

# Implications and Challenges of Carbon Pricing

Aruna Xiayimulati \*

School of Management, University of Science and Technology of China, Hefei, China

\*Corresponding author: aruna@mail.ustc.edu.cn

**Abstract.** With the global climate crisis looming, the public look forward to the Paris Agreement setting countries on a new path to reduce global warming. Carbon pricing policies are the most cost-effective or "first-best" response to climate-related externalities and are a way to achieve greenhouse gas reductions across countries. This paper first introduces the mechanism and classification of carbon pricing in detail, then reviews the influence of carbon pricing in the field of energy and finance, and finally sorts out the existing challenges of carbon pricing. In energy, carbon pricing will promote the transformation of traditional coal energy to clean energy. In the financial field, the combination of carbon pricing with carbon finance and carbon market will help the implementation of carbon pricing policies. At the same time, carbon pricing faces some challenges in political environment, citizen acceptance, international unified normative system, and other aspects. Although there are still some challenges, carbon pricing plays an indispensable role in climate policy implementation and research and global sustainable development. It is foreseeable that carbon pricing has broad prospects in measures to reduce carbon dioxide emissions and combat climate change.

**Keywords:** Carbon pricing; Energy fuel; Carbon finance; Climate change.

## 1. Introduction

To deal with global warming, 186 countries signed the Paris Agreement, promising to keep the global average temperature rise under 2°C, and continue to control the temperature above the pre industrialization level of 1.5°C [1]. As a result, global greenhouse gas (GHG) emissions must be rapidly reduced in the coming years. Carbon price is an effective lever to tackle with the climate change and greenhouse gases at the required speed and quantity. Therefore, many advocacy groups and researchers around the world are promoting carbon dioxide pricing policies.

This paper will briefly introduce the basic concept of carbon pricing, classification, and the basic concept of computable general equilibrium (CGE) model and its application in carbon pricing policy analysis. Then introduce the impact of carbon pricing on energy fuel and carbon finance and propose the challenges of carbon pricing in today's environment. Finally, the paper summarizes the paper and puts forward the future impact of carbon pricing on energy fuel and carbon finance.

## 2. Methodology

This paper will make a systematic summary of the impacts and challenges of carbon pricing. Most of the articles were published in 2021 and 2022. This paper is mainly obtained through Google Scholar search, and one article is obtained from the official website of the World Bank. Search keywords included carbon pricing, carbon pricing mechanism, carbon energy, carbon finance, challenges of carbon pricing, etc.

## 3. Carbon pricing

Carbon pricing is a mechanism through which the price of GHG emissions per ton of carbon equivalent can be clearly determined [2]. Pricing GHG emissions can generate financial incentives to reduce these emissions or enhance removals. The entire carbon pricing process is based on the accurate calculation of social carbon costs, which requires reassessment of climate risk and fair climate weight. By incorporating the cost of climate change into economic decisions, carbon prices help stimulate changes in production, consumption, and investment patterns to support low-carbon

growth. From a theoretical point of view, the higher and wider the coverage of carbon price is, the more conducive it is to improve the awareness of emission reduction in the whole society and make the policy play its due emission reduction effect. However, in practice, it is often necessary to consider the negative economic impact of reducing CO<sub>2</sub> emissions [3]. There are many existing carbon pricing mechanisms in the world, such as carbon tax, carbon emission trading, carbon credit mechanism etc. Carbon taxes and carbon emissions trading are widespread in the world [4]. As of April 2022, 68 carbon pricing instruments are in use globally, with another three in progress, including 37 carbon taxes and 34 emissions trading instruments [1]. At present, about 23% of global GHG are controlled by carbon pricing tools, as shown in Fig. 1.

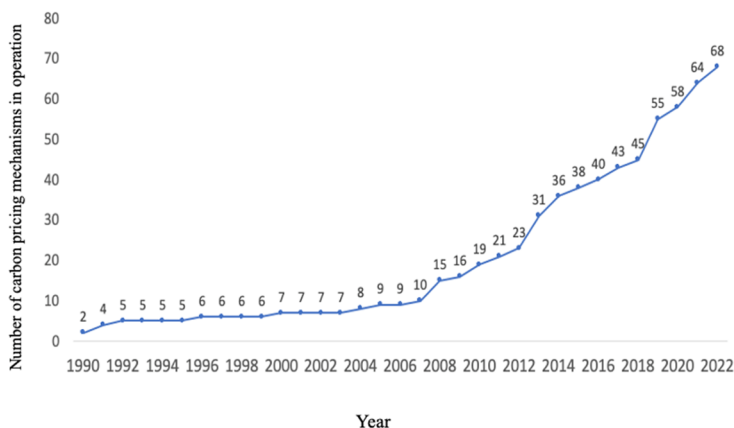


Fig. 1 Number of carbon pricing mechanisms in operation

The carbon tax is based on the Pigouvian tax [5], which is a tax on emissions of GHG such as carbon dioxide. It taxes emission control units based on carbon content or emissions generated by fossil fuel consumption. The government stipulates the tax rate, and the companies covered by the carbon tax must pay the corresponding tax according to each ton of carbon dioxide emissions. Carbon tax can quick effect, low implementation cost, stable tax rate and income redistribution, but it also has the disadvantages of limited control of total carbon emissions. The evolution of global carbon pricing revenues over time can be found in Fig. 2.

The carbon emission trading system (ETS) based on Coase theory is a policy tool which based on market for energy conservation and emission reduction [6], which is used to reduce GHG. As a part of the total amount control and trading system, the government sets a carbon emission ceiling for the industries that one or more enterprises can purchase, purchase or trade. The government has set a ceiling on the carbon emissions of one or more industries under the cap-and-trade system, and companies can purchase, purchase, or trade these quotas. The carbon trading system can set emission reduction targets, encourage enterprises to reduce emissions through pricing, and help coordinate cross-border emission reduction, but there are also irreparable defects such as design difficulties [7].

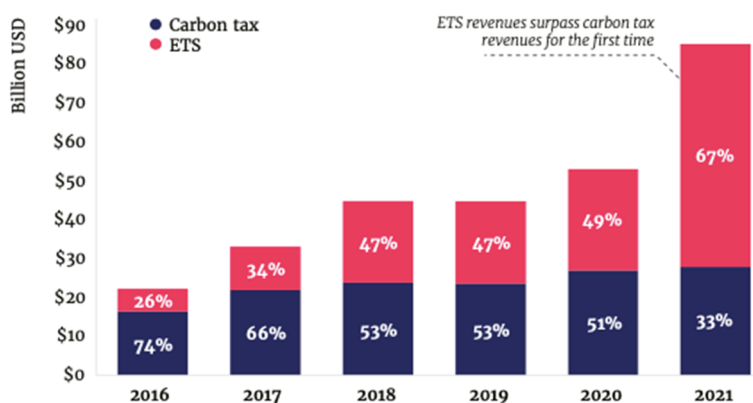


Fig. 2 Evolution of global carbon pricing revenues over time [1].

Many studies use CGE model to study the role and influence of carbon pricing. The CGE model uses several equations to describe supply, demand, and market relationships to study the impact of external shocks on the environment and economic system, thus supporting the selection of economic policies that are more beneficial to the economy and have less environmental impact [8]. As a typical comprehensive evaluation model of macroeconomic policy impact, CGE model can comprehensively examine the operation effect and economic impact of carbon market under different carbon quota allocation mechanisms and is the mainstream analysis tool in the research field of carbon market mechanism design and economic impact [9]. Rodica and Gaston et al [10] analyzed the positive significance of R&D under the carbon emission trading system to the Romanian economy through the CGE model, and believed that R&D could reduce the production cost of enterprises, cut down carbon dioxide emissions, and be conducive to the development of macro economy.

#### **4. Energy Fuel**

The idea behind carbon prices is to take the cost of the environment, to tie these costs to the price of CO<sub>2</sub> [11]. This will mark the reduction of carbon dioxide emissions by individuals and businesses and promote society's transition to low-carbon clean energy. The pricing standard of carbon pricing is related to the level of coal and increasing the development and use of clean energy will make carbon pricing policy play an important role. Steinebach [12] et al. constructed a model including internal diffusion factors and external diffusion factors, and found through regression analysis that the motivation for to accept carbon pricing policy is the democratic political system and the country's coal production level. The policy simulation results of Cao, J. et al. [13] based on the CGE model found that the more flexible energy substitution, the lower the coal use and carbon emissions. Therefore, increasing clean and flexible energy can better implement the carbon pricing policy. And Benjamin et al. by assessing the WTP for CO<sub>2</sub>-dependent economies such as Canada and Canadians' preferred income distribution, find out that Canadians support the redistribution of CO<sub>2</sub> price revenues and investments in clean energy technology. Carbon pricing would reduce bunker fuel use, which in turn would reduce carbon dioxide emissions and slow global warming. At COP26, the Climate Vulnerable Forum proposed the Dhaka-Glasgow Declaration and around 50 developing countries have urged IMO members to impose a mandatory GHG tax on bunker fuels.

In dealing with the global climate crisis, it is not enough to rely on the state to promote the construction of systems and regulations, and the enterprises that bear the main responsibility for GHG are the key to solving the problem. Increasing companies' net zero emission commitments drive demand for the voluntary carbon market segment. Among them, energy companies, mainly large oil, and gas companies, led the credit purchases, with demand increasing nine times from the previous year [14].

Indirect carbon pricing policies, such as providing fossil fuel subsidies, affect the emissions of energy fuels. Oecd research suggests that an additional 1 to 4 per cent CO<sub>2</sub> emissions will be reduced by removing fossil fuel subsidies globally. However, the elimination of fossil energy subsidies will reduce the global demand for fossil energy and energy prices, resulting in a huge financial burden on energy exporters. How to strengthen international coordination and help these countries strengthen development capacity building, realize low-carbon transformation, and diversify income sources, and enhance sustainable development capacity is a key area of international coordination in the future.

#### **5. Carbon Finance**

It is urgent for us to control GHG. As one of the cores of carbon finance related research, carbon pricing is also the most potential emission reduction policy. ETS lays the basic framework for carbon finance related research. Price evolution in select ETSs from 2008 to 2021 was presented in Fig. 3. Carbon financing refers to various financing mechanisms and financial transactions aimed at reducing GHG emissions, including but not limited to the transfer of carbon quotas and their derivatives, low

carbon project development, investment and financing and other relevant financial intermediaries [15]. Based on carbon pricing policies, financial markets have derived many instruments related to carbon neutrality. Carbon emissions are treated as a commodity with a price and traded spot and futures. In the process of carbon finance and carbon market operation, carbon financial derivative pricing emerges at the historic moment. In the pricing process of financial derivatives, the operation process of financial asset prices has been reasonably simplified, and the Black-Scholes model has been applied, which has a relatively mature theory [16].

If carbon pricing is to play a role on the international stage, it needs the linkage between the domestic carbon market and other carbon markets to expand the scope and benefits of the policy. Pizer [17] such constraints based on minimizing the total cost structure mathematical model, the two-carbon market on the part of connection, in different time system of two carbon price equal conditions, carbon emissions trading system link will lead to convergence and the reducing of the price, thus provides participants with a clear market expectation. In this way, carbon pricing policies can expand their reach through the carbon market and move towards international integration. Carbon finance and carbon emission trading are interdependent and mutually promoting. Carbon emission trading is the premise and foundation of the development of carbon finance. Generally speaking, the carbon financial market can only develop after the carbon emission trading market develops to a certain scale, has certain qualified subjects and a healthy risk control mechanism.

The carbon pricing policy has spawned many financial derivatives. Carbon finance includes various business activities and suitable financial strategies to reduce GHG emissions, low carbon project development and other relevant financial intermediaries [18]. Carbon pricing policy is closely related to carbon finance and carbon market, but the structure of the existing carbon finance system is relatively single, and the product types are still in the stage of continuous enrichment. The risk prevention and control system are difficult to cope with the rapid changes in the market economy, which not only has the risk of excessive costs, but also causes abnormal fluctuations in the carbon price and reduces the liquidity of enterprises [19].

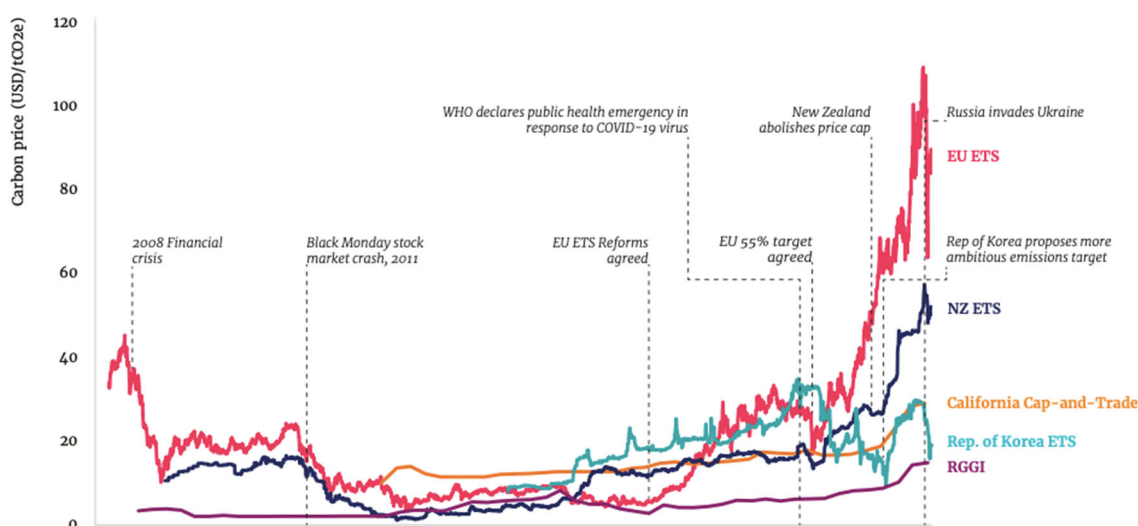


Fig. 3 Price evolution in select ETSs from 2008 to 2021[1].

## 6. Future Challenge

The current political economy environment presents both challenges and opportunities for carbon pricing. Global oil and gas prices have risen sharply over the past year as the economic recovery after COVID and the war in Ukraine [20] led to increased demand and supply constraints. The natural gas price in Europe is now in the early stage of rising, while the global oil price is at the highest level in a decade. In economies highly exposed to fuel prices, a new, expanded or raised carbon price will put additional price pressure on consumers at a time when citizens and businesses are already struggling

to pay their energy bills. The backlash to higher energy prices is particularly strong because it is perceived to disproportionately affect vulnerable groups. The removal of subsidies for liquefied petroleum gas (LPG) in Kazakhstan triggered widespread protests. The sharp rise in energy prices and the consequent inflation have brought pressure on the government, which requires the government to protect consumers and vulnerable families from energy poverty by regulating or limiting energy prices, implementing subsidies, or canceling surcharges. While generally only applicable for a limited time, any direct reduction in energy prices weakens the incentive to reduce emissions.

The future of carbon pricing and its effectiveness depend on government policy [21]. For carbon tax, the link to government policy is quite direct, as the price of carbon will affect the producers and consumers' decisions. The distribution of carbon tax affects the acceptability of policies to a large extent, while the return distribution is disadvantageous to vulnerable groups, reducing the opportunities for policy implementation and sustainability. Thus, if energy prices rise, social equity issues may soon dominate public debate [22]. The need to ensure fairness in the energy transition has been highlighted by the UK Climate Change Committee, which states: "The impact of low carbon policy costs on energy bills is regressive, with a higher share of household income in lower income groups than in higher income groups. Klenert et al. [23] examine carbon revenue use outcomes from recent behavioral and political studies and economic analyses of equity and efficiency and find that efficient use of the substantial revenue raised, increased public acceptance of carbon pricing, and one-time unified recycling of carbon benefits to citizens would be welcome. Ireland has announced that additional revenues from an increase in carbon taxes in 2022 will be used to support initiatives to ensure a just transition, including increasing social welfare spending and preventing fuel poverty.

At present, carbon pricing has not received a unified pricing scope and mechanism at the international level. In the most ambitious countries, carbon leakage may translate into losses in GDP, jobs and tax revenues that inhibit action and reduce the effectiveness of climate policy by shifting emissions to other countries. In countries with salmon, this could lead to a growth in the emission of global carbon dioxide. Although there is little evidence so far that carbon leakage occurs in practice, it remains an important issue for politicians and industry stakeholders.

## 7. Discussion

Carbon price is an important policy tool to deal with climate change and achieve sustainable human development goals. However, carbon prices have some drawbacks. First, addressing climate change requires a fundamental change in the existing system, which requires a profound and interdependent adaptation of social and technological systems, which cannot be simplified through a single carbon pricing. For example, to change energy demand, it is necessary to develop and replace new energy, new business models, new regulatory systems, etc., rather than just change the carbon price. Tvinnereim and Mehling outlined a series of major carbon pricing strategies aimed at optimizing existing business models and technologies but ignored the more fundamental institutional changes required for deep decarbonization.

Second, carbon pricing places special emphasis on efficiency rather than effectiveness, that is, achieving carbon neutrality by whatever means are practically feasible. This means going beyond the least-cost solution and stimulating a variety of mitigation options, including those with considerable potential for immediate emissions reductions (for example, phasing out coal) and others that could radically change the system in the long run.

Finally, carbon pricing coverage is not enough, and the carbon price level needs to increase. Carbon pricing schemes, which cover 23% of global greenhouse gas, are in the works in many countries. While ETS prices hit record highs this year in markets such as the EU and California, prices will have to rise significantly to meet the Paris Agreement temperature target, as direct carbon prices in the range needed by 2030 currently cover less than 4 per cent of global emissions.

In the future, carbon pricing policies will stand on the international stage, and carbon markets of various countries will be linked to develop effective carbon pricing mechanisms within a certain range. Carbon pricing will bring great waves in the field of traditional energy. It will promote the transformation of traditional coal energy to clean energy and further accelerate the construction of low-carbon and environmentally friendly society. The combination of carbon pricing, carbon finance and carbon market help to improve the participation of individuals and enterprises in carbon emissions, and further catalyze the implementation of carbon pricing policies through carbon financial derivatives. Although carbon pricing still faces many challenges such as political environment and citizen acceptance, carbon pricing will certainly be an important part of future climate change policies, and these challenges will be solved through changes and adjustments of countries, individuals, enterprises, and institutions.

## 8. Conclusion

This paper reviews some of the implications and applications of carbon pricing policies. This paper first introduces the mechanism and classification of carbon pricing in detail, then reviews the influence of carbon pricing in the field of energy and finance, and finally sorts out the existing challenges of carbon pricing. The CGE model is commonly used in the study of carbon pricing. In the field of energy and fuel, carbon pricing will promote the transformation of traditional coal energy to clean energy and further accelerate the construction of low-carbon and environmentally friendly society. In the financial field, the combination of carbon pricing with carbon finance and carbon market is conducive to the implementation of carbon pricing policies. Carbon pricing faces many challenges in political environment, citizen acceptance, international unified normative system, and other aspects. Although carbon pricing faces many challenges, it is an important way to cope with climate change and adhere to sustainable development. In the future, carbon pricing will certainly play a greater role through multi-dimensional changes and adjustments of countries, individuals, enterprises, and institutions.

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