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The Feasibility of Introducing an Alternative Dual Market for Tradeable Pollution Permits to Improve its Economic Efficiency in Addressing Global Warming

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ABSTRACT

Under growing public awareness of global warming, economists proposed a system that marketises the cost of pollution to firms in the form of tradable permits, aiming to discourage carbon emissions. In this system, pollution cost is determined by a free market force, making it more efficient than the government directly taxing producers. Nevertheless, the system's efficiency still can be improved, and the urgent situation of climate change calls for policyholders to take a more effective and comprehensive approach, one of which is a regulated, online, dual market with the involvement of both producers and individuals around the world. The thesis, thereby, aims to examine whether this self-proposed system, with a higher market efficiency, can trigger more joint efforts to carbon reduction. The analysis will include a description of the new system and a comparison between the current and new system. The paper will then use mathematical modelling to determine key figures for the new scheme. The primary objective set for the model, which determines the market's feasibility, is achieving the Paris Agreement's 2-degree goal and restoring the atmosphere's carbon emissions to the pre-industrial level.

Key words: cap-and-trade system, alternative dual market structure, private sector investment, global market with national subbranches, global hedge fund for green project.

1. Introduction

1.1. Background

By 2022, global temperatures had risen to an average of 0.89 °C above the pre-industrial level (NASA, 2023). This increase in temperature is leading to extreme weather events, with potential annual costs to the global economy estimated to be between $1.7 to $3.1 trillion by 2050

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(Bennett, P, 2023). This situation calls for immediate policy changes globally to address environmental issues, especially the emission of greenhouse gases, the primary cause of global warming (EPA, 2024).

Fortunately, the world at large has responded to this environmental threat by ratifying the Paris Agreement. It aims to "keep global temperature rise this century to below 2 degrees Celsius above pre-industrial levels and to pursue efforts for a more ambitious target of below 1.1 degrees Celsius above pre-industrial levels (United Nations, no date a). To meet their commitments, some countries have implemented a cap-and-trade system[1] (Our World in Data, 2023a), in which the government gave liable entities (firms that emit pollutants) a legal right to pollute up to a limit (pollution[2] permit). Firms then need to purchase more permits if they produce more emissions. Equally, they can sell extra permits to others if they pollute less. In other words, it is a "carrot and stick system", with firms getting "punishment" for extra pollution and "reward" for producing less emission (Pettinger, T, 2019a). In addition, the price of permits is determined by a free market. Thus, it is considered to be more effective in promoting carbon reduction than other tools like tax: a "punishment" for pollution solely determined by the government.

The history of cap-and-trade system can be traced back to the early 1970s, when the U.S introduced emission reduction credits for elements like lead (Farber, S, 2004). Three decades later, the "EU emissions Trading System" (EU ETS) marked a milestone as the first international system for pollution permit (European Commission, no date a).

Despite its growing size, this economic system isn't efficient enough to fully address the issue, in other words, to meet the 2 degree Paris Agreement. At the time when the paper was written, the predicted 2030 greenhouse gas emissions still must fall by 28 percent for the Paris Agreement 2°C pathway and 42 percent for the 1.5°C pathway (UNEP, 2023). The chart for per capita CO2 emission (Figure 1) provides a visual context of how daunting it would be to achieve either of the two numbers when one sees UK needing close to three decades to reduce emissions by 55%. This highlights the challenging prospect of achieving the 2 degree Paris Agreement. (Our World in Data, 2023b).

[1]The terms cap-and-trade system and emission system are used interchangeably in this thesis and unless specified refers to the same thing which is the current system for pollution allowances.

[2]The terms pollution and emission are used interchangeably in this thesis and unless specified refers to the same thing which is carbon emission.

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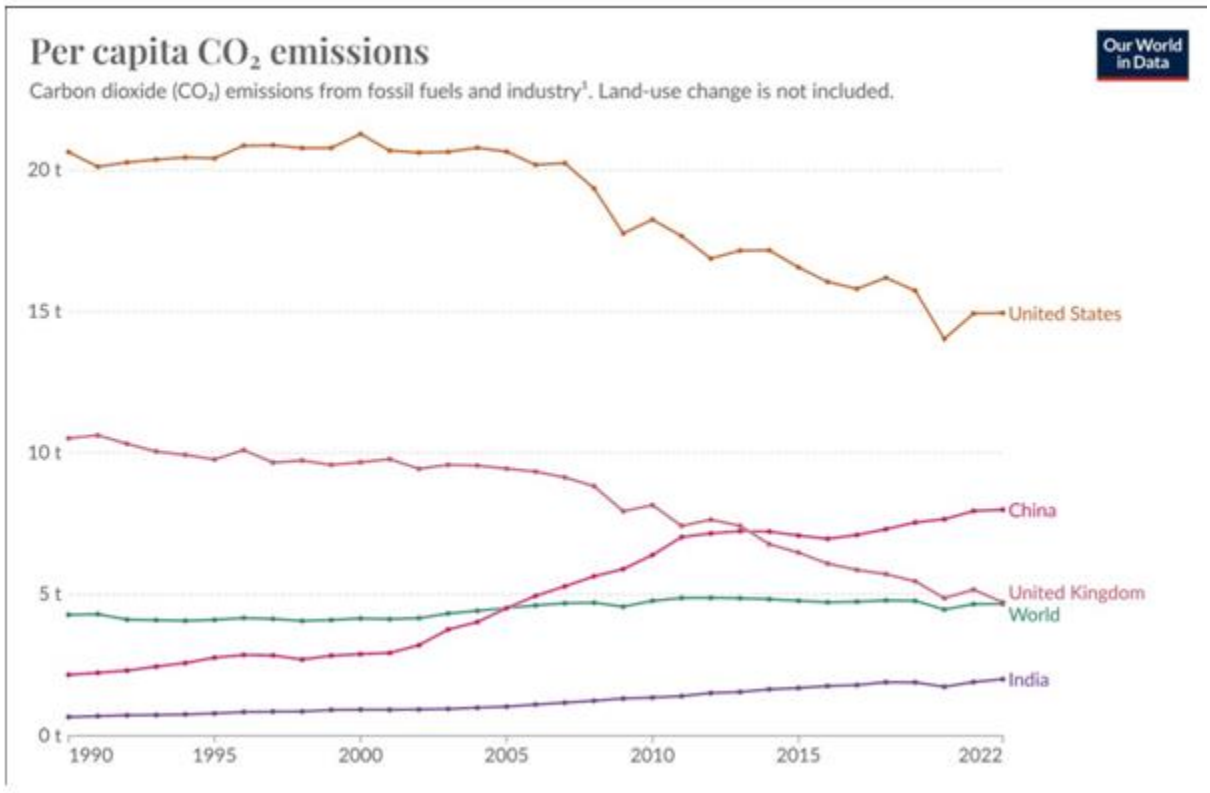
Figure 1



1.2. Key objectives of the thesis

This thesis' key objective is to evaluate a new system for pollution permits, to determine its capability of incentivising more carbon reduction with its higher market efficiency. This study will focus on the period of 2005 to 2023 for contextual historical data and will use projections up to 2050. As the cap-and-trade system is so far the most efficient tool, instead of looking for a novel alternative, the thesis will focus on proposing an improved version of the system and evaluate its feasibility in creating more incentives and, thus, increasing the efficiency in reducing greenhouse emissions globally.

The new system is named the “Tee” market for convenience. A Tee is the solid support from which a golf player hits the ball. The "Tee" market intends to act as the earth's solid base, ensuring it’s functioning properly so that humanity can live in harmony.

The “Tee” market is an online market that issues international pollution permits represented by electronic currency for the entire world. The market encompasses two submarkets, with not only

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firms but also private investors allowed to purchase the currency/coin[3] (permit). Regulations are set for the market to maintain its functioning.

1.3. Structure of the thesis

The thesis is divided into 7 sections. Section One and Seven are the introduction and conclusion, respectively. Section Two gives an overview of literature relevant to the thesis. Before analysing the "Tee" market, Section Three will first examine the main issues of the cap-and-trade system. Part 3.1 offers a more thorough and technical introduction to the system, and part 3.2 indicates its drawbacks that hinder the market's economic efficiency. Notice that in this thesis, the reference case study of the cap-and-trade system will be the EU- ETS, as it's the world's most extensive system currently (IPCC, no date), which is closest to the global market scale of the "Tee" market.

Section Four gives a detailed introduction on the "Tee" market with fundamental rules and designs. Section Five evaluates whether the "Tee" market possesses a higher economic efficiency on emission reduction. This encompasses analysing the market structure and regulations intended to promote market efficiency and its well-functioning. Part 5.1 explores Tee's market features mentioned in Section Four with some related regulations, aiming to examine their abilities to create more incentives for reducing carbon emissions. Part 5.2 will then look at additional rules imposed to further improve the "Tee" market efficiency. Section Six reports the process of modelling with key results.

1.4. Significance of the thesis

The thesis examines the solution to tackle one of the most pressing issues in the world— global warming triggered by carbon emissions, a scenario which threatens the living prospects (NASA, 2024) of the entire 8 billion populations on Earth (Worldometer, 2024). However, the situation is worsening despite growing public awareness (See Figure 2). The reason for such scenario may be that reducing individuals' carbon emissions is challenging. Despite the fact that industrial activities contribute to a high percentage (70%) of total emissions (Horný, M. and Matějovcová, K, 2023), individuals still account for certain pollution levels, with annual carbon production of four tons per person (UCAR, 2024). In addition, firms perform marketing strategies that respond to consumer behaviour. Thus, encouraging carbon reduction from individuals can, in turn, influence their consumption habits, and encourage them to purchase more environmentally friendly products that incentivise industries to cut emissions. This means more carbon reduction

[3] The terms coin and currency are used interchangeably in this thesis and unless specified refers to the same thing which is pollution allowance.

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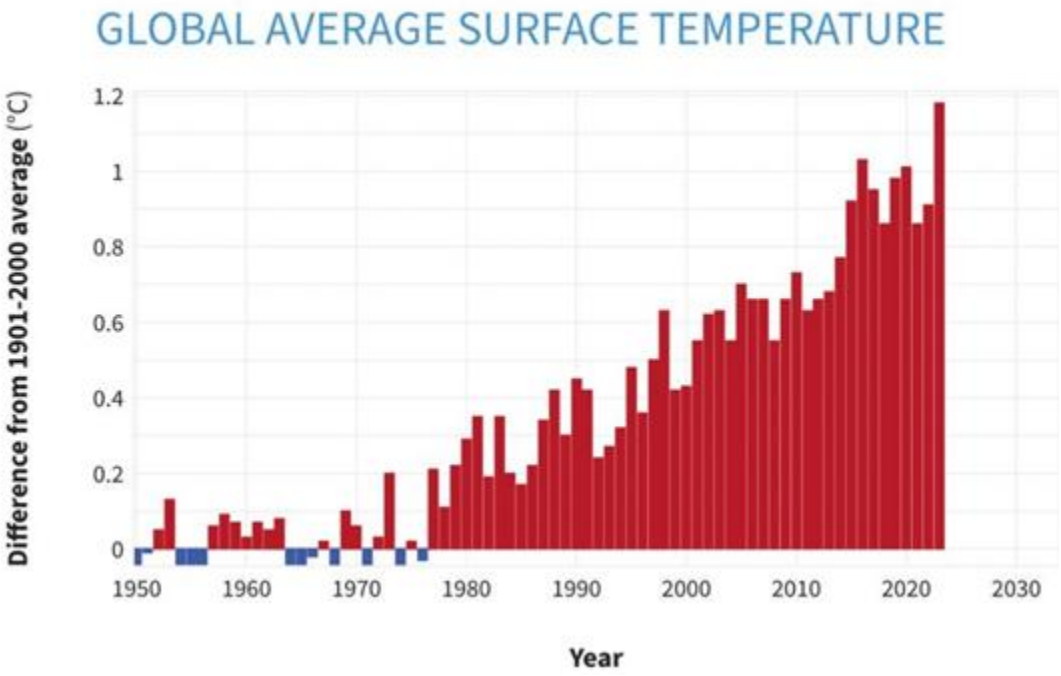
from individuals can be crucial to discourage worldwide carbon emissions entirely.\

Figure 2



Reducing Individuals' carbon emissions is hard in the sense that everyone is connected or interdependent in this complex world (Sheng, A, 2023). This means that pollution exists because from an individual's perspective, instead of themselves facing the consequence, the world is the ultimate victim of doing so. Therefore, if others choose to pollute, a person themselves is also harmed by that action. This in turn cultivates a scenario called tragedy of the commons (Spiliakos, A, 2019), when people don't actively protect the environment as they know others may pollute. The efforts those (who protect the environment) made can be cancelled out by others' action, which harms their interests and discourage them to protect the environment at the beginning. In other words, although there are environmentalists striving for preservation of the environment, it's essentially an ethical action, which fails to create enough incentives for all individuals to follow due to the uncertainty on other people's behaviours. This is the key problem that needs to be addressed to tackle climate change.

Although the emission trading system has incentivised firms to cut pollution, it fails to effectively influence individuals' behaviour, which is vital to discourage pollution, as argued above. The "Tee" market introduced by the thesis will use an innovative approach to create incentives not just for firms but also for ordinary citizens, which is done by utilising investors'

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profit-motive action.

The significance of the thesis, hence, is innovation. Looking back at history, "innovation" is an indispensable factor for the advancement of the times. The thesis proposes a new system that identifies the critical issues with the current cap-and-trade system, which may be “radical” but also becomes a pivotal moment in addressing the prolonged global issue. The thesis will determine whether this idea is the ultimate solution to global warming. In addition, the thesis will also point out further studies that should be undertaken, as the “Tee” market also has drawbacks that will be mentioned in the evaluation process. Another distinguishing feature of this study is modelling for real-life applications. It presents crucial figures for the market operation, demonstrating the market’s timeline and proving its feasibility in promoting further carbon reduction to meet environmental targets (will be mentioned).

2. Review of literature

2.1. Introduction

This section reviews relevant economic literature. Given the thesis's primary objective of increasing the efficiency of the cap-and-trade system (by introducing the "Tee" market), all reviewed papers identify issues with the system that hamper its efficiency and suggest improvements. The problems pointed out can be used to evaluate the “Tee” market to identify if the same issues persist. These policies can reference what rules might be imposed for the “Tee” market.

2.2. Problems with ETS

The increasing public awareness of the emission trading system (ETS) has led to many researchers scrutinising it and pointing out its shortcomings, with some also providing responsive policies.

(Zhao, X. *et al*, 2016) analysed the efficiency of the Chinese carbon trading system by first defining “liquidity, volatility, price clustering and information efficiency as the main aspects to discuss market efficiency of the carbon market.” Subsequently, they use their findings to propose policies that improve market efficiency, particularly for the ETS pilots. These policies aim to address the issues with the ETS pilots, including inaccurate quota allocation, a lack of trading mechanisms, and lagging legislation, which pave the pathway to constructing a national trading market.

Unlike the previous one, the next two literature focus on policy changes for the EU-ETS to improve its market efficiency.

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(Clò, S., Battles, S. and Zoppoli, P, 2013) applies a multi-criteria analysis to rank policies that improve the effectiveness of the EU-ETS, with options for intervention on either the ETS cap (−30% target, set-aside, carbon central bank: CCB, long-term target) or on the carbon price (European and national price floor). Their results suggest that specific ranking depends on the goals to be achieved. For instance, as the preference for environmental and implementation goals gradually increases, the EU price floor and CCB are ranked the first and the second-best policy, respectively.

Similar to the above literature, (Kollenberg, S. and Taschini, L, 2016a) proposes the policies for the system to respond external shocks. The thesis started by introducing the actions of set- aside for EU-ETS through the establishment of Market Stability Reserve (MSR) system to make the ETS "more resilient to supply–demand imbalances. The thesis then proposes a "hybrid" instrument that applies a price floor and ceiling on the ETS to improve market efficiency. They then emphasis the importance of adjustment rate to control system responsiveness. Finally, a mathematical tool is used to derive the optimum adjustment rate for both risk-neutrality and risk-aversion.

In the following two theses, the authors first point out some policies for the cap-and-trade system but then express concern with the policies by explaining their weaknesses.

(Palma, A. de and Lindsey, R, 2020) compares the efficiency of introducing a Tradeable Permit Scheme (TPS) for a congested facility such as an airport with a congestion fee, particularly when experiencing supply and demand shocks. The result shows that a fee outperforms the TPS, a more efficient policy for several demand and cost shocks.

(Flachsland, C., Marschinski, R. and Edenhofer, O, 2011) evaluates the idea of "linking" the emission trading system around the world. The author suggests that an international system may not be welfare-enhancing for all countries due to the presence of market distortions and terms of trade effect. They also indicate regulatory disadvantage may arise due to countries' partial de facto cession of discretionary control over domestic permit supply and linked system's inconsistency with original policy objectives.

Instead of focusing on the market-oriented policies, (Shahab, S. and Allam, Z, 2019a) introduces the idea of using blockchain technology to reduce the transaction cost, and hence, improves the market efficiency of the system. It identifies several benefits of doing so, such as higher information transparency, reduction of information asymmetries and better trading qualities.

2.3. Summary of literature

The literature above provides problems with the system in different prospects and evaluate some

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policies' impact on its efficiency. In summary, the first paper studies the Chinese system and suggests that the state should take more action to improve efficiency. The second and third papers seem to have similar policies mainly related to the EU-ETS, suggesting more "government intervention" in the market. The fourth and fifth theses reviews policies that may hamper the system's efficiency with explanations. The last literature is quite different. It does not propose any supplement but a replacement in technology for trading that reduces transaction cost.

Undoubtedly, regulations and interventions are crucial for the efficiency and functioning of the system. However, the 'Tee' market proposed in the thesis takes a more comprehensive approach by not only considering the above factors but also looking for more structural reforms in the market itself and technological innovation (similar to the final paper). Despite the fundamental operation of Tee still being similar to the current system, the ultimate goal is to make the 'Tee' market more like a financial market with necessary interventions, and with more private sector participation (firms and households). This approach is believed to be the most effective way of triggering more incentives for emission reduction.

3. Evaluation of the cap-and-trade system

3.1. Introduction

This section reviews the cap-and-trade system by providing a detailed economic introduction. Afterwards, the system is analysed regarding issues that hamper its market efficiency, categorised by objective and normative statements.

3.2. Introduction to the cap-and-trade system

The core of the cap-and-trade system is applying the price mechanism of demand and supply on the pollution permit[4]. The government set a fixed amount of permits available for free and for purchase each year and the permits expire annually, meaning firms need to repurchase new allowances. From economic theory, the system can be represented by a demand and supply graph (see Figure 3) (Sang's Economics Blog, 2012), in which a vertical line represents the supply of permits, as the supply doesn't change regardless of any corresponding permit price in one year. The demand for permits is plotted as a downward slopping line, with the demand dropping as the price increases.

[4] The terms permit and allowance are used interchangeably in this thesis and unless specified refers to the same thing which is the permission for liable entities to pollute.

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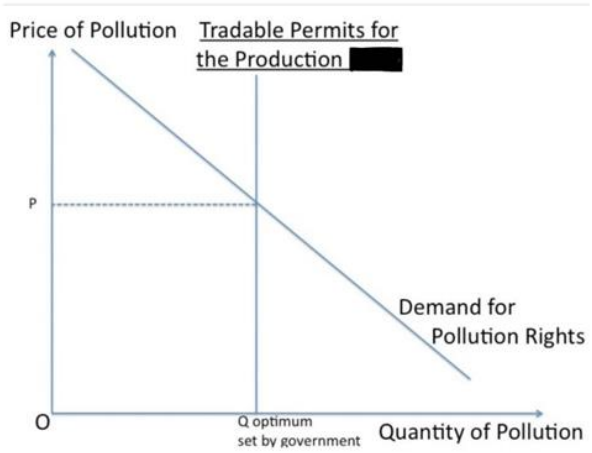
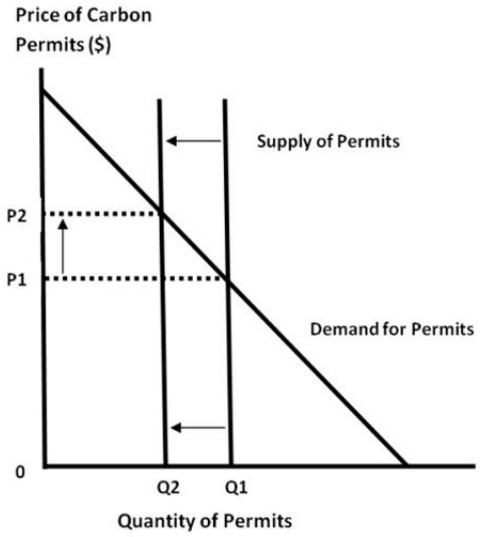
Figure 3



The system incentivises firms to emit fewer pollutants by the government reducing the permit supply yearly. This pushes up the cost of pollution, encouraging technological advancement from firms to cut greenhouse emissions and, hence, the production cost. This scenario is shown by Figure 4 (Pettinger, T, 2019b), in which a reduction in the supply (leftward shift) leads to a rise in price of permits from P1 to P2. Consequently, firms respond by investing in emission cuttings, which effectively reduces their demand for permits. In the long run, the supply of permits keeps declining, meaning a consistent increase in pollution costs. This ultimately motivates firms to invest in emission control to the point that they require few, or no pollution permits. By that time, the problem of promoting carbon reduction should be addressed.

Figure 4



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3.3. Evaluation of the cap-and-trade system

The cap-and-trade system is indeed the most economically efficient so far. The market- based approach determines the most appropriate "level of punishment" for firms that pollute the environment. Furthermore, the system creates sufficient incentives for firms to cut greenhouse emissions through innovation.

However, the system has problems that, if fixed, will dramatically improve the market efficiency for pollution permits and, therefore, creating more incentives for carbon reduction to meet the 2 degree Paris Agreement. Those issues are listed below in Part 3.31, with some extra normative judgements on the system for later evaluative purposes. (Pettinger, T, 2019c)

3.1.1. Market efficiency and transaction cost (objective)

The following points out factors in the system that hamper its market efficiency and increase the transaction cost in the market, with some quoted from the theses in Section Two.

Inaccurate quota allocation

Despite the involvement of market mechanisms in the system, the government allocates free permits for firms based on data of their respective emission of pollutants. However, an inequitable distribution of permits may occur, meaning the government can be too generous or tight, which influences the price of permits and hampers market efficiency. In other words, the system itself isn't solely dependent on free market force (quantity of demand and supply).

Measurement of pollution

It can be difficult to measure pollution levels. Also, there is potential for hiding pollution levels. Both reduces the market efficiency and may leads to inaccurate quota allocation.

Auction (Lack of trading mechanism)

Extra permits in the current system are sold by auctions, in which firms bid for the allowances. Nevertheless, the auction doesn't take place every day. For example, the Common EU auction platform (CAP3) auctions are scheduled to be on Mondays, Tuesdays and Thursdays between 15 January and 16 December 2024. (EEX, 2023)

This means that occasionally, firms cannot purchase permits immediately when they need one, as the auction is "closed." In addition, if a company fails to win a bid and runs out of allowances, the firm, from a legal perspective, needs to suspend production until it gets one.

Both scenarios reduce the liquidity of the ETS, hampering its efficiency due to a lack of trading

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mechanisms. In addition, the current auction system may harm the economy's supply chain and, hence, the economy.

Lagging regulation:

It takes time for the legitimate framework to be updated, meaning sometimes even a necessary regulation that improves market efficiency has been introduced, it needs to wait for years to be in operation. For instance, the market stability reserve mentioned in (Kollenberg, S. and Taschini, L, 2016b) was officially introduced in 2015. However, it did not become operational until 2019 (Dimitrova, M, 2024)

3.3.2. Normative judgement

This section provides some normative critiques of the emission trading system. The thesis won't judge or explain the correctness of those statements. These normative judgements are mentioned because in section Four, when evaluating the "Tee" market, there will be "special designs" in response to those judgements.

Political interference

The engagement of politicians means that occasionally, political interference in the market, such as intervening in the allocation of free allowances, may reduce market efficiency.

Not enough for promoting carbon reduction

Environmentalists have argued that a higher carbon price is insufficient to reduce carbon dioxide levels necessary to stop global warming. More policies may be needed to achieve this aim.

3.4. Conclusion

Introduction and evaluation on the cap-and-trade system has been conducted. When analysing regulations for the "Tee" market, Section 4 will introduce regulations and rules of the "Tee" market that solve the system's problems mentioned above.

4. Introduction on the "Tee" market

4.1. Introduction

Given the functioning of the cap-and-trade system and its drawbacks, this section presents a detailed description of the "Tee" market structure. This encompasses basic market operations, related institutions, and responsive designs to external conditions.

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4.2. market operation

The following describes the core of "Tee" market. It starts by introducing the related technology for the functioning of "Tee" market, followed by differences between the two markets for "Tee", and lastly, the rules of currency conversion.

4.2.l. An online market with blockchain technology

Like the cap-and-trade system that provides an online platform for pollution permits, the "Tee" market is designed to be a global online market. An online market makes managing accounts, monitoring currency supply, performing and tracking trading activities more efficient. Applying blockchain technology to the "Tee" market further improve its efficiency by increasing the transparency of trading, which reduces the transaction cost (Shahab, S. and Allam, Z, 2019a). In addition, blockchain technology records trading activities and may collect data on worldwide pollution, which is useful for the governing institution for monitoring currency supply. (see Part 4.3)

4.2.2. "T" and "E" markets

The "Tee" market is an online dual market, which acts as a global market for the provision of pollution permits for worldwide enterprises separated into national markets. Under the new market, the pollution allowances are represented by electronic currencies categorised into two types. The two currencies are named "T" and "E," and each can only be used in its respective market: the "T" and "E" markets which will be further elaborated in the following two sub-sections. One "T" or "E" currency represents one unit of global pollution permit for all participating countries. The only difference between the two currencies is their corresponding market. However, the demand and supply of the currencies won't be the same (will be explained in Section 5), meaning different equilibrium prices for "T" and "E" coins. "T" and "E" coins can be converted into each other via a floating exchange rate. Furthermore, there are two types of trading account for the market, with Personal Holding Accounts (PHAs) for households (investors) and Operator Holding Accounts (OHAs) for liable firms that produce greenhouse emissions.

"T" market

"T" market is an all-year-round platform for firms with OHAs to purchase and pay up their pollution permits. They receive some free T coins annually based on their emission levels, with more currencies allocated to higher "pollution-level" firms. A firm's historical purchases on the currency will also be considered when allocating free "T" coins for the following year. The currencies will be categorised based on their nations and can only be used to pay for pollution in

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industries associated with that country. In other words, the "T" market is an international market consisting of multiple domestic sub-branches. The overall currency supply in the "T" market is what firms receive for free, which differs from the cap-and-trade system, meaning there won't any selling of "T" coins and enterprises will need to purchase extra coins from the "E" market or PHAs if needed. However, same as the cap-and-trade system, a proportion of "T' coins spent by firms will be reinjected into the "T" market next year, but the supply of "T" coins keeps decreasing over time. Consequently, there should be an increase in demand on "E" coins from firms who demand pollution allowances. This scenario ultimately leads to a consistent increase in the prices of both currencies in the long run.

In addition, the scenario of firms directly purchasing "T" coins from another liable entity (industries) is prohibited in the market. In other words, for operations with OHAs, "T" coins can only be bought and then paid to pollute, with no option for selling. Moreover, all "T" coins in the OHAs will be reset annually. In other words, firms lose their leftover "T" coins after one year (same as cap-and-trade-system). However, enterprises with OHAs can transform T coins into E coins. (see currency conversion below for specific rules).

"E" market

"E" market is designed to be a platform for trading activities mainly from PHAs, which operates every day (until the closing day, see below), meaning trading activities can occur at any time. "E" market acts similar to a "share" market, in which owners of "E" coins receive dividend annually in the form of "E" coins. The dividend period can be longer as the value of the coins increase. Moreover, the dividend rate will decrease by time in response to the decreasing coin supply.

Unlike "T", "E" coins won't be reset. Furthermore, "E" coin is an international currency not restricted to nations, meaning that once converted, it can access all national "T" markets.

The official closing day for the "E" market will be the 22nd of December, Midnight (GMT), in which the currency supply in the "E" market that day will be marked as the final number of "E" coins in the one-year period. (useful for part "dividend scale" in section 4.41). The next opening day of the "E" market will be the start of the new year.

Revenue from selling "E" coins will be used to invest in carbon offsetting and energy conversion projects, tackling global warming. Furthermore, similar to the ETS system, when some used allowances collected by the government will be resold next year, some "T" coins spent in the previous year by firms will be resold in the "E" market next year by governing institutions (see Part 4.3), acting as a consistent source of revenue for environmental projects. Holders of "E" coins can oversee the aggregate contribution from the "E" market represented by a visualised

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progress line divided into scales, indicating the equivalent tons of carbon captured due to the carbon offsetting projects funded by sales revenue in the "E" market. This is calculated by converting the cumulative sales of "E" coins (since the origination of the "Tee" market) into tons of carbon given the average cost of the projects. As a reward for contributing to funding environmental projects, once the total carbon captured reached certain targets (scales), there will be a one-off increase in the rate of dividend in the next dividend payout for all "currency holders" who purchased the asset before the record date (the thesis doesn't consider the specific date for that). (see Section 5 "bonus system" for more details)

Currency conversion

"T" and "E" coins can be converted into each other via a floating exchange determined by free market force but will be intervened when necessary (see Section 4.3), with each national market having their own respective floating exchange rate. However, there's limited times allowed for the currency exchange. "E" and "T" coins can only be converted into each other once, further conversion will lead to the coin being worthless.

"E" coins can be converted into "T" coins and back with a diminished earning potential (see Section Five). In simple terms, the currency exchange between "E" and "T" coins can form a "closed loop". Any further conversion will lead to the "E/T" coins being worthless.

Given the exchange policy for the two currencies, the following will analyse the incentives for PHAs and OHAs to undertake this action.

For investors with PHAs, they won't receive any "free T coins", meaning the "E" market acts the sole platform for them to purchase coins. Despite the fact that firms can purchase "E" coins, they still need to convert "E" into "T" coins to pay for emitting pollutants. As the exchange rate for currencies varies by time (floating), private investors may convert their "E" into "T" coins in advance and sell directly in the "T" market for speculative purposes. The option of "forming a closed loop for currency exchange" means they only get a diminished return on the currency even they fail to sell their converted "T" coins, which reduces the risk for this speculation.

For firms with OHAs, the opportunity to transfer "T" into "E" coins effectively allows them to derive values from their extra "T" coins, avoiding the scenario of "wasted resources (currency)" since "T" coins are refreshed annually. This is also welcomed by the "Tee" market, as it increases market efficiency and incentivises more trading activities from enterprises.

Interpretation of the markets

The cornerstone of the "Tee" market is still the cap-and-trade system. Thus, Figures 3 and 4 still

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represent the operation of the market graphically, in which the price of "T" and "E" coins will rise by time due to decreasing currency supply. However, the "Tee" market aims to include worldwide industries that produce greenhouse emission and allocate unified pollution permits for participants. This means that net zero will be achieved after the "Tee" market is set up and the carbon offsetting projects have been established with the sales revenue, as long as the price of "T" and "E" coins (pollution cost) is greater than the cost of carbon offsetting projects per ton. Fortunately, this is already the case for the EU-ETS, with 83.66 euros/ton as the average pollution allowance price (Tiseo, I, 2024), and around 30 euros/ton on average for carbon offsetting projects (Crawford, I, 2021a). Thus, the "Tee" market, following a similar price trend with the EU-ETS, should instantly meet the 2 degree Paris Agreement after its operation and goes even further, achieving the target for 2050 (United Nations, no date b). The ultimate aim of the "Tee" market will be to capture the carbon emissions back to the pre-industrial level.

In addition, the market makes the purchasing of coins not just for pollution permits, but also as a "global hedge fund" for green projects with periodic returns. This, in turn, encourages more engagement from worldwide individuals as purchasing "T" and "E" coins contributes positively to tackling global warming. Moreover, the increase in private sector trading activities in the "Tee" market is likely to create more jobs from tradable allowance brokers like the Evolution Market, facilitating transactions and proposing investment strategies for E currency holders. (potentially "T" currency holders as well)

There should be two general investment strategies for the "E" market. The first one is to sell their coins to firms with short-term speculative purposes. The second one is more long-term oriented, in which they keep the ownership of "E" coins, as the value of the currency can be almost certain to keep increasing. From firms' perspective, they purchase "E" coins to pay for pollution permits by converting them into "T" coins. However, they may choose to purchase some "E" coins for investment.

4.3. Governing institutions

The International Currency Supervising Association (ICSA), a joint global committee, is responsible for monitoring the global currency supply and performing interventions such as set-aside if necessary. In other words, ICSA plays a similar role to the MSR (market stability reserve) but beyond that. It acts as the (international) central bank of the "Tee" market which also "prints" the currencies and allocates "free T coins" for worldwide firms. The members of the association should be expertise ranging from preeminent economists to IT engineers.

As an international system, the "Tee" market is considered to be too "large" for a single institution (ICSA) to operate. ICSA, hence, delegates the participants' central bank as

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subbranches to be responsible for monitoring local trading activities and "intervening" the floating exchange rate if necessary. In addition, regional commercial banks are permitted to provide services including opening accounts for investors. Similar as the EU-ETS in which commercial banks like AGEAS, UniCredit go beyond the intermediary role by providing services like managing accounts, banks are expected to provide even more financial services in the "Tee" market (Betz, R. and Cludius, J, 2016a) (will be discussed further in Section 5).

4.4. responsive designs

The following section examines two features for the "Tee" market that will only be activated under specific conditions. Part 4.41 first reviews the dividend scale which has been mentioned above, and Part 4.42 subsequently provides a detailed description on the bonus system. Notice that both are designed for the "E" market participants.

4.4.1. Dividend scale

Figure 5

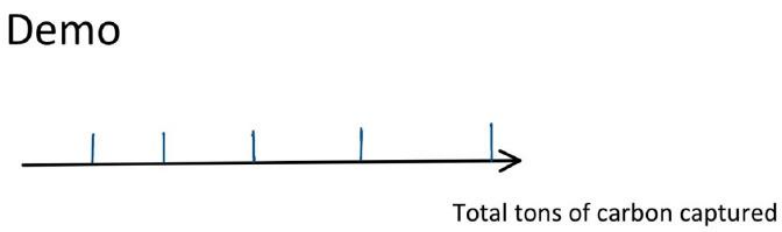

Figure 5 presents a demo of the progress line divided into scales. The scale measures (estimates) specific tons of carbon captured via environmental projects funded by the "E" market, given the cost of projects per ton of carbon and the cumulative sales of "E" coins. The gap between the two adjacent scales gradually increases since the value of "E" coins rises over time, meaning a temporary increase in dividend rate brings more reward. In addition, the rate of dividend rise drops when meeting later "targets" on the progress line. This is because a rise in dividend rate essentially pushes up the currency supply, but the fundamental aim of the "Tee" market is to discourage the emission of greenhouse gases by raising the "cost of pollution", which is achieved by ICSA lowering the total currency supply, and hence, increasing the price of both currencies. Thus, a smaller increase in dividend needs to be rewarded in the latter phase of the "Tee" market.

The following provides a detailed description on the "estimation" of carbon captured due to the "E" market by measuring the currency supply. Notice that the statement assumes all "E" coins in the market are sold without any ICSA's reserve. In the real scenario, ICSA needs to deduct its reserves when measuring the cumulative sales of "E" coins each year.

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As some selling of “E” coins won’t be contributing to environmental protections (projects) in real terms (some “E” coins are converted into “T” coins to compensate for pollution), instead of measuring the daily currency supply over the period, the dividend scale accounts the “E” coin supply in the closing day as the annual sales. This is because by then, firms would have bought sufficient “E” (converted into “T”) coins for pollution allowances, as they wouldn’t be able to purchase anymore. In other words, the leftover “E” coins in the market aren’t bought for emitting pollutants but for investing in environmental projects.

4.4.2. Bonus system

The bonus system is designed to further incentives carbon reduction by influencing the behavior of “E” currency holders. It provides an extra reward on the dividend rate once the real-world temperature increase is managed to go below the predetermined thresholds set by ICSA. The difference between the bonus system and the dividend scale is that the bonus system responds to the real-world figures while the dividend scale only considers the figures for the “Tee” market (“E” currency supply).

As pointed out in Part 1.4, the environmental issues are hard to tackle in the sense that an individual may not be motivated to behave in an environmentally responsible manner due to uncertainty about other people’s actions. The bonus system, therefore, connects coin holders together to promote reduction of carbon emissions, because the action is “profitable” for them: they can receive more dividend if the increase in world temperature is within the threshold. Furthermore, as the value of the “E” currency increases, there should be a point such that the extra increase in dividend has been “attractive” enough to incentivise a lot or even all investors of the “E” market to protect the environment regardless of the uncertainty of others’ behavior. However, there’s no guarantee that this collective action is sufficient for emission control. Still, the economy welcomes such pattern, potentially incentivising industries to perform "environmentally friendly" marketing strategies responding to individuals (‘consumers’) environmentally responsible actions.

Given the above statement, the following suggests the ideal strategy for ICSA when setting the targets for the bonus system. ICSA should set an “easily achievable” threshold for the world temperature increase at the start and gradually raise its difficulty. This, in turn, incentivises “E” currency holders to engage in environmental protection when the value of the “E” coin hasn’t been that “appealing”. In addition, an easy target can eliminate their fears of other people’s behaviour in the early stage of the “Tee” market, which paves the way for long-term cooperation between participants of the “E” market.

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4.5. Conclusion

A detailed introduction to the core of the "Tee" market has been conducted. The section has described the market structure of the "T" and "E", followed by the principle of currency conversion between two markets. ICSA, which plays a vital role in the operation of the "Tee" market, has been introduced, along with its relevant responsibilities. The extra designs on the "Tee" market based on external conditions, including the dividend scale and bonus system, are also mentioned. Hence, the next section will evaluate all those designs in the order noted in this section, together with regulations for better market efficiency and function.

5. Evaluation of the "Tee" market

5.1. Introduction

This Section evaluates the "Tee" market and compares it with the cap-and-trade system. Notice that the thesis doesn't focus on evaluating designs that already exist or are similar to the cap-and-trade system, such as the gradual decreasing dividend rate, designed to align with the decreasing currency supply that increases the price of the pollution allowance over time.

Before evaluating the specific policies of the "Tee" market, this section first determines the feasibility of the "Tee" market" by reviewing its key idea: encouraging more trading activities from the private sector. Then, there will be specific analysis on the market policies split into two parts. First, it examines Section Four's related rules to determine whether the market can further encourage emission reduction. After which, it discusses extra regulations imposed on "Tee" to promote market efficiency. Although a higher "Tee" market efficiency can incentivise further carbon reduction, the thesis emphasises separate analysis for fluency and a comprehensive understanding.

5.2. Feasibility of increasing private sector engagement for Carbon Reduction

This part examines the core idea of the "Tee" market—encouraging more private sector investors to invest in the system, which contraindicates the suggestion from the literature in Section Two, meaning intervention like the price cap/floor won't occur as it reduces the free- market force and private sector interest. However, the thesis regards a more financialised market for pollution allowances as the most effective way to incentivise carbon reduction from industries and individuals. The "Tee" markets' structure creates investment opportunities, encouraging private sector involvement. The market utilises features like bonus system to spark investors' profit motive, promoting more incentives for carbon reduction from individuals and, subsequently, industries due to changes in marketing strategies. In addition, more engagement from the private investor can increase the liquidity of the "Tee" market, making the system more efficient.

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According to (Betz, R. and Cludius, J, 2016b), PHAs and OHAs already exists in the EU- ETS, with 606 PHAs established for investment purposes (private sector), compared to 4,608 OHAs for companies (excluding companies that own both accounts for better comparison) (Figure 6). In addition, there was a high and increasing involvement of financial actors in the trading activities (Figure 7). This shows that private investors have shown a high level of interest in investing in tradable allowances. Hence, the idea of motivating more transactions in the "Tee" market from the financial sector has some credible basis.

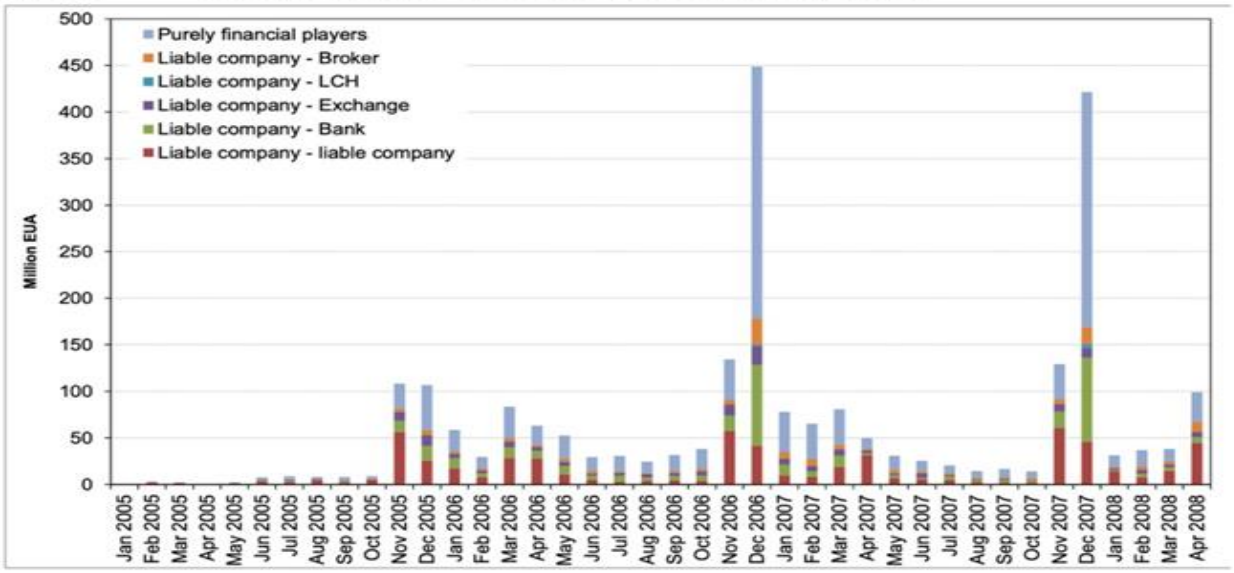
Table 2 **Accounts and entities active during the first period of EU Emissions Trading**

OHAs / Liable entities			
Number of OHAs active in 1st TP	Number of parent companies that own at least one OHA	Number of parent companies that own only OHAs	Number of parent companies that own both OHAs and PHAs
11,141	4,783	4,608	175
PHAs / Non-liable entities			
Number of PHAs active in 1st TP	Number of PHAs associated with liable entity	Number of PHAs not associated with liable entity	Number of parent companies that own only PHAs
1,078	472	606	433

Source: EUTL, own estimation

Figure 7

Figure 3 **Trading partners in first period EU Emissions Trading over time**



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5.3. Ability to further incentivise carbon reduction

Given the core structure of the “Tee” market in Section Four and the system's main idea, which is proven justified, this part moves to the thesis's key objective: evaluating its ability to further motivate carbon reduction.

5.3.1. Policies for Currency selling/purchasing and conversion

Detailed rules with coding of currencies

As the policies for ICSA not selling “T” coins and allowing firms to purchase pollution allowances (“E” coins) at any time has been introduced in Section 4.2, the following explains how the exchange policy between two currencies. Moreover, this part also introduces a design that “marks” the currencies into different types to make currency conversion more convenient. This part then analyses the abovementioned policies, including not selling “T” coins, to determine their impacts on reducing carbon emissions.

The free “T” coins allocated by ICSA will be marked as T*. The initial E coins in the market will be marked as “E”. As mentioned in the previous section, original T coins (T) can be converted into E coins with a diminished earning potential. Those coins will be marked as E*, in which their owners only receive dividend of the asset for three years before “E*” is refreshed. For E coins, they can be converted into T coins, represented as T*. T* plays the same role as T, which is used for paying pollution allowances. T* can be subsequently converted in to “E*” (a diminished earning potential same as above). Some of the used “T” coins will be allocated to firms next year as new “T*”, and others will be sold as “E” coins in the next year. Notice that the total “T” market supply keeps decreasing to discourage firms from emitting greenhouse gases.

Floating exchange rate

“E” and “T” coins are converted into each other through a floating exchange rate, which is pivotal to the exchange rate policy and is designed to increase market efficiency. An exchange rate exists because of the difference in quantity demanded (purchased) of two currencies, as “T” coin represents short-term pollution allowances while purchasing of “E” coins can also be a long-run investment. Furthermore, since trading activities between “E” and “T” market happen frequently due to OHAs purchasing pollution permits, the exchange rate varies (floating) in response to the change in demand and supply of currencies. Floating exchange is set for each national “T” markets instead of one for the entire “T” market, as this makes the floating exchange rate to be self-adjusting and reflects the specific conditions for each national markets.

Consider a situation where floating exchange rates between two markets, countries A and B, are

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not in balance. Suppose country A's exchange rate (from “E” to “T”) is “too low” relative to other markets, resulting in overvalued “E” coins. In that case, investors will responsively convert their currencies into country A's market, pushing the exchange rate and depreciating the overvalued “E” coins. This corrective action is called arbitrage (Fernando, J, 2023), which helps to adjust the exchange rate back to the “right” figure, reassuring the stability of exchange rates.

Interpolation of the policies

This section examines the abovementioned policies and points out their significance in motivating carbon reduction.

The design of ICSA not selling “T” coins directly after allocating T* and prohibiting direct trading activities between firms nudge enterprises to purchase pollution allowances from the “E” market. This incentivises private sector activities, as it provides another investment strategies for investors in the “E” market apart from purchasing “E” coins for long term dividend payment. Furthermore, such a design can prevent insider trading, as firms may form deals with “T” coins that don’t reflect the market price. In addition, the design of E* act as a safety net for PHAs and OHAs. From investors’ perspective, they may be prone to convert their “E” into “T” coins in advance and sell to firms for speculative purposes (floating exchange rate), as even they fail to sell of their currencies, they can still convert it back and receive a three-year dividend. From firms’ perspective, they get rewarded for cutting greenhouse emission: convert their “T” coins into E* for dividend. Furthermore, in an event where there is over purchase of “T*”, they can convert it back to “E*”.

Regarding the floating exchange rate, it incentivises more trading activities from the private sector, as it provides another possible pathway to make profits for investors through arbitrage, making the “Tee” market more appealing to the private sector including investment banks. Consequently, there may be a rise in demand on the currencies, and hence, the price of pollution allowances (T coins), which creates more incentives for industries to cut pollution. Furthermore, more engagement from the private sector may increase public awareness, convincing the public of the severity of global warming and emphasising the need for joint efforts from firms and individuals to address the issue.

5.3.2. A global market

Description and Evaluation

The current EU-ETS covers less than half of all CO2 emissions and does not apply systematically to all sources, with even electricity production not being fully covered. (Huppes, G. et al, 2015) Without fully covering all industrial emissions, implementing the pollution

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allowances creates unfair advantages in pollution costs for those sectors not included in the scheme, which is undesirable for the economy. Thus, the “Tee” market strives to include worldwide industries that emit air pollutants and treat all sectors fairly when tackling climate change, making the market more welfare-enhancing for all nations. An international market creates more incentives to address global warming by applying a pollution cost for all nations with fairness, which discourages worldwide greenhouse emissions, and increase global awareness of environmental protection.

In addition, there are two types of pollution permits in the EU-ETS, with one solely for the aviation sector (EUAAs) and another for other industries (EUAs). Consequently, there are usually price differences between two allowances. There are several reasons for such structure (European Commission, no date b). First, the aviation industry operates at an international scale, making it necessary for the EU to adopt a global market-based measure — the 'Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to align with the momentum in the International Civil Aviation Organisation (ICAO, no date). Moreover, despite accounting for around 2% of the global CO2 emission (Our World in Data, 2024), the aviation sector plays an important role on the global economy, contributing 4.1% of the world’s GDP (ATAG, no date). In addition, aircraft emission can be harder to be decarbonised compared to some other sectors, potentially leading to a different cost and hence, the price of pollution allowances. Thus, it is important to tailor a solution for the sector in order to balance between economic growth and environmental goals.

However, the “Tee” market will not treat the aviation sector differently because the system believes that all pollution should have the exact cost regardless of its location and emitter. Such a design can incentivise more environmental protection since it is fairer. The market, thereby, include all industries. This is practical in the sense that the “Tee” market is already a global market held by an international committee: ICSA. Thus, the market itself will have adopted a global market-based measure. However, ICSA will still treat the aviation sector with extra caution when allocating free “T” coins to maintain the industrial-lead economic growth from aviation. Furthermore, as ICSA categorises industries into different pollution level, it can simply apply higher “pollution cost” to firms by allocating fewer “T” coins instead of setting different prices for pollution allowances.

As the thesis evaluates the “Tee” market, the following indicates some drawbacks of this design. First, a global market can be sophisticated to manage and very hard to establish, meaning it may require a long period for the “Tee” market to encompass all nations, especially for developing nations that weigh economic growth more than environmental protection. In addition, countries may not join the scheme as they may lose the revenue from holding a cap-and-trade system itself (selling of pollution allowances). This means that net zero may not be achieved until a period

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(years) after in the "Tee" market launch. Moreover, the "Tee" market, if introduced, will be the single largest market ever for pollution allowances with a lot more trading activities from the private sector. This, in turn, leads to more uncertainties and volatilities. Even though a market with proper volatility means greater profit (Boyte-White, C, 2022), which triggers more trading activities, high volatility can hamper market efficiency, as suggested by (Hazen, T.L, 1987),

Related policies

Given the above drawbacks, ICSA needs to undertake actions. ICSA will need international joint efforts to manage the market properly. To attract more developing nations to join the scheme, ICSA will impose a more friendly allocation of "T" coins for developing nations, in which domestic firms receive more free allowances(T) compared to foreign industries categorised into same pollution level. Consequently, firms in those developing nations face a lower production cost than their counterparts in developed countries, which helps attracting more foreign direct investment: vital for developing nations to boost economic growth. In addition, ICSA promises priority for environmental projects located in developing countries, which can boost domestic GDP growth. These policies can create unfair competitive advantage against developed nations and thus cause resentment and resistance, but ICSA has to these face trade-offs to promote the participation of more nations in environmental protection.

In addition, ICSA needs to manage the revenue from selling currencies fairly, ensuring all participants receive sufficient investment, to compensate for the revenue loss from the participants' budget due to ICSA's central management on the "Tee" market.

With regards to market volatility triggered by private sector activities, ICSA needs to monitor the market through intervening the floating exchange rate (varying supply of "T" and "E" coins) to maintain an "appropriate" price of the currencies. However, this requires money, and it can be hard for ICSA to find the source of revenue, as all selling of "E" and "T" coins should be spent on investing environmental projects. Consequently, ICSA will need help from the "Tee" market's participants, but countries may be reluctant to use their government budget, meaning ICSA may need to spend a lot of time canvassing funds from international institutions like the United Nations.

5.3.3. Responsive designs

This section reviews the significance for setting up the responsive policies for the "E" market. The dividend scale and bonus system are designed to attract the private sector, but also influence currency holders' daily behavior.

The dividend payout rewards "E" currency holders for funding environmental projects. As

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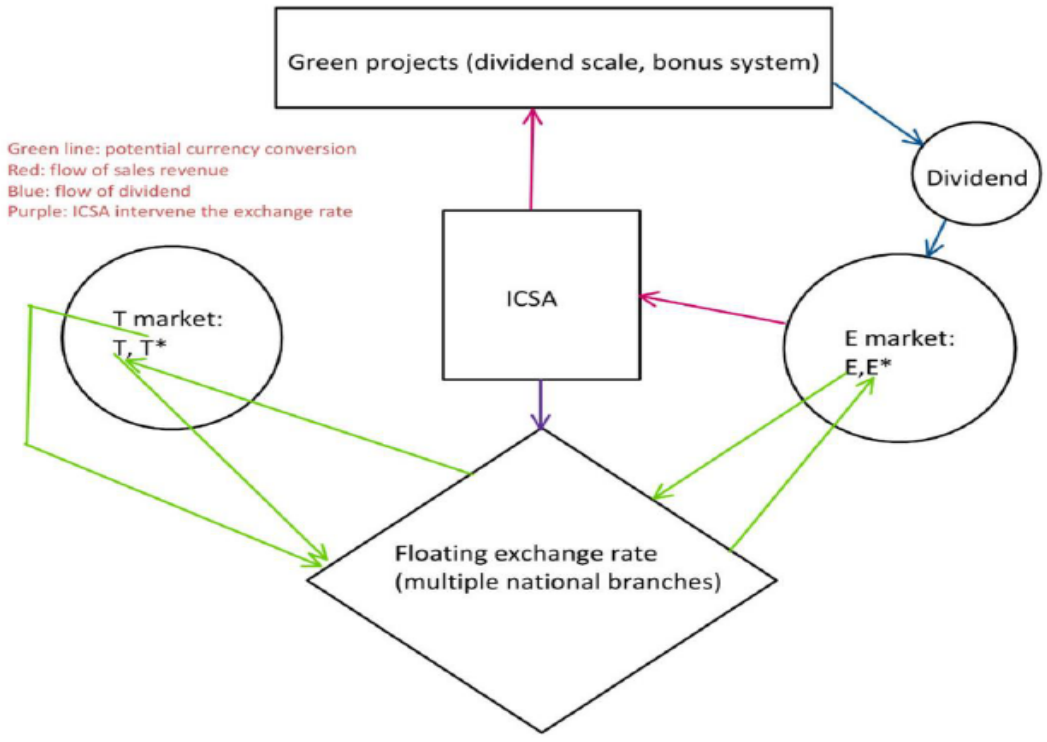
pointed out in Section 3.3.2, some argue that a rising carbon price may not be sufficient to tackle global warming. The investment in ecological protection funded by “E” currency holders further contributes to addressing climate change. Furthermore, the payout of dividend makes the “Tee” market a more appealing investment for investors, encouraging carbon reduction as argued before. The dividend scale further incentivises this action by visually showing the progress line targets.

The bonus system may influence “E” currency holders to be more involved in protecting the environment (as explained in Section Four). Moreover, it can motivate firms with extra “T*/T” coins to reduce pollution, as they can receive more dividends by converting “T” into “E” coins. Even firms without extra “T*/T” coins are still more likely to cut air pollutants, as a rise in the dividend rate leads to a less significant drop in the currency supply, meaning a lower increase in pollution cost next year.

5.3.4. Summary

The evaluation of relevant policies that incentivise carbon reduction has been conducted. So far, all relevant policies and features of the “Tee” market structure have been introduced (Section Four with Part 5.3). Thus, the following provides a graphical summary of the basic “Tee” market operation for a better understanding of the system.



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As shown by the graph, green lines represent the potential route of currency conversion through multiple national floating exchange rates "monitored" (indicated by the purple line) by ICSA. The red lines demonstrate ICSA investing in green projects through sales revenue from the "E" market. The blue line represents the dividend payment rewards to E coin holders for funding green projects, with extra dividends when meeting environmental targets on the dividend scale and the bonus system.

The following section will discover extra regulations that improve the market efficiency of "Tee."

5.4. extra policies for improving market efficiency

This section examines the related policies/regulations that improve the "Tee" market's efficiency.

5.4.1. Related institutions (ICSA, central banks)

Because of its nature, the "Tee" market won't be as liquid as an actual financial market, such as a share market. It is still a platform for trading pollution allowances despite the "E" market providing further investment potential that attract more private investors. Thus, interventions are always required to promote the upward trending price of both currencies and encourage carbon reduction. Consequently, ICSA plays a crucial role in the "Tee" market. It is responsible for monitoring the supply, and hence, price of currencies in both markets, preventing the scenario of over or under-supplying both currencies. This ensures an efficient "Tee" market that operates in a way that incentivises reducing carbon emissions. Furthermore, as ICSA is an international committee, political inference, a problem pointed out in the drawback of the cap-and-trade system that may hamper the market efficiency, may be less likely to occur compared to EU and other ETS.

For better market efficiency, ICSA delegates national central banks to supervise the domestic "T" market. This helps tackle the issue of inaccurate quota allocation for the current system, as ICSA can cope with that better by applying a "double-check" method. National central banks will first review the currency supply of both markets and subsequently hand in a proposal for the domestic supply of "T*" next year. It will then be reviewed by ICSA before the committee ultimately sets the allocation. This procedure helps ICSA to determine an appropriate "T" market supply that follows its long-term pricing trend.

Furthermore, ICSA encourages more roles to be undertaken by retail and commercial banks compared to the current system, such as opening accounts for private investors. Under the current system, companies can own both PHAs and OHAs. This is banned for the new system, as

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the PHAs are designed for the private sector, and OHAs are for firms. For ICSA, this makes tracing transactions and managing the account more efficient, reducing the chance of commercial fraud.

ICSA promotes more engagement from retail/commercial banks because banks have already played an essential role in the EU-ETS. (Betz, R. and Cludius, J, 2016c) shows that banks were responsible for the largest overall trading volume and acted as market makers. They also played several roles, including intermediary and service provider. Although some of the bank's role may be taken over by trading companies, such as hedging counterparties, ICSA believes the bank will be familiar with the "Tee" market operation the most, and its involvement can facilitate trading activities, increasing the "Tee" market efficiency.

Thus, to attract commercial banks to join the scheme, ICSA gives them the privilege of providing financial instruments related to the "Tee" market, including currency loans and derivatives, which enables them to make profits.

Finally, despite the "Tee" market's position as a more financially oriented market, ICSA still needs to intervene in the market and impose trading laws, such as the Markets in Financial Instruments Directive (MiFID II) for the current EU-ETS (Kenton, W, 2023), to ensure low transaction costs.

5.4.2. A 24-hour global market with national sub-branches

The benefit of setting the "Tee" market as a global market is its high resistance to monopolies, as manipulating the market requires a significant amount of money. This, in turn, increases market efficiency.

The 'T' market is structured as national markets supervised by domestic central banks (unlike the "E" market), cultivating higher market efficiency than ICSA's sole supervision. Furthermore, this structure promotes equality for each participant, with ICSA's specific knowledge of the currency supply for every country guaranteeing less-developed participants' access to sufficient pollution allowances.

The intention of setting the "Tee" market as a 24-hour market (excluding a short period of closing for the "E" market) is to improve trading efficiency by addressing the issue with the current auction system, which allows liable firms to purchase pollution allowances only on the scheduled auction days.

5.4.3. Mergers and Acquisitions (M&A) policy

ICSA will impose a policy to avoid a scenario where 'T' coins from two liable entities' OHAs are

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combined without reflecting the market price after an M&A. This practice hampers market efficiency. Therefore, ICSA mandates all 'T' coin transfers for M&A must be linked with a market price predetermined by ICSA.

5.4.4. Minimum purchasing policy

ICSA may need to consider a minimum purchase requirement for “E” coins from PHAs, given the large number of currencies in the “E” market. This measure can help reduce the number of accounts with similar total purchases, leading to a more efficient transaction tracing process and a reduction in the burden on the “Tee” market's online server. However, such a policy shouldn’t occur for all other transactions, such as during currency conversion and when OHAs purchase currencies. Otherwise, the market efficiency will decrease due to inconvenient payment for pollution allowances in the “T” market.

5.4.5. Automatic stabiliser

Unlike the previous parts that reviews some policies to improve the “Tee” market’s efficiency, this part looks at how the structure of the “Tee” market allows it to act as an efficient automatic stabiliser.

The existence of a dual market, particularly the “E” market, cultivates a scenario that when the economy experiences a recession, there could be a responsive decrease in demand for both currencies, meaning the pollution cost is automatically reduced, which increases the GDP and shifts the economy back to equilibrium. Equally, when the economy is in the boom phase, a responsive decrease in currency demand pushes up the pollution cost, which reduces the GDP, shifting the economy back to equilibrium. This, in turn, reduces the peaks and troughs of the economy in the economic cycle without any intervention needed by ICSA. Moreover, the responsive efficiency of the “Tee” market during economic booms/bursts is higher than that of the current auction system, as the auction doesn’t occur at any time, meaning a longer time for the market to react.

5.4.6. Summary

This part has reviewed the related policies that improve the “Tee” market’s efficiency. Part 5.4.5 also indicates that the market acts more efficiently as an automatic stabiliser than the current cap-and-trade system. The next part focuses more on the cons of the “Tee” market.

5.5. Problems and drawbacks

This part lists some problems that the “Tee” market hasn’t been able to tackle, as well as some drawbacks with the “Tee” market for evaluative purposes.

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5.5.1. Hiding pollution

The problem with some liable entities hiding their pollution level may still occur, as the current technology fails to precisely monitor the level of air pollutants emitted from firms. This scenario harms the “Tee” market’s efficiency.

5.5.2. Low regulatory responsiveness

It takes time for ICSA to approve new proposed policies, as this international committee monitors a sophisticated global market. Thus, new regulations will still take time, or even longer, to become operational compared to the cap-and-trade system.

5.5.3. Too big to fall

As mentioned in part 5.4.2, the “Tee” market will be the single largest international market if established. Furthermore, the pollution allowances sold by the market influence the production costs for worldwide industries, and more involvement in the market from the private sector increases the volatility of the market, which may lead to over-speculation on the market, resulting in a market crash. Thus, ICSA needs to intervene carefully in the market to ensure its stability. The market is interconnected to so many industries that a crash will have huge negative impacts on the global economy.

5.5.4. Termination of the market

With the increasing cost of pollution and the ultimate shift of industries towards renewable energy, the value of currencies is bound to decrease as firms demand fewer allowances. In anticipation, ICSA must be prepared for selloffs from currency holders. The “Tee” market will be closed once ICSA achieves its environmental target of reducing carbon emissions to preindustrial levels. By then, ICSA must manage to raise fund to "repurchase" all leftover currencies from currency holders as compensation.

5.5.5. Predictability

The long-term trend of the “Tee” market is more predictable than a pure financial market, such as a share market. Currency holders should foresee the entire phase of the market, starting from a rise in currency price to encourage energy transition and then a short fluctuating period before the demand for allowances begins to drop as many firms have started using renewable energy, leading to a decline in price. In addition, transaction activities are found to be high at the start and end of the year, when firms purchase and pay for pollution allowances. This predictability can hamper market efficiency, potentially leading to larger price swings due to herd behavior. For instance, there may be a large demand for currencies at the start of the market, whereas

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massive selloffs can occur when the price of currencies decreases in the latter period of the market (some entities have completed the energy transition).

5.5.6. Conclusion

An analysis of related policies and regulations for the "Tee" market on incentivising carbon reduction and improving market efficiency has been conducted. However, this section will not make the final judgement on the feasibility of the "Tee" market, as the modelling introduced in the next part provides a vital figure for the market feasibility. Hence, the final conclusion on the "Tee" market will be included in Section Six.

6. Modelling

6.1. Introduction

The purpose of modelling is to provide data demonstrating a brief operating process and price trend of the "Tee" market, making the thesis not just theory based. Moreover, an estimation of the cumulative carbon captured will be included, which is crucial for determining the feasibility of the "Tee" market to meet its aim. As the thesis is economic- oriented, relevant figures are derived with an Excel spreadsheet with input functions without complicated models. Notice that this section presents a simple model that acts as a reference, but won't precisely reflect the future pattern of the "Tee" market. At the end of this section, the final judgment on the "Tee" market will be given based on the information in Sections Five and Six.

6.2. Key objectives and related figures

As the "Tee" market aims to address climate change by reducing carbon emissions back to the pre-industrial level, this model estimates the duration for achieving this aim, particularly via the investment on carbon offsetting projects. Furthermore, the model provides an overall pattern of the market, including the price and quantity change for the pollution allowances. The timeline for modelling will be from now until 2050, when net zero should be achieved based on the Paris Agreement (United Nations, no date c). 2050 will be the checking point for whether the aim of the "Tee" market: reducing carbon emission back to pre-industrial level, has been achieved and the demand for pollution allowances has approached zero, meaning almost all industries have completed the energy transition. The following provides some assumptions made for the sake of modelling.

Assumptions:

This model estimates relevant figures for a fully operational market, meaning that once a global market is established, it helps to achieve net zero instantly. The model also assumes the price for

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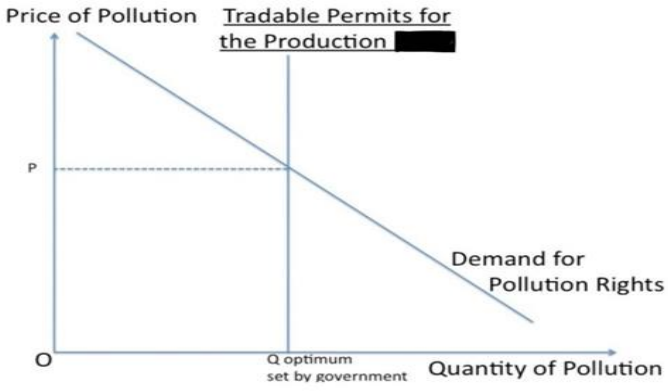
"E" and "T" coins is the same, and dividends for "E" coins are paid annually for convenience. Moreover, the model's currency sales (pollution allowances) don't consider the IPO—the first time selling the currencies. This is because the scale for selling is much greater than in later years, when only used "T" coins will be resold into the "Tee" market. The model, therefore, excludes the IPO for consistency. Furthermore, the currency sales only consider those ultimately purchased by firms (from the "E" market/ PHAs) to pollute, because the provision of new "T*" and the sales of "E" that will be kept by PHAs (after IPO) should only take up a minority of the total currency sales, and the model focuses more on the pollution allowances side of the "Tee" market. The revenue from selling currencies won't be fully used on carbon offsetting projects, as there will be expenses on other environmental projects, such as addressing the harm climate change brings to the commodity sector (agriculture). Thus, the revenue from IPO and later sales of kept "E" coins can be argued to be used on those projects and, therefore, isn't relevant to the model. However, some income from selling allowances to firms in the latter years can also be used on other projects instead of carbon offsetting. Hence, the model will still provide three data sets for the market operation, assuming all or 70% or 50% of sales contribute to the carbon offsetting project. Moreover, if the "Tee" market is established, its operation time will not be 2024, but since all relevant figures in the model are from 2024 or earlier, the model sets 2024 as the starting point of the "Tee" market.

Key concepts/figures

Core function

The basis of the model will be using two functions shown in Figure 8 (same as Figure 3): a function representing the relationship between the price and quantity demanded for pollution allowances, sometimes known as a demand curve; a vertical line (supply curve) showing the supply of pollution allowances set by ICSA (not responsive to price).

Figure 8



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The supply curve is determined by the total currency supply (excluding T* and E). Like the EU-ETS, the supply of allowances will drop by a linear factor that remains constant until the next phase. The model, hence, apply the linear factor similar to the figure for different EU- ETS phases.

The linear factor for the EU-ETS was 2.2% from 2021 to 2023. It almost doubles into 4.3% in 2024 and will stay constant until 2028, when it will be increased to 4.4% (ICAP, no date). The "Tee" market will take a more aggressive approach to create more incentives for reducing carbon emissions, by setting 4.4% as the overall linear reduction factor (after taking into account the dividend rate) from 2024 until 2028. The factor will then be estimated to increase twice into 8.8% for two years and subsequently double again into 17.2% since 2031 for a 5-year "peak period", highly incentivising firms investing in renewable energy. Thereafter, the real linear factor will return to 8.8% and be fixed until the end of the market operation (2050), marking the "Tee" market is about to achieve its aim to reduce carbon emissions back to the pre-industrial level (will be demonstrated later), and some firms have completed energy transition. The demand for pollution allowances in 2050 will represent the final pollution level under the "Tee" market.

The dividend rate (mentioned above) can be represented by a percentage increase in the allowance supply, which is set to be 6% initially and decreases over time to 2% following the trend of currency supply. Notice that the currency supply for the "Tee" market decreases based on the linear factor, meaning that, for example, in the first year, a 6% dividend rate needs to be cancelled out with a 10.4% decrease in the currency supply.

Regarding the demand curve, it can be represented as a function:

$$P(Q, t) = k(t) \cdot Q(t) + C(t)$$

where the price of the allowances (P) t years after 2024 is determined by a linear function represented by the quantity demanded (Q) that year with a changing gradient for time. When the price for pollution allowance is too high, there won't be any demand on the currency. This is represented by C(t), which is essentially the y intercept of the line and decreases overtime as the demand curve shifts leftwards due to more firms investing in renewable resources.

However, when estimating the price of allowance given the quantity and the gradient, the model uses another quantity: b(t), representing the demand when the allowance price is zero (x intercept of the function). b(t) also decreases by time due to the leftward shift of demand. However, the rate of decrease won't be linear following similar pattern with the change in gradient. (will be explained). Thus, the permit price is calculated by applying the formula for the linear function's gradient:

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$$\mathbf{k\ (t) = \Delta y\ (price) / \Delta x\ (quantity)}$$

Substituting the above-mentioned quantities:

$$\mathbf{k\ (t) = \{P\ (t) - \$0\} / \{Q\ (t) - b\ (t)\}}$$

$$\mathbf{P\ (t) = k\ (t) \cdot \{Q\ (t) - b\ (t)\}}$$

The gradient of the demand curve, known as the elasticity of demand, intuitively becomes less steep (more elastic) over time, the model takes the starting point of the elasticity to be -1, and assumes it increases by a percentage of 5 each year, meaning it increases exponentially. This is because the investment in energy transition can initially spark a high decline in firms' reliance on pollution allowances, but after some firms have completed this process, there should be a lower reduction in the steepness of demand.

In terms of the cumulative amount of carbon after the introduction of "Tee" market, it is measured by dividing the sales revenue of currencies in the previous year by the average cost of carbon offsetting projects per ton that year, which is around $20/ton in 2024 (Crawford, 2023 b). This is because the project takes time to set up, and the model assumes the sales revenue will be instantly spent at the end of each year and become operational next year. Moreover, the cost of investment projects is assumed to decrease by 0.5% annually, which has a similar trend to the elasticity of demand. This is because the technology for such projects has a high potential to innovate initially, reducing the cost, which will be increasingly difficult for the latter periods.

Finally, the value of b (t) is assumed to be 100 billion tons at the start and will decrease by 0.1% annually to fit the reduction trend for the gradient (elasticity) of the demand curve. Notice that the above-mentioned rate of reduction for b (t), elasticity of demand, and cost for carbon offsetting projects are purely estimated for the modelling process, which is quite random. After deriving values for k, Q, and b, the price of the allowance, and subsequently the C(t), can be calculated.

Thus, the following presents the data for three occasions: the market operation when 100/70/50% of the sales revenue of "E" coins are invested in carbon offsetting projects.

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Figure 9

C(t) 100%		t	k	b(t) billion ton	P(t) per ton	Cost of project (ton)	i (dividend)	Culmulative carbon (bt)	Years after 2024	Q(bt)	Reduction rate
100	2024	0	-1.000	1.00E+02	60.00	2.00E+01	6%	37.00	0	40	-4.40%
99.4005	2025	1	-0.995	9.99E+01	61.35	1.99E+01	6%	-80.60	1	38.24	-4.40%
98.804594	2026	2	-0.990	9.98E+01	62.69	1.98E+01	6%	-196.20	2	36.48	-4.40%
98.21226	2027	3	-0.985	9.97E+01	64.01	1.97E+01	6%	-309.51	3	34.72	-4.40%
97.623478	2028	4	-0.980	9.96E+01	65.32	1.96E+01	6%	-420.23	4	32.96	-4.40%
97.038225	2029	5	-0.975	9.95E+01	67.72	1.95E+01	5%	-528.08	5	30.05952	-8.80%
96.456481	2030	6	-0.970	9.94E+01	70.10	1.94E+01	5%	-630.94	6	27.15904	-8.80%
95.878224	2031	7	-0.966	9.93E+01	74.17	1.93E+01	5%	-727.69	7	22.4876851	-17.20%
95.303434	2032	8	-0.961	9.92E+01	78.19	1.92E+01	5%	-812.93	8	17.8163302	-17.20%
94.73209	2033	9	-0.956	9.91E+01	82.17	1.91E+01	5%	-884.54	9	13.1449754	-17.20%
94.164172	2034	10	-0.951	9.90E+01	86.10	1.90E+01	4%	-940.38	10	8.47362048	-17.20%
93.599657	2035	11	-0.946	9.89E+01	90.00	1.89E+01	4%	-978.40	11	3.8022656	-17.20%
93.038527	2036	12	-0.942	9.88E+01	89.77	1.88E+01	4%	-996.32	12	3.46766623	-8.80%
92.480761	2037	13	-0.937	9.87E+01	89.55	1.87E+01	4%	-1012.72	13	3.13306685	-8.80%
91.926339	2038	14	-0.932	9.86E+01	89.13	1.86E+01	4%	-1027.56	14	2.99521191	-4.40%
91.375241	2039	15	-0.928	9.85E+01	88.72	1.86E+01	3%	-1041.76	15	2.85735697	-4.40%
90.827446	2040	16	-0.923	9.84E+01	88.32	1.85E+01	3%	-1055.34	16	2.71950203	-4.40%
90.282936	2041	17	-0.918	9.83E+01	87.91	1.84E+01	3%	-1068.27	17	2.58164709	-4.40%
89.74169	2042	18	-0.914	9.82E+01	87.51	1.83E+01	3%	-1080.55	18	2.44379215	-4.40%
89.203688	2043	19	-0.909	9.81E+01	87.11	1.82E+01	3%	-1092.18	19	2.3059372	-4.40%
88.668912	2044	20	-0.905	9.80E+01	86.71	1.81E+01	3%	-1103.16	20	2.16808226	-4.40%
88.137342	2045	21	-0.900	9.79E+01	86.31	1.80E+01	2%	-1113.48	21	2.03022732	-4.40%
87.608958	2046	22	-0.896	9.78E+01	85.91	1.79E+01	2%	-1123.18	22	1.89237238	-4.40%
87.083743	2047	23	-0.891	9.77E+01	85.52	1.78E+01	2%	-1132.22	23	1.75451744	-4.40%
86.561676	2048	24	-0.887	9.76E+01	85.13	1.77E+01	2%	-1140.60	24	1.6166625	-4.40%
86.042738	2049	25	-0.882	9.75E+01	84.74	1.76E+01	2%	-1148.33	25	1.47880756	-4.40%
85.526912	2050	26	-0.878	9.74E+01	84.35	1.76E+01	2%	-1155.40	26	1.34095261	-4.40%

Figure 9 shows the relevant figures when all sales revenue is spent on carbon offsetting projects. Examining the table, the price of the allowance in the first year is set to be $60, similar to the current price of the EU pollution allowance (€65/ton) (Bloomberg NEF, 2024). It peaks at $90 in 2035, a 50% increase in value within 12 years. For the elasticity of demand, it changes from -1 to -8.6 during the period, with b (t) decreasing from 100 to 9.74 bt and C (t) dropping from 100 to 85.5 bt. With regards to the number of allowances (consider only T), it's set to be 40 billion metric ton in 2024, similar to 37.4 billion tons for the 2023 global emission level (IEA, no date). By 2050, the global emission (number of allowances) is estimated to be 1.34 billion tons, which is quite low compared to now (a 96% reduction) (the total carbon emission will be higher in reality as the model excludes T*). For the cumulative carbon, it's set to increase by 37 bt in 2024 (equivalent to total emission) and will reduce to - 1155 bt in 2050. (Moseman, A, 2023) suggests more than 900 bt of carbon needs to be captured to return the emission level back to the pre-industrial level. The estimated figure for 2050 should be enough to achieve this aim. Figure 10 plots the overall pattern for the cumulative amount of carbon from 2024.

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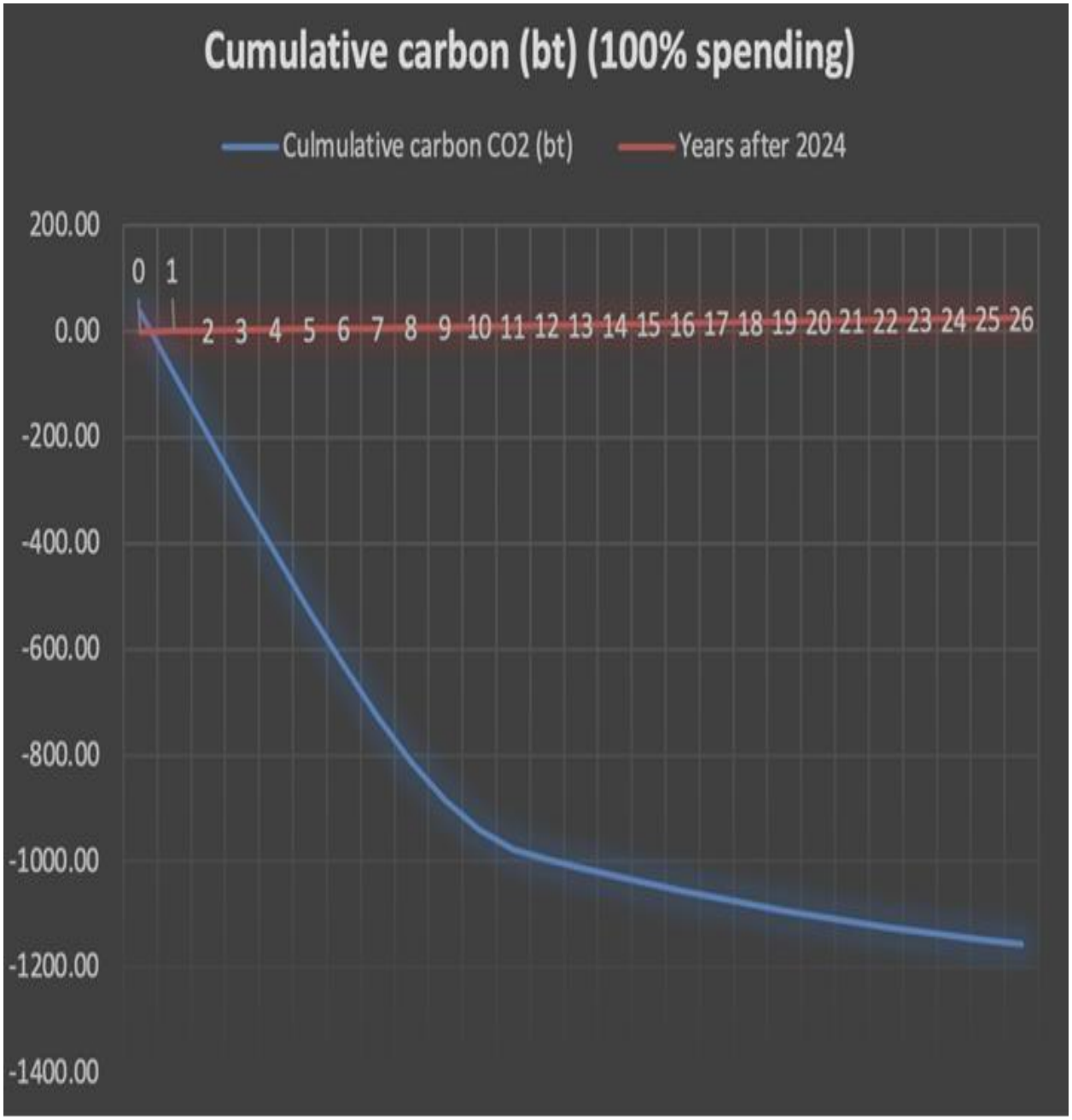
Figure 10



For the case when 70% and 50% of the sales revenue are spent on carbon offsetting projects, the results vary around 2 and 4 bt, respectively, compared to the first case. As other quantities like price, C(t) are the same for each scenario, Figure 11 shows the cumulative amount of carbon under the "Tee" market operation for both cases.

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Figure 11

Culmulative carbon (70%)	Years after 2024	Culmulative carbon (50%)	Years after 2024
37.00	0	37.00	0
-44.60	1	-20.60	1
-160.83	2	-137.25	2
-274.86	3	-251.76	3
-386.39	4	-363.83	4
-495.13	5	-473.16	5
-599.63	6	-578.76	6
-698.25	7	-678.63	7
-787.02	8	-769.75	8
-862.79	9	-848.29	9
-923.43	10	-912.13	10
-966.89	11	-959.22	11
-990.90	12	-987.28	12
-1007.76	13	-1004.45	13
-1023.07	14	-1020.08	14
-1037.47	15	-1034.60	15
-1051.24	16	-1048.51	16
-1064.37	17	-1061.77	17
-1076.84	18	-1074.37	18
-1088.67	19	-1086.33	19
-1099.84	20	-1097.63	20
-1110.37	21	-1108.29	21
-1120.26	22	-1118.31	22
-1129.49	23	-1127.68	23
-1138.07	24	-1136.39	24
-1146.00	25	-1144.45	25
-1153.27	26	-1151.85	26

Examining the table, cumulative reduction in carbon for both scenarios is sufficient to meet the environmental target for the “Tee” market, meaning the market’s aim is achievable under normal operation. Figure 12, 13 plots the cumulative amount of carbon for both scenarios.

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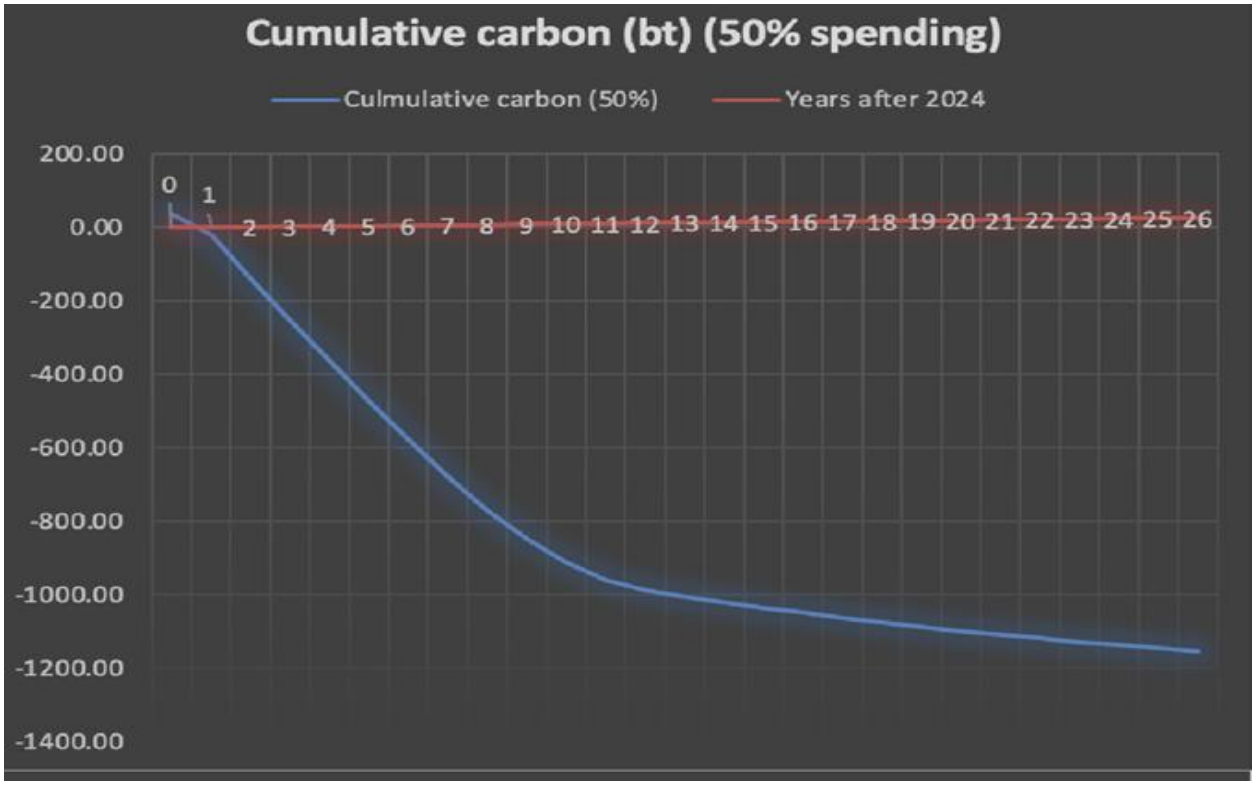
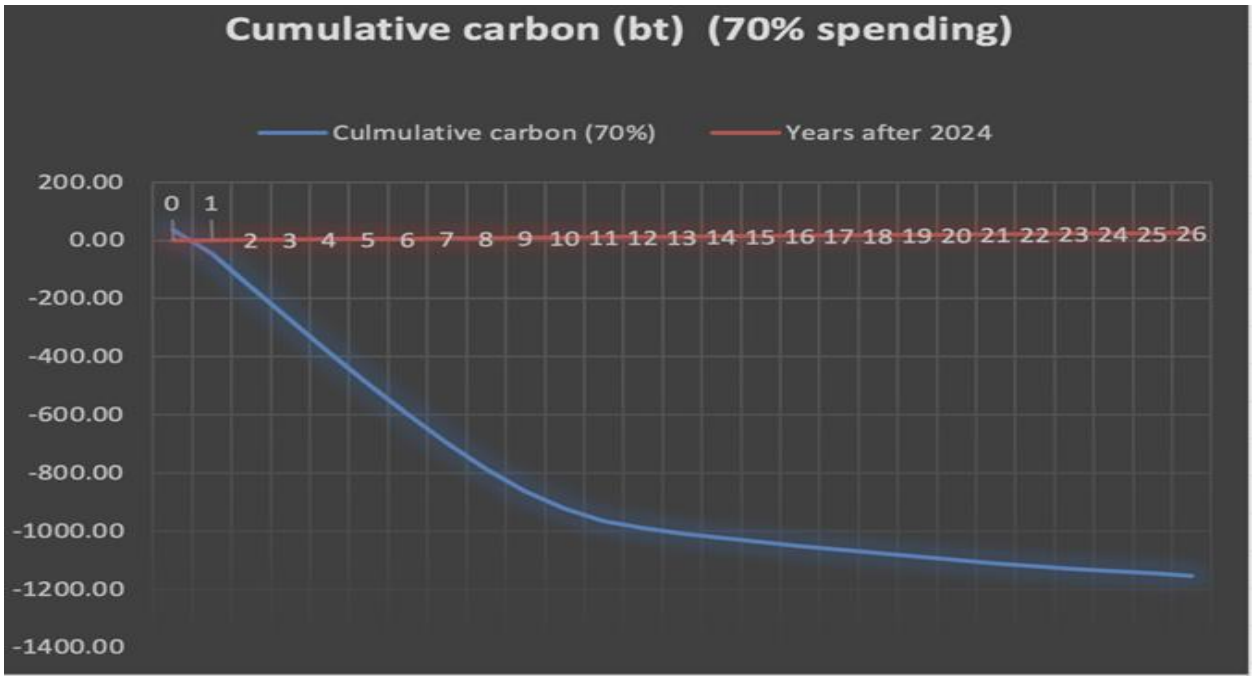
Figure 12





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6.3. Conclusion and judgment

The description on modelling with key figures has been conducted. The following evaluates the "Tee" market with the above information.

From Section Five, several drawbacks of the "Tee" market are pointed out, such as the problem of finding the revenue source for the intervention and termination of the market, inaccurate measurement of pollution, and its predictability. However, the market's dual structure and related policies are proven to be economically efficient, incentivising more environmental protection from firms and the general public by stimulating investors' profit motivated behaviours. This solves the critical issue for tackling climate change: motivating joint effort and reducing fear of interdependency between individuals while protecting the environment. Furthermore, the system addresses problems with the current cap-and-trade system, such as imposing all-time trading "T" and "E" markets that replace the inefficient auction system.

Section Six's findings confirm the potential of a well-functioning 'Tee' market. It is feasible to generate sufficient funding for carbon offsetting projects, effectively reducing carbon emissions to pre-industrial levels within 30 years. Furthermore, by solely selling new 'T and E' coins after the IPO, the final cumulative carbon amount aligns with the 'Tee' market's target. This suggests a high potential for ICSA to utilise the leftover IPO revenues to further promote energy transition and other environmental projects, reinforcing the effectiveness of the 'Tee' market.

Thus, after considering all the factors above, the thesis believes the benefits of the "Tee" market, as an improved alternative to the cap-and-trade system, outweigh its drawbacks. The system is capable of improving the efficiency of addressing climate change, promoting more carbon reduction and energy transition, which ensures a sustainable atmosphere for the world economy and humanity.

7. Conclusion

7.1. Summary of the thesis

In conclusion, after reviewing the current cap-and-trade system, this thesis proposes a more efficient "Tee" market to incentivise ecological protection. The market's unique characteristics of the dual structure, especially the "E" market and its currency conversion rules, cultivate not only industrial but also more private sector activities in the scheme, convincing that environmental protection should be a global action which isn't constrained to liable entities. Furthermore, the fact that a worldwide "Tee" market meets the 2 degree Paris Agreement and net zero soon after operation is a testament to its potential global impact. Other policies and designs, including the establishment of ICSA and the promoting more roles from the commercial banks,

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help lower the transaction cost, facilitating a sustainable and stable market. Finally, the modelling of the market proves its capability of returning global emissions to the pre-industrial level, and therefore, together with the analysis above, helps the thesis to conclude the "Tee" market's feasibility in effectively promoting carbon reduction more efficiently than the current system despite some drawbacks.

7.2. Suggestions for future research

The following provides some future research that can be conducted, which focuses on addressing the issues with the "Tee" market and increasing its impact on environmental protection. The first is to discover further policies and methods to incentivise more developing nations to join the cap-and-trade scheme, which is crucial for setting a global market and raising enough funds to reduce carbon emissions to the pre-industrial level.

The second is to study how to address the issue of finding revenue for the ICSA to intervene and halt the market. Possible suggestions include ICSA introducing "T" currencies that last more than one year and selling them to central banks via future contracts with a premium, acting as revenue to maintain market stability.

To increase the "Tee" market's effectiveness in environmental protection, further research can be conducted on applying the "Tee" market not just in carbon emission, but also other greenhouse gases such as nitrous oxide emitted from using nitrogen fertiliser in agriculture (Pan, S.-Y. et al, 2022). However, unlike the rules for carbon emission, it may be better to introduce a purely "carrot" system, meaning farmers get rewarded for not using such fertiliser. This is because the agricultural sector provides food resources for individuals worldwide, meaning ICSA needs to consider crop yield and quality, apart from the environment. This scheme, in turn, promotes innovation on more environmentally friendly fertilisers. Furthermore, research on increasing the market's significance by allowing the firms to invest in energy transition projects via "E" and "T" coins can also be conducted.

7.3. Concluding remarks

Ultimately, the thesis has proven the likelihood of addressing climate change more efficiently through structural reforms of the cap-and-trade system. The core of the thesis is to emphasise the importance of unifying force, and the utilisation of firms' but also individuals' profit motive action, to promote carbon reduction. In the past, economists realised the ecological issue couldn't be tackled by just introducing a punishment (a carbon tax). They subsequently introduced the carrot and stick system: cap on trade, creating more incentives. Now, it's time to step forward again to solve this problem decisively.

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