJ, Zhao Y (2019) Global carbon market research and its enlightenment to China's carbon market construction. *Northeast Asia Forum* 2019: 97–112.
- Weng Q, Xu H (2018) A review of China's carbon trading market. *Renew Sust Energ Rev* 91: 613–619.
- Wu YY (2009) Carbon Finance Development and Carbon Finance Mechanism Innovation Strategy in China. *Shanghai Financ* 10: 26–29.
- Xiao F (2017) Heterogeneity of the function of the international carbon fund system and its implications for China. *Int Bus (J Univ Int Bus Econ)* 2017: 139–149.
- Yang BW (2019) The legal path of carbon finance regulation in the post-paris era from the perspective of climate finance. *Int Bus Res* 40: 57–70.
- Yi L, Li CP, Xu Y (2014) Research and development of carbon financial products: international experience and China's practice. *J Humanit* 2014: 47–54.
- Zeng G, Wan Z (2009) The Status Quo, Problems and Prospects of the International Carbon Financial Market. *Stud Int Financ* 10: 19–25.
- Zeng S, Zhang S (2011) Literature review of carbon finance and low carbon economy for constructing low carbon society in China. *Low Carbon Econ* 2: 15.
- Zhang YJ (2016) Research on carbon emission trading mechanisms: current status and future possibilities. *Int J Global Energy Issues* 39: 89–107.
- Zhou Z (2018) The current situation and prospect of global carbon pricing mechanism. *Futures Daily*, 2018-08-21(3).



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