



Research Paper

# Role of Carbon Credits in Reducing Carbon Emission- A Mathematical Model

Shubham Das

Research Scholar, Department of Humanities and Social Science, Indian Institute of Technology- Bombay

Received 15 August, 2022; Revised 28 August, 2022; Accepted 31 August, 2022 © The author(s) 2022. Published with open access at [www.questjournals.org](http://www.questjournals.org)

## I. INTRODUCTION

In recent times, climate change has become a serious concern. The problem is largely triggered by the rising Greenhouse Gas (GHG) emissions. International bodies are increasingly prioritizing the problem of climate change. The United Nations Framework Conference on Climate Change (UNFCCC) regularly holds global climate summits called the Conference of Parties (COP), integrating almost all the countries, to address the challenge. As the paper is being written, the most recent summit is the COP 26, which was held in Glasgow in 2021, wherein the countries agreed to come together and reduce carbon emissions by 2030, which was aligned with the broader aim to achieve net zero-emission by the middle of the century [1].

The international bodies have recognized the role of carbon credit in ameliorating the menace of carbon emissions. The mechanism of carbon credit entails that a firm is assigned a maximum amount of emission that it can produce. If the actual emission is less than the maximum limit, then the firm can ‘trade’ the difference between the maximum limit and the actual emission with other firms against some fees. The importance of the strategy of assigning carbon credits was first taken up in the Intergovernmental Panel of Climate Change, also known as the Kyoto Protocol, in 1997. The agreement aimed to set goals for every member country to reduce carbon emissions, and carbon credit was seen as an infallible strategy to meet the goal [2].

This paper attempts to develop a model to understand the role of carbon credit in reducing carbon emissions in a country. The theoretical model uses an optimization technique to show how the level of emission under carbon credit is lower than that without carbon credit. The paper also focuses on some empirical evidence to analyze the success of carbon credit across countries in reducing carbon emissions.

## THE MODEL

We have designed a simplified model of the working of the carbon credits. The model compares the amount of emission by a firm in the presence and absence of carbon emission. We take a representative firm and analyze its behavior by employing the optimization exercise. Let the representative firm produces a commodity whose quantity is represented by  $q$ .

Let the revenue earned by the firm by producing  $q$  units of output is  $R(q)$ , where  $R(\cdot)$  is the revenue function. Let the cost incurred by the firm from producing  $q$  units of output is  $C(q)$ , where  $C(\cdot)$  is the cost function. We have assumed that  $R' > 0$ ,  $R'' < 0$ ,  $C' > 0$ ,  $C'' < 0$ , i.e. the revenue function increases at a diminishing rate, and the cost function increases at an increasing rate.

The firm wishes to maximize its profit, that is, the difference between the revenue and the cost. In the absence of the strategy of carbon credits, the optimization problem of the firm is-

$$\max R(q) - C(q)$$

The first-order condition gives  $R'(q^*) = C'(q^*)$  ..... (i)

where  $q^*$  is the optimal output. The second-order condition gives  $R''(\cdot) - C''(\cdot)$ , which is a negative value due to the assumptions about  $R(\cdot)$  and  $C(\cdot)$ . So  $q^*$  is the optimal value.

Now we introduce the concept of carbon credits. Let the carbon emission by the representative firm is given by  $e(\cdot)$ , where  $e$  is an increasing function of  $q$ . It means that as the firm produces more and more output, the amount of carbon emitted by it increases, and the level of carbon emitted increases at an increasing rate. This assumption seems plausible because whenever a firm produces a large quantity of output, it emits more and more pollutants into the environment. So, we arrive at  $e' > 0, e'' > 0$ .

Let the maximum amount of emission that the firm is allowed to emit is  $\bar{e}$ . Here the role of carbon credits arrives. Whenever the firm emits  $e(\cdot)$  an amount of carbon, it is left with  $\bar{e} - e(\cdot)$  amount of unused or unutilized amount of emissions. Such remaining amount becomes the carbon credits for the firm. Let the firm can trade these carbon credits with other firms against a fee of  $w$  per unit of emission traded.

The implication of the model showing the trading of carbon credits is that if a firm emits less than the maximum allowed emission of  $\bar{e}$ , then it receives a total sum of  $w(\bar{e} - e(\cdot))$  amount of emission by selling the remaining amount of emission. Similarly, if the firm wants to emit more than  $\bar{e}$  amount of emission, it has to buy the excess amount of emission from some other firm by paying a total sum of  $w(e(\cdot) - \bar{e})$ .

So having prepared the model, the firm will maximise the profit by taking the carbon credits into consideration. The new optimization problem of the firm becomes-

$$\max_q R(q) + w(\bar{e} - e(q)) - C(q)$$

The optimization problem can be modified as-

$$\max_q R(q) - w.e(q) - C(q)$$

which means that as the firm emits  $e(q)$  amount of emission while producing the output  $q$ , it faces an opportunity cost of  $w.e(q)$ , which it could have earned if that amount of emission was not emitted.

Now the first-order condition is given as-

$$R'(q^{**}) = C'(q^{**}) + w.e'(q^{**}) \dots\dots\dots(ii)$$

where  $q^{**}$  is the optimal output in the presence of carbon credits. The second-order condition is given as  $R''(\cdot) - w.e''(\cdot) - C''(\cdot)$ , which is a negative value due to the assumptions about  $R(\cdot)$ ,  $e(\cdot)$ , and  $C(\cdot)$ .

Now we compare equations (i) and (ii). We find that  $q^* > q^{**}$ , due to the presence of the function  $w.e'(q)$  in the RHS of equation (ii). It implies that in the presence of carbon credits, the firm produces lesser output, as compared to the absence of carbon credits, which further implies that the emissions under carbon credits are lesser than that in the absence of carbon credits.

Hence the above-simplified model shows the functioning of carbon credits in reducing the carbon emission into the environment.

## II. CONCLUSION AND WAY FORWARD

In recent times, climate change has become a serious threat to the environment. One of the main reasons behind climate change is the massive amount of carbon emissions into the environment. International agreements like Kyoto Protocol and Paris Agreement outlined the need to address the problem of climate change at an intergovernmental level. The summits recognized the role of the carbon credit market in reducing carbon emissions. Having a carbon credit market is one of the infallible market-based methods to control carbon emissions.

In this paper, we developed a theoretical model to understand the working of the carbon credit market. The reward associated with reducing carbon emissions by the firms induces them to reduce their emissions. The model shows the working of the market in a simplified form, using optimization techniques.

The paper only presents a theoretical model which explains the effectiveness of the carbon credit strategy in combating carbon emission. This paper leaves scope for further empirical research to test whether carbon credit markets across the world have played any substantial role to reduce the carbon emission. This shall substantiate the effectiveness of the model put forth by the paper in the real world scenario.

**REFERENCES**

- [1]. COP 26 Explained, UN Climate Change Conference- UK, 2021
- [2]. [https://www.investopedia.com/terms/c/carbon\\_credit.asp#:~:text=A%20carbon%20credit%20is%20a,%2Dand%2Dtrade%22%20program.](https://www.investopedia.com/terms/c/carbon_credit.asp#:~:text=A%20carbon%20credit%20is%20a,%2Dand%2Dtrade%22%20program.)